

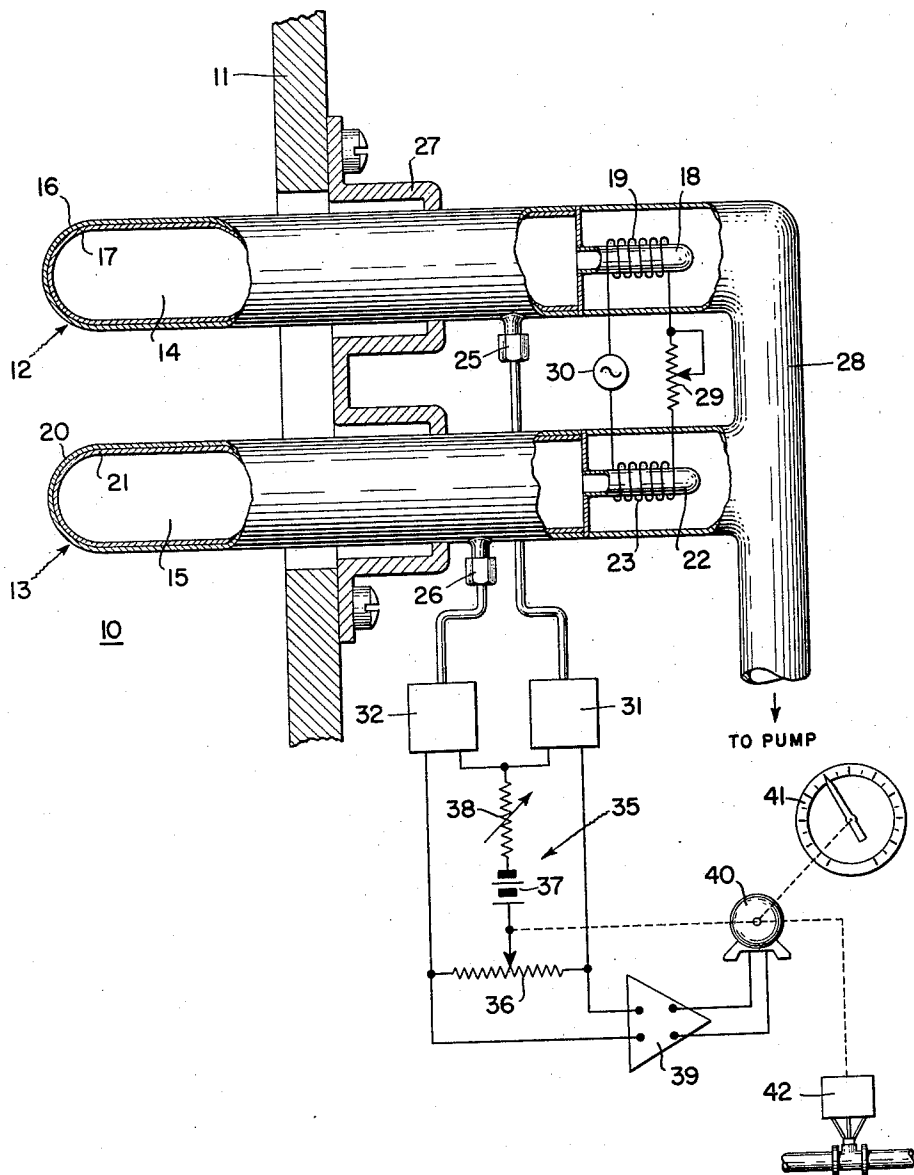
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CONSTITUENT POTENTIAL MEASURING APPARATUS

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CONSTITUENT POTENTIAL MEASURING APPARATUS

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A general object of the present invention is to provide an improved apparatus for measuring the constituent potential of a component of a gaseous atmosphere. More specifically, the invention relates to apparatus useful particularly in the analysis and control of gases of a heat treating furnace wherein the constituent potential of a heat treating gaseous component is measured in accordance with variations in the gaseous permeation rate of a member sensitive to the magnitude of the constituent potential of the atmosphere.

