May 24, 1932. G. E. SEIL 1,859,992

METHOD OF AND APPARATUS FOR SUBDIVIDING MATERIAL

Filed April 1, 1926 2 Sheets-Sheet 1

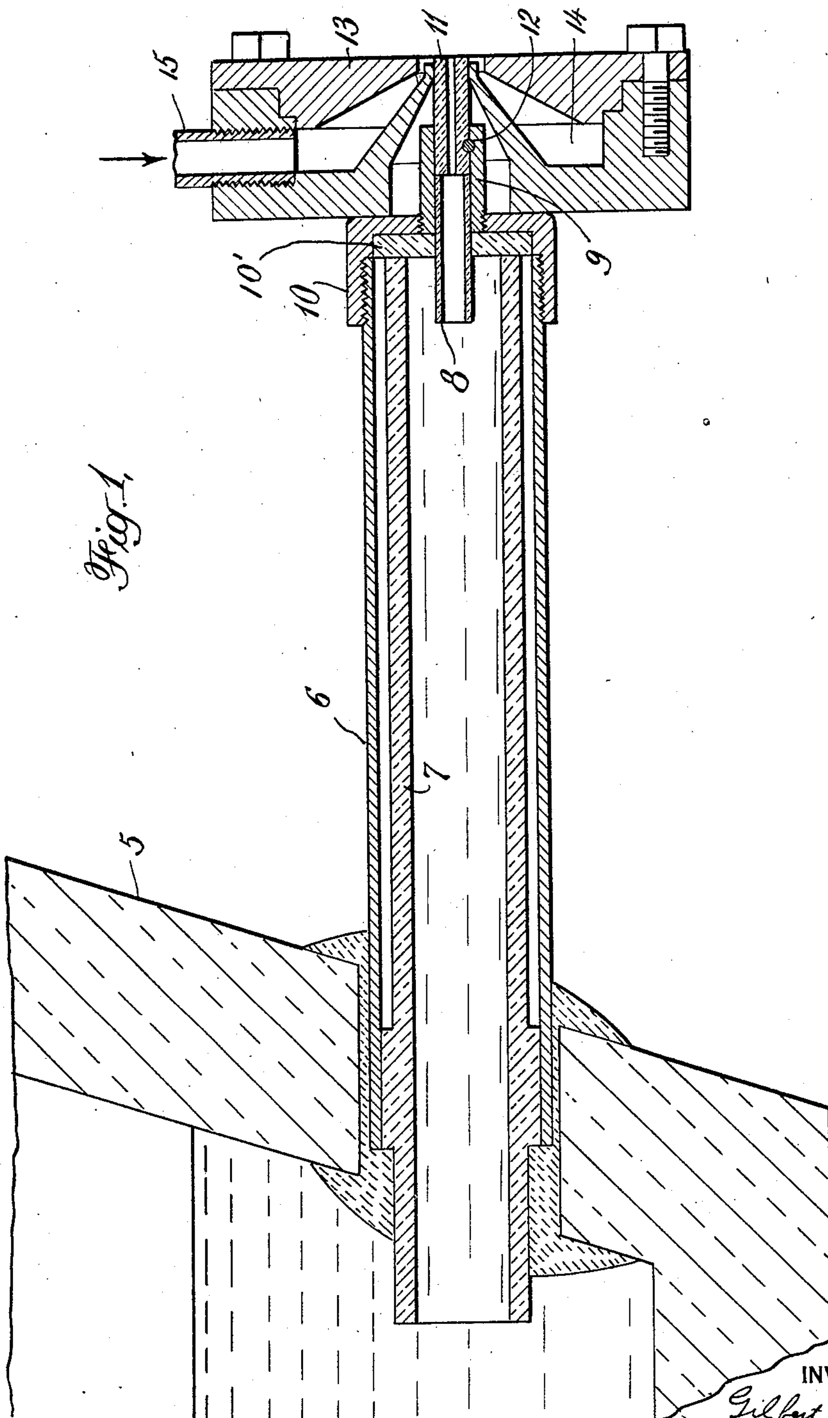

Fig. 1.

