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DUAL STORAGE CAVERNS

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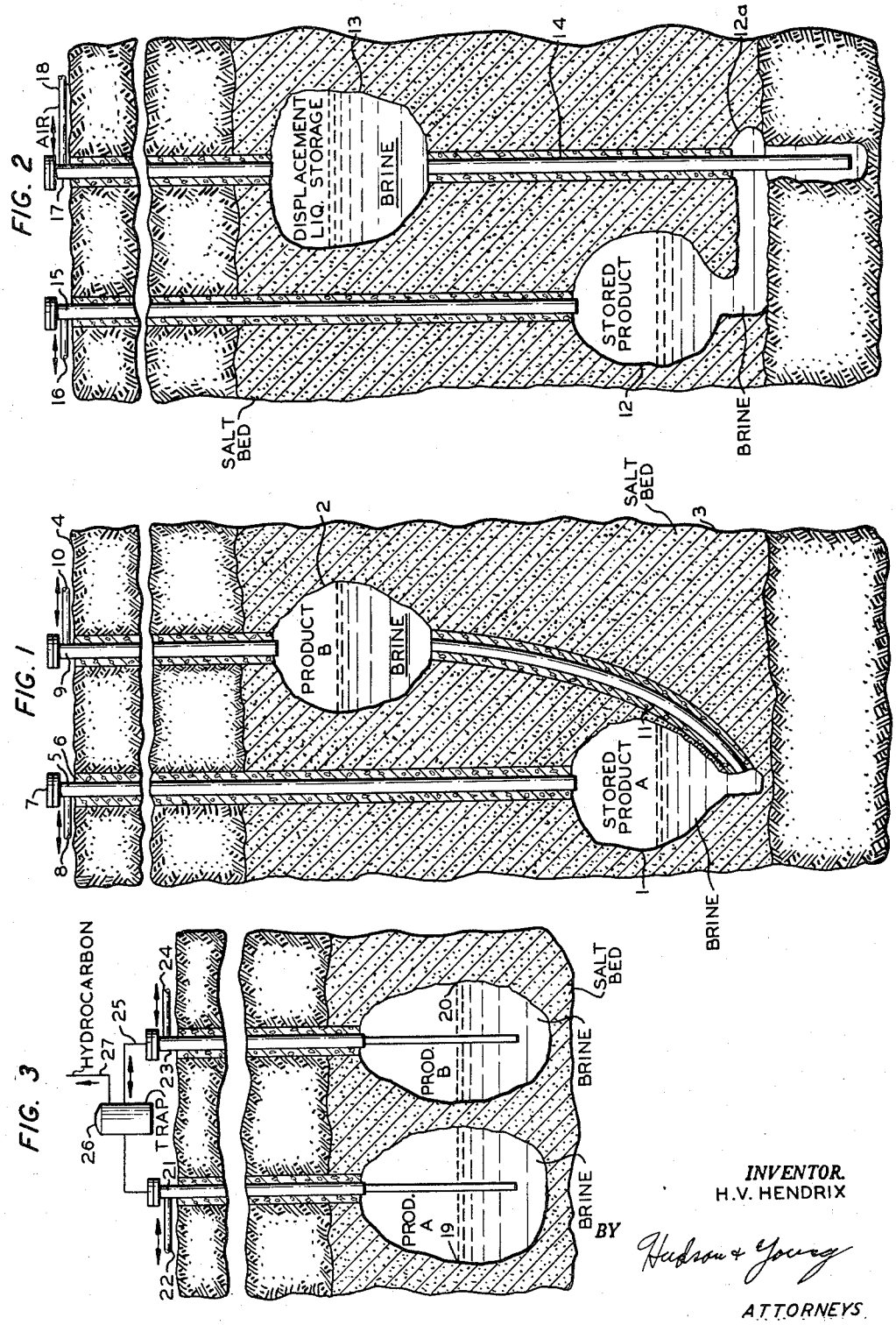

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DUAL STORAGE CAVERNS

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This invention relates to a dual underground storage system and method of undeground storage.

