PATENT SPECIFICATION

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490

PROVISIONAL SPECIFICATION

Improvements in the Production of Gas from Carbonaceous Fuels

A communciation from Firma DIDIER-WERKE AKTIENGESELLSCHAFT, a Company organised according to the Laws of Germany, of Westfälische Strasse 90, Berlin-Wilmersdorf, Germany.

I, EDWARD GEORGE LEWIN, M.Sc., A.Inst.P., Chartered Patent Agent, British Subject, of Ebury and Allington Houses, 136 to 150, Victoria Street, London, S.W.1, do hereby declare the nature of this invention to be as follows:—

The present invention relates to improvements in the production of gas mixtures suitable for use in chemical synthesis processes, from carbonaceous materials, and principally employing as the initial material hard or bituminous coal.

For chemical synthesis such as the production of hydrocarbons, alcohols, ammonia, &c., it is desired to produce a gas mixture consisting mainly or almost entirely of hydrogen and carbon monoxide, preferably in stoichiometric proportions, but to ensure flexibility of the process and to enable the gas mixture produced to be employed in various other chemical processes (e.g., destructive hydrogenation), the relative proportions of hydrogen and carbon monoxide should be controllable at will by changing the operating conditions.

The gas mixture is produced by the distillation of the coal in a continuously-operating externally - heated vertical chamber. The distillation gases travel down the chamber in the same direction as the coal, and are removed through a gas offtake in the side of the chamber, which may be at any suitable level; for example, two-thirds of the way down the chamber. The upper part of the chamber will be termed the " distillation zone " and the central part of the chamber the " reaction zone ". In the lower part of the chamber below the gas offtake, termed the " water-gas zone ", the residual carbonaceous material is steamed to produce water-gas which is drawn off, together with the distillation gases, through the gas offtake, and provides part of the hydrogen and carbon monoxide present in the ultimate gas mixture.

The mixture of hydrogen and carbon monoxide is produced in the reaction zone (where the highest temperatures prevail) by reaction between the gases evolved from the coal in the distillation zone, water-vapour, and the highly-heated carbonaceous material present in the reaction zone.

The relative proportions of the hydrogen and carbon monoxide in the resultant gas depend on the various reactions taking place in the reaction zone, and it is therefore desired to control these reactions in such a manner as to produce a large amount of hydrogen. The factors governing the reactions proceeding in the reaction zone are (a) the time of contact between the reacting gases and the carbonaceous material, (b) the temperature in this zone, (c) the physical nature of the carbonaceous material, which will hereafter be called its " reactivity ", and (d) the partial pressure of the various gases present in the reacting zone.

The object of the present invention is therefore to provide means for controlling the various features (a), (b), (c) and (d) referred to in the preceding paragraph.

According to the present invention, the time of contact of the reacting gases with the carbonaceous material in the reaction zone is controlled by varying the position (relatively to the reaction zone) at which the resulting gases are withdrawn from the chamber. For example, one arrangement suitable for this purpose is to arrange that the gas offtake is recessed in an end wall of the retort and continues upwards for some distance parallel to the chamber, apertures or ports being provided in the wall separating the gas offtake and the reaction zone above the level of the normal outlet, together with a damper in the gas offtake adjacent the normal outlet. When it is desired to reduce the time of contact between the reacting gases and the material in the reaction zone, the damper is partially closed, with the result that part of the gases are diverted into the offtake through the apertures in the wall, and their time

[*Price* 1/-]

of contact in the reaction zone is correspondingly reduced. If desired, a second gas offtake, arranged similarly to the first, and controllable in the same way, may be arranged at the other end of the major axis of the chamber. It may be particularly useful to have two gas offtakes when gasifying smaller-sized materials.

According to a further feature of the invention, the temperature in the reaction zone may be controlled by varying the amount of heat supplied in this region. For example, secondary burners may be provided in the heating flues adjacent this zone of the chamber. Further, the walls of the chamber in this region may be built of materials of high thermal conductivity, such as silicon carbide.

According to another feature of the invention, the "reactivity" of the carbonaceous material in the reaction zone is enhanced by the introduction of superheated steam at some suitable point in the upper part of the chamber, or in the top ironwork thereof. The steam should be introduced into the coal before it enters the high temperature zone of the retort, and before it commences to form coke. It is believed that the effect of the steam is to increase the reaction—promoting power of the carbonised residue, beyond that which it would have possessed if the coal had been converted into lump coke.