INVENTOR
Gilbert E. Seil
BY
Pennie Davis Marvin & Edmonds
ATTORNEYS

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Fig. 2,

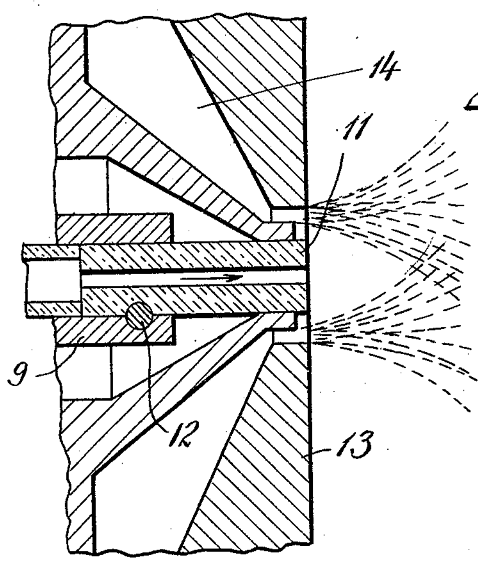


Fig. 3,

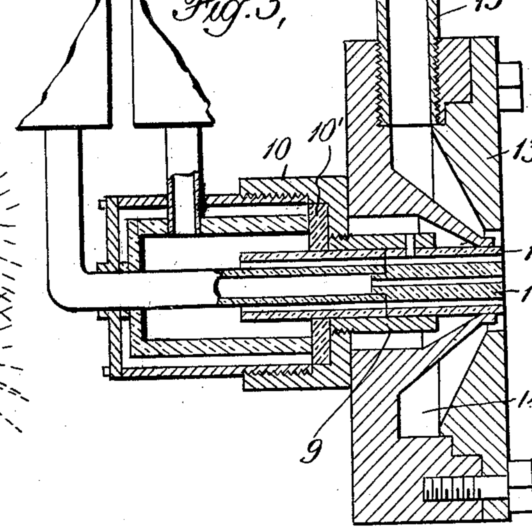
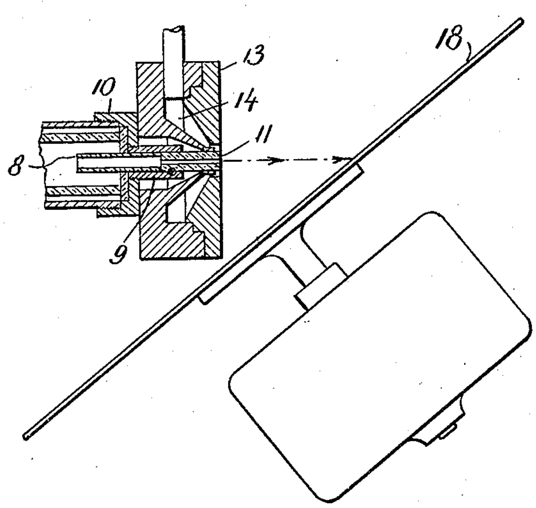


Fig. 4,



INVENTOR
Gilbert E. Seil
BY
Pennie Davis Marvin & Edmonds
ATTORNEYS

Patented May 24, 1932 1,859,992

UNITED STATES PATENT OFFICE

GILBERT E. SEIL, OF NEWARK, NEW JERSEY

METHOD OF AND APPARATUS FOR SUBDIVIDING MATERIAL

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This invention relates to the comminution of materials either with or without additional changes in the physical or chemical condition of the materials treated. The invention may be applied as hereinafter indicated to a variety of purposes by observation of the conditions which are necessary to accomplish the particular object.

The comminution of materials may be the sole purpose of the operation. Thus the reduction of metals or non-metallic materials to a finely divided condition may be desired so that these materials without further change of physical or chemical condition can be utilized for various purposes. Examples are the comminution of the common metals such as lead, zinc, tin and aluminum. The nonmetals, such as sulphur, can likewise be produced in a finely divided form. The invention is applicable, moreover, to the treatment of materials other than the elements such as various gums and resins, bituminous materials and soap. The purpose of the invention includes also the comminution of materials with accompanying physical change as in the homogenization of immiscible liquids or the separation of solvents such as water from the solids which are dissolved therein.

Another important application of the invention is in conducting chemical reactions such, for example, as the production of sulphonated oils and benzene sulphonic acid. The production of metal oxides is another example of the comminution of materials accompanied by a chemical change.

The comminution of metals by subjecting a molten stream of the metal to the action of gaseous jets has been suggested. The earlier attempts in this direction have been unsuccessful and the failure of the suggested methods has been caused primarily by the fact that all depend upon the use of jets or a stream of gas directed to a focus slightly in advance of the orifice through which the molten metal is exuded. Another cause of failure has been the cooling effect of the gas upon the molten stream of metal which causes the stream to congeal before it reaches the point at which comminution is expected.

It is the object of the present invention to avoid the difficulties experienced in previous attempts to accomplish the comminution of materials by the effect of a gaseous stream and to provide a method whereby the successful accomplishment of the desired object can be attained.

Another object of the invention is the provision of a method of comminuting materials and of controlling the conditions of temperature and pressure which affect the operation.

