

April 7, 1942.

J. R. GIER, JR

2,279,231

METHOD AND APPARATUS FOR DETERMINING THE CARBON PRESSURE OF GASES

Filed Sept. 15, 1939

Fig. 1.

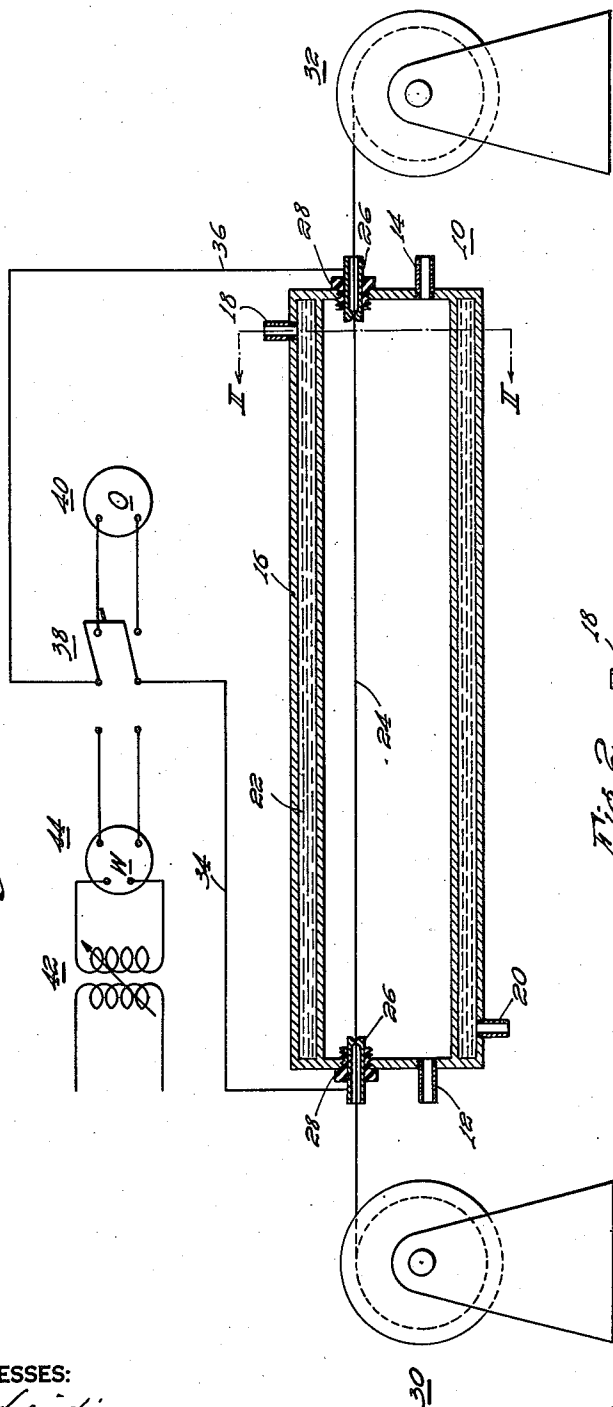
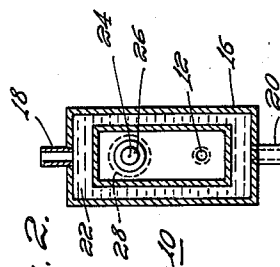


Fig. 2.



WITNESSES:

E. E. Kidding
James R. Ely

INVENTOR

John R. Gier, Jr.
BY *Gra W. Savage*
ATTORNEY

UNITED STATES PATENT OFFICE

2,279,231

METHOD AND APPARATUS FOR DETERMINING THE CARBON PRESSURE OF GASES

John R. Gier, Jr., Wilkinsburg, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application September 15, 1939, Serial No. 295,058

5 Claims. (Cl. 23—232)

This invention relates to the method of and apparatus for determining the carbon pressure of gases.

