

Feb. 22, 1966

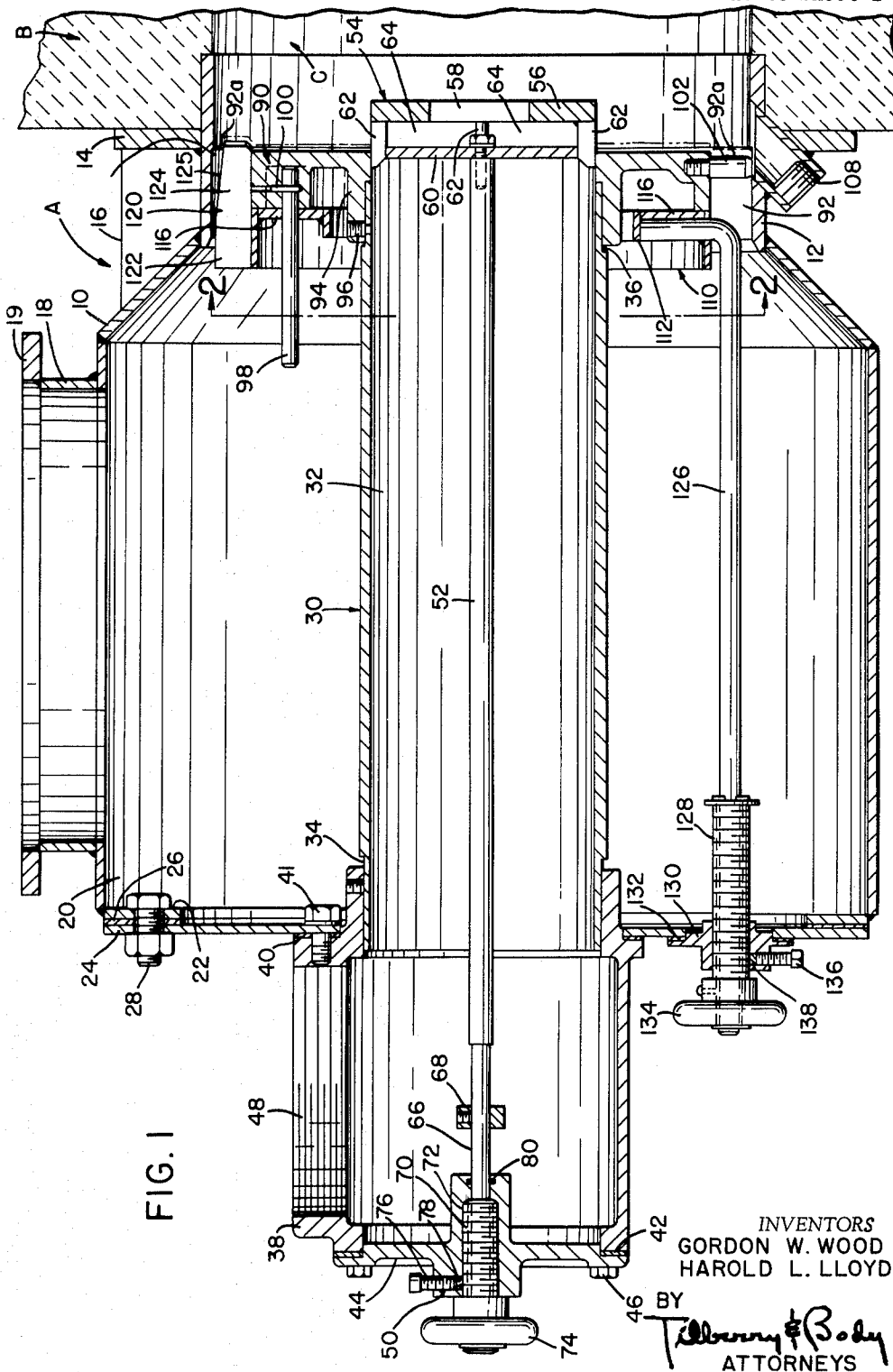
G. W. WOOD ETAL

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FUEL BURNER WITH ADJUSTABLE NOZZLE

Filed March 20, 1963

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FUEL BURNER WITH ADJUSTABLE NOZZLE

