The Killing of the Burning Gas Well in the Caddo Oil Field, Louisiana

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IN the latter part of the summer of 1913 the Conservation Commission of the State of Louisiana, under presidency of M. L. Alexander, decided to stop the waste of natural gas going on at the "burning gas-well," located about ¾ mile southeast of Oil City, La. On several occasions, both in newspapers and in reports, comment had been made on the condition of this well, its harmful effect on the Caddo gas field, and the considerable loss, estimated at several thousand dollars each month, caused by the escape of the valuable fuel. But nothing had been done to bring the well under control and prevent further waste of gas until the State Conservation Commission took the matter in hand.

The gas fields of Louisiana are among the greatest in the country. So far most of the gas has been found in the Caddo field proper, although considerable development has been done in and around the city of Shreveport and near the town of Mansfield in DeSoto parish. To extend the life of the gas fields and to prevent the quick exhaustion of the supply of the natural fuel are matters of vital importance for this section of the country.

Four gas companies have entered the Caddo field and supply the surrounding towns and cities with gas. The Arkansas Natural Gas Co. has pipe lines to Little Rock, Ark., and supplies gas to the following cities and towns in that State: Texarkana, Hope, Garland, Emmet, Prescott, Boughton, Beirne, Gurdon, Arkadelphia, Gum Springs, Malvern, Donaldson, Gifford, Perla, Beaton, Beauxite, Mabelvale, Bryant, Sheridan, Pine Bluff, Little Rock, Argenta, Pulaski Heights, and Hot Springs. The Southwestern Gas & Electric Co. transports gas to Mooringsport, Blanchard, Caddo, Rodessa, Oil City, Vivian, Bloomburg, Hosston, Ida, Dixie, Belcher, and Shreveport. The Marshall Gas Co. supplies gas to the town of Marshall, Texas. The Louisiana Co. has a line to Shreveport.

In the oil field the gas is used for drilling purposes, and the operators either have their own gas system or buy from the gas companies. At the present time the surrounding territory depends for its fuel supply on the Caddo field, and the importance of the conservation of the natural-gas resources of the State was fully appreciated by the Commission, when it ordered the killing of the "wild well."

The object of the present paper is to give an account of the effective method by which the Commission, represented by its Agent, J. W. Smith, brought the well under control, by drilling a relief well to the

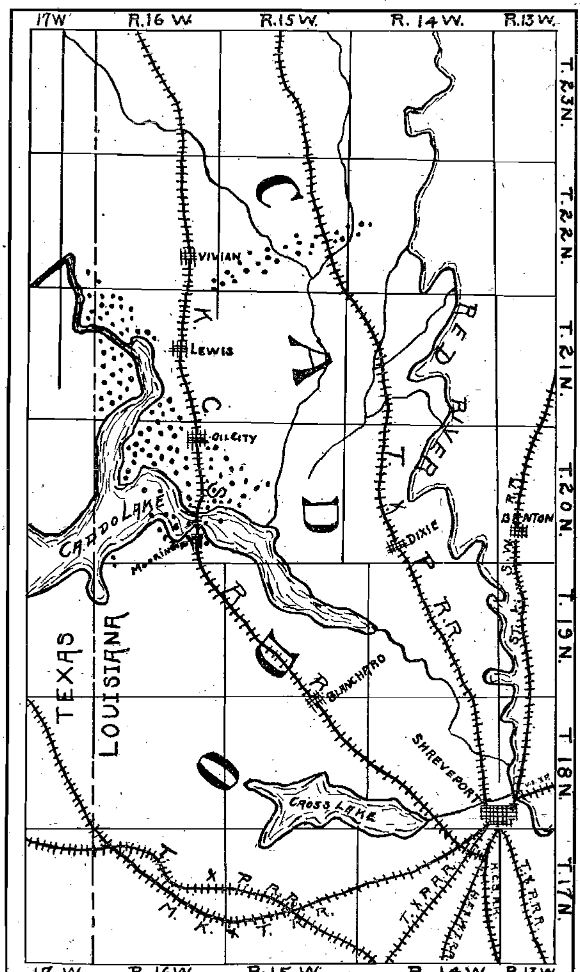

FIG. 1.—SKETCH MAP OF THE CADDO OIL FIELD, CADDO PARISH, LA.

stratum from which the well was blowing out and forcing water under high pressure through the bore hole into the gas sand.

