Simultaneous Storage of LPG and Production of Brine, Pierce Junction Dome, Houston, Texas

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ABSTRACT

A multi-well system is being used for simultaneous storage of LPG pipeline mix, refined LPG products and for the production of brine. The special problems encountered and the safety procedures utilized in this operation are discussed in the paper. Construction and operation of a "U" tube well system for high rate injection and withdrawal of LPG is illustrated.

INTRODUCTION

The Texas Brine Corporation began production of brine by solution mining at the Pierce Junction Dome in 1946. The Pierce Junction plant of Texas Brine Corp. is located in the southside of Houston, Texas as shown in Figure 1. The depth to top of salt at this location is approximately 1,000 feet. Storage of hydrocarbons began late in 1946 and has been concurrent with brine production since that time. At present six wells are being used at the location. Brine is produced and pumped to consumers located near the ship channel in Pasadena, Texas. Some customers are serviced by truck tankers from the Pierce Junction plant or loading stations located at Pasadena.

Six and one half million (6,500,000) barrels of hydrocarbon storage space is now available at this location. This space is being used to store pipeline mix and after fractionation, purity products such as propane, butane and isobutane. The system is also designed to take pure product from the pipeline and place it directly in purity storage.

Although solution mining for salt and storage of hydrocarbons in salt dome cavities is by no means new, we believe the combined operations on a large scale is unique. The mechanics of well design become complex when two primary objectives are associated in the same well such as:

1. Maximum uninterrupted brine production and,
2. Large seasonal variation of hydrocarbon storage.

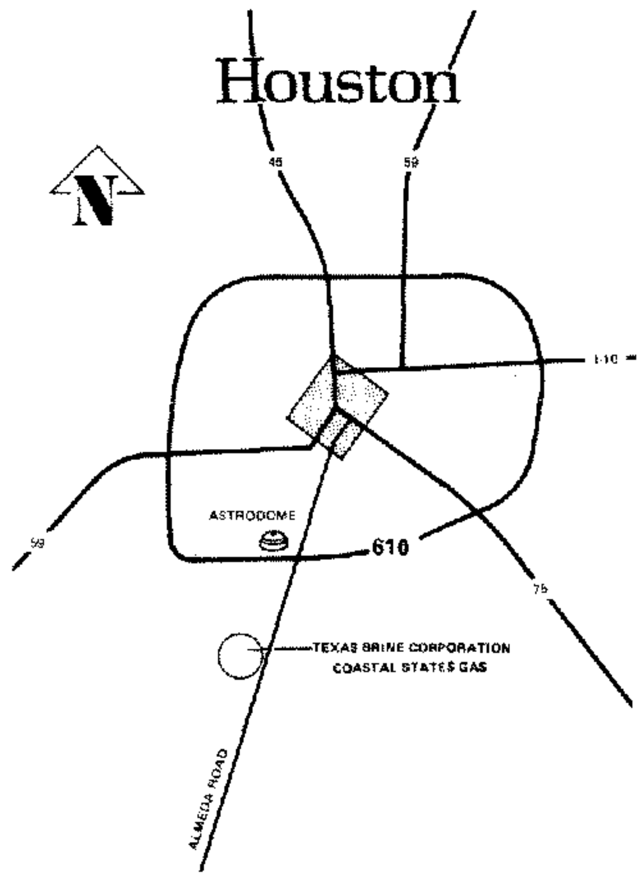

Figure 1. Location map showing outline of Houston, Texas and site of Pierce Junction facility of Texas Brine and Coastal States Gas, south of Loop 610.

Well head equipment and casing differ greatly from a normal brine producing or storage well for a given gallons per minute as both of the rates, with relation to pipe size, have to be incorporated in the same well.

One of the first differences to be noted is that in a brine production well the annulus between the cemented seal string and the hanging casing strings needs only to have sufficient area to inject or withdraw the seal fluid used for casing seal protection. The combined storage and brine well requires that this area be at least equal to in area of the casing tubing annulus or the tubing area.

The well heads remain essentially the same as in a brine well, with the exception that the Braden heads which are usually fitted with 2" taps for seal fluid, now require two 4", one 6" or one 8". This is dependent on well annulus area and pressure drops wanted across the well head. It is desireable to have the pressure drops in the water-brine and product strings close to a balance at the well's design rate.

