March 14, 1933. K. C. McCUTCHEON 1,900,942

OPEN HEARTH FURNACE CONSTRUCTION

Filed Jan. 9, 1931 7 Sheets-Sheet 1

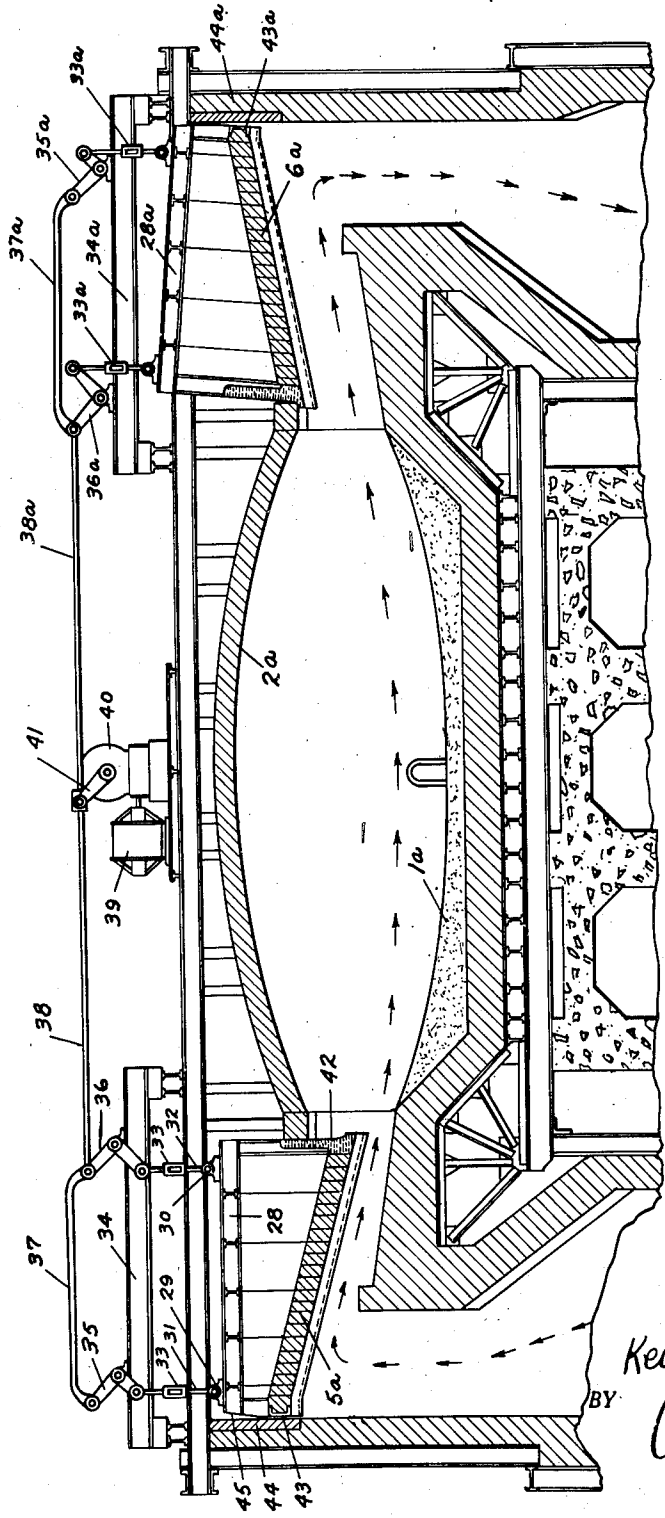

Fig. 1.

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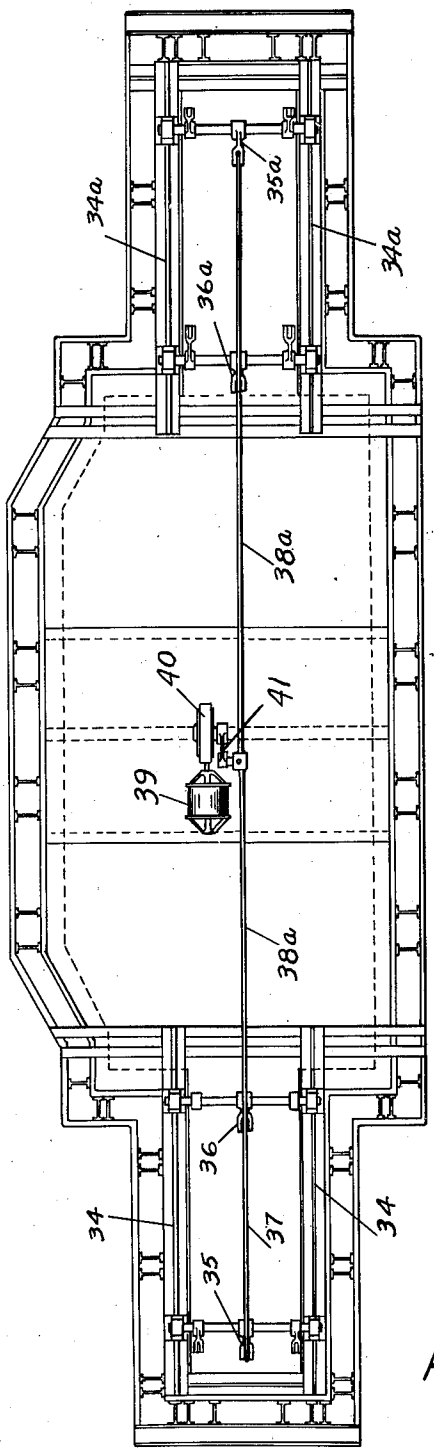

Fig. 2.

