WEST VIRGINIA
GEOLOGICAL SURVEY

VOLUME VIII

Salt Brines of West Virginia

By
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LETTER OF TRANSMITTAL

Honorable Homer A. Holt, Governor of West Virginia, and President of the Geological and Economic Survey Commission.

DEAR SIR:

I have the honor to transmit for publication a report (Volume VIII) on the Salt Brines of West Virginia, prepared by myself, Charles E. Hare, Assistant Geologist, John B. McCue, Chief Chemist, and Homer A. Hoskins, Chemist. This report represents the fourth of a new series dealing with special phases of our natural resources, each covering the subject matter in full detail.

The production of sodium chloride or common salt was one of our very first and important industries in West Virginia. The salt was produced by evaporating natural brines or saline waters recovered from springs and later by drilled or bored wells. It was in the search for brines that petroleum and natural gas were discovered in large quantities.

To-day brines are sought not only for sodium chloride but also for many of the minor constituents which are valuable raw materials to the chemical and other industries.

This report presents full data on our salt brines from the many producing horizons and localities, as well as a complete review of the history of the development of this industry; also a discussion of the geology of brines and their economic utilization.

It is hoped that this report will help to bring about a greater and better development of this important and valuable natural resource.

Respectfully,
PAUL H. PRICE,
State Geologist.

Morgantown, W. Va., September 1, 1937.

CONTENTS

CONTENTS.

CONTENTS.

ILLUSTRATIONS

Plates.

ILLUSTRATIONS.

Figures.

TABLES

ACKNOWLEDGMENT

The West Virginia Geological Survey and especially those members of the staff immediately concerned with the preparation of this report wish to acknowledge their indebtedness to the many persons who have contributed vitally toward the successful completion of this study:

The various oil and gas companies and their operators, listed in the report, not only performed the essential task of collecting and forwarding samples but also cheerfully supplied the descriptive information applying to these samples and to their field operations.

The several manufacturing companies listed in the report gave permission for members of the Survey staff to visit their plants, and also willingly supplied appropriate information pertaining to their operations.

In addition to these, we are particularly indebted to Mr. W. D. Collins and Miss M. D. Foster of the Water Resources Laboratory of the U. S. Geological Survey for very valuable help in connection with the correlation of analytical procedures for the Survey's Chemical Laboratories. Miss Foster actually spent a month in the laboratory of the West Virginia Geological Survey in the summer of 1936 analyzing brines and helping the Survey Chemists acquire facility with the standard procedures of the U. S. Geological Survey.

The Survey is further heavily indebted to the following named individuals for information contained in the report: Mr. E. T. Crawford, Jr., who supplied a number of pictures and permitted the use of some of his material; Mr. Calvin W. Price, Dr. George Grant Lovett, Mrs. Beatrice Giffin, Mr. G. W. LaPeire, and the Hon. J. B. McLaughlin, Commissioner of Agriculture, and many others.

Finally, the authors wish to express their appreciation to each member of the Survey staff all of whom made some contribution to the report. Especial acknowledgment is made to Mr. R. C. Tucker, Assistant State Geologist, for his numerous valuable suggestions and piloting the report through the press.

PAUL H. PRICE,
CHARLES E. HARE,
JOHN B. McCUE,
HOMER A. HOSKINS.

ERRATA.

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Pages 114 to 124, Figures 8 to 18, inclusive:
Density is in grams per cu. cm. instead of p. p. m.

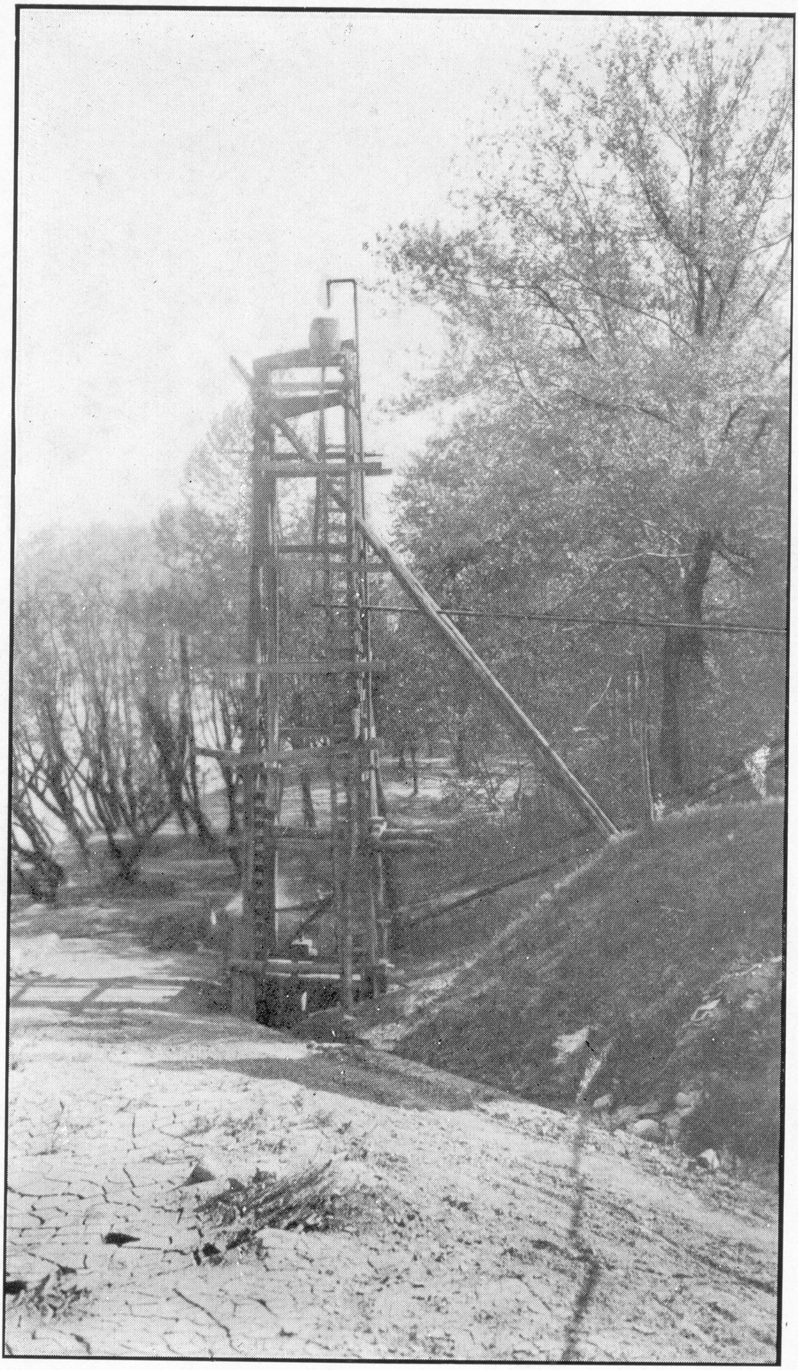

PLATE I.—Oldest Brine Well at Malden, W. Va.—Located on the right bank of the Kanawha River about 200 feet below the salt furnace. This well was drilled approximately 100 years ago; has since been deepened to 1700 feet, but upper sand is still productive.—Photo by Hoskins, 1934.

CHAPTER I.

BRINES OF WEST VIRGINIA.

GENERAL INTRODUCTION.

The work done in connection with the present brine survey consisted primarily of collecting and analyzing about 184 samples of brine for the 28 counties within the western half of the State and in general paralleling the Ohio River. This same area constitutes the gas and oil fields of West Virginia.

The object of the survey was intended primarily to obtain information relating to brines as an economic resource. A secondary objective was to obtain scientific data which would permit of a closer correlation of the geological information pertaining to the area.

Scope.—It was attempted to cover with this survey all of that section of the State believed to contain salt brines of economic importance and to get samples from as many different geological horizons as possible.

The field sampling was done almost entirely by oil and gas operators working in cooperation with a representative of the Geological Survey. The large number of wells drilled during the period of survey made it possible to secure so many samples. A map (Figure 3) showing locations of all wells sampled is enclosed in map pocket attached to back cover.

The analytical work consisted of making practically complete chemical analyses following the procedure adopted by the Water Resource Division of the United States Geological Survey. This work was done by two members of the Survey staff in the Survey laboratories at Morgantown.

The present report represents the most nearly complete report that has been issued to date on the brines of this State. Even so, it is of necessity incomplete in some particulars because it was not found possible to get enough samples to represent some areas as completely as others.

Additional samples of brine from various parts of the State will doubtless be analyzed by the Survey from time to time. The results of those, published in periodic reports, will form additions to the information contained in the present report.

Uses of Brines.—Brines yield various salts chief of which are the chlorides of sodium, calcium, and magnesium. Of these the most important is sodium chloride or common salt.

Salt is an essential substance of general use for household and livestock purposes. It has been so used since earliest time. In addition it forms the raw material for production of a number of important chemicals such as chlorine, soda ash, and caustic soda. This use has increased greatly within the last two decades and promises to increase still more in years to come. Salt is also the basis for manufacture of many pharmaceuticals. Calcium chloride produced as a by-product is important in road building and for other purposes. Magnesium is produced both as the chloride and also as the metal for use in the newer light metal alloys. Bromine and iodine are also produced from brines and used both for pharmaceuticals and industrial purposes. Bromine is used in increasing quantities in the manufacture of anti-knock gasoline. Chlorine, derived from brines, is used in rapidly increasing amounts as a bleaching agent in the manufacture of paper from southern slash pine. It also has a variety of other uses, one of the chief of which is in the purification of municipal water-supplies. Another use is in the manufacture of hydrochloric acid.

From the foregoing it is apparent that salt and its derivatives and by-products are of primary importance to society.

The present study shows that West Virginia, in which salt production was a pioneer industry, and in which it has been produced for over a hundred years, is endowed with vast reserves of salt brine adequate to support a large industry for many decades to come.

Various sections of the report which follows deal with different aspects of the general subject. The principal ones so treated include the history, geology, chemistry, and economic development of the deposits and the industries based on them.

CHAPTER II.

HISTORY OF THE BRINE SALT INDUSTRY.

THE IMPORTANCE OF SALT; ITS HISTORICAL VALUES.

Few people realize the importance of salt to mankind or know what an honorable, even enviable place it has held for centuries in the commerce and governments of the world. It was the need for salt that drove men to conquer the deserts of Arabia, Africa and China, and the chief burden of desert commerce to this day has been salt. Even the coinage of certain countries consisted of blocks of salt, and the United States of America is one of the very few governments that neither has a monopoly of the salt trade nor taxes it for revenue. (26)

It was salt that made possible the discovery of America, for without its quality of preserving meat no trans-Atlantic voyage could have then been made. This same quality was also the bed rock of the great fishing industry of our eastern coast and gave rise to the huge meat packing industry, which made the settling of our western frontier profitable. Salt again enters into the picture by way of mechanical refrigeration, which was such an important factor in the development of the packing trade, and hides are first cured with salt before they are shipped to the tannery or glue factory, even as in olden times.

Lack of salt in the South is given by Lippincott (9) as one of the reasons that the North won the Civil War, and scarcity of salt caused great hardships to the early pioneers, for it

a. prevented colonization,
b. retarded industry, such as meat-packing, and
c. caused livestock to deteriorate. (9)

Colonization Due to Salt Brines.—Salt played a major role in the colonizing of our country, for it was the basis of many a treaty with the Indians and a source of revenue to the youthful States, which reserved the salt lands (as they were called) and leased them to private operators. Even adjacent forest land was reserved as a fuel supply. Much of this revenue was applied to educational purposes. From the "Ohio Saline" in 1819, Illinois received $9,600, or more than one-third the yearly expenditure in that State in 1821 and 1822, and this was pledged as security for a loan of $25,000. Later, in 1825, the influence of the steamboat in bringing foreign salt up from New Orleans and the ability of the Kanawha furnaces to supply a large part of the upper Mississippi Valley brought about legislation permitting the sale of these State-owned salt lands, and requiring the investment of the proceeds for educational purposes in every instance except Ohio. In Missouri this fund amounted to $45,793; in Ohio (where this was voluntary) $41,024, and in Louisiana, $89,480, all in the year 1840, and it was all used for public schools. (9)

The following statistics emphasize the importance and scarcity of salt in the lands to the west of the Ohio River:

Kanawha Salines, Va., Mason City, Va., Hartford City, Va., and Bulltown Salines, Va. (all now in West Virginia) Zanesville and Marietta, O., Shawneetown, Ill., and Ste. Genevieve, Mo., were all settled by salt makers. No doubt many other towns were thus colonized, but "folded up" later.

Data on Early Salt Production.—The following table was compiled from Reference (9) in Bibliography:

Table 1.—Salt Prices.

Place.	Time.	Price per Bushel.
Ohio	1790 to 1800	$ 6.00 to $16.00
Western Virginia	1790 to 1800	12.00 to 5.00[1]
Little Sandy, Ky.	1799	2.00 to 3.00
Pittsburgh, Pa.	Prior to 1800	8.00 to 10.00
Salt Lick Landing, Ky.	1807	2.00 to 3.00
Scioto Springs, O.	1808	3.00 to 4.00

[1]Improved roads caused this reduction.

Kanawha salt began reaching the Pittsburgh market about 1812. It is noteworthy that in 1810, Pittsburgh exported provisions to a value of $40,000 and purchased salt of equal value. (9)

From that time on, the annual production of salt increased quite rapidly, as is shown by the following table [from Reference (9) in Bibliography]:

Table 2.—Annual Production of Salt, 1810 to 1860, in Bushels of 50 lbs.

	1810	1829	1840	1850	1860
Kanawha Co., Virginia	740,000	925,000	1,600,000	3,024,890[1]	2,076,513[2]
Western Pennsylvania	Not Reported	750,000	546,868	606,670	1,011,800
Ohio	24,000	426,350	297,350	550,350	1,743,200
Kentucky	324,870	137,320	219,695	246,500	169,665
Indiana	Not	Reported	6,400	Not	Reported
Illinois	150,000	138,000	20,000	20,000	35,000
Missouri	Not	Reported	13,150	Not	Reported

[1]The total for Virginia was 3,479,890 bushels.
[2]This is total Virginia production.

Having summarized, in the foregoing pages, the reasons that led to the development of the brine salt industry, it is fitting that we now present its history in the State where it first began — West Virginia.

THE INDUSTRY IN KANAWHA COUNTY.

The Story of Brine Discovery by Mrs. Mary Ingles.—In a very romantic fashion, the story of the brine salt industry traces back to the capture of a white woman by a tribe of Shawnee Indians in 1775. This lady was Mrs. Mary Draper Ingles, who had wed Wm. Ingles in 1750 — the first white wedding to occur west of the Alleghenies (5) — and she was about 23 years old when taken captive.

The Shawnees took their prisoners from Draper's Meadows, Va., down the New River to the Bluestone, up that stream a short distance, thence across Flat Top Mountain to the head of Paint Creek and down it to the Kanawha River. This was forded near Cabin Creek and the journey ended temporarily at a salt spring on Campbell Creek.

The story of the rest of the journey to Big Bone Lick, Ky., and Mrs. Engles escape (after being captive for some time) and return to her people is a thrilling chapter in our pioneer history. The reader is referred to an account of it published by her great grandson, Dr. John P. Hale, in his "Trans-Allegheny Pioneers". (4 and 31) For our purpose, however, suffice to say that Mrs. Ingles assisted the Indians in making salt from brine. She, the first white person to see the Kanawha River and to make salt west of the Alleghenies, reported upon the possibilities of salt making when she returned to her family over five months later.

Another authority (3), while not contradicting this story, states that "the discovery of salt water in this region was led to by a large buffalo lick on the northeast side of the river (Kanawha) five miles above Charleston. In this lick was sunk the first salt well in 1809". "Remnants of old pottery show that Indians used this lick for (salt) manufacture."

In 1775, one John Dickinson located five hundred and two acres to include the mouth of Campbell Creek, the bottom above it, and the salt spring. This he sold in 1794 to Joseph Ruffner from the Shenandoah Valley "sight unseen" for the sum of £500 and other sums to be paid according to the amount of salt Ruffner might make. These sums could readily increase the purchase price to £10,000, therefore, he never made any salt from the spring!

Ruffner moved to the Kanawha in 1795 and purchased 900 acres of river bottom from Geo. and Wm. Clendennen, which he farmed. On forty acres of this was a town site that had been laid out and started the year before — the present city of Charleston.

The First Salt Furnace—Elisha Brooks.—Although he had manufactured no salt for sale, Ruffner leased the salt spring and manufacturing rights to one Elisha Brooks, who built a furnace in 1797. Taking his cue from the pioneers, Brooks constructed a sort of long stone oven, with a chimney at one end and set in its top a double row of iron kettles, twenty-four in all. (See Plate XIX). In these he boiled down his brine to salt, which the iron colored a reddish tint; the salt had a very pungent taste which was soon associated with the color, so that all the salt made in the region for some time was known as "that strong red salt of the Kanawha Licks." It also gained a reputation for curing meat well, which is true to the present day.

To obtain his brine, Brooks prepared some "gums" (hollowed logs, like pipe) each eight to ten feet long and sank them, one on top the other, through the mire and quicksand of the spring. He then made a sweep that carried a bucket, by means of which he bailed out the salt water from the bottom.

The capacity of Brooks furnace was 150 pounds of salt per day and he sold it for eight to ten cents a pound at the furnace.

The First Drilled Brine Wells—David and Joseph Ruffner.—Ruffner died in 1803 and on his death bed urged his boys David and Joseph (to whom he willed his property) to build large furnaces for salt making, because of the "demand from the west," so in 1806 these men proceeded to carry out their father's wish. Apparently Brooks lease had expired, for they made a huge "gum" of four feet inside diameter and sank it in their "lick." At thirteen feet down it reached rock, which yielded a fresher water when broken, so they repeated their trial inland from the river 100 yards and had the same trouble.

Finally they tried again at the "lick" and succeeded in getting more brine at a depth of thirty-four feet and a better flow of stronger brine at a depth of fifty-eight feet. They then made a wooden tube which they lowered to the brine, and "packed off" the space between it and the gum with sacks.

