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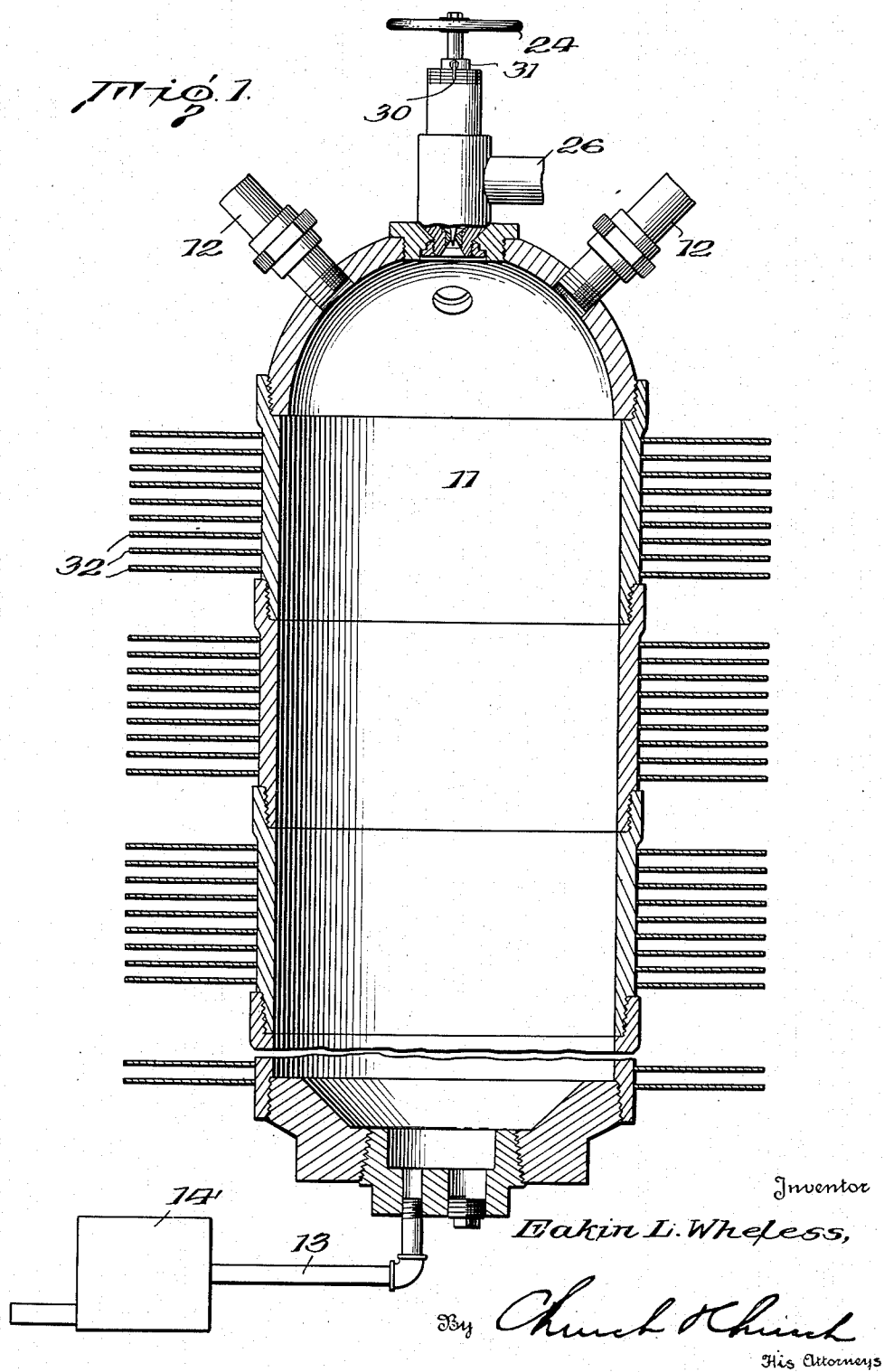
E. L. WHELESS

