

June 1 , 1926.

G. T. SOUTHGATE

1,587,197

JOINT WORKING OF FLAMES AND ARCS AND APPARATUS THEREFOR

Filed May 7, 1924

3 Sheets-Sheet 1

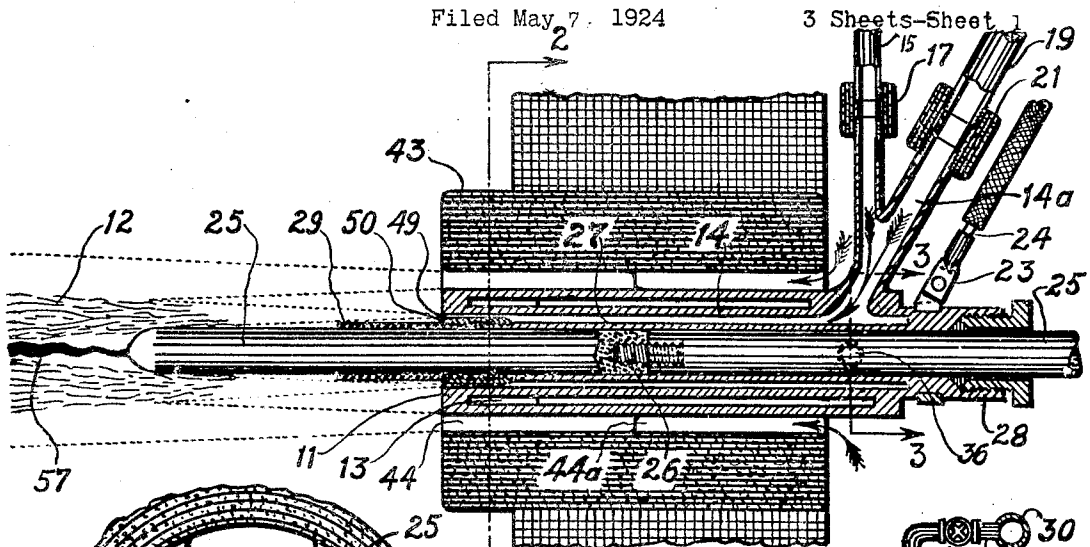


Fig. 1.

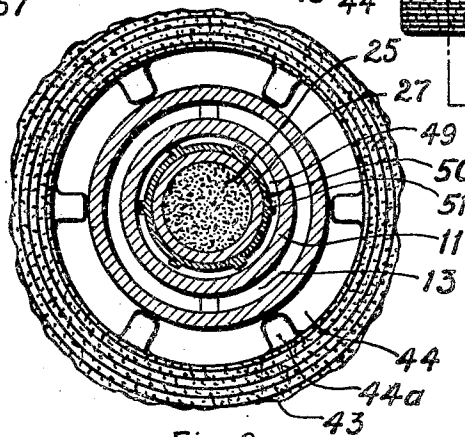


Fig. 2.

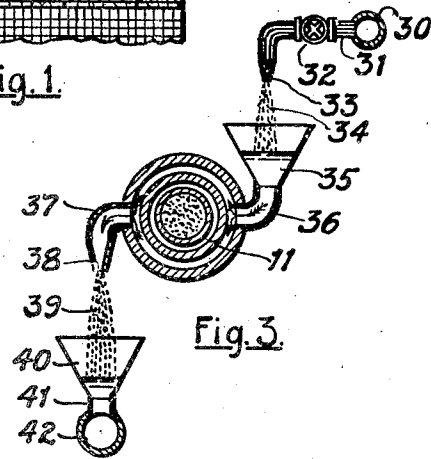


Fig. 3.