It may be useful to give a short sketch of the geological occurrence of oil and gas in the Caddo field. Those interested in the subject are referred to *Bulletin No. 429, U. S. Geological Survey* (Oil and Gas in Louisiana, by G. D. Harris), for a complete description of the field.

Location

The oil and gas field is located in Caddo parish, in the northwestern part of the State of Louisiana, about 20 miles north of the city of Shreveport, as shown in Fig. 1. The field proper begins at the town of Mooringsport and extends in a direction west of north for about 12 miles, the width of the field ranging from 6 to 8 miles.

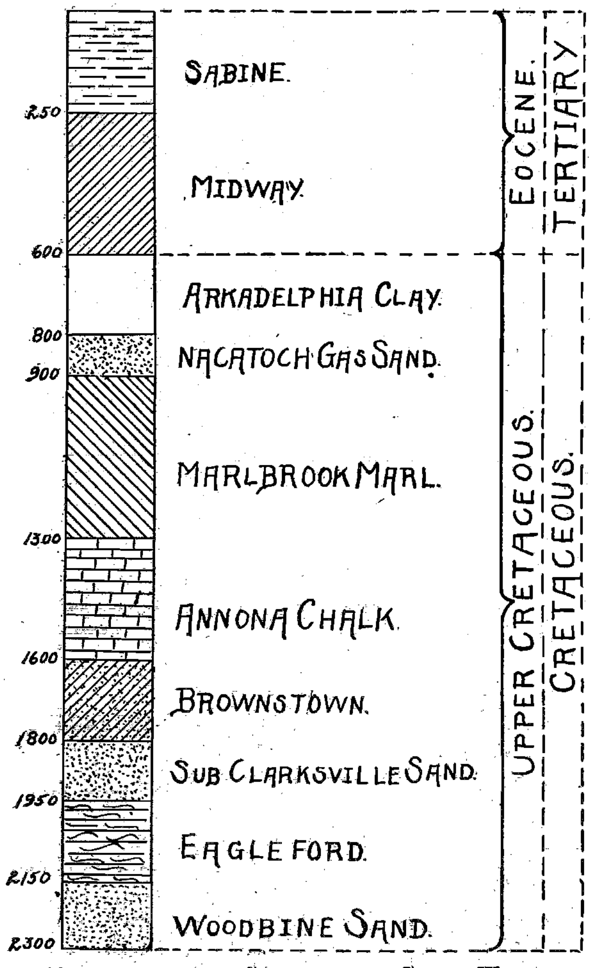

FIG. 2.—LOG AND SECTION OF A CADDO WELL.

Occurrence of Oil and Gas in the Caddo Field

The strata encountered by the drill in the Caddo field belong to the Lower Tertiary and Upper Cretaceous. They consist mostly of soft shales, marls, and clays, with the exception of the Nacatoch sand, the

Annona chalk, the Sub-Clarksville sand, and the Woodbine sand. Fig. 2 is a general section of the strata.

Nacatoch Sand.—The Nacatoch sand is encountered at a depth ranging from 750 to 850 ft. from the surface, according to local topography and stratigraphy. The upper part of the formation is developed as a close, hard quartzite, the thickness of which varies from 8 to 10 ft. The quartzite is an excellent cap rock for the gas, found in the sand below. The gas formation is a close, fine-grained sandstone or a packed sand, the thickness of which seldom exceeds 20 ft.

Directly under the gas sand, still in the Nacatoch formation, the drill strikes sand beds which contain salt water. Great precaution has to be exercised not to drill a gas well into salt water and it is not advisable to enter more than 8 or 10 ft. in the gas formation. The total thickness of the formation may be estimated at 100 ft.

In that part of the field known as the Shallow Territory, lying east of the town of Vivian (see Fig. 1), the Nacatoch sand yields a heavy fuel oil.

