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PATENT SPECIFICATION

Application Date: June 28, 1938. No 19167/38.

516,546

Complete Specification Left: April 11, 1939.

Complete Specification Accepted: Jan. 4, 1940.

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PROVISIONAL SPECIFICATION

Improvements in or relating to the Production of Gas suitable for the Manufacture of Methyl Alcohol

I, FREDERICK LINDLEY DUFFIELD, of Imperial House, Kingsway, London, W.C.2, a British Subject, do hereby declare the nature of this invention to be as follows:—

This invention relates to the production of gas suitable for the manufacture of methyl alcohol.

A gas suitable for the manufacture of methyl alcohol is one comprising a mixture of hydrogen and carbon monoxide substantially in the proportion of 2 (hydrogen) to 1 (carbon monoxide). For this reason water gas, in which these two gases are present substantially in equal volumes, is not suitable.

The present invention is based on the principle underlying the production of water gas, namely passing steam over a column of incandescent carbon, but is differentiated therefrom by introducing a further supply of steam to react with the carbon monoxide of the water gas, already formed by reaction between steam and incandescent coke, to form carbon dioxide and hydrogen, this additional steam being regulated according to the prevailing temperature to ensure a substantially constant composition of carbon monoxide, hydrogen and carbon dioxide in the gas output, in which carbon monoxide and hydrogen are present substantially in the proportion 2 (hydrogen) to 1 (carbon monoxide).

A further feature of the invention consists in providing a lengthy period of gas production by using a long column of coke and heating this column to incandescence by admitting combustion air at different points or levels along the column.

The coke at the bottom of the column may be burnt to form carbon monoxide which in rising through the column burns with additional air supplied at different levels of the column, whereby the relatively long column of coke is brought to a substantially uniform temperature.

Apparatus made according to the present invention may comprise a relatively long shaft suitable for receiving a column of coke to be raised to incandescence, a grate disposed at the bottom of the furnace, means for admitting combustion air to the shaft at a number of different levels, means for supplying steam at two or more different levels, one or more outlet ports for the combustion gases, and means for collecting the reaction gases.

In one way of carrying out the present invention the apparatus comprises a vertical shaft-like structure about 52 feet long consisting of a cylindrical metal casing having a brick or other refractory lining. The interior diameter of the shaft is in general 6 feet 6 inches, but at top it tapers firstly outwardly to form a flat cylindrical chamber of about 10 feet in diameter (in communication with an upper gas manifold referred to hereafter) and then inwardly to the top of the shaft to an aperture having a diameter of 2 feet 10½ inches. This aperture at the top of the shaft serves for introducing the coke charge and is surmounted by a coke hopper from which the coke is supplied to the shaft, through a rotary valve. Coke is supplied to the coke hopper by an overhead bucket conveyor conveying the coke from a coking furnace (for example the furnace described in my co-pending patent application No. 19166/38, Serial No. 516,545).

The bottom of the shaft is provided with a revolving grate driven from a bevel wheel mounted on a shaft carried in bearings in the wall of the shaft. The shaft widens out somewhat above this revolving grate (similarly to the widening out at the top of the furnace above described) again forming a flat cylindrical chamber 10 feet in diameter between two oppositely tapering parts. That part of the shaft having a uniform diameter of 6 feet 6 inches between the top and bottom parts of varying diameter has a length of 30 feet. An air main extends along one side of the shaft and a steam main along the other side. Air is introduced below the revolving grate from the lower end of the air main through an air inlet disposed below the grate. Additional air is introduced at

[*Price* 1/-]

five different levels spaced equidistantly apart along the intermediate part of uniform diameter of the shaft. An annular pipe supplied from the air main is mounted around the shaft at each of these levels, and each annular pipe supplies six tuyeres spaced equidistantly around the shaft through which the additional air is supplied. Steam from the steam main can be introduced at three levels in the shaft, namely at a high level, through the top series of air tuyeres, at an intermediate level, through the bottom series of tuyeres, and at a low level, through a pipe projecting through the wall of the shaft immediately below the revolving grate. At the top and intermediate levels the steam main supplies annular conduits, disposed immediately above the annular air pipes, each of which has six tuyeres passing through the wall of the shaft intermediately of the air tuyeres. The air and steam tuyeres are arranged at an angle of 60° to the shaft. The air and steam mains and each of the air and steam tuyeres are separately valve-controlled.