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FIG. 2

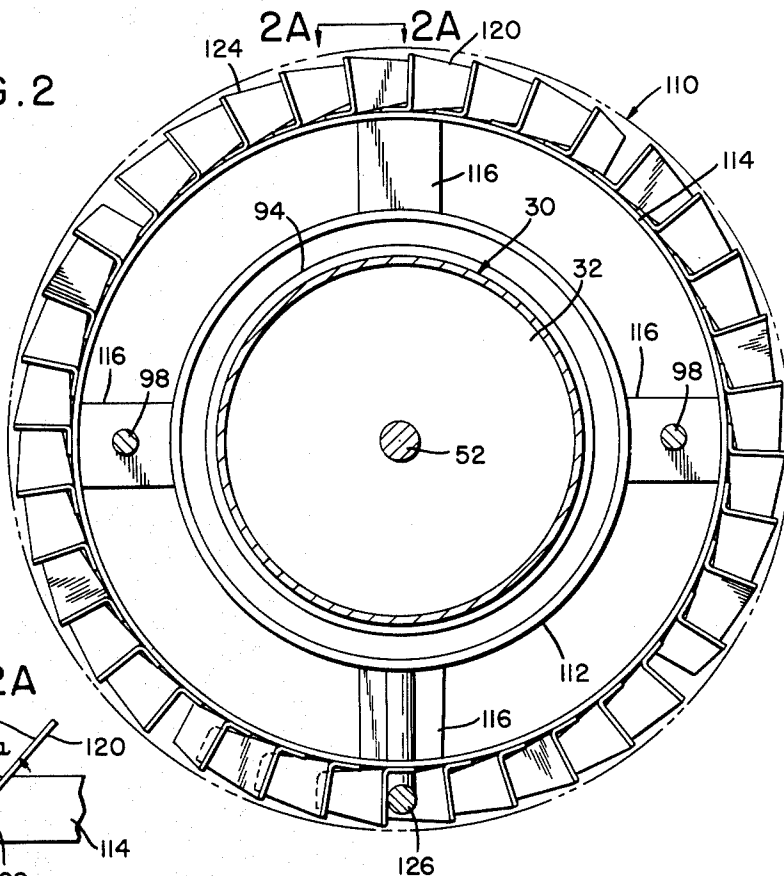


FIG. 2A

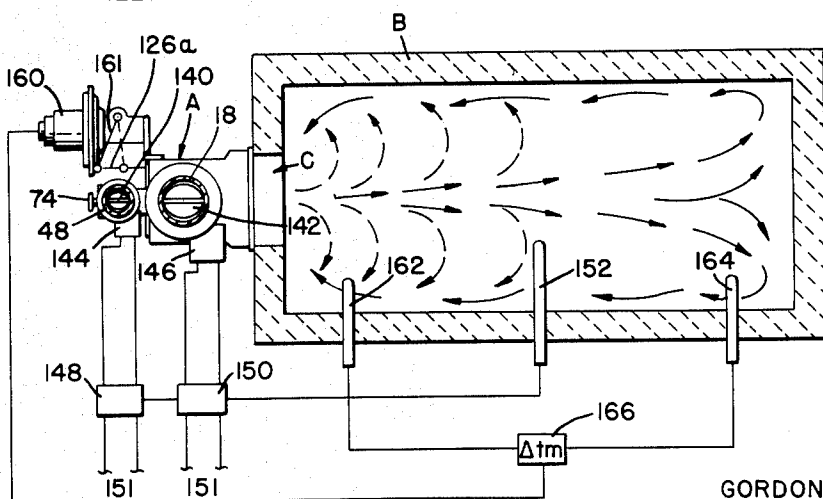
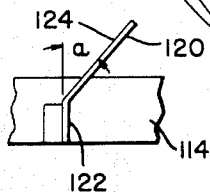