When the Caddo oil field was first discovered the gas from the Nacatoch sand gave the drillers considerable trouble on account of the high rock pressure, which at the time was 450 lb. to the inch. On several occasions the drilling mud was blown out by the gas and the wells could only be kept under control with great difficulty. The rock pressure quickly declined, however, partly because of the enormous quantities of gas used for commercial purposes, partly on account of a great volume of the fuel going to waste. At the present time the rock pressure of the Nacatoch gas sand does not exceed 100 lb. to the inch.

Sub-Clarksville Sand.—The Sub-Clarksville sand is the second gas horizon in the field. It is encountered at a depth ranging from 1,800 to 1,900 ft. Its structure is almost identical with that of the Nacatoch sand. It has shown gas under high pressure in several wells, but so far the Nacatoch sand furnishes practically all the gas now being used from the Caddo field. Like the Nacatoch sand, the bottom of the formation contains salt water in great quantities. Its total thickness varies from 75 to 150 ft.

Woodbine Sand.—This is the horizon from which the bulk of the oil in the Caddo field is obtained. It is overlain by the Eagleford shales. There are no sharp lines of division between the two formations. At a depth of about 2,150 to 2,200 ft. the Eagleford shales become more sandy and change gradually into the Woodbine. The Woodbine is developed in Caddo as a series of interstratified sands and shales; the horizontal as well as the vertical distribution of the sand in the shale is very irregular, caused by the thinning out of the sand lenses and the grading into sandy shale and shale. It is a typical shallow-water deposit, the sudden changes in structure being caused by changing tides, winds, and currents. It is in these sands that the big oil wells, for which the Caddo field is famous, are struck. In the bottom of the Woodbine, under the oil-bearing sands, salt water is encountered, as in the gas sands.

Annona Chalk.—Mention must be made of the occurrence of oil in places in the Annona chalk. The "chalk rock" is struck at about 1,300 ft. and has a thickness of 300 to 350 ft. The occurrence of this oil is not sufficiently explained. From the data at hand it seems that the oil fills crevices which have been caused by slight faulting.

History of the "Burning Well"

The well is situated in the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of Section 7, T. 20 N., R. 15 W., on a 10-acre tract owned by B. G. Dawes,

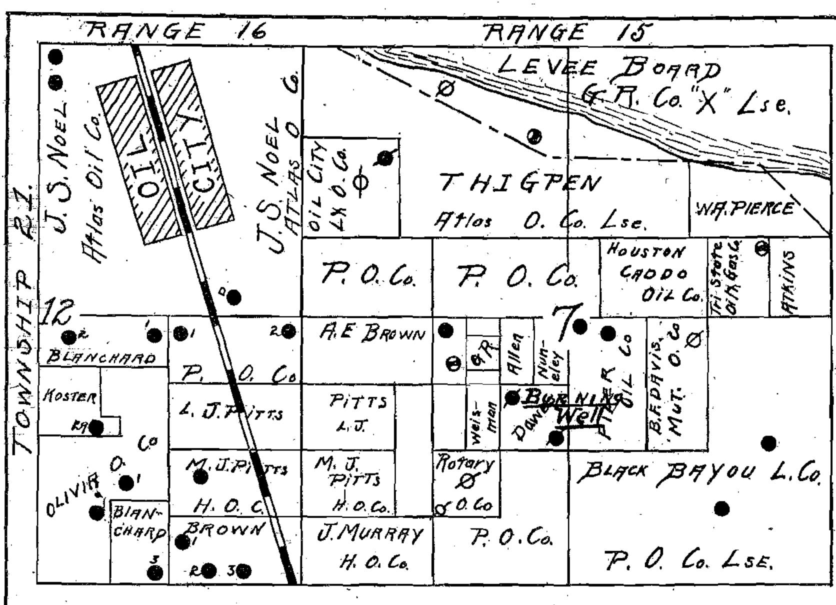

FIG. 3.—MAP SHOWING THE LOCATION OF THE BURNING WELL.