It is also important, according to the present invention, that the partial pressure of the various gases present in the reaction zone should be controllable, as an unduly high concentration of certain products would adversely affect the direction in which the controllable reaction proceeds. The principal reactions occurring in this zone are:—

$$1.\quad \begin{cases} C + H_2O = CO + H_2 \\ C + CO_2 = 2CO \end{cases}$$

$$2.\quad \begin{cases} CH_4 + H_2O \rightleftharpoons CO + 3H_2 \\ CO + H_2O \rightleftharpoons CO_2 + H_2 \end{cases} \Big\| 4H_2$$

It is particularly important to reduce the quantity of CO_2 present in the reaction zone. For this reason, when using coals containing a high percentage of oxygen (which coals form large amounts of CO_2 during the early stages of distillation), all or part of the CO_2 so evolved may be removed from the chamber at this stage. For this purpose, a gas offtake is provided near the top of the chamber, containing a valve which can be set so that any proportion of the CO_2 generated in this region can be removed before it enters the reaction zone. In certain circumstances, it may be necessary to arrange this gas offtake in a preheating zone, external to the chamber proper, in which the coal is heated to a relatively low temperature prior to its admission into the distillation chamber.

The reactions in group No. 2 above are reversible reactions, and in order to influence the direction of the reactions in the desired sense, i.e., the production of hydrogen (left to right of the equations), a more or less large excess of steam is added or otherwise provided in the reaction zone.

In connection with the feature of controlling the temperature in the reaction zone, it will be realised that it is also of importance to obtain, as far as possible, uniformity, in any zone, of the temperatures prevailing there. When employing chambers of large dimensions (long major axis) for carrying out the present invention, one or more vertical walls may be provided internally of the chamber across the minor axis thereof. The walls are of varying length in relation to the gas offtake, and their purpose is to constrain the flow of coal and distillation gases down the chamber, and to prevent short-circuiting of the distillation gases to the gas offtake, which might otherwise lead to irregularity of temperature.

The above arrangements enable effective control to be obtained over the reactions proceeding within the chamber, and are particularly effective when gasifying hard coals for the purpose of producing hydrogen and carbon monoxide mixtures for use in chemical synthesis processes.

Dated this 14th day of February, 1936.

E. GEORGE LEWIN,
Chartered Patent Agent,
Ebury and Allington Houses,
136—150, Victoria Street, London,
S.W.1.

COMPLETE SPECIFICATION

Improvements in the Production of Gas from Carbonaceous Fuels

I, EDWARD GEORGE LEWIN, M.Sc., A.Inst.P., Chartered Patent Agent, British Subject, of Ebury and Allington Houses, 136 to 150, Victoria Street, London, S.W.1, do hereby declare the nature of this invention and in what manner the same is to be performed, as communicated to me by my foreign corre-

spondents, to be particularly described and ascertained in and by the following statement:—

The present invention relates to improvements in the production of gas mixtures suitable for use in chemical synthesis processes, from carbonaceous materials, and principally employing as the initial material hard or bituminous coal.

For chemical synthesis such as the production of hydrocarbons, alcohols, &c., it is desired to produce a gas mixture consisting mainly or almost entirely of hydrogen and carbon monoxide, preferably in stoichiometric proportions, but to ensure flexibility of the process and to facilitate the production of a gas mixture suitable for employment in various other chemical processes (e.g. destructive hydrogenation), the relative proportions of hydrogen and carbon monoxide should be controllable at will by changing the operating conditions.

In the process to which the present invention relates, the gas mixture is produced by the gasification of coal in a continuously-operating externally-heated vertical gasifying chamber. The coal is distilled in the upper part of the chamber, and the entire gaseous distillation products flow downwardly in the chamber through the heated coke resulting from the distillation of the coal. The distillation gases are decomposed in the strongly heated central zone of the chamber, as stated in the succeeding paragraph, to give the desired gas mixture, which is withdrawn through a gas offtake in the side of the chamber, which may be at any suitable level; for example, about two-thirds of the way down the chamber. The upper part of the chamber will be termed the "distillation zone" and the central part of the chamber the "reaction zone". In the lower part of the chamber below the gas offtake, termed the "water-gas zone", the residual carbonaceous material is steamed to produce water-gas which is drawn off, together with the decomposed distillation gases, through the gas offtake, and provides part of the hydrogen and carbon monoxide present in the ultimate gas mixture.