FIG. 3

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FIG. 4

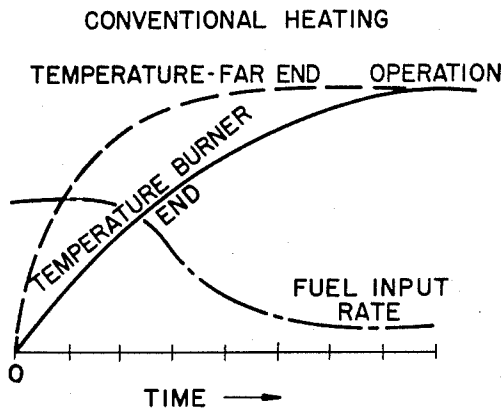
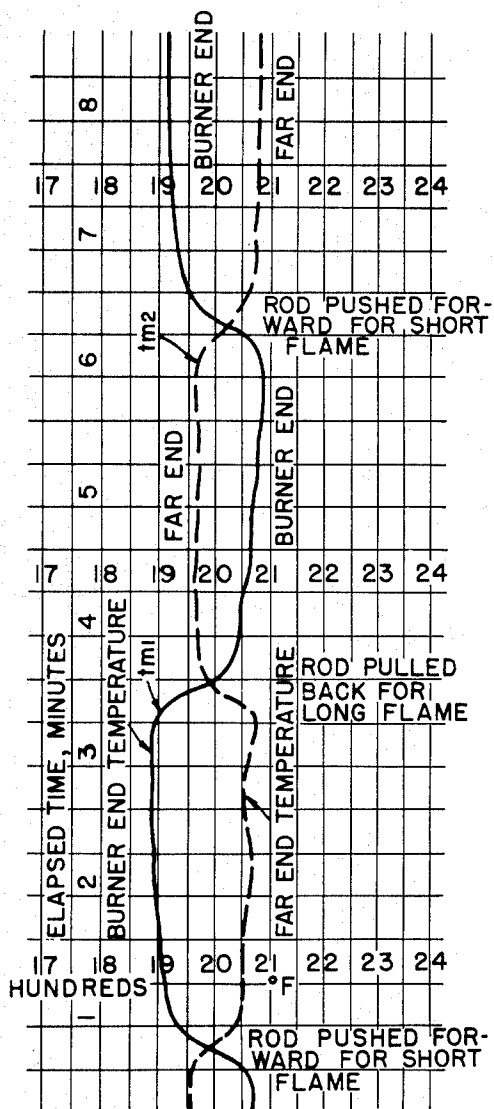


FIG. 5

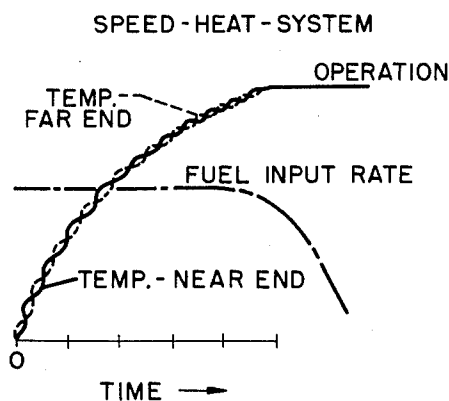


FIG. 6

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3 Claims. (Cl. 239-416.4)

The present invention pertains to the art of fuel burners and more particularly to a fuel burner for firing an industrial furnace or the like.

The invention is particularly applicable to a burner for firing an industrial soaking furnace and it will be discussed with particular reference thereto; however, it is to be appreciated that the invention has much broader applications and may be used in various other industrial heating installations.

In the art of heating steel ingots and large metal castings for various metallurgical purposes, it has become common practice to soak the ingots or castings for a prolonged time at a relatively high temperature. To efficiently accomplish such a large scale heating operation, there is usually provided a soaking furnace which is heated by a single fuel burner adjacent one end of the furnace. A flame is projected by the burner from the burner end of the furnace to the opposite end thereof.

In larger installations, the flame may have a length exceeding twelve feet and the heating capacity of the flame may be greater than 500,000 B.t.u. per hour. To generate such a tremendously large flame, the burner at one end of the furnace often requires a flame projecting nozzle having a diameter exceeding twelve inches. A burner of this size usually comprises an inner fuel passage for forcing fuel outwardly into the furnace and an annular passage for directing a combustion supporting fluid, such as air, around the outwardly propelled fuel. Such burners have been provided with control valves, usually of the butterfly type, for controlling the heat energy imparted by the flame to the interior of the furnace. This is the only major adjustment heretofore provided on such a burner.