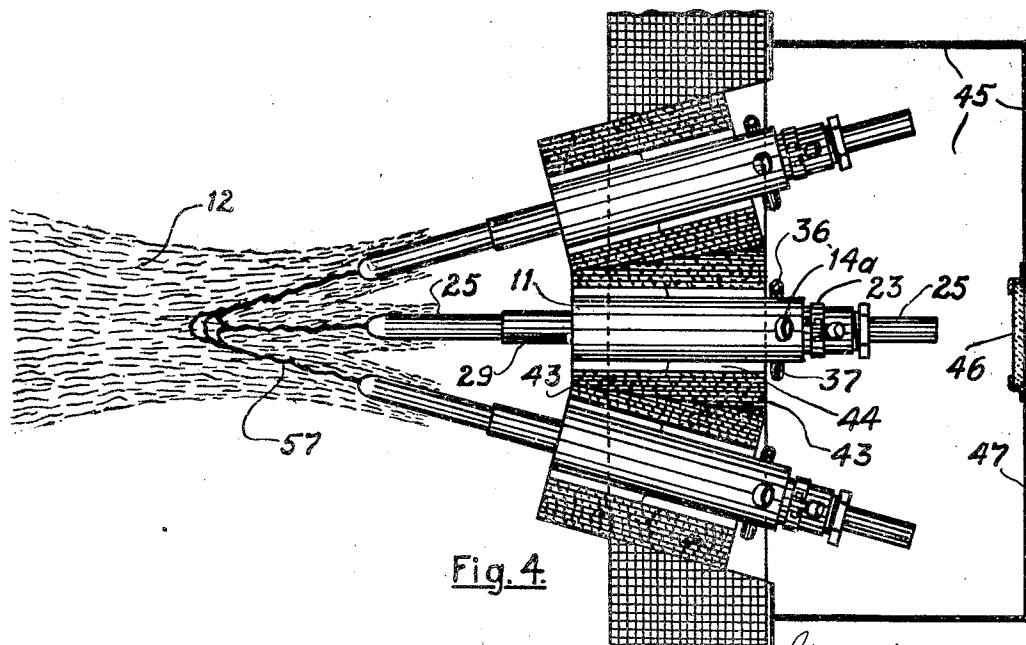


Fig. 4.

Inventor: Geo. Northgate

June 1, 1926.

1,587,197.

G. T. SOUTHGATE

JOINT WORKING OF FLAMES AND ARCS AND APPARATUS THEREFOR

Filed May 7, 1924

3 Sheets-Sheet 2

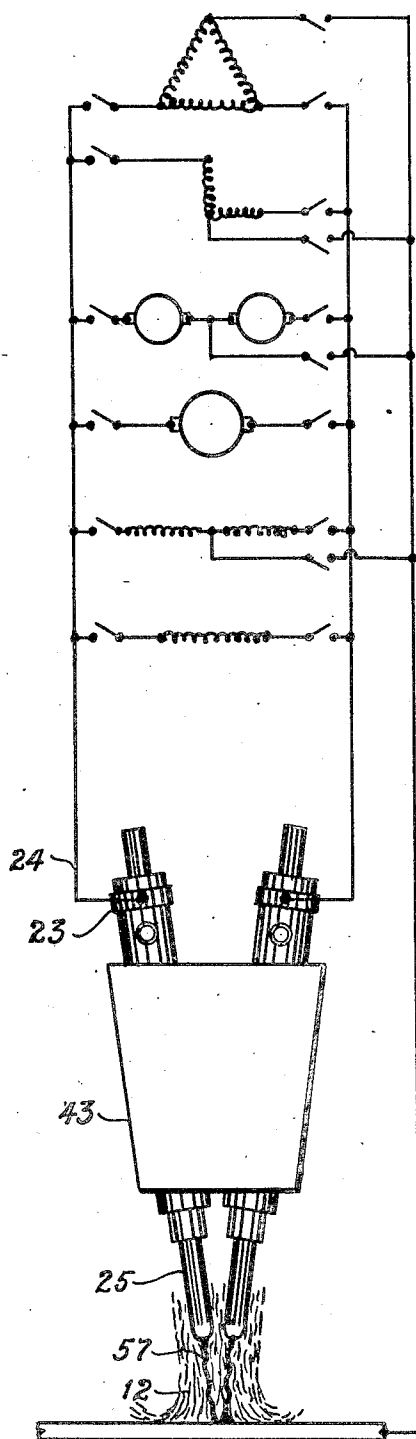


Fig. 5.

Inventor:

Geo. T. Southgate

June 1, 1926.