A further object of the invention is the provision of a method permitting the comminution of materials and the simultaneous and further modification thereof either physically or chemically, by the incorporation of the material with other materials which are introduced simultaneously, or by a chemical reaction between these materials.

Other objects and advantages of the invention will be apparent as it is better understood by reference to the following specification and accompanying drawings, in which

Fig. 1 is a longitudinal section through a type of apparatus adapted for the application of the invention;

Fig. 2 is an enlarged detail in section of the outlet nozzle;

Fig. 3 is a similar view indicating an arrangement which permits the combination of two or more liquid materials to accomplish either a physical change in the material in addition to comminution of a chemical reaction between the entering materials; and

Fig. 4 is a sectional view of a different type of apparatus.

In its broader application for the purpose of comminuting materials the invention depends upon the observation of certain fundamental conditions with respect to the manner in which the streams of molten material and of gas are brought together. I have found that successful comminution depends upon the production of a suction effect upon the stream of molten solid material which is to be comminuted. In the attempts made heretofore to accomplish the purpose of the invention a stream or streams of gas under pressure have been introduced annularly about an orifice through which the molten material is delivered, but the streams have been directed to a focus slightly in advance of the orifice. In such an operation the natural expansion of the gas prevents the formation of suction at the orifice and may even create a back-pressure which will prevent the molten material from escaping therefrom. It is essential, as I have discovered, to employ an annular stream of gas under suitable pressure and to direct it so that it expands and creates a partial vacuum in the space directly in front of the orifice to which the molten material is delivered. This result is accomplished when the stream of gas travels in a direction which is initially substantially parallel to the axis of the orifice through which the material to be comminuted is introduced. I have, in fact, succeeded in producing a vacuum in this manner which will sustain a column of mercury eighteen inches in height. As the result of the powerful suction exerted in the zone at the mouth of the orifice through which the molten solid material is delivered, that material cannot longer exist in the form of a homogeneous stream after it reaches the orifice. The stream is torn apart into a multitude of fine particles of infinitesimal size, which are drawn into the surrounding gas stream wherein they are chilled rapidly. The disruptive effect is such that no stream of molten material is visible at the mouth of the orifice. The particles are torn away before the material passes substantially beyond the orifice. The comminuted material may be collected by discharging the gas stream into a suitable chamber from which the gas may escape after the fine particles of metal or other material have settled or have been separated otherwise therefrom.

The application of the method is not restricted to the subdivision of metals in the manner described. Other molten materials can be disintegrated similarly. Sulphur, for example, can be reduced to a state of extreme subdivision by subjecting the molten sulphur to the disrupting effect of suction produced in the manner described. Other materials, including the ordinary gums and resins, can be disintegrated similarly. Bituminous materials, such as the pitches obtained by the distillation and cracking of petroleum, are disintegrated when subjected in a molten condition to the disrupting effect of suction applied to the molten stream. Soap can be powdered and simultaneously dried in a similar way and solutions can be evaporated with the result that the solid content thereof is separated in an anhydrous condition and in a state of extreme subdivision. In utilizing the invention for the purpose of removing water from materials, it is necessary to consider the nature of such materials. Soap, for example, will not lose all of its water at a temperature of 100° C. It is necessary in this case to raise the temperature of the chamber into which the material is discharged to a somewhat higher point, over 110° C., for example, in the production of anhydrous soap powder. The necessary temperature will vary in the treatment of different materials.

The homogenization of immiscible liquids such as fats or oils and water can be accomplished by the simultaneous introduction of these materials together with a stream of inert gas which provides the necessary suction to disrupt the liquids. The liquids are drawn into the gas stream in a finely divided state and intimately mingled so that upon separation from the gas stream a perfect emulsion is obtained. The method lends itself readily to the homogenization of various materials which are normally liquid or can be readily reduced to a liquid state.

The application of the method in conducting chemical reactions permits the production of various products which have been manufactured heretofore only by more complicated and costly methods. The speed of many chemical reactions depends upon the surface contact between the reagents. There is also to be considered the variation in the total heat liberated by or removed from the system in a given time which causes local differences in temperature. These local temperature differences, in fact, determine the direction of the reaction and are very difficult to control by the methods heretofore available. The former methods of increasing surface contact depended chiefly upon the agitation and stirring and in a few isolated cases upon reactions in the gaseous phase where there is a complete diffusion.