In the heat treatment of steels, and particularly tool steels, protective carbonaceous atmospheres are generally employed. With this type of atmosphere, however, it has been found to be quite difficult to maintain the carbon content of the surface of the steel substantially constant or where it is desired to alter the carbon content, it has been difficult to alter it in a predetermined and definite amount. This is because of the difficulty of adjusting the composition of the protective atmosphere quickly and accurately to the requirements of any particular job and of maintaining the composition constant.

The gases commonly used for such heat treatment of steels usually consist of mixtures of carbon monoxide, hydrogen, nitrogen and small amounts of hydrocarbon, carbon dioxide and water vapor so that the complexity of reactions involved makes it extremely difficult to predict accurately what the resultant effect of any given mixture will be on the basis of its composition.

Carbonaceous gases may be regarded as exerting a carbon pressure variable in amount depending on the composition of the gas. Similarly, hot steels exert a carbon pressure that increases with increasing carbon content and temperatures. When a steel is heated in an atmosphere having a carbon pressure greater or less than that of the steel a transfer of carbon will occur between the steel and the gas in the direction of the higher to the lower pressure. In other words, the steel will tend to change in carbon content until its carbon pressure equals that of the gas. The usual objective in using these protective gases for heat treating is to regulate their composition so that their carbon pressure will be equal to that of the steel and thereby prevent the steel from changing in carbon content. It has been found that the carbon pressure of the gases is an accurate measure of the effect of the carbonaceous atmospheres on the steels, and it is, therefore, desired to provide for the determination of the carbon pressures of the gases employed in the heat treatment of steels in order to better control the heat treatment.

Different devices have been developed in an attempt to indicate the carburizing character of the carbonaceous gases employed as furnace atmospheres, but the devices produced heretofore do not indicate any definite relation to the carbon pressure of the gases. Instead, they have

measured the heat of combustion or the thermal conductivity of the gas, thus rendering them definitely limited in their use. Further, the devices heretofore produced are quite complicated, require considerable maintenance and are not economical from the cost standpoint.

An object of this invention is to provide apparatus for determining the carbon pressure of gases.

Another object of this invention is to provide apparatus for determining the carbon pressure of gases by determining the equilibrium carbon content of a metallic member exposed thereto at an elevated temperature.

A further object of this invention is to provide apparatus having a metallic member therein and through which gases may be passed for establishing an equilibrium carbon content of the metallic member with the carbon pressure of the gases whereby the carbon pressure of the gases may be quickly determined by a measure of the carbon content of the metallic member.

Another object of this invention is to provide a method for determining the carbon pressure of gases by exposing a metallic member to the gas at an elevated temperature for a sufficient period of time to effect an equilibrium between the carbon content of the metallic member and the gas and thereafter determining the carbon content of the metallic member, the carbon content of the metallic member being a direct function of the carbon pressure of the gases.

Other objects of this invention will become apparent from the following description when taken in conjunction with the accompanying drawing, in which:

Figure 1 is a diagrammatic view partly in section of apparatus and associated electrical circuits for the determination of the carbon pressure of the gas in accordance with the teachings of this invention; and

Fig. 2 is a view in section of the apparatus taken along the line II—II of Fig. 1.

Referring to the drawing and Fig. 1 in particular, this invention is illustrated with reference to a particular embodiment of the apparatus of this invention. As illustrated, the apparatus comprises a plurality of elements associated with an enclosing chamber 10. The enclosing chamber is of an elongated design and is formed of any suitable material which is preferably unaffected by moisture or exposures to elevated temperatures, such as stainless steel, bronze, etc., or may be of transparent material such as Pyrex glass or the like. In order to per-

mit the flow of gases, the carbon pressure of which is to be determined, through the chamber, suitable inlets and outlets 12 and 14, respectively, are provided in the walls of the enclosing chamber 10 and are preferably disposed in opposite ends of the elongated chamber to secure a good circulation of the gases within the chamber.