After a furnace of the type described has been idle for a substantial time, it must be reheated by the one burner adjacent one end of the furnace. If the flame issuing from the nozzle of the burner were maintained at its maximum heating rate, i.e., B.t.u. per hour, a problem resulted in that the far end of the furnace would be heated to a destructive temperature before the remainder of the furnace reached the soaking temperature. Consequently, to prevent rapid deterioration of the furnace lining adjacent the end opposite the burner nozzle, the flame issuing from the nozzle was maintained at its maximum heating rate only until the opposite end of the furnace reached the desired soaking temperature. At this time, the flame was shut off, or at least the heating rate was decreased, until the furnace reached an equilibrium temperature. This required a substantial cooling of the end remote from the burner and a corresponding heating of the burner end of the furnace. After the furnace reached equilibrium, a flame having a maximum heating rate was again directed toward the opposite end of the furnace. This procedure of increasing and decreasing the heating rate of the flame was continued until the whole furnace was raised to the desired soaking temperature.

Such a vacillatory heating cycle required a substantial amount of time and was expensive to control.

The present invention is directed toward a fuel burner which allows the use of a flame having the maximum heating rate during the complete warm up cycle of a soaking furnace without causing harmful over heating of any portion of the furnace lining.

In accordance with the present invention, there is provided an improvement in a burner for causing an outwardly projecting flame pattern which burner includes an annular passage for projecting pressurized combustion supporting fluid. The improvement in such a burner comprises means in the annular passage for adjusting the turbulence in the fluid flowing therefrom to change selectively the flame pattern issuing from the burner.

In accordance with another aspect of the present invention, there is provided an improvement in a furnace having a first end and a second end and a burner mounted adjacent the first end and having a nozzle directing a flame toward the second end. The improvement in such a furnace comprises an actuator means for changing the pattern of the flame from a first pattern that concentrates the heating effect of the flame adjacent the first end of the furnace to a second pattern which concentrates the heating effect of the flame adjacent the second end of the furnace, means for determining the temperature differential between the ends of the furnace and control means for energizing the actuator means when the temperature differential reaches a predetermined value to select the proper pattern for offsetting this temperature differential.

In accordance with still a further aspect of the present invention, there is provided a method of heating a furnace having a first end and a second end which method comprises concentrating the heating effect of a flame at the first end, sensing the differential in temperature between the furnace ends, concentrating the heating effect of a flame at the second end of the furnace after the temperature differential between the ends reaches a given value and, thereafter, repeating the controlled heat concentration reversals.

The primary object of the present invention is the provision of a burner for causing an outwardly projecting flame pattern which burner can change the flame heating pattern without substantially changing the heating rate of the flame.

Still a further object of the present invention is the provision of a burner for causing an outwardly projecting flame pattern which burner can produce a long, short or intermediate length flame pattern without substantially changing the heating rate of the flame.

Yet another object of the present invention is the provision of a burner for causing an outwardly projecting flame pattern which burner can direct the heating effect of its flame to a remote portion of a furnace or to a portion of the furnace adjacent the burner by only a simple internal adjustment.

Another object of the present invention is the provision of a burner for causing an outwardly projecting flame pattern which burner has an annular combustion supporting fluid passage and means for controlling the amount of turbulence in this passage for controlling the flame pattern of the burner.

Still a further object of the present invention is the provision of a burner for causing an outwardly projecting flame pattern which burner has an annular combustion supporting fluid chamber and adjustable baffle means in the annular passage for controlling the amount of turbulence or direction of the fluid flowing in the passage which in turn controls the flame pattern of the burner.

Another object of the present invention is the provision of a furnace control arrangement including a burner that can have its flame pattern adjusted without substantially changing the heating rate of the flame, which arrangement has a sensing system to determine the cooler portion of the furnace and means for changing the flame pattern of the burner to concentrate the heating effect of the flame at the determined cooler portion of the furnace.

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These and other objects and advantages will become apparent from the following description used to illustrate the preferred embodiment of the present invention as read in connection with the accompanying drawings in which:

FIGURE 1 is a side elevational view, in section, illustrating the preferred embodiment of the present invention;

FIGURE 2 is a front elevational view, in section, taken generally along line 2—2 of FIGURE 1;

FIGURE 2a is a partial top view illustrating the baffle blades of the present invention;

FIGURE 3 is a top, somewhat schematic, plan view illustrating another preferred embodiment of the present invention;

FIGURE 4 is a temperature strip chart showing the operational characteristics of the invention as disclosed in FIGURE 3;

FIGURE 5 is a rate of temperature rise chart showing the operation of the prior art; and

FIGURE 6 is a rate of temperature rise chart showing the operation of the preferred embodiment of the present invention.

