

3 Sheets--Sheet 1.

Patented July 10, 1956

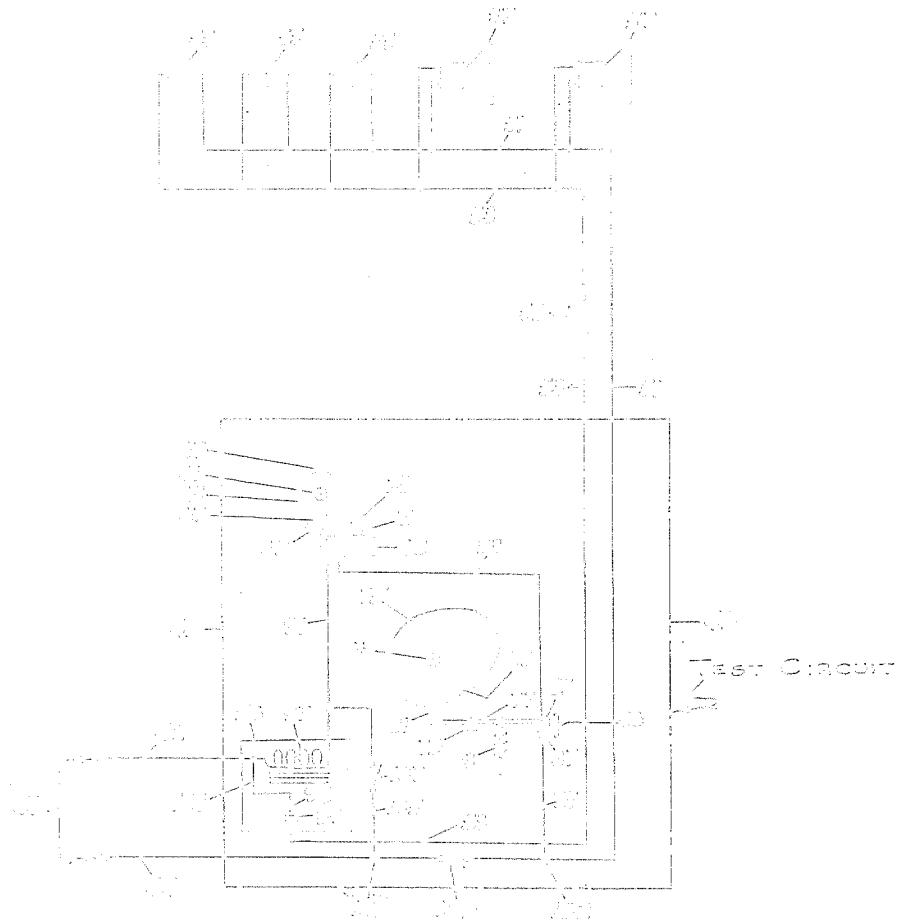
U.S. PATENT OFFICE

7,250,000

TESTING APPARATUS FOR GAS VESSELS

Filed May 11, 1955

3 Sheets-Sheet 3



INVENTORS
James E. Thompson
Charles E. Thompson
By *James E. Thompson*
Attorney

1. *Journal of the American Medical Association*, 1997; 277: 1039-1043.

3 Sheets-Sheet 3

100

RECEIVED

RECEIVED

RECEIVED

100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200

[illegible]

UNITED STATES PATENT OFFICE

2,637,019

WARNING APPARATUS FOR GAS FURNACES

John de Wiccocks, Boston, Mass., and Walter J. Montgomery, Cleveland, Ohio, assignors, by direct and mesne assignments, to Republic Steel Corporation, Cleveland, Ohio, a corporation of New Jersey

Application July 11, 1953, Serial No. 178,190

5 Claims. (Cl. 240-223)

This invention is directed to the provision of apparatus and procedure for providing prompt warning of cut plates or tuyères during blast furnace operations.

As is well known, the tuyère noses and the metal cooling plates within a blast furnace are subject to operating conditions which frequently result in the cutting through of these plates and tuyères so that the cooling water circulating therethrough is released into the furnace. This unbalances more or less the furnace operations, because of the cooling effect due to the water gas reaction ($\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$) which increases the hydrogen content and decreases the carbon monoxide content of the furnace gas; some physical damage to the furnace itself may also result. In particular, a cut plate or tuyère causes an explosion hazard, and hence a potential danger to the personnel working around the blast furnace and around the apparatus which handles the blast furnace exit gases.