Meanwhile, they had started work on their furnace, which was like Brooks' in design, but of larger size. The kettles, also, were larger and arranged better. On Feb. 8, 1808 they "lifted" their first salt and sold it for 4 cents per pound. (See Plate II).

These operations inaugurated a boom in salt manufacture along the Kanawha; by 1817 there were fifteen to twenty brine wells and thirty furnaces in operation, producing six to seven hundred thousand bushels of salt per year. (14)

One of these, on the north side of Kanawha on the Elk River was called Kanawha Big Chimney. The present town of Big Chimney derives its name from this furnace.

In the furnaces up to this year, wood was used for fuel, but the demand had been so great that the supply had receded far back from the river.

The Discovery of Coal.—Coal, however, was discovered in 1817, and the industry was not only saved, but given a real impetus thereby. Howe says: (3)

> "The contiguous forests having been almost stripped to supply fuel to the salt furnaces, the precious mineral (salt) — must have remained forever useless but for the discovery of — coal, so convenient of access as to make the cost of procuring it scarcely worth considering."

David Ruffner was the first to use coal, and wood soon passed out of the picture as a fuel. Crawford states (2-Nov.) that the furnaces had no grates at first; coal was merely shoveled into the furnace at the end opposite the chimney, and ashes were removed at the same place. This was a very wasteful use of the coal, so David and Tobias Ruffner experimented for some months, and finally hit upon the use of grates and their proper arrangement. "Henry Ruffner (later the president of Washington College, which became Washington and Lee University) experimented with the fires and found that a small jet of steam turned under the grate bars formed small gravel like clinkers that were easily handled." (2-Nov.)[1]

One of the most inspiring aspects of the growth of the industry is this: none of these men had any mechanical training, few of them had much schooling, and there were no power-driven tools at that time, yet they met each new problem as it arrived with what now appears to have been pure grit — and solved it. If tools were lacking, they devised and made them and many are still in use with little, if any change of pattern. In other words, these men exhibited a wonderful use of their brains to meet conditions as they arose, and found within themselves the resources the times demanded.

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[1]This plan is used at Hartford plant of liverpool Salt Co. to-day.

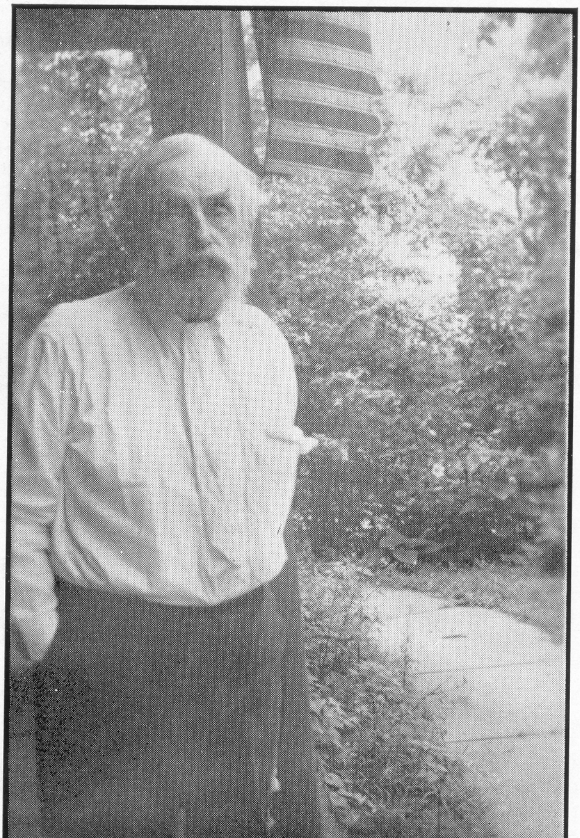

PLATE II.—Mr. Ernest Ruffner, of Cincinnati, O.—This gentleman is the great grandson of the David Ruffner who drilled the first brine well in the Kanawha Valley.—Photo by E. T. Crawford, Jr.

Early Drilling Tools vs. Modern Drilling Tools.—Further examples of their resourcefulness that are still in use are: (See Plates III, IV and V) (a) well tubing with screw joints, (b) well packer, (c) jars, or "slips," (d) the stem, or "sinker" and (e) the multiple effect evaporator, described later in this chapter, and it may be well to note at this point that the science of drilling deep wells with what are now called "cable tools" was originated and developed along the Kanawha to such an advanced point that when Drake desired to drill a well for oil at Titusville, Pa., he employed men from the Kanawha already skilled in this trade. Hence the salt industry really fathered the giant oil industry of to-day.

To resume this narrative, however, the first well tubing, as already noted, was a log bored out lengthwise. Following this, a Charleston tinner made a tubing from tin and the joints were soldered end to end as it was put into the well. Then came copper pipe with screw joints, and finally steel pipe with screw joints. The literature does not yield, so far as known, the exact dates in which these changes occurred.

In order to prevent surface and fresh water (from upper strata) mixing with the brine, these pioneers made a packing by either wrapping the lower end of their tubing with burlap sacks, or surrounding it as far down as possible with sacks filled with flaxseed, which eventually swelled to make a very tight seal. From this has been evolved the steel and rubber type of packer employed in the oil and gas wells of to-day.

Wm. ("Billy") Morris, a blacksmith, who became a well driller, invented the jars in 1831; he made them of steel and they were thirty inches long (14), but Dr. Hale does not state who invented the stem; perhaps it was a natural evolution from the weight that was swung from the spring-pole. (See Plate V).

A "horse mill", on the order of the sorghum mill of more recent times, replaced the sweep used for pumping, and in 1827, the horse was replaced by steam. In 1828, all "horse mills" had passed out of the picture. (14)

The advent of the steam engine, coupled with the invention of the jars and stem, made deeper drilling possible, and many such wells were sunk to depths as great as two thousand feet, however, no brine was found lower than one thousand feet. (14)

With coal for fuel and new and larger supplies of brine, the salt industry underwent a real boom. Howe (3) says, "Terra Salis, or Kanawha Salines,[2] is a flourishing town about six miles above Charleston," and "The Kanawha salt works commence on the river near Charleston and extend on both sides of the river for about fifteen miles, giving employment, directly or indirectly, to about three thousand persons."

Up to 1833, the original plan of the Brooks furnace was used by everyone; the only change made was to employ larger kettles. This was naturally a batch operation, made semi-continuous by "lifting" the salt from the kettles of one furnace while the kettles of a second were boiling and those of a third were being filled with brine. The salt was colored by the iron, as mentioned elsewhere, and was drained on perforated boards for twenty-four hours. The largest kettle furnace was built in 1830 by Joseph Friend & Son and it had a capacity of 100,000 bushels per year. (2 and 14) In 1835 there were forty kettle furnaces with a total annual capacity of two million bushels.

Introduction of the Patrick Evaporator.—In 1833, George H. Patrick of Onondaga, N. Y., revolutionized the entire industry by his multiple effect evaporator. Briefly, his design consisted of (a) a large tank to which brine was pumped from the wells and from which it flowed to the evaporating system; (See Plate XIII) (b) a stone or brick furnace, (c) a large cast iron pan. This was flat, eight feet wide, thirty feet long, and six inches deep and built of sections three feet long bolted together and placed above the furnace, (d) a wooden steam chest, three feet high, built over the pan and bolted to it, (e) an open wooden vat, one hundred thirty-five feet long, sixteen feet wide, and three feet deep, (See Plates VI and XIV) (f) a square pipe (16″ x 16″) laid on the bottom of the vat. This was for steam heating.

This plant operated thus: brine from the wells was

[2]Hildreth (1) says Malden was called Kanawha Salines until 1855.

pumped to the reservoir (a) and from thence flowed in the desired quantity to the pan (c) where it was boiled. This was the first effect, and the brine was concentrated almost to the saturation point. It then flowed to settling vats, where muddy material and the iron salts settled out; thence by gravity to the vat, (e).

The steam from the chest (d) was conducted to the square pipe (f), which had a sheet lead top, and thus supplied heat to the brine in the vat for further evaporation. This was the second effect (2) (See Plate VI).

Salt makers called the vat (e) the "grainer" because the salt crystallized, or "grained" therein. From it the salt was lifted by long shovels onto a drain board, allowed to drain, and then was removed to suitable storage. (See Plates VII and VIII).

From a batch process on a small scale the flow was now more or less continuous and the quality of salt greatly improved, for it was now freed of all sediment and iron, hence pure white in color. The fuel consumption was lowered, less labor was required, and more salt could be produced; a "Kanawha Banner" of 1833 (2) states "with these simple fixtures, the proprietors are now making not less than two hundred bushels of salt per day," and "the salt produced is, both in appearance and quality, the equal to any in the world. With the means of production almost unlimited, the salt from this region would have supplied nearly the whole territory on the Mississippi and its tributaries. . . . .".

The Patrick system of evaporation was now universally adopted, and improved in many ways from time to time. The two principal changes were (a) replacing the large square steam pipe in the "grainer" with parallel 5″ copper pipes (See Plate VI) set a few inches off the bottom so that salt would not crust them over and lower their efficiency and (b) liquid seals at the ends of these pipes to maintain the steam pressure and prevent waste of heat — as steam — to the atmosphere. Since 1834 the Patrick system has been in continuous use, and many of the vats at present day plants have served all that long period of time, for the salt in them permeated the wood and preserved it against decay. (See Plates VI and XIV).

In 1851, salt from these new furnaces was exhibited in London's first World's Fair and also at the Paris Universal Exposition in 1868, winning awards and prizes in both places. (2)

The yields of salt brines varied with the locality, and the Kanawha region had the richest brines prior to the discovery of salt water in the Ohio Valley in Mason County. The yield of salt at several furnaces is stated by Lippincott (9) as follows:

1788—Blue Licks, Ky.	1000 gals. per bu.
1835—Along Kanawha Valley	75 gals. per bu.
At Muskingum, O.	50 gals. per bu.
At Zanesville, O.	95 gals. per bu.
At Shawneetown, Ill.	120 to 180 gals. per bu.
At Boone's Lick, Mo.	450 gals. per bu.

Kanawha had the advantage until 1854-1855 over all the other regions for another reason, cheap coal right at the furnace.

With the permission of the author and the copyright owner, the following graph very fully illustrates the production of salt for the period 1800-1890.

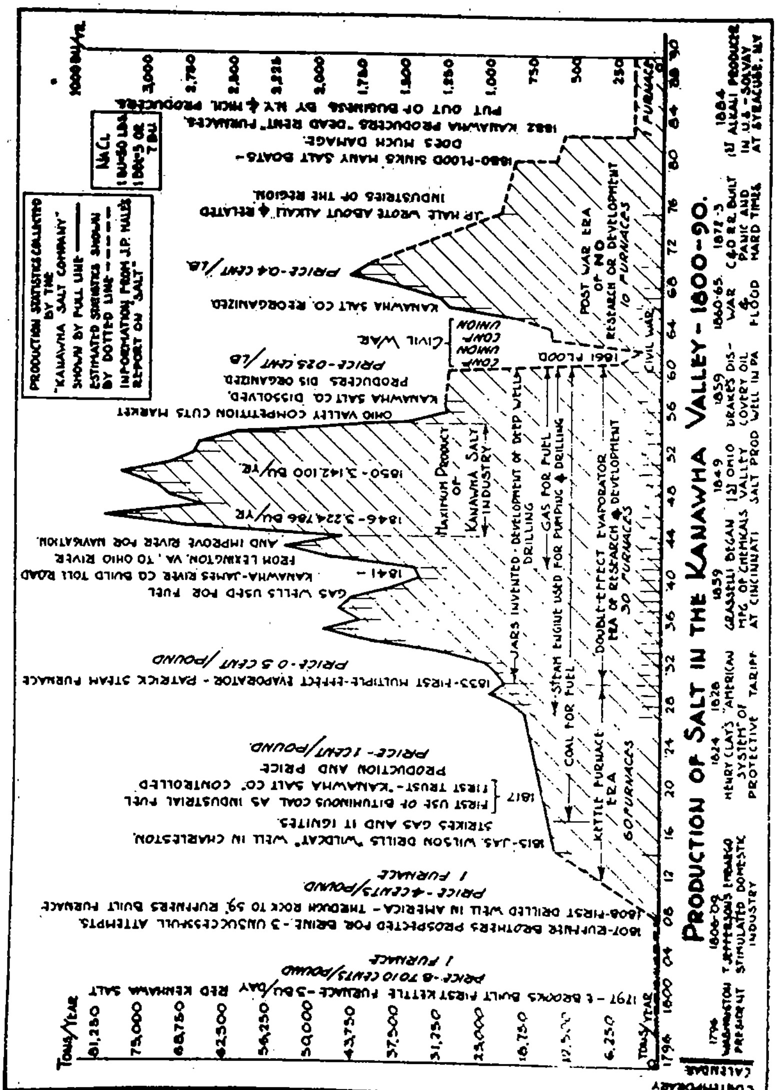

Figure 1.—Production of Salt in Kanawha Valley, 1800-90.

(By Courtesy of Industrial and Engineering Chemistry; designed by E. T. Crawford, Jr.).

Increase in Salt Production Due to Patrick System.—As just stated, the Patrick process caused a big increase in salt production. Hale says (14) that where a kettle furnace made from two to four thousand bushels per month, the new furnace would produce up to forty thousand. He also states that a Mr. Lerner was making bromine from the bitterns both along the (See Plate IX) Kanawha and in Mason County, and that a Belgian chemist, Mr. Bemmelmans, was erecting a plant to make hydrochloric acid from the bitterns and pigments from the iron dropped from the brines in the settling vats — but he gives no data as to when this started; presumably in the year 1876, for that is when he wrote his account.

He states that in 1876 the new furnace cost from $40,000 to $100,000, and a well 1000 feet deep cost from $1200 to $1500 to drill after the equipment was ready. Other costs of manufacture in that year were as follows:

Coal—2¾c to 4c per bushel at the furnace.
Small barrels—to hold 280 lbs. net—25c to 28c each.
Large barrels—to hold 350 lbs. net—28c to 32c each.
(These were preferred by meat packers).
Common labor—$1.00 to $1.25 per day.
Miners—2c per bushel of coal dug.

Based on these figures, he estimated that salt in bulk cost 8c to 11c per bushel to produce and salt in barrels ready for shipment cost 13c to 16c per bushel, or $5.20 to $6.40 a ton. Salt made by the kettle furnace cost — exclusive of the value of the coal and brine used — 29c per 100 lbs. (2)

Mr. Hale owned the largest furnace of the new type, the Snow Hill, and was therefore in the best possible position to know whereof he wrote. His furnace had 1300 sq. ft. of furnace-pan surface (first effect) and 20,000 sq. ft. of atmospheric-pan surface (second effect), and consumed forty tons of coal to make about 1400 bushels or 70,000 pounds of salt per day. (2)

In 1876 there were 120 salt wells and ten furnaces along the Kanawha. He lists them as follows:

Table 3.—List of Kanawha Salt Furnaces.

	Name.	Owner.	Capacity. Bu. per year.	Remarks.
1.	Daniel Boone	W. B. Brooks	300,000	-----------
2.	Crittenden	W. D. Shrewsbury	280,000	Not in repair
3.	Snow Hill	J. P. Hale	420,000	-----------
4.	Washington	J. D. Lewis	230,000	Not in repair
5.	Pioneer	Gen. L. Ruffner	180,000	-----------
6.	Quincy	J. Q. Dickinson	210,000	-----------
7.	Burning Spring	Mrs. R. Tompkins	160,000	-----------
8.	Malden	Mrs. S. Dickinson	240,000	-----------
9.	Lorena	Splint Coal Co.	240,000	-----------
10.	Kenton	Splint Coal Co.	240,000	-----------
			2,500,000	

He also presents a table of the annual salt production from 1797 to 1875 as follows:

Table 4.—Table Showing the Production of Salt in Kanawha.

Date.	Bushels.	Date.	Bushels.
1797	150 lbs. per day	1850	3,142,100 bu. per year
1808	25 bu. per day	1851	2,862,676 bu. per year
1814	600,000 bu. per year	1852	2,741,570 bu. per year
1827	787,000 bu. per year	1853	2,729,910 bu. per year
1828	863,542 bu. per year	1854	2,233,863 bu. per year
1829	989,758 bu. per year	1855	1,493,548 bu. per year
1830	906,132 bu. per year	1856	1,264,049 bu. per year
1831	956,814 bu. per year	1857	1,266,749 bu. per year
1832	1,029,207 bu. per year	1858	No Records
1833	1,288,873 bu. per year	1859	
1834	1,702,956 bu. per year	1860	
1835	1,960,583 bu. per year	1861	
1836	1,762,410 bu. per year	1862	
1837	1,880,415 bu. per year	1863	
1838	1,811,076 bu. per year	1864	1,300,991 bu. per year
1839	1,593,217 bu. per year	1865	861,973 bu. per year
1840	1,419,205 bu. per year	1866	1,275,017 bu. per year
1841	1,443,645 bu. per year	1867	1,321,066 bu. per year
1842	1,919,389 bu. per year	1868	1,528,282 bu. per year
1843	2,197,887 bu. per year	1869	1,822,430 bu. per year
1844	1,874,919 bu. per year	1870	1,721,963 bu. per year
1845	2,578,499 bu. per year	1871	No Records
1846	3,224,786 bu. per year	1872	
1847	2,690,087 bu. per year	1873	
1848	2,876,010 bu. per year	1874	
1849	2,951,492 bu. per year	1875	967,465 bu. per year

The First "Trust" in America.—Having presented, briefly, a history of the rise, growth and development of the salt industry along mechanical lines, it is well that we consider the economic history in order to round out the picture. At first, those desiring salt came to the furnaces and got it; there were no problems of packaging nor transportation, and the price was therefore low.

As the industry grew, however, it not only had to seek its market and package its product for shipment, but meet an increasingly stiff competition (a) among the American makers and (b) from foreign lands. The price of salt fell from 10c a lb. to 4c and then to less than 1c, and many makers were almost bankrupted. Therefore, on November 18, 1817, (33) a large number of them met at Kanawha Salines and formed the first "trust" in America. Its purpose was to control both the production of salt and the selling price; on January 1, 1818, it began to operate.