That portion of the hydrogen and carbon monoxide mixture which is produced in the reaction zone (where the highest temperatures prevail) is generated by inter-reaction between the gases evolved from the coal in the distillation zone, water-vapour, and the highly-heated carbonaceous material present in the reaction zone.

The relative proportions of the hydrogen and carbon monoxide in the resultant gas depend on the variouse reactions taking place in the reaction zone, and it is usually desired to control these reactions in such a manner as to produce a considerable preponderance of hydrogen. The factors governing the reactions proceeding in the reaction zone are (a) the time of contact between the reacting gases and the carbonaceous material, (b) the temperature in this zone, (c) the physical nature of the carbonaceous material, which will hereafter be called its "reactivity", and (d) the partial pressure of the various gases present in the reaction zone.

The object of the present invention is therefore to provide means for controlling the various factors (a), (b), (c) and (d) referred to in the preceding paragraph.

According to the present invention, the time of contact of the reacting gases with the carbonaceous material in the reaction zone is controlled by varying the position (relatively to the reaction zone) at which the resulting gases are withdrawn from the chamber. For example, a preferred arrangement suitable for this purpose comprises a lower gas offtake recessed in an end wall of the chamber and continuing upwards for some distance parallel to the chamber, with one or more upper gas offtakes passing through the chamber wall above the level of the lower offtake, and opening into the recessed portion of the lower offtake, together with dampers for the control of the upper and lower offtakes. When it is desired to reduce the time of contact between the reacting gases and the material in the reaction zone, the damper in the lower offtake is wholly or partially closed, and the damper in the upper offtake or offtakes opened, with the result that part or all of the gases are diverted into the upper offtake or offtakes, and their time of contact with the material in the reaction zone is correspondingly reduced. If desired, a duplicate gas offtake, arranged similarly to the first, and controllable in the same way, may be arranged at the other end of the major axis of the chamber. It may be particularly useful to have two such gas offtakes when gasifying smaller-sized materials.

According to a further feature of the invention, the temperature in the reaction zone may be controlled by varying the amount of heat supplied in this region. For example, a secondary stage of combustion may be provided in the heating flues adjacent this zone of the chamber. Further, the walls of the chamber in this region may be built of materials of high thermal conductivity, such as silicon carbide.

According to another feature of the invention, the "reactivity" of the carbonaceous material in the reaction zone is enhanced by the introduction of superheated steam at some suitable point in the upper part of the chamber, or in the top ironwork thereof. The steam should be introduced into the coal before it enters the high temperature region of the chamber and commences to form coke. It is believed that an important effect of the steam is to increase the reaction-promoting power of the carbonised residue, beyond that which it would have possessed if the coal had been converted into lump coke.

It is also important, according to the present invention, that the partial pressure of the various gases present in the reaction zone should be controllable, as an unduly high concentration of certain products would adversely affect the direction in which the controllable reaction proceeds. The principal reactions occurring in this zone are:—

1. $\begin{cases} C + H_2O = CO + H_2 \\ C + CO_2 = 2CO \end{cases}$

2. $\begin{cases} CH_4 + H_2O \rightleftharpoons CO + \boxed{3H_2} \\ CO + H_2O \rightleftharpoons CO_2 + \boxed{H_2} \end{cases}$ $\Big\Vert$ $4H_2$

It is particularly important to reduce the quantity of CO_2 present in the reaction zone. For this reason, when treating coals containing a high percentage of oxygen (which coals form large amounts of CO_2 during the early stages of distillation), all or part of the CO_2 so evolved may be removed from the chamber at this stage. For this purpose, a gas offtake may be provided near the top of the chamber, containing a valve which can be set so that any proportion of the CO_2 generated in this region can be removed before it enters the reaction zone. In the preferred arrangement hereafter described, this gas offtake is arranged in a preheating zone, external to the chamber proper, in which the coal is heated to a relatively low temperature for the purpose of eliminating carbon dioxide and sulphur compounds from the coal prior to its admission into the gasification chamber.

The reactions in group No. 2 above are reversible reactions, and in order to influence the direction of the reactions in the desired sense, i.e., the production of hydrogen (left to right of the equations), a more or less large excess of steam is added or otherwise provided in the reaction zone.

