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SOLVENT RECOVERY PROCESS

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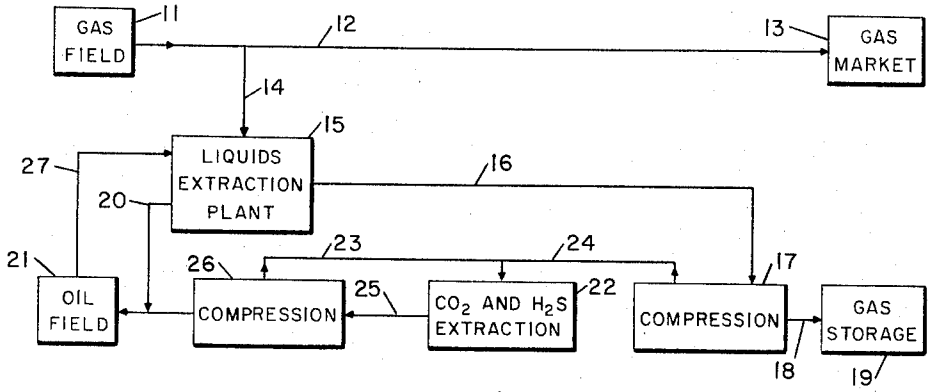



FIG. 1

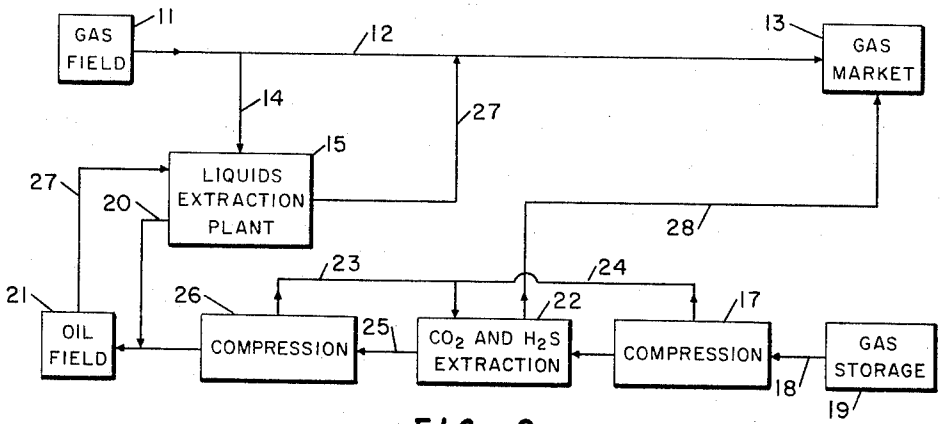



FIG. 2


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# SOLVENT RECOVERY PROCESS

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9 Claims. (Cl. 208—340)

The present invention relates to the processing of natural gas and is particularly concerned with an improved method for processing gas from transmission lines and storage facilities to produce an economical hydrocarbon-carbon dioxide solvent for use in oil recovery operations.

Seasonal variations in the demand for natural gas pose certain problems in the design and operation of gas transmission systems. In order to handle the peak load requirements which are normally encountered during the winter months, it is conventional to provide gas storage facilities near areas of high consumption. By storing excess gas during periods of low or average consumption and withdrawing the stored gas during peak consumption periods, main transmission lines can be sized for the average demand. This simplifies transmission problems but does not eliminate the necessity for providing sufficient compressor capacity at the storage site to handle the peak winter load requirements. Only a part of this capacity is used during most of the year. A recent study of the utilization of compression facilities of major gas companies showed that only about 38% of the installed capacity is utilized on a yearly average basis. During the summer months, the facilities are not needed at all. This idle capacity represents a significant investment and contributes heavily to the cost of operating and maintaining the systems. Efforts to secure more efficient utilization of compressor capacity have in the past been largely unsuccessful.