The Kanawha Salt Company was formed as a sales agency, a definite price was set on salt and the annual production was pro-rated among the members. The trust elected a board of directors and every furnace was placed under its control.

"The importance of the trust and sales organization can be appreciated only after considering the transportation facilities and markets available to the salt manufacturers of that day. The Chesapeake and Ohio Railroad was not built until 1872. The improvement of the Kanawha River with ten locks and dams for slack water navigation was not begun until 1878 by United States engineers. The Kanawha-James River Turnpike, a partially improved toll road, was used by wagons and stagecoaches from Lexington, Va., to Guyandotte on the Ohio River. The Kanawha River, a stream of many variations, was the chief means of transportation. The salt was packed in barrels — 7-bushel hogsheads made at the salt furnaces from white oak wood — and loaded into flat boats constructed in the vicinity. It was floated down with the stream, aided by pole and oar. and then down the Ohio River to supply the settlers of Ohio, Indiana, Kentucky, and Illinois with salt for their 'hog and hominy.' The advent of the steamboat in 1824 increased the market area as it carried the settlers to the West via the Ohio, Mississippi, and Missouri Rivers. The shipments of salt were still dependent upon the stage of the Kanawha River, however. A rise in the headwaters would carry many loaded boats downstream. Some means of regulation of the price was necessary to prevent the flood tide from 'breaking the market.' The maintenance of a western sales organization was also necessary because every salt maker could not leave his plant and go with his product

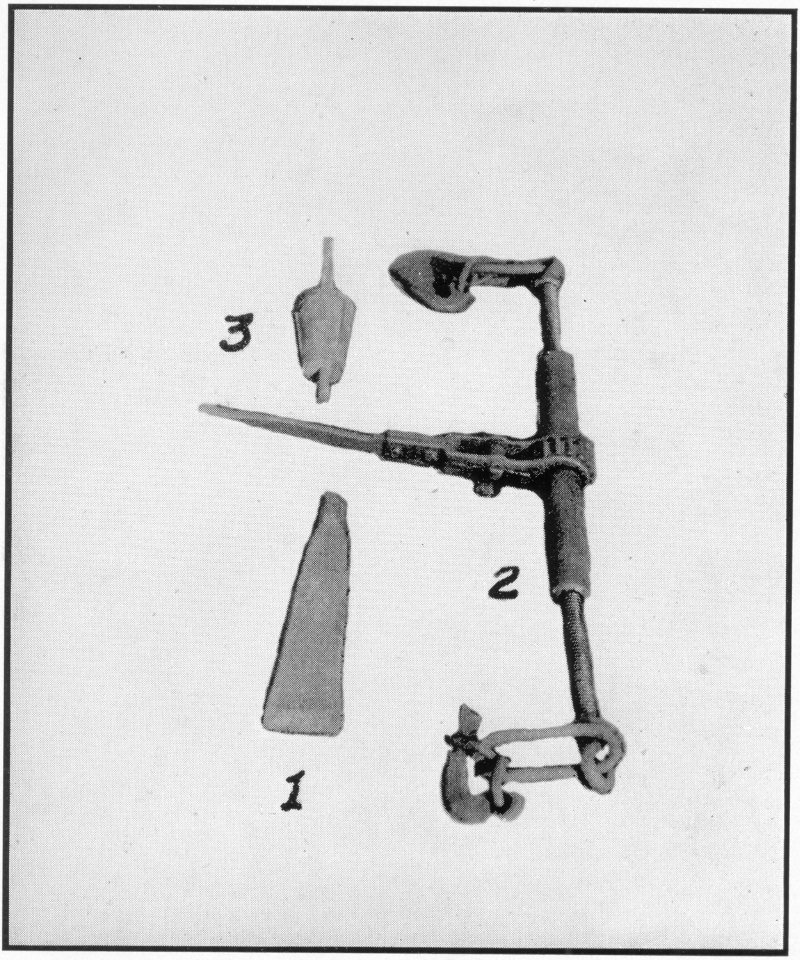

PLATE III.—Early Drilling Tools.—No. 1 is the drill, or bit; No. 2 is a device used to "feed" it, the forerunner of the modern temper screw. No. 3 is a reamer. All these tools were designed by pioneer well drillers.—Photo by E. T. Crawford, Jr.

to look for a purchaser. The Kanawha Salt Company acted as sales agent for the manufacturers in a more or less satisfactory manner.

"The production of salt increased after the Patrick two-stage evaporator displaced the kettle furnace. The maximum production occurred during the years 1845 to 1852, when the average was 145,170,000 pounds per year. The development of salt manufacturing along the Ohio River below Parkersburg materially reduced the market for Kanawha salt after 1852. The Ohio River brine proved to be stronger, and the means of transportation was more dependable.

"The Kanawha Salt Company weakened its financial position by 'dead renting' the furnaces of some of its members to remove their production from the market. A 'dead rent' was a sum paid to the furnace owner not to make salt. It was obtained by assessing the members of the organization who were operating furnaces. A furnace rental of $1500 per year was paid to owners during better times when the Kanawha Salt Company controlled the western market.

"The production was also controlled by operating 6 days per week in accordance with a mutual agreement of the members, as this extract from a salt maker's diary attests: 'Sunday, February 28, 1847. According to an agreement among the Salt Makers that the furnaces should not be worked on the Sabbath, and this was the first Sabbath after the contract, the furnaces were idle, being the first time for many years.'

"From time to time, poor management, the carrying of inefficient plants, and 'chiselers' broke up the trust organization or forced reorganization of the Kanawha Salt Company. In the space of sixty years, this cooperative enterprise was reorganized nine times. The trust finally aided in killing the salt industry of the district by dead renting all member furnaces to a group of New York 'capitalists' at an unusually favorable rental. The rent was paid in advance for six months. At the end of that time, the retired salt makers awaited their next payment, only to find that unwittingly they had been part of a plan to increase their competitor's market. They returned to making salt for a living, only to find their uncared-for plants in bad condition. The furnace pans were corroded and the dry wooden tanks leaky; many never started production again. The hard times of 1876 to 1883 shut down all the other furnaces except one that never joined the last cooperative trade organization." (2-Nov.)

The Duty on Salt Imports and Its Uses.—Another source of stiff competition came from the shipping interests; vessels that transported American merchandise abroad found salt a very convenient and profitable return cargo because it was in demand for fish-curing along the coast. This led to one of the first duties on imports — the Federal Government declared a tariff on salt and paid part of it to the fishermen of New England to subsidize fish-curing.

In 1824, the advent of the steam boat not only increased the market for salt (as noted above) but also provided a ready means for carrying foreign salt into the very heart of the natural market of the Kanawha and Ohio Valley salt men, and to make matters still worse, the merchant marine tried very hard to get the salt duty removed in 1827.

The Kanawha Salt Company so vigorously opposed the removal of this duty that it remained until 1872, when New York and Michigan salt entered the market. The low cost of production in those States made further protection unnecessary (2-Dec.) In connection with their protest, the Kanawha salt makers furnished a very interesting table which is presented below.

Table 5.—Abstract showing the present state and condition of the Salt Business, in the County of Kanawha and Commo-wealth of Virginia. (Congressional Record, 1828).

PROPRIETORS' NAMES.	Number of furnaces	Capital in lands, wells, coal beds, furnaces, machinery, &c. &c. &c.	No. of laborers employed in salt making, coal digging, &c. &c.	No. of bushels annually manufactured, of 50 lbs. each	Cost, per bushel, for manufacturing, barrels and packing	Average price, per bushel, at the manufactories	Quantity of water required to produce 50 pounds of salt	Quantity of coal annually consumed	Quantity of wrought iron used annually	Quantity of cast iron used annually	Amount of agricultural products annually consumed	Annual amount of mechanics bills	Remarks
		Dollars			Cents	Cents	Gallons	Bushels	Pounds	Tons	Dollars	Dollars	
Dickinson & Shrewsbury	2	25,000	30	30,000	25	33	100	75,000	2,000	5	1,500	200	
David Ruffner & Co.	3	50,000	28	50,000	17	23	70	100,000	2,500	7	2,200	400	
Andrew Donnally	3	30,000	28	60,000	20	25	70	125,000	4,000	8	3,300	500	
A. Donnally & Wm. Steele & Co.	4	40,000	27	50,000	18	25	75	100,000	3,000	6	3,500	400	
Donnally & Steele, & P. Alexander	2	20,000	16	20,000	18	25	80	50,000	1,500	2	1,500	200	
A. Donnally & L. Morris	2	20,000	18	20,000	20	25	75	90,000	2,000	3	1,500	250	
A. Donnally & L. Welch	2	10,000	16	20,000	20	25	70	50,000	2,000	2	1,500	200	
A. Donnally & Chas. Brown	1	6,000	8	10,000	18	25	65	40,000	1,000	1	1,000	150	
Andrew Parks	2	25,000	..	.....	..	..	80	......	....	..	....	...	Idl
C. G. & C. Reynolds	2	6,000	15	20,000	20	22	65	45,000	2,000	4	1,200	300	
Farnham Marsh	1	3,000	8	10,000	18	25	70	20,000	1,000	2½	1,000	200	
Van B. Reynolds	1	3,000	8	15,000	20	23	70	25,000	1,000	2½	1,000	150	
James C. McFarland	1	10,000	8	15,000	20	23	70	25,000	1,000	2½	1,000	150	
William R. Cox	1	4,000	8	20,000	18	22½	70	40,000	1,000	2½	1,000	150	
Peter Grant	1	5,000	8	20,000	18	22½	75	45,000	1,000	2½	1,000	200	
Walter Trimble	1	6,000	7	20,000	18	22½	80	35,000	1,000	2	1,000	200	
John Warth	2	11,000	14	20,000	18	25	90	30,000	2,000	3	1,500	350	
John J. Cabell	2	10,000	8	20,000	18	25	70	30,000	1,000	2½	1,000	150	
William Tompkins	2	15,000	20	30,000	20	25	80	45,000	4,000	10	2,500	300	
Aaron Stockton	2	10,000	20	30,000	20	33	80	45,000	4,000	10	2,500	300	
J. D. Shrewsbury, Jr.	1	5,000	8	8,000	25	33	100	30.000	1,000	2½	1,000	150	
Jno. & Saml. Shrewsbury	2	35,000	16	35,000	25	33	80	75,000	2,000	6	1,500	300	
Moses M. Fuqua	1	3,000	8	20,000	18	22½	80	40,000	1,000	2	1,000	200	

Table 5.—Abstract showing the present state and condition of the Salt Business, in the County of Kanawha and Commonwealth of Virginia, (Congressional Record, 1828), (Concluded).

PROPRIETORS' NAMES.	Number of furnaces	Capital in lands, wells, coal beds, furnaces, machinery, &c. &c. &c.	No. of laborers employed in salt making, coal digging, &c. &c.	No. of bushels annually manufactured, of 50 lbs. each	Cost, per bushel, for manufacturing, barrels and packing	Average price, per bushel, at the manufactories	Quantity of water required to produce 50 pounds of salt	Quantity of coal annually consumed	Quantity of wrought iron used annually	Quantity of cast iron used annually	Amount of agricultural products annually consumed	Annual amount of mechanics bills	Remarks
		Dollars			Cents	Cents	Gallons	Bushels	Pounds	Tons	Dollars	Dollars	
Tobias Ruffner	2	12,000	..	.....	..	..	80	......	....	..	....	...	Idle
L. & C. Morris	5	20,000	..	.....	..	..	80	......	....	..	....	...	Idle
L. & J. Leftwich	1	4,000	7	15,000	18	25	80	30,000	1,000	3	1,200	200	
John Anderson	2	8,000	16	30,000	20	22½	90	60,000	1,500	3	1,500	400	
James Bream	4	40,000	35	50,000	20	25	90	120,000	3,000	6	3,000	400	
Joseph Lovell	2	7,000	16	20,000	20	22½	100	60,000	1,500	3	1,500	300	
Daniel Ruffner	2	15,000	16	20,000	19	22½	100	60,000	1,500	3	1,500	300	
Isaac & Bradford Noyes	3	35,000	20	50,000	19	25	100	100,000	2,000	5	1,500	400	
Charles Venable	1	30,000	8	16,000	20	30	100	40,000	1,000	3	1,300	300	
Nelson Priddy	1	5,000	8	20,000	18	22½	80	40,000	1,000	2	1,000	150	
Lewis Summers	1	20,000	8	16,000	18	33	80	30,000	1,000	2	1,000	150	
Total	65	548,000	471	787,000	Average 19½	Average 25¼	Average 80⅛	1,695,000	54,500 24⅓ ton	118½	47,600	7,950	

We do hereby certify that the foregoing Abstract has been carefully compiled, and with as much accuracy as the nature of the subject admits of. Given under our hands this 4th of January, 1828.

JOSEPH LOVELL.
LEWIS RUFFNER.

NOTE.—Furnaces in operation 56
Do. idle 9

As above 65

In the period 1845 to 1852, the Kanawha industry reached its peak. Meanwhile, about 1849, salt works sprang up like mushrooms in Ohio, near Pomeroy until there were fifteen in that vicinity. The brine there was stronger (Author's note—it still is; in 1934 Pomeroy brine had a gravity of 11° Bé. and West Virginia brine had a gravity of approximately 10° Bé.) and shipping facilities were better therefore this region soon cut deeply into the trade from the Kanawha and in 1868 it produced 3,607,968 bushels of salt as compared with the 1,528,282 bushels reported by Hale (see Table 4, above).

Following the rise of the Pomeroy trade, the Civil War and the Ohio River flood of 1861 — the highest up to that date — capped the climax of trouble for the salt men along the Kanawha, and production steadily fell. We have no records of those distressing years, but the war was lost to the South largely because it lacked salt for meat-curing, dye-setting, egg-packing and other human and domestic needs.

Following the war, conditions were much changed. A new State had been carved from the Old Dominion; salt plants, long idle, were in very bad shape; markets, once controlled, had been lost to new competitors — in fact, the industry had to almost start again "from scratch." That it regained an annual production of 1,822,430 bushels by 1879 is a credit to the grit and industry of the pioneer makers, but since that year the production from New York, Michigan, Ohio and Louisiana has steadily invaded the field, and to-day but one plant on the Kanawha and two on the Ohio survive in West Virginia. These are described elsewhere in this report.

The Prophecy of Dr. John P. Hale.—The future of the Kanawha brines was foreseen, however, by Dr. John P. Hale. He envisioned the use of brine salt as the raw material for many chemical products, and in 1876 wrote: (14) "The most important and prospectively promising development in the manufacture of salt here is its probable use on a **large scale** (author's blackface type) in the manufacture of alkalies and other chemicals having salt as a basis or important constituent." He also quotes some very interesting statistics to bolster his prophecy: "With a population of forty million persons, and covering the greater part of a continent, it is an astonishing fact that our last census does not report a single Soda Ash works in operation in the United States, while the official returns show the importation of these chemicals into our country to be enormously large. In 1872, the importation of soda ash, caustic soda, etc., was over 100,000 tons; 1873, 118,000 tons; 1874, 140,000 tons."

The Three "Ages" Along the Kanawha.—Although Hale lived until 1902, he did not see his prophecy fulfilled; nevertheless it came true. Crawford states that there were three ages in this development — (a) the gas and glass age, from 1900 to 1914; (b) the war age, 1914 to 1920; and (c) the synthetic age, 1920 to date. (2-Dec.)

The First Gas Well.—The first gas well known seems to have been drilled by Capt. James Wilson in 1815, within what are now the city limits of Charleston, West Virginia. Howe (3) writes thus about the gas wells of Kanawha in 1845 — "They are, in fact, a new thing under the sun, for in all history of the world it does not appear that a fountain of strong brine was ever before known to be mingled with a fountain of inflammable gas sufficient to pump it out in a constant stream and then, by its combustion, evaporate the whole into salt of the best quality." Both Howe (3) and Hale (14) say that Mr. Wm. Tompkins got gas in 1841 while drilling for salt water a short distance above Burning Spring, which was, in turn, three miles above the mouth of Campbell Creek, and that he fired his salt furnace with it.

In 1843, Dickinson and Shrewsbury also struck a big gas flow at a depth of 1000 feet just a few yards beyond Tompkins well, and the pressure blew their tools and casing out of the well. After much effort they successfully controlled the flow and made the gas pressure force the brine through more than a mile of pipe to the reservoir at the furnace, where the gas was separated from the brine and used in the salt furnace and for lighting the premises (14). Even to-day practically the same thing holds true at the Liverpool Salt Company plant at Hartford City. Petroleum oil was frequently found in more or less quantity with brine, but it was considered a detriment in salt manufacture. However, Drake and others soon proved its real worth and much drilling was now done for oil, itself, and gas was soon a drug on the market. This fact attracted industries that required large amounts of cheap fuel, such as carbon black and glass plants, to this vicinity and it is noteworthy that the Charleston district is still a leader in the production of gas and of glass, and the home of the largest plant that makes glass in continuous flat sheets.

The Fulfillment of Hale's Prophecy.—About the beginning of the Great War, in 1913, a group of English business men built the Rollins Chemical Company at South Charleston for the manufacture of barium peroxide; this plant has expanded into the Barium Reduction Corporation, a large user of electric current and manufacturer of many barium compounds.

In 1914, Roessler and Hasslacher Chemical Company began to chlorinate natural gas to make chloroform and methyl chloride, and this initiated the "synthetic age" in the Kanawha Valley. Other chemical companies soon followed, including the Warner-Klipstein Chemical, the Charleston Chemical and the Rollins Chemical all of whom began using brine as a raw material in the manufacture of caustic soda and chlorine. Many manufacturers of war materials and a United States Naval Ordnance plant located in this area prior to the signing of the Armistice and did a great deal to help win the World War.

Since 1920, the Westvaco Chlorine Products Company, formerly the Warner-Klipstein Chemical Company, (established 1914), the Carbide & Carbon Chemicals Corporation (established 1925), the Belle Alkali Company (established 1921) and the du Pont Company (established 1926) have built large chemical plants in the vicinity of Charleston, West Virginia. These are described elsewhere in this report. The Carbide & Chemicals Corporation was at first a development plant built at Clendenin (during 1918-1920) to experiment with natural gas and chemicals derived from it, which was moved to the present location in South Charleston five years later. It manufactures more than sixty organic chemicals and is also a large consumer of products made from brine.

