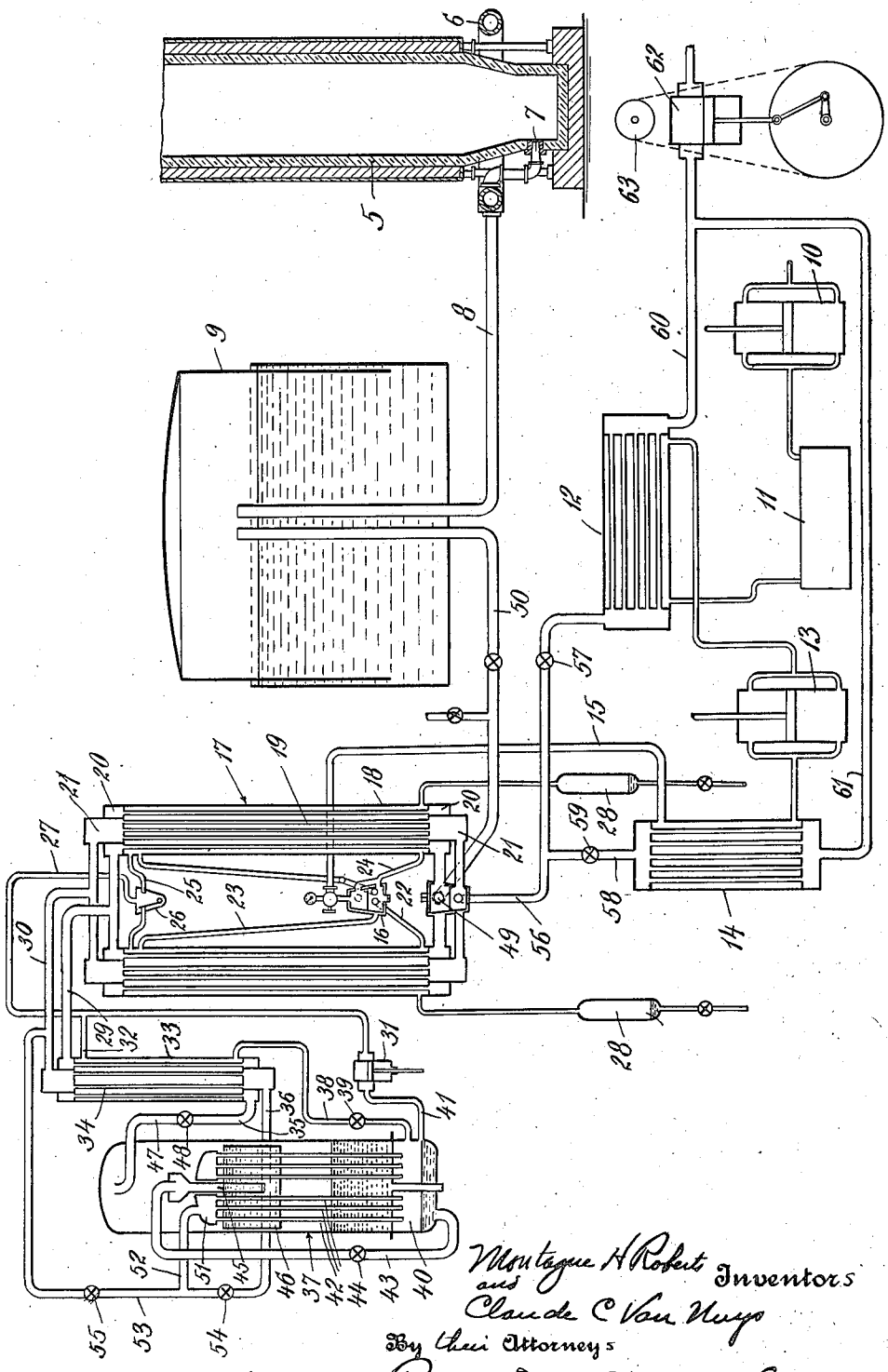
Feb. 20, 1923. 1,445,973.

M. H. ROBERTS ET AL.

OXYGENATED BLAST FOR METALLURGICAL FURNACES.

ORIGINAL FILED FEB. 4, 1919.