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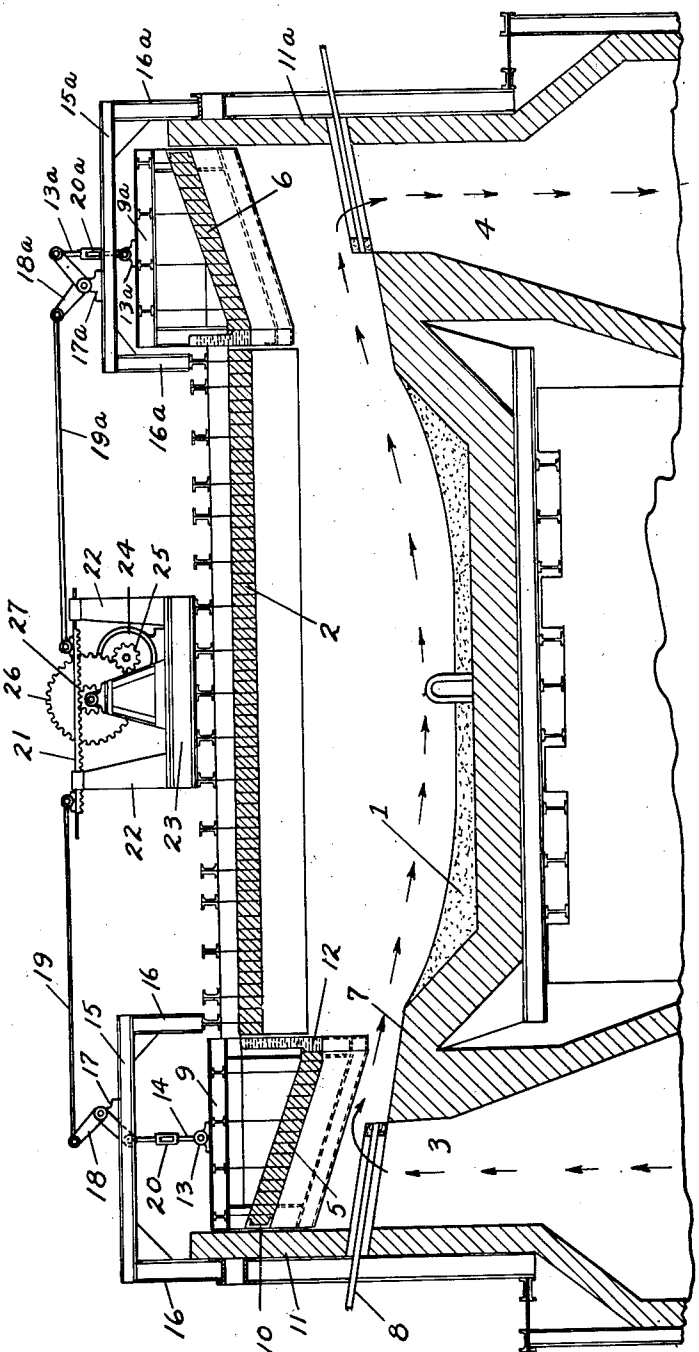

Fig. 3.

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OPEN HEARTH FURNACE CONSTRUCTION

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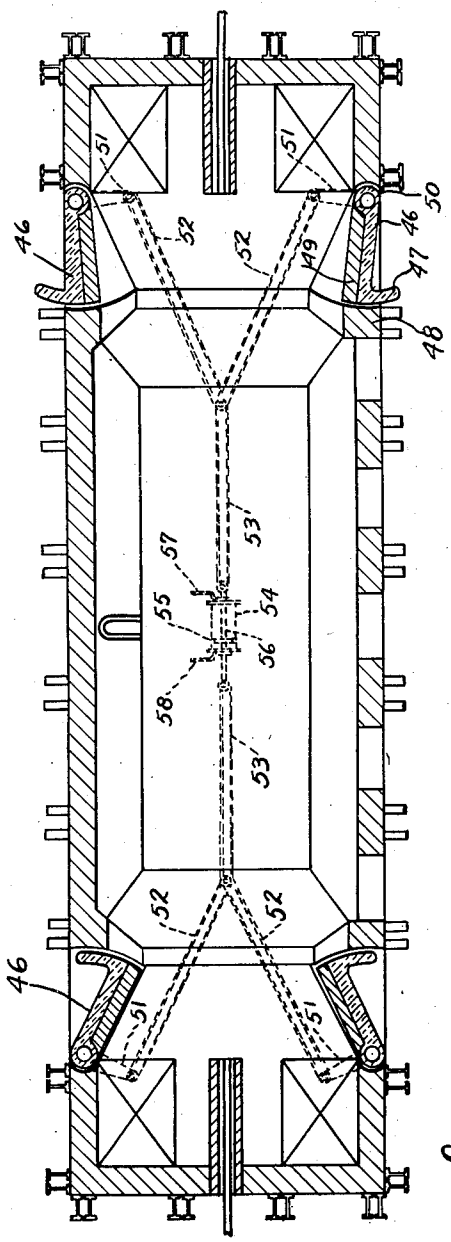

Fig. 4.