As illustrated in Figs. 1 and 2 in order to control the temperature within the enclosing chamber 10 when cooled, as hereinafter described, a cooling jacket 16 is disposed about and sealed to the elongated chamber 10 and is preferably formed of the same material as the walls of the elongated chamber. An inlet 18 and an outlet 20 are disposed in the cooling jacket for the ingress and egress of a cooling medium 22 to and from the space formed between the cooling jacket 16 and the walls of the elongated chamber 10.

In order to obtain a true indication of the carbon pressure of the gases admitted to the chamber 10, a metallic member, preferably in the form of a fine wire 24, is disposed lengthwise within the chamber 10. In order to secure the wire 24 in its initial position within the chamber, a plurality of spring clamps 26 of any suitable material are disposed in opposite ends of the elongated chamber 10, these clamps being adapted to apply sufficient pressure to the wire 24 to maintain it in a substantially straight line as initially disposed in the chamber. The clamps 26 are preferably of electrical conducting material and are suitably insulated from the chamber 10 by means of the insulating bushings 28 disposed through the ends of the chamber.

In order to insure a fresh supply of the wire 24 through the chamber 10, a supply reel 30 of the wire is disposed adjacent one end of the chamber 10 and a retrieving reel 32 is disposed adjacent the other end of the chamber 10. Thus the wire can be drawn from the reel 30 through the conducting spring clamps 26 and the chamber 10 to the reel 32 as desired in order to supply a given length of fresh wire to the chamber to replace wire that has been exposed to the gases within the chamber.

It has been well known that the electrical resistivity of a hardened or martensitic steel varies directly with the carbon content of the wire. Thus the resistance of any given length of hardened steel wire may be used as a measure of the carbon content of the wire. This known relation is utilized in this invention by measuring the resistance of the given length of wire 24 disposed within the chamber 10 between the spring clamps 26.

In order to measure the resistance of the given length of wire 24, conductors 34 and 36 are electrically connected to the clamps 26 disposed in opposite ends of the chamber 10 and are connected to a double throw switch 38, as illustrated in the drawing. This switch is disposed to be manually operated to electrically connect the conductors 34 and 36 to an ohm meter 40 or any other suitable apparatus for measuring the electrical resistance of the given length of wire 24. In practice, it is found that the well known Wheatstone bridge arrangement in which the given length of wire 24 is the unknown quantity to be measured is quite satisfactory for measuring the electrical resistance of the wire 24. The double throw switch 38 is also disposed to be manually operated to connect the conductors 34 and 36 to a suitable source of supply of electric

current, not shown, as through a variable transformer 42 and any suitable wattmeter 44 as illustrated, the wattmeter being a direct measure of the power employed and of the heat generated in the wire 24, as will be described hereinafter.

Heretofore, reference has been made to the wire 24 as being a steel wire. In practice, it is preferred that the wire 24 be of that class known as plain carbon steel wire containing approximately .5% manganese. The carbon content of such wire is easily adjusted in use in this invention, as will be evident hereinafter, and as a general rule as initially manufactured is round about .1%. However, even the plain carbon steel wire containing more than 1% of carbon is quite satisfactory for the purpose of this invention.

In practice, the apparatus described hereinbefore is closely associated with the furnace (not shown) in which the heat treatment of the tool steels is being practiced, the gas employed in the heat treatment of the steels being delivered directly to the chamber 10 through the inlet 12 and where desired, it may be returned to a recirculating system (not shown) through the outlet 14.

In order to obtain a determination of the carbon pressure of the gases so that adjustments may be made in the supply of the carbonaceous protective atmospheres to the furnace with which the apparatus of this invention is associated, the double throw switch 38 is manually operated to electrically connect the wire 24 in circuit with the source of supply of current to heat the given length of wire 24 within the chamber 10.

By observing the meter 44 and adjusting the output of the transformer 42, the temperature of the wire 24 may be closely controlled.

