NATURAL GAS INSPECTION FORCE

THEODORE KINGSBURY, Supervisor.

DEPUTIES

Wm. Kelly ..... Geneva
John Ersinger ..... Sullivan
J. P. Horton ..... Montpelier
J. E. McIntyre ..... Marion
Herschell Ringo ..... Muncie
Geo. H. Smith ..... Owensville
John Watson ..... Petersburg
Howard Legge ..... Bloomington
O. H. Hughes ..... Sharpsville
_____ ..... Shoals

FIELD INVESTIGATIONS

The investigation of the geological conditions in the vicinity of the Mt. Carmel fault was undertaken during the regular field period. The Mt. Carmel fault is the most extensive structure of this type within the boundaries of Indiana. It was produced by a downward displacement of a block of strata some two miles in width to a depth of some 200 or more feet. The amount of vertical displacement was determined at a number of places along the fault line by the use of level and stadia. Studies were made in Morgan, Monroe, Lawrence and Washington counties. The area surveyed was about six miles in width and some 90 miles in length.

The economic features of the strata in the region of the fault were studied throughout the area. Outcrops of limestone suitable for building stones, and for use in the manufacture of lime and road materials were located. A portion of the area surveyed was found to contain very limited quantities of suitable road materials.

As an aid to the building of roads in the Borden area the eastern border of the Harrodsburg limestone was mapped. Outcrops of a lens of limestone occurring in the Borden were located. Some of these contained limestone suitable for road building. The lens occurs about 100 feet below the top of the Borden shales and sandstones.

Some geological structures favorable to the accumulation of oil and gas were located in territory adjacent to the fault line and these were mapped.

A study of the structural conditions of an area in the Pennsylvania strata of southwestern Indiana was made by Dr. C. A. Malott who was assisted in the field by Mr. R. R. Shrock. The area studied lies in Vanderburgh and adjacent counties. Cross sections and structural maps were prepared and were accompanied by a geological report.

Dr. W. M. Tucker who was assisted in the field by Mr. A. F. Striker continued the mapping of the lakes of northern Indiana. The lakes surveyed are Wawasee, Syracuse and Manitou. Soundings were taken and depth contours were recorded, and the boundaries and cultural features located.

SPECIAL GEOLOGICAL INVESTIGATIONS

The investigation of a large number of geologic problems was undertaken by the division during the year. Among others were: The supplying of information regarding the value, extent and location of the mineral resources of the state to the Chamber of Commerce of Indianapolis; similar information was furnished to the Bell Telephone Company and the Public Utilities Commission; information regarding coal along the Southern Railroad in Indiana; information regarding minerals along the line of the Baltimore and Ohio Railroad of Indiana; information regarding limestone at Raccoon to Wabash Railroad; information regarding manufacture of silica brick to a Michigan firm; regarding supplies of ground water for domestic use in Jennings, Carroll, Miami and other counties; furnished information regarding building stone to be used in Covington County court house; report on fire clays and shales from Indian Springs; report on porosity of building stones to be quarried in winter; report on coal lands in Sullivan, Greene, Owen and Knox counties; examination and report on foundation and stone to be used in hotel at Clifty Falls state park; report on coal found at Turkey Run state park; survey and report on Silver Lake to be used as boy scout camp; report on molding sand in St. Joseph county, also in Gibson county; survey of lands along Wabash River containing coal belonging to state; survey of oil pools in Gibson county; installation and operation of vertical retort of continuous type of extraction of shale oil also apparatus for determination of sulphur content of oils; report on Indiana limestone to be used in the manufacture of Whiting; testing of clays and shales of Monroe County, preparation of exhibit and report; inspection of oil shale deposits with representative of United States Bureau of Mines; analysis and report on bog iron ore in Jasper County; report on limestone for road building in Dubois County; testing and report on fire brick for the Simpson Brick Co.; examination and classification of limestones being quarried at Salem; and many reports on rocks and minerals for individuals.

Information regarding the mineral resources of Indiana was furnished to teachers in high schools and colleges; to newspapers; to oil operators; and to stone operators and others. The Division co-operated with the Executive Department in supplying information regarding coal on lands belonging to state institutions; with the Secretary of State and the Securities Commission in the examination of mineral properties; with the Department of Mines in furnishing information regarding coal; with the Historical Commission in an archaeological survey; with the United States Bureau of Mines in the investigation of Indiana oil shales; with the American Association of Petroleum Geologists in furnishing information regarding the petroleum resources of Indiana.

PUBLICATIONS

The following articles and books were published during the year; A report on "Progress of Archaelogical Work" in the American Anthropologist. "Work of the Division" in Engineering and Mining Journal-Press. "Kaolin of Indiana," in Menschen and Menschen Werke-Wein. "The Refractory Clays of Indiana," Bulletin American Ceramic Society.

"The Petroleum Industry in Indiana in 1923", prepared at the request of the Association of American Petroleum Geologists and published by the American Mining Institute.

"The Hotmire Oil Field", published by the National Petroleum News. "Geological Conditions in the Oil Fields of Southwestern Indiana", published as Publication 42 of the Conservation Department. "Report on the Archaeology of Lawrence County" by E. Y. Guernsey with introduction by W. N. Logan. Published by Indiana Historical Commission. "Report of the Division of Geology", Indiana Yearbook, 1924. This report contains an account of the field, office and laboratory work of the division and a report of its finances for 1923. It also contains an article on "Petroleum Conservation." In addition to these publications other articles were prepared for newspapers and for presentation at scientific meetings.

OIL SHALE INVESTIGATIONS

The co-operative work with the United States Bureau of Mines in the investigation of the oil shales of Indiana was continued during the year. A small continuous kiln of the vertical type was constructed by Dr. J. R. Reeves and operated successfully in the extraction of shale oil. It is believed that it will be possible to expand this type of kiln into one of larger size which can be used commercially and operated successfully under field conditions.

Apparatus for the determination of sulphur in shale oil was installed in the laboratory.