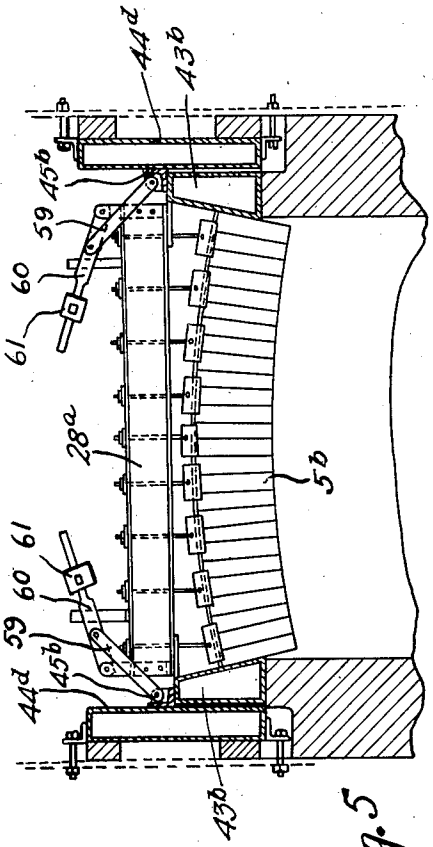

Fig. 5.

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OPEN HEARTH FURNACE CONSTRUCTION

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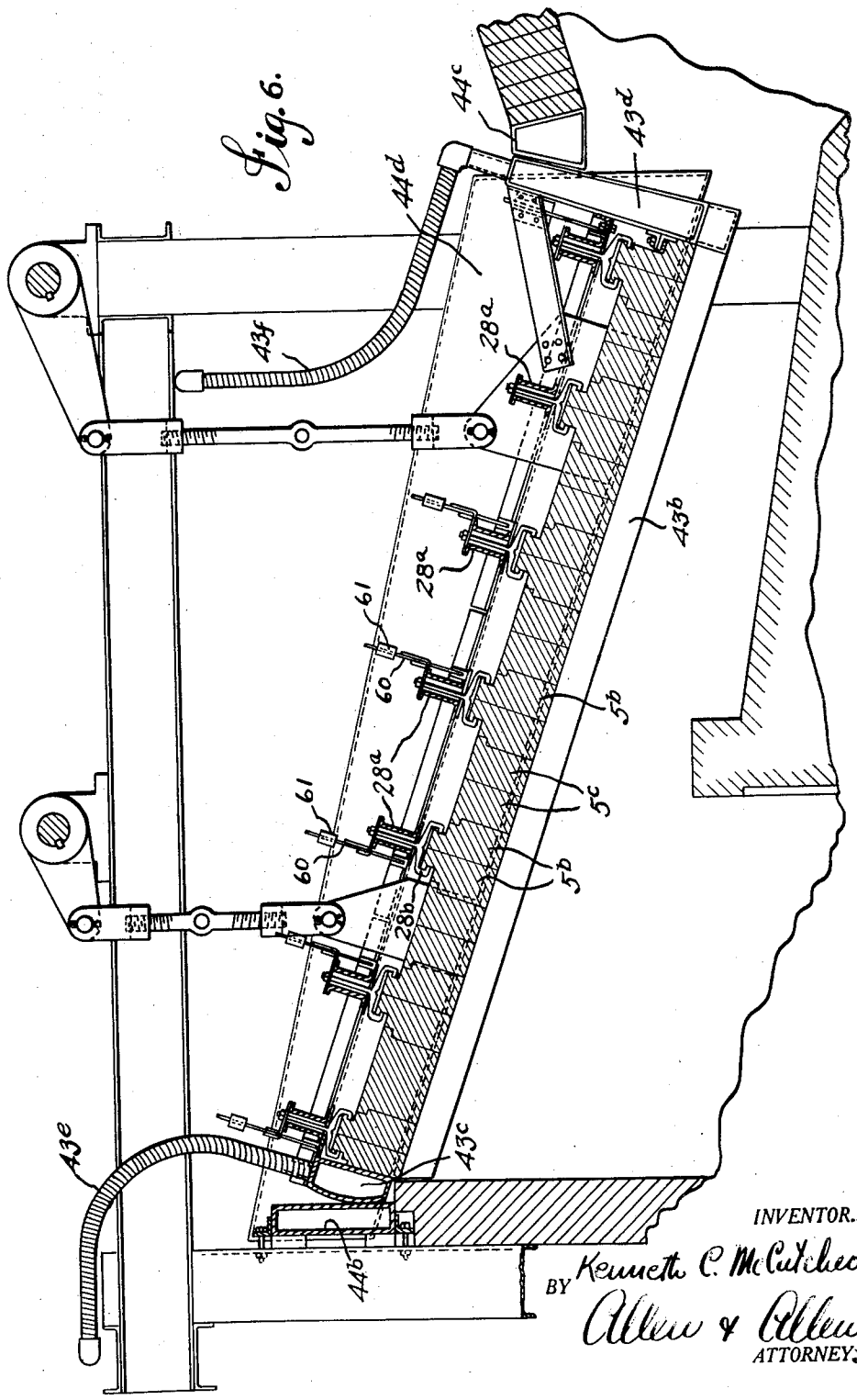
Fig. 6.