REQUIREMENTS FOR OPERATION

Significant items required for a joint production of brine and LPG Storage operation are:

1. Excess fresh water supply and storage.
2. Excess injection facilities.
3. Large brine storage facilities.
4. Piping system to allow the injection of fresh water and/or brine into one or both strings of pipe for hydrocarbon displacements and maximize salt recovery.
5. Plans for batch production brine from certain wells due to predictable increase or decrease in hydrocarbon injections in a given period of time.
6. Designs and placement of casing and tubing strings for normal solution mining in and below the storage cavern, as well as control of product inventories for leaching definite areas of the cavern.
7. Mutual cooperation for the operation is a definite requirement. Texas Brine Corporation and Coastal States Gas maintain constant communications and are both monitoring the operational system.
8. Safety equipment and procedures are a necessity.

The wells are equipped with automatic shut off valves which will close in case of emergencies. This equipment is designed as fail safe in the event of utility failures.

MODES OF OPERATIONS

The seasonal variations of hydrocarbon storage results in two modes of basic operations.

MODE I During the six months of predominately hydrocarbon receipts to the facilities, brine production is derived from gas displacement with fresh water being used for back wash to trim out the operation.

MODE II During the second mode of operation, both brine production and product displacement require the use of fresh water with some brine being used to displace certain wells.

In the first mode of operation, with the high rate batch receipts of hydrocarbon, large brine surge capacities are needed to store the required production brine between these batches. Brine requirements for pipeline delivery is less than brine produced during these high injection times. To give an idea of the surge capacity required, batch injections will normally run for 52 hours every 36 hours. This results in a minimum working brine storage of seven million gallons.

In the second mode of operation, where hydrocarbons are being moved to markets, the fresh water injection, storage and supply facilities have to be approximately twice that required for the normal daily pipeline brine production.

EXAMPLE OF DEVELOPMENT & OPERATION

One of the wells in the Pierce Junction facility is the sixth phase of development. The well was originally drilled and completed in 1962 for primary brine production. The well was operated until 1968 with only a minor part of the cavern being used for LPG storage. During 1968 and to the present four additional phases of the development have been carried out or are now in progress for hydrocarbon storage and increased salt production. A history of this well will show one of the methods used to combine the two operations in one well.

Phase I. The drilling, completion and washing of the sediment pocket at the bottom of the well is shown in Figure 2. Primary tubing injection was used during this period of time. The seal fluid was maintained at the base of the 9-5/8" casing.

Phase II. The continuation of tubing injections of fresh water after raising the 5-1/2" tubing string above the base of the well is shown in Figure 3. It can be noticed that the well retained the same basic shape as in Phase I, but increased in size over the entire cavity. The seal fluid was also maintained at the base of the 9-5/8 as was the case in Phase I.

Phase III. This phase was started by placing the casing string 400 feet below the 13-3/8 cemented seal string, which is 1600 feet below the surface (Fig. 4). The 5-1/2" tubing was then set 1,000 feet below the 9-5/8" casing. During this phase reverse injection was used, that is the water was injected between the 9-5/8" and the 5-1/2", with the brine being removed through the 5-1/2" tubing. The seal fluid was maintained at the base of the 9-5/8" casing. During this period of development very little change was noted in the lower half of the well with the exception of sand accumulations from the washing in the top section. On the other hand, the top half of the well, which was only a bore hole before, has now shown the appearance of a well developed cavity. Due to the water