STATE FAIR EXHIBITS

The exhibit made by the Division at the State Fair consisted of a display of Indiana fuels. The vertical retort of the continuous type for the extraction of shale oil from Indiana shales was exhibited and operated. This exhibit created a very deep interest and many inquiries were made regarding our fuel and oil shale resources. The exhibit was in charge of Mr. R. E. Esarey.

MINERAL AND ROCK DETERMINATIONS

A large number of rocks and minerals were sent to the office and laboratory of the Division during the year with requests for analyses, determinations, and suggestions as to commercial use. The expenditure of much time was required in some of the investigations. A summary of the tests includes the following.

Silver	4	Arsenopyrite	1
Sulphur	1	Marl	4
Iron ores	39	Feldspar	7
Gold	4	Gypsum	27
Galena	11	Gravel	5
Oil	7	Water	19
Oil sands	25	Shales	60
Clays	49	Limestone	39
Pyrite	57	Granite	27
Mica	26	Quartz	28
Peat	7	Coals	20
Well drillings	50	Calcite	24
Sandstone	5	Miscellaneous	27
		Total	573

OFFICE WORK

The supervisor of natural gas serves as assistant state geologist, and with the help of the stenographer, attends to the office work. Considerable time was required to collect and prepare information for callers and for replies to correspondence and in mailing reports, recording well records and information collected on natural resources.

Following is a summarized report of office work for the year:

Letters received	1,625
Packages received	1,181
Letters mailed	3,314
Packages mailed	290
Reports distributed—	
Annual geological	125
Handbooks of Indiana Geology	53
Petroleum and Natural Gas	65
Kaolin in Indiana	24
Oil Fields of Southwestern Indiana	81
Oral reports	1,264

In addition to the above, 681 letters were received at the Laboratory, and 430 letters and 102 packages mailed.

MUSEUM

The registered attendance of the Museum for the year was 50,991 as compared to 44,607 for the previous year, an increase of 5,384 visitors. This is an unusually large increase and is illustrative of the growing interest in the Museum. The attendance during August was 7,128, and during September was 7,2[illegible] by far the largest monthly registration. During the week of the State Fair the Museum had 4,323 visitors.

A special effort was made to emphasize the educational features of the Museum and to attract school children. Many classes from schools of Indianapolis and nearby towns visited the Museum in a body accompanied by teachers and studied the birds, animals, butterflies, etc., native to the state.

There is urgent need for additional space for the Museum and for several new cases to display the exhibits which are now in storage.

Following is a list of donations, additions, etc., made to the Museum during the year:

Collection loaned by Dr. Fletcher Hodges, Indianapolis: Flint-lock-breech-loading musket; cavalry sabre; candle mold; Colonial foot stove; pair African elk horns; pair ox horns; pair deer horns; pair rhinoceros horns from Asia; Mexican sombrero; table scarf, made by natives of Pacific Islands; collection of arrow heads; curio, twig formation.

Mastodon rib bones, 52 inches long, taken from Boots Creek, Marion, Indiana. Donated by E. Hulley, Marion.

Hummingbird's nest. Donated by Weaver Miller, Rockville.

Devil's walking stick (very large specimen). Donated by Miss Vera Beck.

Twig from tree growing in courthouse tower, Greensburg, Ind. Tree is 15 feet in height.

Mexican Revisional money issued in 1915. Six pieces. Donated by S. Huber, Shelby County, Indiana.

Scorpion from Florida. Donated by Alonzo Todd, Bainbridge.

Can of peaches, canned in 1867. Donated by Mrs. Sophrana Jones, Alexandria.

Red-shouldered hawk. Donated by C. C. Golden, Indianapolis, mounted by D. L. Wells.

Collection of 150 large and 185 small shells from Pacific Ocean islands; opium pipes from Japan; 4 shark teeth; wooden comb made by natives of Philippines; silk-cotton from cotton tree in Island of Negros; candlestick used in 1785-1800; 3 specimens of tree coral. Donated by Miss Julia Kerr.

Raincoat woven from fibre of trees and worn by natives of Philippine Islands. Donated by Arthur A. Brookley, Indianapolis.

Civil War uniform—coat, trousers, vest, gloves and handkerchief worn by Capt. Wm. D. Sering, Company I, 15th Ind. Reg. Donated by Miss Helen Rorex, Indianapolis.

Collection of 100 minerals, classified and loaned by T. M. Kingsbury, Indianapolis.

Side saddle used about 1843 by Mrs. Wm. B. McCrea, Christianberg, Ohio.

Ball of marble, weighing 13 pounds, from Japan, and specimen of lava from Japan. Donated by Miss Julia Kerr, Indianapolis.

Chinese statuette, hand-carved of soapstone, for many years a mantlepiece of Dr. Edward F. Hodges. Donated by his son, Dr. Fletcher Hodges, Indianapolis.

Campaign badge used in Wm. Henry Harrison campaign.

Block from the Lincoln log cabin, Spencer, Indiana. Donated by Co. C. C. Schreeder, Evansville.

Baby's shoe worn by 3-year-old boy shortly after Civil War. It is side laced and has high heels. Presented by Roy Danforth, Elizabethtown, younger brother of the owner.

United States two cent piece, 1865. Donated by Michael Carroll, Indianapolis.

Trunk used in 1777 by Mrs. Phere Weeks, deceased. Donated by Mrs. Daisy Phelps, Indianapolis.

Picture frame carved by hand from walnut wood in 1864 by Geo. W. Warner, Madison, Indiana, Co. H, Indiana Cavalry. Donated by his daughter, Harriet Starr, Indianapolis.

Wheat cradle owned by Robert Fitzpatrick's father, 1832, who lived in Johnson County. Presented by Leo E. Williams, Whiteland.

Iron hatchet, supposed to have been used as a tomahawk, dug out of a gravel pit more than 100 years ago by John Varner, in Muskegon County, Ohio. Donated by his grandson, A. G. Varner, Jonesville, Ohio.

Wooden brace made in Scotland 75 years ago. Donated by J. T. Burrows, Losantville, Indiana.

