

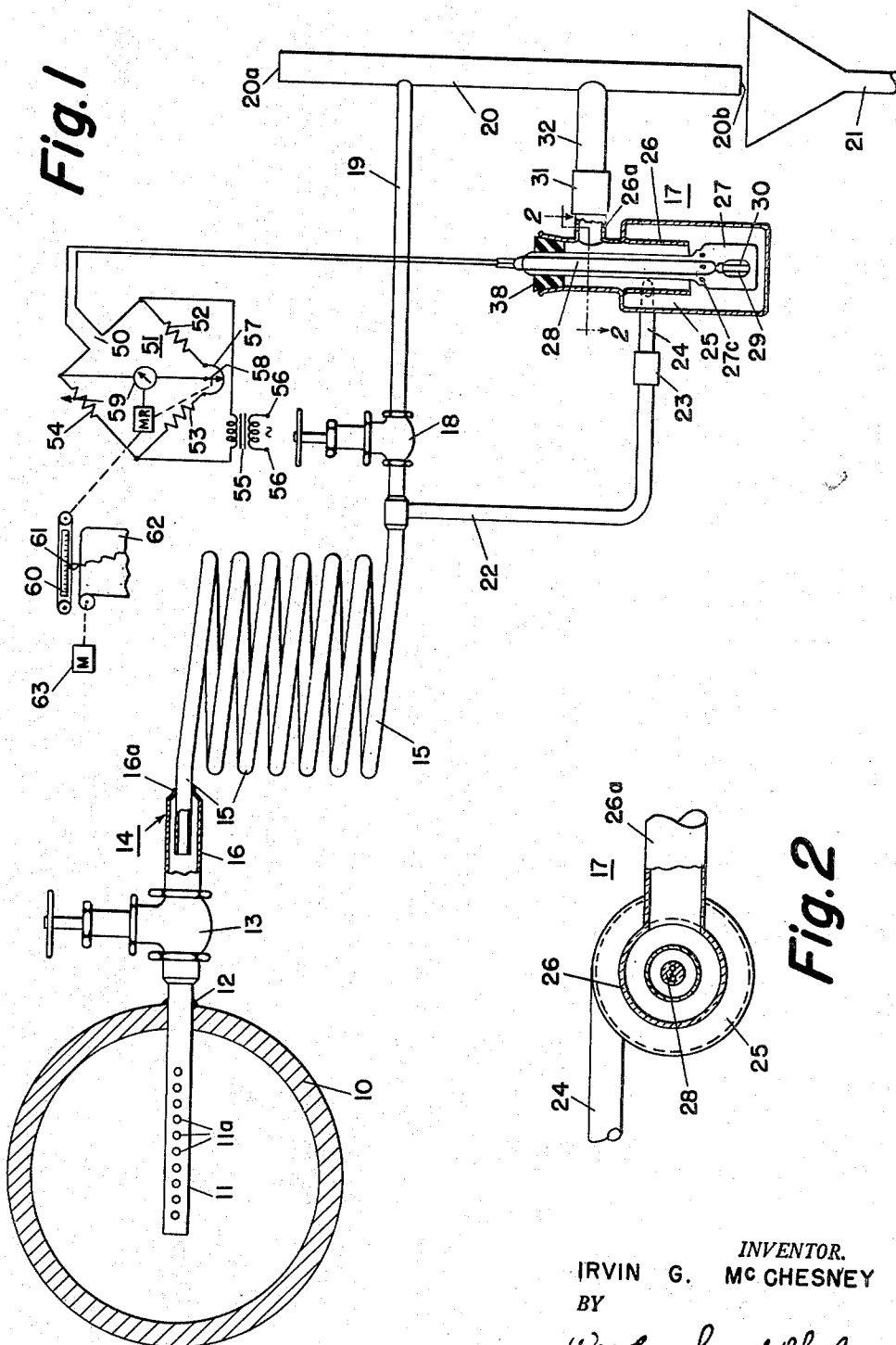
Aug. 24, 1954

I. G. McCHESNEY
CONDENSATE SAMPLING SYSTEM

2,687,185

Filed July 31, 1950

4 Sheets-Sheet 1



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Fig. 3

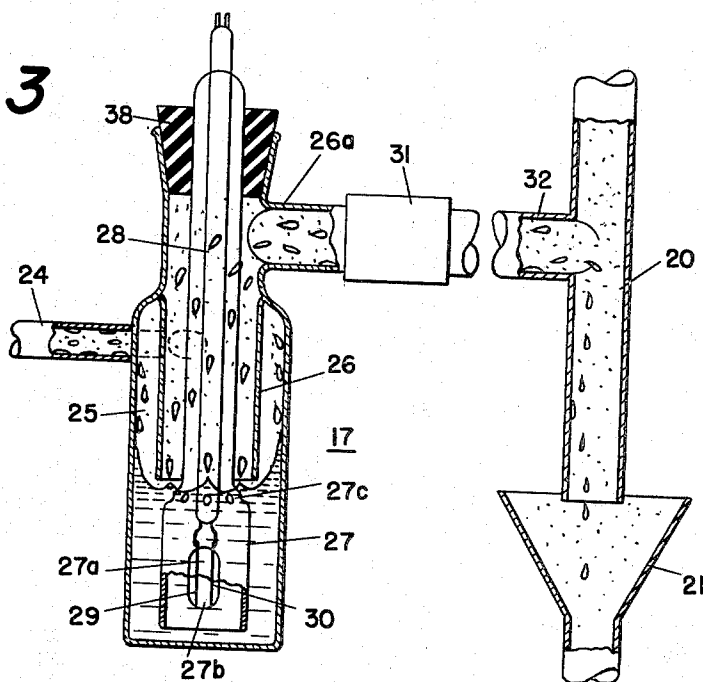
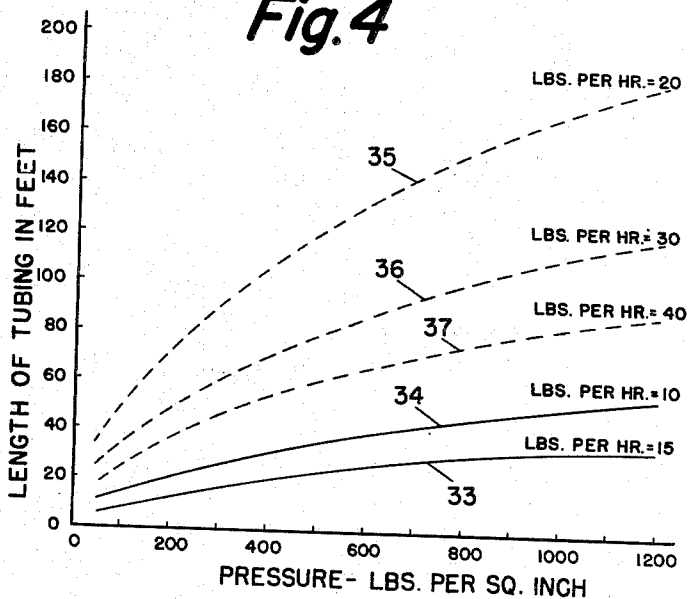


