[Second Edition.]

PATENT SPECIFICATION

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(Divided out of No. 304,251.)

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COMPLETE SPECIFICATION.

Improvements in or relating to Methods of and Apparatus for Catalysing Gaseous Reactions.

(A communication from The Silica Gel Corporation, having a place of business at 1100, Garrett Building, 239, Redwood Street, Baltimore, Maryland, United States of America, a corporation organized and existing under the laws of the State of Maryland.)

I, Harold Wade, a British subject, of 111/112, Hatton Garden, London, E.C. 1, 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 is for improvements in or relating to catalytic gaseous reactions of the type in which a stream of the gas to undergo reaction, carrying with it a pulverised catalyst in suspension, is passed through a converter in which the reaction takes place. The invention concerns more particularly the manufacture of sulphuric acid by a contact process of this type. The present invention is concurrent with Application No. 18,549/27 (Serial No. 304,251), to which reference is directed, as the two inventions are somewhat similar.

In most cases where catalysts are employed for the purpose of effecting certain desired contact reactions, the efficiency of the conversion is controlled by several factors, among which are the temperature of the gas while in contact with the catalyst, and the activity of the catalytic mass.

The activity of the catalytic mass is often seriously diminished by the poisonous effect of impurities present in the gas being treated, for example, arsenic, in the case of sulphuric acid manufacture. Consequently, the gas being treated must be carefully cleaned before it comes into contact with the catalyst.

The temperature of the gas at the time of the reaction is an important factor and in most instances should not exceed a certain maximum. This requirement limits the size of converters that can be used. If a certain size is exceeded, the heat of the reaction cannot be dissipated rapidly enough and the temperature of the gas will be raised above the desired point. The converters, therefore, must not be made of a greater size than one in which a sufficient portion of the heat of reaction may be dissipated. For example, in the case of the manufacture of sulphuric acid by the contact process, small converters of only eight to ten tons capacity per twenty-four hours can be employed. If larger converters are used the temperature of the gas cannot be readily prevented from exceeding the maximum favourable to efficient conversion.

It is the principal object of the present invention to provide improvements in these respects on prior methods and apparatus for effecting catalytic reactions.

According to the present invention, there is provided in processes involving gaseous catalytic reactions of the type described, the method of controlling the reaction temperature which consists in effecting an interchange of heat within the zone of reaction as between the reacting gas therein and fresh gas incoming thereto.

According to a feature of the invention, the method may consist in effecting an interchange of heat as between the contents of the reaction sphere and fresh gas incoming thereto, at a number of points distributed through the reaction sphere and functioning, either all together, or certain only of them selectively, the latter being the case in the event of it being necessary to counteract a tendency to local over-heating or under-heating. By this means it is possible so to control the reaction temperature that the whole of the reaction sphere is maintained at the correct temperature and local over-heating or under-heating is avoided. Moreover, as will be at once appreciated, the invention provides means whereby converters of almost unlimited size may be employed.

According to a further feature of the invention, the improved method aforesaid may be one in which the reacting gas is caused to flow in a stream through the reaction sphere and the fresh gas is caused during the heat transference to pass through the reaction sphere in a direction

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transverse to the flow of the reacting gas and at selectively controlled points situated one in advance of the other in the direction of said flow.

As previously stated, the invention relates more particularly to the manufacture of sulphuric acid by the contact process and according to a further feature of the invention, the process may comprise submitting a gas containing sulphur dioxide and oxygen to a process of catalytic oxidation of the sulphur dioxide, of the type described and as set forth above, separating the catalyst from the treated gas and after activating it returning the separated catalyst to the stream of fresh gas, cooling the treated gas and absorbing its content of sulphur trioxide in sulphuric acid. As will be appreciated, it is possible in connection with this process of manufacture of sulphuric acid to obviate the necessity for apparatus for cleaning and purifying the gases before the latter reach the converter. In addition, the amount of catalyst employed in this system may be relatively small as compared with the amount requisite in the present processes. These are notable advantages as will be appreciated by those acquainted with the art.

The catalyst is preferably a hard porous gel body such, for example, as silica gel, with or without additional catalytic material associated therewith, for example, platinum, copper or iron. As is known, these porous gel absorbents have ultra-microscopic pores, and the preferred gel for use according to this invention is one in which the pore size and total pore volume is such that the gel adsorbs a vapour such as water vapour to such an extent as to contain approximately 21% of water, reckoned on the weight of the gel, when in equilibrium with water vapour at 30° C. and a partial pressure of 22 mm. of mercury.

The invention includes both an improved process and also an improved apparatus for use in connection with the process.

According to this aspect of the invention, the latter comprises apparatus which includes, in combination, a converter, means to pass therethrough a stream of the gas to be treated, means to feed a catalyst in finely divided form into the gas stream so that it becomes suspended and carried along through the converter in said stream, and a tubular heat exchanger situated within the converter in the path of the gas stream therethrough, which exchanger is connected to the inlet of the converter and is arranged to convey thereto fresh gas on its way to the converter, with or without means to regulate the flow of gas in the heat exchanger.

According to a feature of the invention, the heat exchanger may be of such construction as to cause the gas passing through it to traverse the interior of the converter several times before it reaches the converter inlet.

The invention also includes a specific form of converter in apparatus as referred to in the two preceding paragraphs. The converter comprises a reaction chamber, a tubular heat exchanger within the chamber, through which exchanger fresh gas is conveyed on its way to the reaction chamber, means connecting the outlet of the heat exchanger to the inlet of the reaction chamber, which exchanger is of sectional construction and comprises a plurality of tubes spaced apart and crossing the interior of the reaction chamber, preferably transversely to the direction of gas flow therein, and valve means associated with the various sections of the heat exchanger whereby one or more of said sections may be cut out at will so as selectively to control the temperature obtaining in the various parts of the interior of the chamber.