The prompt detection of cut plates and tuyères is therefore highly desirable, in order to permit timely warning so that explosion hazards can be removed and repairs can be made in good season, for example, at the time of the next cast following the warning.

The principal purpose of the present invention is to provide apparatus and procedure whereby this warning is given promptly, i. e. within a matter of minutes from the time of actual occurrence of a significant cut in a plate or tuyère. Hitherto, warning of such cuts has generally been indirect, such as by observing the flow of cooling water to and from the plates and tuyères and then deducing from the characteristics of such flow whether or not any of the water was escaping into the furnace. Hence these cuts usually are not detected at all promptly, so that additional damage will be done that could have been avoided had prompt warning been given and remedial steps taken then.

The present invention takes advantage of the fact that, due to the water gas reaction already mentioned, appreciable amounts of hydrogen are evolved whenever significant cuts appear in plates or tuyères in a furnace. This hydrogen appears in the top gases of the furnace, and analyses of that top gas show that the hydrogen content is indicative of water being introduced into the furnace hearth from cut plates or tuyères, after due allowance is made for the effect of moisture introduced in the blast. For example, the hydrogen content of the top gas may run around 2.5 to 3.0% under normal conditions. Immediately

upon cutting a plate or tuyère, water is introduced into the furnace where it dissociates, according to the water gas reaction, raising the hydrogen content of the top gas to, say, around 4 to 5%. In accordance with the present invention, a continuous gas analyzer is provided to analyze the top gases continuously, and a suitable alarm system is associated with the analyzer and operated thereby, so as to give a perceptible signal (visible, audible, or both) serving as a warning to the furnace operators.

The details of operation of a preferred form of the invention will now be described in connection with the accompanying drawings, which are to be construed as illustrative or, rather than as limiting, the present invention. In the drawings:

Fig. 1 shows an elevational view, more or less schematic, of the arrangement as a whole and its place in a blast furnace operation;

Fig. 2 shows in detail the arrangement of the alarm system of this invention; and

Fig. 3 shows the hydrogen graph line of a typical form of chart made in connection with the gas analysis procedure described herein.

In Fig. 1 are shown a blast furnace 11, dust catcher 12, gas washer 13, and dust precipitator 14, all as in conventional blast furnace practice. Above-normal top pressure operation may be provided, as shown in Avery U. S. Patent 2,181,031; this pressure may be imposed by a suitable throttling valve such as 15, and a bleeder line 16 may then be provided, leading from the top of the gas washer 13, as shown in the copending application of LeViseur and Larson, Serial No. 771,870, filed September 3, 1947, now Patent No. 2,585,820. The cleaned gases from precipitator 14 discharge through conduit 17.

In accordance with the present invention, a gas sampling line 18 leads from conduit 17 to the gas analysis system, which is shown on a much larger scale than the apparatus in Fig. 1 heretofore described (the point of change in scale is indicated by the incomplete circle 19). Line 18 passes first into a conventional pressure regulating device 20 whereby the pressure of the gas to be analyzed is made substantially constant regardless of any fluctuations in conduit 17. Thereafter, line 18 passes to gas cleaner or filter unit 21 and auxiliary pressure regulator 22 for the purpose of removing any residual dust from the gas and eliminating any pressure fluctuations which may not have been taken care of by regulator 22. It is also generally desirable to provide a flow meter in the line, as represented sche-

matically by box 34. The gas, thus prepared, passes to the gas analyzer assembly 35, comprising an analyzer chamber 37 and a recorder 39. Electric power to operate assembly 35 is supplied by leads 41, leading from a suitable power source (not shown). Analyzer chamber 37 and recorder 39 are operably connected by suitable leads passing through conduit 43. Recorder 39 has a window or opening 45, through which is visible a moving chart upon which stylus 47 marks the results of analyses continuously made by the analyzer in chamber 37. The record on such a chart may appear like that shown in Fig. 3, for example, as regards hydrogen analyses. As a rule, the gas is also analyzed for CO₂ and CO, and these are also recorded in different paths upon the moving chart. Any suitable gas analyzer assembly (35), capable of analyzing gases for hydrogen, may be used; these are available on the market and are not herein claimed per se. Gas analyzers suitable for the present purposes are described in the book "Industrial Instrumentation" by Donald P. Eckman (John Wiley & Sons, Inc.), 1950 edition, chapter 6, at pages 168-170, under the sub-head "Gas analysis by thermal conductivity." A typical and suitable recorder 39 is described in the same book under the sub-head "Industrial Potentiometers," pages 25 ff. especially the paragraph beginning at the middle of page 97. A commercial instrument suitable for these purposes is manufactured by Leeds & Northrup Company, Philadelphia, and is known as the "Model S (40,000 series) Micromax Recorder."