The outlet gas manifold referred to above is disposed around the upper widening of the shaft and has four gas ports through which the heating gases are taken off (as hereafter described). Another gas manifold (hereinafter referred to as the "lower gas manifold") surrounds the lower widening in the shaft and has also four gas ports all communicating with a common gas main for collecting and forwarding the gas produced according to the invention.

The shaft is supported above ground level on pillars or piers approximately 9 feet 8 inches in height. An ash hopper is carried immediately below the revolving grate and a bucket conveyor for removing ash is provided below the ash hopper. This bucket conveyor may comprise the return run of the conveyor supplying the coke to the coke hopper.

In operation the shaft is filled with a column of coke from the overhead coke hopper. Approximately half the total air required in the process is admitted through the lower air inlet below the revolving grate in order to burn the coke at the lower end of the column to form carbon monoxide gas. The balance of the total quantity of air required in the process is admitted proportionately through the tuyeres at the various levels of the column to burn with the carbon monoxide gas evolved at the bottom of the column and ascending through the column, in order to raise the column of coke to incandescence. A substantially uniform temperature is thus provided throughout the column, although there will be a tendency for higher temperatures to prevail at the higher levels by reason of the ascensional force of the heat. The enlarged diameter towards the top of the shaft producing a sudden drop in the velocity of the rising gases allows the dust to settle and prevents any lifting of the top layer of coke.

At the top of the coke column the freshly charged coke, at a temperature of approximately 300° C. provides a means of partially utilising the outgoing products of combustion preliminarily to heat such fresh charge which has accumulated from the continuous feed, which proceeds continuously during the air and steam blowing operations.

The ignition and combustion of the producer gas by the supplementary air injected has preference to the burning of the coke, and the heat generated therefrom is more dispersed than the more concentrated heat derived from direct coke burning.

According to practical trials conducted, this method of heating does not involve any local overheating which may cause ash slagging and sticking of the charge, of which there has been no single instance.

The combustion gases are collected and led away through the upper gas manifold. By making the necessary adjustments the air blow period could be made in a period of 60—90 seconds, as is usual in the manufacture of water gas. It has, however, been found more economical to extend this period to 10 minutes, which permits the air blower to be of relatively less capacity, and provides for its continuous operation over a battery consisting, for example, of six water gas producers, in the case, as at present, where the period of gas making is to extend over 50 minutes. It further ensures a non-interrupted flow of combustion products into a common main which serves as a source for preheating the air for combustion.

On completion of the air blow the air supply is closed and purging steam is admitted through the lower steam inlet to purge the shaft of gases. This purging steam blast incurs only one tenth the loss of gas which normally occurs in the manufacture of water gas, by reason of the length of the column of coke.

The purging steam is now shut off and reaction steam is admitted through the upper and intermediate steam inlets disposed respectively towards the top and bottom of the incandescent column of coke.

By admitting steam at the top of the

hot charge immediately below the zone of freshly charged coke, and its descension through the column of coke to the extent of 27 feet below its entry a stratification of the steam over the whole cross-sectional area of the column is provided, ensuring a maximum opportunity for complete reaction. Down to this particular level, where it meets with additional steam injected at the intermediate level above referred to, the composition of the gas at the commencement of the steam blast is wholly carbon monoxide and hydrogen. The additional steam at the intermediate level enters a zone which has been heated only by the sensible heat of the ascending gas from the gas producer below, and has a temperature approximating 800° C.

The superheated steam at 800° C. reacts with the carbon monoxide and hydrogen gas to oxidise a portion of the carbon monoxide to carbon dioxide, and to create more hydrogen. As the temperature of the column above gives up its heat in the endothermic reaction of water gas production, the proportion of carbon dioxide increases. In order now to ensure that a reaction gas having a substantially constant composition of carbon monoxide, carbon dioxide and hydrogen is obtained, it is only necessary to adjust the quantity of surplus steam so that the quantity admitted decreases gradually throughout the gas making period. This gradual adjustment of the quantity of additional steam admitted, taken in conjunction with the cooling temperature of the main gas and the increasing temperature of the oxidising zone arising from the exothermic reaction of oxidising the gas by steam, provides a substantially constant composition of the gas comprising for example 28.6 per cent. of carbon monoxide, 14.2 per cent. carbon dioxide and 57.2 per cent. hydrogen.