Indian arrow heads, four. Donated by Ralph Robison.

Two German swords from St. Mihiel battlefield. Donated by overseas veteran.

Souvenir of the Daily Dispatch, Montgomery, Alabama, April 28, 1880, in commemoration of the laying of corner stone of the Confederate Monument at Montgomery. Donated by Major Wilson of State House police force.

Four seashells, 1 snuff box, 1 pair of spectacles, 1 grandmother's night cap in lace, 1 trinket box, 1 teacup—all more than 100 years old. Donated by Miss Daisy Phelps, Indianapolis.

Cross-section of Washington Elm, under which Gen. Geo. Washington first took command of the American armies, July 3, 1775, at Cambridge, Mass. Presented to the State of Indiana by the city of Cambridge.

Indian spearhead, found on top of mound near LaFontaine, in 1923. Donated by Edwin Reid, Indianapolis.

Bookcase used by Thomas A. Hendricks, while in practice of law and while Governor of Indiana. Donated by John F. Haynes, Indianapolis.

Campaign badge, W. R. C. Donated by Clarence O. Goldrich.

Exhibit with case, showing by-products of petroleum. Donated by Standard Oil Co. of Indiana.

Soldier's discharge papers of Chas. Goodman, 23d Indiana, Co. A. Donated by his widow.

Collection of relics filling two cases. Donated by Miss Adaline Denny, Indianapolis.

Sewing machine, 75 years old, used by Sarah and Mary Newby, Jonesboro. Donated by Jesse Newsom, Carthage, Indiana.

Cannon ball and other Civil War relics found on battlefield near Atlanta, Ga. Donated by Ida Hodgin, Indianapolis.

Book, "United States History from Discovery of America to War of 1812." Donated by Cyrus B. Tranbarger.

Harpoon, invented 1857, used in fisheries and capture of animals along Atlantic coast. Donated by Otto M. Linn, Indianapolis.

Specimen of tufa-fossils in the making—from Waldron. Donated by Stacy Brant, Waldron.

Case of mosses from Pacific Coast, and box of shells from Sahara, Algiers and the Holy Land. Donated by Edna W. Roberts, Indianapolis.

Sample of wheat, raised by Adam Mellis, in Shelby County in 1872.

Collection of 48 stamps from the Vanderburgh County Courthouse. Presented by County Commissioners Jules Held and Henry A. Meyer.

Iron shovel used more than 100 years ago by Moses Harrison. Donated by Mrs. Lawson, Indianapolis.

Mounted bird's and hornet's nests. Collection of Dr. Chas. Yoke, Bridgeport. Donated by his widow.

Fifty centimes of coin (1917). Donated by Clarence Everett, Knoxville, Tenn.

Dinner bell first used by John McCray, Wilkinson, Ind., in 1847. Donated by his daughter, Mrs. Martha J. Stubbs.

Civil War revolver carried by Wm. Taylor, 1st Ind. Cavalry. Donated by his grandson, Jas. Taylor, Indianapolis.

Peculiar stone formation excavated in digging foundations. Donated by J. E. Hodson, Indianapolis.

Trundle bed and historical collection. Donated by Mrs. Oakley Thompson, Versailles, Ky.

Army bugle used during Civil War by John Waterbury, 100th Reg. Ind. Vols., 15th Army Corps, with Sherman in his march to the sea.

Army fife used throughout Civil War by Daniel H. Sharpe, musician, Co. G, 33d Reg. Ind. Vol. Donated by his wife.

Exhibit of wood used in making automobile body. Donated by Ford Motor Co., Detroit.

NATURAL GAS SUPERVISION

The work in this branch consisted in plugging abandoned oil and gas wells in accordance with the state law, collecting and tabulating well records, collecting and distributing information on oil and gas and development activities in the state, and preventing the waste of gas from wells and pipe lines.

During the year, 315 wells were plugged in 26 counties as follows:

Adams	27	Huntington	10
Allen	1	Jay	50
Blackford	11	Knox	4
Cass	1	Madison	5
Clay	2	Martin	2
Daviess	1	Marion	1
Decatur	7	Pike	15
Delaware	15	Randolph	12
Dubois	1	Rush	5
Gibson	16	Shelby	2
Grant	22	Sullivan	13
Greene	1	Wells	78
Hamilton	2		
Henry	11	Total	315

The Oil and Gas News has been issued in mimeograph form, the first of each month and sent to about 200 operators in the state. It gives regularly reports on leasing of land, test wells, production of new wells, and other information of interest to all in the oil and gas business. This news has been very favorably received and has served to establish a closer contact between the office and those in the oil and gas business.

A special effort has been made to collect well records and more than 600 logs are now on file in the office.

A circular giving the laws and regulations affecting oil and gas development operations in the state and accompanied by instructions for properly plugging wells, was issued and has been widely distributed with good results.

PETROLEUM INDUSTRY IN INDIANA

The petroleum industry of Indiana made somewhat notable progress during the year 1923, considering the number of handicaps it encountered. The price of labor and materials continued to have an upward slant while the price of crude oil took a decidedly downward course. In spite of these adverse conditions, the quantity produced closely approximated that of 1922, when it passed the million-barrel mark. The progress of the industry in Indiana should be considered fairly satisfactory as long as the present production is maintained. In other words, if the loss of production from the waning old wells can be offset by the production from the new for a period of 10 or 15 years longer, the industry may have cause for congratulation.

In recent years a number of tests of strata lying below the Trenton limestone have been made in Indiana. Several of these tests were completed in 1923. Indications of oil were reported by drillers from several horizons below the Trenton. The most satisfactory of these came from the St. Peter sandstone lying immediately below the Trenton limestone, but no production has yet been obtained from any of the Sub-Trenton horizons.

