Nov. 18, 1941. R. C. ROE 2,262,860

STEAM DRIER

Filed Nov. 22, 1939 2 Sheets-Sheet 1

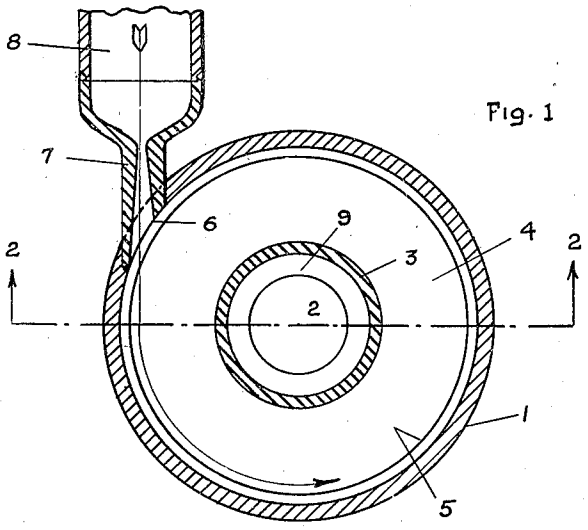


Fig. 1

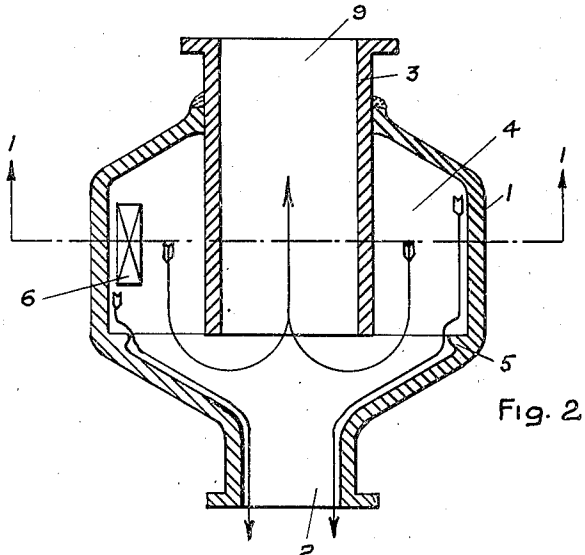


Fig. 2

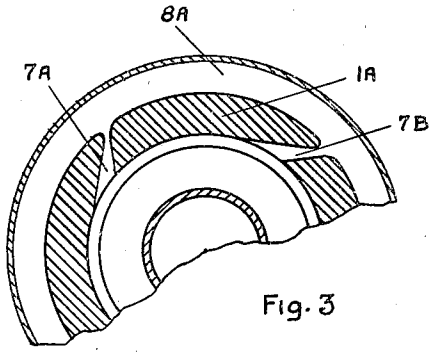


Fig. 3

Inventor

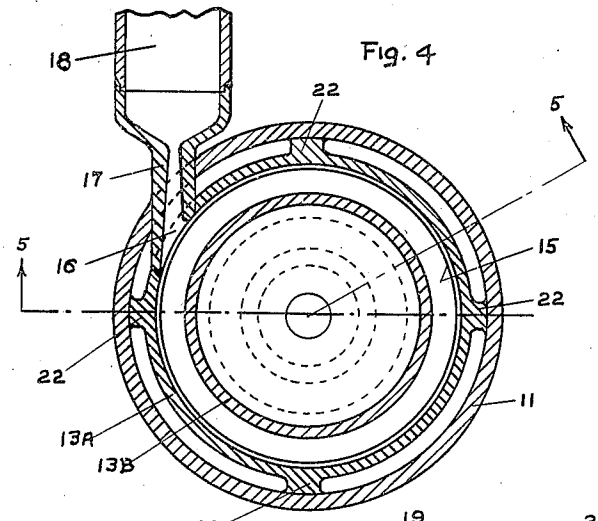
Ralph C. Roe

Nov. 18, 1941. R. C. ROE 2,262,860

STEAM DRIER

Filed Nov. 22, 1939 2 Sheets-Sheet 2

Fig. 4



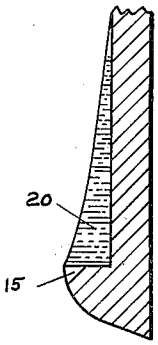


Fig. 6

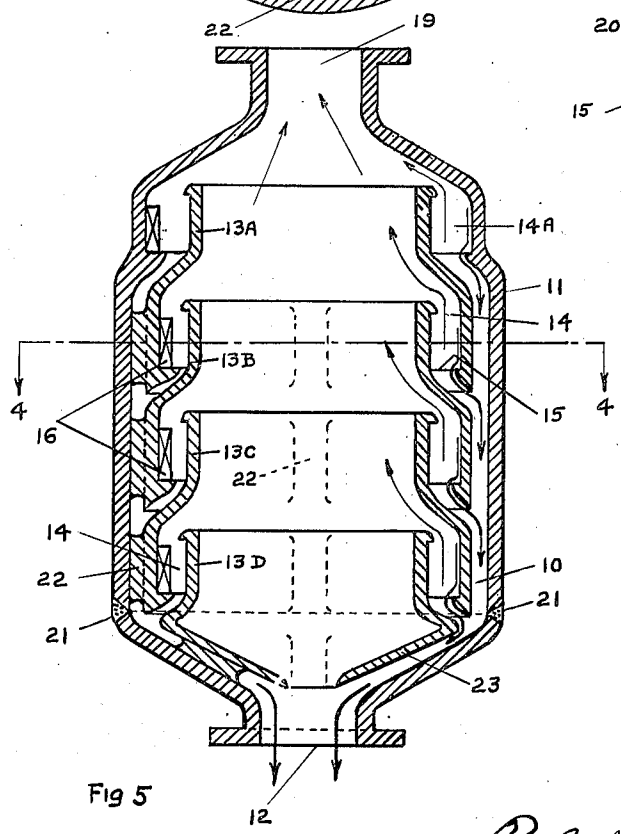


Fig 5

Inventor

Ralph C Roe

Patented Nov. 18, 1941 2,262,860

UNITED STATES PATENT OFFICE

2,262,860

STEAM DRIER

Ralph C. Roe, Englewood, N. J., assignor of one-half to Stephen W. Borden, Summit, N. J.

Application November 22, 1939, Serial No. 305,606

9 Claims. (Cl. 183—83)

This invention of improvements in apparatus for the drying of air and gases, or the separation of liquids from gases, has relation in particular to apparatus for separating water from steam, and the term "steam drier" herein employed is intended to cover apparatus for any or all of the purposes mentioned.

The invention has relation to steam driers of the centrifugal type and has for its object the provision of improvements which shall enable certain advantages to be obtained.

One object of the invention is to provide a steam drier in which the velocity of the steam in the separating chamber is very greatly increased by converting some of the pressure energy of the steam into velocity energy and thereby obtaining a more complete separation of moisture from the steam. Another object is to obtain a very greatly increased velocity but with a very simple type of construction because the simplicity of construction is highly desirable when a multiplicity of such separators are combined into a single unit as hereinafter described.