In recent years, the use of underground storage caverns has been widely adopted. These storage caverns are drilled, mined, dissolved or otherwise formed within an impermeable strata of the earth's crust. Quite frequently, these caverns are formed by dissolving with water a cavity within a salt bed. The material to be stored is then introduced into the cavern where it remains until it is to be used. Many methods have been devised to remove such stored material, however, all of these methods have certain disadvantages. For example, these caverns are frequently quite deep and pumping costs are consequently quite high. If the pump is in the bottom of the well, maintenance is difficult, if not impossible without removing the entire pumping equipment. Frequently, the material can be removed by vaporization, however, in this case, the heat exchange equipment frequently becomes encrusted with salt. One method employed has been to displace the stored material with water or brine, however, many such caverns are located where water or brine is scarce and bulky brine or water storage facilities are required above ground. When such caverns are formed in salt beds, then brine must be used or the cavern will continually be enlarged by further dissolving the salt in fresh water. Frequently, one using underground storage will have a product which is high in demand in one season and a different product is in high demand during another season. For the most economical operation of processing equipment, such equipment should operate at a uniform rate on a year round basis. This invention is especially useful where two such products are being produced. Examples of such products are liquid petroleum gas (LPG) and gasoline. The LPG has a high winter demand while gasoline has a high summer demand.

An object of this invention is to provide a novel storage system for storing dissimilar liquids underground.

Another object of this invention is to provide a storage system wherein the displacement liquid is always contained therein.

Still other objects, advantages and features of this invention will be apparent to those skilled in the art having been given this disclosure.

The apparatus of this invention comprises two underground caverns having a means of communication there between and containing the displacement liquid therein.

The method of this invention comprises containing a product liquid in one cavern, containing a displacement liquid in a second cavern and displacing said product liquid with said displacement liquid to remove said product liquid.

When only one product is to be stored, one cavern will generally be formed at a higher level than is the other cavern. The lower cavern will then be filled with a displacement liquid such as water or brine after which the liquid to be stored is forced into said lower cavern under pressure so as to force the displacement liquid through a conduit means to the upper cavern. When it is desired to remove the stored liquid, the weight of the displacement liquid will force the stored liquid up and out of the cavern. On the other hand, when two products are to be stored during opposite seasons, the caverns can be at the same level or at different levels depending upon the cost of installation, nature of the formation in which the caverns are to be formed, etc. In this two product storage system, when one cavern is full of product the displacement liquid will be in the other cavern and if the caverns are of the same volume, as will usually be the case, the other cavern will be full of displacement liquid. The storage requirements will then change and the second liquid to be stored will be pumped into the cavern initially containing the displacement liquid thereby forcing said displacement liquid into the cavern containing the first stored liquid and displacing same.

The two caverns will, in general, be of substantially equal volume, however it is within the scope of the invention to use caverns of different volumes. However, if caverns of different volumes are used, auxiliary equipment will be required to remove the last portion of the product being stored in the larger of the two caverns. In any case, provision will be made for passing liquid from a position near the bottom of one cavern to a position near the bottom of the second cavern and a product conduit will be installed in each cavern.

The advantages and features of this invention can best be described by referring to the drawings of which:

Figure 1 is a sectional schematic diagram of caverns in a salt formation wherein two products are being stored with one cavern at an elevation greater than the other;

Figure 2 is a sectional schematic diagram of caverns in a salt formation wherein one of said caverns is used for storing the displacement liquid, the connecting conduits being of different arrangement than is Figure 1; and

Figure 3 is a sectional schematic diagram of caverns in a salt formation wherein both caverns are at the same elevation and the caverns are connected by conduit communication from a position near the bottom of said caverns and passing overhead.

In the above drawings, the overhead conduit is most conveniently employed in caverns of the same level wherein caverns located at different levels, the underground conduits or passage ways are most conveniently employed, however, it is within the scope of this invention to use either communication means in either arrangement of caverns.

In the description of the drawings which follows, it will be assumed that the caverns are in salt formations, however, it should be understood that said caverns can be in any impervious formation whether natural or artificial; that the displacement liquid is brine; that the product being stored in one cavern (product A) is LPG and the product being stored in the other cavern (product B in Figures 1 and 3) is gasoline.