The invention will now be further described with reference to the accompanying drawings which illustrate the invention by way of example, and in which;

Figure 1 is a diagrammatic view of one form of apparatus for effecting catalytic reactions between two or more gases, in accordance with the present invention;

Figure 2 is a similar view, but showing the added feature of means for regenerating the catalyst;

Figure 3 is a diagrammatic view of a contact sulphuric acid plant constructed and arranged to operate in accordance with the present invention;

Figure 4 is a sectional view of the converter taken substantially on the line 4—4 of Figure 3.

Figure 5 is a diagrammatic view of a part of an acid plant showing a modification;

Figure 6 illustrates a further modification of the plants of Figures 1, 2, 3 and 4.

In the apparatus illustrated in Figure 1, the gas is supplied to the converter C through the pipe 100 at the bottom thereof, it being understood that the converter is any suitable conduit or chamber wherein the gas and the catalyst may come into intimate contact. As shown, the converter is a vertically arranged casing or tube forming a reacting chamber. The catalyst, in pulverized form, is fed into the stream of gas flowing in the pipe 100 in any suitable manner, a worm conveyor

101 being shown for this purpose. The gas and catalyst pass upwardly through the converter and thence by means of a pipe 102 are conveyed to a separator 103. It will be understood that the converter is designed to permit the catalyst and gas to remain in contact for a sufficient length of time for the reaction to take place. Preferably, a converter of a novel type, which will be described hereinafter, is employed, this converter being designed to control the temperature of the gas therein, rapidly and delicately.

In the separator 103, which may be of any desired type, the gas and the catalyst are separated. The separator shown in Figure 1 is of the cyclone type, but, of course, others might be employed, such as the electrical type of precipitators. The gas is withdrawn from separator 103 by a suction fan 104 connected with the discharge pipe 105. It will be understood that this fan effects the circulation of the gas through the entire apparatus.

The catalyst separated out in the separator 103 is conducted by suitable means, as pipe 106, to the hopper 107 which supplies the feed worm 101. In this manner, the catalyst travels in a closed cycle, being used over and over again.

As the catalyst is employed in pulverised form it has an immense surface and its catalytic effectiveness is very much greater than where the catalytic body is arranged in the form of beds. Moreover, inasmuch as the catalyst is used over and over again, the total amount required in the system is small compared with the case where the catalytic body is disposed in beds. In such cases there has been in practice a certain economic maximum as to the permissible quantity of catalyst in relation to the gas being treated. With the catalyst in suspended pulverised form, however, and using the catalyst over and over again, although the total amount of catalyst in the entire system is small, it may be fed into the gas at a rate such that the amount used per unit of gas treated is considerably greater than is economically possible with the catalyst arranged in the form of beds, since the time taken for the catalyst to travel through the converter and to be separated from the gas and return to the hopper 107 is quite short, being, in practice, a matter of only a few seconds. By reason of this fact, a very high efficiency and activity are obtainable. I wish it to be understood, however, that I am aware that it is not broadly new to employ a pulverised catalyst in suspension in the reacting gases and to separate the catalyst from the gases after the reaction has taken place, activate the separated catalyst and re-cycle the activated catalyst back to the gas stream for re-use upon fresh gas therein, and I do not claim this combination of operations per se. Prior Specification No. 23,045/10 discloses an arrangement of this character, and I do not claim anything described or claimed therein.

In many cases there are impurities present in the gas which poison the catalyst or have the effect of gradually decreasing its efficiency. It is a well known fact, in many cases of catalytic reactions, that the principal item of cost is due to the expensive treatments required to remove the poisonous substances from the gas to avoid poisoning the catalyst, which however is not entirely accomplished, so that the catalyst must be regenerated from time to time, resulting in the loss of active material. In the present invention the catalyst is continually regenerated, thereby making it unnecessary to clean the gas, it being much cheaper to regenerate the catalyst than clean the gas.

Thus, referring to Figure 2 of the drawings, which is a diagrammatic view like Figure 1, a regenerator R of any suitable type is interposed preferably between the separator and the point at which the catalyst is fed into the stream of gas. The most appropriate regenerative apparatus for the particular problem would be used. Thus, as shown, the catalyst separated out by the separator is delivered to a feed tube 108 which has a feed device, such as a worm conveyor for feeding the catalyst into a rotatably mounted tube 109, disposed in a casing 110 with the ends of the tube projecting from the casing. A furnace 111 is connected to the casing to heat the interior thereof and thereby the tube. The hot gas from the furnace is drawn into the casing and in turn exhausted therefrom by any suitable means, such as a suction fan 112 having its inlet connected with the casing. The catalyst passes through this tube and is heated therein to drive off the objectionable substances and is then conducted by any means, such as tube 113, to the hopper 107 which supplies the feed worm 101. Usually, it is necessary to admit air or some other gas to the interior of the tube to effect the proper treatment of the catalyst. For this purpose an inlet 114 for the tube is provided and this inlet may be controlled by valve 115.

For the most efficient results, the active material employed must be carried in such a way that a very large contact surface is presented. Although the invention is not limited thereto, it is preferred to employ a catalyst wherein silica gel or a substance having substantially the same structure is the carrier for the active material. Thus, for oxidising SO_2 to SO_3, a platinum impregnated silica gel or a copper-iron impregnated silica gel or other suitable gel might be employed.