In accordance with the present invention, the recorder 39 is provided with special attachments and circuits, as shown within the broken-line box 48 in Fig. 2. These are operably connected through leads 51, 53 with perceptible signal means such as lights 55 and horns 57, as shown in Figs. 1 and 2. The connection through leads 51, 53 may be controlled by switch 59, as referred to in more detail hereinafter.

The special attachments and circuits shown within the broken-line box 48 will now be described.

A conventional recorder 39 suitable for recording the analysis of a gas for H₂, CO₂, and CO has a switch advance shaft, 61, and a slide wire shaft 63. The switch advance shaft acts to move the stylus 47 (Fig. 1) into its proper positions to record the content in the gas of H₂, CO₂, and CO, each of which is recorded in a different path on the chart. In effect, then, the stylus plots three separate paths, one for each of the three substances analyzed for. The slide wire shaft 63 turns about its axis in accordance with the quantity of the particular substance (H₂, CO₂, or CO) which is at the moment being analyzed for.

In operation, shaft 61 will turn about its axis to move the stylus to a position adjacent the path on the chart which is to be plotted for (say) hydrogen; analyzer 37 performs the analysis of the gas for hydrogen, and the result, communicated through the leads in conduit 43 (Fig. 1) actuates shaft 63 thereby to locate the stylus 47 to record at just the proper point on the chart. Shaft 61 then turns sufficiently to move the stylus to a position adjacent the next path (say CO₂); analysis proceeds and shaft 63 causes the stylus to record the analysis of that gas. Similarly, recording of CO takes place. The cycle is then repeated. About 3 or 4 minutes is required per cycle. All this is conventional in a gas recorder of the type referred to above.

In accordance with the present invention, the switch advance shaft 61 is provided with a non-conducting cam 65 the surface of which is concentric with shaft 61 except at the hydrogen points, where ears 67 are provided. A micro-switch assembly 68 is provided, having an arm 69 pivoted at 71 by means including a spring to urge it against the circumference of cam 65, and a contact point 73 which arm 69 is caused to touch when cam 65 turns to a position whereby either ear 67 depresses the arm 69. Contact is thus made each time the gas analyzer is analyzing and recording for hydrogen, and contact is broken at all other times.

Slide wire shaft 63 is provided with a non-conducting eccentric disc 75, which rotates as the shaft rotates. Adjacent this disc is a switch arm 77 pivoted at 79 and provided with a roller 81 which is urged into contact with the periphery of disc 75 by tension spring 83. Arm 77 is also provided with a contact point 85, which is moved into contact with another contact point 87 when disc 75 moves so that its shorter radius extends between shaft 63 and roller 81. Disc 75 is so positioned on shaft 63 that its shorter radius will be moved adjacent roller 81 when the hydrogen analysis reading is high, and its longer radius will be moved adjacent roller 81 when the hydrogen analysis is normal. (The notch 89 is for calibration purposes, to assist in setting the disc in the proper relation to the analysis results.) It follows, therefore, that contact will be established between points 85 and 87 whenever the hydrogen analysis is high. This switch which comprises points 85 and 87 will be referred to hereinafter as switch 96.

Hence, when hydrogen is being analyzed for, switch 96 will be closed, thereby closing the circuit between electrical lead 91 (which is connected with contact 85) and electrical lead 93 (which is connected with arm 69 through pivot means 71). If the hydrogen analysis is normal, switch 96 will not close, but if the reading is high, switch 96 will close, and a circuit will be established through leads 91, 93 and 95. (Note that if readings for any of the other gases analyzed for are high, switch 96 will close, but there will be no circuit established through leads 91, 93 and 95 because switch 98 will be open).

Since a few or several seconds are generally required for the recorder to become balanced on the hydrogen point (or the CO₂ point or the CO point, for that matter), a timer unit should accordingly be employed to introduce a delay into the circuit after the above-mentioned two contacts, by switches 96 and 98, are made. Such a timer unit is represented by numeral 99, and comprises a motor (not shown) having a field coil 97, the shaft of which motor, through any suitable gearing, moves a contact point 99 through a suitable short distance, as the shaft rotates, until said point 99 touches another contact point 99.