Westvaco Chlorine and Belle Alkali are also large consumers of brine and brine products as raw materials, while the du Pont Company not only manufactures large quantities of synthetic ammonia and methanol, but over a hundred other chemical products. Brine is not one of their raw materials, however.

Thus has the brine industry grown from the Indian salt kettle, which Mrs. Mary Ingles reported, to one of the largest chemical manufacturing centers in the world, one that is today growing steadily larger and larger, and demands from its creators the same stamina, intelligence and foresight that characterized the pioneer brine well driller and salt maker.

The history of the salt industry in other counties of West Virginia follows.

THE SALT INDUSTRY IN OTHER PARTS OF WEST VIRGINIA.

MASON COUNTY.

Encouraged by the success of the salt industry on the Kanawha and believing that drilling would yield salt water along the Ohio River, where transportation facilities were much better, Messrs. Williams, Stevens, and Capt. Tom Friend, all Kanawha salt makers, initiated a salt works at West Columbia, Mason County, in 1847. (14 and 22)

They encountered brine at a depth of 700 feet and built a furnace, but soon sold it to New York parties, who remodeled it to yield 1200 bushels of salt per day, using Patrick's plan.

In 1854, a company formed in Hartford, Conn., secured a property several miles east of the first salt works, drilled a well and built a second furnace. This was managed for a time by Mr. W. O. Healy, later by Mr. G. W. Moredock. A fine seam of coal 4.5 to 5 feet thick was also found on the property which the late Dr. I. C. White identified as the Pittsburgh bed. (22) A little later, two more furnaces, also conforming to Patrick's plan, were added, and a town was laid out. This was named Hartford City in honor of their home. (See Plate XVIII).

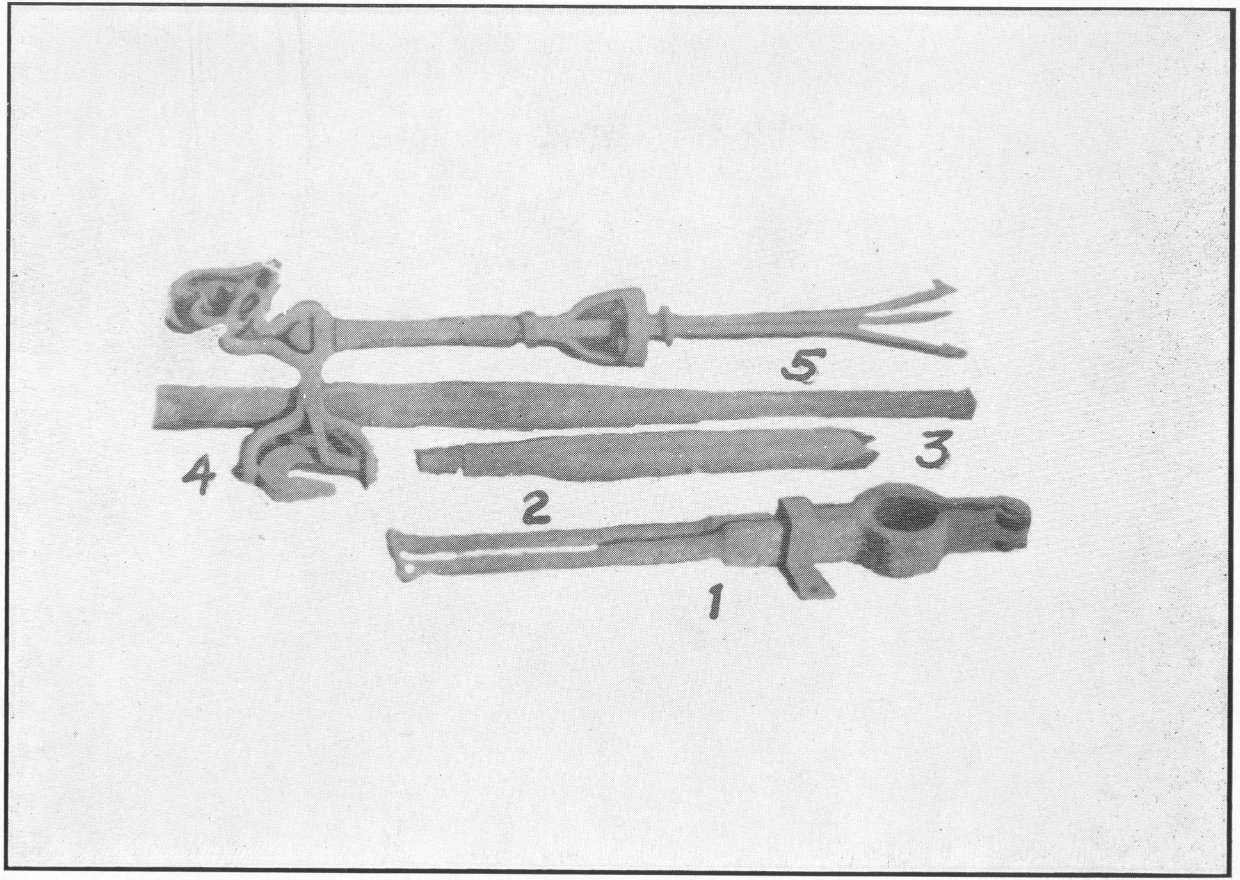

PLATE IV.—Early Drilling Equipment.—No. 1 is a clamp, similar to that on the modern temper screw. No. 2 and No. 3 are sections of hickory poles used as drilling 'cable', forerunners of the modern 'sucker rod'. No. 5 is a fishing tool; use of No. 4 is not known.—Photo by E. T. Crawford, Jr.

The industry then expanded by leaps and bounds; in 1855 R. C. M. Lovell, a Kanawha salt maker, bored wells and erected a large furnace about midway between Hartford and the pioneer salt works and laid out a town which he named Mason City. This works was sold, first to L. H. Sargent of Cincinnati, O., and later to Messrs. Root and Kilbreth of that city.

Immediately afterward, the following salt works were built: New Castle, Burnup, Clifton, Bedford, Hope, German, Jackson, Valley City, Star, New Haven City; ten in all, or a total of thirteen along the Virginia shore of the Ohio for approximately as many miles, and all employed Patrick's scheme of evaporation.

By April 5, 1876, the capacity of all these furnaces was 3,000,000 bushels salt per year. The following table gives these data more completely. Note: A bushel of salt was fifty pounds Avoirdupois. As elsewhere, the salt was not purified after it was dipped from the vats.

Table 6.—Number, Owners, and Capacities of Mason County Furnaces, 1876.

(Data compiled by G. W. Moredock) (14)

Name of Furnace.	Capacity. Bu.	Well Depth. Feet.	Name of Owners.
New Haven	300,000	1200	Hartford City Coal & Salt Co.
Hartford City	300,000	1150-60	1100 Acres of Coal Land.
Star	325,000	1150-60	----------
Valley City	350,000	1125-35	Valley City Coal & Salt Co.
Jackson	200,000	1125-30	V. B. Horton, Jr.
German	250,000	1125-30	German Salt Co.
Hope	350,000	1125-30	Hope Salt Co.
Mason City	325,000	1125-30	Mason City Salt Co.
Bedford	300,000	1150	Bedford Salt Co.
Clifton	300,000	1150	Not running.
Burnup or Quaker City	150,000	1150	Not running.
New Castle	250,000	1155	Not running.
West Columbia	300,000	1125-40	Not running.
Actual Capacity	3,700,000	------	----------
Actually made in 1875	2,500,000	------	----------

The brine along the Ohio was found to be heavier than Kanawha produced; its strength averaged 8° to 10° Bé. and each well made 15 to 50 gallons per minute. (14) The wells averaged 1100 to 1200 feet deep and were tubed with 4″ iron pipe and "bagged" with burlap sacks filled with flaxseed at a depth of 600 to 800 feet, at which depth the pumps were also placed. These were run by steam power, which was by now developing rapidly, also.

G. W. Moredock (14) stated: "It takes one bushel of coal to make a bushel of salt, strength of brines at Hartford 9°-10°, measured by Baume's salometer —, making the brine stand 40% salt." Hale states (14) that bromine and some calcium chloride were produced, but does not say how early this began. (See Plate XVII).

The salt produced here found a ready market to the west, as the Ohio River furnished cheap transportation, and the industry prospered for some time. The meat packing industry at Cincinnati required large quantities and seemed to prefer this product to any other. But the same influences that throttled the industry along the Kanawha also adversely affected the plants along the Ohio, so that in 1911 only two plants were in operation — namely, the Dixie Salt Company at Mason City and the Hartford City Salt Company at Hartford City. (22) These plants are still successfully operated (1937). (See Plates XII to XVIII, inclusive).

In 1904, Mr. C. D. Howard took samples of the Hartford City brines and analyzed them. He made a special search (22) for calcium[3] and rubidium, but failed to find either. A comparison with his analysis and one recently made by the author on a sample taken personally from one of the old wells there (it might be the same one Howard analyzed) is given in the chapter of detailed brine reports.

For a more detailed history, the reader is referred to references 3, 9, 14, 22 and 25 in the Bibliography of this report.

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[3]This probably is a misprint, and intended to read "caesium".

BRAXTON COUNTY.

The literature yields very little data on the salt industry once carried on at Bulltown, Braxton County. Atkinson (27) mentions "an almost extinct tribe of friendly Indians" (whose chief was Capt. Bull, for whom Bulltown was named) manufactured salt at Bulltown in 1772. Hale (14) lists the furnace there as one of the principal salt producers, and mentions that the iron kettle of the pioneer naturally became a part of the early salt furnaces because it served the pioneer in four ways:

1. For cooking the daily "hog and hominy,"
2. For boiling the clothes on wash day,
3. For boiling down brine to make salt, and
4. For boiling maple sap to make sugar.

In another place (p. 368) of the same article he states "two salt wells and furnaces are at Bull Creek near Sutton on Elk river."

In his history of Braxton County, (15) John D. Sutton states that Bulltown was noted for "the further fact that it was a point at which, for many years, salt was manufactured in quantities sufficient to supply a great region of country. It was carried by pack horses to various neighborhoods in Braxton, Lewis, Upshur, Gilmer, and Webster counties before the Civil War." (See also 27 and 30).

In the Treasury Report (U. S.) of Feb. 26, 1827 the salt manufacturers of Virginia include production of the Bulltown Salines, which is the early name for the community. These are about all the references the literature yields on this once famous works.

Dr. Geo. Grant Lovett, of Bulltown, (Napier P. O.) gave the following information, which is corroborated by Mr. E. L. Lockhard and Mr. W. L. Currence, also of Bulltown: Mr. Wm. Haymond drilled the salt well and operated a furnace. The well was dug by means of a spring-pole to a shallow depth, and tubed with lead pipe three inches in diameter. (This is the only place, so far as the author can ascertain, where lead pipe was so used). Many local water wells near by taste salty, hence the brine was not so very deep.

The well was located near the upper side of the river bridge at Bulltown, which still stands, and the furnaces, of which there were two, were located in the flat river bottom near by.

In order to supply fuel for evaporating the brine, over five hundred acres of virgin timber were felled and cut into cord wood and much coal was mined from the local thin veins.

Salt from this furnace was supplied to the counties of Braxton, Lewis, Nicholas, Upshur, Harrison, Doddridge, Clay, Gilmer, Webster, Barbour and Preston.

When Senator Johnson N. Camden was born, his father was operating the well and furnaces under lease from the owners.

Production of salt was discontinued and the lead pipe pulled from the well in 1882. Only about thirty feet of the pipe was recovered and was moulded into bullets by local hunters, hence none of it remains to-day. While the furnaces were producing salt, much of it was floated out by river, packed in home-made barrels and tubs. The rest was taken at the furnace and removed by the buyers principally on pack horses.

To-day, mere vestiges of the furnace location and the old well are all that remain of a once prosperous salt works. No one was able to state the reason for its discontinuance, but one man thought that lack of cheap fuel (the deeper veins of coal were unknown, as was the presence of oil and gas) was responsible. Undoubtedly the Kanawha salt industry was also an important factor, because of its many advantages.

Plate XIX is a picture of one of the large size kettles used in the Bulltown furnace. This kettle was purchased by Mr. W. L. Currence when a lad, from John Currence, his grandfather, who pulled the lead pipe from the salt well about 1882. Mr. Currence states that two sizes of kettles were in use, and that there were about twenty to each furnace.

UPSHUR COUNTY.

Beside the Buckhannon River, one-half mile north of Sago, Upshur County, is situated the farm first cleared by one Cornelius Clark, a native of New England. Here, about the year 1847, Mr. Clark drilled a well for brine by means of the old-fashioned spring-pole. This required three years of constant effort, but salt water was eventually discovered at a depth of seven hundred and fifty feet.[4]

Mr. Clark tubed his well in a very peculiar, but practical manner. He bored small saplings lengthwise, thus making tubes. These were then split in two lengthwise and clamped around a copper pipe, and then lowered into the well, section by section, until the well was tubed. Sacks filled with flax seed were packed around this tubing as far down as possible to prevent, by swelling of the seed, any surface water entering the brine sand.

The farm is now owned by Mrs. Anna L. Burner, and she pointed out a spot in her garden where Mr. Clark had his furnace. He made salt there for several years, and supplied a large region. Mr. I. N. Weaver, of Morgantown, W. Va., remembers that shipments of this salt were brought to Morgantown by boat from Sago.

After he had made salt from this brine for some time, either the brine supply diminished or his custom increased to a point where a larger flow was required, so Mr. Clark deepened his well in an attempt to secure more salt water. He soon struck oil, and not knowing its worth, allowed it to escape into the river. He is reported to have said, "Boys, I knew we were over an underground corner of the ocean, but now we've hit a dead whale and I'm d------d if I know what to do about it."

Being an ingenious fellow, Clark next tried plugging off the oil by means of a section of log driven down the well by means of a ram swung on his spring-pole, but he never regained his supply of brine, and had to abandon his salt project. He finally succeeded in plugging the well below a fine supply of fresh water and this has been in use ever since. Gas escapes from the sand (Salt Sand) where he found the oil and bubbles up through the water, and it may be lighted at the surface to-day. A trace of the brine also seeps past Clark's

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([4]The log of Geo. Burner No. 1 well — p. 134, Detailed Report for Barbour and Upshur Counties — 1918, confirms this depth).

plugs and gives a salty tang to the water, which the people of the locality seem to relish. They even attribute health-giving properties to it because of this feature. (See Plate XX).

While the oil from this well was never marketed (for the reason above stated), this was one of the first oil wells of West Virginia, and the first in that section of the State. Very little, if any, mention is found in the literature, and most of this information was gleaned from the descendants of Cornelius Clark. (20 and 21)

MONONGALIA COUNTY.

Samuel T. Wiley (29) states that "About 1824 or 1825, Peter A. Layton and Andrew Brown bored a well for salt water, near Cassville, but abandoned the project." He further says, "At Stumptown, in 1869, an abandoned oil well was converted into a salt well, and Thursby, Kidd & Co., put up the Monongalia Salt Works, at which about fifteen barrels of good salt was made per day. It was a very white article, but coarse for want of proper machinery to reduce it. The enterprise was abandoned."

Mr. W. F. Brewer, of Morgantown, W. Va., showed the author the site of a salt well from which salt was manufactured about 65 years ago. It is approximately one hundred feet north of the tipple of Pursglove No. 5 mine on Scott Run, and is now covered by a railroad fill and the tracks that serve the tipple. The latter is five and a quarter miles from the Court House.

He also states that the land was owned by Mr. Christopher Core, who leased the site for the well and furnace. The latter was constructed of stone and covered with sheet iron pans that were twelve or fourteen feet wide, thirty to thirty-five feet long and eight to ten inches deep as he remembers them.

The salt had a reddish color and was sold for some distance up and down the Monongahela River from Morgantown. He can not remember the names of the operators, nor why the plant was abandoned, but recalls that it operated for only a year or so. His father obtained salt there when Mr.

Brewer was a boy. Mr. I. N. Weaver, of Morgantown, also remembers seeing the furnace and that his family used salt therefrom, but little else.

This is no doubt the salt works mentioned by Mr. Willey, but there seems to be some discrepancy in the statements as to the color of the salt. The writer is inclined to believe it was somewhat reddish, as Mr. Brewer states.

GREENBRIER COUNTY.

The literature is silent about many of the early salt works of West Virginia. Buffalo and deer led the Indian to their salt licks, and he, it seems, early learned to produce a low grade salt by evaporating the brine when obtainable in sufficient quantity at such places. Hence, the white man in need of salt soon learned where to obtain it and probably made it in most parts of the State.

In certain counties, such as Greenbrier, a small works sprang up and flourished for a time until some economic factor made salt manufacture unprofitable. Of these only the legend oft remains.

Mr. Calvin W. Price, of Marlinton, W. Va., kindly supplied the Survey with the legends of several such salt works, as follows:

(a) At the "Narrows" on the east side of the Greenbrier River about three miles below Spring Creek, four miles upstream from Anthony Station, and about a mile above the mouth of Laurel Run there were three, four, or possibly five wells sunk in an old buffalo lick by means of a tilt-pole (spring-pole). The brine obtained was pretty rich in salt, but there was a small flow. Copper tubing, made on the premises from sheet copper, was used to tube these wells, and for many years a family named Luddington made and sold salt there. They went out of business about 1820, the economic factors being cheaper salt from the Kanawha and the completion of the James River and Kanawha Turnpike.

(b) "Salt was also made from a brine seep on Stony Creek, two and a half miles from Marlinton. I have a pretty good line on the strength of this brine — it was just salty enough to make corn meal mush just right."

In the late 1840's, the late Capt. William Cochran attempted to drill the seep using a tilt-pole having hickory poles linked together for a rope and finally reached a depth of four hundred fifty feet. Tradition has it that he encountered a gas pocket which blew up his equipment and ruined the flow of brine. This may indeed be true, for at Marlinton, about two miles away, there is a well of record in which gas was found at the same depth.

(c) "Tradition has it that salt was also made from the weak brine of Clover Lick, twelve miles northeast of Marlinton."