Such a gas composition in which hydrogen and carbon monoxide are present in approximately the ratio 2 hydrogen : 1 carbon monoxide is particularly suitable for the manufacture of methyl alcohol or the higher alcohols for use as a motor spirit, more particularly for admixture with spirit obtained from mineral oils.

The lower gas manifold conveys the reaction gas through an air heater and then to a centrifugal cleaner which collects all the dust carried over with the gas. The gas is then cooled and the surplus steam condensed out in an atmospheric air-cooled condenser.

In order to make the gas suitable for use in the manufacture of methyl alcohol, when it leaves the condenser the gas enters a governor controlled exhauster and is delivered to the carbon dioxide removal plant. The gas is now compressed to 30 atmospheres and enters a scrubbing tower where the carbon dioxide is washed out. The internal energy of the carbon dioxide in solution in the water leaving the tower may be used to provide about 60 per cent. of the power required to inject the water into the tower.

The gas which now consists of hydrogen and carbon monoxide only, in the proportions of 2 volumes hydrogen to one carbon monoxide, is compressed to 200 atmospheres and after passing through a lead bath heater where the temperature is raised to 400° C., the gas is circulated through reaction vessels containing suitable catalysts. The methyl alcohol formed is then condensed and flows into high pressure and low pressure separators where the pressure is broken down to atmospheric, and the final product then flows or is pumped to storage tanks.

The method of gas manufacture described is particularly applicable for use in the manufacture of methyl alcohol since it provides a long period of gas formation. If a battery of six of the apparatus described is used, a single air blower may be used for all six apparatus, and an uninterrupted flow of combustion products into a common main, serving for preheating combustion air, is obtained, as above described.

Dated this 28th day of June, 1938.

MEWBURN, ELLIS & CO.,
70—72, Chancery Lane, London, W.C.2,
Chartered Patent Agents.

COMPLETE SPECIFICATION

Improvements in or relating to the Production of Gas suitable for the Manufacture of Alcohols

I, FREDERICK LINDLEY DUFFIELD, of Imperial House, Kingsway, London, W.2, a British Subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the production of gaseous mixtures more particularly suitable for the manufacture of methyl alcohol.

A gas suitable for the manufacture of methyl alcohol is one comprising a mixture of hydrogen and carbon monoxide substantially in the proportion of 2 (hydrogen) to 1 (carbon monoxide). For this reason water gas, in which these two gases are present substantially in equal volumes, is not suitable.

The present invention is based on the principle underlying the production of water gas, namely passing steam over a column of incandescent carbon, but is differentiated therefrom by introducing a further supply of steam to react with the carbon monoxide of the water gas, already formed by reaction between steam and incandescent carbon, to form carbon dioxide and hydrogen, this additional steam being regulated according to the prevailing temperature to ensure a substantially constant composition of carbon monoxide, hydrogen and carbon dioxide in the gas output, in which carbon monoxide and hydrogen are present substantially in the proportion 2 (hydrogen) to 1 (carbon monoxide).

A further feature of the invention consists in providing a lengthy period of gas production by using a long column of coke and heating this column to incandescence by admitting combustion air at different points of levels along the column.

The coke at the bottom of the column may be burnt to form carbon monoxide which in rising through the column burns with additional air supplied at different levels of the column, whereby the relatively long column of coke is brought to a substantially uniform temperature.

Apparatus made according to the present invention may comprise a relatively long shaft suitable for receiving a column of coke to be raised to incandescence, a grate disposed at the bottom of the generator, means for admitting combustion air to the shaft at a number of different levels, means for supplying steam at two or more different levels, one or more outlet ports for the combustion gases, and means for collecting the reaction gases.

The invention is illustrated in the accompanying drawings in which Figs. 1*a* and 1*b* show a sectional elevation of one form of apparatus for carrying out the present invention.