Fig. 4



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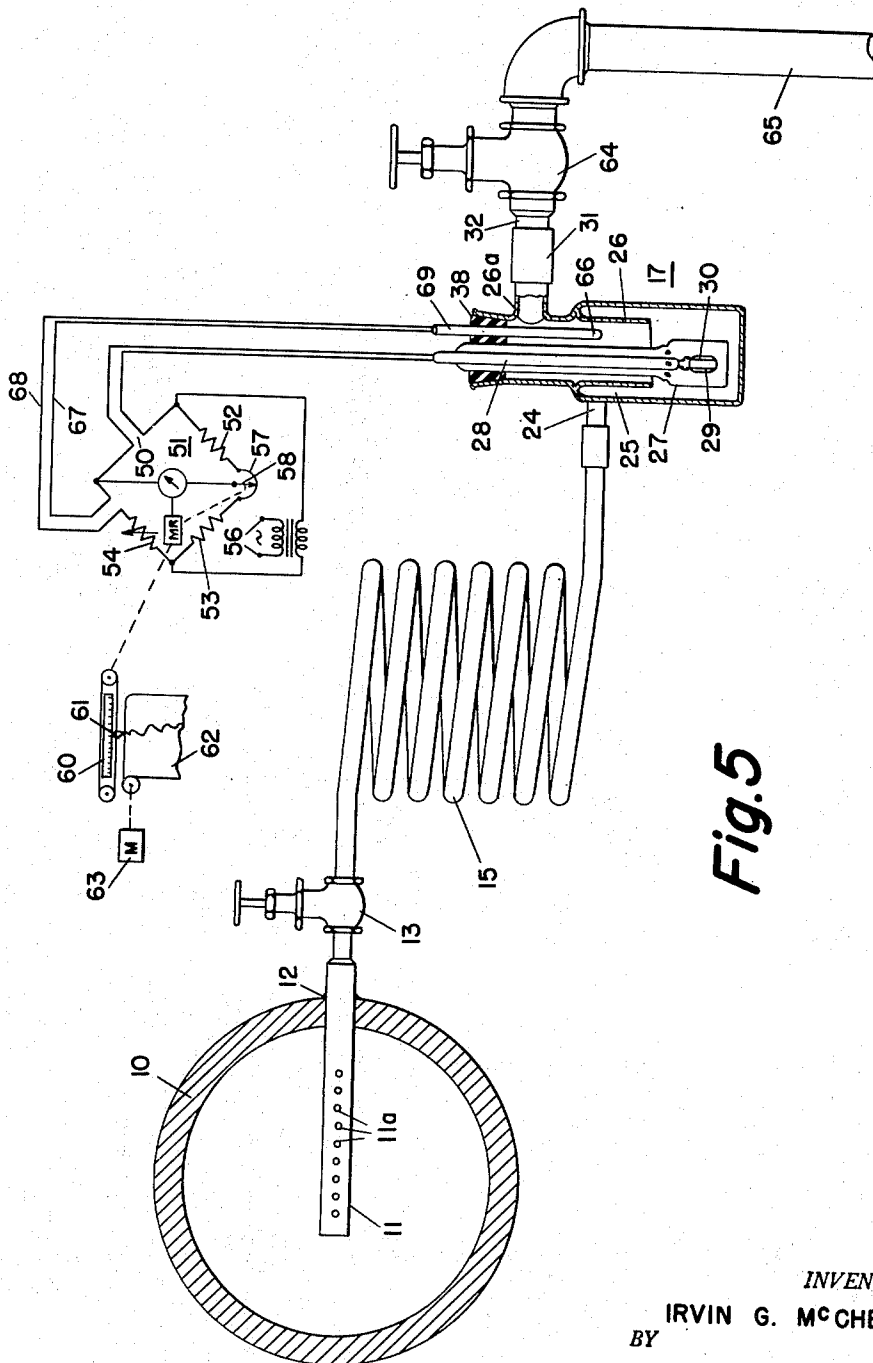


Fig. 5

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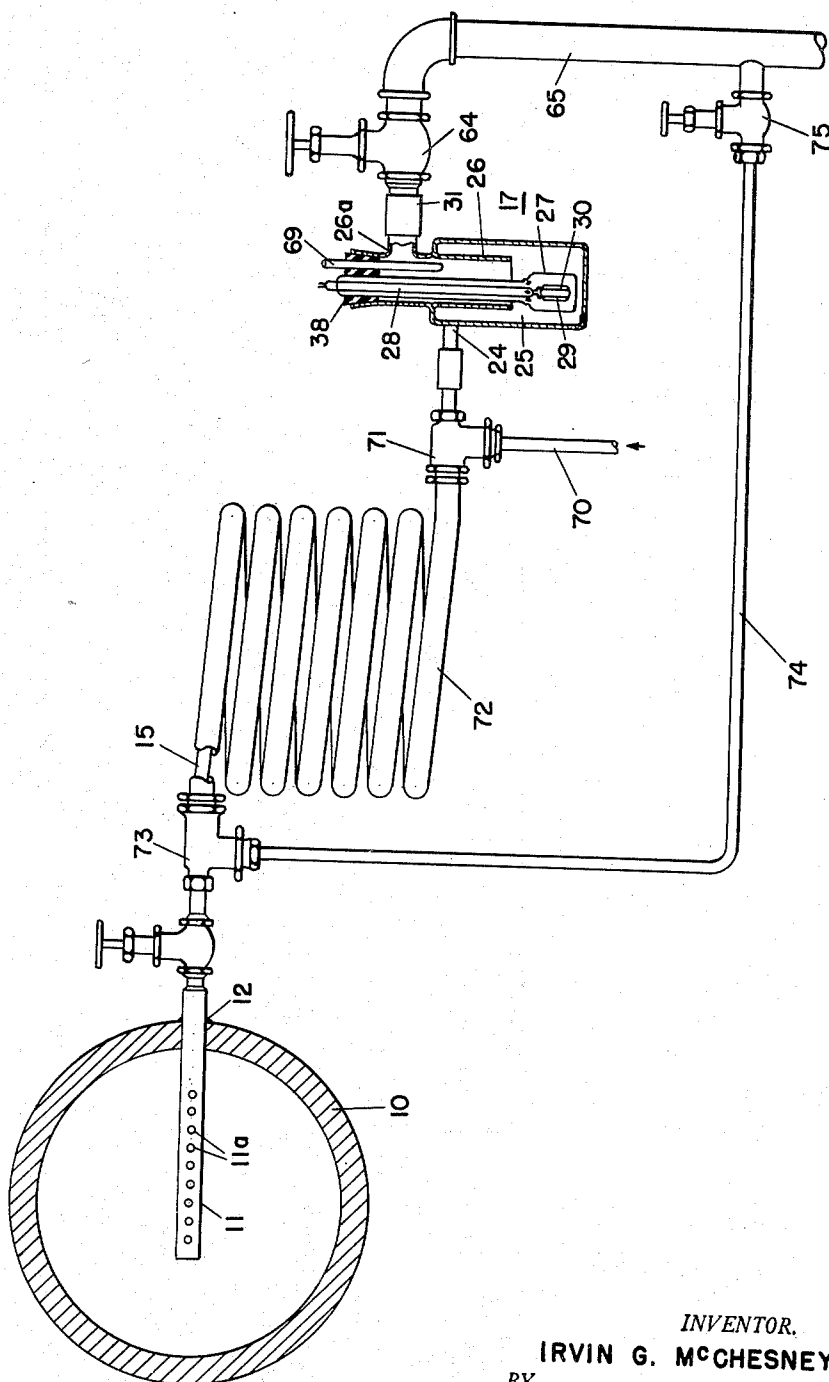
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Fig. 6



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UNITED STATES PATENT OFFICE

2,687,185

CONDENSATE SAMPLING SYSTEM

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Application July 31, 1950, Serial No. 176,895

18 Claims. (Cl. 183—32)

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This invention relates to methods and apparatus for detecting and measuring impurities in a vapor, as in steam, which may be in the form of dissolvable solids carried with the vapor or steam in the vapor line and has for an object the provision of methods and apparatus for producing condensate sampling from a vapor in the presence of contaminating gases without contamination of the condensate by said gases.

The measurement of electrical conductivity of a condensed sample of a vapor is now well established as a satisfactory quantitative means of determining the presence of dissolved solids. That method of analysis also has been found useful in control of contamination of vapors in various processes of manufacturing such as in sugar refining, preparation of tomato juice, and the like. The present invention in general is useful in the analysis by electrical conductivity measurement of materials carried through processing apparatus in vapor form, such as in the manufacture of pharmaceutical products, antibiotics, and in the elimination of pyrogens in preparation of distilled water used for medicinal purposes. The present invention is particularly useful in determining the scale-forming impurities in steam. Where steam is used in power generation, such impurities, dissolvable solids, may be deposited as solids on the blades of the turbine or on the surfaces of heat exchangers, the effect in either case being a loss of efficiency and an increase in hazard of operation.

It has been recognized heretofore that the measurements of the conductivity of a condensed vapor indicate not only the total dissolved solids but also the dissolved gases present. In very dilute solutions the effect of dissociation of the various ions present must also be taken into account. In the past, many schemes have been proposed for lowering the pressure on the condensate and/or applying heat in an effort to remove the dissolved gases and thus to eliminate their effect on the conductivity of the condensate. Gases commonly occurring in vapors include ammonia, carbon dioxide, hydrogen sulphide and sulphur dioxide. Some of these gases, particularly ammonia and carbon dioxide are frequently present in quantity to cause greater effect on the electrical conductivity of the condensed vapors than many of the dissolvable solids carried in suspension in the vapors. In consequence, the effect upon conductivity of such gases, if absorbed by the condensate, will be as great or greater than that of the dissolved solids whose concentration in the condensate is to be ascer-

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tained by electrical conductivity measurement. Moreover, the variation in electrical conductivity due to the dissolvable solids carried by the vapor may have an entirely different effect than that of dissolved gases present in the condensate. Hence, presence of gases in the condensate greatly affect the conductivity measurements and in most cases make it relatively impossible accurately to determine the concentration of the dissolvable solids in the presence of the gas.