Present day methods of metal heat treatment involve surrounding a metal to be treated with a gaseous atmosphere which contains, as a constituent thereof, components which it is desired to absorb on and beneath the surface of the metal being treated. The component to be absorbed may well be carbon or nitrogen when the heat treatment of steel is involved. Thus, in the heat treatment of iron or steel, carbon bearing gaseous atmospheres are placed around the material to be carburized and the carbon potential of the atmosphere is arranged to be maintained higher than that of the associated steel so that carbon will be formed on the surface of the steel and then will move below the surface by means of a process generally referred to as a sorption process. If the carbon potential of the atmosphere is lower than that of the associated steel, the carbon within the steel will be transferred from the steel back to the atmosphere which surrounds the steel.

The most effective manner of measuring the carburizing effect of a particular atmosphere is to place a sample of the material to be carburized in the atmosphere and make some observation of its physical characteristics. The particular characteristic observed in the present invention is the character where the permeability of the heat treated material varies in accordance with the amount of the heat treating component absorbed thereby.

In a copending application of Richard B. Beard, filed June 29, 1953, bearing Serial No. 364,666, now Patent No. 2,811,037, and titled "Measuring Apparatus," there is disclosed an apparatus for measuring the constituent potential of carbon in a heat treating atmosphere. In this Beard apparatus, a gaseous permeable membrane is used to measure the carbon potential of a gaseous atmosphere. This gaseous permeable membrane is selected to be of the type which will absorb from the heat treating atmosphere some components such as carbon or nitrogen so that the rate of permeation of a selected gas of the atmosphere through the membrane will be proportional to the amount of carbon which has been sorbed by the membrane.

The present invention is directed to an improvement in the Beard type apparatus where two gaseous permeable sensing means of substantially similar construction are used in measuring the constituent potential of a component in a heat treating atmosphere. One of the two sensing means is arranged so that its permeation rate is variable with constituent potential variations while the other of the sensing means serves as a reference or compensating means. Each of the sensing means comprises two

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separate gaseous permeable members positioned on the inlet of an enclosed chamber so that any gas coming into the chamber must pass through first one and then the other of the two members. One of the gaseous permeable members is formed of a material which will absorb a heat treating component from the atmosphere with the amount of the component absorbed being directly dependent upon the constituent potential of that particular component in the atmosphere. The permeation rate of this member will vary as a function of the amount of the component absorbed thereby. The other of these two members is formed of a material with a highly selective permeability to a single gaseous component in the atmosphere, this latter material having a substantially constant permeability at the particular temperature at which the device is operative.

One of the two sensing means is arranged so that the member which will absorb the heat treating component from the atmosphere is exposed directly to the atmosphere. The other sensing means, which serves as a reference or compensating element, has the corresponding member which is capable of absorbing the selected gaseous component from the atmosphere isolated from the atmosphere. Thus, the chambers have similar inlet paths which, under conditions of balance in both of the sensing means, will produce identical conditions within the associated chambers. However, upon the unbalance of the permeation rates on the inputs of the chambers due to one of the sensing means absorbing the component from the atmosphere, the atmospheric unbalance on the inside of the chambers will be indicative of the constituent potential of the atmosphere.

It is therefore a more specific object of the present invention to provide a new and improved apparatus for analyzing a gaseous atmosphere incorporating a pair of gaseous permeable elements of similar construction arranged so that one of the elements will have a gaseous permeation rate which is variable in accordance with the constituent potential of a component of the gaseous atmosphere.

Another more specific object of the present invention is to provide an improved apparatus for determining the carbon potential of a carburizing atmosphere by means of a pair of gaseous permeable elements which project into the atmosphere with one of the elements having a permeation rate which is variable in accordance with the carbon potential of the atmosphere and the other of which is constructed in the same manner as the first mentioned element but serves as a reference or compensating cell.

A still further object of the present invention is to provide an improved gaseous analyzing apparatus wherein two gaseous permeable elements are used to determine the constituent potential of the heat treating component of a gaseous atmosphere where each of the elements comprises a double layer gaseous permeability member formed of palladium and iron with one of the elements being arranged so that the iron is positioned to be exposed to the atmosphere under examination and the other where the iron is isolated from the atmosphere.