The apparatus comprises a vertical shaft-like structure about 52 feet long consisting of a cylindrical metal casing 1 having a brick or other refractory lining 2. The interior diameter of the shaft is in general 6 feet 6 inches, but at top it tapers firstly outwardly to form a flat cylindrical chamber 3 of about 10 feet in diameter (in communication with an upper gas manifold referred to hereafter) and then inwardly to the top of the shaft to an aperture 4 having a diameter of 2 feet 10½ inches. This aperture 4 at the top of the shaft serves for introducing the coke charge and is surmounted by a coke hopper 5 from which the coke is supplied to the shaft, through a rotary valve 6. Coke is supplied to the coke hopper by an overhead bucket conveyor conveying the coke from a coking furnace (for example the furnace described in my co-pending Patent Application No. 19166/38) (Serial No. 516,545).

The bottom of the shaft is provided with a revolving grate 8 driven from a bevel wheel 9 mounted on a shaft 10 carried in bearings 11 in the wall of the shaft. The shaft widens out somewhat above this revolving grate (similarly to the widening out at the top of the furnace above described) again forming a flat cylindrical chamber 12 about 10 feet in diameter between two oppositely tapering parts. That part of the shaft having a uniform diameter of 6 feet 6 inches between the top and bottom parts of varying diameter has a length of 30 feet. An air main 14 extends along one side of the shaft and a steam main 15 along the other side. Air is introduced below the revolving grate from the lower end of the air main through an air inlet 16 disposed below the grate 8. Additional air is introduced at five different levels spaced equidistantly apart along the intermediate part of uniform diameter of the shaft. An annular pipe 17 supplied from the air main is mounted around the shaft at each of these levels, and each annular pipe supplies six tuyeres 18 spaced equidistantly around the shaft through which the additional air is supplied. Steam from the steam main 15 can be introduced at three levels in the shaft, namely at a high level, through the top series of air tuyeres, at an intermediate level, through the bottom series of tuyeres, and at a low level, through a pipe 19 projecting through the wall of the shaft immediately below the revolving grate 8. At the top and intermediate levels the steam main 15 supplies annular conduits 20, disposed respectively immediately above and below the annular air pipes, each of which has six tuyeres 21 passing through the wall of the shaft intermediately of the air tuyeres 18. The air and steam tuyeres are arranged at an angle of 60° to the shaft. The air and steam mains 14 and 15 and each of the air and steam tuyeres 18 and 21 are separately valve-controlled.

The outlet gas manifold 22 referred to above is disposed around the chamber 3 and has four gas ports 23 through which the heating gases are taken off (as hereafter described. Another gas manifold 24 surrounds the chamber 12 and has also four gas ports 25 all communicating with a common gas main for collecting and forwarding the gas produced according to the invention.

The shaft is supported above ground level on pillars or piers 26 approximately 9 feet 8 inches in height. An ash hopper is carried immediately below the revolving grate and a bucket conveyor for removing ash is provided below the ash hopper. This bucket conveyor may comprise the return run of the conveyor supplying the coke to the coke hopper.

In operation the shaft is filled with a column of coke from the overhead coke hopper. Approximately half the total air required in the process is admitted through the lower air inlet 16 below the revolving grate 8 in order to burn the coke at the lower end of the column to form carbon monoxide gas. The balance of the total quantity of air required in the process is admitted proportionately through the tuyeres 18 at the various levels of the column to burn with the carbon monoxide gas evolved at the bottom of the column and ascending through the column, in order to raise the column of coke to incandescence. A substantially uniform temperature is thus provided throughout the column, although there will be a tendency for higher temperatures to prevail at the higher levels by reason of the ascensional force of the heat. The enlarged diameter of the chamber 3 towards the top of the shaft producing a sudden drop in the velocity of the rising gases allows the dust to settle and prevents any lifting of the top layer of coke.

At the top of the coke column the freshly charged coke, at a temperature of approximately 300° C. provided a means of partially utilising the outgoing products of combustion preliminarily to heat such fresh charge which has accumulated from the continuous feed, which proceeds continuously during the air and steam blowing operations.

The ignition and combustion of the producer gas by the supplementary air injected has preference to the burning of the coke, and the heat generated therefrom is more dispersed than the more concentrated heat derived from direct coke burning.

According to practical trials conducted, this method of heating does not involve any local overheating which may cause ash slagging and sticking of the charge, of which there has been no single instance.