While reboiling or other schemes of removing gases in solution in the condensate is a step in the right direction, considerable difficulty is encountered because both acidic and basic gases combine with the condensate upon condensation of the vapor. Hence, only partial removal of uncombined gases can in any event be possible. Moreover, some gases, as in the case of ammonia, will combine with salts dissolved in the condensate altering and increasing the conductivity. The solubility in water of ammonia is so high that total removal by reboiling is also virtually impossible. Moreover, ammonia has a very high conductivity and greatly affects the measurement even though only a small amount remains in the solution. More particularly, if there were present in a solution ten parts per million of carbon dioxide and a half a part per million of ammonia, the conductivity of the solution would be increased by $4\frac{1}{2}$ micromhos. If in such a solution, total dissolvable solids were but one part per million the corresponding conductivity would be but 1.7 micromhos. However, the total observed conductivity would be the sum of the two, or 6.2 micromhos. Obviously, the measurement with gases present in the amounts indicated would be of little value in determining the amount of dissolvable solids present.

In Patent 2,146,312 there is described a method of testing the purity of steam by maintaining the condensate under a vacuum in order to minimize contamination by gases in the condensate. There was also described in said patent the fact that in the liberation of steam, droplets of boiler water containing appreciable quantities of dissolved and suspended materials were entrained with the steam. Such materials mainly comprise inorganic salts, such as sodium hydroxide, carbonates, the phosphates, and the chlorides, and sulphates. While the method and apparatus of the patent are entirely operative and have been used successfully, much was left to be desired in a system which did not require the production of the relatively high vacuum needed for the operation and in which there could be avoided the

need for lengthy water column necessary to the maintenance of a high vacuum on the conductivity cell.

In accordance with the present invention there is obtained condensate from a vapor for determination of its electrical conductivity by a method and apparatus which avoids contamination of the condensate by gases present in the vapor sample. More particularly, the present invention is characterized by the production of turbulent flow of a stream of the vapor along a path from which heat is removed from the stream to form condensate droplets. The vapor in turbulent flow sweeps over the droplets to maintain the surface of the droplets at the boiling temperature of the condensate. There is thus prevented absorption by the condensate of gas in the vapor stream.

Further in accordance with the invention, the vapor stream is introduced into a measuring zone in which there is an abrupt change in direction of the flow of the stream including the vapor, the gases, and the condensate droplets, the change of direction being such as to separate the droplets from the vapor and gases. The condensate droplets are collected in a pool, the conductivity of which can be measured at a subsurface location. The gases and excess vapor are removed in manner to avoid gas-contamination of the collected condensate. In this connection, it is desired to reduce the pressure above the surface of the collected condensate in order to maintain boiling at the surface thereof, the boiling preventing contamination or absorption by the condensate of gases carried with the vapors.

As applied to the measurement of conductivity of steam, there is provided a sampling line of substantial length which discharges steam into a condensate cell with abrupt change in direction of flow. More particularly, it may be connected to the cell to discharge the steam tangentially therein to produce vortical flow therein. The dimensions of the sampling pipe and the differential pressure at opposite ends are such that there is maintained throughout the length thereof turbulent flow of the steam. By inducing the vortical flow within the condensate cell centrifugal action causes the drops of condensate to collect on the walls of the cell and to flow downwardly where they are collected to maintain a predetermined liquid level within the cell. The condensate cell is provided with an inlet to a discharge or outlet passage of somewhat greater diameter than the sampling line and is so disposed and utilized as to maintain a low pressure region above the level of the condensate to induce boiling thereof at the liquid level. Preferably, there is intense boiling at the surface with drops of condensate thrown upwardly from the surface to be picked up or entrained by the steam passing outwardly through the outlet pipe. Thus there is a continuous fresh supply of condensate descending along the wall of the cell and a continuous withdrawal of condensate through the outlet passage located centrally of the cell.

In accordance with the foregoing method and apparatus, electrodes disposed below the level of the condensate are effective for the measurement of the conductivity of the condensate in which there has not been absorbed any of the gases present in the vapor. Not only has the apparatus as a whole been greatly simplified both as regards operation, manufacture and maintenance, but also measurements are now possible substantially unaffected by the gases which have here-

before introduced errors into the determination of the dissolvable solid content of the vapor.

In accordance with a further aspect of the invention, there is avoided the need for any of the heretofore complicated and relatively expensive arrangements which have been proposed to eliminate absorbed gases from the condensate.

For further objects and advantages of the invention, reference is to be had to the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 illustrates a preferred embodiment of the invention with certain parts in section and including diagrammatically a suitable measuring system;

Fig. 2 is an enlarged sectional view taken on the line 2-2 of Fig. 1;

Fig. 3 is an enlarged view of the condensate cell of Fig. 1;

Fig. 4 illustrates graphs presenting design data for the sampling line; and

Figs. 5 and 6 illustrate further modifications of the invention, certain of the parts of each Figure being shown in section.

Referring to the drawings, the invention in one form has been illustrated in Fig. 1 as applied to the determination of the concentration of dissolvable solids in vapor flowing from any suitable source through a supply pipe 10. Extending into the supply pipe 10 is a sampling nozzle 11 shown in the form of a pipe having a plurality of openings 11a facing the direction of flow of vapor. The nozzle 11 may be secured to pipe 10 in any suitable manner, as by welding, as indicated by the welding bead 12. Withdrawn vapor flowing through the nozzle 11 passes through a shut-off valve 13 which is provided only for emergencies, the intent being that the valve 13 shall normally remain in the open position in avoidance of possible abrupt changes in cross-sectional area of the flow passage there-through as might occur due to intermittent opening and closing thereof with resultant dislodgment of deposits of solid material on the interior surfaces of the valve. It is to be observed that the valve 13 is located closely adjacent supply pipe 10 from which extends the sampling line 15.

In avoidance of carry-over of solid particles, a trap 14 is included on the discharge side of valve 13 and in its simple form may include an extension of pipe 15 within pipe 16 of somewhat larger diameter, the larger pipe being welded or otherwise secured to the pipe 15 as indicated by the welding bead 16a.

While the pipe 15 may lead directly to a condensate cell 17, a more general arrangement has been illustrated in Fig. 1 as including a by-pass valve 18 adjustable to regulate the flow of steam through by-pass pipe 19 connected to a discharge pipe 20 which at both ends 20a and 20b is open to atmosphere. The end 20b discharges condensate into a drainage system 21.

From the lower end of the cooling coil formed by sampling line 15 and on the inlet side of valve 18 there extends a pipe 22 which is connected by a coupling 23, shown as a short length of rubber tubing, preferably made from one of the synthetic rubbers such as "neoprene," or the like, to the inlet 24 of the cell 17.

As best shown in the enlarged sectional view of Fig. 2, the inlet 24 enters an annular chamber 25 of cell 17 in a direction tangential thereto and so directs the inflowing vapor as to produce vortical flow within chamber 25. An outlet pipe 26 extends downwardly, Fig. 1, into the condensate

cell 17 and forms the inner wall of the annular chamber 25. The opening in the lower end of pipe 26, forming the inlet to the discharge path, is located just above a plurality of openings 27c of a conductivity cell 27 into which extends a stem 28, having depending from the lower ends thereof electrodes 29 and 30 which are best seen in Fig. 3. Vapor and gases flow upwardly through pipe 26 and outwardly through the pipe 26a, a synthetic rubber coupling 31 and pass by way of pipe 32 into the discharge pipe 20, with downward flow of condensate and with both upward and downward flow of vapor and gases.

In accordance with the present invention, the pressure drop from the inlet of sampling line 15 to the condensate cell 17 is such that there is maintained turbulent flow from inlet head 11 to the cell 17. By maintaining turbulent flow from pipe 10 to cell 17, gases entrained or otherwise present within supply pipe 10 are not absorbed by condensate therein.