Referring now to the drawings, wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only and not for the purpose of limiting same, FIGURE 1 shows a burner A for directing a flame into furnace B through flame opening C so that the interior of the furnace is sufficiently heated for various purposes such as soaking steel ingots prior to rolling or heat treating large castings.

Although the burner A could assume a variety of structural features, in accordance with the preferred embodiment of the present invention, the burner comprises a main casing 10 having a nozzle 12 adapted to extend into flame opening C. To secure the casing 10 onto the furnace B, the casing is provided with a mounting plate 14 and circumferentially spaced supports 16. At the upper portion of casing 10 there is a combustion supporting fluid inlet passage 18 which receives air having a high volume and under a pressure of approximately 6-8 ounces per square inch. The passage is provided with a mounting flange 19 to secure an appropriate air supply line onto the casing 10. In accordance with the preferred embodiment of the present invention, air is introduced into passage 18; however, it is appreciated that various other combustion supporting fluids may be used without departing from the intended spirit of the invention.

Within casing 10 there is provided an air plenum chamber 20 having a rearwardly facing back flange 22 for mounting cover plate 24 having gasket 26 and appropriately positioned bolts or other fastening devices 28. In this manner, the chamber 20 is substantially closed for receiving pressurized fluid from passage 18 which fluid is directed through nozzle 12 into opening C.

Referring again to the details of burner A, there is provided a fuel casing 30, which is a tubular structure generally concentric with respect to the nozzle 12 and having an internal fuel passage 32 and reduced end portions 34, 36. Adjacent the rear of casing 30 there is provided a further casing 38 for directing fuel into passage 32. The forwardmost end of casing 38 is adapted to be received upon reduced portion 34 of casing 30 and the casing 38 is sealed by gasket 40 and is held against plate 24 by appropriate fastening devices such as bolts 41. In sealing engagement with the other end of casing 38 is a gasket 42 adapted to seal cap 44 held onto the casing 38 by appropriate means such as bolts 46. Threaded opening 48 provides an access passage for fuel, such as natural gas, which is directed into passage 32 for combustion when mixed with the air from plenum chamber 20. Centrally disposed with respect to cap 44 is a hub 50 which will be hereinafter described in more detail.

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is provided a control rod 52 having supported on one end thereof a cap 54 which cap comprises end plate

Extending coaxially with respect to passage 32, there 5
56 with axial aperture 58, support plate 60, and support fingers 62 which define radially facing openings 64. At the opposite end of control rod 52 there is provided a reduced portion 66 having a stop 68 secured thereto and terminating in a threaded end 70. The threaded end is received within threaded bore 72 of hub 50 so that rotation of control rod 52 by a handle 74 adjusts 10
the outwardly extending distance of cap 54 with respect to the end of passage 32. With the cap 54 in the position shown in FIGURE 1, fuel entering inlet 48 and passing through passage 32 is directed into nozzle 12 in both an axial direction through aperture 58 and a radial direction through openings 64. This disperses the fuel in the nozzle to control the quality of the flame passing through opening C in a manner which will be described later. To secure the rod 52 in the desired axial position with respect to passage 32, there is provided a lock bolt 76 adapted to apply a pressure to fiber slug 78 so that the end 70 is secured within bore 72 in any desired position. Gasket 80 is utilized for preventing egress of fuel through the bore 72.

Referring now to the forwardmost end of casing 30, there is provided a support ring 90 attached onto reduced portion 36 by a sleeve 94 and locked into position by a bolt 96. The support ring defines an annular combustion supporting fluid passage 92 generally concentric with respect to passage 32 and terminating in an annular outlet 92a as shown in FIGURES 1 and 2. The combustion supporting fluid can pass through the passage 92 and around the fuel being projected through aperture 58 and opening 64. Facing rearwardly from ring 90 there is provided spaced generally parallel guide pins 98 secured onto ring 90 by lock pins 100. To center the ring 90 with respect to the nozzle 12, there is provided a plurality of circumferentially spaced centering pegs 102.

The operation of burner A as so far defined comprises propelling fuel through passage 32, which fuel is mixed with combustion supporting fluid flowing through passage 92. By providing an appropriate igniter in tube 108, the fuel and air mixture is ignited and continues to burn to form a flame which is projected through opening C into furnace B.