In connection with the feature of controlling the temperature in the reaction zone, it will be realised that it is also of importance to obtain, as far as possible, uniformity, in any zone, of the temperatures prevailing there. When employing chambers of large dimensions (long major axis) for carrying out the present invention, one or more vertical walls may be provided internally of the chamber across the minor axis thereof. The walls are of varying length in relation to the position of the gas offtake, and their purpose is to constrain the flow of coal and distillation gases down the chamber, and to prevent short-circuiting of the gases to the gas offtake, which might otherwise lead to irregularity of temperature in the chamber.

Examples of the manner in which the present invention may be applied in practice will now be described with reference to the accompanying diagrammatic drawings, which show apparatus for the production of hydrogen/carbon monoxide mixtures of the kind referred to above, but these illustrations are exemplary only, and the invention is not to be considered as limited to the details thereof.

In the accompanying drawings, Figure 1 is a vertical section on the major axis of a chamber, taken on the line B—B of Figure 2;

Figure 2 is a vertical section on the minor axis of a chamber taken on the line A—A of Figure 1; and

Figure 3 is a detail of the apparatus, shown as a section taken on the line C—C of Figure 1.

The apparatus shown in the Figures comprises a continuously-operating externally-heated vertical gasifying chamber, the upper part, the central part and the lower part of which form respectively the distillation zone, the reaction zone and the water-gas zone referred to in the introductory passages of the present Specification, and in which the various stages of the process take place as described above.

Above the gasifying chamber is a preheating chamber 1 in which the coal is preheated prior to entering the gasifying chamber 2. The coke residue remaining at the lower end of the gasifying chamber is cooled in a cooling zone 3 and is continuously removed by extractor mechanism 4 of any suitable type, and is periodically discharged through water-sealed doors 5. The gasifying chamber is heated by the combustion of fuel gas and air in the heating flues 6, the preheated gas and air being supplied to the heating flues 6 through the passages 7 and 8 respectively. The waste heating gases

are collected in the waste gas flue 9 and are transferred through the waste gas ducts 10 to the two sections of a recuperator 11 in which fuel gas and/or air are preheated prior to their introduction into the heating flues 6. After traversing the recuperator 11, the waste gases pass upwards through the setting into the flues 12 and from thence into the waste gas main 13.

In accordance with the present invention, each gasifying chamber contains upper and lower offtakes for the gas mixture generated in the chamber. The lower offtake comprises a recessed portion 14 in the end wall of the chamber with a vertical duct 14*a* leading upwards therefrom, and at a higher level in the chamber are arranged one or more upper gas offtakes 15 comprising similar recessed openings in the end wall of the chamber communicating with the upper end of the duct 14*a*. As shown in Figure 1, dampers are provided between the offtakes 14 and 15, and the duct 14*a*.

When it is desired to prolong to the maximum extent the time of contact between the reacting gases and the carbonaceous material in the reaction zone, the upper damper is closed, so that the offtake 15 becomes inoperative, and the gases must traverse the full height of the reaction zone before escaping through the lower offtake 14. Alternatively, if it is desired that the time of contact in the reaction zone should be short, then the lower damper is closed and the upper damper opened, so that only the upper offtake 15 is operative, whereby the length of the path of the gases in the reaction zone is correspondingly reduced. If it is desired to obtain an intermediate condition, both dampers may be partially open, so that part of the gas is withdrawn through each offtake. If more than one offtake of the character of the offtake 15 is provided, further variation in the time of contact of the gas in the reaction zone can be obtained. The effect of a reduction in the time of contact of the gases in the reaction zone (the factors of temperature, reactivity of the carbonaceous material, and the partial pressure of the various gases present, being assumed to be unchanged) is generally to increase the ratio of carbon monoxide to hydrogen in the resulting gas mixture.

The gas mixture withdrawn from the gasifying chamber passes through the pipe 16 into the gas main 17, or it may be employed for preheating the fuel gas supplied to the heating flues, as hereafter described with reference to Figure 3.

In accordance with the present invention, some degree of control may be exercised over the temperature in the reaction zone by varying the amount of heat supplied in this region, and for this purpose, in the present apparatus, secondary burners 18 may be provided to produce a stage of secondary combustion adjacent this zone of the chamber, in the heating flues 6. The secondary burners 18 are supplied with secondary air from the air duct 8 through the passages 18*a* arranged in the division walls between the heating flues, as shown in Figure 1. Further, the walls of the chamber in this region may be constructed of materials of high thermal conductivity, such as silicon carbide, in order to increase the rate of heat transfer from the heating flues to the material in this zone of the chamber; the silicon carbide section 19 is shown as a cross-hatched section in the Figures.