A further object is to provide a drier of multiple construction whereby a multiplicity of streams of steam, each stream containing a different moisture content, may be led through the multiple drier and each stream will receive separate and independent drying treatment.

In the drawings, Figs. 1 and 2 illustrate a single drier, Fig. 1 being a horizontal section on line 1—1 of Fig. 2, and Fig. 2 being a vertical section on line 2—2 of Fig. 1. Fig. 3 is a similar section to Fig. 1 but showing a multiplicity of nozzles entering a single separation chamber. Figs. 4 and 5 illustrate a multiple type drier, Fig. 4 being a horizontal section on line 4—4 of Fig. 5 and Fig. 5 being a vertical section on line 5—5 of Fig. 4. Fig. 6 is an enlarged view of portion 5 of the drier.

Referring now to Figs. 1 and 2, 1 is an outer casing in the form of a cylindrical or a volute housing and provided with an outlet 2 in the bottom thereof and provided also with an inner casing 3 extending through the upper portion of casing 1 and projecting downwardly inside said casing forming a closed circuit separating chamber 4 between the inside of the outer casing 1 and the outside of the inner casing 3. Inner casing 3 is desirable and it improves the separation but it is not essential. 6 is an opening through which steam is admitted into the separating chamber 4. Thus far the construction is conventional and wellknown in the art. It is readily seen that a cylindrical (or volute) form for separating chamber 4 will provide a steam flow path having a rapidly changing direction and in a closed circuit. However, similar results may be obtained by a guided change in direction, of at least the dry portion of the fluid, without its actually making a complete circle.