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OPEN HEARTH FURNACE CONSTRUCTION

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Fig. 7

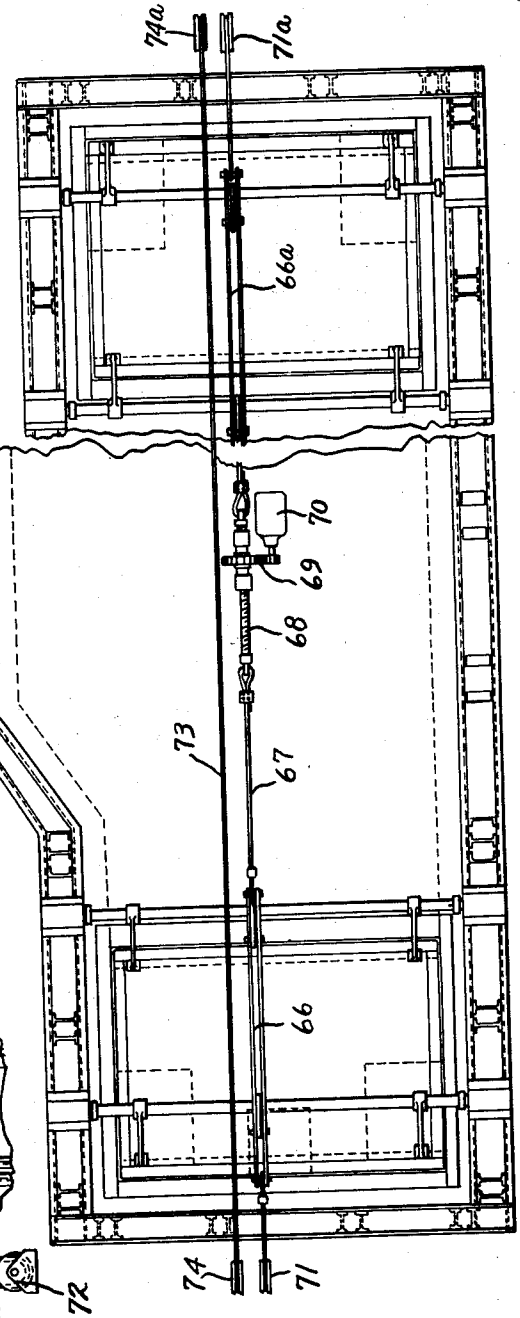
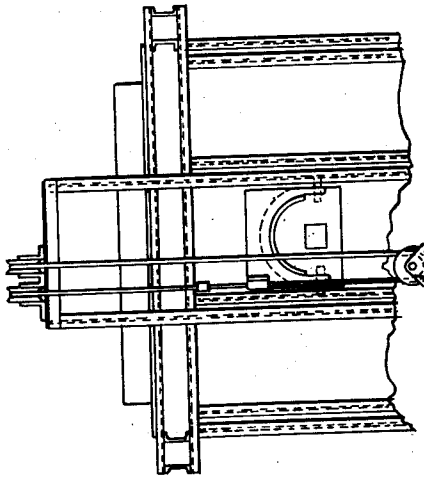


Fig. 8.



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OPEN HEARTH FURNACE CONSTRUCTION

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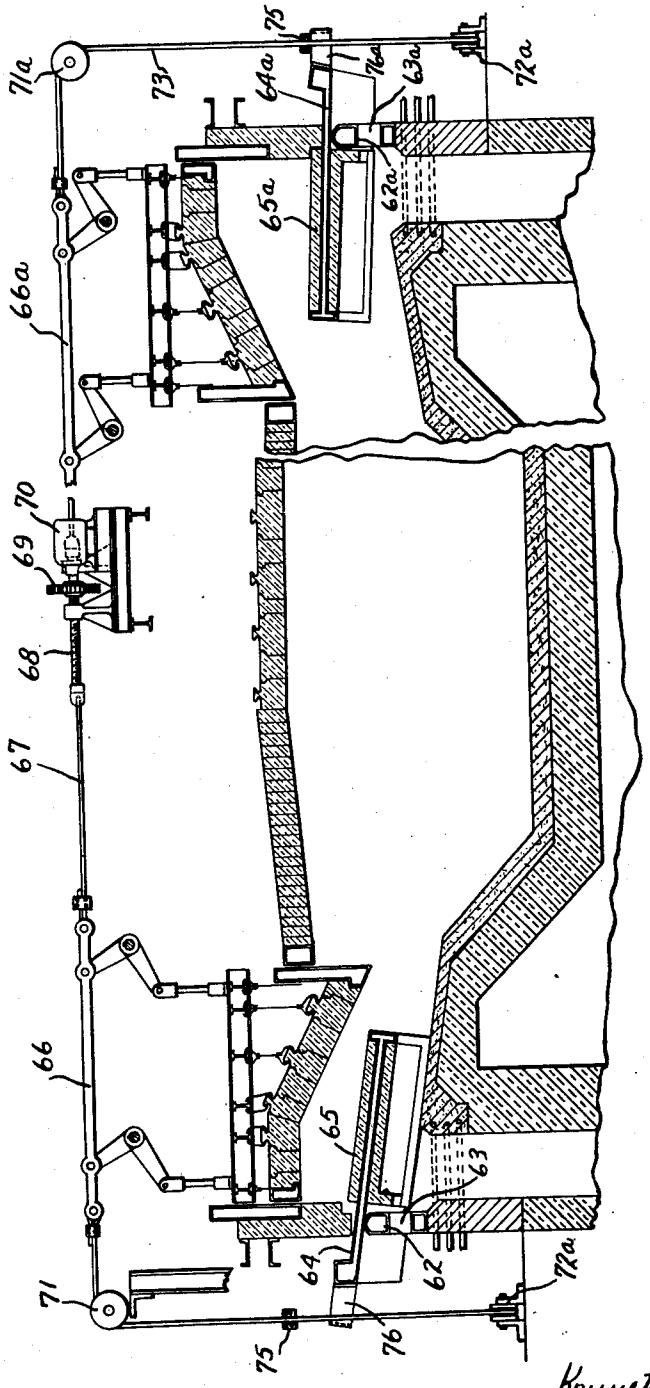

Fig. 9.