It is well known that reactions occurring in the gaseous phase permit the control of temperature and pressure to a predetermined standard. The present invention is adapted to bring the reagents involved into a state approaching that of a gas and consequently to permit the control of temperature and pressure. When, therefore, a chemical reaction such as oxidation is desired there is an ideal condition for the completion of the reaction in the shortest possible time. Thus, for example, the solid material such as a metal to be oxidized is melted and introduced in a molten condition to the point where it comes under the influence of suction produced by an oxidizing gas. The metal is disintegrated immediately and the fine particles are subjected at once to the oxidizing agent with the result that an oxide in finely divided form is produced. Oxides of lead, zinc, tin, aluminum and other metals can be formed by subjecting these metals in molten condition to the action of a stream of air or of oxygen applied in the manner herein described.

In conducting the operation for the comminution of materials without chemical change, it is important to observe the precaution that in the presence of reacting gases such as oxygen the initial temperature of the chamber into which the material is discharged should be relatively low. The cooling effect of the expanding gas prevents then the attainment of a temperature at which a chemical reaction can occur. Thus, if a molten metal is subjected to the suction effect of air there will be no substantial oxidation if the initial temperature of the chamber is below about 150° C. If, however, oxidation is desired the initial temperature of the chamber should be above the ignition point of the metal. Upon contact with the air, for example, the metal will oxidize and the heat thereby released will be sufficient to maintain the oxidizing reaction thereafter. Similarly, in conducting other exothermic reactions the heat of the reaction may be relied upon to maintain it. The operation may be carried on for various purposes with modifications of the temperatures as well as the pressures of the materials treated. Moreover, the temperature and/or pressure of the chamber into which the material is discharged may be varied at will. Heating and cooling means may be introduced at different points in the apparatus to heat or cool the materials treated appropriately either before or after or during the comminution of the materials.

If reactions are to be conducted between reagents which are normally solid, both can be reduced to a molten condition and brought together under the effect of suction produced by the gaseous stream. The materials are disintegrated, incorporated in the gaseous stream, and react immediately to produce the desired product. A reaction can be conducted similarly between the reagent which is normally solid and one which is normally liquid, or between a reagent which is normally solid or liquid and one which is gaseous.

As an example of the application of the invention in conducting chemical reactions between two or more liquids which are immiscible in each other, concentric conduits are employed to permit the introduction of fish oil and sulphuric acid to the zone in which they are simultaneously subjected to suction produced by an inert gas. The two materials are disrupted and intimately mingled in the inert gas such as air. The resulting product is sulphonated fish oil. A marked improvement over the ordinary method of producing this product is evident when it is considered that a rise in temperature above 32° C. produces difficulty ordinarily and results in a considerable loss. The expansion of the stream of air avoids overheating and permits, therefore, the continuous production of a product without loss.

The invention can be applied likewise in the production of benzene sulphonic acid. In this case sulphuric acid enters as a liquid and benzene vapors form the gaseous stream. The stream of benzene produces the necessary suction and disrupts the sulphuric acid which, being drawn into the stream of gas, reacts with the benzene to form benzene sulphonic acid and water. The excess of benzene carries away the water, leaving the benzene sulphonic acid as a dry and finely comminuted solid. The benzene can be dried to remove the water content and returned with such additions as are necessary to the process.

Since some of the materials treated, for example the metals, must be at a relatively high temperature sufficient to maintain their molten condition at the moment when they are subjected to the disrupting effect of suction, it is essential that the apparatus employed be so designed as to prevent any substantial cooling effect either by radiation, conduction or otherwise by the gas employed to produce the suction. In the preferred form of apparatus the gas chamber which surrounds the outlet nozzle has the slightest possible contact therewith and is designed so that the gas does not flow in heat exchange relation with the stream of molten material for any considerable distance. Furthermore, the stream is insulated by non-heat-conducting material from the gas passage.

In the accompanying drawings, Fig. 1 represents a type of apparatus adapted particularly for use in connection with a crucible or other receptacle in which a body of material such as a metal can be maintained in a molten condition. Referring to the drawings, 5 indicates the wall of a crucible in which a pipe 6 of metal is secured. An inner tube 7 of refractory and insulating material such as "Alberene" is supported within the pipe 6 preferably in spaced relation with the wall thereof. A smaller tube 8 also of the same refractory and insulating material is mounted in a collar 9 of metal which is supported in a reducer 10 on the pipe 6. A tip 11 of molybdenum or other suitable metal which is not affected materially by the molten material passing therethrough is held in the sleeve 9 by a pin 12. A washer 10′ of "Alberene" is disposed between the reducer 10 and the end of the tube 7.