Two wells in Marion County were drilled into St. Peter sandstone. About 30 feet of sand saturated with a dense asphaltic oil was found in the upper part of this formation in one of the wells, which contained about 10 per cent of the light oils, or more easily volatile residue. A well was drilled near Greensburg to a depth of 3055 feet, descending 2190 feet below the top of the Trenton and passing through this formation, the St. Peter, Lower Magnesian and possibly into Upper Cambrian strata. No very encouraging indications of petroliferous horizons were found but some gas and some showing of oil were obtained in strata below Trenton. A well near Middle Fork in the northern part of Jefferson county was drilled through Sub-Trenton strata. Its total depth was 2725 feet, or about 1825 feet below the top of the Trenton, but no oil showings of importance were found. A well drilled near Bryant in Jay county reached a depth of 3290 feet, which was about 2285 feet below top of Trenton. Favorable indications of oil were found at one horizon below the Trenton but the sand was not shot.

The most extensive development in the Trenton area during the year has been in the Hotmire field near Ridgeville, along the southern boundary of Pike Township in Jay County and along the northern boundary of Ward Township in Randolph County. The pool is an outlier to the east of the old field. This field was opened in 1922. Prior to 1923, 40 producing wells, six of which have been abandoned, one gas well and five dry holes were drilled. In 1923, 53 wells were drilled; eight were dry, one was abandoned and 44 are producing. Most of the dry holes were drilled at some distance from producing territory, in an

attempt to locate new pools. The Hotmire field is the most important one in this part of the Trenton area. The wells have an average initial production of about 40 bbl.; a few have produced from 200 to 300 bbl. and have settled down to from 20 to 25 bbl. at the end of six months. The producing horizon lies from 25 to 40 ft, within the Trenton, the top of which lies 1000 to 1100 ft. below the surface. The total production from this field in 1923 was about 110,000 barrels.

There is still some untested territory around the borders of the old producing areas of the Trenton field, which may prove productive. Some areas that years ago were tested and abandoned because of light production may be developed to advantage in the future. There is still much untested territory on the distant slopes of the geanticline, somewhat remote from producing territory. Experience has demonstrated that such remote producing areas are not closely associated with other producing areas, so that prospecting in the immediate vicinity of a remote producing area may afford no better chances of success than prospecting at more distant points.

The present productive oil pools of the southwestern part of Indiana are confined to the area of outcrop of the Pennsylvania strata. They are distributed from the attenuated margin of the outcrop to where the strata approach their maximum thickness in Indiana. Productive oil areas are present in the following counties: Daviess, Knox, Martin, Gibson, Pike and Sullivan. The larger part of the production comes from the last three counties.

The production of oil in the southwestern part of Indiana in 1923 was about the same as for 1922, in spite of the fact that development work came to a standstill following the cut in the price of crude oil. The total production was approximately 800,000 bbl. for this area.

There is, in southwestern Indiana, a large amount of territory in which the shallow sands of the Pennsylvanian and the Mississippian strata have not been adequately tested. The deeper Devonian and Ordovician strata in the producing areas are largely untested. Both of these may be considered fair prospects for new production, though the former is supported by the stronger evidence, namely, present production in the general region. The more complete testing of territory containing the shallower sands and the consequent discovery of new petroliferous areas will probably sustain production at about its present level for several years providing the price of crude oil justifies the development work.

Indiana produced 1,043,000 barrels (42 gallons each) of petroleum during the calendar year 1923. During the first eight months of 1924 the production was 640,000 barrels, as compared to 706,000 for the same months of the year previous. Of this amount the southwestern Indiana fields produced 457,000 barrels, and the northeastern Indiana fields, 192,000 barrels. The low price of oil is probably responsible for the decrease in production in the southwestern part of the state, and the newly discovered Hotmire pool has been the principal cause for the increase in the northeastern Indiana fields.

The production of petroleum in Indiana for the first eight months of the year 1924, follows:

Month	Southwestern Field	Northeastern Field	Total
January	52,000 bbls.	18,000 bbls.	70,000 bbls.
February	55,000 bbls.	22,000 bbls.	77,000 bbls.
March	52,000 bbls.	24,000 bbls.	76,000 bbls.
April	61,000 bbls.	27,000 bbls.	88,000 bbls.
May	62,000 bbls.	26,000 bbls.	88,000 bbls.
June	58,000 bbls.	26,000 bbls.	84,000 bbls.
July	62,000 bbls.	26,000 bbls.	88,000 bbls.
August	55,000 bbls.	23,000 bbls.	78,000 bbls.

THE CONSERVATION OF NATURAL GAS

W. N. LOGAN

Natural gas is a mixture of hydrocarbons, chiefly, which are gaseous at ordinary temperatures. The principal hydrocarbon is marsh gas, CH_4, fire damp, or methane. Natural gas also contains small quantities of thane, C_2H_4, olefine, C_2H_6, carbon dioxide, CO_2, carbon monoxide, CO, Oxygen, O, Nitrogen, N, Hydrogen, H, Helium, He, and Hydrogen Sulphide, H_2S. Natural gas is colorless and usually odorless, though at times, it has a slight odor. It burns readily with a luminous flame and when mixed with air is explosive.

The maximum amount of the various constituents are: Marsh gas, 98.40; Ethane, 14.60; Olefine, 0.39; Carbon dioxide, 1.6; Carbon monoxide (CO), 2.5; Oxygen, 3.46; Nitrogen, 85.83; Hydrogen, 11.51; Helium, 1.84; Hydrogen sulphide, 0.20.

COMPARISON OF NATURAL AND MANUFACTURED GASES

Constituents	Natural			Manufactured		
	Pa. & W. Va. Aver.	O. & Ind. Aver.	Aver. Kansas	Aver. Coal Gas	Aver. Water Gas	Aver. Pro. gas Bit. Coal
Marsh gas	80.85	93.60	93.65	40.00	2.00	2.05
Other Hydrocarbons	14.00	.30	.25	4.00	.00	.04
Nitrogen	4.60	3.60	4.80	2.05	2.00	56.26
Car.-dioxide	.05	.20	.30	.45	4.00	2.60
Car.-monoxide	.40	.50	1.00	6.00	45.00	27.00
Hydrogen	.10	1.50	.00	46.00	45.00	12.60
Hydrogen sulphide	.00	.15	.00	.00	.00	.00
Oxygen	tr.	.15	.00	1.50	1.50	.05

Uses of Natural Gas. Natural gas is used for illuminating purposes in domestic use; in the manufacture of lamp black; as a fuel in the smelting of zinc and in other metallurgical works; as a fuel in the manufacture of glass, cement, brick, tile and pottery.

