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- [54] Title: METHOD OF RETURNING GEOTHERMAL GASES TO THE UNDERGROUND
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U. S. Pat. Nos. 4,632,601 12/1986 Kusada
4,457,375 7/1984 Sumins
- [57] (see abstract next page)

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SPECIFICATION

1. TITLE OF THE INVENTION

Method of Returning Geothermal Gases to the Underground

2. FIELD OF THE INVENTION AND RELATED ART STATEMENT

The present invention relates to a method for returning geothermal gases discharged from geothermal plants to the underground.

At present, large amounts of noncondensing gases and toxic gases such as H_2S and SO_2 that are contained in geothermal steam are extracted at condensers or the like and simply released into the atmosphere or released after being desulfurized at very high costs.

3. OBJECT AND SUMMARY OF THE INVENTION

The method of the present invention is an alternative to the conventional release of these noncondensing or toxic gases into the atmosphere, treated or untreated. According to the present invention, the noncondensing or toxic gases present in geothermal steam for geotherm turbines are returned to the underground by way of an underground return well for waste water together with the waste water. When returning to the underground in this way, however, the flow inside the return well becomes a two-phase vertical downward flow of the gas and

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liquid phases. Therefore, when the apparent gas velocity V_{go} ,
in relation to the apparent velocity of the waste fluid V_{eo} ,
becomes greater than a certain value for the ratio $\alpha_{cr} = V_{go}/V_{eo}$,
the waste water does not carry (accompany) all the gas phase,
and it becomes impossible to return the gas to the underground.

Taking advantage of the flow characteristics of a two-
phase vertical downward flow of the gas and the liquid phases
in a tube, the present invention resolves the above problem by
controlling the range of apparent velocities, V_{eo} and V_{go} , of
the waste water and the gas with respect to the return well so
that the size (diameter) of the return well can be selected to
suit the amount of waste water Q_e and the amount of waste gas
 Q_g .

The present invention is characterized in that, when
the geothermal gas is returned to the underground together with
the waste water through an underground return well, the range
of the apparent velocities, V_{eo} and V_{go} , of the waste water and
the gas, respectively, is set by an equation, $V_{go} < 1.33V_{eo} -$
 0.41 , so that the geothermal gas is accompanied downward by the
waste water and the hydrostatic pressure in the depth direction
becomes effective at the same time. This is achieved in the
present invention by studying the flow characteristics of a
two-phase tubular flow of the gas and the liquid phases in the
vertical and downward direction.

According to the present invention, the geothermal gas which goes downward accompanied by the waste water in the return well is compressed by the water pressure and is also dissolved into the waste water so that the volume of the geothermal gas is reduced with respect to that of the waste water, and at the bottom of the well, the geothermal gas becomes completely dissolved or is turned into fine bubbles so as to flow into the earth crust together with the waste water.

4. BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic diagram for describing an embodiment of the present invention;

FIG. 2 shows flow patterns of the waste water and the geothermal gas in the return well;

FIG. 3 is a graph showing the relation between the velocity of the waste water and that of the gas according to an embodiment of the present invention; and

FIG. 4 shows the pressure distribution according to the present invention.

5. DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 shows an embodiment of the present invention. Waste water Q_w flows into a return well 3 by way of a water pipe 2 above the return well by the action of a pump 1. A

geothermal gas Q_g is forced into a gas pipe 5 by a blower 4 and

into the waste water in the return well 3 through a top opening
6. 7 indicates the ground level.

For the geothermal gas sent into the waste gas to be
accompanied (carried) by the waste water all the way down to
5 the bottom of the return well, the apparent velocity of the
waste water V_{eo} ($= Q_e/A$, where $A = \pi D_3^2/4$) relative to the well
3 is set to a value equal to or more than 1.0m/s. Furthermore,
in order to put the gas flowing downward under a hydrostatic
pressure of the waste water, the apparent velocity of the gas
10 V_{go} ($= Q_g/A$, where $A = \pi D_3^2/4$) is controlled in the range
satisfying an equation: $V_{go} < 1.33V_{eo} - 0.41$.