The combustion gases are collected and led away through the upper gas manifold 22. By making the necessary adjustments, the air blow period could be made in a period of 60—90 seconds, as is usual in the manufacture of water gas and the steam blow could be made 5 minutes. It has, however, been found more economical to extend the period or air blow to 10 minutes, which permits the air blower to be of relatively less capacity, and provides for its continuous operation over a battery consisting, for example, of six water gas producers, in the case, as at present, where the period of steam blow is to extend over 50 minutes. It further ensures a non-interrupted flow of combustion products into a common main which serves as a source for preheating the air for combustion.

On completion of the air blow the air supply is closed and purging steam is admitted through the lower steam inlet to purge the shaft of gases. This purging steam blast incurs only one tenth the loss of gas which normally occurs in the manufacture of water gas, by reason of the length of the column of coke.

The purging steam is now shut off and reaction steam is admitted through the upper and intermediate steam inlets disposed respectively towards the top and bottom of the incandescent column of coke.

By admitting steam at the top of the hot charge immediately below the zone of freshly charged coke, and its descension through the column of coke to the extent of 27 feet below its entry a stratification of the steam over the whole cross-sectional area of the column is provided, ensuring a maximum opportunity for complete reaction. Down to this particular level, where it meets with additional steam injected at the intermediate level above referred to, the composition of the gas at the commencement of the steam blast is wholly carbon monoxide and hydrogen. The additional steam at the intermediate level enters a zone which has been heated only by the sensible heat of the ascending gas from the gas producer below, and has a temperature approximating 800° C.

The superheated steam at 800° C. reacts with the carbon monoxide and hydrogen gas to oxidise a portion of the carbon monoxide to carbon dioxide, and to create more hydrogen. As the temperature of the column above gives up its heat in the endothermic reaction of water gas production, the proportion of carbon dioxide increases. In order now to ensure that a reaction gas having a substantially constant composition of carbon monoxide, carbon dioxide and hydrogen is obtained, it is only necessary to adjust the quantity of surplus steam so that the quantity admitted decreases gradually throughout the gas making period. This gradual adjustment of the quantity of additional steam admitted, taken in conjunction with the cooling temperature of the main gas and the increasing temperature of the oxidising zone arising from the exothermic reaction of oxidising the gas by steam, provides a substantially constant composition of the gas comprising for example 28.6 per cent. of carbon monoxide, 14.2 per cent. carbon dioxide and 57.2 per cent. hydrogen.

Such a gas composition in which hydrogen and carbon monoxide are present in approximately the ratio 2 hydrogen : 1 carbon monoxide is particularly suitable for the manufacture of methyl alcohol or the higher alcohols for use as a motor spirit, more particularly for admixture with spirit obtained from mineral oils.

The lower gas manifold conveys the reaction gas through an air heater and then to a centrifugal cleaner which collects all the dust carried over with the gas. The gas is then cooled and the surplus steam condenser out in an atmospheric air-cooled condenser.

In order to make the gas suitable for use in the manufacture of methyl alcohol, when it leaves the condenser the gas enters a governor controlled exhauster and is delivered to the carbon dioxide removal plant. The gas is now compressed to 30 atmospheres and enters a scrubbing tower where the carbon dioxide is washed out. The internal energy of the carbon dioxide in solution in the water leaving the tower may be used to provide about 60 per cent. of the power required to inject the water into the tower.

The gas which now consists of hydrogen and carbon monoxide only, in the proportions of 2 volumes hydrogen to one carbon monoxide, is compressed to 200 atmospheres and after passing through a lead bath heater where the temperature is raised to 400° C., the gas is circulated through reaction vessels containing suitable catalysts. The methyl alcohol formed is then condensed and flows into high pressure and low pressure separators where the pressure is broken down to atmospheric, and the final product then flows or is pumped to storage tanks.

The method of gas manufacture described is particularly applicable for use in the manufacture of methyl alcohol since it provides a long period of gas formation. If a battery of six of the apparatus described is used, a single air blower may be used for all six apparatus, and an uninterrupted flow of combustion products into a common main, serving for preheating combustion air, is obtained, as above described.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Process for the production of gaseous mixtures comprising passing steam through a column of incandescent carbon to form water gas and introducing a further quantity of steam to react with part of the carbon monoxide of the water gas to form carbon dioxide and hydrogen, the additional steam being regulated so that in the gas produced carbon monoxide and hydrogen are present substantially in the proportion of two parts of hydrogen to one part of carbon monoxide.