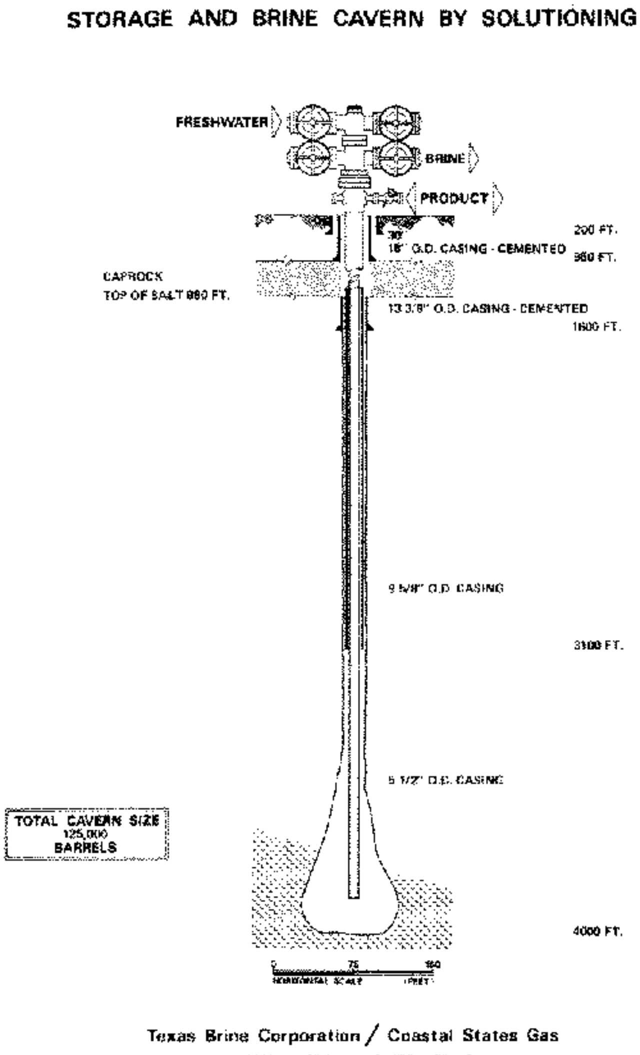

Figure 2. Development of a storage and brine cavity in the Pierce Junction salt dome. Initial phase shown here after cavern has reached size of 125,000 barrels.

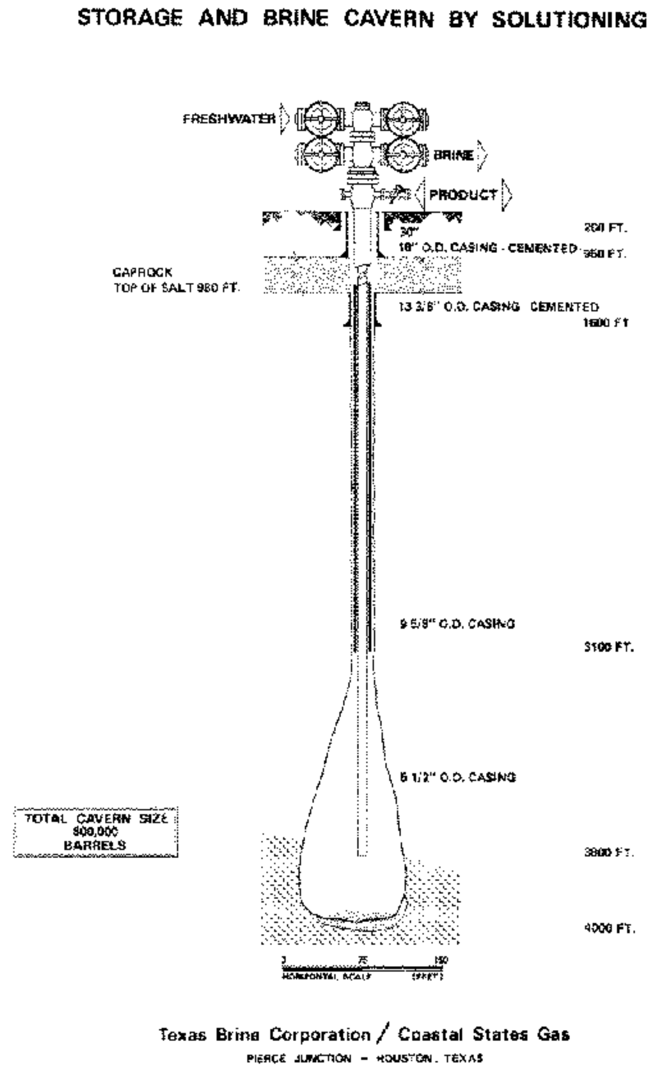

Figure 3. Development of cavern shape at size of 800,000 barrels.

being injected at the top, the roof, at this time, is almost flat.

Phase IV. This procedure was initiated to dome the roof of the cavern (Fig. 5). The casing and tubing strings of pipe were left as in Phase III. Reverse circulation was again performed with the seal fluid varied from the end of the 9-5/8" casing located at 2,000 feet to 1,900 feet in four 25 foot steps. This was done to dome the roof of the cavern in the bore hole area. No other change in the cavern size was noted at this time.

Phase V. During this phase the 9-5/8" casing was lowered 400 feet into the cavern (Fig. 6) with the 5-1/2" tubing set 1,400 feet below the casing. Product storage was then utilized in the top 375 feet of the cavern. Both tubing and casing injections were used during this period of development. The top and bottom sections of the cavern were enlarged, with the neck section of the cavern remaining very close to the same. Additional sand accumulations are also noted at the base of the cavern. At this time the total depth of the well has decreased by some 125 feet due to the sand (anhydrite) accumulations from salt solutioning.