(d) "I am reminded, too, there was a salt well one mile above Renick on an island at Burr Ford. I understand the brass casing is still in it. The rock furnace was destroyed when the railroad was built thirty-eight years ago. Salt from this well was floated down the Greenbrier in 'johnboats' and canoes."

HARRISON COUNTY.

Josiah Hughes (30) gives the West Fork of the Monongahela River in Harrison County as one of the salt-making localities. Mr. W. B. Gribble, of Clarksburg, told the writer that this salt works was on the Duncan farm near the old Country Club, and that it was operated prior to 1850. Page 13, Detailed Report for Doddridge and Harrison Counties, quotes from "Border Warfare" by A. S. Withers, p. 127 (1908) a reference to the old salt works on the West Fork. No other data appear available.

SUMMERS COUNTY.

The Survey's report for Summers County (45) reads:

"**Mercers Saltworks.** — Mercers Saltworks were located on Lick Creek one-half mile above its junction with New River in the southern end of Summers County; the brine came from the Jabez Anderson Salt Well, drilled by Charles Clark and others about 1860 with a reported depth of about 1,100 feet. According to J. Anderson, present owner of the property and grandson of Jabez Anderson, salt brine was found at an unknown depth and was manufactured into salt for a time by Jabez Anderson but the plant was burned during the Civil War and was not rebuilt."

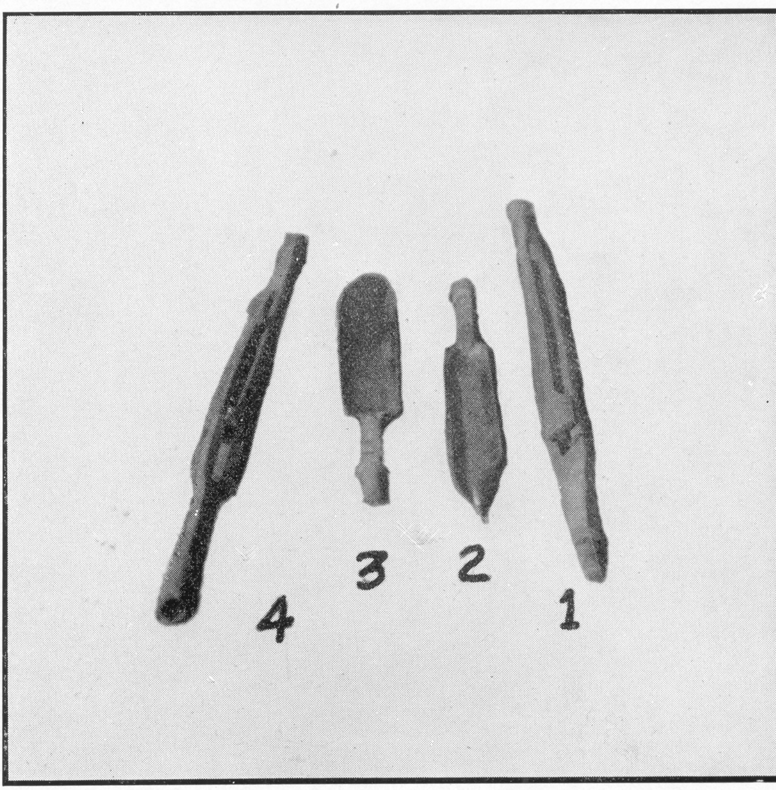


PLATE V.—Early Brine Well Tools.—No. 1 and No. 4 are hand-forged jars, or slips. No. 2 is a wood bit used to bore logs length-wise to make pipe, and No. 3 is a reamer used to enlarge the hole at one end.—Photo by E. T. Crawford, Jr.

ALL OTHER COUNTIES.

Hughes (30) states that salt was made on the New River, in Mercer County. Hale (14) mentions the same place, and also two others, namely, Louisa, on the Big Sandy, and near Birch, on the Elk, but there seems to be no description nor data of record. They were probably, as stated under Greenbrier County, small, temporary, local projects that soon retired from the market.

CHAPTER III.

GEOLOGY OF WEST VIRGINIA BRINES.

GENERAL.

The area in West Virginia in which brines are now found was, in the long geologic past an inland sea in which sands, lime and other muds, and often organic remains were deposited. Because the trough or basin occupied by this sea gradually subsided, several thousand feet of sediments were permitted to accumulate. At times the sediment was predominantly sand grains, at others it was lime muds, at others it was composed of mostly clay minerals, and even more often a mixture of two or more. These sediments upon burial were by compaction or cementation converted to consolidated sedimentary rocks. During the sedimentary process however, large quantities of the sea water were held or entrapped in the interstices between the mineral grains as connate or "fossil sea water" some of which has remained there to the present time.

During the long period of entrapment, changes both physical and chemical may have taken place. In some cases the brine has become more concentrated while in others it may be diluted. Such changes are brought about as a result of several influencing factors including migration due to earth movements; evaporation; temperature and pressure changes; contact with hydrocarbons; and mixing with surface or meteoric waters. (A discussion of how these changes may take place is found in Chapter IV).

HORIZONS CONTAINING BRINES.

Brines may occur in any porous, permeable bed deposited under marine conditions. Since it was possible to secure samples only from wells which encountered brine that were being drilled during the investigation, or wells already producing, this survey was limited to those areas in which active drilling was going on. Fortunately however, the large amount of drilling, in search for oil and gas, permitted the securing of samples from most of the areas in the State in which brine would be expected and from a representative geological range. The productive brine area includes the western half of the State. Since brines are unwanted by the oil and gas driller and must be cased off, their position in the well is usually accurately determined.

The outcropping rocks in the brine producing counties are of Permian or Pennsylvanian age, although rocks of Mississippian and Upper Devonian age get to the surface on the eastern edge of the basin.

To date the greatest producers of brines are the rocks of Pennsylvanian age and especially the several sandstone and conglomerate horizons of the Pottsville Series. Other horizons, in the Mississippian and Lower Devonian especially, offer excellent possibilities.

A generalized geologic column (Figure 2) showing the position together with intervals and thickness of the oil and gas horizons (possible brine horizons) for northern West Virginia and southern West Virginia has been prepared to which the reader is referred.

The Survey has published county reports covering all counties of the State, except Greenbrier, which is soon to go to press. In these reports will be found intervals for each county described, and also several thousand well records giving more specific intervals at designated locations.

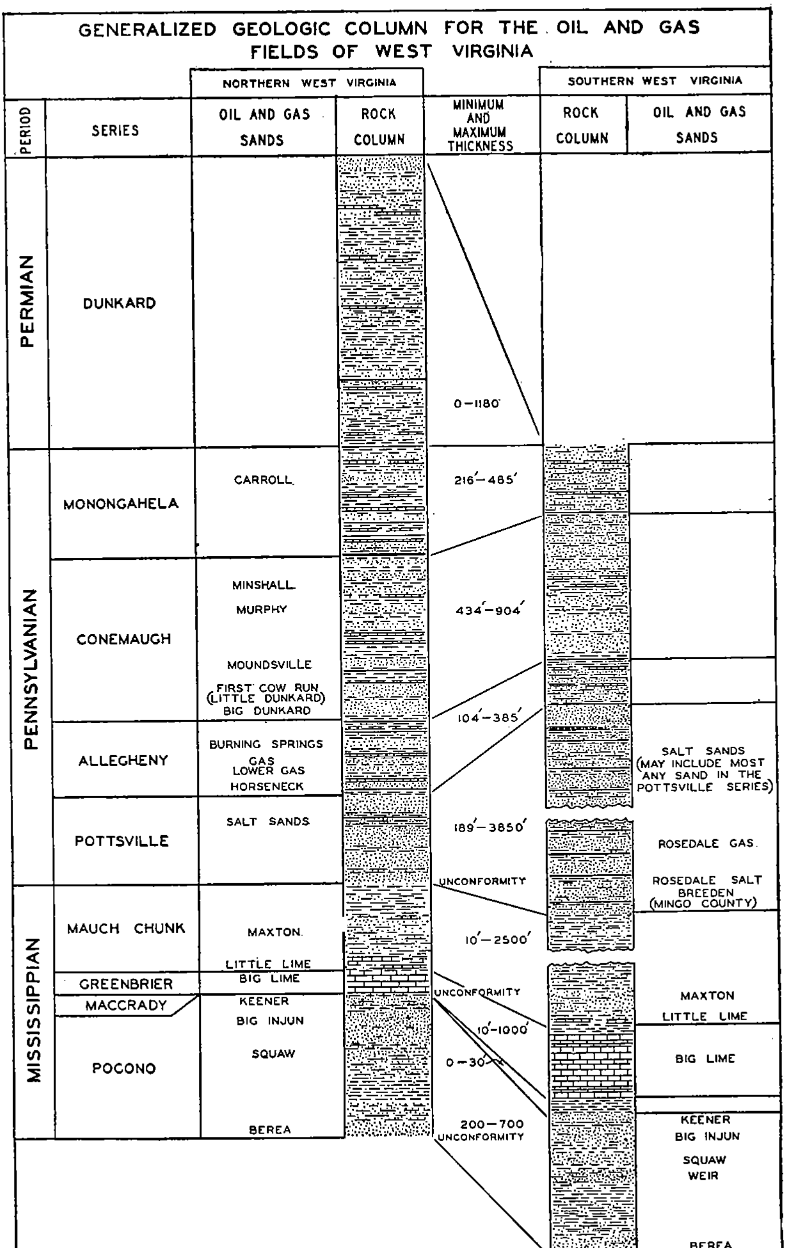
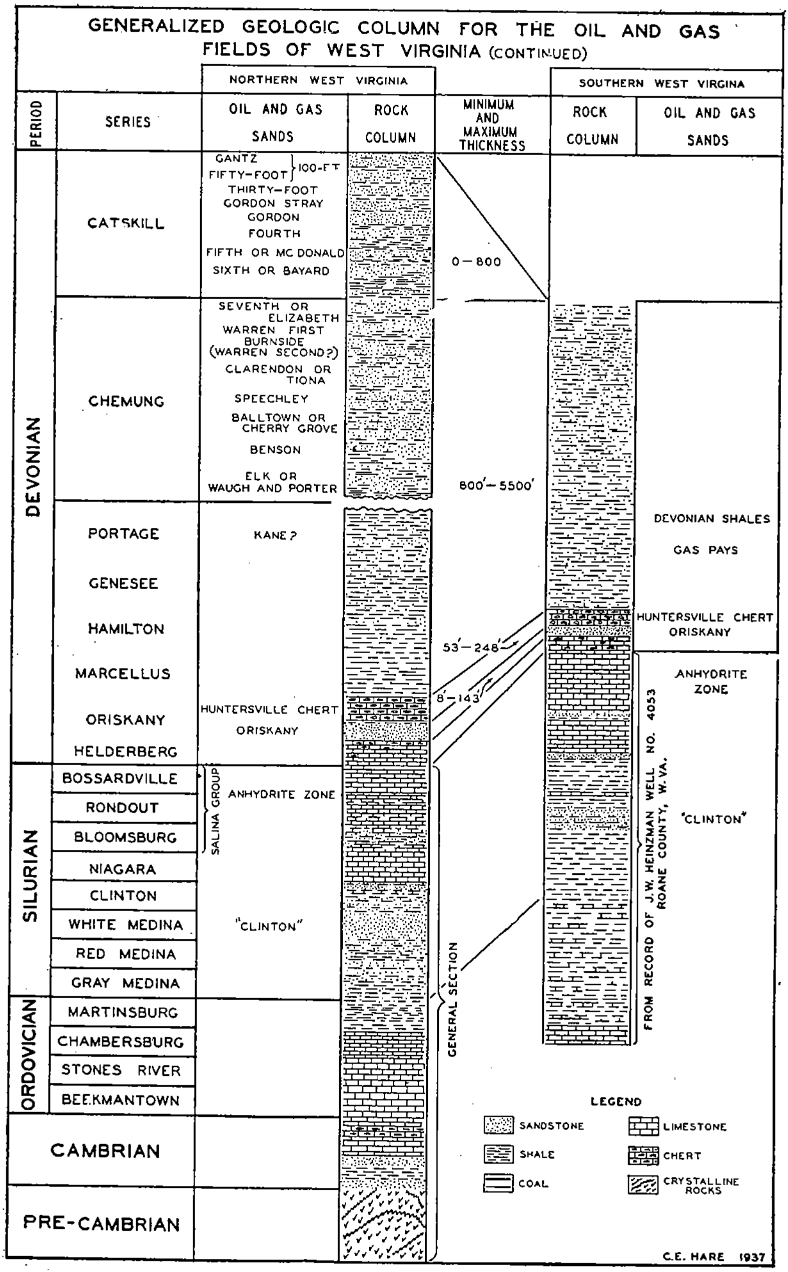


FIGURE 2.—Generalized Geologic Column for the Oil and Gas Fields of West Virginia.


GENERALIZED GEOLOGIC COLUMN FOR THE OIL AND GAS FIELDS OF WEST VIRGINIA (CONTINUED)
NORTHERN WEST VIRGINIA
SOUTHERN WEST VIRGINA
PERIOD
SERIES
OIL AND GAS SANDS
ROCK COLUMN
MINIMUM AND MAXIMUM THICKNESS
ROCK COLUMN
OIL AND GAS SANDS
DEVONIAN
CATSKILL
GANTZ
FIFTY-FOOT
100-FT
THIRTY-FOOT
GORDON STRAY
GORDON
FOURTH
FIFTH OR MC DONALD
SIXTH OR BAYARD
0—800
CHEMUNG
SEVENTH OR ELIZABETH
WARREN FIRST
BURNSIDE (WARREN SECOND?)
CLARENDON OR TIONA
SPEECHLEY
BALLTOWN OR CHERRY GROVE
BENSON
ELK OR WAUGH AND PORTER
800′—5500′
PORTAGE
KANE ?
GENESEE
HAMILTON
MARCELLUS
ORISKANY
HELDERBERG
DEVONIAN SHALES
GAS PAYS
HUNTERSVILLE CHERT
ORISKANY
53′—248′
8′—143′
HUNTERSVILLE CHERT
ORISKANY
SILURIAN
BOSSARDVILLE
RONDOUT
BLOOMSBURG
SALINA GROUP
ANHYDRITE ZONE
NIAGARA
CLINTON
WHITE MEDINA
"CLINTON"
RED MEDINA
GRAY MEDINA
ANHYDRITE ZONE
"CLINTON"
FROM RECORD OF J. W. HEINZMAN WELL NO. 4053 ROANE COUNTY, W. VA.
GENERAL SECTION
ORDOVICIAN
MARTINSBURG
CHAMBERSBURG
STONES RIVER
BEEKMANTOWN
CAMBRIAN
PRE-CAMBRIAN
LEGEND
SANDSTONE
LIMESTONE
SHALE
CHERT
COAL
CRYSTALLINE ROCKS
C.E. HARE 1937

PERMIAN SYSTEM.

The **Dunkard Series** of the Permian System covers the northwestern part of West Virginia, and with the exception of stream deposits, is the most recent in formation of the sedimentary rocks. In the area under consideration this series reaches a maximum thickness of 1180 feet. The Dunkard Series consists of a succession of brown and grayish-green sandstones, red shales, thin limestones, and a few thin and unimportant coal seams. These sediments were deposited in fresh or brackish water and would not be expected to contain a true brine.

PENNSYLVANIAN SYSTEM.

In West Virginia the Pennsylvanian System is divided into the following series: Monongahela, Conemaugh, Allegheny, and Pottsville.

In the northern part of the State the **Monongahela Series** consists of shales, limestones, thin sandstones, and coals. The three important coal seams are, namely, the Waynesburg, Sewickley, and Pittsburgh. In passing to the southwest the coals disappear almost entirely, and the limestones are replaced by red shales and massive sandstones. Thicknesses for the State as a whole range from 216 to 485 feet. Since these sediments are also of fresh or brackish water origin, this sample is probably not a true brine and the sands of this series are not important sources of brine.

The **Conemaugh Series** is composed of massive sandstones, soft, red and marly shales, and attains a minimum and maximum thickness of 434 to 904 feet. The limestones and coal seams in this series are few and thin. The Ames or green Crinoidal Limestone which occurs near the middle of the Conemaugh Series represents the last marine phase of deposition during the Pennsylvanian Period. Brines are encountered at the base of the Conemaugh Series in the Little Dunkard or First Cow Run (Buffalo), and the Big Dunkard (Mahoning) Sands. One sample was also collected from the Moundsville (Saltsburg) Sand in Calhoun County. These massive sandstones are probably shore deposits and could contain connate waters. In the northern part of the State where brines are encountered in these sands, they are very shallow in depth. Analyses of samples show that these brines are very weak and have probably been diluted by the infiltration of surface waters. They are not important as a source of brine for commercial use.

The **Allegheny Series** consists of massive sandstones, coals, fire clays, thin shales, and limestones, with thicknesses ranging from 104 to 385 feet. The important coal seams are the Upper and Lower Freeports, and the Upper, Middle and Lower Kittannings. The sandstones are more massive at the base of the series. Brines are seldom encountered in these sands. Only two samples, from the Gas Sand, are available for this report. They were very dilute and contained only 9.050 and 22,600 parts per million total dissolved solids, respectively.

The **Pottsville Series** in northern West Virginia consists of massive sandstones and conglomerates, with thin coals and fire clays, with an average thickness of 200 feet. The series thickens toward the south and attains a maximum thickness of 3850 feet. The southern section consists of massive sandstones and conglomerates, thick shales, thin marine limestones, and numerous important coal seams. The key horizons that have been used for structural mapping of the Pottsville Series are the Kanawha Black Flint, No. 2 Gas Coal, Sewell Coal and No. 3 Pocahontas Coal. The fossiliferous limestones in the southern section indicate that marine conditions did exist at times during the deposition of the Pottsville Series. The Salt Sands produce brine throughout the oil and gas fields of the State. (See Figure 4). The brine may occur alone or it may be associated with oil and gas. In northern West Virginia the Salt Sands (1st, 2nd, 3rd, etc.), include the Upper and Lower Connoquenessing Sandstones, while in the southern part of the State they may include most any sand in the Pottsville Series. These sands are usually porous and open textured and produce a seemingly unlimited amount of brine. Brine from these sands in the northern part of the State are generally less concentrated and in many instances the water from these sands is used for drinking purposes. The connate water which had been trapped in the sediments at the time of deposition has subsequently been diluted or entirely replaced by percolating ground waters entering at the outcrop. The brine from this series in southern West Virginia is usually very concentrated. The maximum concentration as shown by analyses was 158,900 parts per million total dissolved solids, while 100,000 parts per million is not uncommon. For the State as a whole, from the analyses available, the Salt Sands offer the greatest possibilities for commercial brine because of their presence over a wide area, relatively shallow depths, and the large volumes of brine present within the sands.