2. Process according to Claim 1 where a long column of coke is brought to incandescence by the combustion of CO produced at the bottom of the column and combusted by the admission of air at different points or levels along the column.

3. Process according to Claim 1 or 2 wherein approximately half the total air required is introduced below the grate, the other half being introduced through tuyeres at various levels along the column to maintain a substantially uniform temperature therein.

4. Process according to Claims 1 and 2 whereby the periods of gas making and heating are increased by five to ten times the period of standard practice in water gas generation.

5. Apparatus for producing gaseous mixtures according to the process claimed in Claims 1—4, comprising a relatively long shaft adapted to receive a column of coke to be raised to incandescence, a grate disposed at the bottom of the generator, means for admitting combustion air to the shaft at a number of different levels and means for supplying steam at two or more different levels, one or more outlet ports for combustion gases and means for collecting the resultant gases.

6. Apparatus according to Claim 5 wherein the shaft is cylindrical for greater part of its length and is provided with two chambers of wider diameter, one at the top of the shaft and the other at the bottom above the grate.

7. Apparatus according to Claim 6 wherein an air inlet is arranged below the grate and a plurality of air tuyeres are provided at different levels long the main cylindrical portion of the shaft.

8. Apparatus according to Claim 7 wherein the steam inlets are arranged below the grate and at the top and bottom air tuyeres.

9. Apparatus according to Claim 6, 7 or 8, wherein outlets for the resulting gases

are arranged in the said chambers of wider diameter.

10. Processes for the production of gaseous mixtures particularly suitable for the manufacture of methyl alcohol substantially as described.

11. Apparatus for the production of gaseous mixtures substantially as described with reference to the accompanying drawings.

Dated this 11th day of April, 1939.

MEWBURN, ELLIS & CO.,
70 & 72, Chancery Lane, London, W.C.2,
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1940.

[This Drawing is a reproduction of the Original on a reduced scale.]