In the process just described, therefore, the catalytic action is effected by contact between the gas and a solid catalyst, the catalyst being in pulverised form, and travelling in a closed cycle, being used over and over again. Furthermore, before it is returned for re-use, the catalyst is treated to remove objectionable substances, this treatment merely being one of the steps in the closed cycle of movement of the catalyst.

As further illustrated, a contact plant for the manufacture of sulphuric acid, constructed and operated in accordance with the present invention, will now be described.

Referring to Figure 3 of the drawings, the gases to be treated, in the plant shown, are obtained by roasting ores in a roaster 10 of any suitable type. From the roaster the gases pass through a dust catcher 11, of any suitable type, and are delivered to the converter C. If the gases are produced by burning sulphur, then the dust catcher may be eliminated and the gases delivered directly from the burner to the converter C. If desired, a cooling device 9, of any suitable type, may be provided to cool the gases before they enter the converter.

The catalyst, in pulverised form, is fed into the stream of gases passing through the converter C and delivered to a separator 13 of any suitable form. In this separator, the catalyst is separated from the gases. The catalyst thus separated passes to a regenerating apparatus R wherein it is treated for the purpose of removing poisons or other substances taken up during the reaction. After this treatment, the catalyst is delivered into the stream of gases entering the converter so that the material is used over and over.

The gases separated out in the separator 13 are delivered to a cooler 14 and then to an adsorber 15 wherein the gases come in contact with concentrated sulphuric acid which absorbs the sulphur trioxide.

The sulphuric acid is delivered from the bottom of the absorber to a separator 17 wherein any of the catalytic material, not previously removed, is separated from the sulphuric acid. The sulphuric acid delivered from this separator passes to a cooler 18 and the smaller part is discharged by pipe 19. The greater part, by means of pump 20, is returned to the top of the absorber.

There may be a small amount of catalyst present in the acid delivered by pipe 39, and means is provided to recover this catalyst from the acid and return it to the converter for re-use.

The apparatus will now be described more in detail.

The converter employed is of novel form and is designed so that a delicate control of the temperature of the gases may be had during the period of conversion. With the converters heretofore employed, no entirely satisfactory means have been provided for dissipating the heat of reaction. As a result, converters of limited size only can be employed because, if the maximum size were exceeded, the temperature of the gases would be raised to a point beyond the maximum for efficient reaction. Even with the smaller type present-day converters, the temperature throughout the same is not uniform. In spots, the converter may become far too hot. It is one of the aims of the present invention to provide a converter which will permit regulation of the temperature of the various parts of the converter so that no spots may become excessively hot.

As shown in Figures 3 and 4, the converter comprises a central conduit or chamber 26 having small tubes or pipes 27 extending transversely of the same. These tubes form passages for gases to pass directly from one side of the converter chamber to the other, and may be termed temperature control tubes. Disposed on one side of the chamber or conduit 26 is an inlet or supply pipe 33 and on the opposite side an outlet pipe 34. The inlet pipe 33 is provided with a plurality of small outlets or nozzles 33^1 in each of which there is a damper 31. These nozzles 33^1 discharge into flues 28 which provide communication between the nozzles and one end of the temperature control tubes 27. In the form shown in Figure 3 of the drawings, there are three of these inlet flues 28.

Similarly, the outlet pipe 34 is provided with a plurality of nozzles 34^1 each of which is provided with a damper 32. Flues 29 afford communication between the ends of the temperature control tubes 27 and said nozzles 34^1. In the form shown in the drawings, there are three of these flues 29.

It will be seen that the flues 29 on one side of the converter chamber are staggered with respect to the flues 28 on the other side. The purpose for this will presently appear.

In operation, the gases leaving the cooling device 9 flow through conduit 33, any of the nozzles 33^1 in which the dampers may be open, flues 28, thence through the temperature control tubes 27, flues 29, any of the nozzles 34^1 that may be open and finally into the pipe 34 which conveys the gases to the central chamber of the converter. The gases, reacting in the chamber 26 of the converter, give out heat, which, by means of the temperature control tubes, is transferred to the gases passing through said tubes.

The design of the converter is such that the cool gases before they are supplied to the converter may be caused to pass back and forth through the temperature control tubes many times, or only once. Furthermore, said gases may be cut off from passing through certain of the tubes. Thus, the temperature of the temperature control tubes may be delicately regulated. If all of the individually controlled dampers 33^1 and 34^1 are open, then the gases pass directly from pipe 33 to pipe 34 in the manner described above. With this arrangement of the dampers, the cool gases are in contact with the temperature control tubes for a short time only. Now, if any section of the converter chamber becomes too cold, the temperature control tubes of that section may be cut out as conduits for the cool gases and thus their temperature raised. With another setting of the dampers, the two upper dampers 31 and the two lower dampers 32 might be open, all the remaining dampers being closed. With this setting, the cool gases from the pipe 33 pass through the two upper nozzles 33^1, the upper flue 28, the upper group of temperature control tubes into the upper flue 29. The dampers 32 being closed, the gases cannot pass into pipe 34 but are caused to pass back through the temperature control tubes into the middle flue 28. The dampers 31 opening into the flue, being closed, the gases again pass through another set of temperature control tubes into the central flue 29, thence to the left through the temperature control tubes into the bottom flue 28, then to the right into the bottom flue 29. As the two lower dampers 32 are open, the gases are now discharged into the pipe 34 and delivered to the converter. Thus, depending on the settings of the dampers, the gases may be caused to pass one or more times through the tubes.

As for this particular phase of the invention, that is, the conversion of sulphur dioxide to sulphur trioxide, the temperature range within which the reaction may be carried out is of no particular importance, in as much as the temperature of such reactions are well known in the art. By way of example it may be stated that the temperature may vary from 325° C. to 625° C., according to the percentage of conversion from sulphur dioxide to sulphur trioxide desired.