2,193,309

METHOD AND APPARATUS FOR FLOWING WELLS

Filed Aug. 29, 1935

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

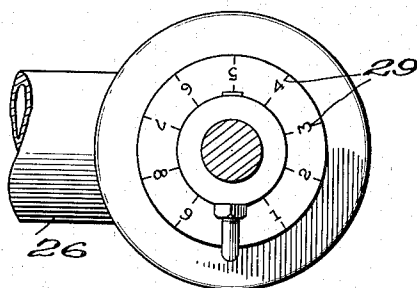
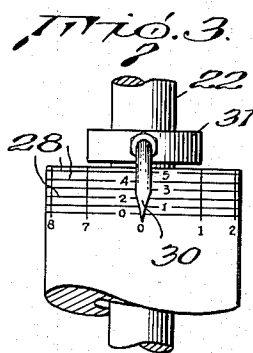
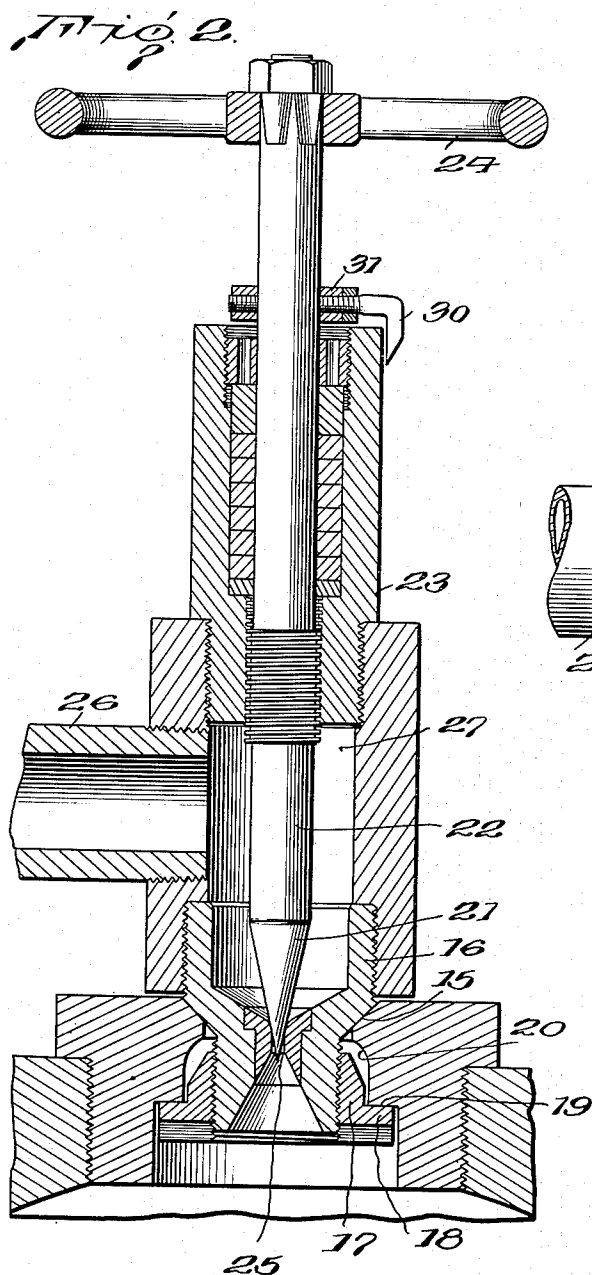


Fig. 4.

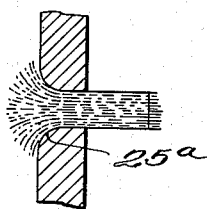


Fig. 5.

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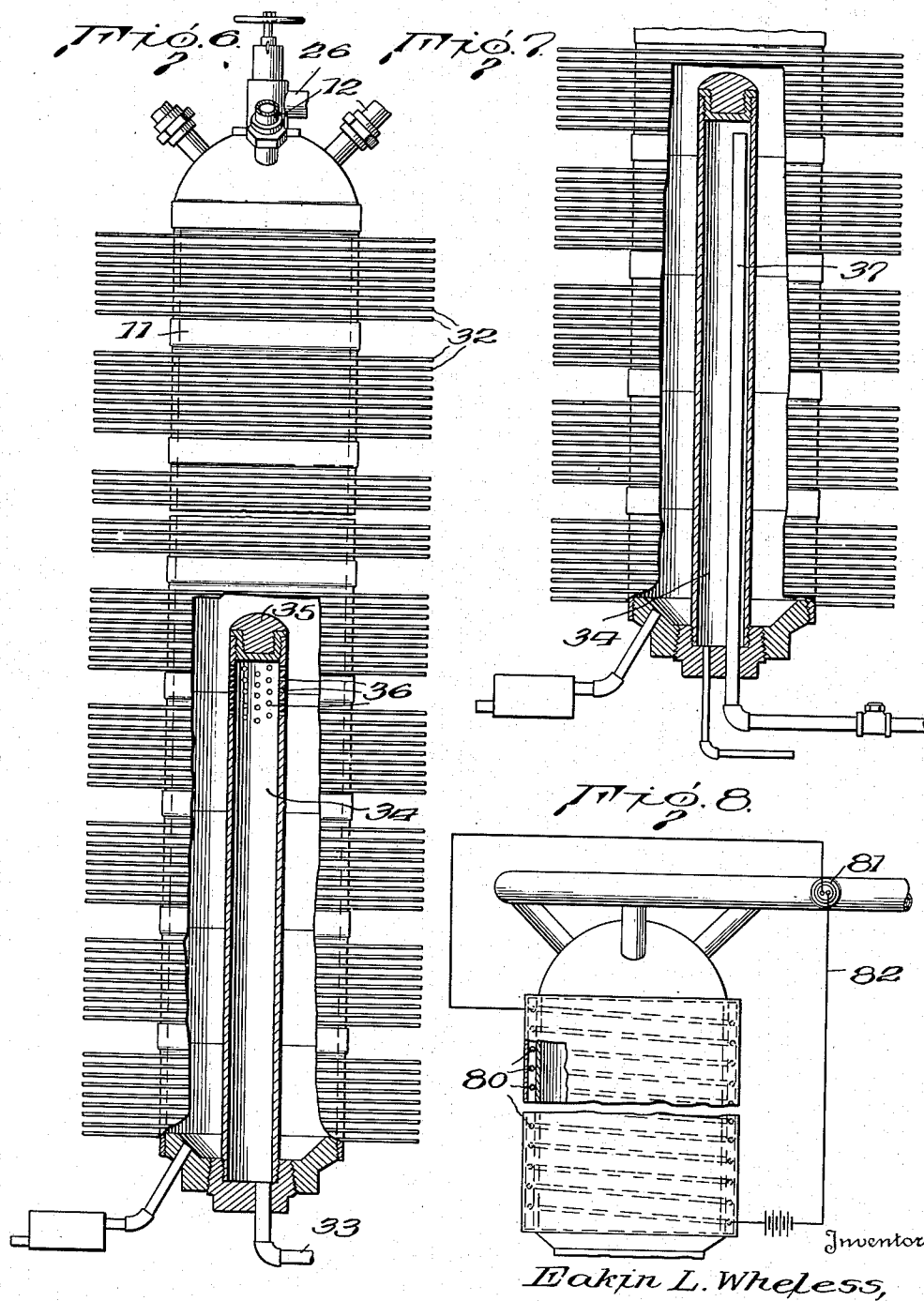
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METHOD AND APPARATUS FOR FLOWING WELLS

