Southeastern Michigan Gas Company's High Pressure Gas Holder in a Salt Strata

by

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ABSTRACT

Southeastern Michigan Gas Company sought and evaluated all available data including studies of well cuttings in the area containing an abandoned salt cavern formed by routine brine production of the Morton Salt Company.

The gas company measured the size and shape of the cavern, the density of the cement column behind the casing, the scale inside the casing, the casing corrosion, and the shape of the casing cross-section, and compared the sample logs from the well cuttings with all electrical logs in the area.

After evaluating all data by steps to this point, the cavern was made ready to receive the gas for storage by casing and tubing the hole (including preparation for pulling tubing under pressure at a later time), installing the well head, blow out preventer, safety controls, etc.

The gas company geologist kept close liason with a petroleum engineer, a natural gas specialist, Mr. H. L. Gentry of Jackson, Michigan, concerning all phases of the investigation of this proposed high pressure gas holder; but Mr. Gentry originated, guided and directed the final design and installation of all above ground structural and mechanical devices, as well as formulating the rules, instructing, and training the men to the operation, maintenance, and safety habits connected with this high pressure gas holder and its piping, valving, compression, metering, testing, as well as the de-waxing, heating, cooling, and moisture control including mist extraction and water injection operations.

Although all the brine has not yet been removed from this cavern which Southeastern Michigan Gas Company has leased from the Morton Salt Company, the actual performance of this high pressure gas holder has been very close to expectations.

The usefulness of this high pressure gas holder for a utility or an industry is measured first by the assurance of a constant dependable gas supply during emergencies or peak cold periods; and second, by the money difference between the cost of gas on a firm basis and the cost of gas on an interruptable basis.

This is primarily a summary of the preliminary geologic investigations necessary for a salt cavern to be used as a high pressure gas holder by the Southeastern Michigan Gas Company. This cavern was developed by Morton Salt Co. during routine brining operations, near their plant at Marysville, Michigan.

These preliminary investigations were reported from time to time to Mr. H. L. Gentry, who later supervised the design and construction of the installation. Mr. Gentry reports the essentials of the design and construction of the facility in the article which follows this summary.

The second part of the report pertains to a brief summary of operations of the holder together with a suggestion of the economics of the facility, notwithstanding the short time involved and the use of only minimum compression facilities to obtain a test of the cavern.

The salt strata in which the cavern was developed contained, in addition to the salt, three non salt strata. See Figure 1.

One or both of the two lower non salt strata in this salt unit had interferred with the Salt Company's producing the brine. This interference was due in part to rock falls cutting the tail from the production tubing; and, as a result, this potential brine producer had been out of the service of the Salt Company for several months.

The Southeastern Michigan Gas Company acquired the use of this abandoned brine producer, containing about 4, 122, 000 cubic feet of brine, for experimental testing with the idea of using the cavern for the storage of natural gas.

The hole above and below the cavern, and the rock ledge in the cavern, was calipered by a conventional mechanical tool with the result that the total depth was found at 2, 250 feet, about 100 feet above the base of the salt strata. A restriction was found in the cavern at 2, 087-94 feet. The diameter of the uncased hole above the cavern varied between 10 inches and 16 inches; and, the bottom part of the casing was located a short distance above the cavern.

The cavern top was at 2, 057 and was at the top of the salt strata. The salt strata as drilled prior to the development of the cavern contained not only the non salt strata between 2, 087 and 2, 094 feet, which was found by the caliper log, but the salt strata contained a shale between 2, 100 and 2, 106 which had collapsed, and a dolomite between 2, 305 and 2, 313 which was buried by the insolubles within the salt, which salt had been dissolved to create the cavern.

The Sonar log then obtained the size and shape of the cavern, a cross section of which is shown in Figure 2. Figure 3 shows the superimposed profile of the cavern taken at the eight compass bearings; and this profile indicates that the hole is quite symmetrical.

The old casing which set a short distance above the cavern was then reamed to dislodge the scale in the casing.

The corrosion caliper was run to check for pits and splits in the casing as well as indications of slumping of the formations overlying the cavern. The corrosion caliper showed no measurable loss of casing wall below three joints from the top of the hole.