The pulverised catalytic material is fed, by any suitable means, such as the conveyor 35, into the conduit 34 at a point below the tubes 27, so that the reaction takes place while the gases are travelling through the chamber 26 and around the tubes 27. The heat of reaction may be transferred to the gases before they react, by causing them to pass through the tubes 27, the extent of contact of the gases with these tubes being controlled by the setting of the dampers 31 and 32 as described above. Thus, the heat of reaction is utilised for heating the gases supplied to the converter, and being dissipated in this way there is no limit to the size of the converter that may be employed, as far as the dissipation of heat is concerned.

The catalyst employed, preferably, is of the type described hereinbefore. For oxidising sulphur dioxide to sulphur trioxide, platinized silica gel, iron silica gel or copper-iron silica gel are preferred.

Although, as stated, gels, or materials having a porous structure like gels, are preferred for the present invention, it is to be distinctly understood that the invention is not limited to these materials but includes others that may be used for effecting catalytic reactions in the manner set forth in this Specification.

The mixture of gases and pulverised catalyst is conveyed by a pipe 36 to the separator 13, which in the drawings is illustrated as a cyclone separator, where the catalytic agent is separated and drops to the regenerating apparatus R. On the other hand, the gases separated out by means of the separator 13 are conducted by conduit 37 to any suitable form of cooler 14 and after passing through this cooler, the gases are delivered by means of a conduit 38 to the absorber 15. In the absorber, the sulphur trioxide passing vertically up through the same is met by concentrated sulphuric acid falling through the tower for the purpose of absorbing the gaseous sulphur trioxide and thereby increasing the concentration of the sulphuric acid.

The flow of gases through the apparatus just described from the ore roaster to the exit of the absorber may be effected in any suitable manner, but as shown the suction fan 16 is connected to the gas outlet of the absorber 15 and effects the movement of the gases through the entire apparatus.

The sulphuric acid is conveyed from the bottom of the absorber by a pipe 39 to a separator 17 of any suitable type. In this separator, any of the catalytic agent that has been carried along by the gases is separated from the sulphuric acid. The sulphuric acid, by a pipe 40, overflows from the separator and is delivered to a cooler 18 and the final product is discharged by pipe 19. Part of the cooled sulphuric acid by means of pump 20 is returned to a reservoir 41 at the top of the absorber, this acid being used to percolate down through the absorber, or the acid may be returned from the bottom of the absorber to the top thereof without passing through a separator, and a small quantity of the acid may be taken from the bottom of the absorber and delivered to the separator 17. Water is also supplied to this reservoir 41 to reduce the concentration of the acid to the desired point. The catalytic material separated out in the separator 17 is conveyed to an agitator 21 through a pipe 42, movement being effected by a pump, indicated diagrammatically at 43. Water is supplied to the agitator so that the sulphuric acid is diluted making it possible to handle the catalyst without damaging subsequent apparatus.

The mixture is discharged from the agitator 21 by means of a pipe 44 to another separator 22. The liquid separated out in this separator is discharged by pipe 23 and the recovered catalytic material, by means of pipe 45 and a pump 46, is delivered to a filter 24 of any suitable type, such as an Oliver filter. The dried catalytic material delivered from this filter is conveyed by any suitable means to the regenerating apparatus R. As shown, an elevator 25 is employed for this purpose.

The apparatus 17, 43, 45, 24, 25, etc., is employed to recover any of the catalytic agent that may not have been separated by the separator 13. Usually, however, the separator 13 is so efficient that practically no catalytic material passes along with the gases in conduit 37, so that said apparatus may be omitted, as shown in Figure 5. Here the sulphuric acid passes from the absorber 15 directly through pipe 39 to the cooler 18, and parts 40, 17, 42, 43, 21, 22, 23, 45, 46, 24 and 25 of Figure 3 are omitted.

The regenerating apparatus R consists of any suitable means for subjecting the catalytic material to heat or other treatment that will remove poisons or any other substances associated with the same. As shown a tube 47 is rotatively mounted in a housing 49. This tube is heated in any suitable manner, as by hot gases surrounding the tube and supplied from a furnace 49^a, circulation being effected by a suction fan 49^b. The catalytic material is fed into one end of the tube by any suitable means, such as a worm conveyor 50 and is delivered at the other end into a chamber 51. This chamber has an outlet for delivering the regenerated catalytic agent to the worm conveyor 35. If desired, a magnetic separator 52 may be interposed between the chamber 51 and the worm conveyor 35 for the purpose of removing any magnetic iron oxide that may be present with the catalytic agent.

A dust collector 53, of any suitable type, is adapted to recover any dust present in the chamber 51, a suction fan 53^a being connected with the dust collector to effect circulation.

In treating the catalyst in the regenerator, it is often necessary to provide oxygen to burn off substances associated therewith, and for this purpose an air inlet 50^a is provided with may be associated with the worm conveyor 50, said inlet being controlled by a valve 50^b.

It is to be distinctly understood that the application of the invention to a contact sulphuric acid plant is described merely by way of illustrating one form of the invention. The invention is not limited to sulphuric acid plants but may be employed for effecting other catalytic reactions, such as the synthesis of ammonia, the hydrogenation of oils, and many other similar reactions depending on contact phenomena.

The apparatus for hydrogenating oils in accordance with the present method might be like that diagrammatically illustrated in Figure 2 of the drawings. The catalyst used, preferably, would be a nickel silica gel. The catalyst in the usual methods becomes poisoned with nickel carbonyl. According to the present invention, however, this poison is removed in the regenerative apparatus where, if necessary, hydrogen, instead of air may be supplied through the inlet 114.