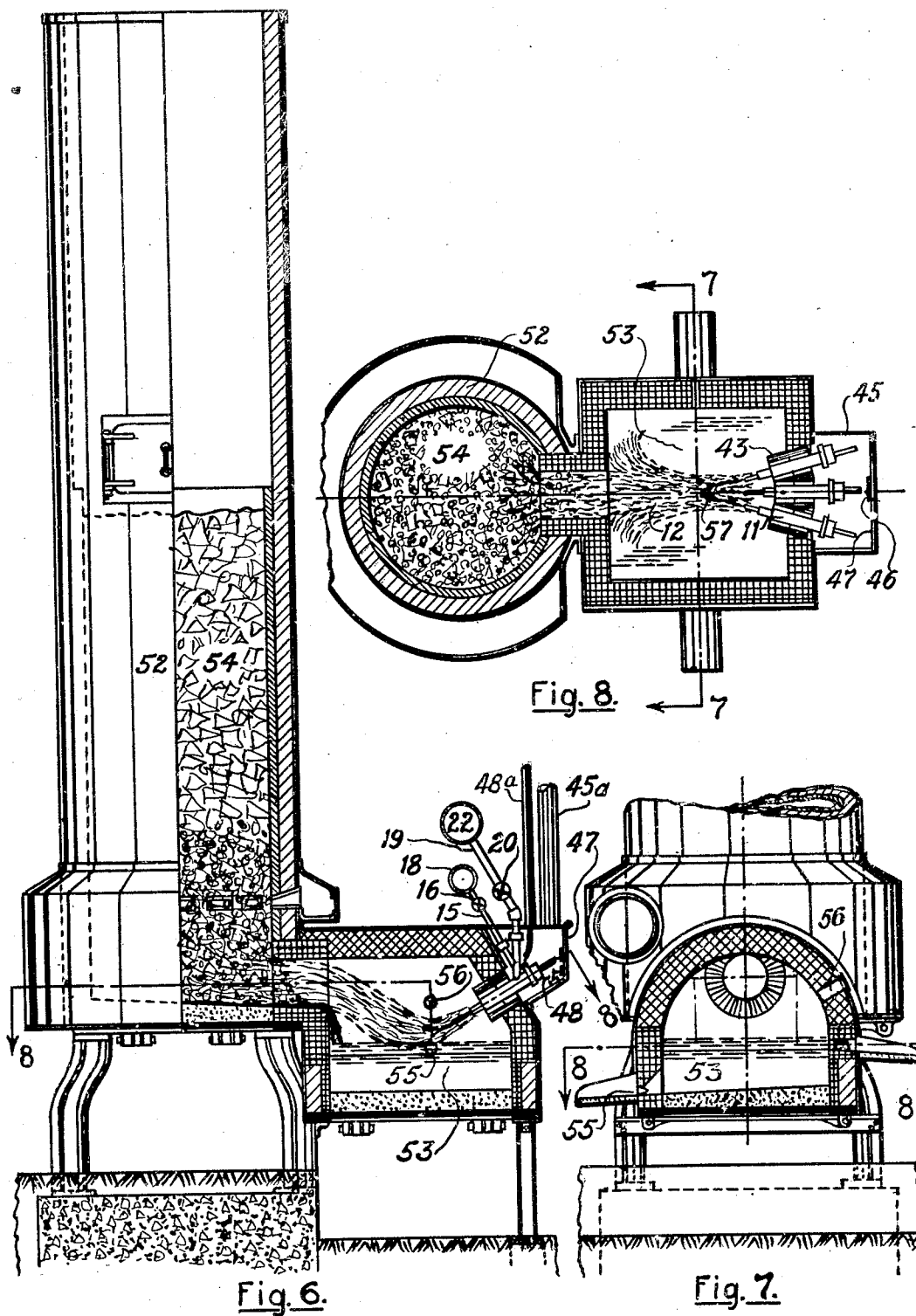
G. T. SOUTHGATE

1,587,197

JOINT WORKING OF FLAMES AND ARCS AND APPARATUS THEREFOR

Filed May 7, 1924

3 Sheets-Sheet 3



Inventor:

Geo. T. Southgate

UNITED STATES PATENT OFFICE.

GEORGE THOMPSON SOUTHGATE, OF ANNISTON, ALABAMA.

JOINT WORKING OF FLAMES AND ARCS AND APPARATUS THEREFOR.

Application filed May 7, 1924. Serial No. 711,615.

The invention relates to the joint use of combustion flames and electric energy in thermal, thermo-chemical and electrochemical effects and particularly to an improved process and apparatus for producing combustion flames having electric arcs extending along the same.