At this time a gamma density log indicated satisfactory results from the original cement job done on the well when the well was first completed.

Simultaneous with the investigation of this hole, known as Morton No. 16, detail and regional maps were made of the area. These maps showed a total Silurian Salt thickness of about 550 feet at this location. The 550 feet of salt is distributed over about 1, 000 feet of vertical section in this area. The salt of the Silurian occurs in four groups with each group of salt containing some non salt strata. Regionally in this area the Silurian Salt thickens to the north and westward. About 1, 800 feet of Silurian Salt is believed to occur near the center of the Michigan basin. This abundant reserve of salt in densely populated areas is prospective for development as a peak shaving or pressure shaving facility.

Due to high concentrations of population and the favorable location of salt strata, a part of Southern Michigan, Ontario, Eastern Ohio, Western New York, Western Pennsylvania, and other areas, are prospective for the development of high pressure gas holders in salt strata.

The above geological investigation pertaining to regional and detailed structural, stratigraphic, and sedimentary processes of the area, together with the physical condition of the well, were then reviewed with Mr. H. L. Gentry, a petroleum engineer specializing in natural gas, who then estimated the cost of completing the project, but with no guarantees as to limit of expense.

Construction began with only minimum essentials included in the preliminary design of the facility for test purposes. Design included provision for expansion and for completing the facility after the test period by the installation of after coolers and adequate sized compressors for the injected gas. After coolers, for example, were not necessary in the initial installation