To produce a clear flame, the cap 54 is adjusted in the position shown in FIGURE 1. In this manner, fuel flows through radial openings 64 where it is quickly combusted to produce a clear blue flame. To produce a luminous or yellow flame, handle 74 is rotated to retract cap 54 into passage 32 so that fuel from passage 32 is propelled into the furnace B in a core surrounded by air from passage 92. In this manner, the natural gas or other hydrocarbon fuels tend to crack, because of the heat of the furnace and the flame, which produces a yellow luminous flame. The particular flame desired is dictated by the wishes of the furnace operator through manipulation of handle 74.

In accordance with the present invention, there is provided a means for controlling the amount of turbulence in the combustion supporting fluid passing from plenum chamber 20 through annular passage 92. In accordance with the illustrated embodiment of the present invention, such a means is a baffle means 110; however, it is appreciated that various means could be devised for accomplishing the desired result. Baffle means 110 comprises an inner sleeve 112, an outer sleeve 114 and radial support braces 116 joining the sleeves to produce a unitary element or rim. There are provided a number of circumferentially spaced blades 120 on the outwardly facing surface of sleeve 114 as is best shown in FIGURES 2 and 2a. Each of these blades comprises a mounting end 122 which is secured by appropriate means onto the surface of sleeve 114 and a baffle plate portion 124 which actually causes a turbulence of the fluid flowing through

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passage 92. The plate 124 forms an angle a with respect to the normal direction of flow of fluid through passage 92. In accordance with the preferred embodiment of the present invention, angle a is approximately 30° ; however, it is appreciated that various other angles may be provided which will produce the desired turbulence as will be explained later. An angle of 45° has also been used with some success. It is appreciated that the blades 120 should impart only slight aerodynamic drag or loss to the fluid flowing through passage 92. In other words, the plates 124 should cause the fluid in passage 92 to form a vortex of fluid issuing from the passage 92 without substantially decreasing the volume of flow of the fluid.

To control the amount of fluid flowing through passage 92 which is actually affected by plates 124, there is provided a means for adjusting the axial position of the baffle plates 124 with respect to the passage 92 or nozzle 12. Since the plates 124 have a forwardly facing relief 125, as best shown in FIGURE 1, as the plates are shifted rearwardly with respect to passage 92, less of the fluid passing through the passage 92 is affected by the plates 124. Although various structures could be accomplished for shifting the baffle means 110 rearwardly, in accordance with the preferred embodiment of the present invention, there is provided a control rod 126 having a shank 128 threadably received within cap 130 with a sealing gasket 132 to prevent egress of air from plenum chamber 20. The rearwardmost end of rod 126 terminates in handle 134 that may be rotated to axially shift rod 126. To secure the rod 126 in the desired axial position, there is provided a lock bolt 136 and a fiber slug 138 similar to the corresponding bolt 76 and slug 78 which have been previously discussed.

In operation, adjustment of the axial position of baffle means 110 changes the amount of turbulence created by the baffle means on the fluid flowing through passage 92; however, there is very little volume loss of combustion supporting fluid from such turbulence. Accordingly, the amount of heat caused by the combustion of the fuel flowing through passage 32 and the fluid flowing through passage 92 is not substantially changed. When the means 110 is positioned in the forwardmost location as shown in FIGURE 1, the baffle means affects substantially all of the fluid flowing through passage 92 so that the fluid is created into a vortex which swirls outwardly and causes a flame generated by the burner to be located substantially adjacent the exit end of nozzle 12. When the handle 134 is rotated to shift the baffle means 110 rearwardly on pins 98, the plates 124 are shifted from their position within annular passage 92 so that fluid flowing through passage 92 is not swirled and is propelled outwardly across the furnace B so that the main heating effect of the flame caused by the burner A is substantially remote from the end of nozzle 12.

In this manner, by simple manipulation of rod 126 a flame having a long pattern can be provided for heating the opposite end of the furnace or a flame having a short pattern, i.e. caused by the vortex or turbulence of the air flowing through passage 92, for heating the furnace adjacent the burner end. This ability to change the flame pattern issuing from the end of the burner A is a substantial advantage in an industrial burner and allows improved control of the heating effect caused by the burner without decreasing the actual heating rate, i.e. the B.t.u. per hour produced by the burner. In essence the means 110 changes the direction of the air flowing through passage 92 when in its forwardmost position to produce a short flame and does not change the direction substantially when shifted to its backwardmost position which produces a long flame.