Referring to Figure 1, a cavern 1 is formed at a low level in salt bed 3 and cavern 2 is formed at a higher level. These caverns can be formed by any method known in the art, however, in a salt formation, one convenient method is to sink a shaft from the surface of the earth 4 to a position near the bottom of the desired cavern. A conduit is lowered into the shaft to a position near its bottom and a liner 5 is placed in the shaft from the earth's surface to a position wherein it is desired that the top of the cavern be located. This liner is cemented in place by concrete 6. Water is then pumped through the first said conduit to the bottom of the shaft wherein it dissolves salt forming the cavern, the brine so formed flowing out through liner 5. After the cavern is formed, the first conduit is removed and the liner can be capped

such as by 7. A product line 8 is installed in liner 5. Cavern 2 is formed in the same manner leaving liner 9 and product conduit 10. The bottom of the two caverns is then joined by conduit 11.

In the operation of this embodiment, sufficient brine is introduced, or left after preparation, to fill one of said caverns. LPG is then introduced into cavern 1 via conduit 8 and liner 5 displacing the brine forcing it into cavern 2 via conduit 11. When the season for storing LPG is over, gasoline will be stored by passing it into cavern 2 via conduits 10 and liner 9 thereby pushing the brine back into cavern 1 displacing LPG which is removed via conduit 8. The following season, the cycle is reversed and LPG is again stored forcing the brine into cavern 2 displacing gasoline.

Referring to Figure 2, cavern 12 is formed in much the same manner as was cavern 1 of Figure 1 with the exception that 12*a* is formed by leaching or fracturing methods. Cavern 13 is formed as was caverns 2 and the bottom of cavern 13 is joined to the projection 12*a* by means of a conduit or liner 14. Cavern 12 is equipped with inlet-outlet conduit 15 cemented in place, said conduit 15 having a product conduit 16 installed therein. Cavern 13 is also equipped with an inlet-outlet conduit 17 and this conduit has an air line 18 installed therein. This line 18 can consist merely of a bleed vent or opening in conduit 17. Brine is introduced into the system and then the material to be stored is passed via conduits 16 and 15 to cavern 12 displacing brine which passes via projection 12*a* and conduit 14 to cavern 13. This cavern will generally be opened to the atmosphere. Now when it is desirable to remove product from cavern 12, the pressure of the brine, being at a higher level, will force the stored product back up the conduits 15 and 16. Air from the atmosphere will fill in the space left in cavern 13.

Referring to Figure 3, two caverns 19 and 20 are formed in an impervious formation at about the same level. Like the caverns of Figures 1 and 2, these caverns are equipped with product conduits 21 and 22 to cavern 19 and 23 and 24 to cavern 20. These caverns can be joined by a conduit means joining the bottom of the two caverns such as by a projection such as 12*a* of Figure 2. In this case, the operation of the cavern would be the same as that described for Figure 1 with the exceptions

that the gasoline would also have to be introduced under pressure since the brine is not elevated as it was in Figure 1. In the modification shown in the figure, a conduit 25 extends down through conduits 21 and 23 to a position near the bottom of the caverns. This conduit 25 connects to a trap 26 wherein any hydrocarbon which might be accidentally drawn off with the brine, will be caught and bled off via conduit 27.

Several modifications have been suggested in the preceding discussion. Those skilled in the art will see many modifications which can be made without departing from the scope of this invention.

I claim:

1. A method of storing and withdrawing, respectively, two different fluids, one being in relatively great supply while the other is in relatively short supply, said method comprising forcing the fluid which is in relatively great supply into one of two subterranean cavities, said other cavity containing said fluid which is in relatively short supply, said cavities being in open communication with each other at their lower ends via conduit means, said cavities being partially filled with a liquid which is heavier than, and immiscible with, said two fluids, thus forcing said liquid into said other of said cavities and forcing the fluid which is in relatively short supply out of said other cavity.

2. The method of claim 1 wherein the displacement liquid is brine, the first said fluid is liquid petroleum gas and the second said fluid is gasoline.

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