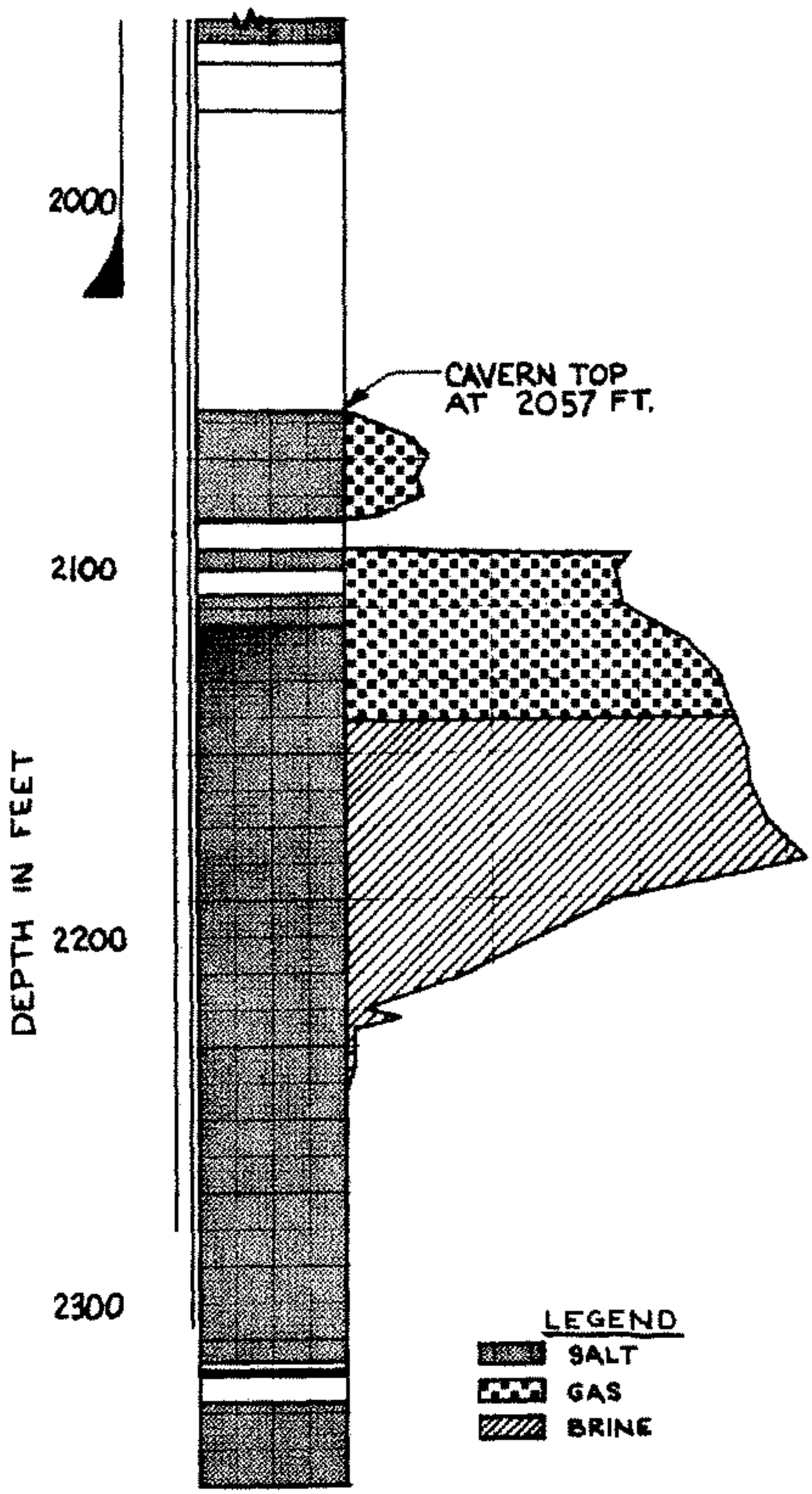

Figure 1. A graphic diagram primarily of a typical cross-section of one-half the cavern, and the strata containing this cavern now being evacuated of brine by injecting gas. Also shown is the respective salt strata above the cavern.