In connection with the plants shown in Figures 1, 2 and 3, it may be desirable to have a separate source of supply of cooling gases. As shown in Figure 6, the gas supply pipe 200 may deliver the gases through a pipe 201 directly to the converter or through pipe 202 to the temperature control tubes of the converter. These two pipes are supplied with valves 203 and 204 respectively for controlling the flow. Pipe 202 may be provided with an air inlet 205 controlled by valve 206. The outlet pipe 207 for the cooling gases is connected by pipe 208 with the inlet of the converter, flow in this pipe 208 being controlled by a valve 209. The outlet pipe 207 is also in communication, through pipe 210, with an exhaust fan 211, flow in this pipe 210 being controlled by a valve 212.

In the operation of this modification of the invention, when it is desired to employ air for cooling the converter, the valves 203, 206 and 212 are opened and valves 204 and 209 closed. Then the exhaust fan 211 will draw air in through the air inlet 205 and this air will be circulated through the temperature control tubes and exhausted through fan 211. The reactant gases will flow through pipe 201 to the inlet of the converter. When it is desired to use all of the reactant gases as the cooling medium, then valves 203, 206 and 212 are closed and valves 204 and 209 opened. The apparatus will then operate as explained in connection with Figures 1, 2 and 3. Except as described above, the structure of the converter is the same as illustrated in Figures 3 and 4.

In the claims and Specification the term "gas" is intended to describe the physical state of the substance being treated and to include a single gas or vapour and a mixture of gases and/or vapours.

Although various embodiments of the invention have been described in detail, it is to be understood that the invention is not limited to these forms but includes modifications and changes which come within the scope of the appended claims.

I am aware that it is not broadly new in catalytic gas reactions to effect an interchange of heat in the reaction sphere as between the reacting gas therein and fresh gas incoming thereto and in this connection I disclaim anything described or claimed in prior Specification No. 221,229. I make no claim, moreover, to anything claimed in my concurrent Application No. 18,549/27 (Serial No. 304,251).

Having now particularly described and ascertained the nature of the 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. In processes involving gaseous catalytic reactions of the type described, the method of controlling the reaction temperature which consists in effecting an interchange of heat within the zone of reaction as between the reacting gas therein and fresh gas incoming thereto.

2. In processes involving gaseous catalytic reactions of the type described, the method of controlling the reaction temperature so that the whole of the reaction sphere is maintained at the correct temperature and local over-heating or under-heating is avoided, which method consists in effecting an interchange of heat as between the contents of the reaction sphere and fresh gas incoming thereto, at a number of points distributed through the reaction sphere and functioning, either all together, or certain only of them selectively, the latter being the case in the event of it being necessary to counteract a tendency to local over-heating or under-heating.

3. The method claimed in Claim 2, wherein the reacting gas is caused to flow in a stream through the reaction sphere and the fresh gas is caused during the heat transference to pass through the reaction sphere in a direction transverse to the flow of the reacting gas and at selectively controlled points situated one in advance of the other in the direction of said flow.

4. In processes of catalytic gaseous oxidation of sulphur dioxide the method of controlling the reaction temperature claimed in Claim 1, Claim 2 or Claim 3.

5. A process of manufacture of sulphuric acid, which comprises submitting a gas containing sulphur dioxide and oxygen to a process of catalytic oxidation of the sulphur dioxide of the type described and according to any of the preceding Claims 1—3, separating the catalyst from the treated gas and after activating it returning the separated catalyst to the stream of fresh gas, cooling the treated gas and absorbing its content of sulphur trioxide in sulphuric acid, substantially as described.

6. The method claimed in any of the preceding claims, wherein the catalyst is a hard porous gel body, with or without additional catalytic material associated therewith, for example, platinum, copper or iron.

7. Apparatus for use in effecting processes involving gaseous catalytic reactions of the type referred to and according to Claim 1, which apparatus comprises, in combination, a converter, means to pass therethrough a stream of the gas to be treated, means to feed a catalyst in finely divided form into the gas stream so that it becomes suspended and carried along through the converter in said stream, and a tubular heat exchanger situated within the converter in the path of the gas stream therethrough, which exchanger is connected to the inlet of the converter and is arranged to convey thereto fresh gas on its way to the converter, with or without means to regulate the flow of gas in the heat exchanger.

8. Apparatus according to Claim 7, wherein the heat exchanger is of such construction as to cause the gas passing through it to traverse the interior of the converter several times before it reaches the converter inlet.

9. Apparatus according to Claim 7, or Claim 8, and arranged for continuous

operation, which apparatus comprises, in combination with the elements set forth in said claims, means to separate the catalyst from the gas after the reaction, means to activate the separated catalyst and means to re-cycle it back to the gas stream for re-use therein.

10. In apparatus as claimed in Claim 7, 8 or 9, a converter comprising a reaction chamber, a tubular heat exchanger within the chamber, through which exchanger fresh gas is conveyed on its way to the reaction chamber, means connecting the outlet of the heat exchanger to the inlet of the reaction chamber, which exchanger is of sectional construction and comprises a plurality of tubes spaced apart and crossing the interior of the reaction chamber, preferably transversely to the direction of gas flow therein, and valve means associated with the various sections of the heat exchanger whereby one or more of said sections may be cut out at will so as selectively to control the temperature obtaining in the various parts of the interior of the chamber.

11. A converter according to Claim 10, wherein means are provided whereby the fresh gas passing through the heat exchanger is caused to traverse the interior of the reaction chamber first from one side thereof to the opposite side, then back to the first side, again across to the opposite side, and so on, with or without valve means for controlling the inlet and/or the outlet of the reaction chamber.

