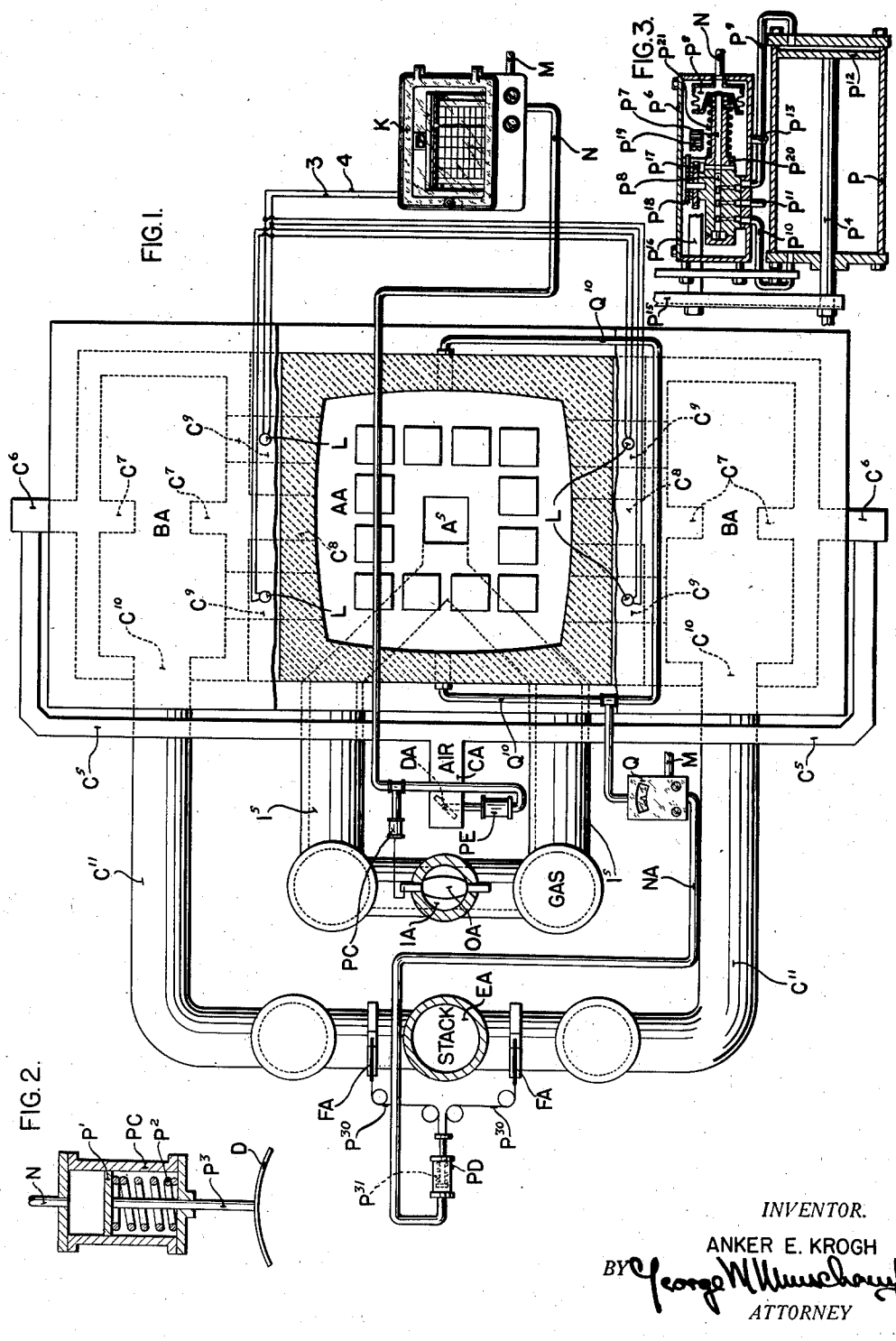
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CONTROL SYSTEM

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CONTROL SYSTEM

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The general object of the present invention is to provide an improved method of and improved apparatus for controlling the operation of metallurgical furnaces for the batch heating of billets, slabs, ingots, or the like, so as to effect a desirable economy in the use of fuel, while at the same time avoiding conditions tending to surface oxidation of the articles heated.

