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by

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THE STORY OF THE HUGOTON NATURAL GAS FIELD

By

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The fact that I am employed by a pipe line company causes me to make this observation. Over the past several years, from time to time, my ideas and opinions have not exactly coincided with those of the Management of the Company. In fact, this has happened on several occasions. Therefore, I would like to make it clear that any opinions or ideas I give are my own and are not necessarily in agreement with those of the Management of the Company.

The Hugoton Gas Field, without doubt, holds a much greater interest to the several millions of people who are using the gas produced from it than I feel this discussion will hold for you, and I will try to tell you, briefly, the story of the field.

GENERAL DESCRIPTION:

The Hugoton Gas Field, like all Gaul, is divided into three parts – Kansas, Oklahoma and Texas. The divisions are state lines only and not the result of geological changes. The surface land overlying the Hugoton gas reservoir is a large treeless plain except in the areas of the Cimarron River in Kansas and the Beaver River in Oklahoma, which cross the field from west to east, and the drainage tributaries flowing into the two rivers. Driving through the Hugoton Field an impression is gained that it is a flat plain but actually it grades from west to east at about 20 feet per mile.

To give a better idea of the geographic location of the field, it will be related to state boundary lines. The outlying well to the west is about 18 miles from the Kansas-Colorado state line. The field extends to the north 90 miles from the Oklahoma-Kansas line with an extreme width of 72 miles in the State of Kansas. It crosses the entire Oklahoma Panhandle, a distance of about 34 miles and has an average width of 50 miles in Oklahoma. The field extends south into Texas a distance of 36 miles with an average width of about 40 miles. It covers portions of eight most southwestern counties in Kansas, a large portion of Texas County, Oklahoma, and portions of Hansford, Sherman and Moore Counties, Texas. The proven extent of the Hugoton Field is approximately 4,112,000 acres which are divided between states as follows:

Kansas	2,451,000 acres
Oklahoma	1,026,000 acres
Texas	635,000 acres

The Hugoton Field, if superimposed on the State of New Jersey, would cover approximately 80% of that state. It is about five times the size of the State of Rhode Island and the original estimated recoverable reserve from this field to an abandonment pressure of 50# is in the order of 25 trillion cubic feet.

Further discussion of the field will be divided into the following six parts: (1) Geology; (2) Development; (3) Methods of Well Testing; (4) Markets; (5) Proration; and (6) last but not least, Conservation.

GEOLOGY:

The regional geology of the Hugoton Field shows that the producing formations were laid down during Permian times in a large bay which was a northwest extension of an inland sea occupying what is now known as the Anadarko Basin. From the deeper waters the floor of the bay formed a gentle slope to the northwest. The probable most westerly shore line was the Los Animas Arch which runs southeast-northwest through Southeastern Colorado and which is a prominent geologic marker.

As the level of the waters of the inland sea raised, limestone deposits were laid down and as the water level was lowered shale beds were washed in over the limestones. There appears to have been successive times when the water level changed. Today we find six layers of limestones in the northern part of the field with beds of shale forming a separating blanket. There is some evidence that at two times the waters fell entirely below the shore line level. That is evidenced by the discoloration of the shale – becoming a red. We do not know whether it came from washing off the Los Animas Arch or whether it was caused by shale being exposed to air. The Hugoton Field is often referred to as the Hugoton Embayment.

The formations encountered in the Hugoton Field might be likened to a huge layer cake composed of six layers, with the deposition of shale forming the cake frosting. However, this would be a very irregular and lopsided cake around the edges, with the different layers thickening and thinning, often disappearing entirely, and becoming one thick layer in the southern part of the field. The local geologic names of the formations as they are encountered from top to bottom are as follows: Herington, Krider, Winfield, Upper Fort Riley, Lower Fort Riley, and Florence. The Herington and Krider formations are encountered over the greatest areas above the salt water level.