Phase VI. During Phase VI, which is the current phase of this development, the 9-5/8" casing is set 900 feet into the cavern (Fig. 7) with the 5-1/2" tubing 750 feet below the casing. In this stage of development three things will be accomplished by the use of casing and tubing injections based on the product storage depths:

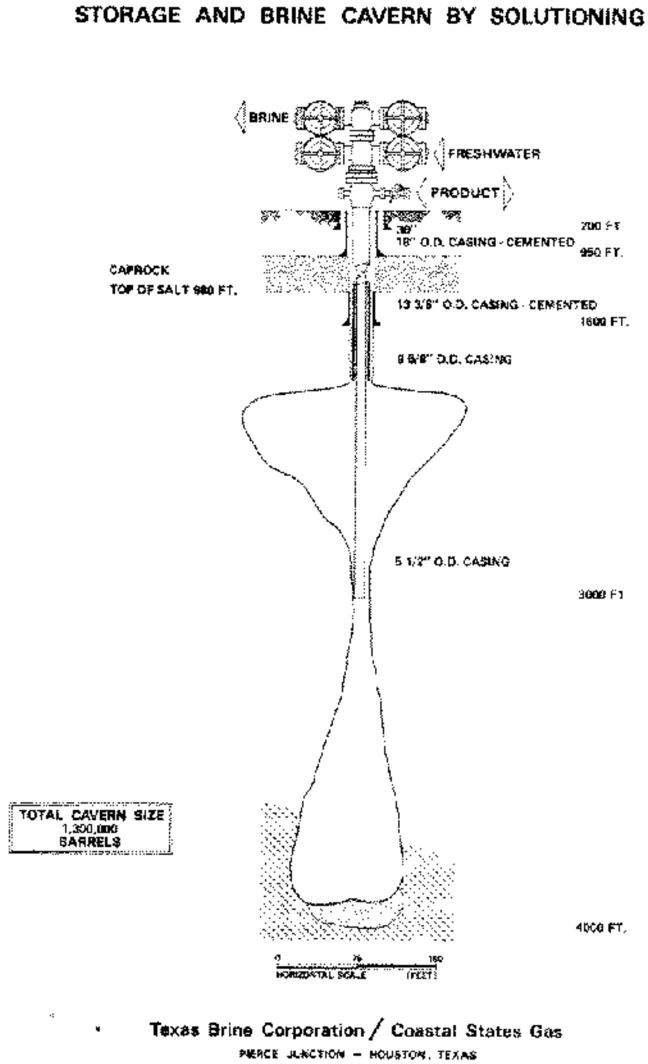

Figure 4. Development of cavern shape at size of 1,300,000 barrels capacity. Note cavity development at top of cavern after reverse injection.