The sampling line 15 between the supply line 10 and the cell 17 is of such length that there will be adequate loss of heat to produce discrete particles or droplets of condensate along the sampling line. However, by reason of the turbulent flow maintained within the line, the wall thereof is constantly engaged, scrubbed or washed by hot vapor which is constantly changing its direction of flow. Thus, as a droplet is formed it is brushed or lifted from the inner wall of the pipe and propelled along the pipe toward the cell. The droplets lag behind the flow of the vapor and the gases. Advantage is taken of the fact that the boiling-point temperature of each droplet decreases as the pressure decreases. Hence the exposed surface areas of the droplets of condensate remain at boiling temperature throughout their passage to the cell 17. Their temperature is maintained at the boiling point because of the continuous maintenance of heat-transferring conditions between the vapor stream and the surface areas of the droplets by the turbulent flow, the temperature of the vapor being at least as high as the boiling temperature of the condensate at the pressure to which said droplets are then exposed. Thus, there is avoided any collection of condensate, the exposed surface of which has been at a sub-boiling temperature. By maintaining the surface area of the condensate at the boiling point there is avoided absorption of gases thereby.

The manner in which the droplets form in the sampling line 15 has been indicated diagrammatically in inlet line 24 in Fig. 3. Since there is turbulent flow within lines 15, 22 and 24, it will be understood, of course, that the velocity of the stream therein is relatively high. The diameter of the sampling line 15 will be selected in terms of the pressure drop in order to insure turbulent flow of the vapor therein, as also will be the diameters of the lines or pipes, 22 and 24.

As shown in Fig. 1, the sampling line 15, in order to provide the required length in a compact space, is shown in the form of a coil. The length of the line 15 is selected to provide the amount of cooling needed to produce droplets of condensate during passage of the vapor from supply line 10 to the cell 17. While those skilled in the art will understand how to select the needed length of a line for the cooling requirements, a number of illustrations in terms of a preferred application of the invention, namely, to the determination of the concentration of the dissolvable solids in steam, will be supplied together with the

essential requirements. It is preferred that there shall be condensation of from 25% to 75% by weight of the steam as it arrives at cell 17. As shown by the graphs in Fig. 4, based upon ambient air-cooling at 72° F., the length of the sampling line 15 needed will depend upon the boiler pressure, a longer line of course being required as the pressure increases. While the data of Fig. 4 may be utilized in the design of equipment, it is to be understood that Fig. 4 is not to be taken as limitative upon the scope of the invention as regards requirements of the length of the sampling line 15. Referring now to Fig. 4, if the pressure of steam is of the order of 400 pounds per square inch, with an inside diameter of .061 inch and an outside diameter of .1875 inch for sampling line 15, for a flow of steam through line 15 of the order of 15 pounds per hour, the length of line 15 should be of the order of 20 feet. However, if the pressure should be of the order of 300 pounds per square inch it will be observed that the line 15 would only need to be about 18 feet long, while if the pressure is of the order of 500 pounds per square inch a length of line 15 of about 23 feet would be indicated. Thus, the selection of a median value of about 20 feet would be adequate to take care of a range of pressure changes on the steam in line 10 without adversely affecting the operation of the invention as will be more fully set forth hereinafter. Inasmuch as the condensate cell 17 will function satisfactorily for wide changes in per cent of condensation, a length of line 15 of the order of 20 feet will be quite satisfactory for pressures from 200 pounds per square inch to 600 pounds per square inch, the two limits not being critical in either case. The curve 33 illustrates the relationship between the pressure in pounds per square inch and the length of tubing in feet for a flow of 15 pounds per hour in sampling line 15 having the aforesaid inner diameter while the curve 34 illustrates the same relationship where the flow in pounds per hour through the same sampling line 15 is ten pounds per hour.

Where the internal diameter of the sampling line 15 is increased, as for example to 0.120 inch, with an outside diameter of 0.25 inch, a somewhat longer length of line will be required as indicated by the curves 35, 36 and 37 respectively corresponding with flow rates of 20, 30 and 40 pounds per hour. From the foregoing, those skilled in the art will understand at once how to select proper lengths of the line 15 for any desired set of operating conditions.

In connection with the formation of the condensate droplets within line 15, it is to be understood that water in common with other liquids at a constant pressure boils at a fixed temperature. At the boiling point a large amount of heat is required to convert water to steam and, conversely, in cooling a large amount of heat must be withdrawn to convert steam to water. For example, a pound of water may be heated from room temperature to the boiling point by the addition of say 140 British thermal units (B. t. u.). However, at atmospheric pressure it would require the addition of about 1000 B. t. u.'s to convert a pound of water into steam, the entire conversion taking place at a temperature of 212° F., the boiling temperature of water at atmospheric pressure. Similar relations hold, as are well understood by those skilled in the art, for the higher and lower pressures and for the boiling of liquid other than water. As heat is applied to water it does not instantaneously form

steam as the boiling point is reached. On the contrary, there is heat transfer to particles of water equal to the heat of vaporization so that these particles are evaporated to steam and separate from the main body of the water. The process is exactly the same if heat is lost by the main body of water in the presence of steam at the boiling point. The cooling process involves the condensation of a small quantity of steam which adds heat to the main body of the condensate at the boiling point. These heat exchanges are instantaneous and reversible and during the processes both the steam and the water remain at the boiling temperature until all the condensate is boiled away or until all the steam is condensed. However, if all of the steam and all of the condensate in the system are to be maintained at the boiling point it is necessary to maintain them intimately mixed in such a way that no condensate can be stored at one point of the system and covered with a layer of steam and gases which are quiescent to prevent the heat exchange process between them. If that were to occur, then the radiation from the sampling tube would cool the stored condensate to below its boiling temperature and gases would be immediately absorbed thereby.

With the foregoing understanding of the physical principles involved in the present invention, it will now be better understood that the radiation of heat from the sampling line 15 which results in the cooling of the vapor or steam in turbulent flow through line 15 results in the formation of small droplets of condensate along the line 15, such droplets being shown adhering to the walls of line 24 of Fig. 3 which is to be taken as representative of the phenomena occurring throughout line 15, line 22 and line 24.

As soon as a droplet forms on the inner wall of line 15 it is continuously scrubbed by the vapor or steam in turbulent flow. Thus the surface of the droplet is maintained at the boiling temperature, the temperature of the steam. Additionally the turbulent flow moves each droplet along the inner wall of pipe 24, which because of its movement loses its adherence thereto and then becomes a discrete particle supported and carried forward by the turbulent flow of steam. Because the droplets are somewhat heavier than the steam, they tend to lag behind it, this phenomena also assuring continued scrubbing of the surface of the droplets by the vapor which is at a temperature at least as high as the boiling temperature of the condensate droplets to keep them at their boiling temperature. The lag of the droplets behind the steam has the further advantage that they are contacted by higher temperature steam and thus there is absolute assurance that the surfaces of the droplets shall remain at the boiling temperature.

Since from the supply line 10 to the chamber 17 there is maintained turbulent flow and the heat exchange with the vapor or steam and the droplets, there has been avoided the possibility of any gas absorption by the condensate during any part of the passage between the two points. The reference to turbulent flow within the sampling line has been in the technical sense of that term; that is, a condition of flow in which the head required for the flow is proportional to the square of the velocity in contrast with laminar (or viscous) flow wherein the head varies directly in proportion to velocity. In general, the velocity of flow will be of the order of several hundred feet per second and the flow condition will be up-

wardly of three thousand as expressed in Reynold's numbers.

In the condensate cell 17 the stream in turbulent flow is arranged so that there is an abrupt change of direction of flow thereof, as may be accomplished by impingement of the stream upon a solid surface abruptly to change its direction of flow. By changing the direction of flow of the stream, the condensate droplets are readily separated from the vapor and gases and are collected at the bottom of the chamber to form a liquid level therein.

In the preferred form of the invention, the inlet pipe 24 directs the high velocity stream into the annular chamber 25 in a tangential direction, Fig. 2, and produces in that chamber vortical flow of the stream including the condensate droplets, the steam and the gases. The centrifugal force exerted on the heavier droplets of condensate will move them outward and into contact with the inner surface of the outer wall of the cell 17. These droplets then descend by gravity along the wall to the lower part of the cell, entering a body of condensate collected therein. On the other hand, the gases and steam will flow through a preferential low-resistance path defined by the walls of annular chamber 25 downwardly to its open end, and upwardly through pipe 26 and outwardly through pipe 26a, coupling 31 and pipe 32. The vortical flow of the stream within the annular chamber 25 continues from the upper portion thereof downwardly and, in general, will impart rotary flow to the body of liquid which collects at the bottom of the cell 17.