The Hugoton Field, after its formation, was tilted some millions of years later by the Rocky Mountains uplift so that the local gradient of the producing formations across the field is about 20 feet per mile. The water table along the east side of the field is somewhat dependable and regular and it is found that the four lower formations become submerged some distance from the east proven boundary of the field. The Krider formation is the most dependable producing formation in the field but it also becomes submerged along the north, south, and east edges, and the last few miles on the east of the field are limited to the Herington producing formation. However, few, if any commercial wells, have been drilled to the east of points where the Krider becomes submerged. The west edge grades into sands and shales as the limestone beds disappear.

The water table along the west side of the field is erratic and varies from location to location. The Hugoton Field, like most limestone reservoirs, differs widely from location to location (640 acre spacing) in effective porosity and permeability.

DEVELOPMENT:

The two discovery wells of Hugoton Field were completed about the same time in 1922. These wells were drilled by the hardy pioneer wildcatter who was drilling in the search for oil and the quick riches where made possible at that time. One well was drilled about 3 miles west of the town of Liberal, Kansas, and the other some 6 miles north of the town of Texhoma, Oklahoma. The airline distance between these two wells was 51 miles and certainly little thought was given at that time to the fact that these two wells tapped the same common natural gas reservoir. No oil was encountered, only natural gas, so the wells were considered to have little or no value and remained unused for some time. The Town of Liberal now receives a small portion of its supply from one of the discovery wells.

It would require a good deal of time to discuss the rate of development by years, so I have prepared a tabulation of the number of wells drilled by years and it is available if anyone cares to get a copy.

The Crawford well, which was drilled in 1926 southwest of the town of Hugoton, Kansas, is often considered as the real discovery well in the field. By the end of 1928 twelve wells had been drilled in the field – five were located in Kansas, three in Oklahoma and four in Texas. The first gas was transported by pipe line from the Hugoton Field in 1928 and served some local Kansas markets near the field. It was known as the Argus Pipe Line.

During the late twenties risk capital began to show a real interest in the possibilities of using Hugoton Field as a natural gas supply for long distance pipe lines and in 1929 the construction pipe lines was commenced to furnish major cities a gas supply. We are all familiar with the far reaching demand for natural gas today but the situation was quite different when the first pipe lines were completed into new market areas. Many cities were dubious of continuous and continued supply and fought shy of changing from artificial to natural gas. The volumes transported through the newly completed pipe lines required only a small percentage of the pipe line capacity. Many of the pipe lines did not sell more than 10 to 20% of the gas which could be transported through the systems and the result was a very high gate price which, of course, further hampered the demand for additional supply and I might say that when gas that price there was no question about end use. It was not until about 1935 that natural gas as a replacement fuel began to be recognized in the areas which had not been afforded the advantage of natural gas theretofore.

The pipe line company, in order to finance and make sales contracts, had to control a sizeable reserve. This caused the individuals who were organizing a pipe line company to either make gas purchase contracts for large blocks of acreage or to acquire leases which were to be drilled by the pipe line company. Many independents leased smaller blocks of acreage as it appeared that there would be a demand for any gas which would be made available. Owing to the length of time that was required to build up pipe line gas sale, many of the independent producers were unable to continue to pay delay rentals and thousands of acres were dropped. During the depression years and the period while demand was building, the independent producer found it almost impossible to obtain a market for gas as the pipe line companies were required to drill owned leases which were in excess of market requirements. The loudest cries heard in the Hugoton Field have come from independent producers who were unwilling to join risk capital over the rough period of market building but who did not, apparently, understand the problem which confronted the pipe line company in trying to hold together the financing of the pipe line projects. There are now nine pipe line companies taking gas from the Hugoton Field. Approximately 16% of the total volume is being produced from leases owned by the pipe line companies. Today the independent operator with gas for sale has a well beaten path to his door made by purchasing companies.