By way of explanation, this apparatus may be calibrated by experimentally determining the relation between the resistance of the cold test wire, after exposure at high temperature to the gas, and the carbon content of thin steel specimens after heating to various temperatures in this same gas until equilibrium has been attained. Thus a series of curves may be developed showing the relation between equilibrium carbon content of steel for various temperatures and the electrical resistance of the test specimen. The temperature of the test specimen should be sufficiently high that its carbon content will respond to changes in the carbon pressure of the gas over the entire working range of carbon pressures required for heat treating various steels.

In practice, temperatures of the order of 800° to 1100° C. are generated in the wire 24, it being found that this is quite satisfactory for the purpose of this invention.

With the wire heated to any predetermined temperature within this range and exposed to the carbonaceous gases as they pass through the chamber 10, it is found that an equilibrium is quickly established between the carbon content of the given length of wire 24 and the gases within the chamber 10. In a particular example, with a plain carbon steel wire having a diameter of .007 inch, it is found that less than 5 minutes is required with the wire heated to a temperature of approximately 1050° C. to balance the carbon content of the wire against the carbon pressure of the gas. In all cases, it is found that regardless of the initial carbon content of the wire, whether higher or lower than that of the gases within the chamber, an equilibrium between the carbon content of the wire and the gases will be quickly established.

After a carbon equilibrium has been established

between the wire and gas, the double throw switch 38 is manually operated to interrupt the flow of current to the wire 24 and the wire is cooled rapidly, thereby causing the carbon in the wire to be retained in a martensitic structure when cold. In cooling the wire, the cooling medium 22, such as water or the like, within the cooling jacket 16 insures the maintenance of the walls of the elongated gas chamber 10 at a constant temperature, preferably between 60° and 90° F. The presence of the cooling medium about the gas chamber aids in cooling the wire and minimizes variations in its resistance due to changes in the ambient temperature.

After the wire 24 has been cooled to approximately room temperature, the double throw switch 38 is manually operated to connect the wire 24 in circuit with the resistance measuring device 40 and the electrical resistance of the wire 24 is then measured, thereby securing a direct determination of the carbon content of the wire. Since a carbon equilibrium has been established between the wire and the gases to which it has been exposed, the measurement of the resistance of the wire to determine the carbon content thereof is also a determination of the carbon pressure of the gases. If upon determining the electrical resistance of the wire exposed at the elevated temperatures to the gases for a sufficient period of time to establish a carbon equilibrium between the wire and the gases, it is found that the carbon pressure of the gas is too large or too small for the particular conditions which it is desired to obtain or maintain in the furnace with which the apparatus is associated, the carbon content of the carbonaceous atmosphere supplied to the furnace can be quickly adjusted by well-known methods to obtain any given set of conditions.

The wire which has been utilized and exposed to the gases at elevated temperatures need not necessarily be renewed after each determination as it has been found from experience that it can be employed for as many as 3 or 4 determinations. However, when it is desired to supply fresh wire, that is, wire that has not been exposed to the gases at the elevated temperatures, to the chamber 10, the reel 32 is wound to draw the exposed wire from the chamber 10 while simultaneously supplying a fresh wire to the chamber to replace the removed exposed wire. In all cases, since the clamps 26 are fixed in position in the ends of the chamber 10, and since the tension applied to the wire by reason of the reels 30 and 32 and the clamps 26 is the same, it is found that upon removal of the exposed wire, fresh or unexposed and unheated wire of definite length is supplied to the chamber. Thus the resistance of the wire 24 will be measured for the same length of wire for all determinations. Regardless of whether or not fresh wire is employed for each determination, it has been found through experience to be essential that the carbon in the wire on cooling be completely in the martensitic phase, as this structure provides the most dependable and sensitive relation between resistance and carbon content of the wire.

By utilizing the apparatus and method of this invention, the apparatus being, in effect, a carburizing gauge for gases, it is quite evident that it is possible to closely control the carbon pressure of protective carbonaceous atmospheres employed in the heat treatment of steels. It is further evident that the apparatus and method employed are quite economical, accurate determina-

tions being made in a very short time with a minimum of equipment.