Extending from opening 6 and positioned radially to the chamber 4 is a nozzle 7, the exact nature of which is hereinafter defined, for conducting the steam to be dried from a duct member 8 into chamber 4. While I have shown the outlet of the nozzle 7 positioned flush with the inner surface of the outer casing of the separating chamber it is to be understood that this exact position is not essential and that nozzle 7 may project somewhat into the chamber 4, or may be entirely within chamber 4 and that the nozzle may be integral with casing 1 or constituted therein as in Fig. 3 in which 1A is the outer casing and 7A and 7B represent a multiplicity of nozzles receiving wet steam from the duct 8A.

Steam driers may be used under conditions where the pressure and velocity of the steam in duct 8 and the pressure and velocity of the steam as it leaves duct 3 and the pressure and velocity of the moisture and steam, if any, leaving the opening 2 are determined by operating conditions in the system with which the drier is used and cannot be modified for the purpose of obtaining better operation in the drier itself. At the same time if the drier be of sufficient size so that the pressure drop through the drier itself remains within allowable limits then the velocity of the steam within the chamber 4 may not be sufficiently high to produce as high a degree of separation as may be desired.

The trend in modern steam turbine plants is toward higher steam pressures and plants operating well up toward the critical pressure are in contemplation. As the pressure increases the difference in density between the steam and water decreases until at critical pressure they are alike and consequently the separating effect, due to the centrifugal force at any given velocity, becomes increasingly less as the steam pressure is increased and it is therefore apparent that it may be highly desirable to greatly increase the velocity in chamber 4 and it is the purpose of nozzle 7 to produce this increased velocity quite independently of velocity conditions outside the drier and to some degree independently of the area within the separating sections of the drier.

When the drier is dimensioned so that the area of the internal parts such as chamber 4 control the velocity, the velocity must necessarily be comparatively low in order that the friction losses will not be excessive. The velocity may however be increased several times by the use of a nozzle or orifice actually converting pressure energy into velocity energy which is the function of nozzle 7 in my arrangement. Nozzle 7 converting pressure energy into velocity energy increases the velocity in chamber 4 to several times what it would be if the energy conversion nozzle or orifice were not

used. This means in turn that some portion of the steam entering chamber 4 from duct 8 might make several complete circuits around chamber 4 before leaving the drier. Since the centrifugal separating effect increases substantially as the third power of the velocity any increase in velocity greatly facilitates the separating process.

The purpose of nozzle 7 is to convert a portion of the pressure energy of the steam in duct 8 into velocity energy at the exit of the nozzle. A nozzle of this type is really an orifice designed for a predetermined pressure drop and to convert a portion of the available heat in the steam represented by said pressure drop into kinetic energy which results in a tremendous increase in velocity of the jet of steam leaving the nozzle because the energy which was previously a pressure energy has now become a kinetic energy or a velocity energy and is therefore converted from one form of energy to another. The sides of the nozzle or orifice are carefully proportioned so that they occupy the optimum position in the steam path and are not so close to the edge of the steam path as to cause swirls or rotary motion in the steam path itself due to excessive contact with the edge of the path nor so far apart as to produce space into which the steam path will expand and cause regeneration of the energy back to its original form, that is from velocity to pressure. It is thus seen that nozzle 7 must have a very specific design and that a slight variation therefrom may render a nozzle useless for its purpose, as would be a diffuser type nozzle, or inefficient as would be a straight orifice.

Nozzle 7 is the same type of nozzle used in impulse turbines and is used for the same purpose, namely, for converting pressure energy into velocity energy and the principles involved in the design are well-known in the steam turbine design art and complete specifications and formulae are to be found in modern textbooks on steam turbine design and it is thought to be both unnecessary and undesirable to attempt to incorporate this highly technical and cumbersome detail data herein.