Trustee. Fig. 3 is a map of the region. Work on the well was started on Mar. 17, 1908. On May 11, 1908, the drillers had reached a depth of 2,065 ft. The well was cased off with 300 ft. of 10-in. casing pipe and 900 ft. of $8\frac{1}{4}$-in. casing pipe. The 6-in. casing pipe was not set yet. During the day the well began to give trouble and blew out from the 1,800-ft. gas stratum (Sub-Clarksville sand). The drilling mud was made as heavy as possible and the driller started to pull the 4-in. drill pipe out of the hole to change the drill bit. In the night during a heavy rainstorm, while the 4-in. drill pipe was being put back and was about 350 ft. from the bottom, the well blew the drilling mud out again with much more violence than before. The gas pressure raised the drill pipe up, which unlatched the elevators, and the drill pipe dropped 350 ft. in the bore hole.

The well continued to blow out, increasing all the time in volume, which was estimated the next day at 40,000,000 cu. ft. in 24 hr. The well also made a strong salt-water flow. The owners of the well did everything in their power to get the well under control. A lubricator[1] was made of two pieces of 8¼-in. pipe and screwed on the 8¼-in. casing to kill the well, but as soon as the valves were closed the gas broke the seats of the 8¼-in. and 10-in. casings and began to blow out under the derrick floor. The valves on the lubricator had to be opened up again, to release the pressure from the casing, but the flow of gas around the 8¼-in. casing had relieved the pressure of the drilling mud on the 800-ft. gas, which now started to blow out between the 10-in. and the 8¼-in. casings.

On the evening of May 13 a cyclone completely destroyed the derrick and drilling rig. A deep hole was dug around the 10-in. casing, with the well open, flowing gas and salt water, with the object of putting a cement block around it, which might hold the gas back long enough to lubricate the well. At 20 ft from the top a split was found in the 10-in. casing pipe. After several days the drillers succeeded in getting a joint of 14-in. pipe over the 10-in. pipe and the two were cemented together, and a big block of solid cement was placed around the casing. The cement was allowed several days to harden, while the well was blowing gas and salt water. Then a second attempt was made to lubricate, but the pressure was so strong that the gas escaped outside the 10-in. casing into the shallow-water sand, which is found at about 75 ft. in that part of the field, and blew out on the ground about 300 ft. away from the well. The well had to be opened up again and all the material brought in safely and a last attempt made to kill the blowout. But the gas continued to escape around the well, coming closer and closer to the hole. The owners

[1] A well is killed with a lubricator in the following manner: Two lengths of pipe, with gate valves at the top and bottom, are screwed on the casing of the well, the lower valve is closed and the two pieces of pipe filled with heavy mud. Then the upper valve is closed and the lower valve opened. The pressure in the well and in the lubricator becomes equal and the mud drops through the lower valve into the well. The lower valve is closed and the upper valve opened again and the operation is repeated until the bore hole is filled to the top with heavy mud and the blowout stopped. The operation of lubricating takes considerable time, and nowadays a better method is used. The well is directly connected up with a line pump, that can put up a pressure of 700 or 800 lb. to the inch. Then the well is closed in and the pressure in the well runs up to the rock pressure; but the pump is able to work against that pressure, and the bore hole is filled with mud in a much shorter time than with the lubricator.

then abandoned the well, considering it impossible to get it under control. In less than three weeks' time the escaping gas and water had formed a crater around the well at least 100 ft. in diameter, which the waves made larger and deeper as the time passed.

In June, 1908, the well was put on fire because the gas was a continuous danger to those who had to work and live in the surrounding woods. The well stopped burning in Feburary, 1909, but caught fire again soon afterward. The well was allowed to run wild until the summer of 1913. Most of the time the gas was burning, but heavy rainstorms and wind would put it out. After a few days the gas would catch fire again. The muddy waves caused by the escaping gas kept on washing more and more material in the hole, thus increasing the size and depth of the crater, until finally they had formed a circular pool 225 ft. in diameter, in the center of which the escaping gas threw up a body of mud 25 or 30 ft. high.

The volume of the gas escaping from the well at the end of its life was estimated by experts to be between 8,000,000 and 10,000,000 ft. per day. Not only was this waste of gas deplorable, the value of which at about $2\frac{1}{2}$ c. per 1,000 cu. ft. at the well, amounted to about $250 per day, but also the well affected the rock pressure of the surrounding territory, which had fallen below 100 lb. to the inch, and allowed the salt water which occurs in the bottom of the Nacatoch sand to enter the gas formation.