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR FLOWING
WELLS

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15 Claims. (Cl. 183—2.7)

This invention relates to an improved method and apparatus for flowing wells, being particularly adapted for use in the flowing of high-pressure gas wells.

5 Primarily, the object of the invention is to provide a method of flowing wells, and an apparatus for practising that method, wherein the freezing troubles encountered in high-pressure gas wells are eliminated. In high-pressure gas wells, the extremely low temperatures caused by the expansion of the gas passing through a valve from a zone of high pressures, such as in the well, to zones of lower pressures, as in the pipe lines which gather and transport the gas, cause the formation of frozen particles and it is the prevention of this freezing which is accomplished by the present invention.

10 Another object is to provide a valve which cannot become clogged by snow or ice particles formed during the progress of the gas through the valve, due to the freezing of water vapors carried in the gas.

15 Another object is to project and to segregate frozen particles, formed in the gas by the chilling of vapors therein, into a locality out of the main line of flow of the gas, so that they will not be carried further by the gas, but will be deposited in an area where they can be properly disposed of, as by melting and removal from the piping system in which the gas is carried.

20 A still further object is to project the gas into, and pass said gas through, an enclosed chamber or compartment in such a manner as to create a maximum amount of turbulence therein, this turbulence generating heat in the gas by the effect of friction, so as to facilitate melting of the frozen particles.

25 Another object is to provide for the absorption of heat from suitable sources to melt the frozen particles which are formed in the gas by virtue of its expansion.

30 Still another object is to incorporate in the control valves of high-pressure gas wells a restriction in the passage therethrough of such limited area that even when fully opened, the gas cannot be withdrawn from the well at a rate dangerous to the well or to the piping or to the gas-bearing sand from which the gas is produced.

35 A further object is to provide an arrangement whereby the jet of gas issuing from the expansion valve will be projected in such a direction that it cannot impinge upon any constricting surface for a considerable distance from the point of original expansion, thereby avoiding both

the abrasive effect of the frozen particles against the compartment walls and the building up of large bodies of frozen particles which might close up, or restrict, the flow areas and which, sometimes, under present operating conditions, disintegrate and pieces of it get into, and damage, regulators, meters and valves down stream.

40 Another object is to provide an efficient and practical means for mixing the expanding gas, which is very cold, with another body of gas of higher temperature from other sources, to assist in the liquefaction and removal of frozen particles from the colder gas.

45 Another object is to remove the liquids which have accumulated in the heat absorption chamber through outlets other than those through which the gas makes its exit, part of these liquids being due to chilling and liquefying of various hydrocarbon vapors contained in the gas, and part due to the melting of the icy particles referred to.

50 Another object is to provide a practical and efficient means for warming the expanding gas with artificially produced heat, in such a manner that there will be a minimum of heat loss in the carrying out of the present method.

55 With these and other objects in view, the invention consists in certain details of construction and combinations and arrangements of parts, all as will hereinafter be more fully described and the novel features thereof particularly pointed out in the appended claims.

In the accompanying drawings—

Figure 1 is a vertical sectional view, partly broken away, through the preferred form of apparatus for carrying out the present method;

Fig. 2 is an enlarged vertical section of the valve controlling the flow of gas from the high-pressure zone to the low-pressure zone;

Fig. 3 is a side elevation showing the indicating devices for denoting the position of the valve;

Fig. 4 is a plan view of the devices illustrated in Fig. 3;

Fig. 5 is an enlarged, sectional view through the discharge orifices of the valve;

Fig. 6 is a view, partly in section and partly in elevation, illustrating a modified form of apparatus;

Fig. 7 is a similar view, illustrating still another form of apparatus; and

Fig. 8 is a similar view, illustrating, more or less diagrammatically, automatically controlled electrical heating means for the apparatus.