Montague H Roberts Inventors
and
Claude C Van Nuys
By their Attorneys
Pennie Davis Marvin & Edmonds

Patented Feb. 20, 1923. 1,445,973

UNITED STATES PATENT OFFICE.

MONTAGUE H. ROBERTS, OF JERSEY CITY, NEW JERSEY, AND CLAUDE C. VAN NUYS, OF NEW YORK, N. Y., ASSIGNORS TO AIR REDUCTION COMPANY, INC., A CORPORATION OF NEW YORK.

OXYGENATED BLAST FOR METALLURGICAL FURNACES.

Application filed February 4, 1919, Serial No. 274,928. Renewed March 17, 1922. Serial No. 544,682.

To all whom it may concern:

Be it known that we, MONTAGUE H. ROBERTS and CLAUDE C. VAN NUYS, residing at Jersey City, county of Hudson, State of New Jersey, and New York city, county of New York, State of New York, respectively, have invented certain new and useful Improvements in Oxygenated Blasts for Metallurgical Furnaces; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

Our invention relates to the operation of blast and other metallurgical furnaces, and more particularly to the oxygenation of the blast and to apparatus capable of economically producing a blast having varying proportions of oxygen above the normal proportion in atmospheric air.

Our invention contemplates, moreover, the elimination of certain elements of a blast furnace plant, the functions of which are either accomplished in or rendered unnecessary by the method and apparatus hereinafter described and claimed.

The purpose and object of our invention will be better understood by reference to the following specification when read in connection with the accompanying drawing which diagrammatically illustrates a form of apparatus best adapted to their accomplishment.

The possible advantages of oxygenating the blast of blast and similar metallurgical furnaces has long been the subject of speculation by metallurgists and others who have agreed that, if attainable, the solution of the problem presented would mark a considerable advance in blast furnace practice comparable with the introduction of the hot and dried blasts. The discouraging nature of the problem arises from the difficulty of conceiving any means for producing the necessary oxygen without increasing the cost of operation beyond a prohibitive point and has led to the general conclusion that while certainly advantageous in theory the suggestion was more or less chimerical so far as its practical application is concerned.

The suggestion has been made to produce oxygen from the air by liquefaction and rectification thereof and to add this oxygen to the blast otherwise produced and delivered to the furnace in the customary manner. This, as will at once be apparent, adds a considerable expense to the already high cost of producing and treating the blast. It cannot be predicted that the advantages, however great, of enriching the blast with oxygen will compensate such an added burden of expense, much less accomplish an actual saving in operation. This is sufficient reason for the failure of such a suggestion to engage the attention of blast furnace operators and to provide a satisfactory solution of the problem as presented.

We have conceived a solution, based on the treatment of all of the air intended for the blast in a liquefying apparatus capable of separating and rejecting a certain proportion of the nitrogen leaving a residual gas having the desired proportion of oxygen which is led directly, under the pressure at which it leaves the liquefying apparatus, to the blast furnace. All of the work of the present blowing engines is accomplished by the compressors of the liquefying apparatus which therefore perform the two functions of compressing the air preliminary to liquefaction and delivering the blast at suitable pressure to the furnace. All moisture, and in addition carbon dioxide, is removed in the liquefying apparatus, thus eliminating the expensive refrigerating plant where a dry blast has been heretofore employed. Furthermore, the blast enters the furnace at an exactly even temperature which is easily maintained regardless of atmospheric conditions. The higher initial temperature produced by the oxygenated blast makes the preheating of the blast superfluous, and the hot blast stoves, heretofore, an expensive and troublesome adjunct to blast furnaces are no longer required. The rejected nitrogen from such a plant escapes at a relatively high pressure, and power may be recovered therefrom by employing suitable engines.

Summarizing the advantages of our invention, we are enabled to eliminate the hot blast stoves and refrigerating plant and to use the power, ordinarily employed in delivering the blast to the furnace, to compress the air preliminary to liquefaction. By separating and rejecting a portion of the nitrogen content of the air we produce a blast of any desired oxygen enrichment, and

this enriched blast increases the combustion temperature in the melting zone of the furnace. It carries, at the same time, a lower proportion of inert nitrogen to absorb heat from the furnace. The enriched blast is thoroughly dried and has therefore all of the advantages of the dried blast and is supplied at an exact predetermined temperature. It may or may not be heated in stoves, as preference may dictate. The higher combustion temperature attained through the enrichment renders such preheating unnecessary.