The present invention provides an improved system which permits more efficient storage and utilization of the gas than has generally been possible heretofore and at the same time alleviates certain difficulties characteristic of systems utilized in the past. In accordance with the invention, it has now been found that problems caused by seasonal variation in the demand for natural gas can be overcome in part by establishing transmission systems in which gas is withdrawn from a main transmission line and processed for the removal of high ethane liquid hydrocarbons useful in oil recovery operations. During periods of low gas consumption, the resulting dry gas is compressed and stored underground. Carbon dioxide and hydrogen sulfide are extracted from the combustion products generated by the compressors, combined with the extracted liquid hydrocarbons, and transmitted to an oil field for injection into the oil-bearing formation. During periods of high gas consumption, dry gas from the liquids extraction plant is recycled to the main transmission line and previously stored gas which has been compressed and treated for the removal of carbon dioxide and hydrogen sulfide is sent to market to fulfill the increased demand. The liquefied carbon dioxide and hydrogen sulfide are again blended with the extracted hydrocarbons and used in the oil recovery operation. Studies have shown that such a system assures an adequate supply of gas to meet peak in demand without unduly large main transmission lines, permits more efficient use of the compression facilities required to handle the gas, facilitates operation of the carbon dioxide and hydrogen sulfide recovery system, and makes available large quantities of a highly effective solvent for use in oil recovery operations at relatively low cost. The overall system is therefore considerably more attractive



from an engineering and economics standpoint than systems employed in the past.

The exact nature and objects of the invention can best be understood by referring to the following description of one embodiment of a system constructed in accordance therewith and to the accompanying drawing, in which:

FIGURE 1 is a flow sheet schematically illustrating the system during the gas storage phase of the operation; and

FIGURE 2 is a flow sheet schematically illustrating the system during the gas withdrawal phase of the operation.

The system shown in FIGURE 1 includes a gas field **11** from which natural gas is withdrawn and transmitted through a main transmission line **12** to a gas consuming area **13**. The main transmission line may be several hundred miles long. At an intermediate point on the transmission line, generally within about 100 miles from the gas consuming area, gas is withdrawn from the transmission line and passed through line **14** to a natural gasoline plant or similar liquid extraction unit **15**. This unit may be of conventional design and will normally include two or more adsorption columns in which the higher hydrocarbons are adsorbed from the natural gas onto charcoal or a similar material. The treated gas, normally consisting essentially of methane, is passed through line **16** to a gas compression unit **17**. A portion may be recycled to the main transmission line if desired. Here the gas is compressed to a pressure within the range between about 100 pounds per square inch and about 1,000 pounds per square inch or higher. The compressed gas is then delivered through line **18** into gas storage unit **19**. The gas storage unit will normally consist of a porous subterranean formation or an underground cavern. If a porous subsurface formation is utilized as a storage reservoir, the formation selected may be a depleted section of an oil reservoir in which field recovery operations are being carried out or may be a separate formation. Storage of the residue gas in a depleted section of an oil field undergoing secondary or tertiary recovery is normally preferred, since the injected dry gas will be enriched during storage by contact with residual hydrocarbons left in the formation following the recovery operation. The injected gas may also assist in maintaining the reservoir pressure. There are many areas where main transmission lines pass reasonably close to producing oil reservoirs in which the gas can be stored at low cost.

The liquid hydrocarbons extracted from the stored natural gas in gasoline plant **15** and subsequently recovered by contacting the charcoal or other material with steam or similar desorbant are passed through line **20** to oil field **21**. The gasoline plant and gas storage facilities will normally be located adjacent the oil field. It is generally preferred, as pointed out above, to utilize a depleted portion of the oil reservoir for storage of the gas. The liquefied hydrocarbons consist primarily of ethane, propane and butane. These are employed for the recovery of oil from the field. It is preferred to utilize the hydrocarbons as a solvent by injecting alternate banks of slugs of hydrocarbons and water or gas into the oil-bearing zone in the conventional manner but they may also be utilized in other solvent-type processes. One of the difficulties associated with such processes heretofore has been the problem of supplying the large volumes of solvent required. The use of tank cars or similar facilities to supply 10,000 or more barrels of solvent per day to a large recovery operation normally makes the cost of the solvent phohibitive. The system shown provides large quantities of solvent at extremely low cost. In a gas driven slug type recovery operation, the stor-

age gas compressor facilities can be utilized for injecting gas into the field, thereby further reducing over-all costs of the operation.