Another feature of the present invention consists in improving the reaction-promoting power, or "reactivity", of the carbonaceous material in the reaction zone. This is effected by the introduction of steam (preferably superheated) into the coal before it enters the distillation zone of the chamber and commences to form coke.

As shown, steam inlets 20 are arranged in the preheating chamber 1 just above the inlet to the gasifying chamber proper, through which inlets steam is passed into the coal. In addition, steam inlets 21 in the upper part of the preheating chamber enable the coal to be subjected to the action of steam during its passage through the preheating chamber.

A gas offtake 22 is provided in the upper part of the preheating chamber 1, and is connected through a valve to a separate main, as shown in Figure 1. In accordance with the invention, the valve can be set so that any proportion of the carbon dioxide generated in the preheating or early distillation stages can be removed from the chamber through the offtake 22. The carbon dioxide is thus prevented from entering the reaction zone, where it might adversely affect the balance of the reactions tending to the formation of hydrogen and carbon monoxide. If necessary a second gas offtake similar to 22 can be provided in the region of the junction of the preheating chamber and the gasifying chamber.

In order to constrain the flow of coal and distillation gases vertically down the chamber and prevent short-circuiting of the gas to the offtake, there is a vertical partition wall 23 down the centre of the chamber in the minor axis thereof, as shown in Figure 1; apertures in the partition wall opposite each gas offtake 14 and 15 allow the gases generated in the

part of the chamber remote from the offtake to flow to the offtake. If the chambers are built in a single line, with offtakes similar to 14 and 15 at the opposite end of the major axis of each chamber, then the apertures in the partition wall 23 will be unnecessary. When employing chambers of large dimensions with long major axes, more than one vertical wall similar to 23 may be provided in the interior of the chamber, the length of each wall being graduated in relation to the position of the gas offtake, so that a proper flow of coal and gases down the chamber is produced, thus preventing the gases flowing diagonally across the chamber to the gas offtake or offtakes, and so avoiding irregularities of temperature or an irregular descent of the material in the chamber.

The preheating chamber 1 is constructed of metal, and comprises a central portion through which the coal passes, with heating flues 24 on either side thereof traversed by the waste gases from the heating flues of the gasifying chamber. The hot waste gases enter the heating flues 24 through the inlet 25 and return to the waste gas main through the outlet 26; the damper 27 is provided in the main waste gas flue to assist in regulating the amount of waste gases passed through the heating flues 24. Very effective preheating of the coal may be obtained by dividing the preheating space 1 into two parallel sections which converge into the top of the gasifying chamber, with additional heating flues 24 between the two sections, so that the coal is sub-divided into two thin layers, each layer being heated on both sides.

If desired, the sensible heat contained in the gas mixture generated in the chamber may be utilised in the manner described and claimed in my co-pending Patent Application No. 4563/36. The gases leave the gasifying chamber in the zone of highest temperature, and by means of the apparatus shown in Figure 3 a part of their sensible heat content may be employed for preheating the fuel gas supplied to the heating flues 6 of the chamber. If the valve 28 in the connection 16 is closed and the valves 29 and 30 opened, the hot gas from the gas offtake flows through the heat-exchange apparatus 31 in counter-flow to the fuel gas admitted from the main 32. The preheated fuel gas is supplied to the heating flues at 33, and in this case the whole of the recuperator 11 can be used for preheating the combustion air. By this means, a considerable amount of heat may be supplied to the heating system of the chamber in the form of preheat in the heating gases, so enabling higher temperatures to be maintained in the interior of the chamber, which is particularly advantageous when treating hard or bituminous coals. At the same time the thermal efficiency of the plant is enhanced by the utilisation of the sensible heat of the gas generated therein.

Steam is admitted to the water-gas zone of the chamber through the steam inlets 34, and the water-gas produced by the reaction between the steam and the heated coke in the lower part of the chamber is withdrawn, in admixture with the gases from the reaction zone, through the gas offtakes 14 or 15, and mixes with the gas from the reaction zone to provide part of the hydrogen and carbon monoxide present in the ultimate synthesis gas.

The arrangements described enable effective control to be obtained over the various factors which, as above-mentioned, govern the reactions proceeding within the chamber.

The apparatus described is especially suitable for the gasification of hard or bituminous coal to produce hydrogen/carbon monoxide mixtures for use in chemical synthesis processes.