12. A converter according to Claim 10 or Claim 11 and comprising, in conjunction with the heat-exchange tubes, an inlet conduit common to the tubes and extending along the exterior of the reaction chamber on one side thereof, an outlet conduit common to the tubes and extending along the exterior of the reaction chamber on the opposite side thereof, a fresh gas inlet manifold extending along the first mentioned conduit and communicating therewith at a number of points, a fresh gas outlet manifold extending along the second-mentioned conduit and communicating therewith at a number of points, means connecting the outlet manifold to the inlet of the reaction chamber, and valves in the branches of one or both of the manifolds.

13. A converter according to Claim 12, wherein the conduits are so partitioned along their length as to divide the heat exchanger into sections, with or without the partitions being in staggered relation to one another in the two conduits.

14. A converter according to Claim 12 or 13, wherein the valves in the branches of one or both of the manifolds are independently controlled.

15. The method of controlling the reaction temperature in gaseous catalytic reactions, substantially as hereinbefore described with reference to the accompanying drawings.

16. Apparatus for the manufacture of sulphuric acid by a contact process, which apparatus is constructed and operates as herein described and as illustrated in Figures 3, 4 and 5 of the accompanying drawings.

17. A converter for use in effecting gaseous catalytic reactions, which converter is constructed and operates as herein described and as illustrated in Figure 1, 2 or 6 of the accompanying drawings.

Dated this 20th day of November, 1928.
BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London,
E.C. 1,
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2nd Edition

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

FIG. 1.

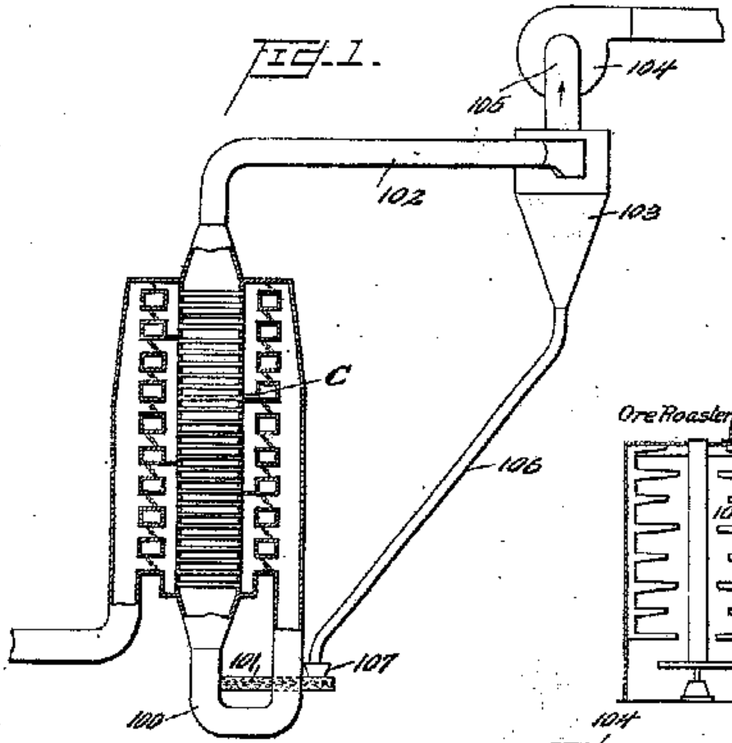
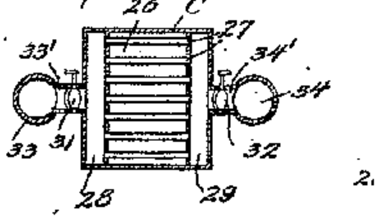


FIG. 4.



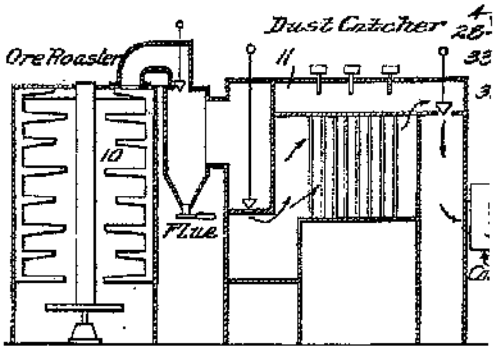
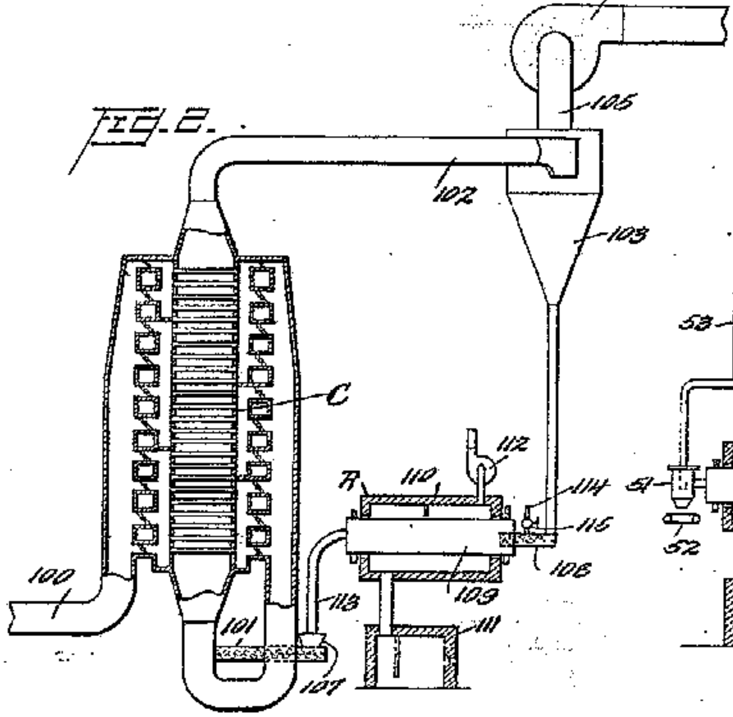


FIG. 2.