The tip 11 extends through an opening in a metal casing 13 having a chamber 14 therein which is adapted to be supplied with gas under pressure through an inlet 15. The gas chamber 14 surrounds the tip 11 and forms an annular orifice through which the gas is ejected. It will be noted that the walls of the orifice are parallel to the axis of the tip so that the annular stream of gas is projected in the direction of the axis. Upon expansion of the gaseous stream it will form the suction pocket in front of the orifice in the tip 11 and the material flowing through the orifice will be subjected to the suction effect so that from the disruption thereof the desired comminution will be accomplished.

In Fig. 3 of the drawings I have illustrated a type of apparatus which is adapted for use in bringing two liquid materials together for the purpose of comminuting these materials and causing either a further physical change therein or a chemical combination of the materials. The apparatus differs from that heretofore described only in the provision of two concentric tubes 16 of refractory and insulating material and corresponding concentric tips 17 of material such as molybdenum or other suitable metal which is not affected materially by the molten reagents. It is to be understood that any number of concentric tubes and tips may be used for the purpose of bringing together two or more materials under the influence of suction produced by the gas stream flowing through the surrounding circular orifice. When two or more materials are brought together under the effect of suction the streams of these materials are disrupted and the particles are brought into intimate relation in the surrounding gas stream. As a result a further physical change such as homogenization may occur or the materials, if of suitable character, may react to produce chemical compounds.

In Fig. 4 of the drawings an apparatus such as that illustrated in Fig. 1 is employed with a plate 18 which provides a surface disposed at an acute angle to the axis of the gas stream. The finely divided particles are caused to impact upon the surface of the plate with the result that the substantially globular particles are flattened. Preferably the plate 18 should be rotated at a relatively high speed. The use of the plate permits the production of flakes of metal or of other materials such as soap.

The nature and pressure of the gas employed to provide the necessary suction will vary, depending upon the purpose to be accomplished. Thus, I may employ air or steam or inert gases such as nitrogen. If active oxidation is desired the gaseous stream may consist of substantially pure oxygen or of a mixture containing a larger percentage of oxygen than is normally present in the atmosphere.

Reducing gases such as hydrogen or mixtures thereof with other gases may also be used. In fact, any gas which is adapted for the purpose of the invention may be utilized to produce the suction and in certain cases the gaseous stream will consist of one of the reacting materials where a chemical combination is desired. I have found that pressures varying from forty to one hundred pounds per square inch are desirable. The pressures will vary depending upon the nature of the operation to be conducted and the character of the materials treated. The pressures noted are not to be considered as limits of the possible pressures to be employed. In general the pressure should be such as to afford the suction effect necessary to accomplish the disruption of the liquid material as it is delivered through the orifice, and I have found that pressures of several hundred pounds per square inch can be employed to advantage in certain cases.

The temperatures to which the material to be comminuted will be subjected will vary likewise in accordance with the nature of the material. It should in general be a few degrees higher than the melting point of the material or sufficient to maintain it in a substantially fluid state until it leaves the orifice and is subjected to the suction effect. Obviously in the case of a metal the temperature will be somewhat higher than in the treatment of materials melting at lower temperatures.

The feeding of the liquid material may be accomplished in any suitable way, it being preferable usually to permit it to flow by gravity from a source in which it is maintained in molten condition to the orifice. Pressure may be exerted, however, upon the liquid by the use of a pump or otherwise so as to force it through the orifice at a velocity higher than that attainable by simple gravity flow.

As an example of the use of the invention to comminute a metal such as zinc, the latter may be melted in a crucible and permitted to flow by gravity to the orifice where it is subjected to the suction effect produced by a stream of air or steam which is delivered at a pressure of, for example, one hundred pounds per square inch. The air or steam thus surrounding the orifice and traveling at high velocity will create suction sufficient to disrupt the stream of molten zinc. The fine particles of zinc will pass into the gas stream and can be deposited therefrom in a suitable chamber. The zinc will be found to be in an extreme state of subdivision and may be utilized for any desired purpose in this form.

Sulphur may be melted likewise and delivered through the orifice in a fluid condition. The molten sulphur should be heated to a temperature of not less than 122° C., at which temperature it has the lowest viscosity. It may be subjected to the action of a stream of air or steam at a pressure of from forty to one hundred pounds per square inch. Steam is preferred because the cooling of the minutely divided particles of liquid sulphur is more readily effected thereby. The cooling is effected more rapidly because of the expansion of the steam which absorbs a large quantity of heat. The minute particles of sulphur cool rapidly and can be separated from the gas.

Products such as gums and resins which are not easily brought to a finely divided condition may be comminuted by subjecting them to a suitable suction in the apparatus described herein. Thus, gums such as resin (colophony), copal, kauri, dammar and benzoin, should be heated to a temperature sufficient to maintain them in a fluid condition. In that condition they can be subjected to suction effect produced by air or steam. These gums are reduced immediately to a finely divided form in which they can be separated from the gas employed in the operation. Bituminous materials such as the residues from distillation and cracking of petroleum can be treated likewise for the production of pulverized products.