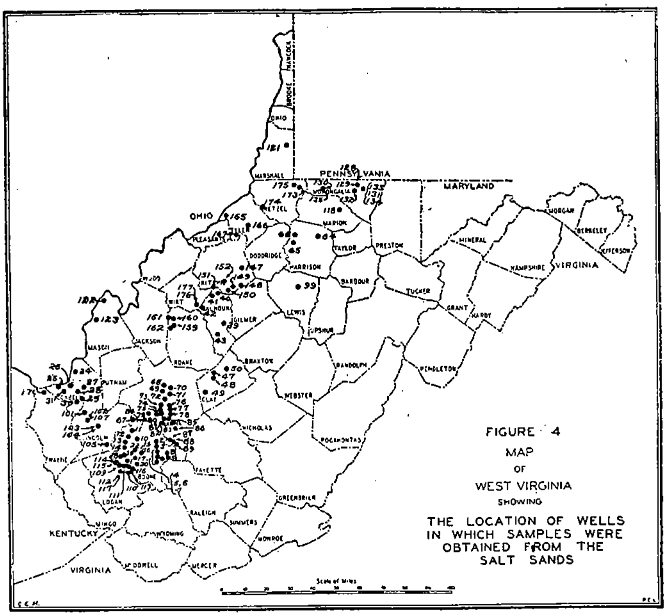


FIGURE 4
MAP
OF
WEST VIRGINIA
SHOWING
THE LOCATION OF WELLS IN WHICH SAMPLES WERE OBTAINED FROM THE SALT SANDS

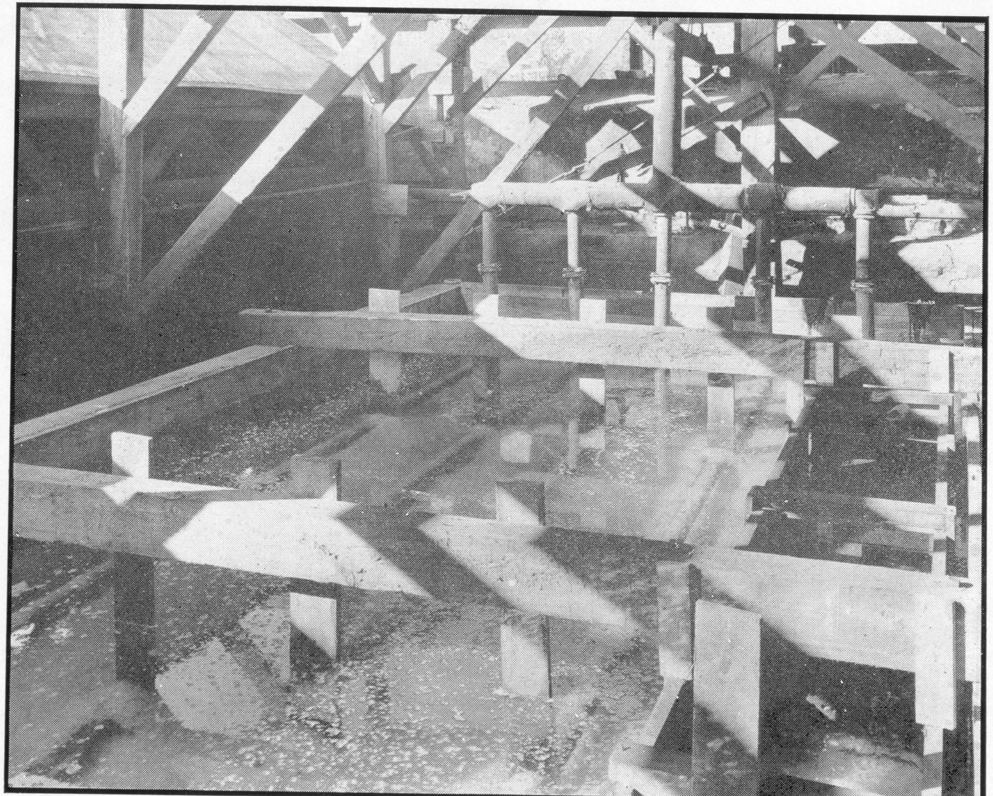


PLATE VI.—"Grainer" Vat of the Patrick Evaporator.—This picture shows pipe from steam chest, steam manifold, copper pipes in bottom of vat and salt crystals forming at surface of the brine.—Photo by E. T. Crawford, Jr.

MISSISSIPPIAN SYSTEM.

The Mississippian System is divided into the following series: Mauch Chunk, Greenbrier, Maccrady, and Pocono.

There is a distinct wide-spread unconformity between the Pennsylvanian and Mississippian Systems. This unconformity is supported by the complete absence of beds and a sharp break in lithology from the massive sandstones and dark shales of lower Pennsylvanian to the thick red shales and thin sandstones of the Mississippian.

In northern West Virginia the Mauch Chunk Series is composed mainly of red shales and thin sandstones, and varies in thickness from 10 to 300 feet. This series thickens to the south and consists of red shales, sandstones and conglomerates, limestones and thin streaks of coal. The southern section varies in thickness from 100 to 2500 feet. There are more marine sediments in the lower part of the series than in the upper portion. The Maxton oil sand belongs near the base of this series and is an important oil and gas sand especially in the northern counties. This sand also in many instances contains brine which as a rule is very concentrated. The analyses of samples from Ritchie and bordering counties show a maximum concentration of 167,000 parts per million total dissolved solids. Although not so productive over a wide area as the Salt Sands, the Maxton may be considered as a good source of brine in localities where it is encountered. The area from which the Maxton Sand was sampled is shown by Figure 5.

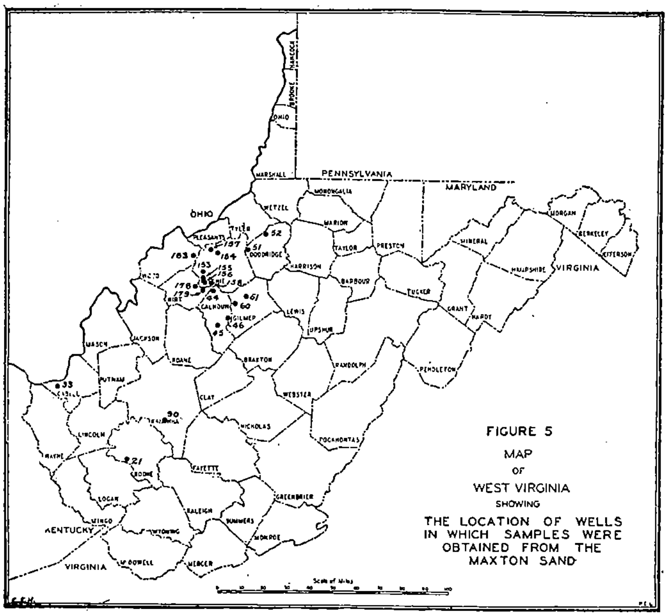


FIGURE 5
MAP
OF
WEST VIRGINIA
SHOWING
THE LOCATION OF WELLS IN WHICH SAMPLES WERE OBTAINED FROM THE MAXTON SAND

A definite marine phase of the deposition of the Mississippian System is represented by the **Greenbrier Series.** This formation is largely a massive limestone with red shales at the top and a few sandy streaks at the bottom. This limestone series contains abundant marine fauna and in southern West Virginia it attains a maximum thickness of 1000 feet. However, in the northern part of the State it is usually less than 100 feet thick. The Greenbrier Series or "Big Lime" as called by the drillers, has produced oil and gas in the State and brine has been reported in a few localities. One sample from Kanawha County was available for this report.

The **Maccrady Series** attains a maximum thickness of only 30 feet in the present oil and gas territories and is present only in southern West Virginia. It is predominately red shales and is not important as a source of brine.

The **Pocono Series** of West Virginia is predominately sandstones and shales and ranges in thickness from 200 to 700 feet. Marine fossils are found at the outcrop indicating that marine conditions did exist at times during its deposition. The oil and gas sands of this series include the Keener, Big

Injun, Squaw, Weir, and Berea. The Big Injun Sand which occurs near the top of the series, is one of the most prolific oil and gas sands in the State. Frequently the upper part of the Big Injun is separated from the main body of sand by a few feet of shale, and this upper portion is designated as the Keener Sand. The same is often true at the base of the Big Injun, and this basal portion is called the Squaw Sand. The Weir Sand is important as an oil and gas sand in southern West Virginia. The Big Injun contains large volumes of brine in some localities and for the State as a whole the brine from this sand is very concentrated. Areas from which samples were taken in the Big Injun are shown in Figure 6. Although the Keener, Squaw, and Weir Sands are possible brine horizons, they are not important as a source of brine for commercial use. The Berea Sand which occurs at the base of the Pocono Series is important as a reservoir rock for oil and gas and in a few instances produces brine. No samples were available from this sand for this report.

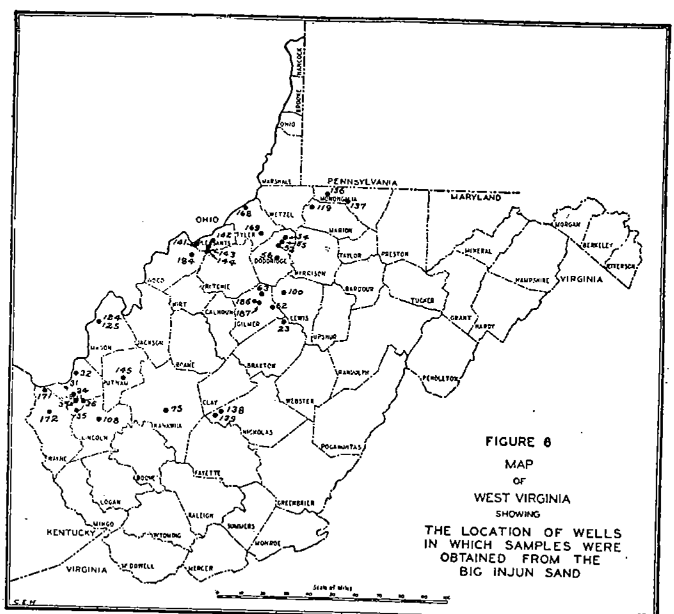


FIGURE 6
MAP
OF
WEST VIRGINIA
SHOWING
THE LOCATION OF WELLS IN WHICH SAMPLES WERE OBTAINED FROM THE BIG INJUN SAND

DEVONIAN SYSTEM.

The Devonian System consists of a succession of great thicknesses of shales interstratified with sandstones. The system as a whole thickens greatly in the northeastern part of the State, and thins to the southwest. The **Catskill Series** which is the top portion of this system is present in northern West Virginia, and contains numerous oil and gas sands. This series thins out completely toward the south. Only one sample of brine was taken from the Catskill Series, and it was from the Fifth Sand. The **Chemung Series** lies directly beneath the Catskill Series in northern West Virginia, and it also contains numerous oil and gas sands which are not productive in the south. From the base of the Chemung Series to the top of the Oriskany Series there is a succession of thick shales with sand lenses, which in southern West Virginia contain numerous gas pays. For the oil and gas regions of the State, these Devonian shales reach a maximum thickness of 6300 feet in the northeast and a minimum thickness of 800 feet in the southwest.

The **Oriskany Series** is represented by the Huntersville Chert and the Oriskany (Ridgeley) Sandstone. The Huntersville Chert corresponds to the driller's "Corniferous Lime". From records of wells drilled through the Oriskany Series, it ranges in thickness from 61 feet in Boone County to 391 feet in Doddridge County. The sediments of this series are definitely of marine origin and the Oriskany Sandstone contains abundant marine fauna. Both members are calcareous throughout. The Oriskany Sand is now an important gas sand in Kanawha County and with further prospecting will probably be productive in other parts of the State. Brine has been encountered in this sand in Kanawha, Roane, Wirt, and Wood Counties. (See Figure 7). Six samples of brine from the Oriskany were available for this report and according to the analyses, average 252,717 parts per million total dissolved solids. This concentration is much greater than that of brine from the more shallow sands.

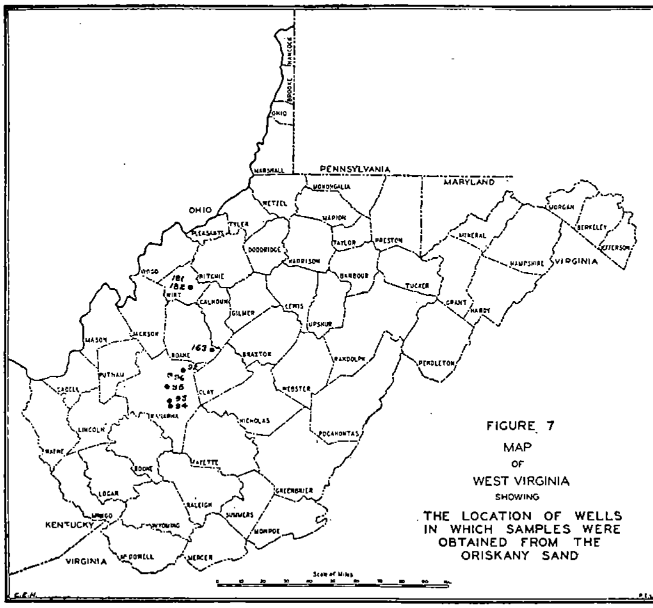


FIGURE 7
MAP
OF
WEST VIRGINIA
SHOWING
THE LOCATION OF WELLS IN WHICH SAMPLES WERE OBTAINED FROM THE ORISKANY SAND

The **Helderberg Series** forms the base of the Devonian System and lies directly beneath the Oriskany Sandstone. This series is composed of cherty limestone with a sandstone member near the top. This sandstone probably corresponds to the Healing Springs which is identified at the outcrop of the Helderberg in eastern West Virginia. Although the Healing Springs Sandstone contains marine fossils at the outcrop, the presence of brine in this series has not been reported.

SILURIAN SYSTEM.

At the present time very little is known about the Silurian System except at the outcrop in the eastern part of the State. The system has been penetrated by the drill in Boone, Kanawha, Roane, Randolph, and Doddridge Counties. According to the records of these deep wells, the **Salina Group** at the top of the Silurian is composed of anhydrite, dolomite, and limestone, with a sandstone just below the middle. This sandy member has been tentatively called the Newburg Sand. The basal portion of what has been identified as the Salina Group probably contains the equivalents of older Silurian limestones. The thicknesses of this group range from 722 feet in Kanawha County to 1268 feet in Randolph County. Two samples of brine were analyzed from this series. One sample from Boone County was highly charged with hydrogen sulphide gas and contained 196,400 parts per million total dissolved solids. Rock salt was encountered within the Salina in a deep well in Doddridge County.

The top of the **Clinton Series** is represented by a fine-grained dolomitic sandstone (Keefer?). The rest of the series is composed of red, green, and gray shales and a dolomitic limestone which occurs just below the middle of the column. No brines have been reported from this series.

The **White Medina Series** consists mostly of white, fine-grained sandstones interstratified with shales. A thickness of 175 feet was recorded in the J. W. Heinzman well in Roane County, and 121 feet in the J. A. Hill well in Kanawha County. One sample of brine was analyzed from the Clinton Sand and contained 200,300 parts per million total dissolved solids. The Clinton Sand represents the lowest stratigraphic level in which brine has been encountered in West Virginia.

The **Red Medina Series** (Queenston Shale) is composed almost entirely of red shales, with thin layers of sandstone. This series was 505 feet thick in the J. W. Heinzman well in Roane County.

THE ORDOVICIAN AND CAMBRIAN SYSTEMS.

Sediments of the Ordovician System are largely shales, limestones, and dolomites. The J. W. Heinzman well in Roane County was drilled through 1145 feet of Martinsburg Shales and 190 feet into the Trenton Limestone. Lower Ordovician and Cambrian sediments have not been reached by the drill in West Virginia.

CHAPTER IV.

PHYSICAL AND CHEMICAL STUDIES.

CHEMISTRY RELATING TO BRINES.

The general term brines as used in this report includes a variety of underground waters, usually of relatively deep-seated occurrence and of relatively high content in dissolved mineral matter.

Sources of Brines. — Brines often differ widely in composition and concentration in different parts of the world and sometimes even in different parts of a given geological region. These differences result from a number of different causes including both differences in source waters and varying influences which have acted on the brines since their entrapment in subterranean formations.

The main source of brines appears to have been sea water. There are, however, many brines composed largely of meteoric waters which have migrated into their present horizons. In a few rare instances also, it seems that certain brines are in part at least derived from magmatic waters.

In the Appalachian field with which the present study is concerned, the brines seem mainly derived from ancient sea water entrapped during sedimentation. There are, however, many instances in which even Appalachian brines seem to include, mixed with waters of marine origin, greater or less proportions of ground waters of meteoric source.

In other regions, the San Joaquin Valley of California, (38), for instance, the proportion of water of meteoric origin in the brines is much greater, especially nearer the outcrops of the water-bearing horizons. In the deeper sections of these strata farthest from the outcrops, the brines more nearly approximate water of marine origin.

Brines in general have undergone profound changes during the geologic period since their entrapment in the earth.

In the discussion that follows it will be attempted to trace, in main outline, the various factors influencing these changes. The first part of the discussion will deal with factors and their results considered to be generally applicable. In the later part of the discussion special mention will be made of the particular characteristics of the brines analyzed for this study.

General Sequence of Geologic Changes Accompanying Development of Brines. — In general the first step in brine formation is sedimentation. (36) During this period solid material settles out of water, usually marine water, to form bottom muds which contain a certain amount of organic matter.