In accordance with the present invention, I regulate the supply of fuel and combustion air to the furnace, and the discharge therefrom of products of combustion, so as to provide a suitable furnace heating effect, while avoiding overheating of the articles treated, and so as to maintain a proper furnace chamber atmosphere, and a furnace chamber pressure high enough to prevent said atmosphere from becoming unduly oxidizing as a result of the inleakage of atmospheric air. To this end, I combine suitable regulating devices with controlling means therefor, which are automatically responsive to furnace temperature and furnace pressure conditions. The manner in which the regulating and controlling devices are desirably combined may vary somewhat. Thus, for example, I may employ a controlling device responsive to furnace chamber pressure to directly control said pressure by adjustment of a stack damper and in such case, I employ means suitably responsive to the furnace chamber temperature condition, to control the supplies of fuel and combustion air to the furnace chamber.

My invention is desirably characterized by the fact that the regulating and controlling devices required may be of relatively simple and operatively reliable, commercial types.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, and of specific objects and advantages attained with it, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described preferred embodiments of the present invention.

Of the drawing:

Fig. 1 is an elevation, partly in section, of a heating furnace including a somewhat diagrammatic representation of control and regulating devices associated therewith;

Fig. 2 is a section of a regulator shown in Fig. 1; and

Fig. 3 is a section of a regulator differing from, and usable in lieu of the regulator shown in Fig. 2.

In the drawing and referring first to Fig. 1, AA represents the furnace chamber of a heating furnace commonly called a soaking pit for the batch heating of metal ingots *a*, preparatory to rolling or other operations on said ingots. Furnace AA is of the recuperative type wherein preheated combustion supporting air passes from the inlet CA, adjustably throttled by the damper DA, through branch pipes C^5 to the inlets C^6 to the air passages C^7 of recuperators BA which open through ports C^8 to the furnace chamber or soaking pit AA. Products of combustion pass from the pit AA through ports C^9 to the gas outlets C^{10} of the recuperators BA, from which the products pass through conduits C^{11}, leading to the chimney or stack EA. As shown, a separate throttling damper FA is provided to variably throttle the discharge of products of combustion to the stack through each conduit C^{11}. A fan C^{12} may be located in each recuperator inlet C^6, to provide the proper volume of draft without such reduction of the pit pressure below atmospheric pressure, as necessarily results when the draft is wholly due to stack suction. As shown the pit chamber AA is heated by the combustion therein of fuel gas supplied to the pit chamber from a supply conduit IA, including a regulating damper or valve OA, through branch conduits I^5 leading to a gas inlet port A^5 formed in the bottom wall of the chamber AA.

As shown in Fig. 1, the air inlet damper DA and the fuel gas valve OA are controlled by a controlling device K, in accordance with the furnace temperature condition to which a plurality of thermocouples L, located at suitably distributed points in the furnace chamber are responsive. The instrument K may be of any usual or suitable form, and in particular it may be, and is shown as, a commercial potentiometer, known as the "Brown potentiometer," having air controller provisions associated therewith in the manner in which they are commercially associated with that type of potentiometer. In the preferred arrangement shown in Fig. 1, the terminal conductors 1 and 2 of the different thermocouples L are connected in parallel to the instrument galvanometer terminals 3 and 4 respectively, so that the voltage impressed on the galvanometer terminals, is the average of the different thermocouple voltages, the instrument K thus being responsive to the average of the

temperatures to which the thermocouples L are exposed.

The known form of air controller provisions included in the instrument K, comprise means whereby compressed air, received at a suitable and approximately constant pressure through an air supply pipe M, is delivered to a control pipe N at a pressure varying directly or indirectly with the furnace temperature condition indicated by the voltage impressed on the galvanometer terminals 3 and 4 of the instrument K. The pressure in control pipe N directly governs regulators PC and PE which respectively actuate valve OA and damper PE. With the regulators PC and PE arranged as shown and described the control pressure in the pipe N, varies directly with the controlling temperature.

The regulators PC and PE shown in detail in Fig. 2 comprise a damper or valve actuating piston P' working in a cylinder to one end of which the control pressure is transmitted by the pipe N. The piston P' moves in the cylinder as required to balance the opposing actions on the piston of the control pressure, and a loading spring P^2. As shown in Fig. 3, the piston P' thus moves downward as the control pressure is increased. The piston stem P^3 extends out of the cylinder at its lower end, and is shown as directly connected to its respective damper.