Leads 41 (Figs. 1 and 2) from a source of electric power are connected by suitable other leads (not shown) with various parts of the gas analyzer assembly 35, in known manner, for the purpose of operating the assembly and recording the results. They are also connected, by leads 42 and 44, with the equipment and circuits shown within broken-line box 48, and thence to the visual and audible signal means 55, 57 through leads 51, 53. Lead 42 is connected to field coil 97, with a branch lead 101 leading to contact point 99, while contact point 99 is connected to

lead 41. Field coil 41, in turn, is connected to lead 42, and thence through leads 43 and 44 (when switches 45 and 46 are closed) with lead 47, with which lead 48 is also connected, both at point 49.

The operation of timer unit 33 is as follows: when switches 45 and 46 are closed, a circuit is established across lines 47 and 48 through field coil 41, and leads 42, 43 and 44. Accordingly, the motor of timer unit 33 is actuated, moving the contact point 51 toward contact point 50. Meanwhile, the recorder becomes balanced on the hydrogen point. In this point remains high (i. e. recording an abnormally high percentage of hydrogen in the gases being analyzed), switch 52 will remain closed and point 51 will be moved into contact with point 50. Circuit will thereupon be completed from lead 48 to lead 49, whereby the visual signal means 49, such as lights, and the audible signal means 50, such as horns, will be actuated, switch 52 being closed and kept closed ordinarily. However, if it is desired to shut off the signal means from continuous operation once the alarm has been given, switch 53 may be opened until the desired repairs have been made.

On the other hand, if the recorder, when balanced on the hydrogen point, is finally at or about a normal reading, switch 52 opens, the motor in timer unit 33 stops, and point 51 is moved back by any appropriate retracting mechanism to its starting point before it has an opportunity to touch contact point 50.

As already indicated, it will ordinarily always be necessary to provide the timer unit 33, as otherwise the signal means may be actuated by the closing of switch 45 before shaft 38 becomes stabilized for its reading, as already indicated. However, if for any reason a timer unit such as 33 should not be required, it may be omitted and the rest of the system (Fig. 2) modified as follows: Provide lead 101, controlled by switch 102, extending between lead 41 and a point 103 on the power side of connection 104, insert a switch 105 in lead 41 between connection 103 and connection 104; remove timer unit 33, except that lead 41 is retained and points 50 and 51 are kept permanently in contact. Then, with switch 102 closed and switch 105 open, the system operates as described above with respect to actuating switches 45 and 46. When both of these are in closed position, the warning signals 49, 50 are actuated. However, in the usual operation of the device herein described, using timer unit 33, switch 102 will always be closed, and switch 105 will always be open, or lead 101 and switches 102 and 105 will be omitted entirely.

Visual signal means 49 and audible signal means 50 may be placed at any suitable location or locations around the plant and convenient to the personnel operating the blast furnace. As soon as they are actuated, by the procedure indicated above, steps can be taken promptly to shut down the furnace and repair or replace the hot plate or tuyère. Usually this can be postponed for a short while until the next cast, as was done in the actual operations plotted in Fig. 3.

Fig. 3 shows that portion of the moving chart appearing in opening 35 upon which hydrogen analyses are marked by stylus 41. These analyses may appear as a substantially continuous line, as shown at 106, or as a series of slightly spaced dots, depending upon the speed of the chart and the frequency of the recordings. The chart moves downwardly, as viewed by the reader of

Fig. 3, the time being measured along the line of travel, as indicated, and the percentage of hydrogen as abscissae. Normally, line 106 runs along between the lines indicating respectively 2% and 3% of hydrogen. On the occurrence of any significant tuyère or plate leak, however, the line 106 swings sharply to the right, as indicated at about the 10 p. m. line in Fig. 3, to provide an immediate recording of the increase in hydrogen in the blast furnace exit gases, due to water release into and dissociation in the furnace. The mechanism hereinabove described, particularly with respect to Fig. 3, then goes into operation, and perceptible signals such as means 49 and 50 are actuated. Thus within a matter of a very few minutes from its actual occurrence, every significant cutting of a plate or tuyère is brought to the attention of the furnace operators for correction.

The warning thus given is far in advance of the warning given by any other commercially used means of which we are aware, and it thus gives the operators ample time to take countermeasures that will not only prevent further cutting of the plates or tuyères or irregular operation of the furnace, but also prevent a possible explosion, due to the presence of excess hydrogen, which might endanger the lives of personnel around either the furnace or the treating apparatus through which the furnace exit gases pass.

While the apparatus of this invention has been described in connection with blast furnace operations and control, for which purpose it is especially useful, it may also be used in other situations when it is desired to ascertain and give warning of an abnormal increase or variation in the content of a gaseous constituent of a mixture of gases, e. g. in the CO or CO₂ content of a body or stream of air.