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, its advantages, and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

Referring to the single figure, the numeral 10 designates a space wherein an atmosphere is to be analyzed by means of the present invention. This space may well be a heat treating furnace where a carburizing or a nitriding action is to take place. A section of wall 11 is

shown to designate the manner in which the space 10 may be enclosed. Projecting through the wall 11 are a pair of gaseous permeable elements 12 and 13. The elements 12 and 13 serve as inlets to closed chambers 14 and 15 respectively.

The element 12 is formed of two layers of metal, the first layer or outer layer 16 being formed of iron and the inner layer 17 being formed of palladium. The outlet for the chamber 14 is formed by a further palladium tube 18 which is adapted to have a heater 19 wound thereon.

The element 13 is constructed in a manner similar to the element 12 and includes an outer tube 20 formed of palladium and an inner tube which is formed of iron. It will be noted that the position of the palladium and iron in the element 13 is reversed from that of the element 12. The outlet for the chamber 15 is formed by a palladium tube 22 having a heater winding 23 wound thereon.

Chamber 14 has a pressure tap at 25 and the chamber 15 has a pressure tap at 26. The elements 12 and 13 are supported in the hole in the wall 11 by means of a mounting bracket 27. The outlets for the elements 12 and 13 formed by the tubes 18 and 22 are in communication with a conduit 28 which is adapted for connection to a suitable exhausting pump. The exhausting of the chambers 14 and 15 may be regulated by the adjustment of the rheostat 29 which is connected in series with the heater resistors 19 and 23 and a suitable power supply source designated by the numeral 30.

The pressure taps 25 and 26 are connected to suitable pressure to electric transducers 31 and 32 respectively which are connected in their electrical outputs to form branches of an electrical network 35. The network 35 includes a rebalancing potentiometer 36, a supply battery 37, and a span adjusting resistor 38. The output of the network 35 is connected to a suitable amplifier 39 which is in turn connected to reversibly drive a rebalancing motor 40. The motor 40 is adapted to drive the slider of potentiometer 36 as well as the pointer of a suitable indicator 41. The motor 40 may also be adapted to control a suitable regulating valve 42 which in turn may be used to regulate the condition of the atmosphere within the enclosure 10.

It should first be noted that with respect to the element 12 and the associated chamber 14 that hydrogen in the atmosphere will pass through the element 12 into the enclosure 14 in accordance with the partial pressure of the hydrogen within the enclosure 10. The rate at which this permeation will take place will be dependent upon the gaseous permeability of the iron element 16 and the palladium element 17. Under substantially constant temperature conditions, the permeation rate through the element 12 into the chamber 14 will vary with the permeability of the iron 16. Since the iron 16 is exposed to the atmosphere within the enclosure 10, it will sorb the heat treating constituent thereof, such as carbon, and the permeation rate will vary in accordance with the amount of the carbon absorbed thereby.

As the amount of carbon absorbed will be a direct function of the carbon potential, and the permeability will vary directly in accordance with the amount of the carbon absorbed, it is possible to correlate the permeability of this iron 16 with the carbon potential of the atmosphere. This is accomplished by effectively exhausting the chamber 14 by way of the heated palladium tube 18 which acts as a regulable valve to the hydrogen which has been passed into the chamber 14 through the element 12. As the tube 28 is connected to an exhausting pump, the effect is to pull the hydrogen from the chamber 14 out through the tube 18. The rate at which this will take place will be dependent upon the amount of heat applied to the palladium tube 18 and this is regulated by the adjustment of the rheostat 29 which is in series with the heater 19. As the tube 18 acts as a valve or restriction, the pressure

within the chamber 14 will be a direct function of the rate at which the gases are flowing into the chamber through the iron element 16 and the palladium element 17. The pressure condition within the chamber 14 will be applied to the transducer 31 by way of the pressure tap 25 so that the electrical resistance of the transducer will vary in accordance with this pressure condition.