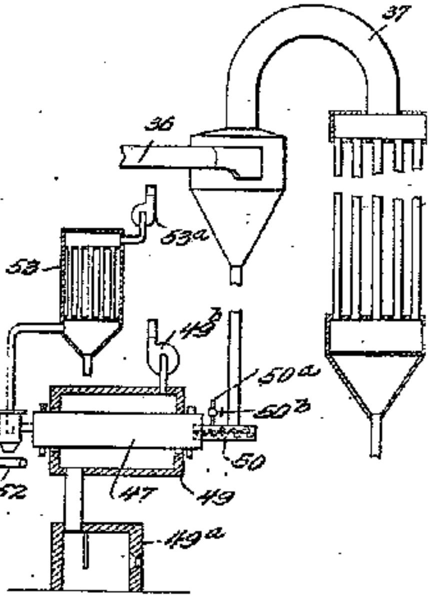


FIG. 4.

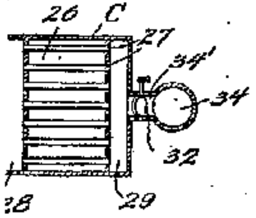


FIG. 3.

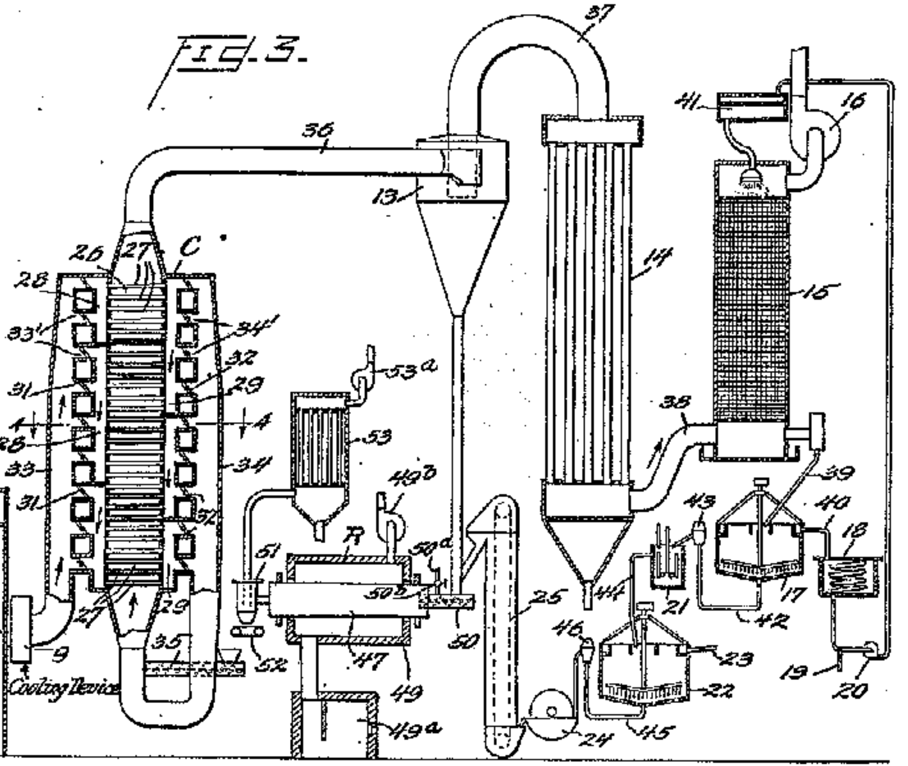


FIG. 5.

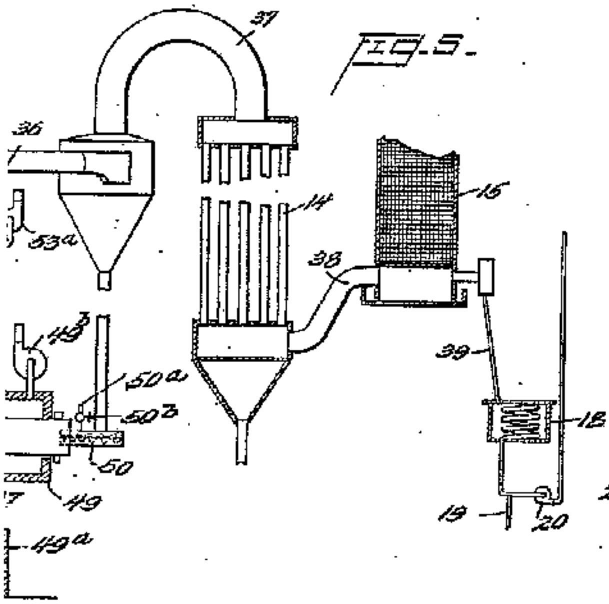
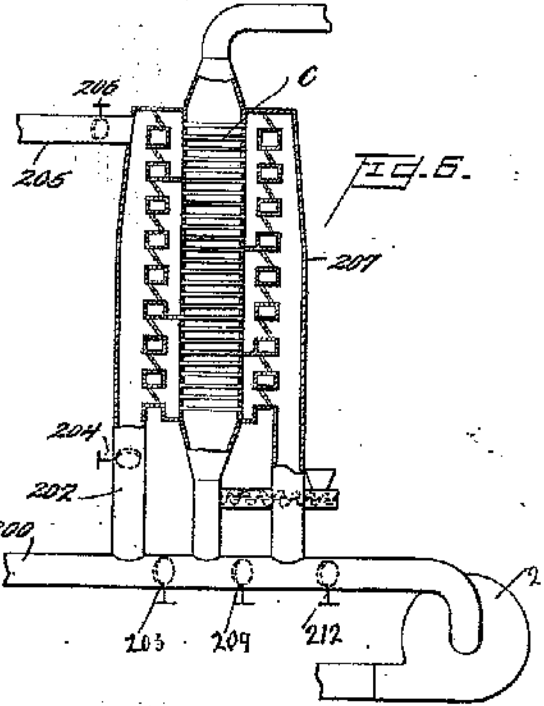