In the manufacture of gasoline, natural gas is now used. The heavier members of the gaseous hydrocarbons and the lighter member of the liquid hydrocarbons may be changed to liquids by pressure at low temperature. The gas which is given off from oil wells, known as casing-head gas, is composed of the heavier gaseous hydrocarbons and is especially adapted to the manufacture of gasoline. In the process of extraction the gas is subjected to considerable pressure at low temperature. Some gases will give gasoline by a lowering of the tempera-

ture without increasing the pressure. Thus the heavier portions of the gas are converted into gasoline and the larger portion of the light hydrocarbons are left in the gaseous form. The usual production of gasoline is from 2 to 4 gallons per 1,000 ft., but as high as 10 gallons have been produced.

Origin. The origin of natural gas is similar to that of petroleum which has already been discussed. In many cases it is derived from petroleum.

Mode of Occurrence. As a rule natural gas occurs with petroleum and is found under the same geological conditions. In a porous stratum, which contains water, oil and gas, the gas will be found at the highest point in the collecting ground. As its movement is not controlled by oil or water it will always be found at the highest point in the porous stratum. Oil will be found at the highest point when water is present; if no water is present, at the lowest point.

Extent of Gas Fields. The gas fields of the United States contain about 10,000 sq. mi., occupying parts of 20 states. The value of natural gas in the U. S. in 1922 was $215,000; in 1888, $22,600,000; in 1896, $13,000,000; in 1901, $27,000,000; in 1907, $54,000,000; in 1914, 94,000,000; in 1920, 798,210,000,000 cubic feet were produced valued at $196,194,000; in 1921, 662,052,000 cubic feet valued at $174,617,000.

Length of Life. The future life of natural gas is certain to be short. Fields in N. Y., in Ohio, Pennsylvania, West Virginia and in Indiana have been exhausted. Others are decreasing in output. Only a few years ago, Indiana was not only supplying her own needs but piping large quantities of gas into Chicago. Today she is importing large quantities of gas from West Virginia. It is probable that the natural gas of the United States will be exhausted in 25 years, if the present rate of consumption continues.

Waste of Natural Gas. Natural gas, the most perfect fuel, has been wasted as has no other natural resource. The sources of waste of natural gas are: 1. Failure to control high-pressure wells. In the early days of gas and oil production, when a well of high pressure was drilled there was supplied no adequate method of controlling the gas flow and the well was allowed to blow off for days. Even today there is considerable loss from this source. All wells should be provided with adequate valves for closing the well.

2. Burning Was at the Well. Many wells which have reached gas reservoir have been ignited and allowed to burn for years unceasingly. In some cases the rocks above the reservoirs have given way and the gas has escaped and burned in gigantic cauldrons of flame. This has occurred in Louisiana to an enormous extent. In the Caddo field, in the early days of its development, this waste amounted to 70,000,000 cubic feet per day—enough gas to light 10 cities the size of Washington, or to the daily waste of 10,000 barrels of petroleum. This waste went on from year to year without any successful attempt upon the part of the state to check it. The question arises as to whether any state shall escape moral responsibility for waste of its natural resources.

3. Waste from Oil Wells. Many oil men have had no regard for natural gas, and since natural gas usually accompanies oil, they have allowed large quantities of gas to escape without making any attempt to utilize it. Indiana is the only state in which laws for the prevention of waste of natural gas were passed at an early date. It was the first state to attempt the conservation of gas from oil wells, for it is possible to obtain the oil without wasting the gas. This may be done by separating the oil and gas as they come from the well, or by drilling wells below the gas stratum and casing off the gas.

4. Waste from Pipe Lines and Containers. Much gas is wasted through the joints of pipes and of containers. Many pipe lines are poorly constructed and leak at every joint. This waste is easily prevented. In West Virginia the daily waste in 1907 was estimated by I. C. White, the State Geologist, at one billion cubic feet, which in heating value is equivalent to one million bushels of coal. Dr. White estimates the total waste as equivalent to a 45 ton car of coal per minute for 20 years. Nine-tenths of the waste is estimated to be in connection with the oil industry.

Total Loss of Gas. It is estimated that the yearly waste of natural gas amounts to as much as that used. In 1907 the amount produced was 400 billion cubic feet; in 1914, 591 billion cubic feet; in 1920, 798 billion cubic feet. About 75% of the total waste is in connection with the oil industry and is easily preventable.

Law Restricting Waste Needed. The United States Supreme Court holds that no one has the right to waste a natural product. The states then have the authority to pass laws to prevent waste. The State of Indiana, in 1891, passed a law providing for a gas inspector, whose duty was to prevent leakage in pipes, select the kinds of pipes, determine the pressure allowed, and to see that proper means were provided for the prevention of waste of gas while extracting other products. This law has been up-held by the highest state courts. Other states that failed to secure this much needed legislation lost enormous quantities of the most perfect fuel found among the fuel resources of the earth. A Federal law should be passed to prevent the waste of natural gas in any and all states.

Necessity for Immediate Action. If anything is to be gained, action must be taken within the next few years. For with the present rate of use and present rate of waste, natural gas will be an unknown quantity within 20 years. Of all the extravagance in the use and abuse of our natural resources none have approached that of the extravagant waste of natural gas. We boast of American progress; of the degree of civilization; of our leadership; and yet in the wasting of our natural resources we have been guilty of more stupendous folly than any other people in the civilized world.

We should remember that when coal, petroleum and natural gas are once taken from the ground they are soon used; and once used they are destroyed forever. Therefore, they should be extracted slowly and used economically. As far as possible other fuels should be substituted for them.