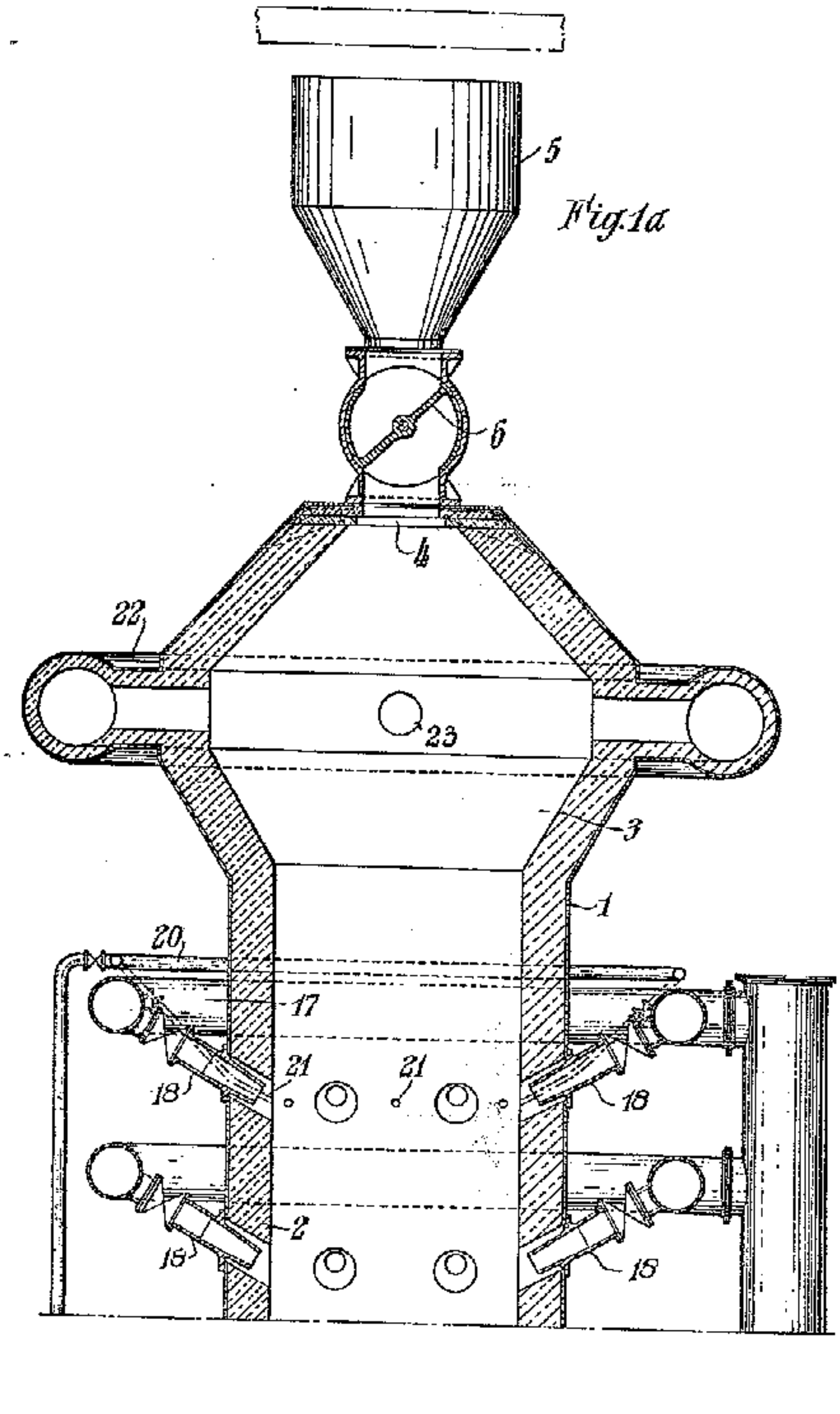
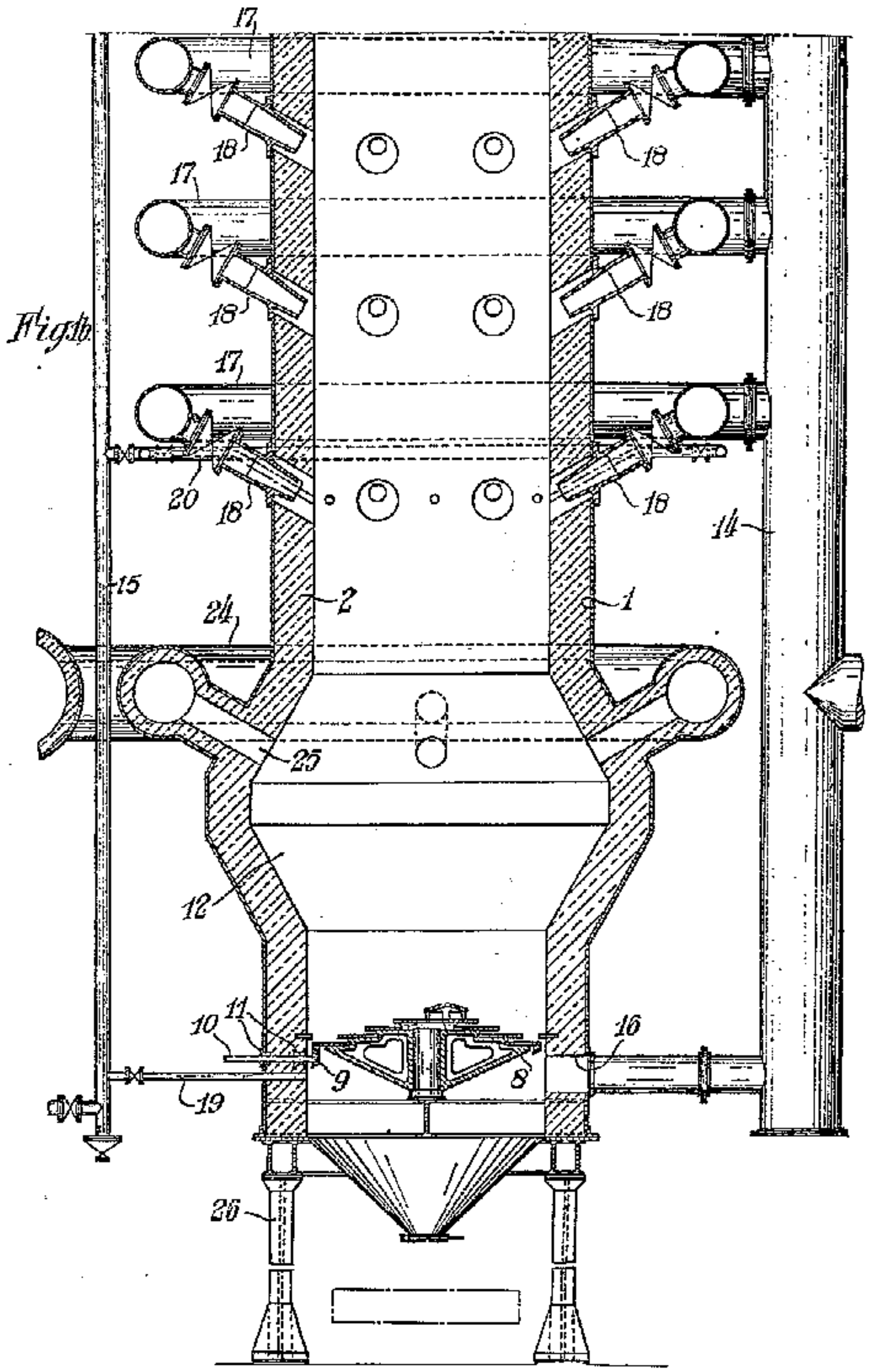