Though the vortical flow within the annular chamber 25 is not deemed an essential requisite of the invention, it is usefully present in the operation of the embodiment of Figs. 1-3. It is important in accordance with the invention to separate the condensate droplets from the steam and gases under such conditions as to avoid contact of the condensate while below its boiling temperature with gases to prevent their absorption thereby. Such contact cannot occur in cell 17 because of provisions now to be explained. First, the liquid level of condensate within cell 17 is self-regulating. As the condensate level rises from the bottom of the cell 17 to a region approaching the lower end of tube 26 it will be observed that the entrance-area to the inlet of the outlet tube 26, i. e., the space for flow of steam and gases between the level of the condensate and the lower end of tube 26, gradually decreases. As that flow area decreases, the velocity of the gases and steam increases and in accordance with the well-known Bernoulli's theorem is a reduced pressure area created which occurs at the surface of the condensate within the region of the projected area of the inlet end of pipe 26, which, of course, is of less diameter than the outer wall of the cell 17. The lowered pressure at the surface of the condensate reduces the boiling point of the condensate. As a result there is violent boiling of the surface of the collection of condensate in cell 17. As the level of condensate tends to rise, the boiling becomes more and more violent because of the greater reduction of pressure due to the increased velocity resulting from the further decreased area of the flow path. Hence, the droplets thrown upwardly from the violently boiling surface of the condensate below the inlet end of outlet pipe 26 increase in number and are carried off in greater quantity. Thus there is continuous removal of condensate from the pool in cell 17 and constant

replenishment thereof by flow downwardly of condensate droplets along the inner surface of the outer wall of cell 17. The boiling surface of the pool of condensate prevents gas absorption.

It will now be seen that there has been obtained from the supply line 10 a sample of condensate within cell 17 which has at no time been subject to conditions favorable to absorption of gas. Accordingly, the conductivity cell 27 with its electrodes 29 and 30 disposed at a subsurface location within the condensate is effective for the measurement of the conductivity thereof unaffected by gases which may have been present in the sample taken from the line 10. The conductivity cell itself is open at the bottom, with window openings 27a and 27b on opposite sides thereof and is provided with a series of openings 27c near the top and adjacent the lower end of outlet pipe 26, the openings 27c being provided to prevent accumulation of vapor within the cell 27 which within a period of time might be accumulated in sufficient volume to expose one or both of electrodes 29 and 30. The effect of such exposure would be to change the effective area in contact with the condensate and thus due to the change of area would produce an apparent change of conductivity which would not in fact be present.

The lower end of the tube 25 and the level of condensate within cell 17 in effect forms an orifice or flow restriction of variable area. It has been found that a smoother outward flow of the steam and gases is attained by providing an inclined or a chamfered end on the tube 26 of approximately three degrees. While this feature has been illustrated in the preferred form of the invention, it is to be understood it is not essential though it is desirable for conditions of reduced flow within the cell 17.

Inasmuch as there is substantial expansion of the steam and gases upon entry into the cell 17, of substantially larger cross-sectional area than the line 24, there will of course be a reduction of pressure therein. Accordingly, the outlet lines 26, 26a and 32 are of materially larger diameter than sampling lines 15, 22 and 24 in order to decrease the pressure drop in lines 26, 26a and 32.

Another reason for the relative large diameter for the outlet lines, which may be of the order of five-eighths to three-quarters of an inch I. D. (inner diameter), is that the cell 17 in the modifications of Figs. 1 to 3 operates at atmospheric pressure. This will at once be understood by remembering that the pipe 20 is open at 20a and 20b to the atmosphere. The pressure in cell 17 then depends upon the pressure drop through outlet pipes 26, 26a, coupling 31, pipe 32 and the parallel paths through pipe 20 to atmosphere at openings 20a and 20b. Since the pipes forming the discharge path are relatively large in cross-sectional area for the flow of steam, gases, and condensate droplets therein the pressure drop is negligible.

The condensate cell 17 is preferably formed of glass which by reason of its transparency makes convenient visual inspection as to the conditions of operation and is useful to indicate the presence of deposits of undesired colored substances within the cell itself, such as black iron oxide. The outlet pipe 26, of glass, may be formed integrally with the outer wall of the cell 17. Since the cell itself is not subjected to pressures much greater than atmosphere it is feasible to utilize an ordinary rubber stopper 38 to seal the cell 17 and to support the conductivity cell 27 in the illustrated position.

Further in accordance with the invention, it is necessary to avoid diffusion of gases backwardly or in counterflow to the stream leaving through the outlet pipes 26 and 26a. This has been accomplished by lengthening the pipe 32 so that gases cannot diffuse backwardly as far as the cell 17. Experience has indicated that the length of the outlet pipe leaving the cell 17 should be of the order of eighteen inches and above, a length of two feet in general being preferred. This length refers to the point of outlet from chamber 17 to that point in the discharge system which is at atmospheric pressure and at which there is materially reduced rate of flow as in the parallel paths provided by the pipe 20.

Another feature of the invention embodied in the modification of Figs. 1 to 3 resides in the fact that the boiling point of the condensate within the cell 17 remains substantially constant. This follows from the fact that the pressure within the cell 17 is maintained approximately equal to that of the atmosphere at which pressure the boiling temperature of water is substantially constant, 212° F. at sea level. This is a distinct advantage since it obviates the need for temperature compensation in the measuring system later to be described in detail and utilized in conjunction with the modification of Figs. 1-3.

Though not limited thereto, typical dimensions of the cell 17 illustrative of one embodiment of the invention, Fig. 3, are given as exemplary. The outer diameter of cell 17 may be one and three-quarter inches, with the inlet pipe 24 entering at a point about three and three-eighths inches above the base of the cell, and being about three-eighths inch outside diameter. The outlet pipe 26, having its end preferably chamfered at about a 3° angle, will have its lower edge about two inches above the cell base, being made of tubing of about one and one-quarter inch diameter to provide an annular chamber 25 about one-quarter of an inch in radial width. The outlet pipe 26a, having an outside diameter of about three-quarters of an inch, may have its center about four and three-quarters inches above the cell base. The annular junction of outlet pipe 26 and the outer cell wall then would be approximately four inches above the base. The conductivity cell 27 is preferably about one inch in diameter supported by a stem of about five-eighths of an inch in diameter.

While not critical to the invention, it has been found that a flow rate of the stream flowing from pipes 22 and 24 into the cell 17 may be of the order of eight pounds per hour. With such a stream violent turbulence will be required at the surface of the condensate within cell 17 to hold down the liquid level. Yet the condensate will be sufficiently quiescent in the region of electrodes 29 and 30 to prevent exposure thereof during the continuous measurement of the conductivity thereof. If the rate were to be increased materially above eight pounds per hour, the dimensions of the cell would have to be changed in order to prevent turbulence of such violence as would expose the electrodes 29 and 30. By providing the by-pass valve 18, the desired flow to the cell 17 may be regulated as desired, independently of flow within pipe 10, and may be readily set to the desired value, the excess passing by way of pipe 19 to the exit pipe 20. The inclusion of the by-pass valve 18 makes for greater flexibility in the application in the field of a single embodiment of the invention to a variety of conditions without the need to supply a wide variety

of sampling lines 15 as regards length and internal diameter, or cells of different dimensioning.

The electrical system diagrammatically illustrated in Fig. 1 is to be taken as typical of a suitable balanceable measuring system for determination of the conductivity of the condensate. As shown, the conductivity cell 27 including the electrodes 29 and 30 forms an arm 50 of the Wheatstone bridge 51, fixed resistors 52 and 53 being connected in two adjacent arms of the bridge and a variable resistor 54 being connected in the fourth arm of the bridge. The resistor 54 may be adjusted to compensate for variations in temperature due to use of the instrument at different altitudes. One diagonal of the bridge is supplied from the secondary winding of a transformer 55, the primary winding of which is energized from a suitable source of alternating current supply, as indicated, at supply terminals 56. An adjustable resistor 57 of the slidewire type is connected between the arms including resistors 52 and 53 with a contact 58 associated therewith for relative adjustment to bring to zero the potential applied to a sensitive galvanometer 59 of the alternating current type which is connected across the remaining diagonal of the bridge.

The galvanometer 59 preferably forms a part of a mechanical relay MR, the two being associated together in manner fully disclosed in Squibb Patent No. 1,935,732, deflection of the galvanometer 59 producing through the mechanical relay MR relative adjustment between contact 58 and slidewire 57 until there is zero or null deflection of galvanometer 59. Thus, a scale 60 having an associated index or pointer 61 driven by the mechanical relay MR may be calibrated directly in terms of the resistance between electrodes 29 and 30, or in terms of impurities in the condensate. A pen may be combined with index 61 to mark on record chart 62, driven at constant speed by motor 63, a continuous record of the conductivity of the condensate. Resistor 54 has been shown as adjustable to take care of small differences which may appear as between different conductivity cells and for calibration purposes.