Referring now to FIGURE 3, the burner A is utilized for heating the interior of furnace B by passing the flame through opening C. The burner A has an outwardly extending control rod 126a which corresponds substantially to the control rod 126 as shown in FIGURE 1 with the

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exception that the control rod 126a reciprocates from a first position with means 110 in the forwardmost location to a second position with means 110 in the backwardmost location. In other words, the infinitely variable arrangement as shown in FIGURE 1 is eliminated and the means 110 is shifted from one position to another to produce either a long flame or a short flame. Inlet 48 is provided with a butterfly valve 140 and passage 18 is provided with a similar butterfly valve 142. These valves are controlled by motors 144, 146, respectively, which motors actuate the butterfly valve in accordance with signals received from motor controls 148, 150 receiving power from sources 151. A temperature sensor such as thermocouple 152 is positioned within furnace B to sense the average temperature within the furnace. By introducing a signal from thermocouple 152 into controls 148, 150 the valves 140, 142 are controlled to regulate the heating rate, i.e. B.t.u. per hour, of the flame issuing through opening C.

To control the position within the furnace wherein the heat is concentrated irrespective of the heating rate of the flame, there is provided a fluid motor 160 having an actuator arm 161 which arm shifts rod 126a from its first to its second position which positions are shown in solid and dashed lines. When the arm 161 is in its forwardmost position as shown in dashed lines, the baffle means 110 is in its forwardmost position within passage 92; therefore, turbulence is imparted to the fluid flowing through the passage so that the flame issuing through opening C remains substantially adjacent the opening. This is depicted by the heating or flame pattern shown in dashed lines within the furnace. When the motor 160 shifts the arm 161 to the solid line position, baffle means 110 is retracted from passage 92 so that the flame or heating pattern is substantially as shown in the solid lines in the furnace B. In this manner, operation of arm 161 changes the heating or flame pattern within furnace B from one pattern which tends to heat the rear end of the furnace to a second pattern which tends to heat the front end of the furnace. This alternation between heating or flame patterns is advantageously utilized in heating the furnace and in maintaining the temperature of the furnace during operation.

Adjacent the front or burner end of the furnace B there is provided a temperature sensor 162 and at the rear end of the furnace there is provided a second temperature sensor 164. These temperature sensors at the ends of the furnace are directed into a differential control 166 which directs a signal to motor 160 in accordance with the difference in temperature sensed by sensors 162 and 164. The differential control 166 is so constructed that when the temperature adjacent sensor 164 is a given value over the temperature adjacent sensor 162, motor 160 is actuated to shift arm 161 in its forward position. In this manner, the heating pattern is changed so that the major amount of heat is directed toward the front furnace B adjacent sensor 162. After operation in this position, the sensor 162 will be heated to a temperature greater than the sensor 164 and when the differential in temperature is sufficient, the control 166 will again signal motor 160 to shift the arm 161 into its rearwardmost position to change the heating or flame pattern to a pattern which will concentrate the heat energy adjacent sensor 164.

FIGURE 4 shows a temperature strip chart of continuous operation of furnace B, the solid line indicating the temperature at the burner end and the dashed line indicating the temperature adjacent the rear end of the furnace. When the temperature adjacent the burner is at a preset maximum value t_{m1} , rod 126 is pulled back and the flame is made long to heat the far end of the furnace; thereafter, when the temperature adjacent the rear end is at a preset maximum t_{m2} , the rod is pushed forward to cause a short flame for heating the furnace adjacent the burner. The amount of fuel and combustion supporting fluid is controlled by the temperature of the furnace as

sensed by thermocouple 152. It is appreciated that the differential control 166 also controls the position of arm 161 in accordance with maximum temperatures, i.e. t_{m1} and t_{m2} , as well as by preset temperature differentials. The maximum temperature control is more appropriate for continuous operation whereas the differential control is more appropriate for warm-up of the furnace as will be described.