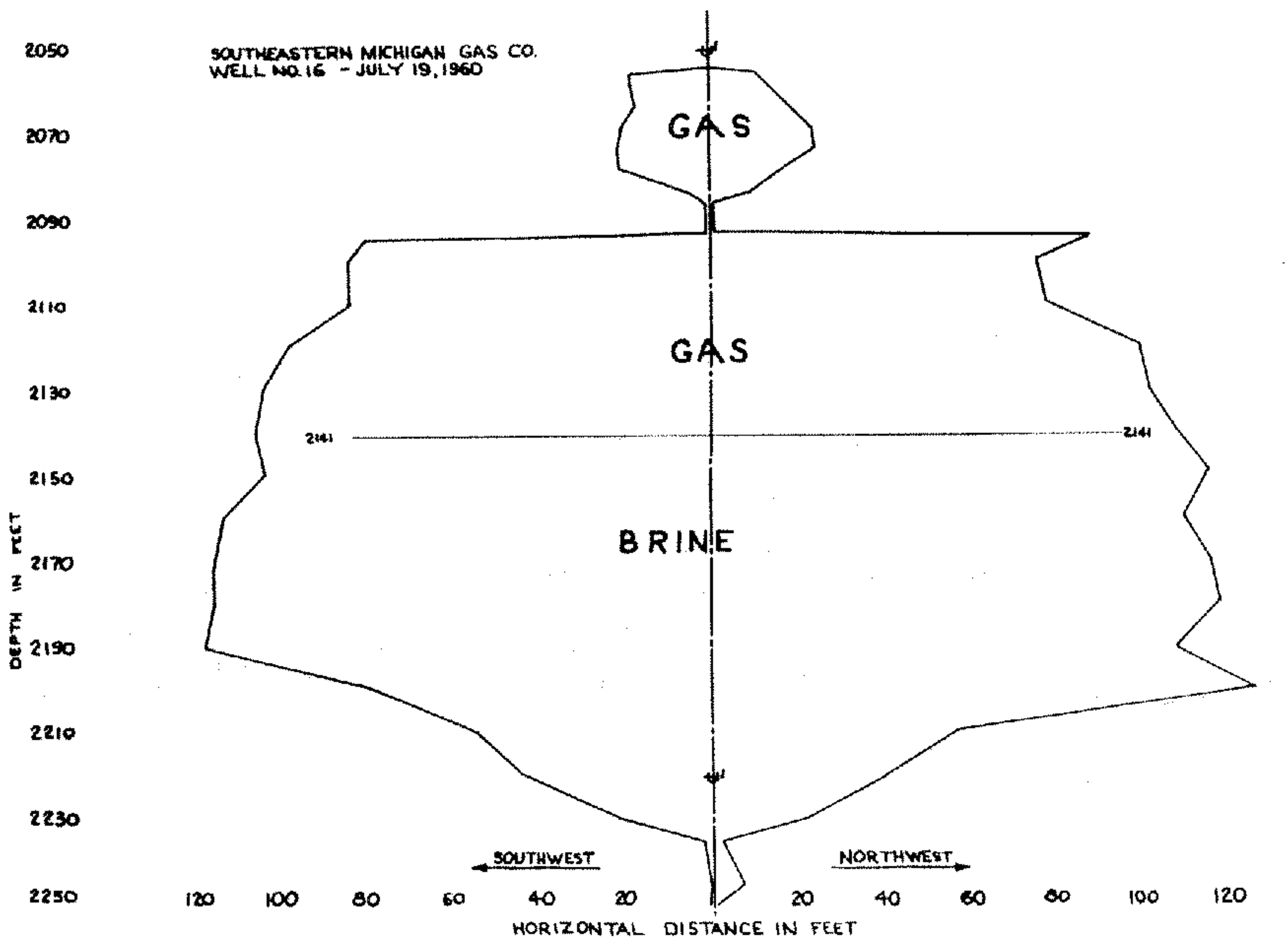

Figure 2. A cross-section of the cavern. Note: Dowell of Tulsa (Attn. Art Myers) probably can supply a better picture.