The element 13 operates in substantially the same manner as the element 12 with the exception that the iron 21 is on the inside of the chamber 15 where it is not exposed to the heat treating effects of the atmosphere within the enclosure 10. Consequently, the permeability of the iron 21 will vary only in accordance with temperature variations. Thus, more specifically, the evacuating conduit connection 28 is effective to pull the hydrogen from the chamber 15 through the palladium tube 22 which is heated by the heater 23. By placing corresponding heaters on each of the two tubes 18 and 22, it is possible to apply an effective balanced evacuating pressure to both of the chambers 14 and 15. Since the tube 22 will act as a restriction in the line between the evacuating pump and the input element 13, the pressure within the chamber 15 will be a direct function of the rate of permeation of hydrogen through the element 13. Since the palladium 20 is on the outside, and since palladium is insensitive to the carburizing action or heat treating action of a heat treating atmosphere, the permeability of the element 13 remains substantially constant even though the constituents of the atmospheric components change. The pressure condition within the chamber 15 will be applied to the transducer 32 by way of the pressure tap 26. The resistance output change in the transducer 32 will be reflected into the bridge circuit 35. The balance of the bridge network 35 will be sensed by the amplifier 39 and the motor 40 will be readjusted until a balance in the network 35 is achieved. The adjustment will produce an indication on the indicator 40 representative of the pressure conditions affecting the transducers 31 and 32.

Under conditions in which there is no heat treating component in the gaseous atmosphere within the enclosure 10, the iron 16 will have the same permeation characteristic as the iron 21. Thus, the rate of the permeation through the elements 12 and 13 into the chambers 14 and 15 respectively will be the same. Consequently the pressures taken from the taps 25 and 26 will be the same. This will be reflected into the network 35 as an electrically balanced condition and the indicator 41 will indicate that there is no heat treating constituent within the atmosphere in the enclosure 10.

If a carbon bearing atmosphere is to be put into the enclosure 10, the carbon will be picked up by the iron 16 and absorbed thereby. With the carbon being sorbed by the iron 16, its permeation rate will change so that less hydrogen will be able to diffuse through the element 12 over a particular time. Consequently, there will be a reduction of the pressure within the chamber 14 and this will be reflected through the pressure tap 25 to the transducer 31 to unbalance the bridge by an amount proportional to that pressure change. This will be detected by the amplifier 39 which in turn will readjust the motor in the balancing potentiometer to the new balance position. The new balance position will be in a direction indicative of the constituent potential of the particular heat treating component in the atmosphere, carbon under the assumed set of circumstances.

If the carbon potential, or constituent potential, should remain constant and the temperature should change, the apparatus would not detect the temperature shift due to the fact that the elements 12 and 13 would both respond to the temperature change and there would be a corresponding shift in pressure. Since both chambers 14 and 15 would shift in pressure for the same amount, the differential between the two would remain the same. Practically speaking, however, a shift in temperature will, with a particular heat treating atmosphere, change

the effective carbon potential or constituent potential of the atmosphere so that the temperature change would produce a difference in the pressure between the chambers 14 and 15. However, this shift in pressure would be representative only of a change in the constituent potential of the atmosphere.

The iron 16 and the palladium 17 may be formed as separate elements or they may be formed as one single integral unit. When formed as a single integral unit, the unit may be made considerably more sensitive by utilizing a very thin layer of iron formed on the palladium tube as a base. When so formed, the iron will be able to respond much more quickly to constituent potential changes. The formation may be accomplished by an electroplating process with an accompanying heat setting process whereby the plated material will tend to fuse into the surface of the palladium base. When such a process is used for the element 12, a corresponding process must be used for the element 13 so that the units are effectively balanced in their basic permeation characteristics under identical conditions.

While, in accordance with the provisions of the statutes, there have been illustrated and described the preferred embodiments in the invention, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention as set forth in the appended claims, and that some features of the invention may be used to advantage without a corresponding use of other features.