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

1. Method and apparatus for the production of gas mixtures from carbonaceous materials in continuously-operating externally-heated vertical gasifying chambers, of the kind wherein the carbonaceous material is distilled in the upper part of the chamber and the entire gaseous distillation products flow downwardly in the chamber in contact with the hot carbonaceous residue of the material in a reaction zone of the chamber until a gas mixture of the desired composition is formed, characterised in this, that the time of contact of the reacting gases with the carbonaceous residue in the reaction zone is controlled by varying the position, relatively to the reaction zone, at which the resulting gases are withdrawn from the chamber.

2. Apparatus as claimed in Claim 1, in which two or more gas offtakes, at different vertical levels, are provided from the central region of the chamber, the said gas offtakes comprising damper-controlled ports in the end wall of the chamber, opening into a gas-collecting duct in the wall of the chamber.

3. Method and apparatus as claimed in Claim 1, in which the temperature in the reaction zone of the chamber is controlled

by varying the heat supplied to this zone from the heating system of the chamber.

4. Apparatus as claimed in Claim 3, in which a secondary stage of combustion is provided in the heating flues of the chamber in the region of the reaction zone.

5. Apparatus as claimed in Claim 3 or 4 in which the walls of the chamber in the reaction zone are constructed of a material of high thermal conductivity, e.g., silicon carbide.

6. Method and apparatus as claimed in Claim 1 or 3, in which the carbonaceous material is preheated in a preheating chamber arranged above the gasifying chamber.

7. Method and apparatus as claimed in Claim 1 or 3, in which steam is introduced into the carbonaceous material before the latter enters the distillation zone of the chamber.

8. Apparatus as claimed in Claim 6 or 7, in which the steam is introduced into the carbonaceous material while the latter is in a preheating chamber arranged above the gasifying chamber.

9. Method and apparatus as claimed in Claim 1, 3, 6 or 7, in which means are provided to remove excess carbon dioxide from the gases present in the upper part of the gasifying chamber and/or in the preheating chamber.

10. Apparatus as claimed in Claim 9, in which a gas offtake is provided from the preheating chamber and/or from the upper part of the gasifying chamber.

11. Apparatus as claimed in Claim 6, in which the preheating chamber is heated by the passage, through flues in the preheating chamber, of waste gases from the heating flues of the gasifying chamber.

12. Apparatus as claimed in any one of the preceding Claims, in which the hot gas mixture leaving the gasifying chamber is employed in heat exchange apparatus to preheat the fuel gas and/or combustion air supplied to the heating flues of the chamber.

13. Apparatus for the production of gas mixtures from carbonaceous materials in continuously-operating externally-heated vertical gasifying chambers by the method claimed in any one of the preceding Claims, comprising a gasifying chamber, above which is a preheating chamber, the gasifying chamber including a distillation zone, a reaction zone and a water-gas zone, with extractor gear for removing the residue from the lower end of the gasifying chamber, two or more gas offtakes at different vertical levels in the region of the reaction zone of the chamber, the said gas offtakes comprising damper-controlled ports through the end wall of the chamber opening into a gas collecting duct in the wall of the chamber, steam inlets to the upper part of the gasifying chamber and/or to the preheating chamber, and a gas offtake or offtakes from the preheating chamber.

14. Method and apparatus for the production of gas mixtures from carbonaceous materials, substantially as described with reference to the accompanying drawings.

Dated this 19th day of December, 1936.