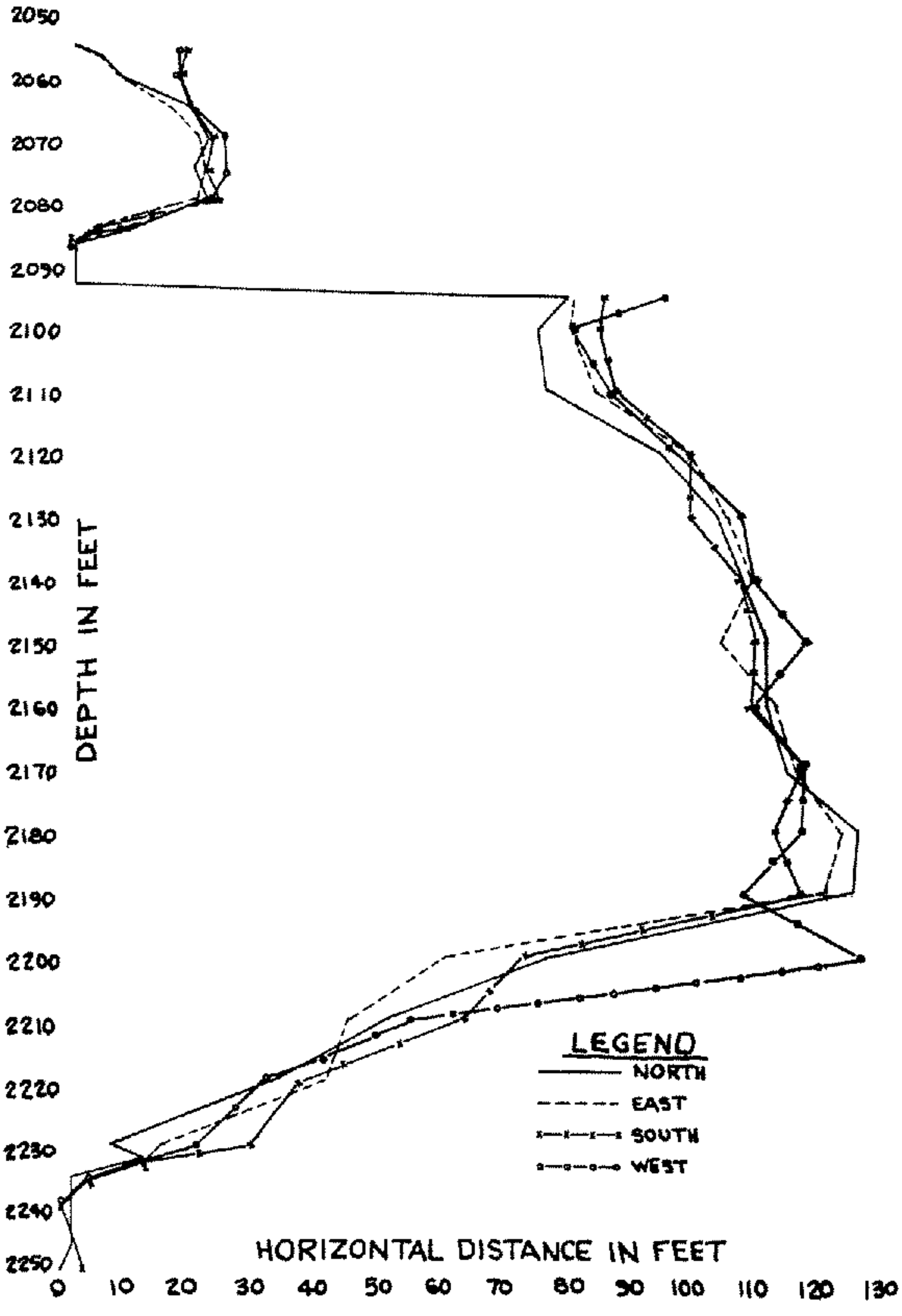

Figure 3. Superimposed cross-sections of the cavern show the near symmetry of the cavern.

because the injected gas was cooled near the casing head by the brine as the brine left the well. The gas was injected into the annulus between the casing and the tubing with sufficient pressure to force the brine from the cavern through the tubing. The brine, therefore, cooled the gas which was injected at the heat of compression which varied between 250° and 275° F.

The brine as it left the well was cold and contained some dissolved gas. Any significant pause in the flow of brine would allow a part of the dissolved gas to accumulate in the top of the brine header. The actual quantity of gas in the header was small and was to a large degree a function of the temperature of the brine column. During the winter, however, when the cavern pressure became considerably less than the original injection pressure, enough gas would leave the brine in the cavern to cause a pressure rise on the cavern capable of being measured with a dead weight gage of the wellhead pressure. No gas would accumulate in the brine header after the cavern pressure decreased (due to withdrawing the gas) below the brine static pressure.

Prior to the 1961 season's final day of injection, test runs were made on the facilities for putting the gas from the cavern into the distribution line. Injection into the cavern continued for several more days due to availability of gas; and the cavern was then shut in for a 30-day pressure test. The pressure test showed the cavern to be tight.

A neutron log was then run and compared with previous logs to indicate brine level in the cavern and to indicate the occurrence of gas, if any, above the casing seat. This neutron log showed the brine to be located where it was expected, due to knowing the size and shape of the cavern and the quantity of brine metered from the cavern. The casing seat portion of the neutron log duplicated the control log.

This high pressure gas holder has a working capacity of about 341 million cubic feet of gas between a wellhead pressure of 1,100 psia and a minimum line pressure of 150 psia. This 341 million cubic feet of gas is available to the line due to the gas pressure within the cavern. Design of the compressor facility provides for about 40 million cubic feet of additional gas (when the cavity is free of brine) to be compressed into the line from this cavern by using the compressor which is normally used for gas injection only.

Although only 1/3 of this salt cavity was usable during the past winter due to the brine occupying 2/3 of the cavern; and, although the cavern was usable only after December 27, 1961, the use of this cavern proved profitable for that part of the winter after the above date. For the months of January, February and March, about $70,000.00 extra profit was made by the gas company due to reducing the cost per unit of gas sold.

This $70,000.00 does not include savings in future construction cost made possible by the ability with the strategically located high pressure holder to send out two or three times as much gas (in our case) than could be receivable, if available, on cold days from our chief point of gas purchase.

Because the $70,000.00 figure may seem of slight significance to a company many times larger than Southeastern Michigan Gas Company, I can report that cold weather and the gas holder cause first quarter 1962 earnings to increase 34% when compared with the same season of the previous year. A further boast is that there has been no interruption or curtailment for any customer in our service area during the past winter.

To conclude with a bit of serious humor, the gas dispatch clerks would trade part of their grocery money to eliminate part of the responsibility pulsations that are cured by a sure source of high pressure gas.

But, as a final acknowledgment, after the project has demonstrated its economic attractiveness, this report would not be complete without credit being given to H. L. Gentry who supervised the design and the construction of the facility (Figure 4), and who trained the company men in the operation and maintenance of the equipment, and who instructed these men in necessary safety practices when dealing with gas pressures of up to 1,200 psi. It is with definite satisfaction that it can be reported that totally inexperienced personnel have caused the operation to function smoothly. Also, they have kept accurate and detailed records, and have avoided any damage to property or personnel.