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UNITED STATES PATENT OFFICE

KENNETH C. McCUTCHEON, OF ASHLAND, KENTUCKY, ASSIGNOR TO THE AMERICAN ROLLING MILL COMPANY, OF MIDDLETOWN, OHIO, A CORPORATION OF OHIO

OPEN HEARTH FURNACE CONSTRUCTION

Application filed January 9, 1931. Serial No. 507,662.

My invention relates to regenerative furnaces, such for example, as the open hearth furnaces used in the manufacture of iron and steel, and has to do with mechanism whereby better control of the furnace conditions may be attained.

Fundamentally, the port end of a furnace is a burner. It is fairly simple to design a burner which will be efficient in mixing and burning fixed amounts of gas and air. When, as in open hearth furnace control at different times during the heat, the burner must handle varying amounts of both gas and air, the problem is complicated. When the direction of the flame so formed is also important and affects the efficiency of burning, the problem is still more complicated. Additional complications arise when the burner must handle different fuels. One of the objects of my invention is the provision of mechanism which will enable me to effect more perfect furnace control in the practical solution of these problems.

The velocities and directions of the two mixing streams play an important part in furnace operation, together with the velocity and direction of the mixed streams and flame so formed. One of the objects of my invention is to provide means adequate to control the velocity and direction of the fuel and air, and the velocity and direction of the flame, to do this with widely varying flows, and in some furnaces for different fuels. A fundamental object of my invention is the provision of means whereby such control may be had irrespective of the reversals of the furnace, and the provision of a construction such that the furnace ends will serve alternately, first as burners and then as outgoing ends each as efficiently as possible.

The standard furnace construction of today does not meet these problems with a satisfactory solution. The openings through which fuel and air enter are fixed, the rate of flow being controlled by more or less remote valves, and the mixing obtained by means of fixed slopes and monkey walls. It has been appreciated that the reversals of the furnace render advisable changes in configuration of the inlet and outlet ends and the various port sizes; but such attempts as have been made to improve conditions have not taken into consideration the control of the direction and velocity of the fuel, air and flame at the furnace port or burner. Attempts have been made to restrict the entrance end or entrance ports of a furnace or to enlarge the exit end through the employment of baffles, mushroom valves, sliding sections and the like; but these have been relatively cumbersome in construction, expensive to maintain and operate, and most important of all have not made adequate provision for flame direction and control. It has been proposed to pivot sections of the furnace roof so that on the entrance end they may be swung inwardly, effecting a restriction of the furnace opening. The restriction is achieved however, without regard to proper direction and control of the gas and air streams, and the increased angle of the entrance roof section has invariably resulted in an improper direction of the flame.

It is an object of my invention, therefore, to provide means for restricting and enlarging alternately the entrance and exit ends of the furnace while at the same time effecting efficient flame direction and control.

It is also an object of my invention to provide, for the utilization of certain types of fuel, controlling means for the gas port comparable to the controlling means supplied for the air passage ways at the furnace ends.

Still another object of my invention is the provision of means as will hereinafter be set forth for the control of the several features of my invention combined with means such as gas seals and the like to make the operation of the furnace more efficient and also to provide for the mechanical correlation of the operation of the several features of my novel furnace.

These and other objects of my invention which I shall hereinafter point out, or which will be apparent to one skilled in the art upon reading these specifications, I accomplish by that certain construction and arrangement of parts of which I shall now describe an exemplary embodiment, reference being had to the drawings which form a part hereof.

In the drawings:

Figure 1 is a cross section through an open hearth furnace equipped with my invention.

Figure 2 is a plan view of the same furnace, showing the operating mechanism.

Figure 3 is a cross sectional view through another type of furnace.

Figure 4 is a horizontal section through the same furnace showing additional features of control.

Figure 5 is a vertical section through an end of my furnace equipped with a movable roof section of preferred type and provided with a gas seal of novel construction.

Figure 6 is a longitudinal vertical section through one of my movable roof members.

Figure 7 is a plan view of a furnace equipped with movable roof sections and also a movable gas port construction.

Figure 8 is an end view of the same furnace.

Figure 9 is a vertical longitudinal section of the furnace of Figures 7 and 8, which may be a producer gas type furnace.

In the practice of my invention, I provide at either end of a regenerative furnace a movable section of the roof, and I provide means for moving this section either to a position wherein I secure the maximum space for the passage of products of combustion at the outgoing of the furnace, or to a position in which the port volume is sufficiently restricted at the incoming end of the furnace, at the same time providing means whereby, when the roof section is at its lowest point, its position and configuration will be such as to exert the proper directive influence on the flame.

I have shown in Figure 3, an open hearth furnace, having a hearth 1, a roof 2, suitably supported as well understood in the art, and uptakes 3 and 4 leading to the usual checker chambers. I have shown at either end of the furnace movable roof sections indicated broadly at 5 and 6.

The section 5 is shown at its lowest position, forming in connection with the floor or block 7, the entrance port of the furnace. Its configuration and disposition are such as have been determined for this particular furnace to give the proper entrance port area for the furnace together with the desired directive influence upon the flame. I have indicated by arrows the direction of the flow of gases through the furnace, in this phase of its operation. A burner is indicated, semi-diagrammatically, at 8, and it will be understood that the roof section 5 serves to control the flow of heated air through the uptake 3, to mix fuel and air as required, and to direct the flame onto the charge resting upon the hearth 1.