Referring now to FIGURE 5, if the only control in furnace B was thermocouple 152 for controlling the heating rate of the flame issuing from burner C, the flame issuing from the burner would heat the rearwardmost portion of the furnace first. To prevent overheating of this portion of the furnace during the initial warm-up of the furnace, the fuel input rate or heating rate of the burner B as shown in the phantom line of FIGURE 5 would have to be decreased during the warm-up period. Accordingly, before the furnace is completely heated to the desired operation temperature, the heating adjacent the far end must be slowed to allow the temperature to gradually increase adjacent the burner end of the furnace. This consumes a substantial amount of time and is thus disadvantageous.

Referring to FIGURE 6, as the temperature of the far end of furnace B increases a given amount over the temperature at the near end of the furnace, the flame or heating pattern is shifted to the near end of the furnace as has been explained without decreasing the fuel input rate to the furnace. By repeatedly reversing the heat concentration adjacent the opposite ends of the furnace, maximum fuel input rate may be maintained while the furnace is being raised to operation temperature. This substantially decreases the time for heating the furnace and thus saves the expense of the warm-up delay as exhibited in the prior art represented by FIGURE 5.

If the charge within furnace B is not uniform, the sensor 152 may not provide accurate control within the furnace and portions of the furnace may be substantially higher in temperature than indicated by this sensor. This problem is completely eliminated by the use of the dual temperature sensors and differential control as shown in FIGURE 6 or the maximum temperature control as shown in FIGURE 4.

The present invention has been discussed in connection with certain structural embodiments; however, it is appreciated that various structural changes may be made without departing from the intended spirit and scope of the present invention as defined by the appended claims.

Having thus described our invention, we claim:

1. In a burner for causing an outwardly projecting flame pattern including a nozzle, a centrally located casing with a first outlet for directing fuel through said nozzle, means forming a substantially annular passage within said burner, around said casing and coaxial with said casing, said passage forming means including an outer cylindrical wall in said burner and an inner cylindrical wall, said passage having an annular second outlet adjacent the same end of said nozzle as said first outlet whereby said second outlet is concentric with the first outlet, said second outlet having a substantially fixed cross-section and means directing pressurized combustion supporting fluid through said passage and out said second outlet, the improvement comprising: adjustable means in said annular second outlet for adjusting the turbulence of said fluid flowing therethrough to change said flame pattern between a pattern concentrated at said outlets and a pattern remote from said outlet without substantially changing the amount of fluid flowing through said annular second outlet, said turbulence adjusting means comprising a plurality of blades extending radially within said passage and mounted on said inner

wall, each of said blades forming an angle with the axis of said annular passage, said blades tapering downwardly from a height generally matching the width of said second outlet at the rear of said blades to a height substantially less than the width of said second outlet at the front of said blades, and means for moving said blades and inner wall as a unit, in unison, axially within said passage between a rearwardmost position where the lesser height portions of said blades are within the second outlet of said annular passage to impart a lesser amount of turbulence to said fluid flowing therethrough and a forwardmost position where the greater height portions of said blades are within the second outlet of said annular passage to impart a greater amount of turbulence to said fluid flowing therethrough.

2. The improvement as defined in claim 1 wherein said blades form an angle generally in the range of 30°-45° with respect to the axis of the annular passage.

3. In a burner for causing an outwardly projecting flame pattern including a nozzle, a centrally located casing with a first outlet for directing fuel through said nozzle, means forming a substantially annular passage within said burner, around said casing and coaxial with said casing, said passage forming means including an outer cylindrical wall in said burner and an inner cylindrical wall, said passage having an annular second outlet adjacent the same end of said nozzle as said first outlet whereby said second outlet is concentric with the first outlet, said second outlet having a substantially fixed cross-section and means directing pressurized combustion supporting fluid through said passage and out said second outlet, the improvement comprising: adjustable means in said annular second outlet for adjusting the turbulence of said fluid flowing therethrough to change said flame pattern between a pattern concentrated at said outlets and a pattern remote from said outlet without substantially changing the amount of fluid flowing through said annular second outlet, said turbulence adjusting means comprising a plurality of blades each of which is tapered downwardly in a direction radial of said passage and is disposed at an angle with respect to the axis of said passage, said blades being mounted on said inner wall, and means for moving said blades and inner wall as a unit, in unison, axially within said passage between a rearwardmost position where the lower parts of said tapered blades are within said second outlet to impart a lesser amount of turbulence to said fluid flowing therethrough and a forwardmost position where the higher parts of said tapered blades are within said second outlet to impart a greater amount of turbulence to said fluid flowing therethrough.

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