It is to be understood that instead of a mechanical relay and galvanometer of the type illustrated, there may be utilized any suitable form of measuring instrument for measuring the unbalance of the Wheatstone bridge 51. The contact 58 may be manually or automatically adjustable. Another type of system suitable for the purpose is disclosed in Anschutz-Kaempfe Patent No. 1,586,233 (Fig. 2). While direct current systems or balanceable networks of other types might be utilized, the alternating current bridge is preferred in avoidance of polarization effects between electrodes 29 and 30.

The embodiment of Fig. 1 is particularly adapted to the measurement of condensate derived from steam at high pressure, that is, substantially above atmospheric pressure and has been successfully utilized for steam pressures as high as of the order of 1250 pounds per square inch though such example is not to be taken as limitative upon the invention since the modification of Fig. 1 is applicable to even higher steam pressures. In the past when it has been desired to measure conductivity of condensate from steam which is at approximately atmospheric pressure there was need of sub-atmospheric sealing means.

In the modifications of Figs. 5 and 6 parts similar to those already described have been given like reference characters. In Fig. 5 the inven-

tion has been illustrated as applied to a supply line 10 in which it will be assumed that there is steam flowing at a pressure substantially that of the atmosphere or lower. In any steam generating plant there are present a number of flow lines where steam pressures of the order of atmospheric or lower will exist. In accordance with the invention, steam is supplied to the sampling coil 15 from line 10, the temperature of the entering steam being materially above ambient temperature.

In contrast with Fig. 1 where the outlet pipe 32 is connected to atmosphere, in the modification of Fig. 5 the outlet pipe 32 is connected by way of control valve 64 to an outlet pipe 65 which is connected to the steam generating system at a point or to a line of lower pressure than that existing in supply line 10, for example, at a pressure of the order of five pounds per square inch absolute. In this manner the temperature of the vapor within the sampling coil or line 15 is maintained not only substantially above ambient temperature but also above the boiling temperature of the condensate. There will be material cooling of the vapor and turbulent flow through the sampling line 15 will be maintained. Droplets of condensate are deposited in the cell 17 as described in connection with Figs. 1-3.

In the modification of Fig. 5 the valve 64 is adjusted to raise the pressure in coil 15 by the amount necessary to maintain a temperature difference between the steam therein and the ambient temperature for the desired cooling of the steam while in turbulent flow therethrough.

In Fig. 5 the valve 13 may be adjusted to regulate the flow within the sampling coil 15 to that which is best adapted for the cell 17 and will ordinarily be of the order of about eight pounds per hour. The valve 64 controls both the quantity of flow through, and the pressure and temperature within, coil 15. Thus there is not needed in the modification of Fig. 5 the by-pass line described in Fig. 1.

It will be remembered that in Fig. 1 the temperature within the cell 17 is maintained at the atmospheric boiling temperature of the condensate since cell 17 in Fig. 1 was at approximately atmospheric pressure.

In Fig. 5 the pressure in cell 17 may vary somewhat over that established at the beginning of a run and the flow rate may change due to change in pressure differential as between line 10 and line 65. In order to take care of all variations of temperature within cell 17 there is preferably included in the balanceable network or bridge 51 a temperature-compensating element connected therein by conductors 67 and 68. The temperature-compensating element 66 may comprise the sensitive element of a temperature-variable resistor having a suitable negative temperature coefficient, such as a "thermistor," suitably supported within a protective housing 69. Suitable temperature-compensating resistors are disclosed in Wainer Patent No. 2,371,660. The housing itself may be supported by the rubber stopper 38, the stopper being provided with two openings, one for the conductivity cell 27 and the other for the housing 69. Thus, the opening for the conductivity cell is slightly off center in contrast with the concentric arrangement of Fig. 1. The compensating element 66 changes its temperature with changes in temperature of the condensate cell 17 and introduces the needed correction into the arm of the bridge 51 to compensate for changes in conductivity between electrodes 29

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and 30 due solely to change in the temperature of the condensate. Thus, the measuring system is maintained in calibration with respect to standard conditions of measurement. This temperature-compensating arrangement may be used in all forms of the invention, if desired.

Referring now to Fig. 6, the invention has been shown as applied to the sampling of steam below atmospheric pressure. With the steam or other vapor flowing through the line 10 at a pressure materially below atmospheric pressure, the exit or outlet line 65 will be connected to a pressure materially below that of the line 10 and sufficiently low as to produce the needed pressure drop between line 10 and line 65 for turbulent flow in the sampling line 15 of the vapor withdrawn through the nozzle 11. With sub-atmospheric pressures both in lines 10 and 65 the temperature within the sampling line or coil 15 will likely be below the ambient temperature (ordinarily assumed to be about 72° F.). Consequently it is necessary to provide additional cooling means, other than air cooling, which may readily be done by cooling coil 15 as by enclosing the coil 15 in a pipe of somewhat larger diameter through which there may be circulation of a cooling fluid, which may be water. The cooling water may flow by way of inlet line 70 through coupling 71 and the outer pipe 72. The cooling fluid or water passes by way of coupling 73 and line 74 to the discharge line 65, a valve 75 preferably being included in line 74 to regulate the rate of flow of the cooling fluid.

It is to be understood that the illustrated counterflow of the cooling liquid is not essential but it is the preferred arrangement. It is to be further observed that in steam power plants the ambient temperature sometimes rises far above 72° F. and may sometimes be as high as 110° F. In any case, it is desirable that the fluid entering through line 70, which may be derived from the condensate pump discharge, will be approximately twenty degrees cooler than the steam entering the cell 17. Thus it will be seen that the cooling requirements of the coil 15 are not excessive and may readily be provided by available streams of condensate in the usual steam plants. Further in connection with the operation of Fig. 6, it is to be remembered that the requirements are not only of turbulent flow of the vapor within the sampling line 15 but also of condensation of the order of 25% to 75% by weight of the vapor stream. Therefore, the cooling fluid entering line 70 must not produce cooling which will yield a greater percentage of condensation of vapor or steam in the line 15 than the indicated upper limit of about 75% by weight. Even though the temperatures within the line 15 are materially below 212° F., it will, of course, be understood that because of the lower pressures existing within the coil 15 the vapors in turbulent flow through the line 15 are at the boiling temperature of the condensate. There is retained the scrubbing action of the steam upon the surfaces of the droplets of condensate which form in the manner described in connection with Figs. 1-5.

While preferred embodiments of the invention have been disclosed, it is to be understood that modifications thereof may be made and features of one modification utilized with other modifications, all within the scope of the appended claims.

What is claimed is:

1. A system of obtaining condensate from a vapor for determination of its electrical conduc-

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tivity in avoidance of contamination by gases present in the vapor which comprises a sampling line, means for producing turbulent flow of a stream of the vapor through said line, cooling means for removing heat from the stream to form condensate droplets, the uncondensed vapor at a temperature at least as high as the boiling temperature of said droplets sweeping the surface of the droplets to maintain the exposed surfaces of said droplets at their boiling temperature to prevent absorption by said droplets of said gases in said vapor stream, means for changing the direction of flow of said stream including said vapor and said gases to separate said condensate droplets from said vapor and said gases, a collection chamber in which said condensate droplets are collected to form a pool of condensate, and an outlet line, said outlet line having an inlet opening adjacent the level of said pool forming therewith a flow-restriction for said stream for reducing the pressure above the surface of the collected condensate to produce localized boiling at the surface thereof.

2. In a method of testing the purity of steam, the steps which comprise discharging steam and gases in turbulent flow into a condensate cell in a direction to produce vortical flow of said steam and gases within said cell, discharging said steam and gases from the upper part of said cell, particles of condensate condensing from said steam accumulating within said cell to form a liquid level therein, and maintaining within said cell a continuously reduced pressure above the level of condensate for violent surface boiling of said condensate and removal of particles thereof with the discharge of steam from said cell.

3. A process of producing from vapor a condensate uncontaminated by gases present during partial condensation of the vapor, which comprises producing along an elongated path turbulent flow of a stream of said vapor including said gases at a temperature at least as high as the boiling temperature of condensate to be formed therefrom, by applying to said elongated path a pressure head, as between inlet and outlet of said path, which maintains flow conditions such that said pressure head is proportional to the square of the velocity of said stream within said path, cooling said stream during its flow along said path to induce formation of condensate droplets, the uncondensed portion of said vapor stream continuing at a temperature at least as high as the boiling temperature of said droplets, sweeping the surfaces of said droplets with said vapor stream to maintain their exposed surfaces at their said boiling temperature to prevent absorption by them of said gases present in said vapor stream, collecting said droplets to form a pool of gas-free condensate while continuously sweeping said droplets with said uncondensed portion of said vapor stream, and sweeping the surface of said pool with said portion of said vapor stream at a temperature at least as high as the boiling temperature of the surface of said pool.