Proration schedules issued by the Kansas, Oklahoma, and Texas Commissions for the month of October, 1952 showed 2,817 wells in the State of Kansas; 1,101 in Oklahoma; and 776 wells in the State of Texas; a total of 4,695 wells.

METHODS OF WELL TESTING:

The index to the value of a natural gas field is a petroleum engineering problem. The first in matter of importance is the volume of gas that a well will produce, and the second, which is more important, is the volume of the gas that a well will continue to produce over an extended period.

The original wells in Hugoton Field were tested by what is known as the pitot tube method. This test requires that the well be blown wide open to atmosphere for a period of 20 minutes, at which time the impact pressure is measured by a U gauge. This type of test in the Hugoton Field was undependable and furnished information which had only slight value. If this type of test was in use today in the Hugoton Field, more than 1-1/2 billion cubic feet of gas would be lost annually during the test period.

The second type of test which was tried in Hugoton Field was the United States Bureau of Mines back pressure open flow test. The low permeability in the Hugoton Field required several hours to reach a stabilized rate of flow, and the average volume of gas per well required to make a back pressure open flow test was about 4,000,000 cubic feet. At today's prices, with the number of wells in the Hugoton Field, the value of this gas for an annual test would be approximately $1,800,000.

In order to avoid this type of waste, many hours were spent in the field by company and commission engineers perfecting a test into the pipe line which would eliminate the waste of gas. Today the one point deliverability test is used. This test follows an approximate 72 hour shut-in pressure buildup; the well is then produced into a pipe line at a rate of flow which will cause a working pressure at the well head to exist which is as near as possible to 80% of the average a shut-in field pressure. At the end of a 72 hour flow, the rate of flow is calculated and the well head pressure measured with a dead-weight gauge. This type of test has been found to be very dependable and produces data on which field productive tests can be based.

The one point deliverability test was developed and adopted. Kansas and Oklahoma were both working on it at the same time but Kansas was the first to adopt it in an order, followed by Oklahoma and Texas with a slight modification. The important thing is that this type of test provides an accurate appraisal of well value without any waste of gas.

MARKETS:

The annual metered production tells the story of the history and trend of market development. A tabulation of annual production is attached to this paper.

A large percent of all gas produced has been used to furnish pipe line requirements, however, at one time six carbon black plants were supplied by Hugoton Field gas. At the present time three furnace plants are operating on a limited scale and one ammonia-nitrate plant receives a portion of its requirements from Hugoton Field, and here again we have price entering into the use of gas. Approximately 16 states are supplied all or in part by gas produced from the Hugoton Field.

The average daily rate of gas produced from Hugoton has multiplied ten times over the last ten years. Today the average rate of production is about 2 billion cubic feet per day.

PRORATION:

The proration orders under which the Hugoton Field operates are the first proration orders that I know of which were ever accepted by industry without the aid of the courts. The first order was made effective in Kansas in 1944. In 1945 Oklahoma adopted the same general order. Texas made a similar order effective in 1948. Each state made its order effective at about the same stage of field development.

It would require a great deal of time to discuss all of the first long and heated hearings held by the State Commissions but there were many of them and the first proration orders were promptly taken to court for stays by both producers and pipe line companies.

Effective proration is, in reality, a problem of pressure equalization. The existing state orders have created a pressure control which is gradually tending to equalize the overall field pressure. Without effective proration, great pressure differentials would exist today. The State Commissions and industry can well be proud of the job which has been accomplished in creating ratable taking in this vast gas reservoir.

If you are interested in the detail of the orders, you can write to –

The Kansas Corporation Commission
Topeka, Kansas

The Oklahoma Corporation Commission
Oklahoma City, Oklahoma

The Texas Railroad Commission
Austin, Texas

And they will supply you with copies of the orders.

There are a good many people in this room who have spent many hours in arriving at a desirable answer to a problem which at one time appeared to be without an answer.