In the above equation Q_e is the volume flow rate of the
waste water, Q_g the volume flow rate of the gas, V_{eo} the
apparent flow velocity of the waste water in the return well,
15 V_{go} the apparent flow velocity of the gas in the well, and D_3
the diameter of the return well.

Thus, as shown in FIG. 2, the manner of flow below the
mixing point of gas and liquid in the return well turns from a
froth flow to a slug flow and then to a bubble flow as going
20 down in the well. The volume of the gas becomes reduced while
the gas is carried to the bottom of the return well,
accompanied by the waste water.

FIG. 3 shows the waste water velocity condition, $V_{eo} >$
1.0m/s, as a limit for accompanying (carrying) the geothermal
25 gas and for the downward flow of the gas. FIG. 3 also shows

the experimental relationship between the waste water velocity V_{eo} and the gas velocity V_{go} for making the hydrostatic pressure effective in the return well. Also, FIG. 4 shows an example of the pressure distribution in the return well. In this figure, in the flow pattern region (A) where the waste water velocity V_{eo} is large compared to the gas velocity V_{go} and a large annular spray flow or an annular flow is observed, the pressure in the return well is almost constant and the hydrostatic pressure does not play any role. Thus, changes in the gas volume in the return well are small, and most of the gas is carried to the bottom of the well as it is, remaining in the gaseous state. This makes it more difficult to return the gas to the earth crust.

When the gas velocity becomes relatively small and the manner of the flow below the mixing point becomes a froth flow, however, the hydrostatic pressure becomes effective in the depth direction and sloped as shown by the pressure distribution (B). As the gas flows down deep in the well, the gas volume is reduced, and the change of the flow pattern is supported by these data.

The divisional line in the V_{go} - V_{eo} plane in FIG. 3 is obtained by plotting the experimental bordering points at which the pressure distribution becomes sloped immediately after the mixing point of gas and liquid and at which the hydrostatic pressure begins to be effective.

WHAT IS CLAIMED IS:

1. A method of returning geothermal noncondensable gas including H₂S gas together with geothermal waste water into an underground stratum through a waste water return well under the two-phase gas-and-liquid flow conditions of froth or slug flow at the gas returning point around the wellhead,
5 characterized in that the introduction of the geothermal gas at the gas returning point around the wellhead is regulated to satisfy the following equation;

$$V_{go} < 1.33V_{eo} - 0.41,$$

10 where V_{go} and V_{eo} are the apparent velocity of the geothermal gas and the waste water at said gas returning point, respectively, and V_{eo} at said gas returning point is not less than one meter per second, and where apparent velocity is defined as the volumetric flow rate of the fluid divided
15 by the well cross-sectional area at said gas returning point.

2. The method of Claim 1, wherein the gas is introduced into the waste water above the ground level of the stratum.

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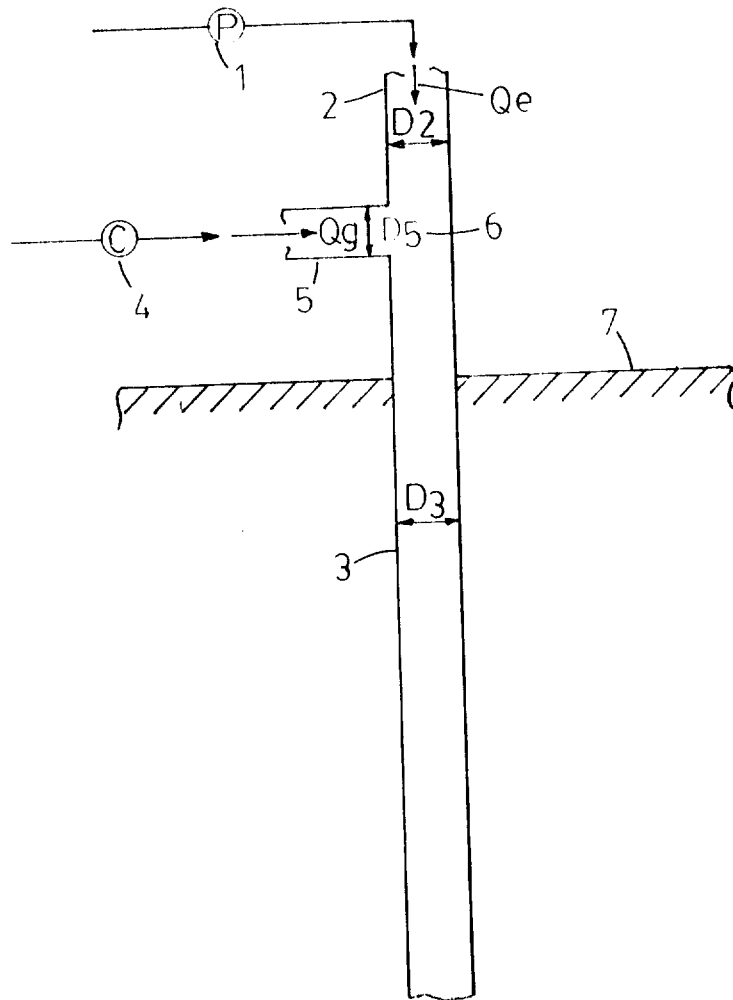
METHOD OF RETURNING GEOTHERMAL GASES TO THE UNDERGROUND