Fig.1a



Malby & Sons, Lith.

516,546 COMPLETE SPECIFICATION

2 SHEETS

SHEET 1

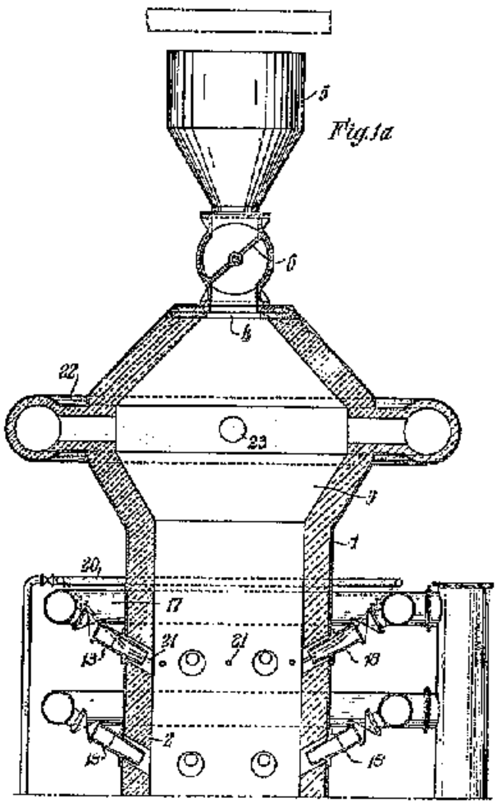


Fig.1a

SHEET 2

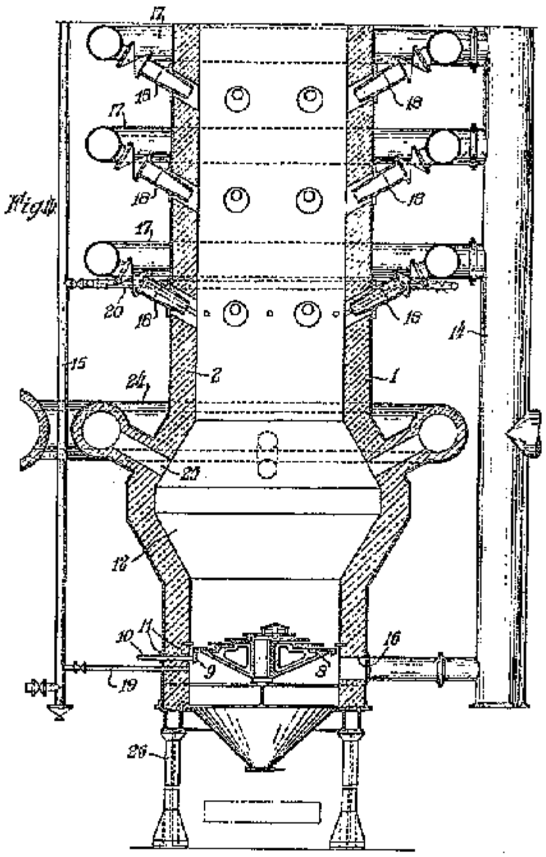


Fig.1b

[This Drawing is a reproduction of the Original on a reduced scale]

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