As these muds form, the beds become thicker and compaction sets in on the deeper layers which brings about upward expulsion of a part of this interstitial water and a closer contact of the particles of solid matter. Meanwhile cementation sets in and aids in consolidating the mass.

After surface deposition and compaction of the lower strata have continued over long geologic periods the lower portions acquire the properties of sedimentary rock. Their interstices are still filled with the unexpelled portion of the original water.

Subsequent land movements may elevate these layers above sea-level or otherwise alter them through formation of faults or fissures. Outcrops may be exposed which will permit the entrance of surface or shallow ground waters. Through faults and fissures some of the originally contained water may be expelled to other horizons or the sands may be invaded by fluids from different horizons which will expel a part of the originally contained brine and mix with the rest to form a new mixture with somewhat different properties from those of either of the two liquids before mixing.

Through some deep-seated faults or fissures there may be, in rare cases, intrusions of magmatic waters (42) or emanations which will influence the composition of the brine.

In some places there will be invasion of the water sands by either gas or petroleum or both. In such cases there may

PLATE VII.—Drainage Boards in Grainer Shed, Malden, W. Va.—This view shows piles of snowy salt recently "lifted" onto the drain boards from the grainer vats below by means of the long-handled copper shovels. This salt is the first grade, known as "Table and Dairy Grade."—Photo by E. T. Crawford, Jr.

be concentration of the waters by evaporation into the gas. There may also be chemical reactions between the waters and the hydrocarbons.

There may be localized temperature changes resulting from various causes and also pressure changes resulting not only from deeper burial but also from rock movements due to faulting. Both such changes would have pronounced effects upon the environment of the waters and could lead in various ways to changes in composition.

It is thus obvious that underground waters contained in a given horizon at a given time may have passed through a long and complicated series of transformations which have been adequate to greatly alter them from their original character either as marine or meteoric waters.

In the next section will be discussed in detail various major changes believed to take place in brines under the various conditions postulated.

Influencing Factors Producing Chemical Changes.— Brines are essentially water solutions of various mineral constituents. It follows that the composition of a brine during its evolution will be powerfully influenced by the following factors:

1. Composition of source water.
2. Temperature changes.
3. Pressure changes.
4. Different materials with which the brine may come in contact, including rocks, gases, hydrocarbons, and other waters.

Brines migrate from point to point and even from horizon to horizon. They thus come in contact with different rocks, and also with other brines, with which they mix. They also come in contact with hydrocarbon gases and liquids. In their early stages they may be in contact with organic matter inhabited by bacteria. In this section will be given a condensed summary of the chemistry of the waters and a discussion of many of the more important conditions likely to produce physical or chemical change in the brine solutions.

Prior to the detailed discussion of possible chemical changes we give in the following section, first a comparison of brines and ocean water and next a condensed summary of the present distribution and significance of the various constituents.

COMPARISON OF BRINES AND OCEAN WATER.

In the following tables, table No. 7 and table No. 8, are shown analyses comparing ocean water with brines from producing horizons in West Virginia:

Table 7.—Comparison of Analyses of Ocean Water and Brines—Percentage Basis.

Horizon.	1 Ocean Water.	2 Salt Sand.	3 Maxton Sand.	4 Big Injun Sand.	5 Oris-kany Sand.
Iron (Fe)	------	.002	.028	.000	.042
Calcium (Ca)	1.197	5.843	11.132	8.607	9.942
Strontium (Sr)	------	.197	.272	.218	.325
Barium (Ba)	------	4.507	.051	.000	.000
Magnesium (Mg)	3.725	1.682	2.936	1.566	1.502
Sodium (Na)	30.593	27.464	22.264	26.804	24.890
Potassium (K)	1.106	.183	.116	.337	1.243
Carbonate (CO_3)	.207	.000	.000	.000	.000
Bicarbonate (HCO_3)	------	.076	.037	.000	.042
Sulfate (SO_4)	7.692	.003	.014	.010	.040
Chloride (Cl)	55.292	59.736	62.735	61.695	61.399
Bromine (Br)	.188	.288	.393	.751	.567
Iodine (I)	------	.006	.004	.012	.008
Total	100	100	100	100	100

1. Mean of 77 Analyses of Sea Water, U. S. Geological Survey Bulletin No. 695, p. 123.
2. Sample No. 162 (Present Report), Roane County.
3. Sample No. 21 (Present Report), Boone County.
4. Sample No. 119 (Present Report), Marion County.
5. Sample No. 182 (Present Report), Wirt County.

Table 8.—Comparison of Analyses of Ocean Water and Brines—Parts Per Million Basis.

Horizon.	Ocean Water.	Salt Sand.	Maxton Sand.	Big Injun Sand.	Oris-kany Sand.
Iron	-----	1.8	45	0.75	115
Calcium	447	7,170	18,200	15,830	27,200
Strontium	-----	242	444	401	889
Barium	-----	5,530	84	0	0
Magnesium	1,392	2,064	4,800	2,880	4,110
Sodium	11,433	33,700	36,400	49,300	68,100
Potassium	413	224	189	620	3,400
Carbonate	77	0	0	0	0
Bicarbonate	-----	93	61	0	114
Sulfate	2,875	4.1	23	19	101
Chloride	20,662	73,700	102,600	113,500	168,000
Bromine	70	354	642	1,382	1,550
Iodine	-----	7.4	7.1	22	21
Total dissolved constituents	37,369	123,090	163,495	183,955	273,600

Samples shown in this table are the same as those in the preceding Table No. 7.

COMPARISON OF PERCENTAGES.

Table No. 7 shows analyses of the dissolved matter on a percentage basis, whereas Table No. 8 shows analyses in the form of parts of dissolved material per million of total solution.

Referring to Table No. 7 which is on a percentage basis the following points may be noted:

Calcium.—The percentage calcium is several times higher in the brines.

Strontium and Barium.—The brines also show appreciable amounts of strontium and in two out of the four cases barium, whereas, the ocean water shows neither.

Magnesium.—The ocean water on the other hand shows a considerably higher percentage of magnesium than the brines.

Sodium.—The percentage sodium in ocean water is considerably higher than that in the brines.

Potassium.—The percentage of potassium in ocean water is higher than that of three out of the four brines.

Carbonate and Bicarbonate.—The table shows an appreciable percentage of carbonate in ocean water and no carbonate in the brines. It is probable however, that some of the carbonate shown for ocean water existed as bicarbonate in solution before the water was evaporated for analysis. Sea water is known to contain considerable amounts of bicarbonate. In general it contains a higher percentage than that shown in the brines.

Sulfate.—One of the most remarkable points of comparison relates to sulfate. Ocean water salts show over 7% sulfate, whereas, the brine salts show a very small fraction of 1%.

Chloride.—The percentage chloride in the brines is materially higher than that in ocean water.

Bromine.—The percentage bromine in the brines is also materially higher than that in ocean water.

Iodine.—The percentage iodine is not shown for ocean water in the table. In general, however, ocean water contains approximately two parts per million of iodine which would correspond to about .005% in the table. Compared with this figure the percentage of iodine in three of the brines is higher.

COMPARISON OF PARTS PER MILLION.

Table No. 8 showing a comparison of parts per million between ocean water and brines exhibits some striking features not shown by the table giving percentages. Perhaps the most outstanding point of comparison is the much greater concentration of the brines. The weakest brine is nearly four times as concentrated as ocean water and the strongest brine shown is over seven times as concentrated as ocean water. This is more easily seen by comparing the totals of dissolved constituents. The table showing parts per million should be compared with the percentage table in scrutinizing the comparison of different constituents. The comments made relative to the percentage comparisons are reflected in the figures given for parts per million. The latter table in addition shows clearly the contrast between total quantities of the different constituents in a given amount of solution.

Particular note should be made of bromine and iodine in sea water as compared with brines. In the weakest brine there is five times as much bromine as in sea water and in the strongest there is twenty times as much bromine. Taking the iodine concentration of sea water as about two parts per million we note that the brines shown contain three and one-half to eleven times as much iodine.

DISTRIBUTION AND SIGNIFICANCE OF VARIOUS CONSTITUENTS.

The following discussion of distribution and significance of constituents applies in a general way to all salt-bearing natural brines, but it also applies especially to West Virginia brines.

Alkalies.—The alkalies (Na and K) are by far the most abundant bases in brines. Of the two, sodium is the principal constituent. Potassium is usually equal to not over 1 to 2 per cent. of the sodium.

Alkaline Earths.—The alkaline earths Ca and Mg are the next most abundant bases after the alkalies. There are in most of the brines also small amounts of Sr and Ba. Calcium is almost invariably more abundant than magnesium. The ratio of Ca to Mg usually ranges from 4 to 6.

Sulfates.—Sulfates are never present in large amounts. There is frequently no sulfate. In a few cases, in which barium is absent, the amount of sulfate present is appreciable.

Chloride.—Chloride is by far the major constituent. It is present in all the brines and in approximately the same percentage of total dissolved solids.

Carbonate.—Carbonate is very rarely present.

Bicarbonate.—Bicarbonate is usually present but in small amounts. In rare instances acid brines are found which contain no bicarbonates.

Bromine.—Bromine is usually present but the amount is quite variable. There is usually most bromine in the more concentrated brines. The bromine concentration, is frequently many times as great as it is in sea water.

Iodine.—Iodine is often present in the brines that contain bromine. The amount present is usually of the order of 1 or 2 parts per million but sometimes it reaches concentrations as high as 25 to 40 parts per million.

Sulfides.—No systematic test for sulfides has been made. In a few brines, however, sulfides have been detected.

Total Mineral Solids.—The concentration in total mineral solids varies widely. The most dilute brines tested contained less than 1000 parts per million. The most concentrated contained nearly 300,000 parts per million.

SUMMARY OF POSSIBLE CHEMICAL CHANGES.

Changes in Waters of Sedimentation.

Considerable investigation has been made of the chemical changes that take place in waters of sedimentation after they are included in the sediments on the ocean floor.

These sediments include decaying organic matter. They are also inhabited by certain species of micro-organisms which are believed to facilitate various chemical changes.

Decaying animal matter gives rise to the formation of $(NH_4)_2CO_3$. This is believed to react with $CaSO_4$ from the sea water to form $CaCO_3$ and $(NH_4)_2SO_4$ according to the following reaction:

$$(NH_4)_2CO_3 + CaSO_4 = (NH_4)_2SO_4 + CaCO_3.$$

Ammonium sulfate has been found in the waters of ocean muds.

Calcium sulfate appears to react, either directly or through the influence of bacteria, with hydrocarbons resulting from the decomposition of organic matter. The result of these reactions is the reduction of sulfates and the formation of carbonates and hydrogen sulfide. The following type equation with methane is intended to illustrate the reaction, but it is believed that the actual process is much more complicated as regards the organic substance (here assumed to be CH_4):

$$CaSO_4 + CH_4 = CaO + H_2S + CO_2 + H_2O.$$

The reaction may be somewhat differently written as follows:

$$CaSO_4 + CH_4 = CaS + CO_2 + 2H_2O = CaCO_3 + H_2S + H_2O.$$

The hydrogen sulfide evolved reacts, at least in part, with iron from the waters or the muds to give an unstable iron sulfide which imparts to the bottom muds their characteristic blue color. This may be illustrated by the following type reaction:

$$2H_2S + Fe_2O_3 = FeS + 2H_2O + \frac{1}{2}O_2.$$

The actual process is probably much more complicated than this, involving in some cases doubtless the life processes of living organisms.

The chief result of the reaction just discussed is to reduce the sulfate content of the water in the sediments and to increase the amount of $CaCO_3$ formed. Since the latter has a very low solubility the larger part of it is deposited as cementing material in the sediments.

Some evidence has been cited to show that Mg is also deposited as $MgCO_3$ from marine waters in ocean muds through the action of living organisms in a manner analogous to that by which $CaCO_3$ is deposited. Such action would help to explain the existence of dolomitic limestone in marine sediments.

Deposition of Mg by Hydrolysis. (36)

Certain investigators have studied the possible methods whereby magnesium may have been deposited from carbonates or chlorides by hydrolysis. Assuming a certain rise in temperature, the following reactions will take place:

$$MgCO_3 + H_2O = Mg(OH)_2 + CO_2.$$
$$MgCl_2 + 2H_2O = Mg(OH)_2 + 2HCl.$$

We see here the evolution of the gas CO_2 and hydrochloric acid.

If there should be calcium carbonate adjacent to a region in which the second reaction should take place there would result the following reaction:

$$CaCO_3 + 2HCl = CaCl_2 + CO_2 + H_2O.$$

In this way the amount of Ca in the brine would be increased and likewise the total amount of CO_2 liberated would be increased.

Interactions with Rocks. (36)

Various investigators have shown that brines may react with types of rock called zeolites in such a way as to interchange alkali and alkaline earth bases. These reactions are illustrated by the following equations:

1. $Na_2Al_2Si_2O_8 + Ca(HCO_3)_2 = CaAl_2Si_2O_8 + 2NaHCO_3.$

   In this reaction K can substitute for Na; SO_4, 2Cl, or $2NO_3$ can substitute for $2HCO_3$; and Mg, Ba, or Sr can substitute for Ca.

Such a reaction is used in a patented process for softening hard waters by use of an artificial zeolite known as Permutit.

2. $CaAl_2Si_2O_8 + 2NaCl = Na_2Al_2Si_2O_8 + CaCl_2.$

   In this reaction Mg, Ba, or Sr can substitute for Ca, and K can substitute for Na. In the artificial process above referred to the Permutit is regenerated by treatment with a strong NaCl brine with the result indicated by equation 2.

It is likely that such reactions as No. 2 have taken place in certain instances and have thereby caused an accession of Ca in the brines.

It is also probable that magnesium has been lost from

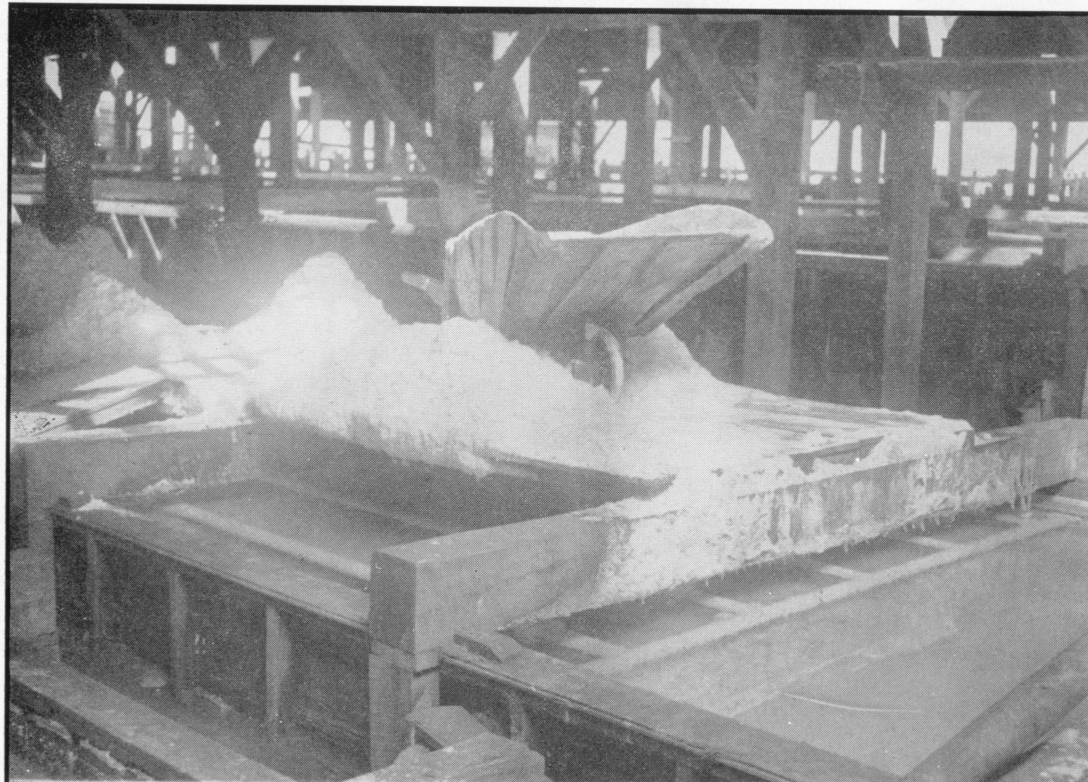


PLATE VIII.—Salt Wheelbarrow at Malden, W. Va.—This wheelbarrow is so nicely balanced that one man can readily transfer half a ton of salt per load from the drain board to the salt storage bin.—Photo by E. T. Crawford, Jr.

the water to form magnesium silicates and calcium chloride. This is indicated both by the preponderance of Ca over Mg in the brines and also by the occurrence of secondary magnesium silicates (chlorites) disseminated through some of the oil and gas bearing rocks. A type reaction illustrating this change might be written as follows:

$$MgCl_2 + H_8(CaFe)_5Al_2Si_3O_{18} = CaCl_2 + H_8(MgFe)_5Al_2Si_3O_{18}.$$

Reactions Due to Mixing of Waters. (36)

Waters containing alkali carbonates or bicarbonates may mingle with waters containing calcium chloride. In such cases the following reactions will take place:

$$Na_2CO_3 + CaCl_2 = CaCO_3 + 2NaCl.$$
$$2NaHCO_3 + CaCl_2 = Ca(HCO_3)_2 + 2NaCl.$$
$$Ca(HCO_3)_2 = CaCO_3 + H_2O + CO_2.$$

The migration and mingling of brines has doubtless been accompanied by these reactions in many cases.

SUMMARIZED DISCUSSION OF RESULTS ON WEST VIRGINIA BRINES — CORRELATION OF CONSTITUENTS WITH DENSITY.

A study has been made to show how concentration in various constituents varies with density. For each horizon taken, various constituents have been plotted as ordinates against density as abscissa.

It has been found that the major constituents plot against density in such a way as to form fairly smooth curves. The results may be conveniently summarized as follows:

Total solids, very smooth curve.
Chloride, very smooth curve.
Sodium (calculated), smooth curve.
Calcium, fairly smooth curve.
Magnesium, fair curve.
Bromine, very rough curve.
Other constituents, no correlation.