ABSTRACT OF THE INVENTION

Disclosed is a method of returning geothermal gases discharged from geothermal plants to the underground together with waste water through a return well, characterized in that the apparent velocity of waste water V_{eo} relative to the return well is equal to or more than 1m/s and the range of the apparent velocity of waste water V_{eo} and of an apparent velocity of the geothermal gases V_{go} is regulated to satisfy the following equation:

$$V_{go} < 1.33V_{eo} - 0.41.$$

FIG. 1



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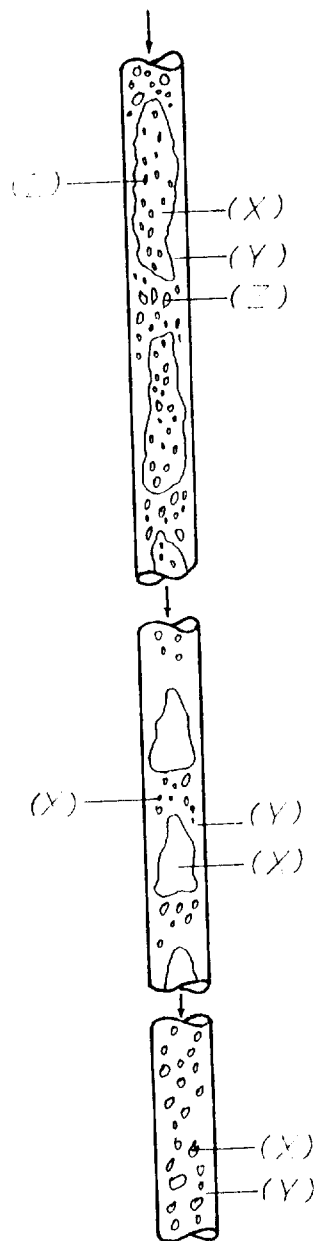


FIG. 2

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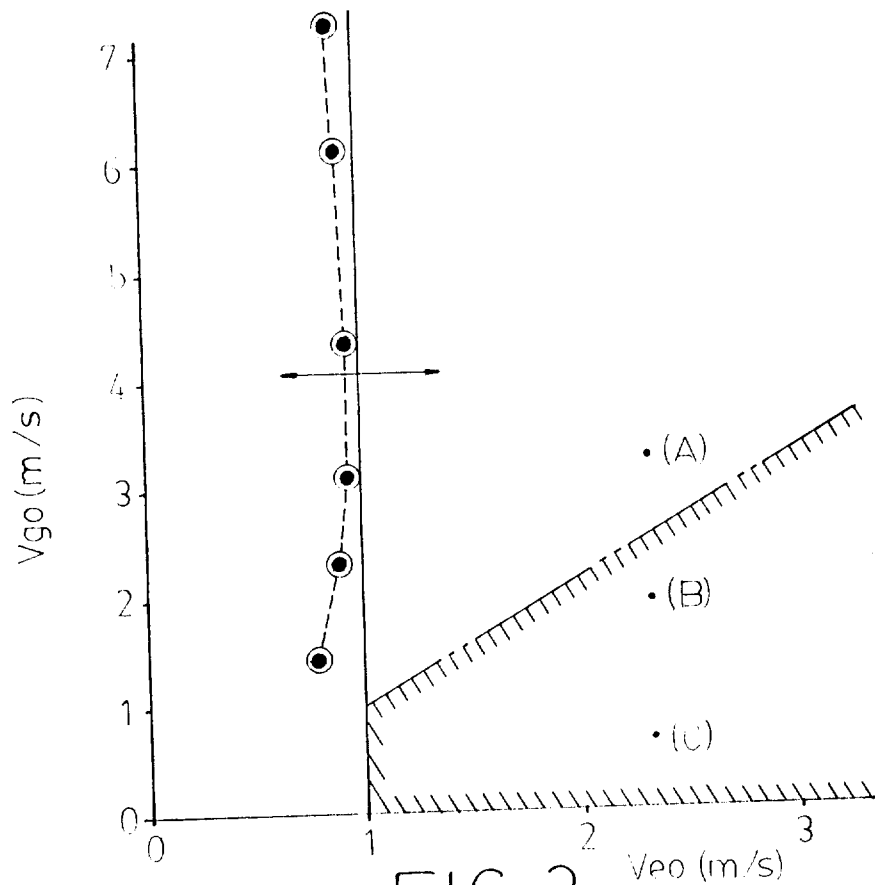