Continual improvement in well-drilling appliances has permitted the drilling of deeper and

deeper wells for the production of oil and gas from geological formations formerly inaccessible. As deeper wells are drilled, higher pressures are encountered, and these higher pressures introduce new problems in the operation or flowing of the well. Among the troubles encountered in high-pressure gas wells are those due to the low temperatures resulting from the high expansion ratio at the point where the gas passes through the control valves from the high-pressure area or zone in the well casing to the comparatively low-pressure area or zone in the pipe lines. The pressures encountered in oil and gas-bearing strata are roughly proportional to the depth of such strata and, generally, in new fields, are about the same as the pressure which would exist at an equal depth in a column of water or about .43 lb. per square inch pressure for each foot depth of the well. In other words, wells 5,000 feet deep would have an estimated pressure of about 2,150 lbs. per square inch, while the pressure in 6,000 foot wells would be about 2,500 lbs. per square inch. When gas is withdrawn from such wells and discharged into pipe lines with pressures of from 200 to 250 lbs. per square inch, the ratio of expansion at the valves is about 10 to 1, and the theoretical temperature drop, for dry gas (methane) is roughly about 175° to 200° F. Assuming the temperature of the gas in the casing head of the well to be about 60° F., the temperature, after expansion, would be, theoretically, considering dry gas, about 120° below zero, or about 150° below the freezing temperature of water. However, the temperature does not actually drop this low, as the gas is practically never dry, but probably always contains some vapors of the gasoline fractions or heavier constituents of natural gas, and some water vapor. The drop in temperature, due to expansion, will cause the liquefaction or condensation of these heavier fractions and the condensation and freezing of the water vapors present, and the latent heat given off thereby will balance a part of the temperature drop, so that the ultimate temperature will be considerably above that which would result from the expansion of dry gas only. Incidentally, the water and the water vapors carried by the gas are brines, whose freezing temperatures are below the freezing temperature of water.

Nevertheless, the temperature resulting from the expansion of the gas at the head of the well is frequently low enough to cause the formation of troublesome or dangerous quantities of ice in the valves and in the pipes beyond the control valves, and to cause damage to meters from pieces of ice carried by the gas, as well as the sticking of regulators, thus making them inoperative, and the stoppage of pipes or outlets from separators, the latter permitting the building up of dangerously high pressures which have, in the past, caused serious accidents.

In overcoming these difficulties, two problems are involved. First, the handling of the ice formed at the point of expansion, so as to prevent clogging of the valve itself, or the stoppage of pipes and fittings beyond the valves. Ice is particularly apt to accumulate at elbows or offsets in the pipe or at points where the direction of flow is altered. At such places, the fine ice particles or snow, formed in the gas stream at the point of expansion, tend to impact and accumulate to form large pieces which, gradually increasing in size, finally completely close the pas-

sage. The second problem is the removal of this ice from the pipe lines.

The temperature, as well as the pressure, found in oil and gas-bearing strata, also varies with the depths of these strata. In some oil fields, the temperature is, roughly, about one degree higher for approximately each 50 or 60 feet in depth, although this gradient varies widely in different localities. The temperature at the bottom of a 6,000 foot well therefore might be expected to be about 190° F. Gas at this temperature expanding from the well pressure to the line pressure might not drop below freezing temperature. However, at the ordinary rate of withdrawal, the gas, in passing up from the bottom of the well to the top, loses a considerable amount of its heat to the sides of the well and expansion in the valve would take place at a temperature somewhere between the bottom hole temperature and the surface temperature, the actual temperature at the point of expansion depending more or less upon the rate of withdrawal. For this reason, it sometimes occurs that a certain well will have considerable freezing troubles if the gas is withdrawn at a slow rate, while less difficulty is encountered if it is flowed at a higher rate. For the same reason, considerable freezing troubles may occur when the flowing is resumed after the well has been shut in long enough for the gas to cool off in the upper part of the well, whereas the cold or freezing may not be so intense after flow has been maintained for a while and hot gas has been brought up from the bottom of the well.