While in the preferred form of our invention, as hereinafter described in detail, we have illustrated an apparatus in which only the portion of nitrogen to be rejected is separated from the liquefied air, it is to be understood that rectification of the air may proceed to a greater extent if desirable, and that the separated gases may be recombined in any desired proportions as may be found in commercial operations to produce the most satisfactory results. It is to be further understood that our invention is not limited to any specific apparatus or arrangement thereof, it being our intention to claim broadly as our invention the mode of operation as well as the apparatus whereby we are enabled to achieve markedly advantageous results in the operation of metallurgical furnaces.

Referring to the drawings, 5 indicates a blast furnace having a bustle-pipe 6 and tuyères 7. The bustle-pipe 6 is fed through a pipe 8 from a gasometer 9 in which a supply of oxygenated air is maintained under a suitable pressure adapted to the size and character of the furnace. The gasometer is preferably sealed with oil or other suitable anhydrous liquid so that the gas therein may not absorb moisture.

The oxygenated air is produced in a liquefying apparatus which differs quite materially from apparatus commonly used for separating the components of air, it being unnecessary to rectify any considerable proportion of the liquefied air.

The amospheric air after compression in the compressor 10 preferably passes through a water intercooler 11, thence through an intercooler 12, where it is subjected to heat interchange with the rejected nitrogen as hereinafter described. The compressed air cooled in the intercoolers 11 and 12 passes to a secondary compressor 13, where the air is further compressed. Thence the air passes through an aftercooler 14, where it is cooled by a portion of the rejected nitrogen, and through a pipe 15 to the valve casing 16 of an exchanger 17.

The exchanger 17 may be constructed in varying forms, but preferably comprises two or more cylinders 18, each having a plurality of tubes 19 terminating in chambers 20 and 21. The air passes through the valve chamber 16 through a pipe 22 to one of the cylinders 18 in which it circulates about the pipes 19. Thence it passes through a pipe 23 to the valve chamber 16, and through a pipe 24 to the other cylinder 18, where it again circulates about the pipes 19 and escapes through a pipe 25 to a valve chamber 26 to which the outlet pipe 27 is connected. The cylinders 18 are each connected to purging bottles 28, through which liquids condensed in the cylinder may be withdrawn. The exchanger is cooled by cold rejected nitrogen and enriched air delivered to the chambers 20 and 21 through pipes 29 and 30. The valve chambers 16 and 26 are provided with valves to permit the reversal of the direction of flow of air through the cylinders 18, so that moisture and carbon dioxide condensed and separated from the air by the cold in the exchanger and tending to congeal in the cylinders 18 may be melted and withdrawn.

The cooled compressed air is delivered through the pipes 27 to an engine 31, a portion of the air passing through a branch pipe 32 to a liquefier 33, where it is subjected at its original pressure to indirect contact with cold enriched air and rejected nitrogen passing through the tubes and delivered thereto through pipes 35 and 36 from the column 37. The liquid air from the liquefier 33 is delivered through a pipe 38 and valve 39 to the bottom compartment 40 of the column, where it is met by the cold expanded air delivered through a pipe 41 from the engine 31.

The expanded air passes upwardly through tubes within the column and surrounded with evaporating liquefied air and is thus partially liquefied, the liquefied portion dropping back into the chamber 40. From this chamber the liquid air is conveyed through a pipe 43 and valve 44 to the upper portion of the column and is delivered through a pipe 45 to a pot 46, which is thus maintained full of liquid air which overflows into the lower section of the column. As previously stated, the liquid air within pot 46 and the lower section of the column supplies by evaporation the necessary cold to liquefy the air in the pipes 42.

The evaporation product from the column escapes through a pipe 47 and valve 48 to the liquefier 33, passing through the pipes 34 when it gives up a portion of its cold to incoming air. Thence the enriched gas passes through the pipe 29 to the exchanger 17, as hereinbefore described, and issues through an outlet 49 to a pipe 50, which conveys it to the gasometer 9.