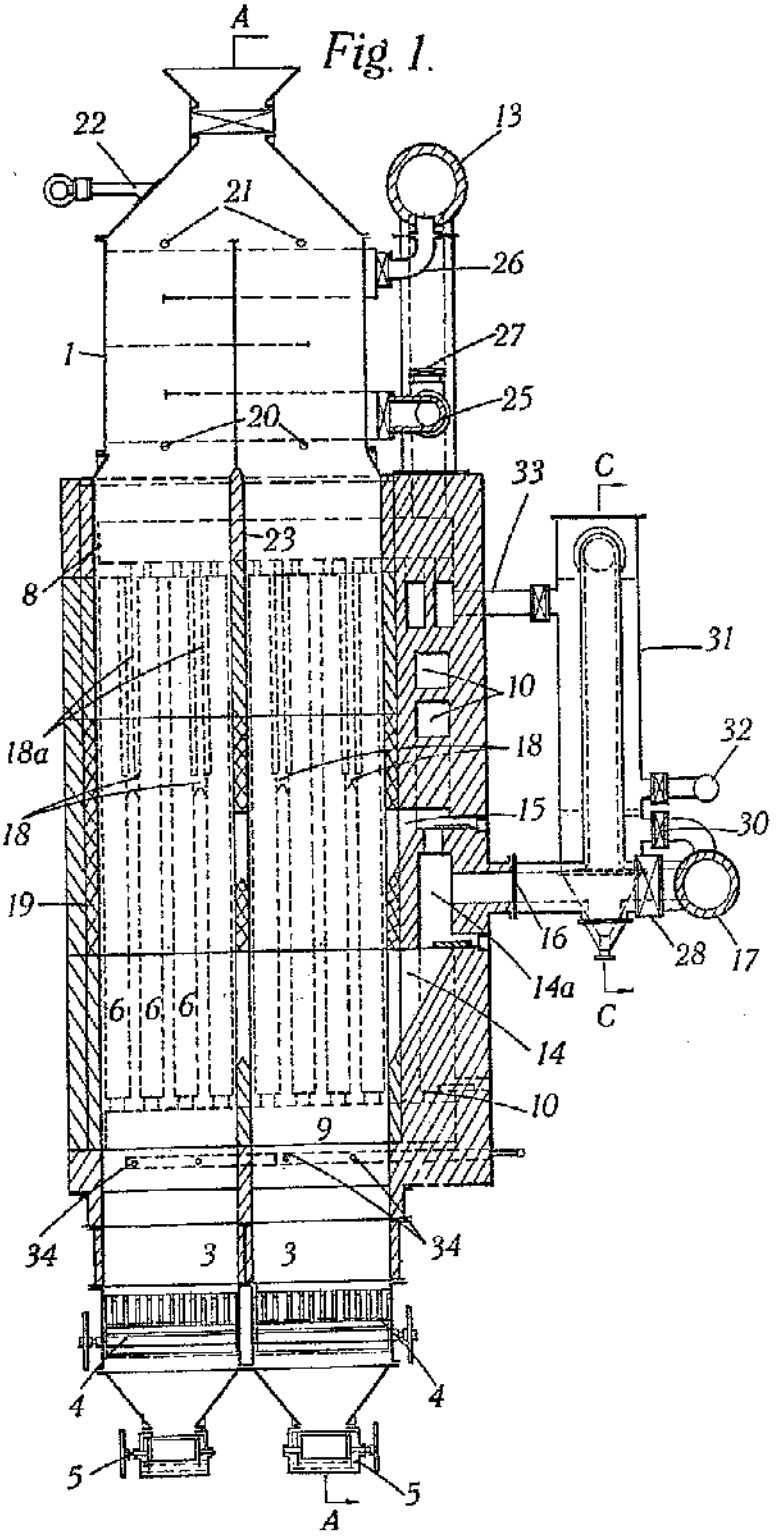
E. GEORGE LEWIN,
Chartered Patent Agent,
Ebury and Allington Houses,
136—150, Victoria Street, London, S.W.1.

Reference has been directed, in pursuance of Section 7, Sub-section (4), of the Patents and Designs Acts, 1907 to 1932, to Specification No. 106,189.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1937.

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

Fig. 1.



SHEET 1

Fig. 2.