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

1. An atmospheric analyzing apparatus comprising a pair of selective gaseous permeable elements adapted to project into a heat treating atmosphere where a constituent of the atmosphere is to be measured, one of said pair having a constituent sensitive coating on the outer surface thereof which coating has a permeability which is invariable in response to the amount of said constituent sorbed thereby, its permeation rate being indicative of the amount of the selected constituent in the atmosphere, the other of said pair having a constituent sensitive coating on the inner surface thereof in a position to be isolated from said constituent, and means connected to said pair of elements for differentially measuring the permeation rate therethrough.

2. In an apparatus for measuring the constituent potential of a component of a heat treating atmosphere comprising a pair of selective gaseous permeable elements which are adapted to project into an atmosphere where a constituent of the atmosphere is to be measured, each of said pair having a constituent sensitive coating on a surface thereof and being effective to vary the permeation rate in accordance with the constituent sorbed by the coating, one of said coatings being on the atmospheric side of the associated element and the other coating being on the side of said element isolated from said atmosphere constituent, the permeability of said second mentioned element being variable only in response to thermal variations, and means connected to said elements to measure the differential in the permeation rates of said elements to determine the constituent potential of the atmosphere.

3. A constituent potential measuring apparatus for a component in a heat treating gaseous atmosphere comprising first and second gaseous permeable elements whose permeation rate is adapted to vary in accordance with the constituent of the atmosphere sorbed thereby, means including said elements for defining a pair of enclosed chambers, each of said elements comprising an inlet for the associated one of said chambers, means positioning one of said elements so that it is directly exposed to the atmosphere, a selective gaseous permeable element positioned between said atmospheric exposed element

and the associated chamber, means including a second selective gaseous permeable element positioned with respect to said second constituent sensitive element to isolate said second element from said atmosphere, and means differentially responsive to an atmospheric condition within each of the associated chambers for indicating the constituent potential of a component of the atmosphere.

4. Apparatus for measuring the carbon potential of a heat treating atmosphere comprising a pair of palladium tubes adapted to be projected into the atmosphere where the carbon potential is to be measured, each of said tubes having closed ends and defining chambers into which hydrogen from the atmosphere will permeate, an iron coating formed on each of said tubes, the coating being placed on one of said tubes on the external side thereof, the coating on the other tube being placed on the internal side thereof, and means responsive to a hydrogen partial pressure within said tubes for determining the constituent potential of the atmosphere.

5. In an apparatus for measuring the constituent potential of a component in a heat treating atmosphere comprising means defining first and second enclosed chambers, an inlet for said first chamber comprising a pair of gaseous permeable elements, one of which is selectively permeable to a particular component of the atmosphere and the other of which has a permeability which is variable in accordance with the amount of the constituent sorbed thereby and has a permeation rate which is variable in accordance with the magnitude of a constituent potential of a gaseous component of the atmosphere, said latter element being exposed directly to the atmosphere, an inlet for said second chamber comprising a pair of gaseous permeable elements, one of which is selectively permeable to a particular component of the atmosphere and the other of which has a permeability which is variable in accordance with the amount of the constituent sorbed thereby and has a permeability which is variable in accordance with the magnitude of a constituent potential of the atmosphere, the latter of which is positioned within the chamber and effectively isolated from the atmosphere, and means connected to both of said chambers to measure the difference in atmospheric pressure in said chambers which is indicative of the constituent potential of the heat treating atmosphere.

6. Apparatus defined in claim 5 wherein said selective gaseous permeable element is selected of a material permeable to hydrogen.

7. Apparatus as claimed in claim 5 wherein said selective gaseous permeable element is formed of palladium and the variable permeability elements are formed of iron.

8. Apparatus for measuring the constituent potential of a component in a gaseous atmosphere comprising means defining a pair of chambers, said means including gas permeable members constituting inlets for each of said chambers, each of said gas permeable members comprising a first and a second gas permeable element when heated, one of said elements having a permeability which is variable in response to the amount of said constituent sorbed thereby, one of said inlet members having said variable permeability element external of the other element with respect to its associated chamber, the other of said inlet members having said variable permeability element internal of the other element with respect to its associated chamber and means differentially responsive to an atmospheric condition within said chamber for determining the constituent potential of the atmosphere.

References Cited in the file of this patent

Metals Reference Book, Smithells, 1949, pages 387, 388.