Killing of the Well

When the Conservation Commission took the matter in hand it was decided to first empty the pool which the blowout had made, to find out the condition of the casings. It took about 20 days to empty the crater. The shape of the crater is shown in Fig. 4. The bottom of the pool sloped from the border for about 50 ft. until it reached a depth of about 10 ft. below the surface. From there the crater had a conical shape, with a diameter of about 125 ft. sloping down to the old bore hole, where it had a depth of from 37 to 40 ft. The top of the 10-in. and the $8\frac{1}{4}$-in. casings could be seen in the bottom of the crater. The well was not blowing outside the 10-in. casing pipe. Evidently after the pressure of the well had gone down, the caving mud had fallen in around the 10-in. casing so that the water and gas could only escape between the 10-in. and $8\frac{1}{4}$-in. casings. It was observed that the well blew out cold salt water, which showed from what depth the blowout was taking place, because the salt water found in the deep sand rock is warm, whereas the water from the Nacatoch sand has a much lower temperature.

The tops of both casings were worn very thin and it was impossible to screw any connections on to them. The original plan was to set a disk wall packer inside the $8\frac{1}{4}$-in. casing on 4-in. pipe about 100 ft. from the top and let the well blow through the 4-in. pipe, then pack the space between the $8\frac{1}{4}$-in. and the 10-in. casings with a stuffing-box casing head and make a cement block outside the 10-in. casing, after which the well perhaps could be closed in. But the condition of the top of the casings would not allow this scheme to be carried out. Then it was de-

FIG. 4.—VIEW OF CRATER OF BURNING WELL AFTER BEING PUMPED DRY.

cided to drill a well, which was called a "relief well," as close to the old hole as was possible under the circumstances, and to try to stop the flow of gas and water by pumping water or mud in the gas formation. The contract for drilling the well was let to W. W. Blocker.

When the pumps were moved the crater filled up with the salt water thrown out by the well.

This relief well was drilled on the southeastern side of the crater, at a distance of 125 ft. from the center, as shown in Fig. 5. The hole was cased off with 211 ft. of 10-in. casing and 792 ft. 11 in. of 8-in. casing pipe, both cemented. The 8-in. casing pipe was set on the top of the Nacatoch sand. The cement was allowed to harden for nine days, after which the seat of the 8-in. casing was tested. Mr. Smith ordered

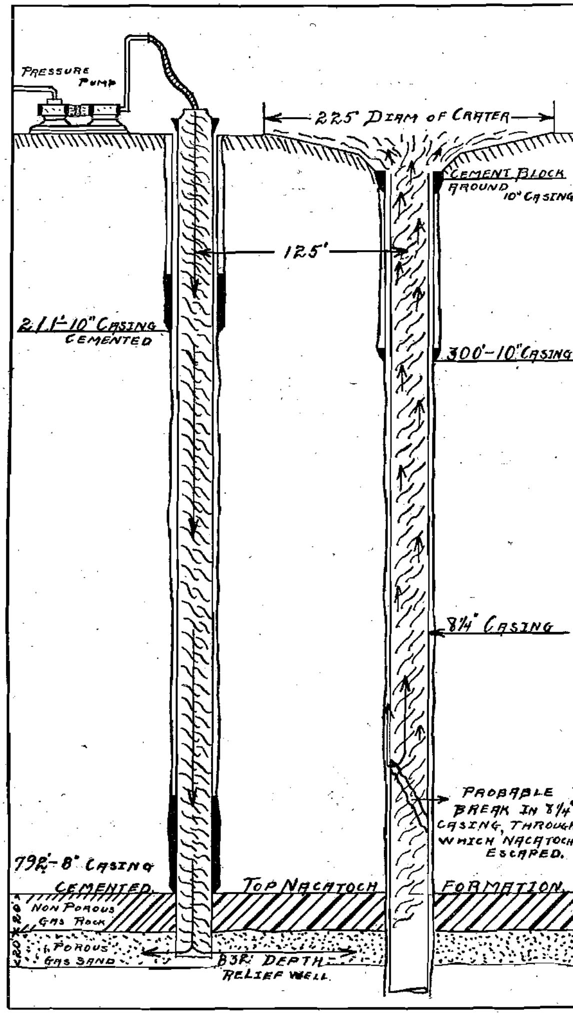

Fig. 5.—Section through Burning Well and Relief Well.