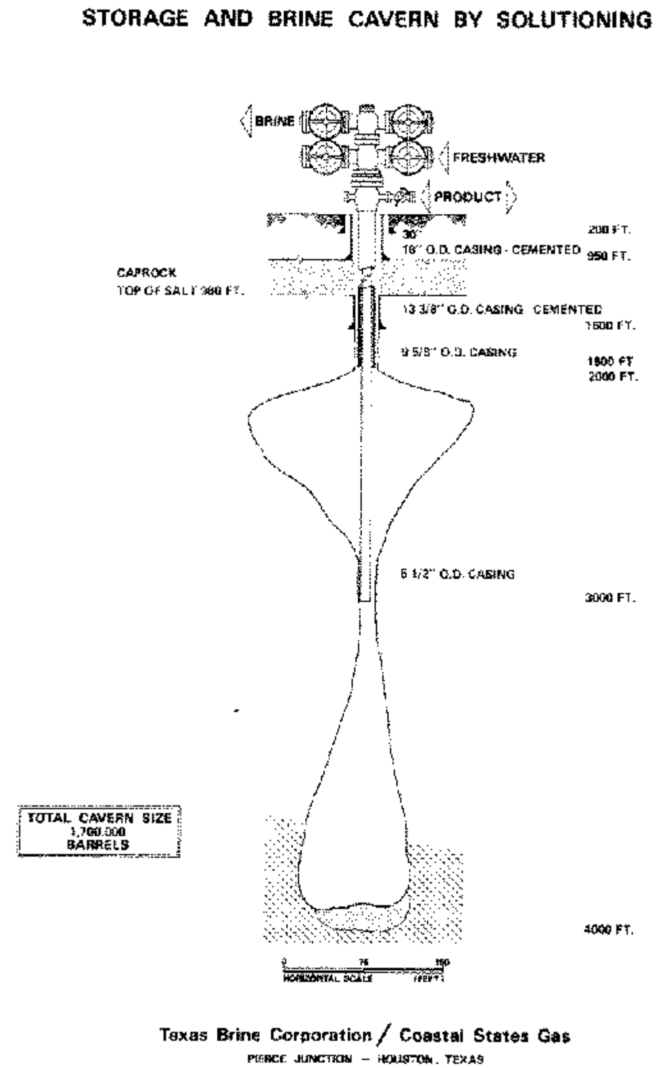

Figure 5. Doming of roof of cavern and slight increase in size shown at end of Phase IV.

1. Increase in the product cavern size.
2. Additional salt recovery in the lower part of cavern.
3. Enlargement of the neck area in the middle of the well.

All development steps in this well have been verified by sonar surveys.

DEVELOPMENT OF A HIGH RATE WELL FROM AN EXISTING CAVERN

Some two and a half years ago the need arose to have a storage well that could receive hydrocarbons at 3,500 gallons a minute. The development time schedule for a new well of this size was estimated to be 18 to 24 months. As this did not meet the needs, the insertion of U-tubing of one of the existing wells was then considered. The well that was picked had to have the proper cavern shape and size, so that the U-tubing could be inserted safely. The number 1 well at Pierce Junction fit the basic requirements. A second well head site was picked 120 feet to the west-northwest of the existing well head. No. 1 well was emptied of product and tested. Upon completion of the tests, drilling was started on the new access well to the cavern. No major problems were encountered and the new well bore entered the cavern at the expected point 1,520 feet below the surface. The completed well heads are shown in Figure 8. The well head on the right is the

STORAGE AND BRINE CAVERN BY SOLUTIONING

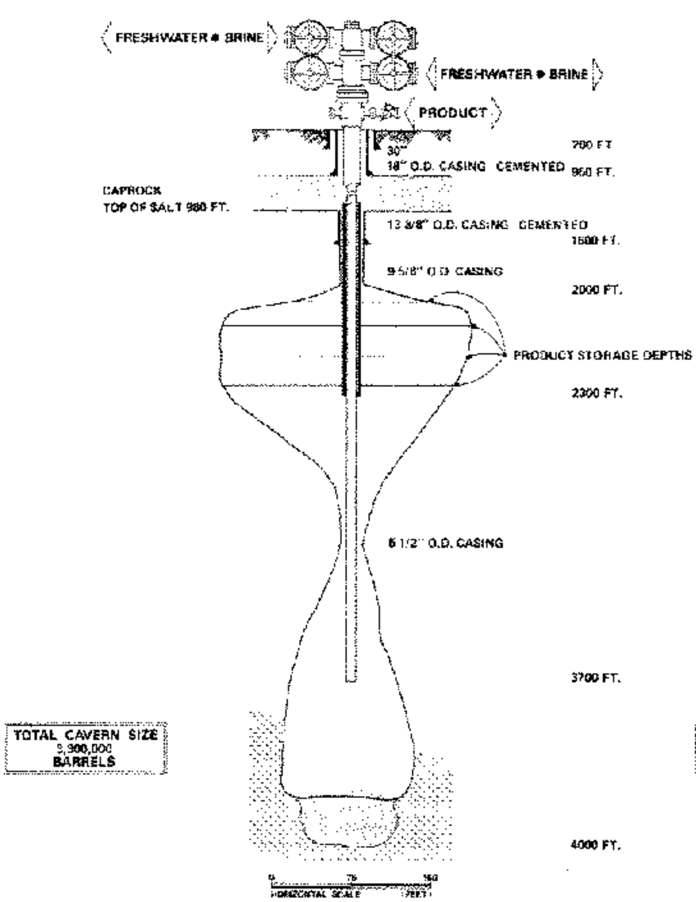

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Figure 6. Product storage begins in upper portion of cavern concurrent with cavern enlargement.