For the operation of the relatively heavy control dampers and valves of a metallurgical or analogous furnace, there are advantages in employing a regulator of the servo-motor, or fluid pressure relay type, in which the control pressure directly controls a valve mechanism regulating the admission of a motive fluid, such as compressed air, to a motor cylinder having its piston directly connected to and actuating the furnace damper or valve. The regulators PE and PC of Fig. 1 may be of the servo-motor type just described. In the regulator P, which is shown in detail in Fig. 3, the control pressure is transmitted to the interior of a bellows located in a valve casing P^6, mounted on the working cylinder of the regulator. The movable end wall of the bellows P^5 acts through a rod P^7 on a valve mechanism P^8. The latter is adjusted, as the bellows P^5 contracts or expands, to connect one or the other of pipes P^9 and P^{10} respectively communicating with the opposite ends of the working cylinder of the regulator to a motive fluid supply pipe P^{11}, and thereby give movements in the one direction or the other to the damper actuating piston P^{12} in the working cylinder. When either of the pipes P^9 and P^{10}, is thus connected to the motive fluid supply pipe P^{11}, the other pipe is connected by the valve mechanism to the interior of the casing P^6 which is open to the atmosphere through a vent pipe P^{13}. In the regulator shown in Fig. 3, when a change in the control pressure and resultant adjustment of the valve mechanism P^8 starts the piston P^{12} into motion in either direction, that motion continues until the piston movement is sufficient to effect a corresponding readjustment of the valve mechanism P^8.

The valve mechanism readjustment means, as shown, comprises a cross head or arm P^{15} carried by the piston stem P^4 and carrying a rack bar P^{16} parallel to said stem. The rack bar P^{16} extends into the casing P^6, and has its teeth in mesh with the teeth of a spur gear P^{17}, journalled in said casing and carrying an edge cam P^{18}. Each rotative movement of the cam P^{18}, produced by a movement of piston P^{12}, in one direction or the other gives a movement in said other, or in said one direction, respectively, to the arm P^{19} of a rocking element engaging the edge of the cam and to a tubular member P^{20} coaxial with the rod P^7 and engaged by the arm P^{19}. The member P^{20} serves as a movable abutment for a spring P^{21} acting between it and the movable end wall of the bellows P^5. Each increase in the control pressure, elongates the bellows P^5 and starts an up movement of the piston, which stops only when the resultant down movement of abutment P^{20} increases the tension of the spring P^{21} sufficiently to contract bellows P^5 to its normal length, thereby restoring the valve mechanism P^8 to its normal neutral position, in which neither pipe P^8 or P^9 is connected to the supply pipe P^{11}, or to exhaust. On a decrease in the control pressure, operations which are the converse to those just described, are effected.

The bellows P^5 has the same normal length for all values of the control pressure, and while each change in that pressure produces a short initial elongation or contraction of the bellows, the normal length of the latter is restored by the resultant movement of piston P^{12} and adjustment of cam P^{18}.

While as before stated, it is practically desirable to employ a regulator P of the servo-motor type, and the particular form of the regulator P illustrated in Fig. 3 is desirable for such use, that particular form of regulator constitutes no part of the present invention, and hence need not be further illustrated and described, herein. It is noted, however, that the regulator P shown in Fig. 3 comprises novel features of construction and arrangement which are fully disclosed and claimed in an application of Coleman B. Moore, Serial No. 137,247, filed April 16, 1937.

As shown in Fig. 1, the damper FA provided in the stack EA, and employed to variably throttle the discharge of products of combustion from the latter to the atmosphere, is actuated through a cable P^{30}, connected to the piston stem of a regulator PD, which may be of the type of the regulator P, but may be like the regulator PC or PE, or, may take other known or suitable forms. The control pressure for operating the regulator PD is transmitted to the latter through a pipe NA from a control instrument Q, which is responsive to the pressure in the furnace chamber A transmitted to the instrument through a pipe Q^{10}. The instrument Q may be of any usual or suitable type. In particular, it may be a controller of the type known as the "Air-O-Line" controller, and now in extensive commercial use, receiving compressed air through the air supply pipe M, and operating to decrease or increase the control pressure transmitted to the regulator PD through the pipe NA, as the pressure in the furnace chamber increases or decreases, respectively. In consequence, when the pressure in the chamber AA rises above or falls below the standard which the controller Q tends to maintain, the latter actuates the regulator PD to give a corrective opening or closing adjustment, respectively, to the damper F. For the purpose of the present invention, the pressure in the furnace chamber should ordinarily be approximately constant, and high enough to prevent any significant inleakage of air into the furnace chamber. With the furnace draft wholly due to stack suction, the furnace chamber pressure is necessarily subatmospheric, but it may be higher when the combustion air is moved into the furnace by a

fan or blower. In such case, the furnace chamber pressure should not be allowed to rise appreciably above the pressure of the atmosphere, so as to create an outrush of flame or hot products of combustion when the furnace doors, or inspection holes in the wall of the furnace chamber, are opened. As those skilled in the art will understand, the controller Q and regulator PD may readily be devised and calibrated so that the full required range of adjustment of the damper FA, may be secured as a result of a variation in furnace chamber pressure as large or as small as conditions make practically desirable.