LAWS AND REGULATIONS AFFECTING OIL AND GAS DEVELOPMENT OPERATIONS IN INDIANA

T. M. KINGSBURY, Natural Gas Supervisor

Several laws have been enacted by the Indiana Legislature affecting oil and gas development operations in the state, some of which have been superseded by other acts, more especially by the act creating the department of conservation. The administration of these laws is under the jurisdiction of the department of conservation through its division of geology. This compilation contains the laws and regulations now in force, and at the close of each section is given the citation to the page of the session laws where the section is found as well as the corresponding section in Burns' Annotated Statutes of 1914 and the Supplement of 1918.

Duties of Natural Gas Supervisor. The act creating the office of state natural gas supervisor and defining his duties was enacted in 1891. (Acts 1891, page 379, Burns 1914, Sec. 9056.) Section 1 of this act empowered the supervisor, under the direction of the state geologist, to make personal inspection of all the gas wells of the state, so far as practicable; to see that every precaution is taken to insure the health and safety of workmen engaged in opening gas wells and laying mains and pipes, and of those who use gas for mechanical, manufacturing, domestic or other purposes; to see that all the provisions of law pertaining to the drilling of wells and the piping and consumption of natural gas are faithfully carried out and that the penalties of law are strictly enforced, and to promptly report all violations of law to the attorney general.

Transfer of Power to Department of Conservation. By the act creating the department of conservation (Acts 1919, page 375) the office of natural gas supervisor was abolished and his rights, powers and duties were transferred to said department (Sec. 24), and the division of geology was empowered to "secure the enforcement of laws for the conservation and development of the natural resources of the state" (Sec. 15). Under said act of 1919 the department, and its officers and employes, have power to administer oaths; to certify to official acts; to require information for any lawful purpose under the act from public officers, corporations, associations and individuals; to issue subpoenas; to require the attendance of witnesses and to examine them under oath; to require the production of books, accounts, papers, records and documents (Sec. 9); to execute and serve all warrants and processes issued by any justice of the peace or any court having jurisdiction under the act or under any act which the commission is empowered to execute and administer; and to arrest and detain without a warrant any person found by them violating any of said acts, until a legal warrant can be obtained (Sec. 14). It is made a misdemeanor to obstruct or hinder any member of the commission, or any officer, assistant or employe thereof, in the lawful discharge of his duties. (Sec. 25).

Leakage of Gas and Repair of Leaks. Section 1. That it shall be and is hereby made the duty of the natural gas supervisor of the State of Indiana, upon the discovery of any leak in any pipe line for the

transportation of natural gas, or in any machinery, apparatus, appliance or device used in the regulation or distribution thereof, to forthwith notify, in writing, the owner or superintendent of said pipe line, machinery, apparatus, appliance or device, to have the same repaired within two days from the receipt of said notice. In case such leak has not been repaired within two days from the time of receiving such notice it shall be the duty of said natural gas supervisor to make such repairs as may in his judgment be necessary to stop said leak; and such natural gas supervisor shall have a lien upon said pipe line and all wells with which the same may be connected, for the cost of making such repairs, for the enforcement of which, with all costs of suit, and a reasonable attorney's fee, an action may be maintained by him in any court of competent jurisdiction; and the judgment so obtained shall be collectible without relief from valuation or appraisement laws of the state. In case of any pipe line, machinery, apparatus, appliance or device, owned by a corporation, partnership, or by a nonresident of or absentee from the State of Indiana, the notice herein provided may be served upon any person in charge of such pipe line. (Acts 1899, page 83, Burns 1914, Section 9058.)

Pipes for Carrying Gas, Pressure. Section 1. That any person or persons, firm, company or corporation engaged in drilling for piping, transporting, using or selling natural gas may transport or conduct the same through sound wrought or cast iron castings and pipes tested to at least four hundred pounds pressure to the square inch: Provided, Such gas shall not be transported through pipes at a pressure exceeding three hundred pounds per square inch: Provided, That the provisions of this act shall not affect the costs in any pending litigation. (Acts 1891, page 89, as amended by Acts 1903, page 110, Burns 1914, Section 9060.)

Penalty. Section 3. Any person or persons, firm, company or corporation violating any of the provisions of this act shall be fined in any sum not less than one thousand dollars or more than ten thousand dollars, and may be enjoined from conveying and transporting natural gas through pipes otherwise than in this act provided: Provided, That nothing in this section shall operate to prevent the use of nitroglycerine or other explosives for shooting any well or wells from which gas is procured. (Acts 1891, page 89, Burns 1914, Section 9061.)

Gas Confined in Pipes. Section 1. That it shall be unlawful for any person, firm or corporation having possession or control of any natural gas or oil well, whether as a contractor, owner, lessee, agent or manager, to allow or permit the flow of gas or oil from any such well to escape into the open air, without being confined within such well or proper pipes, or other safe receptacle for a longer period than two (2) days next after gas or oil shall have been struck in such well. And thereafter all such gas or oil shall be safely and securely confined in such well, pipes or other safe and proper receptacles. Any person, firm or corporation violating any of the provisions of this section shall be fined in any sum not less than fifty dollars, nor more than two hundred dollars, and for any second or subsequent violation of this section he shall be fined in any sum not less than two dollars, nor more than

five hundred dollars, (Acts 1893, page 300, as amended Acts 1913, Page 66, Burns 1914, Section 9062.)

Civil Liability. Section 4. Whenever any person or corporation in possession or control of any well in which natural gas or oil has been found shall fail to comply with the provisions of this act, any person or corporation lawfully in possession of lands situate adjacent to or in the vicinity or neighborhood or such well may enter upon the lands upon which such well is situate and take possession of such well from which gas or oil is allowed to escape in violation of the provisions of section one of this act, and pack and tube such well and shut in and secure the flow of gas or oil, and maintain a civil action in any court of competent jurisdiction in this state against the owner, lessee, agent or manager of said well, and each of them jointly and severally to recover the cost and expense of such tubing and packing, together with attorney's fees and costs of suit. This shall be in addition to the penalties provided by section three of this act.[1] (Acts 1893, page 301, Burns 1914, Section 9063.)