STORAGE AND BRINE CAVERN BY SOLUTIONING

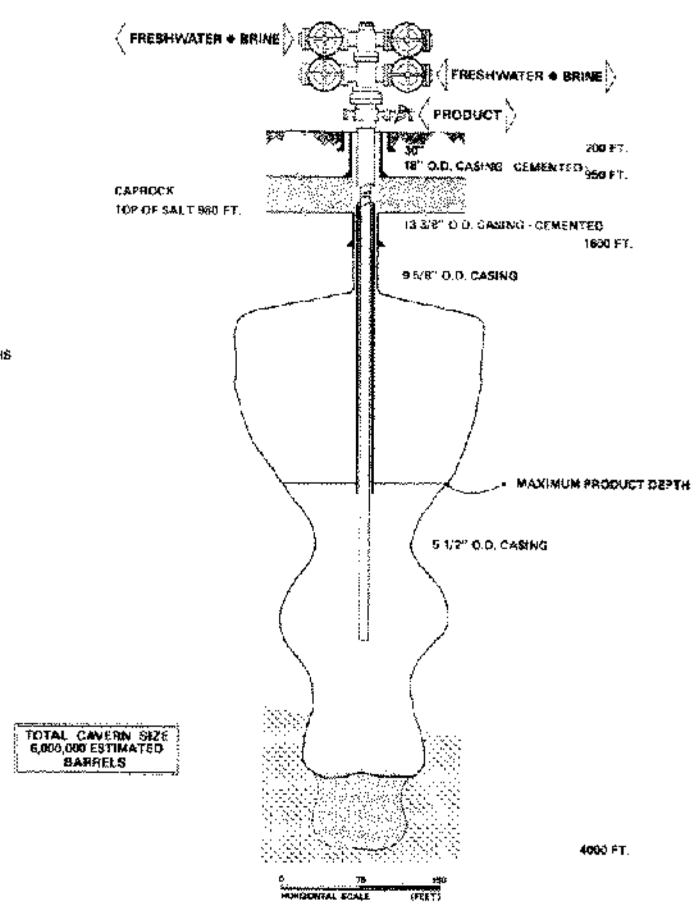

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Figure 7. Current operating phase (1973) includes product storage, salt recovery from lower cavern, and enlargement of neck of cavern.

original No. 1 well with the new No. 1A well head being on the left. With seal depths close to the same elevation, the main difference is noted in the casing and tubing sizes. The original well had 6-5/8 seal casing while the new well has 16 inch seal string. The old well head is now used for product withdrawals only, the new well head handles all product injection and brine displacements or withdrawals. This well has been in operation for some time and has exceeded the original design on a continuous basis.

CONCLUSION

The simultaneous storage of LPG and production of brine at Pierce Junction has been successful. It is a feasible and economical operation if the basic guidelines and requirements outlined earlier are adhered to.

The present facilities and operations are quite different than in earlier years. As growth occurred the problems that were encountered with equipment and operating procedures were upgraded to meet the changing situation.

With the steady increase in energy demand the need for storage facilities certainly will also increase. Cavern development requires time and results in brine production. This brine must be either used or disposed of by surface or subsurface methods. The Pierce Junction plant of Texas Brine Corporation is favorably located to serve many of the industries of the Houston area with their raw material needs for brine and at the same time creating space for future hydrocarbon storage.

HIGH RATE STORAGE WELL #1

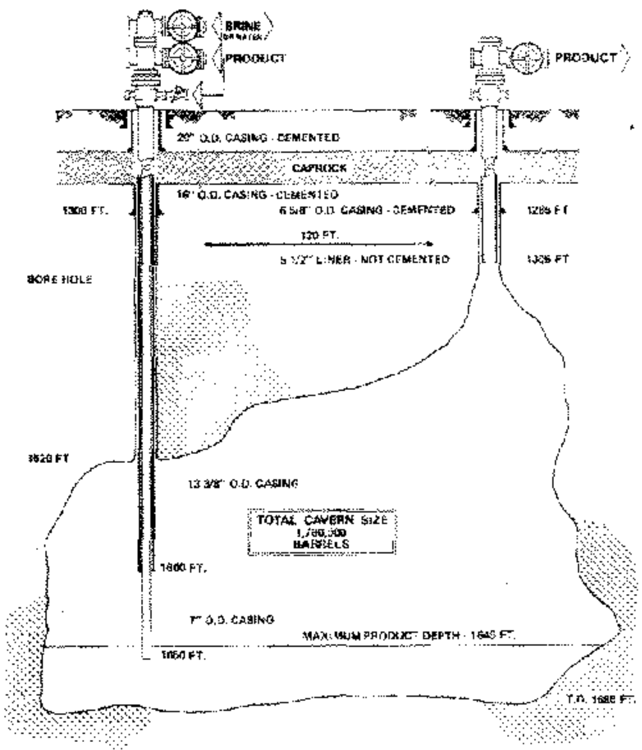

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Figure 8. Two-well system for high rate storage and production.