4. A process of producing from vapor a condensate uncontaminated by gases present during condensation of the vapor, which comprises producing along an elongated path turbulent flow of a vapor stream at a temperature at least as high as the boiling temperature of condensate to be formed therefrom by applying to said elongated path a pressure head, as between inlet and outlet of said path, which maintains flow conditions such that said pressure head is proportional to the square of the velocity of said stream within

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said path, cooling said stream during its flow along said path to induce formation of condensate droplets, the uncondensed portion of said vapor stream continuing at a temperature at least as high as the boiling temperature of said droplets, sweeping the surfaces of said droplets with said vapor stream to maintain their exposed surfaces at their said boiling temperature to prevent absorption by them of gases present in said vapor stream, changing the direction of flow of at least a part of said stream including said droplets to separate them from said stream, collecting said separated droplets to form a pool of gas-free condensate while continuously sweeping said droplets with said uncondensed portion of said vapor stream, and sweeping the surface of said pool with said portion of said vapor stream at a temperature at least as high as the boiling temperature of the surface of said pool.

5. A process of producing from vapor a condensate uncontaminated by gases present during condensation of the vapor, which comprises producing along an elongated path turbulent flow of a vapor stream at a temperature at least as high as the boiling temperature of condensate to be formed therefrom by applying to said elongated path a pressure head, as between inlet and outlet of said path, which maintains flow conditions such that said pressure head is proportional to the square of the velocity of said stream within said path, cooling said stream during its flow along said path to induce formation of condensate droplets, the uncondensed portion of said vapor stream continuing at a temperature at least as high as the boiling temperature of said droplets, sweeping the surfaces of said droplets with said vapor stream to maintain their exposed surfaces at their said boiling temperature to prevent absorption by them of gases present in said vapor stream, collecting said droplets from at least a portion of said stream to form a pool of gas-free condensate, reducing the pressure above said pool of condensate to induce surface boiling, and sweeping the surface of said pool with said portion of said vapor stream at a temperature at least as high as the boiling temperature of the surface of said pool, and removing vapor and gases from above said pool of condensate.

6. A process of producing from vapor a condensate uncontaminated by gases present during condensation of the vapor, which comprises producing along an elongated path turbulent flow of a stream of said vapor including said gases at a temperature at least as high as the boiling temperature of condensate to be formed therefrom by applying to said elongated path a pressure head, as between inlet and outlet of said path, which maintains flow conditions such that said pressure head is proportional to the square of the velocity of said stream within said path, cooling said stream during its flow along said path to induce formation of condensate droplets, the uncondensed portion of said vapor stream continuing at a temperature at least as high as the boiling temperature of said droplets, sweeping the surfaces of said droplets with said vapor stream to maintain their exposed surfaces at their said boiling temperature to prevent absorption by them of said gases present in said vapor stream, collecting said droplets from at least a portion of said stream to form a pool of gas-free condensate while continuously sweeping said droplets with said uncondensed portion of said vapor stream, passing said vapor stream through an outlet passage having its inlet disposed above said

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condensate pool, rise and fall of the liquid level of said condensate pool varying the area of said inlet through which said vapor stream passes, whereby with rise and fall of said liquid level surface boiling is induced for a rate of removal of condensate from said pool to maintain a self-regulating liquid level of said pool, and sweeping the surface of said pool with said portion of said vapor stream at a temperature at least as high as the boiling temperature of said surface of said pool.

7. A process of producing from vapor a condensate uncontaminated by gases present during condensation of the vapor, which comprises producing along an elongated path turbulent flow of a stream of said vapor including said gases at a temperature at least as high as the boiling temperature of condensate to be formed therefrom, said flow condition being upwardly of 3,000 as expressed in Reynolds numbers, cooling said stream during its flow along said path to induce formation of condensate droplets, the uncondensed portion of said vapor stream continuing at a temperature at least as high as the boiling temperature of said droplets, sweeping the surfaces of said droplets with said vapor stream to maintain their exposed surfaces at their said boiling temperature to prevent absorption by them of said gases present in said vapor stream, collecting said droplets from at least a portion of said stream to form a pool of gas-free condensate, while continuously sweeping said droplets with said uncondensed portion of said vapor stream, passing said portion of said stream through an outlet flow path having an inlet disposed above said pool, rise and fall of the liquid level of said pool varying the area of said inlet through which said portion of said stream passes, and inducing surface boiling of said pool by decreasing said area with rise in said liquid level, change in the degree of surface boiling varying the rate of removal of condensate from said pool to maintain a self-regulating liquid level.

8. A process of producing from vapor a condensate uncontaminated by gases present during condensation of the vapor, which comprises producing along an elongated path turbulent flow of a vapor stream at a temperature at least as high as the boiling temperature of condensate to be formed therefrom, cooling said stream during its flow along said path to induce formation of condensate droplets, the uncondensed portion of said vapor stream continuing at a temperature at least as high as the boiling temperature of said droplets, sweeping the surfaces of said droplets with said vapor stream to maintain their exposed surfaces at their said boiling temperatures to prevent absorption by them of gases present in said vapor stream, changing the direction of flow of at least a portion of said stream including its said droplets to separate them from said stream, collecting said separated droplets to form a pool of gas-free condensate while continuously sweeping said droplets with said uncondensed portion of said vapor stream, passing said vapor stream along a flow passage adjacent the liquid level of said pool to maintain the reduced pressure along the surface thereof to induce surface boiling of said pool of condensate, and removing condensate boiled from said surface in mixture with said uncondensed portion of said stream through an outlet path having a length sufficiently great to prevent counter-flow diffusion of gas in contamination of condensate collected in said pool.

9. A process of producing from vapor a condensate uncontaminated by gases present during condensation of the vapor, which comprises producing along an elongated path turbulent flow of a stream of said vapor including said gases at a temperature at least as high as the boiling temperature of condensate to be formed therefrom and with the turbulent flow having a Reynolds number above about 3,000, removing heat from said stream to induce formation of condensate droplets, the uncondensed portion of said vapor stream continuing at a temperature at least as high as the boiling temperature of said droplets, sweeping the surfaces of said droplets with said vapor stream to maintain their exposed surfaces at their said boiling temperature to prevent absorption by them of gases present in said vapor stream, said droplets not exceeding 75% by weight of said vapor stream, collecting from at least a portion of said stream its said droplets to form a pool of gas-free condensate while continuously sweeping said droplets with said uncondensed portion of said vapor stream, passing said portion of said vapor stream through an outlet passage having an inlet adjacent a desired liquid level for said pool, and varying the velocity of flow of said portion of said vapor stream in the region above said desired level of said pool to induce surface boiling of said pool of condensate at a rate which maintains substantially constant the liquid level of said pool.

10. The method of testing the purity of steam by measurement of a physical characteristic of a pool of condensate uncontaminated by gases present in the steam, which comprises producing throughout the length of an elongated path turbulent flow of steam under pressure at the inlet of said path, the length and cross-sectional area of said elongated path establishing flow conditions for said steam such that the pressure head producing said turbulent flow of said steam throughout the length of said path is proportional to the square of the velocity of said vapor along said path, continuously removing heat from said steam while in said turbulent flow through said elongated path to produce particles of condensate within said path, said steam continuing at a temperature at least as high as the boiling temperature of said condensate particles, sweeping said condensate particles with said steam in turbulent flow to maintain their exposed surfaces at their boiling temperature to prevent absorption by them of gases present in said steam, after passage through said path directing at least a portion of said flow of said steam and said particles of condensate into a condensate cell in a direction to produce vortical flow of said steam and said particles of condensate, collecting said particles to form a liquid level in said cell, and discharging from a central zone of said cell uncondensed steam and gases carried thereby during continued flow of condensate particles into said cell.