In operation the steam to be dried passes from duct 8 through nozzle 7 into the separating chamber 4 around which it travels at extremely high velocity which results in substantially all the moisture being thrown out against the inner wall of casing 1 and it then flows downwardly and finds its way out through outlet 2 while the dry steam is forced inwardly toward the casing 3 and flows around the lower edge thereof and up through the central passage and thence out through opening 9. The purpose of dam 5 is to allow an accumulation of water or at least an accumulation of a dense mixture of steam and water to accumulate. as shown at 20 in Fig. 6, prior to flowing over the dam. This mixture gives a solid body to which rotary motion is imparted by the velocity energy or kinetic energy from the nozzle in much the same manner that rotary motion or power is imparted to the wheel of an impulse turbine. In both cases the velocity energy in the steam jet as produced by nozzle 7 is impinging or striking a solid non-porous surface and this process is more efficient than would be a process whereby the steam jet were striking an elastic fluid such as steam or gas. Therefore, the conversion of velocity energy into rotary motion in the form of power, which produces the velocity required for separation within the separator, is made more efficient by providing a solid substance for rotation by the impact of the incoming steam rather than a more gaseous substance as would be the case without the dam.

Referring now to Figs. 4 and 5. 11 is an outer cylindrical casing having a dry steam outlet 19 at the top and a moisture outlet 12 at the bottom. Suspended within the casing 11, but spaced therefrom, as by members 22, sufficiently to form a vertical waterway as 10, are a number of cylindrical inner casings as 13A, 13B, 13C and 13D. Each of the casings 13A, 13B and 13C consists of an upper and lower portion, the lower portion being of greater diameter than the upper portion and these sections are so positioned within housing 10 that the smaller portion of one is inserted inside the larger portion of the adjacent casing the spaces 14 between the telescoped portions of adjacent casings each constituting an independent separation chamber having its own dry steam and moisture outlets. The uppermost casing 13A forms a chamber, 14A, between itself and the housing 10 and the bottom casing, 13D, has a retracted lower portion, 23, which follows the contour of the housing 11. Each of the drier chambers has an individual wet steam inlet as 16 and each of these inlets is the termination of an individual nozzle 17 which may be fed from an individual duct 18 which may be the terminal of one or more boiler tubes. The nozzle 17 is of the same design as nozzle 7 of Fig. 1 and may be similarly positioned and needs no further comment. Any number of individual units may be combined in a common housing 11 and the number in Fig. 4 has been limited to four elements merely to limit the size of the drawing. The housing may be split for assembly purposes and then joined by a weld as 21.

In operation the steam from duct 18 passes through nozzle 17 into the separation chamber around which it travels at high velocity causing the moisture to be thrown out against the inner wall of casing 13A where it accumulates until it flows over the lip or dam 15, after which it flows into water space 10 and eventually finds its way out through opening 12. The dry steam is forced inwardly against the outer surface of the smaller portion of casing 13B and from there flows upward into the central passage and thence through the upper outlet 19.

A multiple drier of the type shown might be used in connection with a very high pressure boiler of the forced circulation type and in which the pressure is so high that there is a relatively small difference in density between the steam and water. Such a boiler might have, for instance, twenty-five or thirty tube circuits and the steam flowing from these different circuits would have very different moisture contents varying anywhere from a few percent to perhaps fifty percent moisture and the small difference in density between the steam and water means that the steam would not separate sufficiently from the water, by ordinary gravity effect, as in the case of lower pressure boilers. Now, all of these tubes might be led into a common header where the steams of various qualities would, to a certain extent, become co-mingled into one body of steam having characteristics which would be a conglomeration of the various constituent steam flows but it is well known that such mixings represent a considerable loss of power and furthermore, to obtain a complete and reliable mixing is not as simple a matter as might at first

appear and in fact may involve rather large and unwieldly equipment. If the steam be so mixed and then led through a single element drier or separator the most satisfactory separation will not be obtained unless the mixture is uniform so that the moisture content of the steam entering the drier remains practically the same at all times and if the mixture is not complete, then there will be first a steam flow containing one percentage of moisture and then the flow will change to one containing a different percentage of moisture, etc., whereas to obtain the best operating conditions for the separator each individual separator should be designed, particularly with respect to the nozzle, for steam having a definite moisture content.