During the passage through the pipes 42 in the column, only a portion of the air is liquefied, and this portion, through the principle of backward return in the pipes 42, is rectified and enriched in oxygen. The air

treated is only partially liquefied in the pipes 42, the action being selective so that the liquid produced contains a higher proportion of oxygen than the air treated. Inasmuch as this liquid returns into the chamber 40 where it remains in contact with the incoming air, the proportion of oxygen in the liquid can never exceed the proportion which in a liquid is in phase equilibrium with a gaseous mixture of air composition. The limiting proportion of oxygen in the liquid under this condition is approximately 47%, and consequently the liquid cannot be further enriched by the operation as described. In practice, the proportion of oxygen will be somewhat less than 47% owing to the addition of liquid air from the liquefier 33 and because of other conditions which tend to prevent the attainment of the limit of enrichment. The unliquefied portion is principally nitrogen, which is to be rejected. The evaporation product from the column is therefore enriched air suitable for use in the blast furnace, and escapes at a pressure sufficiently high to permit delivery directly to the blast furnace, or preferably to the gasometer, which maintains the desired pressure.

The nitrogen is delivered from the head 51, in which the pipes 42 terminate, to a pipe 52 provided with two branches 36 and 53, having suitable valves 54 and 55. The pipe 36 delivers the nitrogen to the liquefier 33, where it gives up a portion of its cold to the incoming air. The pipe 53 is a bypass which conveys a portion of the nitrogen around the liquefier if desired. From the liquefier the pipe 30, which is joined by the pipe 53, carries the nitrogen to the chamber 21 when the gas passes through the tubes 19 of the exchanger 17, and escapes through an outlet pipe 56 controlled by a valve 57 to the intercooler 12, where it gives up a portion of the cold to the incoming air as previously described. A portion of the nitrogen may be withdrawn through a pipe 58 controlled by a valve 59 to the aftercooler 14, where it serves to reduce the temperature of the incoming air after final compression. Pipes 60 and 61 deliver the gas from the intercooler 12 and the aftercooler 14, respectively.

The nitrogen issuing from the apparatus is at a relatively elevated pressure and work may be recovered therefrom by conveying the gas to a suitable engine 62 connected, for example, to a generator 63. The nitrogen may then be exhausted to the air or preserved in a suitable gasometer (not shown) for any available purpose.

From the foregoing it will be apparent that we have devised and perfected a method of and apparatus whereby we are enabled to successfully accomplish our purpose of economically oxygenating the blast of metallurgical furnaces. The improved results due to higher internal combustion temperatures of fuels consumed in a highly oxygenated atmosphere, which have long been anticipated, may now be realized.

Various changes may be made in the details of our method, and other apparatus may be adapted for operation in accordance therewith without departing from the spirit and scope of the invention or sacrificing any of its material advantages.

We claim:

1. A method of providing an oxygenated blast for metallurgical furnaces and the like, which comprises subjecting air sufficient in quantity to provide the desired blast to a liquefying operation with enrichment in oxygen, rejecting the unliquefied constituent consisting principally of nitrogen and recovering the vaporized product thus enriched in oxygen.

2. A method of providing an oxygenated blast for metallurgical furnaces and the like, which comprises subjecting air sufficient in quantity to provide the desired blast to a liquefying operation with enrichment in oxygen, evaporating the liquefied constituent to reduce the temperature of further quantities of air, rejecting the unliquefied constituent and recovering the vaporized product of the liquefied constituent thus enriched in oxygen.

3. A method of providing an oxygenated blast for metallurgical furnaces and the like, which comprises, subjecting air sufficient in quantity to provide the desired blast to a liquefying operation by indirect contact with a liquefied constituent thereof, said constituent being enriched in oxygen by backward return in contact with the unliquefied air, rejecting the unliquefied constituent and recovering the vaporized product.

4. A method of operating a blast or similar metallurgical furnace, which comprises, subjecting a volume of air sufficient to maintain the blast at a pressure exceeding the desired pressure of the blast to a liquefying operation whereby a portion of the nitrogen in the air is rejected and discharging the air enriched in oxygen at the conclusion of the liquefying operation at the desired blast pressure.

5. A method of operating a blast or similar metallurgical furnace, which comprises, subjecting a volume of air sufficient to maintain the blast at a pressure exceeding the desired pressure of the blast to a liquefying operation by indirect contact with a liquefied constituent of the air, rejecting the unliquefied constituent consisting principally of nitrogen, evaporating the liquefied constituent at substantially the desired blast pressure and maintaining said pressure until the vaporized product is delivered to the furnace.