The interior face of section 5 is formed of refractory materials supported upon a framework 9, the top portion of which may in this case be made horizontal or not. The refractory material may be suspended from the framework in any suitable manner, as by a modification of the structure employed in the roof 2, or any other means within the purview of those skilled in the art to devise. I may, and usually do employ a structure of brick similar to the structure of the roof, and suspended upon supports so proportioned in length, that when the framework 9 is in its lowest position, the section 5 will have the proper position and configuration for the purposes aforesaid. The outer end of the section 5 may be fitted with a metal face plate 10, adapted to lie adjacent to and move with respect to the end wall 11, of the furnace. The inner end of the section 5 is fitted with an upwardly projecting water cooled closure member 12, adapted to lie in all positions of my movable roof section adjacent to the end of the roof 2, and to act as a gas seal for the furnace. Suitable flexible connections are made between this wall member 12 and a supply of fluid for cooling purposes. Member 12 may be made of refractory substance alone, with no watercooling, if desired.

The movable roof section 5 has at substantially its point of balance a knuckle or knuckles 13, to which may be pivoted a suspension rod or rods 14. It will be understood that the construction of the roof section 6 is similar to the roof section 5 and that similar parts are employed for the movement thereof. I mount above my furnace, a framework comprising a cross member 15 and supports 16. A pivot block or knuckle 17 is mounted on a cross-bar, and a bell crank 18 is pivoted thereon. Instead of the bell crank, I may employ a plurality of lever arms mounted on a shaft. The rod 14 is connected to one of the arms of the bell crank, and to the other I pivot a second pull rod 19. The corresponding members for the movable section 6 are indicated by the same numerals with the exponent "*a*".

I provide motive mechanism such that upon one reversal of the furnace, the roof section 5 will be lowered into the fuel inlet position shown, while the section 6 will be raised into the position shown to permit the passage of a large volume of the products of combustion, while upon a reversal of the mechanism the two roof sections will be moved into correspondingly opposite positions. A turnbuckle 20 or other suitable adjustment device may be included in the pull rod assemblies 14 and 19 so that the position of section 5 may be independently adjusted.

For the movement of the sections I may connect the rods 19 and 19*a* to a rack bar 21 suitably mounted for sliding motion upon supports 22 extending upwardly from a suitable base 23. A motor 24 through gears 25 and 26 drives a gear 27 meshing with the teeth

of the rack bar. The motor is one of the reversing type. It will be understood that other means for moving the roof sections may be employed.

It will be seen that the movable sections 5 and 6 move respectively up and down between the ends of the roof 2 and the outer walls 11 and 11*a* of the furnace. The motion is a sliding vertical motion, and is adequate for my purpose providing the angularity and configuration of the refractory face of the movable sections have been fixed to give the most efficient combustion conditions at the entrance end of the furnace. While by means of the turnbuckle 20 the height of the roof sections may be adjusted, the angularity and configuration hereinabove mentioned is fixed and not subject to independent adjustment. Moreover this angularity and configuration is determined by a calculation of the combustion condition at the entrance or burner end of the furnace and does not have primary reference to efficiency at the outgoing end of the furnace. The roof section there is raised merely to increase the port volume.

To permit independent adjustability of conditions during combustion and to control the configuration and disposition of the roof section on the outgoing end of the furnace, I have devised the modification set forth in Figure 1. In this view I have indicated the hearth at 1*a*, and the furnace roof at 2*a*. I have shown movable roof sections 5*a* and 6*a*, having refractory inner faces formed of brick work or the like, supported upon framework members 28. As respects the movable section 6*a*, I have indicated members corresponding to the members of section 5*a*, by the same numerals with the exponent "*a*." In the embodiment shown in Figure 1, my roof sections have an angular as well as vertical movement, and I am enabled not only to secure the proper height and proper angularity of the section 5*a* on what is shown as the incoming end of the furnace, but also of the section 6*a* on the outgoing end. I have furthermore provided means whereby the angularity of section 5*a* may be determined for the utmost efficiency of flame direction, while the angularity and configuration of the section 6*a* may be disposed for maximum efficiency of the evacuation of the products of combustion from the furnace. The optimum positions are calculated in both cases; and I have provided mechanism suitable for the alternate movement of either section to either of the two positions. Since such movement usually involves an angular as well as vertical motion, it has partially the effect of pivoting the movable sections about some remote point. The same effect cannot be attained, however, as will be obvious, by pivoting the roof section on the end walls of the furnace. Furthermore, my arrangement permits the separate adjustment where necessary, of the roof sections, and particularly their determination by trial for given combustion conditions. In this modification of my invention, it is not necessary to rebuild a roof section to gain a different directive influence upon the flame.

A pair of knuckles 29 and 30 serve as means whereby the movable roof section may be suspended upon rods 31 and 32, which may be fitted with turnbuckles 33 or the like means for adjustment. Upon a framework member 34, above the movable roof section, I pivot a bell crank 35 or 36 or a pair of shafts with lever arms for each of the rods 31 and 32, which are respectively pivoted to the lower arms of the bell crank. The upper arms of these bell cranks are of equal length and are connected by a pitman 37. The operating rod 38 is likewise pivoted to the upper arm of the bell crank 36 so as to operate it and, through the pitman 37, the bell crank 35. For the operation of the rod 38, I have provided in this instance a motor 39, driving a worm gear arrangement in a housing 40. This drive operates an arm 41, connected with the rod 38, so as to move this rod and the bell cranks or lever arms attached to it. The motor is of course reversible, and equipped with suitable controls. The inner ends of the movable roof sections are equipped with water cooled closure members 42, and the outer ends have end plates 43, which move adjacent to members 44, in the end walls of the furnace. The framework 28 may be cut slantwise at the outer end as shown at 45 to permit the angular movement of my roof sections without binding against the end walls.