With these factors in mind, the present invention contemplates a method of flowing high-pressure wells wherein the gas flows from the well through a conduit without substantial restriction until it reaches an expansion valve through which it passes into what might be termed an expansion chamber but which is, in fact, a compartment in which the expanding gases have their temperatures raised. Any particles of ice or snow formed by the expansion of the gas discharging into said compartment are collected in said compartment and, due to the heating effect had in said compartment, such frozen particles are liquefied and the liquid withdrawn or drained from the compartment. The gas, then of higher temperature and substantially free of the frozen particles, flows from the chamber or compartment through one or more outlets provided for that purpose. Preferably, the apparatus is so designed that the gas is discharged through the expansion valve into said compartment and has its exit from said compartment so arranged as to create a maximum amount of turbulence within the compartment for the purpose of generating heat which assists in melting the frozen particles. In some instances, the method is modified in that a second body of gas, of higher temperature than the expanding gas, is discharged into the heating compartment, to raise the temperature of the expanding gas or, in accordance with another form of apparatus, artificial heating means may be employed in conjunction with the heating chamber. However, stated broadly, the method consists in initially flowing the gas through a substantially unrestricted conduit, then passing the gas through a restricted aperture from said conduit into a compartment of comparatively large cross section whereby the gas expands and its temperature is reduced; then increasing the temperature of the gas within the compartment to melt ice particles within the compartment; draining the liquid from

said compartment; and withdrawing the gas, substantially free from the frozen particles, from the compartment.

In the apparatus shown in Fig. 1, gas flows from the well through conduit 26, which communicates with the interior of heating compartment 11 by means of an expansion valve, preferably in the upper end of said chamber. The gas passing through the expansion valve is projected longitudinally of the compartment or toward the bottom thereof and must rise again to escape through the discharge outlets 12 which are also in the upper portion of the compartment. By projecting the expanding gases into the compartment in this fashion, there is a tendency for the frozen particles to accumulate or collect in the lower portion of the compartment and by reason of the necessity of the gas reversing its direction of flow before reaching the exits 12, a maximum amount of turbulence is created, thus developing friction and generating heat which will raise the temperature of the gas and aid in the melting of such frozen particles. The liquid thus produced in the lower portion of the compartment may be drained off through a pipe 13 provided with a liquid trap shown, more or less diagrammatically, at 14.

The preferred construction of the valve is illustrated in detail in Fig. 2. The upper end of the warming chamber 11 has an opening therein, a portion of the wall of said opening being of frusto-conical formation as at 15 and seating in said opening is a ported member 16, a portion of the exterior surface of said member 16 conforming to the frusto-conical wall 15. Member 16 is held against the seat 15 by a washer 17 threaded on said member 16 and provided with a flange 18 engaging against a shoulder 19 at the upper end of the warming chamber. Suitable packing may be interposed in the space 20 to perfect the seal between the member 16 and the warming chamber wall. A valve 21, of conical formation, is carried by a valve stem 22 threaded in the valve bonnet 23, the exterior portion of said stem being provided with a handle 24 whereby the valve stem may be rotated to adjust the valve 21 relatively to the port or passage 25 in member 16 to regulate the size of the opening of said port and thus determine the flow of gas therethrough. The gas flows from the well through conduit 26 and a space 27 in the valve bonnet, these members constituting a substantially unrestricted passage so that there is no opportunity for the gas to expand prior to its passage through port 25. Port 25 is preferably formed in a section of metal detachable from the main body portion of member 16 and said port is preferably flared at both its entrance and exit ends. Its entrance end is illustrated in greater detail in Fig. 5, wherein the rounded corners 25^a are more or less accentuated. By thus rounding the corners at the entrance end of the port, the gas substantially fills the entire port during its flow therethrough and by flaring the exit end of the port, it is impossible for the expanding gas to impinge upon any obstructions immediately after it passes through the port, with the result that any particles of ice or snow which might be formed in the expanding gas are projected clear of the valve and into the main compartment 11. In fact, by having the valve located at the upper end of the warming chamber 11, particles of ice and snow that might be formed in the expanding gas are projected the entire length of the chamber before encountering any obstructions.

Usually one or more cut-off valves (not shown) will be used in the conduit 26, which can be either fully opened or fully closed to control the flowing of the well, although, the use of such a valve is not necessary in the present construction, because the valve 21 may be said to constitute both a control valve and an adjustable choke. In other words, by fully closing valve 21, the flowing of the well will be terminated, and by opening said valve to the desired extent, the flow can be initiated in any volume desired. The flow of gas through the main conduit is without restriction so that, as mentioned, there is no opportunity for the gas to expand prior to reaching valve 21 and as the gas cannot expand until after it passes said valve 21, it is impossible for particles of ice to plug up or choke the valve opening. Furthermore, the valve itself is kept warm by the inflow of fresh warm gas from the well, since the gas does not become chilled until after it passes through and is leaving the exit end of the valve passage 25. In view of the fact that port 25 is formed in a separate section of metal, said port, which really constitutes the valve seat, is readily removable, so that in case of wear or erosion from any cause whatever, it may be removed and replaced.