As those skilled in the art will understand in a furnace like that illustrated in which the admission of combustion air and the discharge of products of combustion are controlled by separate regulators, an adjustment of either regulator tends of itself to change both the volume of draft and the furnace chamber pressure. However, when either regulator is suitably controlled by a device directly responsive to the furnace pressure chamber as is the controller Q, that regulator directly controls the furnace pressure, and the dominant controlling effect on the volume of draft then results from the adjustment of the other regulator. The general equivalency of the two arrangements just mentioned for regulating furnace pressure and furnace volume of draft is illustrated, for example, in the Gibson Patent 1,582,648, granted April 27, 1926. In consequence, while the furnace chamber responsive controller Q acts on the stack damper FA, it may well act on the air inlet damper DA and in each case control the furnace chamber pressure, and while the furnace temperature responsive controller K controls the inlet damper DA it may well control the stack damper FA and in each case, exert a dominant control on the volume of draft and increase and decrease the latter as it increases and decreases the fuel supply by adjustment of the valve OA.

Whether it is more advantageous to regulate the furnace pressure by throttling the air inlet or by throttling the stack outlet, depends upon operating conditions and also upon practical considerations having to do with the form and location of the regulators conveniently employed. Ordinarily, where mechanical draft provisions such as fans or blowers in the recuperator inlets C^6 are employed, there is an advantage in controlling the pressure in the heating chamber of a metal heating furnace, by variably throttling the air inlet.

The present invention is desirably characterized by a practically effective control of a batch heating furnace by means of simple and reliable control instruments and regulators, each of which may be of commercial type. The regulation provided eliminates or substantially minimizes risk of overheating the billets, ingots, slabs, or the like, heated, and reduces the wastage due to oxidation of the work, and the interferences with the rolling operation efficiency and the impairments of the rolled products, resulting from such oxidation. The use of the invention effects fuel savings, and not only improves the product and reduces loss due to oxidation, but also prolongs the furnace life and lowers the furnace maintenance charges.

The simple and effective type of control provided is especially well adapted for use with batch heating furnaces, because it tends to the maintenance of the work at the proper rolling temperatures, with a relatively low fuel consumption during temporary shutdowns prolonging the periods in which individual work pieces must be held in the furnace. Certain novel methods and combinations disclosed but not claimed herein, are claimed in my prior application Serial No. 101,063, filed September 16, 1936.

When the furnace is opened for the insertion or removal of the work as for example when the top of the soaking pit furnace shown is removed, the resultant drop in furnace temperature leads to a prompt corrective increase in the supply of fuel and combustion air, and the furnace pressure control quickly corrects for the change in furnace pressure occurring when the furnace chamber is opened to the atmosphere.

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

1. In heating billets and like work in a heating chamber having an air inlet and an outlet for products of combustion and in which fuel and air unite in combustion, the method which consists in regulating the fuel supply to the furnace heating chamber by and in accordance with the chamber temperature, and in subjecting the furnace chamber combustion air inlet and the furnace outlet for products of combustion to separate throttling effects one of which is varied by and in accordance with the furnace chamber temperature and the other of which is varied by and in accordance with the furnace chamber pressure.

2. In heating billets and like work in a heating chamber having an air inlet and an outlet for products of combustion and in which fuel and air unite in combustion, the method which consists in regulating the supply of fuel to, and the volume of draft through, the furnace chamber by and in accordance with the temperature condition therein, and regulating the gas pressure in said chamber by and in accordance with the pressure in the chamber.

3. In heating billets and like work in a heating chamber having an air inlet and an outlet for products of combustion and in which fuel and air unite in combustion, the method which consists in regulating the supply of fuel to and the volume of draft through, the furnace chamber by and in accordance with a furnace temperature condition affected by the temperature of the work being heated therein, and regulating the gas pressure in said chamber by and in accordance with the pressure in said chamber.

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