It has already been proposed to arrange a pair of electrodes with their arcing tips disposed in front of a flame projecting nozzle, the arcing tips being spaced transversely of the flame stream and the arc being elongated into U-shape by the blast, and it has been proposed to use combined electrode and nozzle structures for the formation of arcs along the flame stream, the arrangements being such that the arcs spring from the nozzle or from a point so near the nozzle that the arc could strike back thereto.

The present invention relates to the formation of arcs extending along, as distinguished from across, flame streams, the apparatus and process being such that the arcs are spaced from the nozzle structure and cannot strike back thereto. The apparatus is characterized by the provision of flame-projecting nozzles and rigid electrodes having their arcing ends spaced from the nozzles. The electrode tips are positioned in or closely adjacent to the combustion flames, and the electrodes may extend through the nozzles or they may lie outside the same and pass obliquely into or to points adjacent the combustion flames. In working with such apparatus under my novel process, the supplied fuel and air are projected from the nozzles at such velocity that the arcs cannot strike back to the nozzles.

The invention permits the use of relatively large bodies of combustion flame with much smaller proportions of heat from electric energy. The combustion flames may be reducing, neutral or oxidizing, and the current source may be either direct or alternating, but is usually of relatively high voltage.

In the accompanying drawings:—

Fig. 1 is a longitudinal midsection and Fig. 2 is a cross section in the plane 2—2 of a typical nozzle-electrode constituting one form of my improved apparatus;

Fig. 3 illustrates a preferred manner of

leading water to and from the nozzle or any other part of the apparatus which it may be desired to cool with water;

Fig. 4 is a plan of three of the improved nozzle-electrodes in one of the arrangements suitable for three-phase operation in a closed chamber;

Fig. 5 is a plan of two nozzle-electrodes suitably arranged for operation from different types of electricity supply and showing the connections made to the nozzle-electrodes and to the objective upon which the fuel electric flames impinge;

Figs. 6, 7 and 8 show the invention embodied in a furnace for smelting or melting operations; Fig. 6 being partly an elevation and partly a vertical midsection, Fig. 7 a vertical section in the plane 7—7, and Fig. 8 a plan section in the irregular planes 8—8.

In the drawings, the numeral 11 designates the nozzles through which a combustible substance and a combustion-supporting gas are inducted and together projected into the combustion flame 12. Each nozzle, in the form illustrated, is made of metal and constructed with double walls which provide a closed hollow space 13, through which cooling water may be circulated. Fuel and air may be separately led to the outlet end of the nozzle for admixture thereat, but a simpler arrangement is obtained by introducing the fuel and air together at the rear end of the nozzle bore 14. A Y-inlet 14^a cooperates with the bore 14 to form a blowpipe which is supplied with fuel through the pipe 15 and fuel valve 16, which parts are separated from the blowpipe inlet by a hollow electric insulator 17. The pipe 15 is fed from a main 18 which may be the usual pressure header when a liquid or gaseous fuel is used. With powdered fuel, the main 18 should be provided with means, such as a revolving screw, for insuring a ready feed into the inlet 14^a. The air or other oxidizing gas is led to the blowpipe by way of pipe 19, valve 20 and electric insulator 21, the supply being from pressure main 22. An electric terminal 23 and lead wire 24 connect the nozzle to a suitable source of electromotive force.

Within the bore 14 of each nozzle 11 is arranged an electrode 25 which may be a

solid rod of carbon or graphite, a metal tube packed with carbonaceous material or a fluid-cooled metal tube having a renewable arcing tip. By providing the solid rods or packed tubes with threaded ends 26, new sections may be attached at the outer ends of the electrodes, the stumps being pushed forward and completely consumed. To insure good electrical contact between the electrode and the nozzle as well as to prevent inadvertent movement of the electrode, the nozzle is provided with a slip-tube 27 of such dimensions as to fit the electrode rather snugly. When the apparatus is used in a furnace working under a pressure higher than atmospheric, the outer end of the slip-tube is provided with a packing gland 28. The slip-tube is preferably extended beyond the nozzle 11 by a refractory portion 29 which protects the electrode against excessive oxidation by the flame 12.

For the supply of cooling water to the nozzle 11, provision is preferably made whereby water is delivered both to and from the nozzle in broken streams so disposed that there is no electrically conducting connection between the water supply system and the nozzle, and between the nozzle and the water drainage system. Referring to Fig. 3 and also, in part to Fig. 1, from water supply header 30 is taken supply pipe 31, which terminates in the nozzle 33 capable of breaking up the discharged water into a spray 34 of small drops. Valve 32 is inserted in pipe 31 and used to regulate the supply of water discharged in the spray. The sprayed water falls into funnel 35 and is carried to nozzle 11 by pipe 36. From nozzle 11 the spent water is similarly discharged to the drainage system via pipe 37, nozzle 38, spray 39, funnel 40, pipe 41 and drain header 42.