Although this invention has been described with reference to a particular embodiment thereof, it is, of course, not to be limited thereto, except insofar as is necessitated by the prior art and the scope of the appended claims.

I claim as my invention:

1. The method of determining the carbon pressure of gases comprising, in combination, the steps of admitting the gas to be tested into a chamber containing a metallic wire having a diameter of about .007 inch, the wire having a predetermined carbon content and electrical resistance, heating the wire to a predetermined temperature while exposed to the gas, maintaining the wire at that temperature while exposed to the gas for a period of time sufficient to establish an equilibrium carbon content between the wire and the gas, cooling the wire while retaining it within the chamber, and then measuring the electrical resistance of the cooled wire while it is retained in the chamber after equilibrium of the carbon content is established to determine the carbon content of the wire and thereby obtain a determination of the carbon pressure of the gas being tested.

2. The method of determining the carbon pressure of gases comprising, in combination, the steps of admitting the gas to be tested into a chamber containing a plain carbon steel wire having a diameter of about .007 inch, the wire having an electrical resistance depending upon its carbon content, heating the wire to a predetermined temperature while exposed to the gas, maintaining the wire at that temperature while exposed to the gas for a period of time sufficient to establish an equilibrium carbon content in the wire between it and the gas, cooling the wire while retaining it within the chamber to cause the carbon thereof to be completely in the martensitic phase, and then measuring the electrical resistance of the cooled wire while it is retained in the chamber after equilibrium of the carbon content is established to determine the carbon content of the wire and thereby obtain a determination of the carbon pressure of the gas being tested.

3. Apparatus for determining the carbon pressure of gases comprising, a gas chamber for receiving gases to be tested, a metallic wire of predetermined length capable of absorbing or evolving carbon when heated disposed in the gas chamber, the wire having a diameter of about .007 inch, the gas chamber having a plurality of openings for the ingress and egress of the gases to be tested to and from the chamber, the metallic wire being so disposed as to be in intimate physical contact with the gases to be tested, means for heating the metallic wire to effect an equilibrium between the carbon of the wire and the gases being tested, and means for measuring the electrical resistance of the metallic wire when equilibrium of the carbon content is established without removing the wire from the gas chamber to determine the carbon content of the metallic wire and thereby obtain a determination of the carbon pressure of the gases being tested.

4. Apparatus for determining the carbon pressure of gases comprising, a gas chamber for receiving gases to be tested, a wire of plain carbon steel of predetermined length and which is capable of absorbing or evolving carbon when heated disposed in the gas chamber, the wire having a diameter of about .007 inch, means for supply-

ing and withdrawing the wire to and from the gas chamber whereby fresh wire can be disposed therein as desired, the gas chamber having a plurality of openings for the ingress and egress of the gases to be tested to and from the chamber, means for heating the wire to effect an equilibrium between the carbon of the wire and the gases being tested, and means for measuring the electrical resistance of the wire when equilibrium of the carbon content is established without removing the wire from the gas chamber to determine the carbon content of the wire and thereby obtain a determination of the carbon pressure of the gases being tested.

5. Apparatus for determining the carbon pressure of gases comprising, a gas chamber for receiving gases to be tested, a fine wire of plain carbon steel having a predetermined length disposed in the gas chamber, the wire being capable of absorbing or evolving carbon when heated, 20

means for supplying and withdrawing the wire to and from the gas chamber, the gas chamber having a plurality of openings for the ingress and egress of the gases to be tested to and from the chamber, means for heating the wire to effect an equilibrium between the carbon of the wire and the gases being tested, means for interrupting the heating of the wire, the wire having a diameter of about .007 inch whereby the wire is quickly cooled in the chamber upon the interruption of the heating to effect the complete hardening of the predetermined length of steel wire, and means for measuring the electrical resistance of the fine wire when equilibrium of the carbon content is established to determine the carbon content of the wire and thereby obtain a determination of the carbon pressure of the gases being tested.

JOHN R. GIER, JR.