the well to be drilled with clear water 20 ft. in the Nacatoch formation. The rock encountered in this 20 ft. was not porous enough, in the judgment of Mr. Smith, to attempt to pump in water. The well was then drilled 20 ft. deeper in the same formation, the total depth being 832 ft.

The formation found in the last 20 ft. was a coarse sand rock, considerably more porous than the first 20 ft. below the 8-in. casing. It was decided to make the experiment at this depth. A reservoir covering 3 acres of land, ranging in depth from 6 in. to 3 ft., was filled with water, and the 8-in. casing was connected with the pump and the full pressure put on the formation.

The pump used was an ordinary 10 by 6 by 12 in. rotary drilling pump; the boiler pressure was 120 lb. per inch and the pressure put up by the pump as registered by the gauge was 310 lb. per inch. After the hole was filled, the pump ran at about 5 rev. per minute for 1 hr., corresponding to a volume of about 29 gal. per minute being forced into the gas formation. During the next 5 hr. the number of revolutions increased slowly from 5 to 10 per minute, but the gauge registered the same pressure. During the following days the full pump pressure was left continually on the well, the number of revolutions increasing gradually and the pressure against which the pump had to work decreasing. After the fifth day the pressure registered on the gauge was about 150 lb. to the inch and the number of revolutions 30 per minute, which was equivalent to a volume of 165 gal. being forced into the gas sand each minute.

On the seventh day the pressure was 50 lb. to the inch and the pump was running at the rate of 42 rev. per minute. It was noticed that the pressure would fall considerably for a short time and then run up again to where it had been previously, which can only be explained on the hypothesis that the water opened up a new channel in the formation, thus relieving the pressure, and when the cavity was filled the pressure went up again to the point where it had been before. From the seventh day on a slow decrease in the strength of the eruptions was noticeable, and on the tenth day the eruptions ceased. At the moment the eruptions stopped the salt water and mud in the pool flowed back in the old bore hole, leaving the crater entirely empty.

Although there was no gas escaping from the hole, the pumping was continued for three more days, to drive the gas still further back in the formation and away from the well.

The space between the 8¼-in. and the 10-in. casings was filled with cement and a heavy cement block was put around the 10-in. casing. Then several blasts of dynamite were fired around the circumference of the crater about 10 ft. apart. The explosion caused several tons of shale and clay to fall to the bottom of the crater. If the well should start to flow gas and salt water again, the salt water would mix with this shale and clay and make a thick mud, which would kill the well.

Although the blowout was killed successfully, and the possibility that the well will give trouble again is very small, the derrick and casing were not removed from the "relief well," as a further precaution, so that work can be started at a moment's notice to pump water in the gas sand and cut off the flow of gas.

Value of Gas Wasted and Conserved

A low estimate of the average production of the well during the five years that it ran wild puts it at 15,000,000 cu. ft. per day. The volume of natural gas which escaped into the atmosphere during this time would be 27,000,000,000 cu. ft. At $2\frac{1}{2}$ c. per 1,000 cu. ft., this volume of gas represents a value of $675,000.

In the town of Shreveport the selling rate for manufacturing gas is $7\frac{7}{10}$c. per 1,000 cu. ft. If all the gas which went to waste at the burning gas well had been sold in the city of Shreveport for manufacturing purposes only, it would have brought in $2,079,000.

At the time the well was killed the eruptions were still very violent and during the last year no decrease in their strength had been noticeable. No doubt it would have been several years before the burning well would have died a natural death. It is impossible to estimate the value of the gas that has been saved by the energy and activity of the Conservation Commission, but from the above figures it can be seen that it must amount to several hundred thousand dollars.

The cost of drilling the "relief well" and putting out the burning well was approximately $6,000, which is a very small amount compared with the value of the gas saved.