In furnace structures, each of the nozzles is electrically insulated from the structure and supported by an insulator 43 of thermally refractory material which may be built directly into the masonry of the furnace. The bores of the insulators are fluted with alternating channels 44 and ridges 44^a, which ridges bear against and firmly support the nozzle-electrodes. The insulators preferably extend within the furnace to the ends of the nozzles to protect the latter from overheating by radiation from the furnace interior, which extended length also insures superior electrical insulation by providing a greater length of electrical creepage surface.

The outer ends of the nozzle-electrode assembly are enclosed by a wind box 45 which is supplied, by air pipe 45^a, with air from a suitable source, such as a centrifugal fan or a rotary blower. From wind box 45, air passes to the furnace through the channels 44 as a supply of secondary air for insuring

complete combustion of the fuel projected through the nozzle with the primary air and for the burning of unoxidized gases evolved within the furnace. This secondary air supply cools the nozzles and the wind box 45 insures the safety of the operators by enclosing the electrically live parts. A suitable sight window 46 is provided, preferably in the hinged cover 47 of the box. Door 47 preferably operates a contact 48 in circuit with a relay upon the main switch, the power and relay circuits being so arranged that the electric parts within the wind box are not alive when the relay circuit is broken. When the door 47 is open the relay circuit is opened at contact 48 and the main switch is automatically opened and, if inadvertently closed, will not stay closed. The insulated electric wires enter box 45 through a metal conduit 48^a, and for safety to the operator and to the apparatus, the wind box 45, air duct 45^a and conduit 48^a should be grounded.

When liquid fuel is used, the bore within the nozzle 11 is contracted at its inner end to provide a strictured orifice 49 which restricted opening is not necessary when gaseous or powdered fuel is used. The strictured orifice 49 is preferably formed by mounting a bushing 50 over the slip-tube 27 at its junction with the refractory extension 29, which bushing may act as the coupling between the slip-tube and the extension. The bushing 50 is centered in the nozzle 11 by narrow, low ridges 51. Liquid fuel, for example oil, enters the Y-inlet 14^a from fuel pipe 15 and is entrained in and mixed with the primary air as it flows through the nozzle bore 14, being atomized or finely sprayed therefrom and into the combustion flame as it passes through the strictured orifice 49.

Figs. 6, 7 and 8 show a furnace comprising a stack 52 and hearth 53, which furnace is one of the several types in which the invention may be employed. Stock 54 is fed down the shaft, preheated and melted therein, and further melted in the hearth where the final physical and chemical transformations take place. The hearth is provided with a tap hole 55 and with a peep-hole 56. By providing ample space for the combustion of fuel the dimensions are suitable for the projection of relatively long arcs 57 and commercial line voltages may be employed. In practical operations I have employed electromotive forces ranging from 600 to 6000 volts and both alternating and direct currents have been successfully used.

As shown in Figs. 4 and 6, the electric arcs need not reach the furnace stock but may mutually join each other and play in the space above the bath. With three-phase alternating current an assembly of three nozzle-electrodes is used, each leg of the supply circuit being connected to an individual

nozzle. While no neutral connection is required, if one is available it may be made to the bath in the usual manner.

The supply connections shown in Fig. 5 are alternative, that is, any one of the six illustrated supplies may be used. The system of supply shown diagrammatically at the top of the diagram is a three-phase supply 58, delta-connected with the third point of the delta connected to the crotch or impingement point of the arcs, which connection may be effected through the stock or work 59 upon which the flame-arc is projected. The supply 60 is a quarter-phase alternating current with a neutral connection. The supplies 61 and 62 are three and two wire, respectively, direct current supply systems, and the supplies 63 and 64 are, respectively, three and two wire, single-phase alternating current systems. The arc may be formed in space or the crotch of the arc may impinge upon an objective, such as the charge in the stack 52, which objective may be connected to the neutral of a three-wire direct or alternating current circuit.