Recovery of Expenses of Plugging. Section 5. Whenever any person or corporation shall abandon or cease to operate any natural gas or oil well, and shall fail to comply with the provisions of section two[2] of this act, any person or corporation lawfully in possession of lands adjacent to or in the vicinity or neighborhood of such well may enter upon the land upon which such well is situated and take possession of such well, and plug and fill the same in the manner provided by section two of this act, and may maintain a civil action in any court of competent jurisdiction of this state against the person, persons or corporations so failing, jointly and severally, to recover the costs and expense of such plugging and filling, together with attorney's fees and costs of suit. This shall be in addition to the penalties provided by section three of this act.[2] (Acts 1893, page 301, Burns 1914, Section 9064.)

Plugging Abandoned Wells.—Section 1. That before the casing shall be drawn from any well drilled into gas or oil-bearing rock for the purpose of abadoning the same, it shall be the duty of any person, firm or corporation having the custody of such well, or having charge of removing the casing therefrom for the purpose of abandoning the same, at the time of such abandonment, to properly and securely stop and plug each of said wells so abandoned in the following manner: Such hole shall first be solidly filled from the bottom thereof to a point at least twenty-five (25) feet above such gas or oil-bearing rock with sand, gravel or pulverized rock, on the top of which filling shall be seated a dry pine wood plug not less than two (2) feet long and having a diameter of one-fourth of an inch less than the inside diameter of the casing in such well; above such wooden plug such well shall be solidly filled for at least twenty-five (25) feet with the above mentioned filling material; immediately above this shall be seated another

[1] Section 3 was repealed by the Act of 1903, page 212; and the Act of 1903 was superseded by the Act of 1909, page 234, Sections 1-7, below.

[2] Section 2 was repealed by the Act of 1903, page 212; and the Act of 1903 was superseded by the Act of 1909, page 234, Sections 1-7, below.

wooden plug of the same kind and size as above provided, and such well shall again be solidly filled for at least twenty-five (25) feet above said second plug with such filling material. After the casing has been drawn from such well there shall immediately be seated at the point in said well where such casing was seated a cast iron ball, the diameter of which shall be greater than that of the hole below the point where such casing was seated, and above such ball such well shall again be solidly filled with the above mentioned filling material for a distance of fifty (50) feet. Any person, firm or corporation owning or having charge or supervision of any well which has been drilled into gas or oil-bearing rock, or having charge or control of removing the drive pipe or casing from any such well, and from which the drive pipe and casing or the drive pipe alone has been or shall be pulled, leaving therein the tubing, casing, or both, shall give notice to the state natural gas supervisor, and under the supervision and direction of said supervisor, or one of his assistants, shall plug such tubing, where such tubing only remains in such well, and shall fill from the bottom up not less than three hundred (300) feet with cement and clean sand, one part Portland cement to four parts of sand, and where the casing and tubing remain in any such well, such well shall be filled on the packer with not less than fifty (50) feet of Portland cement and sand, and if there be no such packer, with not less than one hundred (100) feet of Portland cement and sand in the proportions hereinbefore indicated, and in all cases where the drive pipe and casing or either the drive pipe or casing are removed from any such well and the tubing is left therein said tubing shall be plugged as herein provided, and if any part of the tubing, drilling-stem or other substance prevent the plugging of any such well or wells as hereinbefore provided, such well or wells shall be filled to a point within twenty-five (25) feet of the top part of said tubing, drill-stem or substance with sand, gravel or crushed stone, and shall thereupon be filled to a point twenty-five (25) feet above such part of tubing, drill-stem or substance with Portland cement and sand, all proportioned as above provided. (Acts 1909, page 234, Burns 1914, Section 9065.)

Notice to Supervisor, Fee.—Section 2. Any person, firm or corporation, before proceeding to plug any such well so drilled into any gas or oil-bearing rock, or to pull the casing or drive pipe therefrom, shall notify the state natural gas supervisor, or one of his authorized assistants, of such intention and the time and place where such plugging is to be done, and it shall be the duty of said natural gas supervisor or his duly authorized assistants to be present in person all the time while such plugging is being done and the same shall be done under his instructions and supervision, and such person, firm or corporation so plugging such well shall file, or cause to be filed, in the office of the recorder of the county in which any such well is located, within fifteen days after the same has been plugged, as provided in section one (1) hereof, a written statement of such state natural gas supervisor, or his duly appointed assistant, showing that such well was duly plugged under his personal supervision and instruction and in the manner herein prescribed and required, which statement shall be recorded in the mis-

cellaneous records in the office of such recorder. And for supervising and superintending the plugging of any such well said person, firm or corporation plugging such well or having the same done, shall pay in advance of doing any such work or plugging a fee of five dollars ($5.00) to the state natural gas inspector or his assistant, to be by them turned into the state treasury. (Acts 1909, page 235, Burns 1914, Section 9066.)

The fee for plugging wells was increased to ten dollars ($10) by the special session of the legislature of 1920 (see Acts of Special Session 1920, page 77, Section 4d of Appropriation for State Departments), as follows:

For the department of conservation: The sum of twelve hundred and ninety-one dollars, representing fees collected by the state gas inspectors for superintending and supervising the plugging of gas wells, and already turned into the state treasury, is hereby appropriated to the department of conservation to be apportioned as additional compensation among such gas inspectors for their services in inspecting and plugging such gas wells. That hereafter the fee for superintending and supervising the plugging of gas wells shall be ten dollars, which fee shall be collected, as now provided by law, and disposed of as follows: eight dollars for the services of inspection and plugging of wells and two dollars to remain in revolving fund.