Figs. 3 and 4 illustrate a novel arrangement for determining the exact seating of the valve. As illustrated in these figures, the valve bonnet, near the upper extremity thereof, is provided with circumferential markings 28 spaced from each other a distance corresponding to the axial movement imparted to the valve 21 by a complete revolution of the valve handle 24. Other graduations 29, extending radially of the top face of the valve bonnet and continuing longitudinally of the side surface of said bonnet, are spaced from each other distances corresponding to one-tenth of a revolution of valve handle 24. A pointer or indicator 30, carried by a collar 31 on valve stem 22, is adapted to indicate on two sets of graduations the exact position of the valve 21 with respect to its seat 25^a. For instance, when valve 21 is fully closed, the pointer will register with the "0" graduation of both sets of graduations. Then, when the valve is moved away from its seat, the pointer shows the exact amount of the opening. For instance, if the valve is opened three-tenths of a turn, the pointer will register with the "3" graduation line of the radial graduations 29, at a point intermediate the "0" and "1" graduations of circumferential graduations 28. On the other hand, if the valve has been given one and one-half turns, the indicator will register with graduation "5" of the radial graduations 29, at a point intermediate graduations "1" and "2" of the circumferential graduations 28. Of course, the collar 31 should be made adjustable on the valve stem in order that the indicator can be set in registry with the two "0" graduations when the valve is fully closed, and this adjustment having been made, it is a simple matter to make records of the rate of flow for various settings of the valve stem to be used in determining the future proper setting thereof at any given time.

This form of valve is free from the danger of freezing and sticking, and in some cases, as for example, where the actual temperature after expansion of the gas is not too low, by reason of a comparatively low ratio of expansion or a comparatively high well temperature, or where the flow conditions are such that, in a very short time, hot gas from the well bottom will reach the

valve, it is possible for this form of valve to be the only form of special equipment used if the ice formed by the expansion of the gas could soon be melted or could be handled by the separators (not shown), which are usually part of well equipment for the removal of liquids from gas before the latter enters the gathering lines. However, in almost all cases where the well pressure is very high, it is preferred that some auxiliary means be provided for warming the gas after expansion and thus augmenting the melting of the ice particles in the chamber 11. For this reason, the warming chamber is preferably cylindrical and of a size depending upon the individual conditions at the well, but it is preferred that a diameter in the neighborhood of 18 or 20 inches, and a length of 15 or 20 feet, be its maximum size. It is made of a metal of very high thermal conductivity to facilitate the flow of atmospheric heat which it absorbs and conducts to the gas inside, and to facilitate the absorption of heat, it is provided with annular fins 32. It is also preferred that the compartment 11 be made of sections, with each section having one or more fins 32 formed thereon, as this is the most efficient construction from the standpoint of thermal conductivity. Furthermore, this arrangement of utilizing short annular sections has the mechanical advantage of permitting the lengthening or shortening of the heat absorption chamber to meet specific conditions. Therefore, this design provides flexibility and adaptability to field conditions, as well as the most efficient construction from the standpoint of thermal conductivity.

Where additional heating facilities for the warming chamber 11 are desired in flowing the well, the apparatus may be illustrated in Fig. 6, wherein a separate supply of gas, warmer than the gas discharged into the heating chamber is supplied through the lower end of the heating chamber. This gas may be supplied through a pipe 33 which communicates through the bottom of the chamber with an elongated tube 34, closed at its upper end by a plug 35, but provided with a plurality of perforations 36 through which the warm gas issues into the heating compartment. With this arrangement, the auxiliary supply of warm gas not only tends to reduce the temperature of expanding gas by commingling therewith, but the heating effect of the tube 34 itself will also aid in raising the temperature of gases in the chamber and, in addition, augment the melting of ice particles accumulating in the lower portion of the chamber.

A still further modification is illustrated in Fig. 7, wherein the tube 34 within chamber 11 is entirely sealed from communication with the chamber and steam is supplied thereto through a pipe 37 extending through the bottom wall of chamber 11 with its upper extremity terminating adjacent the upper end of tube 34. In this instance, it is the heat radiated from tube 34 which aids in raising the temperature of the gases in chamber 11. Heat radiated in tube 34 will also facilitate melting of icy particles accumulating in the lower portion of chamber 11. In connection with the forms of apparatus illustrated in Figs. 6 and 7, it will also be appreciated that other heating mediums may be substituted for those specifically mentioned herein, it being the intention to simply indicate that auxiliary heating agents may be utilized at the interior of the compartment for raising the temperature of the

expanding gases and melting ice particles accumulating in said chamber.

For instance, as shown in Fig. 8, electrical heating units 80 may also be used as the heating means. It will also be appreciated that the heating means may be controlled automatically by instrumentalities responsive to the temperature conditions in chamber 11. As illustrated in Fig. 8, a thermostatic make and break device 81 appropriately mounted within chamber 11, or in an outlet therefrom, may be included in the heating unit circuit 82. The thermostatic device 81, which is shown diagrammatically, will operate to close said circuit when the temperature within the chamber drops to a predetermined point but, as will be understood, the circuit will be broken when said predetermined temperature is exceeded. In other words, so long as the temperature in chamber 11 remains above a certain point, the electrical heating unit will remain inoperative.