To put the apparatus in operation the electrode tips are arranged well beyond the ends of the nozzles and fuel and air are admitted to the nozzle bores, the combustion flame being ignited by any suitable means and the supply valves adjusted to give a fairly stiff blast flame burning around and beyond the electrode tips. Upon closing the main switch electric arcs will play from the end of each electrode in and along the respective combustion flame to their junction or to the common objective upon which they impinge. The velocity at which the fuel mixture is projected should be such that the arcs cannot strike back along the flames and into contact with permanent parts of the installation.

In operating my improved process in a hearth furnace I discovered that there is a great acceleration of the fuel combustion itself because of the pronounced ignition effect of the intense electric arcs. The discovery was made when it was observed that the combustion flames were shortened upon closing the electric switch and starting the arcs, without any manipulation of the valves of the fuel and air supply. When the switch was opened, the combustion flames were again lengthened, because of the absence of this ignition effect. It is obvious that a shorter flame, under fixed conditions of fuel and air supply, signifies more rapid and consequently hotter combustion. That this was indeed the case was clearly indicated by the greater brilliance of the combustion flames even much beyond the lengths of the arcs.

The arc operation is satisfactory whether the combustion flame be reducing, neutral, or oxidizing, but with an oxidizing flame electrodes of metal tubes packed with car-

bonaceous matter are superior to naked carbon or graphite rods as they resist oxidation better. As the electrodes burn back by arc consumption the regulation of current magnitude is obtained by advancing the rods either by hand or by suitable electromagnetic mechanism.

It is usually preferable to supply the greater part of the energy by fuel and to use only such smaller portion of electrical energy as is required to give the desired increase of the joint temperature by the exceedingly high temperature of the arc. The invention permits the use of any ratio of electric to fuel energy and with perfectly stable operation. With furnaces containing relatively large burdens such that considerable storage of high-intensity heat is practicable, electricity may be used only intermittently during periods of the day when electricity may be purchased cheaply, yet it may be used effectively in maintaining a high average temperature and productivity by intermittent increments of intense superheating.

The process may be used in connection with the gas, oil or powdered fuel burners commonly employed under steam boilers, resulting in higher temperatures and particularly in more stable operation when low-grade or refractory fuel is employed. In this and other applications of the invention the electrodes need not extend through the nozzles but may pass obliquely into the combustion flame somewhat beyond the end of the nozzle. With a single fuel nozzle and flame, two electrodes are used with their arcing portions in contact with the flame, one nearer to and the other farther from the nozzle.

Substances to be subjected to the intense heat of the flame arcs may be introduced through the nozzles in gaseous, liquid or granulated form, or they may be agglomerated into the electrodes. When high voltage direct currents are employed, advantage may be taken of electrolytic effects in the arcs. The introduction into the flame of the vapors of certain substances increases the electric conductivity and improves the steady arcing action of the flames. Granular substances containing moisture or gases in unstable condition are disrupted into much finer condition when introduced into the flames. For example, finely powdered quicklime is obtained when granular limestone is passed through the nozzle and into the combustion flame.

It is obvious that the steps of the process as well as the arrangement of the apparatus may be varied without departing from the spirit of my invention.

The nozzles may be formed of refractory material other than metal and ordinarily fluid cooling of the nozzle is not necessary

when a liquid fuel is employed. The supporting blocks 43 may be of metal, suitable insulation being provided when both the blocks and nozzles are metallic. A single block may be provided with a plurality of channels for receiving the plurality of nozzles of a single assembly.

In place of forming the arc within and along the flame it may be directed along and close to the flame by a blast of air or other gas. On the other hand, a particularly thorough intimacy between the combustion flames and the electrodes may be obtained by the use of a bundle of small rods in place of the single rod electrodes; the gases of the combustion flame being projected partly through the interstices between the rods and partly through the space between the bundle and the bore of the nozzle. If desired, one or more of the nozzle-electrodes of an assembly may be pivotally supported for varying the angle of convergence between the electrodes. These and many other modifications fall within the scope of the invention.

While the invention has been shown and described as embodied in a furnace structure, it will be apparent that the novel process and apparatus may be employed in the cutting, welding or other local heating of metals or other solids.

I claim:

1. In heating by a combustion flame and an electric arc superposed on and extending longitudinally of the flame, the process which consists in establishing the stream of flame and the arc from independent sources, and in directing the arc to and along the flame stream by a gaseous blast which is passed over the arcing portion of the electrode.