In my multiple type separator each of the nozzles is designed for the particular quality of steam which it is to handle, thus insuring that all the fluid will be separated in the most efficient manner regardless of its moisture content and furthermore it is obvious that at no stage of the steam making process is it necessary to co-mingle steam flows having different moisture contents.

The term "impulse turbine nozzle" as used herein means a nozzle designed to convert pressure energy into velocity energy in accordance with the principles well known in the art of impulse turbine design.

What I claim is:

1. A multiple steam drier which includes; a multiplicity of cylindrical separation chambers housed in a common pressure tight outer casing having a common dry steam passageway and outlet for dry steam from the multiplicity of chambers and a common passageway and outlet for moisture from the multiplicity of chambers, each chamber having its own independent dry steam outlet to the common dry steam passageway and its own independent moisture outlet to the common moisture passageway and its own independent passageway for connection to an individual source of steam to be dried.

2. A steam drier which includes; a cylindrical housing having a central portion of uniform diameter, a lower end portion of gradually decreasing diameter and terminating in a moisture outlet and having an upper portion of gradually decreasing diameter terminating in a dry steam outlet; a multiplicity of cylindrical casings each having an upper portion of uniform diameter, a lower portion of uniform but greater diameter than the upper section and a portion of gradually changing diameter connecting the upper and lower portions, each of the multiplicity of casings being positioned within the housing and concentric therewith and with the smaller portion of one casing projecting upwardly into the larger portion of the adjacent casing and forming a separation chamber between the inner wall of the larger portion of one casing and the outer wall of the smaller portion of an adjacent casing, with a clearance space between the casings at the bottom of the chamber for the exit of moisture and a clearance space between the casings at the top of the chamber for the exit of dry steam; an opening in each chamber for the admission of wet steam into the chamber and passageways extending from the openings to receptacles containing steam which is to be dried.

3. A steam drier according to claim 2 characterized by the addition of a lip positioned at the lower end of at least one of the cylindrical casings and extending inwardly therefrom to form a dam for the moisture separated from the steam.

4. A steam drier according to claim 2 characterized by the fact that the wet steam passageways have the form of an impulse turbine nozzle immediately adjacent the opening into the separation chamber.

5. A steam drier according to claim 2 characterized by the fact that at least one wet steam passageway has the form of an impulse turbine nozzle designed for wet steam having a specific moisture content.

6. A steam drier according to claim 2 characterized by the fact that at least one of the wet steam passageways has the form of an impulse turbine nozzle designed for wet steam having a specific moisture content and at least one other of the wet steam passageways has the form of an impulse turbine nozzle designed for wet steam having a moisture content which is different from the specific moisture content before mentioned.

7. A steam drier which includes; an outer cylindrical chamber, the central portion of which is of uniform diameter and the lower portion of which is converged to form a cylindrical moisture outlet of smaller diameter than the central portion and the upper portion of which is converged to form a cylindrical dry steam outlet of smaller diameter than the central portion; a cylindrical tubular member positioned in the dry steam outlet and extending downward to approximately the point where the central portion starts to converge into the moisture outlet, thereby forming a separation chamber between the inside of the central portion of the outer casing and the outside of the tubular member; an opening in the separation chamber for the admission of steam to be dried and a lip extending a short distance inwardly from the outer casing and surrounding the lower end of the tubular member to form a dam for assisting in retaining a film of water on the outside wall of the separation chamber.

8. A multiple steam drier which includes; a multiplicity of cylindrical separation chambers housed in a common pressure tight outer casing having a common dry steam passageway and outlet for dry steam from the multiplicity of chambers and a common passageway and outlet for moisture from the multiplicity of chambers, each chamber having its own independent dry steam outlet to the common dry steam passageway and its own independent moisture outlet to the common moisture passageway and its own independent passageway for connection to sources of steam of different qualities to be dried.

9. A multiple steam drier which includes; a multiplicity of cylindrical separation chambers housed in a common pressure tight outer casing having a common dry steam passageway and outlet for dry steam from the multiplicity of chambers and a common passageway and outlet for moisture from the multiplicity of chambers, each chamber having its own independent dry steam outlet to the common dry steam passageway and its own independent moisture outlet to the common moisture passageway and its own independent passageway to the outside of the outer casing for the admission of steam to be dried.

RALPH C. ROE.