Power of Department of Conservation to Make Regulations.—Section 6 of the act creating the department of conservation refers to the election of officers, rules and regulations. (Acts of 1919, page 377.) That portion of this section relating to rules and regulations says:

"The commission may make rules and regulations authorized by this act and such others as may be necessary in their judgment to carry out its provisions, and such rules and regulations, when approved by the governor, and promulgated as hereinafter provided, shall have the force and effect of law, and any person, firm or corporation who shall violate any of the provisions of such rules or regulations shall be subject to a fine of not less than ten dollars ($10) nor more than three hundred dollars ($300) for each offense, to which may be added imprisonment in the county jail for not less than thirty (30) days nor more than six (6) months. In issuing such rules, the conservation commission shall have full authority to prescribe reasonable fees for any inspection or other like service within the purview of this act, and performed by the commission or any of its assistants or employes."

In accordance with Section 6 of this act creating the department of conservation, the conservation commission has passed two regulations affecting those interested in developing the oil and gas resources of the state, both of which were approved by the governor. One of these increased the fee for supervising the plugging of wells from five dollars to ten. This has been superseded by the law previously given which was passed by the special session of the Legislature of 1920. The other regulation follows:

Furnishing State Geologist with Well Logs.—Pursuant to Section 6 of an act creating a department of conservation commission of the State of Indiana orders that all well drillers engaged in drilling for

oil or gas in the State of Indiana shall furnish to the state geologist the location and accurate log of each well drilled by them, showing the kind and thickness of each rock strata passed through by the drill; that such log shall be completed and mailed to the state geologist within thirty (30) days after the completion of the well; that failure to comply with their order shall subject the driller to the penalty prescribed in Section 6 of the conservation laws. This regulation to take effect by the 30th day of June, 1919. This regulation applies not only to the driller but to the company drilling the well, owner of the land upon which the well is drilled, and others interested in it.

Information on Plugging Wells.—When a well is to be plugged, the nearest deputy supervisor should be notified at least a day in advance. In case there is no deputy near, notify the State Gas Supervisor in Indianapolis. Deputies are assigned territories over which they have charge. They receive no salary, but as compensation for supervising the plugging of wells, they receive a portion of the $10.00 fee collected for each well plugged. The state gas supervisor supervises the plugging of wells outside of territories not covered by deputies and the fees he collects are turned over to the state.

No well should be plugged before the arrival of the supervisor or deputy and all material necessary for plugging, including the filling material, wooden plugs, iron ball and cement, when necessary, should be ready. The filling material should be poured into the well slowly, especially if there is water present, and every precaution taken to prevent its bridging or becoming lodged in the well before it reaches the bottom. In order to insure correct amount of material prescribed by the law, it should be measured before being put into the well, or the depth should be tested with a line. If the line is not used be sure to have enough material to fill to the required depth. Be on the safe side by putting in more rather than less than the law requires. Special care should be taken in putting in material below the first plug. The law states the well should be filled twenty-five feet above the gas or oil-bearing rock, and this does not mean simply twenty-five feet from the bottom of the well. Make allowances also for filling the cavity at the bottom of the well caused by the shot.

Before the plugs are put in, make sure that the filling material is at the bottom of the well. If it becomes lodged, the drilling tools may be required to dislodge it. If water is present, allow plenty of time for the material to settle before dropping the plug. If the hole is dry, it may not be necessary to weight the plug or drive it down, but if water is standing in the well it will be necessary to add some weight to the plug or force it down with the drilling tools. The plug may be weighted with an old piece of two-inch pipe. This can be fastened to the plug by driving a piece of wood into the pipe and then nailing it to the top of the plug. Additional weight can be gotten by filling the pipe with gravel. When cement is used with the filling material, more time should be allowed for it to settle and the casing should be washed with a few bucketfuls of water before the plugs are dropped.

Value of Well Logs.—The glacial drift covers practically all of the northern three-fourths of Indiana and completely conceals the bed rock

or durolith. In many parts of the southern fourth or non-glaciated area the rock is so covered with soil that exposures are few. Where the bed rock is not exposed and can be studied, surface indications are of little value to the oil prospector, and in such regions logs of wells have to be depended on as a means of determining structural conditions favorable to the accumulation of oil or gas. In that portion of the state where the glacial covering is attenuated or in the non-glaciated portion the work of the geologist is not so hampered, and whenever persistent hard layers of rock are present he is usually able to work out structural conditions. Even in such regions well records or logs, correctly interpreted, are of great value. The more logs there are available, the more accurately can the structure of the bed rock be determined and the less hazardous drilling becomes. For this reason the regulation was made requiring that copies of logs of all wells drilled in Indiana be filed in the office of the Division of Geology.

The co-operation of all companies, drillers and others is solicited in the collection and filing of logs. The office has on file more than a thousand logs of Indiana wells and is collecting more all the time. These are constantly in use in supplying information on structural conditions in various parts of the state. When sending well logs to the office, give the location and number of the well, by whom drilled, date of drilling, initial production and list of formations penetrated, including depth and thickness of each.

Co-operation Solicited.—Co-operation of all interested in oil and gas development is urged by the Division of Geology. Report violations of law, such as leaking gas wells, failure to send in well logs, improperly cased wells, etc. Any information on activities in leasing, drilling or production will be useful to the office. Such information is recorded and is available for use of prospective drillers in the state.

REPORT OF THE DIVISION OF ENTOMOLOGY

FRANK N. WALLACE, State Entomologist, Chief of Division.
HARRY F. DIETZ, Assistant Entomologist.
EVERETT SMITH, Inspector of Nurseries.
FRANK B. WADE, Deputy Nursery Inspector.
CHARLES O. YOST, Chief Inspector of Apiaries.
THOMAS C. JOHNSON, Deputy Bee Inspector.
JAMES E. STARKEY, Deputy Bee Inspector.
DAVID FELLOWS, Deputy Bee Inspector.
WOOD J. MILLER, Deputy Bee Inspector.
HAROLD R. SLOAN, Deputy Bee Inspector.
ESTHER KERSEY, Clerk and Stenographer.

NURSERY INSPECTION

The production of nursery stock free from destructive insect pests and plant diseases is becoming more difficult each year. This is due to the more general distribution of insect pests and plant diseases and entails much closer inspection by the nursery inspector. In former