Since the pressure in warming chamber 11 is not very high, thermal conductivity is the primary consideration in selecting the metal to be used, while the strength of that metal is a matter of secondary importance. However, the valve is subjected to exceedingly high pressures, so that here strength is the ruling consideration. As a result, the coefficient of expansion of the two metals used in the construction of the valve and the construction of the warming chamber varies quite a bit, the metal in the warming chamber expanding considerably more with a rise in temperature than the metal of which the valve is made, and, as the apparatus is to be used under conditions where temperatures vary over an exceedingly wide range, special arrangements should be made to prevent leakage under these conditions. This is taken care of in the present invention by the surfaces of contact of the two metals being made frusto-conical in shape. That is, the frusto-conical opening 15 and the frusto-conical surface of member 16 are formed at an angle of about 45° relative to the main axis of the valve stem and the ring of packing material 20 is so located that the radial distance from the axis of the valve stem to said packing ring is approximately equal to the distance from the packing ring to the annular flange 18 of nut 17. With this construction, as the radial expansion of the highly conductive material tends to loosen contact between the metals, such tendency is balanced by the lateral expansion which tends to maintain the contact. Therefore, there is very little variation in the contact pressure between the two metal members and upon the packing or gasket and, therefore, the tendency toward leakage due to temperature fluctuations is held to a minimum.

As before pointed out, the expansion valve 21 is so located that the discharge jet of gas is projected substantially axially of the chamber 11, throwing the ice as far as possible away from the valve itself. If the jet is directed across the chamber, the minute ice particles will impact against the side wall and build up into large pieces, which are not only harder to handle so far as melting is concerned, but which might also build back to the valve itself, blocking the latter. Again, by having the valve located at the upper extremity of chamber 11 and by having the outlets 12 also arranged at the same end, the gas is projected toward the bottom of said chamber and the flow thereof must be reversed and it must travel upwardly the full length of the chamber before it escapes through the outlets. In this

way, a very high degree of turbulence is set up throughout the chamber, resulting in the formation of a very large amount of heat through internal gaseous friction. As before mentioned, this source of heat, together with the heat absorbed from the exterior atmosphere may, alone, be relied upon for warming the gases and melting the ice. It should also be pointed out that the turbulence created in the interior of the chamber assists in the induction of heat into the chamber from the radiating fins, since it causes fresh cold gas to be constantly brought into contact with the walls of the chamber. Therefore, the exceedingly high degree of turbulence warms the gas both by increasing the efficiency of heat transmission through the chamber walls and also by actual internal friction of the gases themselves. However, as this high degree of turbulence is not conducive to the most efficient separation of liquid and solid particles from the gas, it may, under such conditions, be desirable to use supplemental separating instrumentalities such as ordinary separators (not shown) well known in the art for the removal of such particles of moisture.

In some cases it may also be desirable to use several valve and warming chamber assemblies of the design disclosed herein, the same being associated in parallel upon a single well, and so that the flow of gas is divided between them, the arrangement should be such that the same gas does not flow through more than one warming unit. In such a case, valves having comparatively small orifices (about $\frac{1}{8}$ to $\frac{1}{16}$ " diameter) should be used, so that the total flow area of all the orifices, when wide open, would still be small enough to protect the well by holding up the pressure therein. This arrangement could divide the output of the well between any number of valve and chamber units, the number of units required at any well depending upon the conditions prevailing at that particular well, such as the desired rate of withdrawal of gas; the well pressure and temperature; and the atmospheric temperature.

The first step in the removal of the solid and liquid particles from the warming chamber is the melting of the solid ice particles into liquid form and then all the liquids can be removed by any ordinary trap or liquid level control device which is available and suitable for the purpose.

What I claim is:

1. The method of flowing high-pressure gas wells which consists in initially flowing the gas through an unrestricted conduit, passing the gas directly from said conduit through a restricted aperture as it emerges from said conduit into a chamber of large cross-section whereby said gas will expand and effect a reduction in temperature to a point where ice particles will be formed, increasing the temperature of the gas within said chamber to melt ice particles in said chamber, draining liquid from said chamber, and withdrawing the gas from the chamber at a point above the liquid drain.

2. The method of flowing gas under high pressures which consists in passing the gas through a valved opening into a chamber of large cross-section compared to said opening and reducing the temperature of the gas to a point where ice particles will be formed, raising the temperature of frozen particles formed by the gas expanding in said chamber, withdrawing the gas from said chamber, and draining liquid formed by melting

of the particles from said chamber at a point below the gas outlet.

3. The method of flowing gas under high pressures which consists in passing the gas through a restricted, valved opening directly into a chamber of comparatively large cross-section and reducing the temperature of the gas to a point where ice particles will be formed, supplying a heating medium to said chamber for melting frozen particles formed in said chamber, withdrawing the gas from said chamber, and removing the liquid formed by said melted particles from the chamber at a point spaced vertically below the gas outlet.

4. The method of flowing high-pressure gas wells which consists in passing the gas from the well through a restricted, valved opening into a chamber of comparatively large cross-section and reducing the temperature of the gas to a point where ice particles will be formed in said chamber, supplying a second body of gas to said chamber at a temperature above the gas passing through said restricted opening to melt frozen particles in the chamber, draining the liquid so formed from said chamber, and withdrawing the gas from said chamber.