2. In the process of heating by a combustion flame and a superposed arc originating at a source spaced from the source of a stream of flame, the step which comprises directing the arc to and along the flame stream by a blast passing over the arc source at such velocity that the arc cannot strike back to the blast-producing nozzle.

3. In heating by the joint working of combustion flames and electric arcs, the process which consists in projecting a blast of oxidizing gas mixed with fuel from a nozzle and igniting the same to establish a stream of flame, forming an arc between portions of rigid electrodes spaced from said nozzle and at different points along the stream of flame, and maintaining the velocity of the fuel mixture such that the arc cannot strike back to the nozzle.

4. The process of heating mobile substances at high temperatures which comprises establishing a stream of flame and an arc from independent sources, directing said arc upon and along said stream of flame by a gaseous blast, and blowing into said flame

stream the mobile substances to be heated.

5. The process of electrolytically treating mobile substances at high temperatures, which comprises establishing a stream of flame, superposing upon said stream of flame a direct current arc established between electrodes having their arcing portions located at different points along the flame stream and spaced from the source thereof, and introducing said mobile substances into said flame stream by a gaseous blast.

6. The process of subjecting substances to heating at high temperatures, which comprises incorporating said substances in electrodes, establishing a stream of flame, drawing an arc from an electrode which includes the substance to be heated, and directing said arc to and along said stream of flame by a gaseous blast.

7. The invention as claimed in claim 6, wherein the electric supply to said arc is direct current, whereby the substances may be subjected to electrolytic treatment.

8. In apparatus for heating by the joint use of an electric arc and a combustion flame, means for superposing an arc upon and along a stream of flame comprising an electrode, a nozzle for directing a blast over the arcing portion of said electrode and along the stream of flame, and means for delivering a gaseous blast from said nozzle and over said electrode at such velocity that the arc cannot strike back to said nozzle.

9. Apparatus for heating by superposing an electric arc upon and along a combustion flame comprising, a nozzle for delivering a gaseous blast to a stream of flame, and an electrode having its arcing portion in the path of the gaseous blast, said arcing portion being so spaced from the nozzle that the gaseous blast prevents the arc from striking back to the nozzle.

10. In apparatus for heating by superposing an electric arc upon a flame, the combination with a nozzle for projecting a stream of flame, of a plurality of electrodes having the arcing portions thereof spaced from said nozzle and at different distances therefrom.

11. In apparatus for combined combustible and electric heating, a nozzle-electrode comprising a nozzle having a bore there-through for projecting fuel and oxidizing matter into a stream of flame, and an electrode coaxial with said bore and having an arcing portion projecting beyond said nozzle.

12. In apparatus for combined combustible and electric heating, a nozzle-electrode comprising a nozzle having a bore there-through, a tube within said bore, a rigid electrode slidable through said tube and having an arcing portion projecting beyond said nozzle, and a refractory sleeve projecting beyond said tube for protecting the electrode from oxidation.

13. In apparatus for combined combustive and electric heating, the combination with a plurality of nozzles arranged with their bores directed toward the space to be heated, of means for projecting combustible matter and an oxidizing gas from said bores, and rigid electrodes having arcing portions spaced from said nozzles.

14. Apparatus according to claim 13, wherein the nozzles are so directed that their flames meet each other in space, whereby their arcs also are made to meet each other in space.

15. Apparatus according to claim 13, combined with means for supplying secondary air around the nozzles and into the combustion space.

16. Heating apparatus comprising a nozzle for projecting a fuel mixture into a stream of flame, a thermally refractory bushing surrounding said nozzle and having its walls spaced therefrom to permit the introduction of secondary air, and means comprising a rigid electrode having an arcing portion spaced from said nozzle

for superposing an arc upon and along the flame stream.

17. In a furnace, the combination of a plurality of thermally refractory bushings directed into its working chamber, a nozzle-electrode in each of said bushings and spaced from the wall thereof, and an air box adapted to deliver secondary air to said bushings.

18. In apparatus for supplying electric energy to the space of action of fuel combustion, the combination with nozzles having within and spaced from the walls of their bores substantially integral electrodes projecting beyond the ends of said nozzles, of means for producing combustion flames from said nozzles and surrounding said electrodes, and means for supplying electricity of suitable electromotive force to said electrodes to cause electric arc conduction in said flames.

In testimony whereof I affix my signature.

GEORGE T. SOUTHGATE.