It will be observed in Figure 1 that the lower arms of the bell cranks 35 and 36 are of unequal length. By this means I provide for the unequal movement of rods 31 and 32 and the correspondingly differential motion of the inner and outer ends of my movable roof sections. These are so proportioned and the rods 31 and 32 are so adjusted for each roof section that in its lowermost position it will be at the correct height and will have the correct angle for proper flame direction and control, while at its highest position it will have been raised sufficiently to enlarge the exit port for the free passage of the products of combustion without having been placed at such an angle as to restrict such flow in any part of its length or to form an eddy-pocket for the hot waste gases. The differential motion is illustrated in Figure 1, and it may be so proportioned that the angularity of both sections is always proper for efficient combustion so that the size of the entrance and exit ports may be regulated solely by the height of the roof sections. This may be determined by the extent of movement of the gears in any cycle. The specific position of either of the roof sections

may likewise be adjusted by means of the turnbuckles 33.

It will be understood that the alternate movement of the roof sections may be made automatic upon reversal of the furnace and that in either modification the extent of movement and the height of the several sections may be separately controlled, manually or automatically, in accordance with combustion conditions, gas analysis, furnace temperatures, and the like.

In Figure 4. I have shown a horizontal section of a furnace in which I have additionally provided movable side walls or monkey walls further to control the size of the port openings. These comprise water cooled members having a radial section 46, and a transversely arched section 47 adapted to form a closure with the end 48 of the central side wall of the furnace in all positions of the movable section. The section is faced with refractory materials 49 and is pivoted by being affixed to a shaft 50 held in suitable bearings. A lever arm 51 is also attached to this shaft. The several lever arms of the several movable wall sections are attached by links 52 and 53 to a suitable motor, which in the instance shown is a pressure cylinder 54 having a piston 55 and a piston rod 56 attached to the links 53. Suitable fluid connections 57 and 58 are provided, for the introduction of fluid under pressure to move the piston in either direction. Other motor devices may be employed; and the operation of these devices may be synchronized with or made dependent upon the operation of the motor devices moving my movable roof sections.

In Figures 5 and 6 I have shown in detail a type of movable furnace roof section which I have found to be advantageous in practice. It will be understood in this connection that with a change in the shape of the cooperating parts upon the furnace walls and the edges and ends of the movable roof section, the section may be adapted either for vertical movement or for movement in some other direction. A series of beams 28*a* is provided as the primary support for the roof section; and the section itself is made of a plurality of refractory plates or bricks 5*b* and 5*c*. The shape of some of these bricks is such that they may be engaged by a clamping member 28*b* held to the beams 28*a* and the shape of the remainder of the blocks is such as to enable them to be held in place by the blocks or bricks supported as just described. The end wall of the furnace is provided with a water cooled member 44*b* and the end of the hearth roof is likewise provided with a water cooled member 44*c*. Sidewise water cooled members 44*d* are placed upon the side walls of the furnace so that the furnace opening is completely lined with metallic water cooled members against which the furnace roof section is arranged to slide. The section likewise is lined with side water cooled members 43*b* and end water cooled members 43*c* and 43*d* of such a shape as to cooperate with the members 44*b* and 44*c* on the furnace proper, to permit the desired type of motion of the roof section. Flexible hose connections 43*e* and 43*f* are provided to supply water to the water cooled members on the movable roof section, irrespective of its position.

It will be observed particularly in Figure 5 that the side water cooled members 43*b* of the movable open hearth roof section move in close proximity to the water cooled sections 44*d* of the furnace side walls. I next provide a gas seal which in the exemplary modification shown, takes the form of an angle iron 45*b*. I arrange automatic means to hold this angle tightly against the top of the water cooled member 43*f* upon the roof section and against the side of the member 44*d* upon the furnace wall. As the movable roof section rises or falls, the vertical portion of this angle will of course, slide tightly against the smooth face of the water cooled member 44*d*. The means which I employ to hold this angle in such a position that it may serve as a gas seal, I have shown as comprising a link 59 whereby the angle is connected to a lever arm 60 pivoted at some convenient point upon the framework of my movable roof section. A weight 61 which may be adjustable is placed upon the lever arm 60 and the action of this weight is to force the angle 45*b* diagonally against the members 44*d* and 43*d* whereby an excellent gas seal is produced both during the movement and in the stationary positions of my movable roof sections.

In Figure 9 I have shown in section, a furnace, which is equipped not only with a movable roof section (which may either be of the vertical type as shown or of other types falling within the scope of my invention) but with a movable gas port structure. This type of furnace is particularly designed for the burning of either relatively low heat value fuels which must be passed through a gas checker to preheat them or in furnaces in which the gas checker is used to preheat a given quantity of air to be intimately admixed with the fuel in a port construction, prior to the blanketing or admixture thereof with the preheated air from the air checkers, which usually enters the furnace above and at the sides of the said gas port. As respects a gas port, of course the same considerations apply essentially as apply to the exit end of the furnace as a whole. If a gas port is provided of sufficiently narrow dimensions and configuration to give the desired flame directed upon the entrance end of the furnace, and is stationary in the furnace, it is not likely to pass sufficient of the products of