11. The method of determining the dissolvable solid content of steam in the presence of gases by producing from the steam condensate uncontaminated by said gases, which comprises passing steam in turbulent flow throughout an elongated tube, the length of said tube forming a cooling surface adequate to cool the steam for formation of particles of condensate, with uncondensed steam continuing at a temperature at least as high as the boiling temperature of said condensate particles, scrubbing the surfaces of said condensate particles with said uncondensed steam to maintain their exposed surfaces at their said

boiling temperature to prevent absorption by them of the gases present in said steam, discharging said uncondensed steam and said particles of condensate from said tube into a condensate cell in a direction tangent to a wall thereof to produce vortical flow within said cell, the particles of condensate collecting within the cell to form a pool therein, removing said uncondensed steam and the gases included therein from a central region of said cell, maintaining reduced pressure conditions centrally of said cell to induce surface boiling of said pool of said condensate to prevent absorption of gases thereby, removing along with said uncondensed steam and said gases particles of condensate boiled from said pool, and passing said uncondensed steam, its gases and condensate boiled from said pool through a discharge pipe having a length exceeding the range of counterflow gas diffusion from the outlet thereof to said cell.

12. The method of determining the concentration of dissolvable solids in steam by electrical conductivity measurements of condensate formed therefrom substantially unaffected by gases present in said steam, which comprises passing steam in turbulent flow through a tube connected to a condensate cell, the flow condition throughout said tube being expressed by Reynolds numbers upwardly of 3000, said tube having a length providing a cooling surface adequate for removal of sufficient heat to induce the formation of droplets of condensate, the uncondensed portion of said steam and the gases contained therein continuing at a temperature at least as high as the boiling temperature of said droplets, sweeping the surfaces of said droplets with said uncondensed steam to maintain their exposed surfaces at their said boiling temperature to prevent absorption by them of said gases present in said uncondensed steam, directing said uncondensed steam and said droplets from said tube into said cell in a tangential direction for vortical flow thereof, separating said droplets from said uncondensed steam by their movement to the walls of said cell due to centrifugal force produced by said vortical flow, and removing at a region in said cell above a collected pool of liquid condensate said uncondensed steam and the gases present therein.

13. A system of producing from vapor under pressure a condensate uncontaminated by gases present during partial condensation of the vapor, which comprises a sampling line, means for passing said vapor and gases into the inlet of said line for their turbulent flow throughout the length of said line from said inlet to the outlet thereof, the diameter and length of said line establishing flow conditions for said vapors and gases such that the pressure head producing said turbulent flow through said line is proportional to the square of the velocity of the stream of said vapor and said gases along said line, cooling means for removing heat from said vapor within said line to induce the formation of condensate droplets within and along the length of said line, the uncondensed portion of said vapor continuing at a temperature at least as high as the boiling temperature of said droplets, said uncondensed portion of said vapor sweeping the surface of said condensate droplets to maintain their exposed surfaces at their boiling temperature to prevent absorption by said droplets of said gases present in said stream, means including a condensate cell connected to said outlet of said line for changing the direction of flow

of said stream to separate the condensate droplets from the uncondensed portion of said stream, said cell including a collection chamber in which said condensate droplets are collected to form a pool of condensate, and an outlet line extending downwardly into said cell for removing said uncondensed portion of said stream from said cell at a level below the point of connection of said line to said cell, rise and fall of the level of condensate toward and away from said outlet line varying the pressure over the surface of said pool of condensate to maintain boiling conditions at said surface to prevent absorption by said pool of condensate of said gases present in said stream.

14. The method of preventing gas absorption by a pool of condensate, which comprises directing into a sampling cell a stream comprising a mixture of gases, droplets of condensate and uncondensed vapor at a temperature at least equal to the boiling temperature of the condensate droplets, separating from said stream said droplets for collection of condensate within said cell, removing through an outlet passage said uncondensed vapor and said gases from said cell at a region therein adjacent a desired level of said condensate, and continuously varying the area of the inlet to said passage for said uncondensed vapor and gases with change in level of said condensate to maintain a pressure within said cell which induces surface boiling of said condensate for removal of particles of condensate along with said gases and said uncondensed vapor, said surface boiling of said condensate preventing absorption of gases by said pool of condensate.

15. The method of maintaining within a cell a pool of condensate continuously representative of a stream of vapor, which comprises directing into said cell and against the inner surface of an outer wall thereof a stream comprising droplets of condensate and uncondensed vapor at a temperature at least equal to the boiling temperature of said droplets, said droplets collecting along said inner surface and flowing downwardly into said cell to form therein a pool of condensate, removing through an outlet passage said uncondensed vapor at a region therein adjacent a desired level of condensate, the cross-sectional area of the inlet to said passage being less than the surface area of said pool of condensate, and continuously varying the entrance-area to said inlet for flow therethrough of said uncondensed vapor with change in level of said condensate to maintain a pressure over the surface of said pool of condensate within the region of said entrance-area to induce surface boiling of said condensate for removal of particles of condensate from said pool along with flow of said uncondensed vapor through said outlet passage, ingress of condensate particles along said inner surface and egress of said condensate particles from said restricted area of said pool maintaining in said cell condensate continuously representative of the condensable vapors of said stream.

16. The method of maintaining within a cell a pool of gas-free condensate continuously representative of a stream of vapor, which comprises directing into said cell and against the inner surface of an outer wall thereof a stream comprising a mixture of gases, droplets of condensate, and uncondensed vapor at a temperature at least equal to the boiling temperature of said droplets, said droplets collecting along said inner surface and flowing downwardly into said cell to form

therein a pool of condensate, removing through an outlet passage said gases and uncondensed vapor at a region therein adjacent a desired level of condensate, the cross-sectional area of the inlet to said passage being less than the surface area of said pool of condensate, and continuously varying the entrance-area to said inlet for flow therethrough of said gases and said uncondensed vapor, with change in level of said condensate to maintain a pressure over the surface of said pool of condensate within the region of said entrance-area to induce surface boiling of said condensate for removal of particles of condensate from said pool along with flow of said gases and said uncondensed vapor through said outlet passage, ingress of condensate particles along said inner surface and egress of said condensate particles from said restricted area of said pool maintaining in said cell condensate continuously representative of the condensable vapors of said stream, and said surface boiling of said condensate preventing absorption of said gases by said condensate.

17. The method of producing from vapor a condensate uncontaminated by gases present during partial condensation of the vapor, which comprises passing said vapor and said gases in turbulent flow through an elongated sampling line, cooling said vapors during passage through said line, the length of said line forming a cooling surface adequate to cool the vapor for formation of droplets of condensate with uncondensed vapor continuing at a temperature at least as high as the surface boiling temperature of said condensate droplets, applying a differential of pressure from inlet to outlet of said line which maintains said vapor in turbulent flow therethrough, sweeping the surface of said condensate droplets with said uncondensed vapor, the changing pressure on said droplets as they progress through said line and the temperature of said vapor sweeping over said droplets maintaining the exposed surfaces of said droplets at their boiling temperature to prevent absorption by them of said gases present in said vapor stream, discharging at least a portion of said uncondensed vapor and said droplets of condensate together with said gases into a condensate cell for separation of said droplets therefrom, collecting said separated droplets to form a pool of gas-free condensate, removing said uncondensed vapor and said gases through a flow passage having an inlet adjacent a desired level of condensate within said cell, continuously varying the area of the inlet to said passage with change in level of said pool of condensate to maintain on the surface of said pool adjacent the inlet to said passage a pressure which induces surface boiling of said condensate for removal through said passage of droplets of condensate along with said gases and said uncondensed vapor, said discharge passage having a length exceeding the range of counterflow gas diffusion from the outlet thereof to the surface of said pool of condensate.

18. The method of producing condensate from vapor under pressure under conditions preventing absorption by the condensate of gases present in the vapor, which comprises passing said vapor and said gases in turbulent flow through a flow path formed by an elongated sampling line, the length of said line and the cross-sectional area of said flow passage formed thereby establishing between the inlet and outlet of said path flow conditions for said vapor and said gases such that the pressure head producing said turbulent flow

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of said vapor and said gases through said flow path is proportional to the square of the velocity of said vapor and said gases within said flow path, cooling said vapor during its flow through said path to induce sufficient partial condensation for the formation of droplets of condensate, with uncondensed vapor continuing at a temperature at least as high as the boiling temperature of said condensate droplets, the changing pressure on said droplets as they progress through said path and the temperature of said vapor sweeping over said droplets maintaining the exposed surfaces of said droplets at their boiling temperature to prevent absorption by them of said gases, discharging at least a portion of said uncondensed vapor and said droplets of condensate together with said gases into a condensate cell for separation of said droplets therefrom, collecting said separated droplets to form a pool of gas-free condensate, and sweeping the surface of said pool with said uncondensed portion of said vapor stream at a temperature at least as high as the

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boiling temperature of said condensate at the surface of said pool to induce surface boiling thereof to prevent absorption of said gases by said condensate in said pool.

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