CONSERVATION:

Conservation is the inverse of waste and when conservation is discussed it is a rare thing to hear argument over the definition of the word "conservation". However, many hundreds of pages of testimony have been presented at various hearings relating to the subject of waste. Invariably, the question arises as to the type of waste – whether it be physical or economic waste. I will give you my definition for the two classifications as they pertain to natural gas:

Physical waste is the difference between the volume of gas originally contained in a reservoir and the volume of gas which is ultimately made available for consumption at the burner tip.

Economic waste is the difference between the net heat energy input and the net heat energy realized which can be utilized for the economy of the country.

There has been much discussion on the control of the end use of natural gas. As I have listened to different discussions on the end use of natural gas I think of the cartoon appearing in many of the newspapers, which is drawn by Dave Gerard and is entitled "Viewpoint". The domestic user feels that any industrial use is wasteful and much of such use could be replaced by coal or oil. The industrial user, particularly the one who needs closely controlled heat is order to produce specialized products, may have the feeling that gas used for househeating, and even cooking, is most certainly being wasted insofar as the economy of the United States is concerned. Without a combination of both domestic and industrial markets being served by pipe lines, many of today's projects would have fallen by the wayside or would never have been born. Without commercial and industrial markets, the field price would in all probability be only a fractional portion of what it is today but the domestic consumer would be paying a much higher price. Probably the most publicized use of natural gas which has been considered by some as being ultra wasteful is the manufacture of channel type carbon black. While is it true that only a small percent of the heat energy is utilized, it was forcibly brought to bear that this type of hard carbon back was extremely necessary in the war and defense efforts of this country.

There have been only short intervals during the past twenty years when I have not had constant problems relating to the Hugoton Field. When the demand for natural gas was low, the value was low. When the value was low, the operator could not afford to take great pains and expense to operate in a manner that would cause the least waste. Why? Because the gas cost was cheaper than the required investment to construct leakproof transportation facilities.

As the demand has increased and the price has increased, it can be observed that producers are completing wells so as to use less gas while completing the well. The use of hydrochloric acid has increased the ultimate recovery of natural gas; meanwhile, methods of acidizing have been advanced so that less gas is blown to the air during acid treatment. In the early years pipe lines were laid without paint or protective covering. In many cases, independent producers would lay screw lines of old second hand pipe without regard to leakage. Today nearly all pipe lines are laid under rigid specifications which incorporate up-to-date engineering technique. The lines are painted and wrapped with paper or coated with a covering of fibre glass. Cathodic protection is immediately installed and lines are subjected to rigid leakage tests before being placed into operation. These measures cost money but show a desirable rate of return on the high cost of gas saved. The net result is conservation.

To what price level must natural gas reach to accomplish good conservation? I do not believe that any definite figure can be named today which will apply to future conditions, but whatever it may be it should be on a sound economic level. I am firmly convinced that the word conservation also applies to the preservation of the presently proven reserve by augmenting with additional discoveries.

The annual production of the United States for 1951 showed an increase of 61.19% over 1946. Discoveries did not keep pace with production during this period, while during the same period the purchase price of gas in the field increased about 100%.

There are two important contributing factors to be applied, or, I might say, which have caused the price increase, other than the rise which would naturally result from increased demand:

(1)The Federal Power Commission, by arbitrarily and, I think, unfairly taking jurisdiction of pipe line owned reserves and applying original cost value and disappearing rate base theory to a wasting asset, killed the incentive for a pipe line company to acquire acreage and develop its own reserves. This resulted in the pipe line company losing its bargaining position and buying at a seller's market without the protective backup of owned reserves. And, in connection with that, I would also like to say that the F.P.C. has also taken from the pipe line company on its own production the 27-1/2% depletion which Congress intended as an incentive to search for additional gas supply.

(2)The threat of the Federal Power Commission's taking jurisdiction over gas reserves owned by oil companies caused several of the oil companies to withhold major gas reserves from pipe line markets. This created an artificial shortage and again the natural application of supply and demand caused sharp price increases.