5. The method of flowing high-pressure gas wells which consists in flowing the gas from the well through a restricted, valved opening directly into a chamber of large cross-section, said gas passing through said opening longitudinally of said chamber and expanding in said chamber and effecting a reduction in the temperature of the gas to a point where ice particles will be formed in the chamber, melting frozen particles in said chamber, draining the liquid from said melted particles from the chamber at a point remote from the point of inlet of the gas, and withdrawing the gas from the chamber at a point in proximity to said inlet.

6. The method of flowing gas under high pressures which consists in flowing the gas through a passage of substantially uniform cross-section directly into a chamber through a restricted opening at one end of said chamber and expanding said gas to effect a reduction in the temperature thereof to a point where ice particles will be formed in the chamber, melting frozen particles in said chamber, draining the liquid formed by the melted particles from the opposite end of said chamber, and withdrawing the gas from the first-mentioned end of said chamber.

7. The method of flowing gas under high pressures which consists in flowing the gas into a heating chamber through a restricted inlet opening at one end of said chamber and effecting a reduction in the temperature of the gas to a point where ice particles will be formed, supplying a heating medium to said chamber from the opposite end thereof, and withdrawing said gas from the chamber through an outlet adjacent the first-mentioned end of said chamber.

8. The method of flowing high-pressure gas wells which consists in flowing the gas into a heating compartment through an inlet opening adjacent one end thereof and effecting a reduction in the temperature of the gas to a point where ice particles will be formed, supplying a body of gas of higher temperature to said compartment through an inlet adjacent the opposite end thereof, withdrawing the gas through an outlet adjacent the first-mentioned end of the

compartment, and withdrawing liquid accumulating in said compartment.

9. In an apparatus for flowing gas under high pressures, a conduit for the gas, an anti-freezing valve mechanism at the discharge end of said conduit, said conduit being substantially unrestricted to prevent the formation of ice particles therein, said valve mechanism comprising a restricted orifice, a valve member movable into the inlet end of said orifice for controlling the flow of fluid through said orifice, and a chamber into which said valve discharges and in which the temperature of the fluid is reduced to a point where ice particles are produced in said chamber, and means for melting said frozen particles.

10. In an apparatus for flowing gas under high pressures, a conduit for the gas, an anti-freezing valve mechanism at the discharge end of said conduit, said conduit being substantially unrestricted to prevent the formation of ice particles therein, said valve mechanism comprising a restricted orifice, means for controlling the flow of fluid through said orifice, and a chamber into which said valve discharges and in which the temperature of the fluid is reduced to a point where ice particles are produced in said chamber, and means for melting said frozen particles.

11. In a well-flowing apparatus, a fluid conduit adapted to communicate with the well, a valve mechanism at the discharge end of said conduit, said conduit being substantially unrestricted to prevent the formation of ice particles therein said valve mechanism comprising an orifice having an intermediate restricted portion and flared at its inlet and discharge terminals, a valve for said orifice movable through said restricted portion from the inlet side of the orifice, and a heating compartment into which said orifice discharges, the relative sizes of said orifice and said compartment being such that the expansion of the fluid discharged into said compartment will effect a reduction in the temperature of the fluid to a point where ice particles will be formed in said compartment.

12. In a well-flowing apparatus, a fluid conduit adapted to communicate with the well, a valve mechanism at the discharge end of said conduit, said conduit being substantially unre-

stricted to prevent the formation of ice particles therein, said valve mechanism comprising an orifice having an intermediate restricted portion and flared at its inlet and discharge terminals, a valve for said orifice movable through said restricted portion from the inlet side of the orifice, and a heating compartment into which said orifice discharges, said orifice being disposed longitudinally of said heating compartment.

13. In a well flowing apparatus, a substantially unrestricted conduit, an anti-freezing valve mechanism at the discharge of said conduit, a heating chamber into which said valve discharges, means for heating said chamber, and means responsive to the temperature conditions within said chamber for controlling the operation of said heating means.

14. In an apparatus for flowing gas under high pressures, a conduit for the gas, said conduit being substantially unobstructed to prevent the formation of ice particles therein, an anti-freezing valve mechanism at the discharge of said conduit, a heating chamber of comparatively large cross-section into which gas passing through said valve directly discharges and expands, the expansion of the gas reducing the temperature thereof to a point where ice particles will be formed in said chamber, and means affecting the flow of gas through said chamber to agitate said gas and create a turbulent condition thereof, whereby heat will be generated within the chamber to aid in melting frozen particles formed by expansion of the gas passing into said chamber.

15. The method of flowing high-pressure gas wells which consists in passing the gas from the well through a restricted opening directly into a chamber of comparatively large cross-section and expanding the gas in said chamber, the expansion of the gas effecting a reduction in the temperature thereof to a point where ice particles will be formed in the chamber, creating a turbulent condition of the gas in said chamber to raise the temperature thereof to aid the melting of frozen particles therein, withdrawing the gas from said chamber, and withdrawing liquid produced by the melting of said particles.

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