The invention can be utilized for drying as, for example, in the recovery of powdered gelatine from a solution thereof. This is accomplished by delivering the gelatine solution through the orifice and subjecting it to the suction effect produced by a stream of air under a pressure, for example, of from forty to one hundred pounds per square inch. The air absorbs the moisture and the gelatine is delivered in the form of fine particles as the result of the subdivision of the solution in the stream of gas which increases the surface exposed to evaporation. In this instance it is essential that the gas saturated with water vapor be removed rapidly from the chamber into which the material is projected. This can be accomplished by employing an air-tight chamber with a vacuum pump connected thereto, the pump having twice the capacity of the volume of gas and water vapor which is projected into the chamber. In a similar way solutions of soap can be subjected to the suction effect for the purpose of recovering the soap in a comminuted state.

Emulsions may be produced such, for example, as emulsions of oil and water by subjecting the oil as it is delivered through the orifice to the suction effect of steam introduced at a pressure of from forty to one hundred pounds per square inch. The stream of oil is disrupted and the fine particles of oil are mingled intimately with the steam. Substantially stable emulsions of oil and water can be produced in this way. Materials such as asphalt can be melted and emulsified in a similar manner.

The production of metal oxides is carried out similarly to the production of comminuted metals. By utilizing oxygen or a gas enriched in oxygen as the gaseous stream to produce the suction the molten metal when subjected to the suction is comminuted and the fine particles are mingled with the highly oxidizing gas. Oxygen under a pressure of from forty to one hundred pounds per square inch will afford sufficient suction for the comminution of many of the metals and the highly oxidizing action of the gas upon the fine particles of metal will produce oxides of the metals in finely divided condition if the temperature is sufficiently high to permit initiation of the reaction. The particles of oxide can be recovered by permitting them to settle in a suitable chamber or by the use of other separating apparatus.

In sulphonating oils the oil, such as a fish oil, and sulphuric acid are introduced through the concentric tubes and are subjected at the orifices of these tubes to the suction effect produced by a gas such as air which is introduced, for example, under a pressure of sixty pounds per square inch. In this case the temperature should not be permitted to rise above 32° C. The control of the temperature is accomplished readily because of the cooling effect of the expanding air. Particles of oil and sulphuric acid react rapidly in the stream of air to produce the desired product, sulphonated fish oil.

The production of benzene sulphonic acid can be accomplished by subjecting a stream of sulphuric acid at the orifice to the suction effect produced by benzene introduced at a pressure, for example, of sixty pounds per square inch. The operation should be regulated so that the highest temperature in the reaction chamber does not exceed 130° C. and is not lower than 80° C. Below 80° C. the reaction is very slow and above 130° C. the product is contaminated with sulphon. The regulation of the temperature is accomplished readily by control of the temperatures of the materials entering the apparatus and of the chamber in which the reaction is conducted. The benzene sulphonic acid produced by the reaction when the finely divided sulphuric acid enters the stream of benzene is a pure and anhydrous product. It is a substantially white solid which separates readily from the excess of benzene. The latter carries the water vapor which is formed by the reaction from the settling chamber. The water can be removed from the benzene by drying and the latter is then available for further use in the operation. Substantially the same method can be employed in the production of nitrobenzene by substituting nitric acid for sulphuric acid.

The foregoing indicates merely some of the applications of the invention and the conditions necessary to the accomplishment of the object. It is possible to conduct various chemical reactions by the application of the principles herein described and the operation can be utilized for comminuting a variety of materials.

Another development of the invention is the production of flakes of metal or other material. The molten material is subjected to the disrupting effect of suction produced by a stream of gas in the manner heretofore described and the stream is projected immediately upon a flat plate having a polished surface which is disposed at an acute angle to the axis of flow and preferably is rotated rapidly by suitable means such as a motor. The comminuted particles traveling at high velocity strike the revolving plate and the particles, instead of being spherical or substantially so, will be flattened, thus producing metallic products in the form of scales. The revolving plate should ordinarily be from six to twenty-four inches from the orifice through which the molten material is delivered to the gas stream. The revolving plate should be disposed at an angle to the axis of the orifice.