The shortsighted position taken by some members of the Federal Power Commission and some members of its staff will be paid for by the consumer in amounts which will far overshadow the much publicized savings to the consumer that was once front page news.

Facing today's marked increase in the demand for natural gas, the task to supply such markets is gigantic. It is doubtful if it can be accomplished without clarification of federal regulation. With conditions unhampered by federal regulation as to field price, it will take the united effort of the oil companies, the independent operators, and the pipe line companies to discover an adequate future gas supply. Most certainly, risk capital, and drilling money is true risk capital, will not be attracted at a rate of return of 5 -1/2 to 6 -1/2 percent.

The increased cost of discovery from deeper reservoirs, the drilling of marginal wells – that is wells of low potential – can lead only to a higher price to be paid for gas. Without intelligent state regulation which has led to good conservation, the consumer price will be still higher. Today we find state regulatory bodies and the oil and gas industry in the producing states working as a team.

The consumer can be grateful for the guardianship of the Oil and Gas Compact Commission which has concentrated on the conservation of oil and gas supply. The record of accomplishment of this body speaks for itself.

HUGOTON FIELD PRODUCTION
SHOWING VOLUMES BY YEARS
MCF @ 14.65 PSIA

Calendar Year	Texas	Oklahoma	Kansas	Total Hugoton Field
1926	-	-	-	-
1927	-	-	-	-
1928	-	72 974	35 191	108 165
1929	-	195 449	191 951	387 400
1930	-	255 902	993 132	1 249 034
1931	-	302 661	5 247 274	5 549 935
1932	-	378 067	12 360 820	12 738 887
1933	-	337 057	19 015 188	19 352 245
1934	-	356 674	18 956 283	19 312 957
1935	-	375 170	19 759 714	20 134 884
1936	-	401 220	25 190 786	25 592 006
1937	-	915 600	32 663 981	33 579 581
1938	-	2 114 182	30 093 792	32 207 974
1939	-	4 492 944	32 582 238	37 075 182
1940	-	7 534 439	37 164 656	44 699 095
1941	-	7 339 991	40 761 314	48 101 305
1942	-	8 973 255	46 544 952	55 518 207
1943	-	11 628 773	70 729 182	82 357 955
1944	1 002 672	47 114 845	93 233 583	141 351 100
1945	19 672 386	87 353 373	90 262 369	197 288 128
1946	37 368 163	97 226 142	119 994 174	254 588 479
1947	36 487 059	105 890 061	158 147 145	300 524 265
1948	49 162 028	115 582 907	186 475 142	351 220 077
1949	76 642 465	117 689 155	248 402 849	442 734 469
1950	129 501 627	125 894 942	320 603 432	576 000 001
1951	177 516 242	153 541 195	371 008 238	702 065 675
Cum. to 1/1/52	527 352 642	895 966 978	1 980 417 386	3 403 737 006

WELLS DRILLED IN HUGOTON FIELD

Calendar Year	Texas No. Wells	Oklahoma No. Wells	Kansas No. Wells	Total Hugoton Field No. Wells
1926	1	2	2	5
1927	3	3	4	10
1928	4	3	5	12
1929	4	3	8	15
1930	4	6	113	123
1931	4	8	140	152
1932	4	8	141	153
1933	4	8	141	153
1934	4	8	142	154
1935	4	10	144	158
1936	5	10	170	185
1937	5	15	245	265
1938	6	27	271	304
1939	6	28	282	316
1940	8	36	299	343
1941	9	38	310	357
1942	9	46	325	380
1943	10	76	345	431
1944	16	172	413	601
1945	109	250	527	886
1946	126	389	744	1 259
1947	172	564	954	1 690
1948	193	678	1 366	2 237
1949	367	760	1 858	2 985
1950	503	928	2 227	3 658
1951	698	1 013	2 604	4 315

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