6. A method of operating a blast or similar metallurgical furnace, which comprises, subjecting a volume of air sufficient to maintain the blast at a pressure exceeding the desired pressure of the blast to a liquefying operation whereby a portion of the nitrogen in the air is rejected, vaporizing the liquefied constituent of the air, conveying the vaporized product enriched in oxygen to the furnace and maintaining said vaporized product at substantially the desired pressure of the blast until it is delivered to said furnace.

7. A method of operating blast or similar metallurgical furnaces, which comprises, subjecting a volume of air sufficient to maintain the blast at a pressure exceeding the desired pressure of the blast to a liquefying operation whereby a portion of the nitrogen of the air is rejected, conveying the air thus enriched to the furnace, at substantially the blast pressure, and utilizing the cold of the rejected nitrogen to cool the incoming air after compression.

8. A method of operating blast or similar metallurgical furnaces, which comprises, subjecting a volume of air sufficient to maintain the blast at a pressure exceeding the desired pressure of the blast to a liquefying operation whereby a portion of the nitrogen of the air is rejected, conveying the air thus enriched to the furnace, at substantially the blast pressure, utilizing the cold of the rejected nitrogen to cool the incoming air after compression, and subsequently expanding said nitrogen with external work to recover energy therefrom.

9. A method of operating blast and similar metallurgical furnaces, which comprises, subjecting a volume of air sufficient to maintain the blast to a liquefying operation, whereby a portion of the nitrogen is rejected, liquefying and separating moisture and carbon dioxide from the air by cooling prior to liquefaction of the air, vaporizing the liquefied constituent of the air, and conveying the vaporized product at substantially the pressure of the blast to said furnace.

10. In an apparatus of the character described, the combination with a blast or similar metallurgical furnace of means for separating by a liquefaction operation and rejecting a portion of the nitrogen of the blast, said means being adopted to maintain the thus enriched air at substantially the pressure of the blast until it is delivered to the furnace.

11. In an apparatus of the character described, the combination of a blast or similar metallurgical furnace, of a gasometer adapted to contain a quantity of gas enriched in oxygen at the desired pressure of the blast, and liquefying means capable of separating and rejecting a portion of the nitrogen of the blast, and means permitting said liquefying means to discharge directly to said gasometer.

12. In an apparatus of the character described, the combination of a blast or similar metallurgical furnace, means for compressing air for the blast delivered thereto, and means interposed between said compressing means and furnace and adapted to separate and reject a portion of the nitrogen of the air.

13. In an apparatus of the character described, the combination of a blast or similar metallurgical furnace, means for compressing air for the blast delivered thereto, and liquefying means interposed between said compressing means and furnace and adapted to separate and reject a portion of the nitrogen of the air.

14. In an apparatus of the character described, the combination of a blast or similar metallurgical furnace, means for compressing air for the blast delivered thereto, and means interposed between said compressing means and furnace and comprising a column wherein a portion of the nitrogen of the air is separated and rejected, and means whereby the cold of the rejected nitrogen is utilized in cooling the compressed air.

15. In an apparatus of the character described, the combination of a blast or similar metallurgical furnace, means for compressing air for the blast delivered thereto, means interposed between said compressing means and furnace, and comprising means for cooling and liquefying a portion of the air and rejecting another portion consisting principally of nitrogen, and means for recovering work from the rejected nitrogen.

16. A method of providing an oxygenated blast for metallurgical furnaces and the like, which comprises separating a portion of the nitrogen of air by a liquefaction operation, rejecting the nitrogen and recovering the remaining constituents in the form of a mixture of oxygen and nitrogen containing oxygen in a greater proportion than the normal composition of air.

17. A method of providing an oxygenated blast for metallurgical furnaces and the like, which comprises separating a portion of the nitrogen of air by partial liquefaction, rejecting the unliquefied nitrogen and evaporating the liquid to provide a mixture of oxygen and nitrogen, the proportion of oxygen in the mixture being that obtainable by the partial liquefaction.

In testimony whereof we affix our signatures.

MONTAGUE H. ROBERTS.
CLAUDE C. VAN NUYS.