The installation shown in FIGURE 1 of the drawing also includes a unit 22 for the removal of carbon dioxide and hydrogen sulfide from the stored gas and combustion products. The unit employed may be a conventional Girdler plant or similar unit in which the input gas stream is scrubbed with a solution of calcium or sodium hydroxide and sodium chloride, sodium carbonate, sodium phenolate, monoethanolamine, diethanolamine, triethanolamine or the like and the adsorbed carbon dioxide and hydrogen sulfides are later recovered. During the gas storage phase of the operation as shown in FIGURE 1, the combustion gases from the compressors are passed through lines 23 and 24 into unit 22. The carbon dioxide and hydrogen sulfide recovered from the input combustion gases are passed through line 25 into compressor 26 where they are compressed and liquefied. The liquefied products are blended with the liquid hydrocarbon from line 20 and utilized in the oil recovery operation in oil field 21. The stripped combustion gases may be discharged to the atmosphere. The unit 22 will also normally include a heat exchanger for capturing the waste heat in the exhaust gases from the compressors. This heat is then utilized for generating steam to be used in the Girdler unit. Up to about 50% of the total heat requirement for the Girdler plant can generally be obtained in this manner. The use of the Girdler plant or similar unit for the removal of carbon dioxide and hydrogen sulfide from both the stored gas and the combustion products as shown, rather than from the gas alone, improves utilization of the unit and increases the net return on investment.

As the oil recovery operation carried out in oil field 21 progresses, natural gas may be produced in significant quantities. This gas may be collected at the gas-oil separators in the field and passed through line 27 to gasoline plant 15. Here it may be treated, along with gas from the transmission line, for the recovery of liquefied hydrocarbons. This reduces dependence of the recovery operation upon gas from the transmission line for hydrocarbon liquids and generally increases significantly the quantity of liquids available for use in the recovery operation.

The withdrawal and storage of gas from transmission line 12 is continued as long as the quantity supplied through the line exceeds the demand in market area 13. When the demand overtakes the supply during the fall or winter season, storage is discontinued and the system is operated as shown in FIGURE 2 of the drawing. Here the residue of gas following the extraction of liquid hydrocarbons in unit 15 is recycled to the transmission line through line 27. Sufficient additional gas to balance the supply and demand is withdrawn from gas storage facility 19, passed through line 18 to compression unit 17 where the pressure is raised to the level required for extraction of carbon dioxide and hydrogen sulfide, and then introduced into $CO_2$ and $H_2S$ extraction unit 22. Following extraction of carbon dioxide and hydrogen sulfide, the treated storage gas is passed through storage gas sendout line 28 to the market area. Sufficient gas to meet the peak demand is thus supplied without a substantial change in the amount of gas transmitted through main transmission line 12. The extracted carbon dioxide and hydrogen sulfide obtained in unit 22 is again passed through line 25 to compression facility 26 where it is liquefied and raised to the pressure of the liquid hydrocarbons from the gasoline plant 15. The two liquid streams are then blended to oil field for use as a solvent in the oil recovery operation. The processing of combustion gases from the compression units for the recovery of additional carbon dioxide and hydrogen sulfide and the recovery of waste heat may be continued during this phase of operation. Likewise, natural gas from the oil recovery operation in oil field 21 may be passed through line 27 to the liquids extraction plant and the treated gas used to augment the supply from the main transmission line.

It will be apparent from the foregoing that the system described has numerous advantages over systems employed in the past. It provides large quanities of a low cost solvent for use in oil field secondary and tertiary recovery operations; significantly improves the utilization of compressor facilities required in the gas transmission and storage operation; permits enrichment of the stored gas; makes possible the recovery of heat, carbon dioxide and hydrogen sulfide from waste gases; permits more effective utilization of the natural gasoline plant, Girdler unit and other equipment; and facilitates the use of transmission and storage compressor facilities for injecting gas in an oil recovery operation. Because of these advantages, the system permits substantial savings in over-all investment and operating costs. It will be recognized that these advantages are not restricted to the precise system illustrated in the drawing and that various modifications can be made by those skilled in the art.