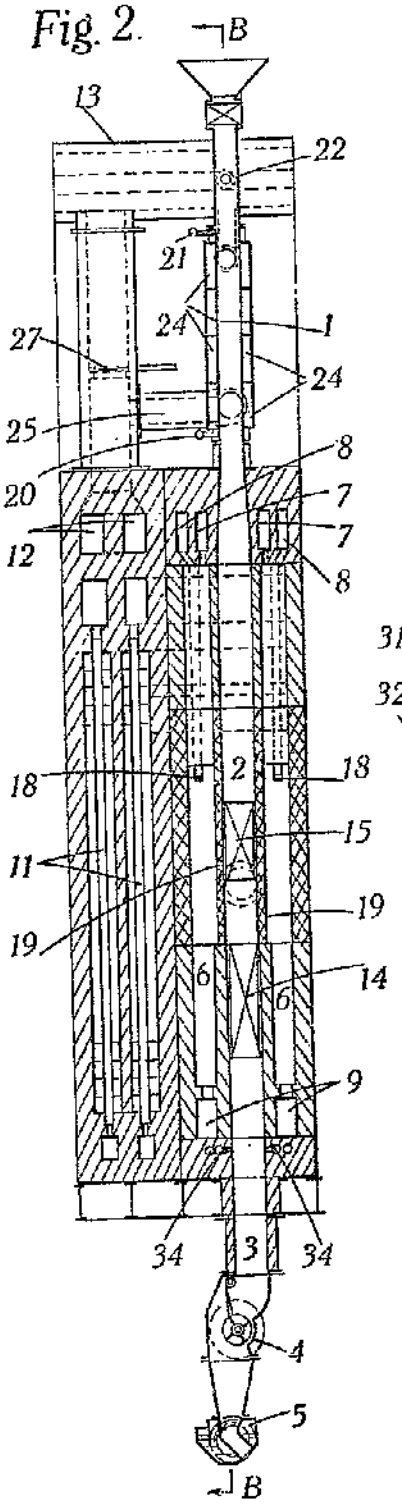
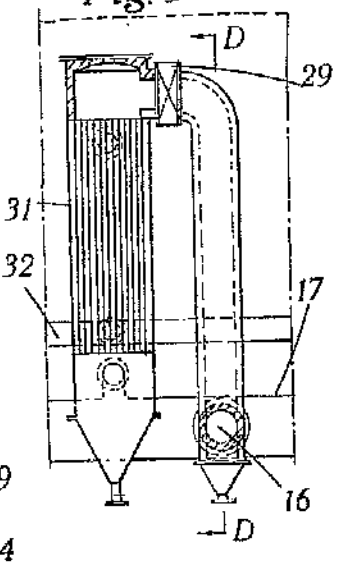


Fig. 3.



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470,275 COMPLETE SPECIFICATION

8 SHEETS

SHEET 1

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

Fig. 1.

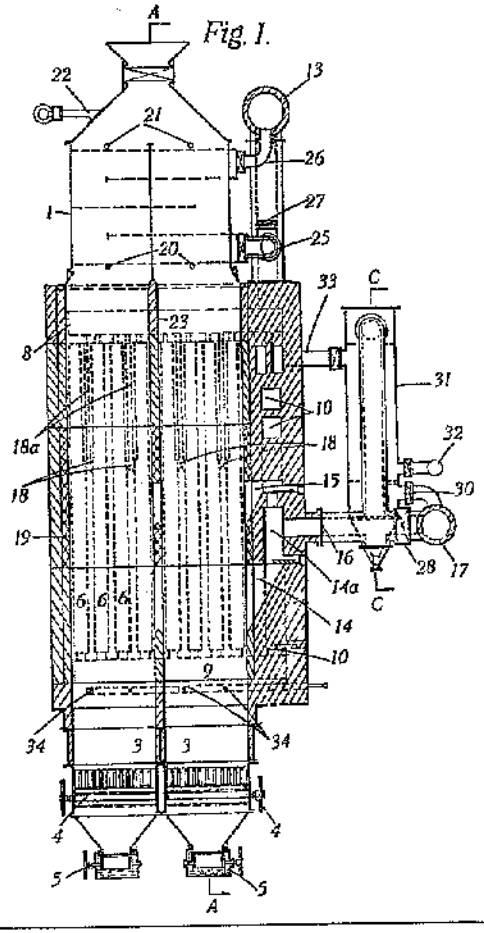


Fig. 2.

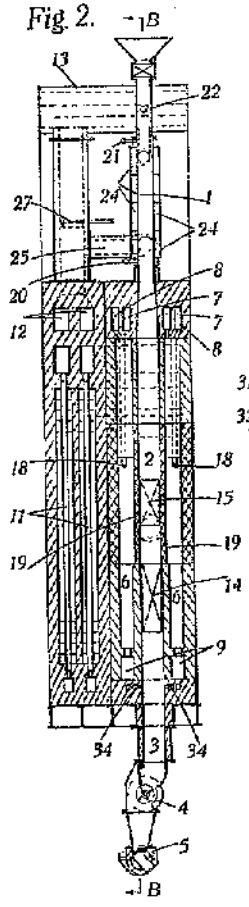
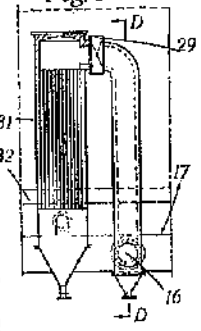


Fig. 3.



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