combustion upon the outgoing end of the furnace to heat the gas chamber with the utmost possible efficiency. Consequently it is an object of my invention to provide in connection with the other means herein described for controlling the effective shape of the furnace upon the outgoing and incoming ends, a movable gas port structure in furnaces where that may be required, which also is arranged to move in synchronism with the movable roof sections. Consequently, in Figure 9, I have indicated a furnace provided with movable roof sections which are similar to or are the equivalent of the movable roof sections which I have described in connection with the other figures in this application and which therefore I do not describe specially at this point. I have also shown in the furnace wall however, a water cooled member 62 which may be perforated if desired, as at 63 for the passage of an auxiliary burner or the like. The upper portion of this member is rounded and serves as a pivot point for a hood shaped member 64 which forms the gas port itself. A portion of this hood shaped member extends within the furnace and a portion of it beyond the furnace walls as shown and it will be clear that it may either be lowered into the position indicated upon the left hand end of the furnace or raised by downward pressure applied to the end of it which projects beyond the furnace walls as indicated at the right in Figure 9. The portion of the water cooled hood or port which extends within the furnace may be lined with refractory 65 so as to protect the water cooled member from the direct action of the hood gases.

My movable roof sections are shown as actuated by a link 66 which connects the lever arms or bell cranks. As exemplary of still another type of mechanical movement adaptable to the purposes of my invention I have shown these links as connected by a cable 67 or the like to a threaded shaft 68 upon which a threaded nut 69, which is also a gear, is placed in rotatable position. The gear nut 69 is held, of course, from longitudinal movement and a motor 70 is provided to turn the gear nut whereby the threaded shaft 68 may be moved longitudinally back and forth upon actuation and reversal of the motor. To the ends of the links 66 and 66*a*, cables are attached passing respectively over sheaves 71 and 71*a* down to the floor outside the furnace and beyond the end walls thereof where the cables run over other sheaves 72 and 72*a*. The cable has been indicated at 73 and it will be seen particularly in Figures 7 and 8 that the cable returns beyond the end of the furnace over sheaves 74 and 74*a* and back over the top of the furnace. Stops 75 are placed upon the cable at either end thereof and it will be clear from the several figures that these stops engage projections 76 and 76*a* upon the ends of the port construction 64. The action of these stops will be such that when upon the outgoing end of the furnace the movable roof section is raised, the corresponding stop will depress the outer end of the gas port construction (64*a* in Figure 9) and cause the gas port to rise within the furnace increasing the area for the passage of products of combustion into the gas downtake. Upon the entrance end of the furnace, the gas port will be in lowered position. The stops 75 are preferably made adjustable.

In my construction the hanger rods, such as rods 33 and 33*a* in Figure 1 need not be made vertical. In one installation these rods toward their tops, were inclined outwardly from the center of the furnace. This kept the end pieces 43 of the movable section in close contact with the stationary end piece 44 and prevented leakage at this point. Some clearance was left between the nose piece 42 and the stationary roof to prevent friction here and to provide a small blanket of cold air along the stationary roof from the incoming means.

Modifications may be made in my invention without departing from the spirit thereof.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a furnace, movable roof sections at either end thereof, a plurality of lever arms for each section mounted on said framework, means for suspending said roof sections at interspaced points from the said lever arms, and means for moving said lever arms, said lever arms being of different lengths whereby different parts of said sections are moved different distances.

2. In a furnace, movable roof sections at either end thereof, a plurality of lever arms for each section mounted on said framework, means for suspending said roof sections at interspaced points from the said lever arms, and means for moving said lever arms, said lever arms being of different lengths whereby different parts of said section are moved different distances, said suspending means being adjustable.

3. In a furnace, movable roof sections at either end thereof, a plurality of lever arms for each section mounted on said framework, means for suspending said roof sections at interspaced points from the said lever arms, and means for moving said lever arms, said lever arms being of different lengths whereby different parts of said sections are moved different distances, said suspending means being adjustable, said means for moving said lever arms operating conversely on the lever arms for each of the said sections, said means having a controllable cycle.

4. In a regenerative furnace a movable roof section at an end thereof, means for moving said roof section to control the port

volume at an end thereof, members respectively upon the furnace wall adjacent said roof section and on said roof section itself adapted for relative sliding motion during the movement of said roof section and a gas sealing member arranged to be pressed in contact with said members simultaneously.

5. In a regenerative furnace a movable roof section at an end thereof, means for moving said roof section to control the port volume at an end thereof, members respectively upon the furnace wall adjacent said roof section and on said roof section itself adapted for relative sliding motion during the movement of said roof section and a gas sealing member arranged to be pressed in contact with said members simultaneously, said gas sealing member comprising an angular body arranged to contact both of said members and means for urging said body diagonally against said members.

6. In a regenerative furnace, a movable roof section at an end thereof, means for moving said roof section to control the port volume at an end thereof, a movable gas port and having a controlling element within said furnace, means for moving said gas port controlling element into operating position and out of operating position, said first and second means being in operative relation with each other, and mechanism operatively connected with said roof section and port controlling elements, for the simultaneous movement of said port controlling elements and said roof section.

7. In a regenerative furnace, a movable roof section at an end thereof, means for moving said roof section to control the port volume at an end thereof, a movable gas port within said furnace and having a controlling element, means for moving said gas port controlling element into operating position and out of operating position, said first and second means being in operative relation with each other, and mechanism operatively connected with said roof section and port controlling elements, for the simultaneous movement of said port controlling elements and said roof section, said means for moving said gas port controlling elements being separately adjustable.

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