FIG. 3

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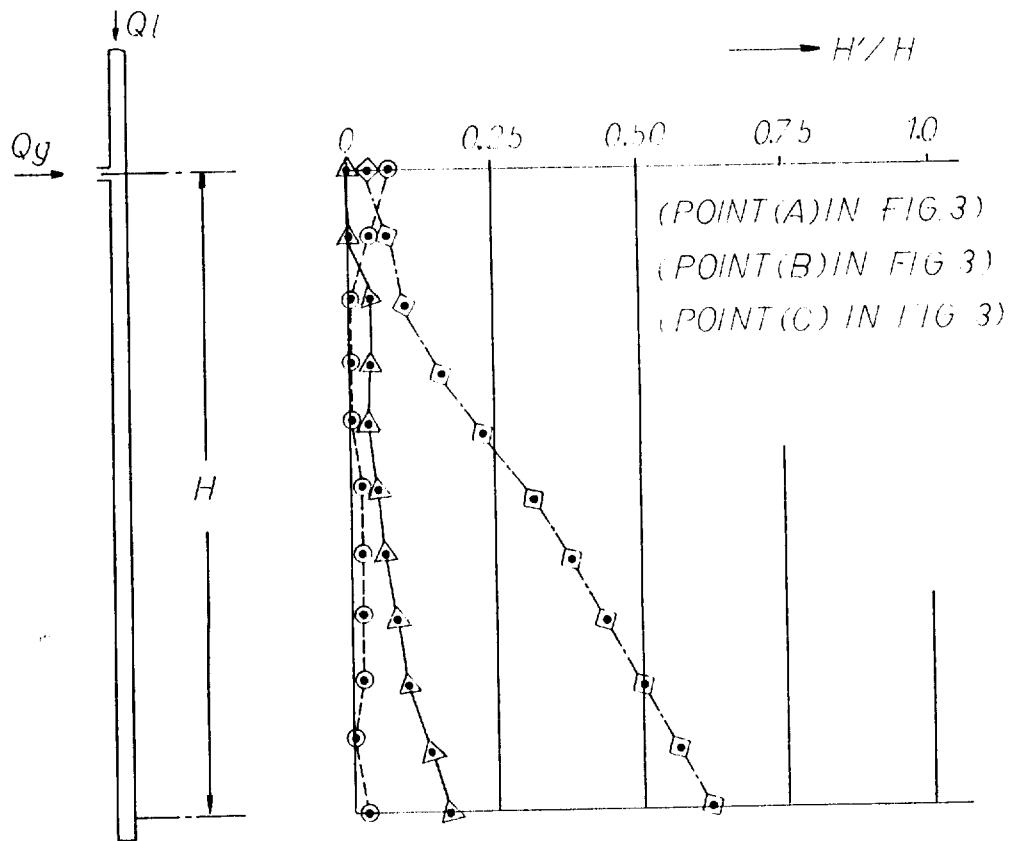


FIG. 4

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