FIG. 6.



2nd Edition

FIG. 1.

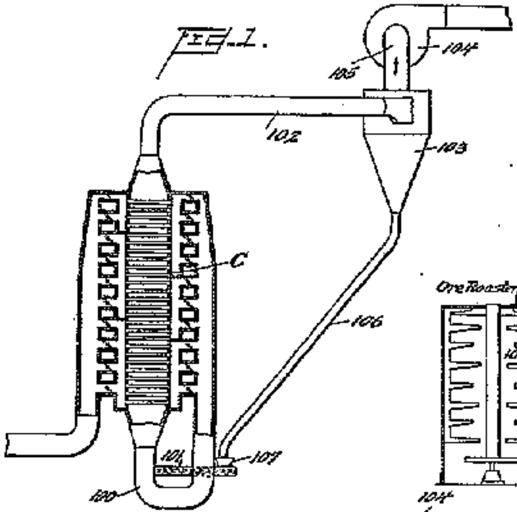


FIG. 4.

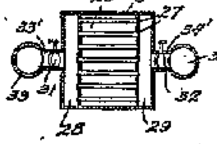


FIG. 3.

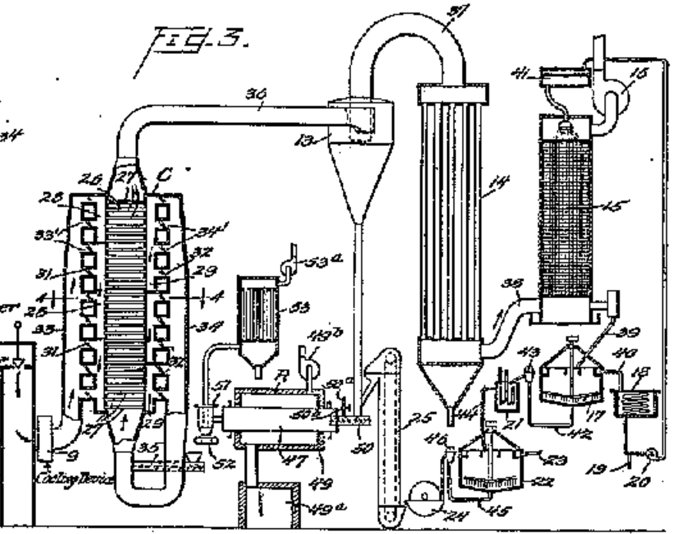


FIG. 2.

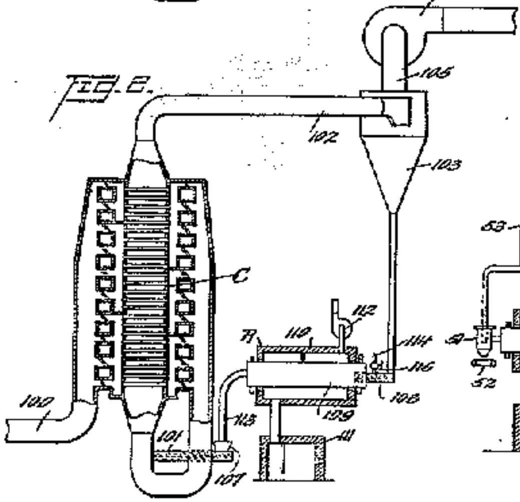
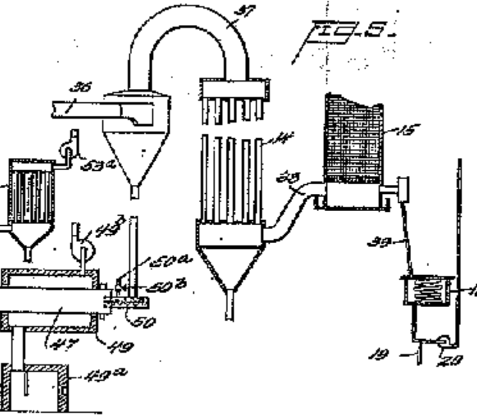


FIG. 5.



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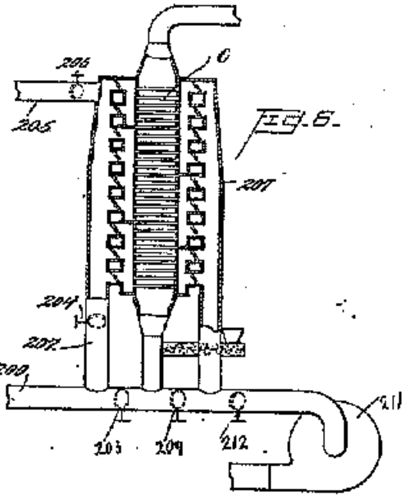

[This Drawing is a reproduction of the Original on a reduced scale]

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