The carrying out of exothermic reactions in the manner hereinbefore described releases a considerable amount of heat. For example, in the oxidation of metals to produce metal oxides the heat evolved may be in excess of the amount required to maintain the metal in a molten condition. The heat evolved is carried away from the chamber in which the oxide particles settle principally by the gas employed to provide the necessary suction. The temperature of this gas may in some cases rise to extremely high points, sufficient in fact to melt refractory brick. The heat can be utilized in various ways and particularly in maintaining the liquid condition of the metal or other material entering the apparatus. It may be caused to circulate about the crucible or other container for the metal or other material for this purpose. A part of the heat may be utilized also for the production of steam, for example, which is used either alone or with an admixture of oxygen or other gas to produce suction in the apparatus.

It is impossible to indicate in a brief description of the invention all of the possible uses and advantages thereof and to specify all of the conditions which may be varied in the practice of the invention. The result obtained depends upon the application of a powerful suction to the material as it leaves the orifice, and various changes may be made in the method and in the apparatus employed without departing from the invention or sacrificing any of the advantages thereof.

I claim:—

1. The method of comminuting materials, which comprises subjecting a liquid stream thereof to the suction effect of a surrounding stream of gas traveling at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream and avoiding any substantial heat exchange between the gas and the liquid until the latter is disrupted and mingled with the gas.

2. The method of comminuting materials, which comprises ejecting a liquid stream thereof in a zone of reduced pressure created by a surrounding gaseous stream traveling at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream and avoiding any substantial heat exchange between the gas and liquid until the latter enters the zone of reduced pressure.

3. The method of drying materials, which comprises subjecting a liquid stream thereof to the suction effect of a surrounding stream of gas traveling at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream and avoiding any substantial heat exchange between the gas and liquid until the latter is disrupted and mingled with the gas.

4. The method of physically combining materials, which comprises introducing the materials in separate streams simultaneously to a zone of reduced pressure created by a surrounding gaseous stream traveling at high velocity and inducing by such reduced pressure the comminution of said materials into fine particles and a forward movement thereof into and with the said gaseous stream.

5. The method of physically combining materials, which comprises subjecting liquid streams of the materials simultaneously to the suction effect of a surrounding stream of gas traveling at high velocity in a direction which is initially substantially parallel to the axis of the liquid streams, and thereby cause said streams to expand and divide into fine particles and to move forward and intermingle with the said stream of gas.

6. The method of conducting chemical reactions, which comprises subjecting the material to the effect of the suction of a stream of a reacting gas to disrupt and comminute the material and cause it to move forward and to mingle with the gas in said stream to increase the surface exposure of the material to the gas and avoiding any substantial heat exchange between the gas and the material until the latter is disrupted and mingled with the gas.

7. The method of conducting chemical reactions, which comprises subjecting the material to the effect of the suction of a stream of a reacting gas to disrupt and comminute the material and cause it to move forward and to mingle with the gas in said stream to increase the surface exposure of the material to the gas, avoiding any substantial heat exchange between the gas and the material until the latter is disrupted and mingled with the gas and recovering the heat released by the reaction.

8. The method of conducting chemical reactions between streams of liquid materials, which comprises introducing the materials in concentric streams and reducing them simultaneously to a comminuted state by a gaseous stream.

9. The method of conducting chemical reactions between streams of liquid materials,

which comprises introducing the materials in concentric streams and reducing them simultaneously to a comminuted state in a gaseous stream by the disruptive effect of suction produced by the gaseous stream.

10. The method of conducting chemical reactions between streams of liquid materials, which comprises reducing concentric streams of the materials simultaneously to a comminuted state in a gaseous medium traveling at high velocity in a direction which is initially substantially parallel to the axis of the concentric streams.

11. The method of conducting chemical reactions between streams of liquid materials, which comprises reducing the materials simultaneously to a comminuted state in a gaseous stream by the disruptive effect of suction produced by the gaseous stream traveling at high velocity and in a direction which is initially substantially parallel to the axis of the liquid streams.

12. The method of conducting chemical reactions between streams of liquid materials, which comprises introducing the materials simultaneously in concentric streams to a zone of reduced pressure produced by a gaseous stream.

13. The method of treating materials, which comprises subjecting the material in a liquid state to the suction effect of a stream of gas traveling at high velocity and discharging the material against a rotating surface.

14. In an apparatus for comminuting materials, heat-insulated means for introducing a stream of material to be comminuted in the liquid state and means for directing a surrounding gaseous stream at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream.

15. In an apparatus for comminuting materials, means for introducing concentric streams of the materials to be comminuted in the liquid state and means for directing a surrounding gaseous stream at high velocity in a direction which is initially substantially parallel to the axis of the liquid streams.

16. In an apparatus for comminuting materials, means for introducing a stream of material to be comminuted in the liquid state and means for directing a surrounding gaseous stream at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream, said means being arranged to prevent substantial heat interchange between the liquid and gaseous streams before they are combined.