We claim:

1. Apparatus for indicating a variation in content of a gaseous constituent of a mixture of gases, comprising gas analysis means into which said mixture of gases is led, and which is adapted to analyze said mixture of gases for a plurality of its gaseous constituents in succession, including said gaseous constituent, first switch means normally in open position and adapted to be actuated into closed position by said gas analysis means when the latter is analyzing said mixture of gases for said gaseous constituent, second switch means in series with said first switch means and adapted to be actuated into closed position by said gas analysis means when the latter is recording a content of said gaseous constituent in said mixture of gases which is higher than a predetermined normal level, and warning means adapted to be actuated by an electric current flowing through said first and second switch means when both of them are in closed position.

2. Apparatus for indicating the presence of a leaking plate or tuyère in a blast furnace, comprising conduit means for continuously removing a small quantity of the exit gases produced by said furnace during the operation thereof, gas analysis means into which said conduit means lead, and which is adapted to analyze continuously the said quantity of exit gases for hydrogen, carbon dioxide, and carbon monoxide, first switch means adapted to be actuated into closed position by said gas analysis means when the latter is analyzing said gases for hydrogen, second switch means in series with said first switch means and adapted to be actuated into closed position by said gas analysis means when the lat-

ter is recording a hydrogen content of said gases higher than a predetermined normal level, and warning means adapted to be actuated by an electric current flowing through said first and second switch means when both of them are in closed position.

3. Apparatus for indicating the presence of a leaking plate or tuyere in a blast furnace, comprising conduit means for continuously removing a small quantity of the exit gases produced by said furnace during the operation thereof, gas analysis means adapted to receive and analyze continuously the said quantity of exit gases successively for hydrogen and for other constituent gases, switch means adapted to be closed by said gas analysis means only at times when the latter is analyzing said gases for hydrogen and is also recording a hydrogen content of said gases higher than a predetermined normal level, and warning means adapted to be actuated by an electric current flowing through said switch means when said switch means is in closed position.

4. Apparatus for indicating a variation in content of a gaseous constituent of a mixture of gases, comprising gas analysis means into which said mixture of gases is fed, and which is adapted to analyze said mixture of gases for a plurality of its gaseous constituents in succession, including said gaseous constituent, first switch means normally in open position and adapted to be actuated into closed position by said gas analysis means when the latter is analyzing said mixture of gases for said gaseous constituent, second switch means in series with said first switch means and adapted to be actuated into closed position by said gas analysis means when the latter is recording a content of said gaseous constituent in said mixture of gases which is higher than a predetermined normal level, delayed-action switch means adapted to be actuated toward closed position upon the closing of both said first switch means and said second switch means, said actuation of said delayed-action switch means continuing, while said first and second switch means both continue to remain closed for at least a predetermined minimum period of time, until said delayed-action switch means is in closed position,

and warning means adapted to be actuated by an electric current flowing through said first and second switch means, and through said delayed-action switch means, when all of them are in closed position.

5. Apparatus for indicating the presence of a leaking plate or tuyere in a blast furnace, comprising conduit means for continuously removing a small quantity of the exit gases produced by said furnace during the operation thereof, gas analysis means into which said conduit means lead, and which are adapted to analyze continuously the said quantity of exit gases for hydrogen, carbon dioxide, and carbon monoxide, first switch means adapted to be actuated into closed position by said gas analysis means when the latter is analyzing said gases for hydrogen, second switch means in series with said first switch means and adapted to be actuated into closed position by said gas analysis means when the latter is recording a hydrogen content of said gases higher than a predetermined normal level, delayed-action switch means adapted to be actuated toward closed position upon the closing of both said first switch means and said second switch means, said actuation of said delayed-action switch means continuing, while said first and second switch means both continue to remain closed for at least a predetermined minimum period of time, until said delayed-action switch means is in closed position, and warning means adapted to be actuated by an electric current flowing through said first and second switch means, and through said delayed-action switch means, when all of them are in closed position.

JOHN DE PICCOLELLIS.
WALTER J. MONTGOMERY.

References Cited in the file of this patent
UNITED STATES PATENTS

Number	Name	Date
759,449	Kloman	May 10, 1904
1,487,911	Arendt et al.	Sept. 11, 1923
1,801,791	Brelsky et al.	Apr. 21, 1931
2,422,604	Weber	June 17, 1947
2,535,950	Page	Dec. 26, 1950