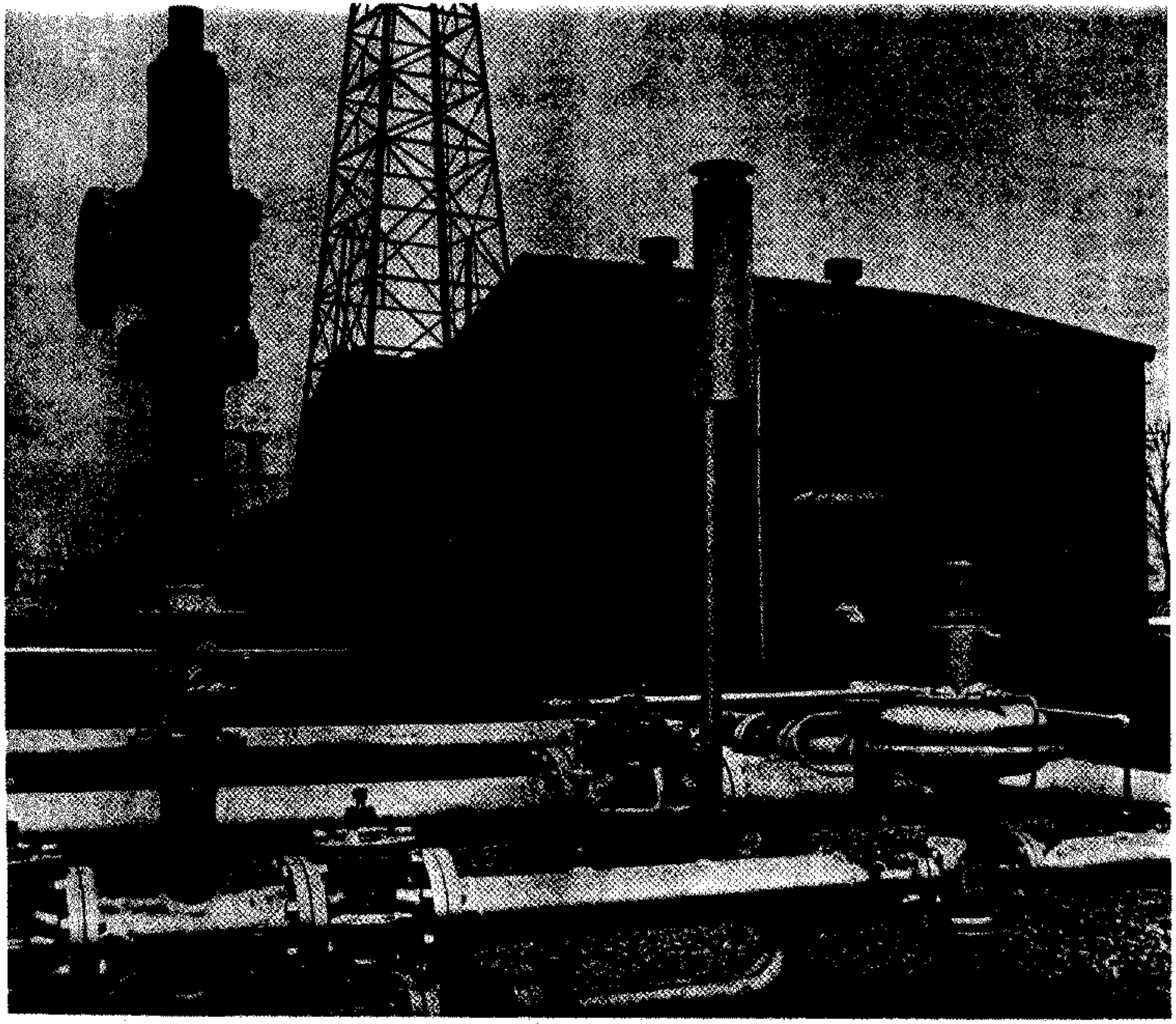

Figure 4. The gas storage site after minimum construction to obtain a test of the cavern.