17. In an apparatus for comminuting materials, means for introducing a stream of material to be comminuted in a liquid state, means for directing a surrounding gaseous stream at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream and a plate disposed at an acute angle to the axis of the liquid stream in the path of the gas.

18. In an apparatus for comminuting materials, means for introducing a stream of material to be comminuted in a liquid state, means for directing a surrounding gaseous stream at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream and a rotating plate disposed at an acute angle to the axis of the liquid stream in the path of the gas.

19. The method of comminuting materials, which comprises subjecting a liquid stream thereof to the suction effect of a surrounding stream of gas traveling at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream and free to expand laterally away from said axis and avoiding any substantial heat exchange between the gas and the liquid until the latter is disrupted and mingled with the gas.

20. The method of comminuting materials, which comprises ejecting a liquid stream thereof in a zone of reduced pressure created by a surrounding gaseous stream traveling at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream and free to expand laterally away from said axis and avoiding any substantial heat exchange between the gas and liquid until the latter enters the zone of reduced pressure.

21. The method of drying materials, which comprises subjecting a liquid stream thereof to the suction effect of a surrounding stream of gas traveling at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream and free to expand laterally away from said axis and avoiding any substantial heat exchange between the gas and liquid until the latter is disrupted and mingled with the gas.

22. The method of physically combining materials which comprises introducing the materials in separate streams simultaneously to a zone of reduced pressure created by a surrounding gaseous stream travelling at high velocity, inducing by such reduced pressure the comminution of said materials into fine particles and a forward movement thereof into and with said gaseous stream, and avoiding any substantial heat exchange between the gas and the streams of materials until the latter are disrupted and minged with the gas.

23. The method of conducting chemical reactions between streams of liquid materials which comprises introducing the materials in concentric streams, reducing them simultaneously to a comminuted state by a gaseous stream, and avoiding any substantial heat exchange between the gas and the liquid materials until the latter are disrupted and mingled with the gas.

24. The method of conducting chemical re-

actions between streams of liquid materials which comprises introducing the materials in concentric streams, reducing them simultaneously to a comminuted state in a gaseous stream by the disruptive effect of suction produced by the gaseous stream, and avoiding any substantial heat exchange between the gas and the liquid materials until the latter are disrupted and mingled with the gas.

25. The method of conducting chemical reactions between streams of liquid materials which comprises reducing the material simultaneously to a comminuted state in a gaseous stream by the disruptive effect of suction produced by the gaseous stream travelling at a high velocity and in a direction which is initially substantially parallel to the axis of the liquid streams, and avoiding any substantial heat exchange between the gas and liquid materials until the latter are disrupted and mingled with the gas.

26. In an apparatus for comminuting materials, means for introducing concentric streams of materials to be comminuted in a liquid state and means for directing a surrounding gaseous stream at high velocity in a direction which is initially substantially parallel to the axis of the liquid streams, said means being arranged to prevent substantial heat exchange between the liquid and gaseous streams before they are combined.

27. In an apparatus for comminuting materials, means for introducing a stream of material to be comminuted in a liquid state, means for directing a surrounding gaseous stream at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream, said means being arranged to prevent substantial heat exchange between the liquid and gaseous streams before they are combined, and a rotating plate disposed at an acute angle to the axis of the liquid stream in the path of the gas.

28. The method of treating materials which comprises subjecting a liquid stream thereof to the suction effect of a surrounding stream of gas travelling at high velocity in a direction which is initially substantially parallel to the axis of the liquid stream, avoiding any substantial heat exchange between the gas and the liquid until the latter is disrupted and minged with the gas, and discharging the material against a rotating surface disposed at an acute angle to the axis of flow.

29. The method of conducting chemical reactions which comprises subjecting concentric liquid streams of materials in reacting proportions to the effect of the suction of a surrounding stream of gas travelling in a direction which is initially substantially parallel to the axes of the liquid streams to disrupt and comminute the materials and cause them to move forward and to mingle with the gas in said stream to increase the surface exposure of the materials to each other and thereby to facilitate the reaction therebetween.

30. The method of conducting chemical reactions which comprises subjecting concentric liquid streams of materials in reacting proportions to the effect of the suction of a surrounding stream of gas travelling in a direction which is initially substantially parallel to the axes of the liquid streams to disrupt and comminute the materials and cause them to move forward and to mingle with the gas in said stream to increase the surface exposure of the materials to each other and thereby to facilitate the reaction therebetween, and avoiding any substantial heat exchange between the gas and the liquid materials until the latter are disrupted and mingled with the gas.

In testimony whereof I affix my signature.

GILBERT E. SEIL.