What is claimed is:

1. A method for processing natural gas which comprises

(a) transmitting natural gas through a gas transmission line from a gas producing area to a gas marketing area;

(b) withdrawing a portion of the gas passing through said transmission line at an intermediate point between said gas producing area and said gas marketing area and extracting ethane and higher hydrocarbons from the gas withdrawn from said transmission line;

(c) passing the ethane and higher hydrocarbons extracted from the gas withdrawn from said transmission line to an oil field for use in an oil recovery operation;

(d) compressing the dry gas remaining after ethane and higher hydrocarbons have been extracted from the gas withdrawn from said transmission line and injecting said dry gas into a gas storage reservoir during periods of low demand for gas;

(e) recovering compressor combustion gases produced in the compression of said dry gas, extracting carbon dioxide and hydrogen sulfide from said combustion gases, and passing the extracted carbon dioxide and hydrogen sulfide to said oil field for use in said oil recovery operation during periods of low market demand for gas;

(f) returning the dry gas remaining after ethane and higher hydrocarbons have been extracted from the gas withdrawn from said transmission line to said transmission during periods of high market demand for gas;

(g) withdrawing gas from said gas storage reservoir, compressing the gas withdrawn from said reservoir, treating the gas withdrawn from said reservoir for the extraction of carbon dioxide and hydrogen sulfide, and passing the treated gas to said gas marketing area during periods of high market demand for gas; and,

(h) recovering compressor combustion gases produced in the compression of said gas withdrawn from said storage reservoir, extracting carbon dioxide and hydrogen sulfide from the recovered combustion gases, and passing the extracted carbon dioxide and hydrogen, together with carbon dioxide and hydrogen sulfide extracted from said gas withdrawn from said gas storage reservoir, to said oil field for use in said oil recovery operation during periods of high market demand for gas.

2. A method as defined by claim 1 wherein said gas storage reservoir is a partially depleted reservoir in said oil field.

3. A method as defined by claim 1 wherein natural gas produced in said oil recovery operation is mixed with gas withdrawn from said gas transmission line and processed therewith.

4. A method as defined by claim 1 wherein the compressor facilities employed for compressing gas withdrawn from said transmission line and said storage reservoir are also used for injecting gas in said oil recovery operation.

5. A method as defined by claim 1 wherein natural gas produced in said oil recovery operation is mixed with gas withdrawn from said gas storage reservoir and processed therewith.

6. A method as defined by claim 1 wherein heat produced in compressing gas withdrawn from said transmission line and gas withdrawn from said gas storage reservoir is recovered and utilized in the extraction of carbon dioxide and hydrogen sulfide from said combustion gases and said gas withdrawn from said gas storage reservoir.

7. A method for producing a solvent for use in oil recovery operations which comprises:

(a) withdrawing natural gas from a gas transmission line extending from a gas producing area to a gas marketing area at an intermediate point between said producing area and marketing area;

(b) simultaneously producing natural gas in an oil recovery operation in an adjacent oil field;

(c) extracting ethane and higher hydrocarbons from the gas withdrawn from said transmission line and from the gas produced in said oil recovery operation and passing the extracted ethane and higher hydrocarbons to said oil field for use as a solvent in said oil recovery operation;

(d) compressing the dry gas remaining after ethane and higher hydrocarbons have been extracted from the gas withdrawn from said transmission line and the gas produced in said oil recovery operation, injecting said dry gas into an underground gas storage reservoir during periods of low market demand for natural gas, and returning said dry gas to said gas transmission line during periods of high market demand for natural gas;

(e) withdrawing gas from said gas storage reservoir during periods of high market demand for natural gas, compressing the gas withdrawn from said gas storage reservoir, extracting carbon dioxide and hydrogen sulfide from the compressed gas from said reservoir, passing the extracted carbon dioxide and hydrogen sulfide to said oil field for use as a solvent in said oil recovery operation, and passing the compressed gas relatively free of carbon dioxide and hydrogen sulfide to said gas marketing area; and,

(f) recovering compressor combustion gases produced in the compression of said gas withdrawn from said transmission line, the compression of said gas produced in said oil recovery operation, and the compression of said gas withdrawn from said gas storage reservoir, extracting carbon dioxide and hydrogen sulfide from said recovered combustion gases, and passing the extracted carbon dioxide and hydrogen sulfide to said oil field for use as a solvent in said oil recovery operation.

8. A process as defined by claim 7 wherein said underground gas storage reservoir is the formation from which said natural gas is produced in said oil recovery operation.

9. A process as defined by claim 7 wherein said underground gas storage reservoir is a cavern.

No references cited.

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