These curves are shown in a later section together with a more detailed discussion.

An attempt has been made to correlate results by horizons by plotting various results of analysis on a well location map. These studies show no systematic correlation. In certain cases general trends are observable but not over large areas. These studies are somewhat handicapped by the small number and irregular areal distribution of the samples available from most of the horizons.

It happens that the most dilute brines tested came mainly from Monongalia and Marion Counties, which are near the outcrop of the Salt Sand. In this connection reference is made to the geological section of the report which discusses the stratigraphy and outcrops.

GENERAL CONCLUSION AS TO SOURCE AND DEVELOPMENT OF WEST VIRGINIA BRINES.

Results of our study indicate that the brines of this area were originally marine waters of sedimentation and that they have undergone various changes since entrapment in the sediments. Two major changes have been:

1. The dilution of certain brines by meteoric water.
2. The concentration of other brines in some way, which may have been evaporation of water into moving bodies of gas.

TABLES AND CORRELATION CHARTS.

In the following pages are given the principal tables and charts showing descriptions of, and results on, the West Virginia brines tested. A brief discussion precedes each table.

SUMMARY OF DESCRIPTIVE DATA ON SAMPLES.

The following summary includes descriptive data on wells. It is important as the key summary showing identity of each sample reported. From it the reader will get location, name of operator, farm names, and other important data.

Table 9.—Summary of Descriptive Data on Samples.

Sample No. 1 *County* Boone *District* Washington
Company or Operator Boone County Coal Corporation *Well No.* "B"
Farm Boone County Coal Corporation
Location Waters of Rockhouse Branch of Spruce Fork, 2¼ mi. N. W. of Clothier
Name of Sand 2nd Salt *Depth to top of Sand* 1525 *ft.*
Salt Water Horizon from 1785 *ft. to* .... *ft.*
Size of Hole 10 *inches.* *Date Sample Collected* 4-19-35
Remarks Makes 1 - 10" bailer per hour.

Sample No. 2 *County* Boone *District* Sherman
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 376
Farm Peytona Coal Land Co. tract
Location Three Fork Br. of Sandlick Creek of Laurel Fork
Name of Sand Salt *Depth to top of Sand* 1455 *ft.*
Salt Water Horizon from 1725 *ft. to* 1744 *ft.*
Height Salt Water rose in Well 389 *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-1-35
Remarks Salt water at 1645 ft. — 1 bailer every two hours
Salt water at 1715 ft. — 2 bailers every two hours
Salt water at 1725 ft — hole filled up to 1336 ft.

Sample No. 3 *County* Boone *District* Sherman
Company or Operator Owens, Libbey-Owens, Gas Dept. *Well No.* 420
Farm Peytona Coal Land Co. tract
Location Three Fork Br. of Sandlick Creek of Laurel Fork, 1¾ mi. S. W. of Seth
Name of Sand Salt *Depth to top of Sand* 1276 *ft.*
Salt Water Horizon from 1385 *ft. to* .... *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 2-1-36
Remarks ½ bailer per hour.

Sample No. 4 *County* Boone *District* Sherman
Company or Operator The Pure Oil Co.
Farm Federal Coal Co. *Farm Well No.* 79
Location Three Fork Br. of Sandlick Creek of Laurel Fork, 2½ mi. S. W. of Seth
Name of Sand *Salt* *Depth to top of Sand* 1423 *ft.*
Salt Water Horizon from 1565 *ft. to* 1577 *ft.*
Height Salt Water rose in Well 200 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 3-14-36

Sample No. 5 *County* Boone *District* Sherman
Company or Operator The Pure Oil Co.
Farm Federal Coal Co. *Farm Well No.* 74
Location Waters of Hopkins Fork
Name of Sand Salt *Depth to top of Sand* 1660 *ft.*
Salt Water Horizon from 1717 *ft. to* 1725 *ft.*
Height Salt Water rose in Well 200 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 7-2-35

Sample No. 6 *County* Boone *District* Sherman
Company or Operator The Pure Oil Co.
Farm Federal Coal Co. *Farm Well No.* 74
Location Waters of Hopkins Fork
Name of Sand Salt *Depth to top of Sand* 1660 *ft.*
Salt Water Horizon from 1760 *ft. to* 1794 *ft.*
Height Salt Water rose in Well 694 *ft. Time required for rise* 23 *hours.*
Size of Hole 8¼ *inches. Date Sample Collected* 7-3-35

Sample No. 7 *County* Boone *District* Sherman
Company or Operator The Pure Oil Co.
Farm Federal Coal Co. *Farm Well No.* 73
Location Waters of Lavina Fork of Hopkins Fork, 6 mi. S. of Seth
Name of Sand Salt *Depth to top of Sand* 1200 *ft.*
Salt Water Horizon from 1255 *ft. to* 1305 *ft.*
Height Salt Water rose in Well 905 *ft. Time required for rise* 24 *hours.*
Size of Hole 8 *inches. Date Sample Collected* 5-7-35

Sample No. 8 *County* Boone *District* Sherman
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 758
Farm J. Q. Dickinson *Farm Well No.* 3
Location Little Elk of Big Coal River, 2 mi. N. W. of Whitesville.
Name of Sand Salt *Depth of top of Sand* 1500 *ft.*
Size of Hole 8¼ *inches. Date Sample Collected* 1934
Remarks Abandoned. (Salt Sand at 1500 ft. — 1670 ft. Slate to 1693′, and Salt Sand from 1693 — 1912 ft.)

Sample No. 9 *County* Boone *District* Sherman
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 783
Farm Federal Coal Co. *Farm Well No.* 53
Location Logan Fork of Hopkins Fork, 3 mi. S. 15° W. of Whitesville.
Name of Sand Salt *Depth to top of Sand* 1636 *ft.*
Salt Water Horizon from 1750 *ft. to* 1840 *ft.*
Size of Hole 6⅝ inches. *Date Sample Collected* 5-11-34
Remarks Hole full at 1680′ Sample from 1750′

Sample No. 10 *County* Boone *District* Scott
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 423
Farm V. G. Vande Linde
Location Waters of Rock Creek
Name of Sand Salt? *Depth to top of Sand* 295 *ft.*
Salt Water Horizon from 465 *ft. to* 475 *ft.*
Height Salt Water rose in Well to 125 ft. below surface.
Size of Hole 8¼ *inches. Date Sample Collected* 7-15-35

Sample No. 11 *County* Boone *District* Scott
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 403
Farm Cassingham Coal Land Co.
Location Near mouth of Bragg Fork of Horse Creek, 4 mi. N. W. of Danville.
Name of Sand Salt *Depth to top of Sand* 673 *ft.*
Salt Water Horizon from 715 *ft. to* 802 *ft.*
Height Salt Water roise in Well 685 *ft. Time required for rise* at once.
Size of Hole 8 *inches.* *Date Sample Collected* 6-7-35

Sample No. 12 *County* Boone *District* Scott
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 440
Farm Cassingham Coal Land Co. *Farm Well No.* 22
Location Horse Creek, 3½ mi. N. W. of Danville
Name of Sand Salt *Depth to top of Sand* 1263 *ft.*
Salt Water Horizon from 1408 *ft. to* 1500 *ft.*
Height Salt Water rose in Well 800 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 5-31-36
Remarks At 1408′ — ½ bailer per hour. At 1435 hole full.

Sample No. 13 *County* Boone *District* Scott
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 421
Farm S. M. Wheeler *Farm Well No.* 3
Location 4½ mi. S. W. of Danville on Pigeonroost Fork of Lick Creek
Name of Sand Salt *Depth to top of Sand* 1079 *ft.*
Salt Water Horizon from 1079 *ft. to* 1389 *ft.*
Date Sample Collected 7-1-35
Remarks Elevation of well 1156 ft. Sample is diluted with fresh water from 927 ft. and 886 ft. from upper sand.

Sample No. 14 *County* Boone *Ditsrict* Scott
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 402
Farm Sylvester Wheeler
Location Lick Creek, 4 mi. S. W. of Danville
Name of Sand Salt *Depth to top of Sand* 1024 *ft.*
Salt Water Horizon from 1110 *ft. to* 1343 *ft.*
Height Salt Water rose in Well 500 *ft. Time required for rise* 8 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 4-16-35

Sample No. 15 *County* Boone *District* Washington
Company or Operator Pond Fork Oil & Gas Co.
Farm Cole and Crane *Farm Well No.* 21
Location Hunters Branch, 6 mi. S. of Madison
Name of Sand Salt *Depth to top of Sand* 800 *ft.*
Salt Water Horizon from 875 *ft. to* 945 *ft.*
Height Salt Water rose in Well 450 *ft. Time required for rise* 12 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-22-35
Remarks Sample at 882 ft.

Sample No. 16 *County* Boone *District* Washington
Company or Operator Pond Fork Oil & Gas Co.
Farm Cole and Crane *Farm Well No.* 21
Location Hunters Branch, 6 mi. S. of Madison
Name of Sand Salt *Depth to top of Sand* 800 *ft.*
Salt Water Horizon from 875 *ft. to* 945 *ft.*
Height Salt Water rose in Well 450 *ft. Time required for rise* 12 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-24-35
Remarks Sample at 945 ft.

Sample No. 17 *County* Boone *District* Washington
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 791
Farm Henry Keadle
Location Little Coal River at Jeffery
Name of Sand Salt *Depth to top of Sand* 855 *ft.*
Salt Water Horizon from 970 *ft. to* .... *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 5-17-34
Remarks Salt Sand, 855 — 905 ft. Slate 905 — 912 ft.
Salt Sand 912 — 1240 ft.

Sample No. 18 *County* Boone *District* Washington
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 790
Farm Sidney White
Location Little Coal River, 1 mi. N. of Jeffery
Name of Sand Salt *Depth of top of Sand* 650 *ft.*
Salt Water Horizon from 669 *ft. to* 805 *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 5-13-34

Sample No. 19 *County* Boone *District* Washington
Company or Operator The Midway City Gas Co.
Farm Bias 15-acre tract *Farm Well No.* 1
Location Hewett Creek, 4 mi. S. W. of Jeffery
Name of Sand Salt
Salt Water Horizon from 1132 *ft. to* .... *ft.*
Height Salt Water rose in Well 60 *ft. Time required for rise* 1 *hour.*
Size of Hole 8 *inches.* *Date Sample Collected* 10-5-36

Sample No. 20 *County* Boone *District* Washington
Company or Operator Boone County Coal Corp. *Well No.* "E"
Farm Boone County Coal Corp.
Location Rockhouse of Spruce Fork, 1¼ mi. N. W. of Mifflin.
Name of Sand Salt *Depth to top of Sand* 1355 *ft.*
Salt Water Horizon from 1526 *ft. to* .... *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 10 *inches.* *Date Sample Collected* 11-11-35
Remarks Produced 33 gals. brine per hour. * Did not stop drilling to make this test.

Sample No. 21 *County* Boone *District* Washington
Company or Operator Boone County Coal Corp. *Well No.* "E"
Farm Boone County Coal Corp.
Location Rockhouse Creek of Spruce Fork, 1¼ mi. N. W. of Mifflin
Name of Sand Maxton *Depth to top of Sand* 1950 *ft.*
Salt Water Horizon from 1955 *ft. to* 1965 *ft.*
Height Salt Water rose in Well 865 *ft. Time required for rise* 5 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 11-22-35

Sample No. 22 *County* Boone *District* Washington
Company or Operator Pond Fork Oil & Gas Co.
Farm Cole and Crane *Farm Well No.* 22
Location Spruce Fork of Coal River, 3½ mi. S. of Madison
Name of Sand Salina *Depth to top of Sand* 4257 *ft.*
Salt Water Horizon from 4559 *ft. to* 4566 *ft.*
Height Salt Water rose in Well 500 *ft. Time required for rise* * *hours.*
Size of Hole 5 *inches.* *Date Sample Collected* 1-30-36
Remarks * Well shut down for 4 days, and water was in hole when drilling was resumed.

Sample No. 23 *County* Braxton *District* Salt Lick
Company or Operator Hope Natural Gas Co. *Well No.* 4044
Farm Hudson Mick
Location Rocky Fork, 4 mi. N. E. of Orlando
Name of Sand Big Injun *Depth to top of Sand* 2136 *ft.*
Height Salt Water rose in Well 500 *ft. Time required for rise* 6 *months.*
Size of Hole 6 *inches.* *Date Sample Collected* 3-16-1937
Remarks From a well producing gas.

Sample No. 24 *County* Cabell *District* Union
Company or Operator Sure Shot Torpedo Co.
Farm Clyde Porter *Farm Well No.* 1
Location Ohio River, 1¼ mi. N. of Lesage
Name of Sand Salt *Depth to top of Sand* 480 *ft.*
Salt Water Horizon from 480 *ft. to* 570 *ft.*
Height Salt Water rose in Well to Surface.
Size of Hole 8 *inches.* *Date Sample Collected* 10-1-35

Sample No. 25 *County* Cabell *District* Gideon
Company or Operator Eureka Gas Co. *Well No.* 4
Farm Hans Watt Realty Co. *Farm Well No.* 1
Location Roby Hollow, City of Huntington
Name of Sand Salt *Depth to top of Sand* 570 *ft.*
Salt Water Horizon from 630 *ft. to* 722 *ft.*
Height Salt Water rose in Well 400 *ft. Time required for rise* 24 *hours.*
Size of Hole 6½ *inches.* *Date Sample Collected* 4-4-36

Sample No. 26 *County* Cabell *District* Guyandot
Company or Operator Not Known
Farm Cole & Crane 40-acre farm *Farm Well No.* 1
Location Gunpowder Branch, 1¼ mi. S. W. of Guyandot
Name of Sand Big Dunkard *Depth to top of Sand* 160 *ft.*
Height Salt Water rose in Well To Surface.
Date Sample Collected 7-8-36
Remarks Artesian, flowing since 1885-1890. Depth of Berea Sand, 1900 ft. See Detailed Report for Cabell, Wayne and Lincoln Counties (1913), West Virginia Geological Survey.

Sample No. 27 *County* Cabell *District* McComas
Company or Operator Kentucky W. Va. Gas Co. *Well No.* 34
Farm A. D. Bledsoe
Location Tom Creek, 1.3 mi. east from Roach
Name of Sand Salt *Depth to top of Sand* 1230 *ft.*
Salt Water Horizon from 1250 *ft. to* .... *ft.*
Remarks No further data supplied.

Sample No. 28 *County* Cabell *District* McComas
Company or Operator Hillcrest Natural Gas Co.
Farm A. J. Gill *Farm Well No.* 1
Location Tyler Creek, ¾ mi. N. E. of Salk Rock
Name of Sand Salt *Depth to top of Sand* 925 *ft.*
Salt Water Horizon from 970 *ft. to* 980 *ft.*
Height Salt Water rose in Well 700 *ft.* *Time required for rise* 4 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 4-27-36

Sample No. 29 *County* Cabell *District* McComas
Company or Operator Fairfax Oil & Gas Co. and Leonard Paugh
Farm Leonard Paugh *Farm Well No.* 3
Location Smith Creek 1½ mi. S. W. of Salt Rock
Name of Sand Salt *Depth to top of Sand* 875 *ft.*
Salt Water Horizon from 950 *ft. to* 953 *ft.*
Height Salt Water rose in Well 750 *ft.* *Time required for rise* 8 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 2-6-36

Sample No. 30 *County* Cabell *District* McComas
Company or Operator Pratt Gas Co.
Farm Adaline Pratt *Farm Well No.* 3
Location Near Salt Rock
Name of Sand Salt?
Remarks No other data supplied.

PLATE IX.—Old Bromine Still, Malden, W. Va.—This stone, the upper half of one of the earliest bromine stills, is hand-dressed; the under side has a hemispherical cavity. This stone rested on a similar stone, also hollowed out by hand. Vent holes for brine, acid and steam are drilled through top of stone in picture. The joints were sealed with clay.—Photo by Hoskins, 1934.

Sample No. 31 *County* Cabell *District* Guyandot
Company or Operator United Fuel Gas Co. *Well No.* 4390
Farm J. W. Starkey
Location Pats Branch, ¼ mi. S. of Guyandot
Name of Sand Big Injun and Salt *Depth to top of Sand* 1090 *ft.*
Salt Water Horizon from 1580 *ft. to* 1596 *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 8-13-34
Remarks Hole full of water at 1090 - 1694 ft.
Salt Sand water came from 1090 ft.

Sample No. 32 *County* Cabell *District* Union
Company or Operator Sure Shot Torpedo Co.
Farm Clyde Porter *Farm Well No.* 1
Location Ohio River, 1¼ mi. N. of Lesage
Name of Sand Big Injun *Depth to top of Sand* 1290 *ft.*
Salt Water Horizon from 1290 *ft. to* 1470 *ft.*
Height Salt Water rose in Well to Surface. *Time required for rise* at once
Date Sample Collected 10-7-35
Remarks Sample from 1290 - 1470 ft.

Sample No. 33 *County* Cabell *District* Gideon
Company or Operator C. C. Wolfe — Natural Gas Corp.
Farm Whittaker *Farm Well No.* 4
Location City Limits of Huntington
Name of Sand Maxton *Depth to top of Sand* 1185 *ft.*
Salt Water Horizon from 1195 *ft. to* 1232 *ft.*
Height Salt Water rose in Well hole full.
Size of Hole 8 *inches.* *Date Sample Collected* 2-10-37
Remarks Mixed with Salt Sand brine.

Sample No. 34 *County* Cabell *District* McComas
Company or Operator Sue Gas Co.
Farm H. S. Fraley *Farm Well No.* 3
Name of Sand Big Injun *Depth to top of Sand* 1330 *ft.*
Salt Water Horizon from 1330 *ft. to* 1337 *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 12-10-35

Sample No. 35 *County* Cabell ? *District* ?
Company or Operator Dave Fox, Huntington
Name of Sand Big Injun ?
Remarks Operator supplied no data.

Sample No. 36 *County* Cabell *District* McComas
Company or Operator United Fuel Gas Co. *Well No.* 4671
Farm J. W. Gill
Location Tyler Creek, 1 mi. E. of Salt Rock
Name of Sand Big Injun *Depth to top of Sand* 1352 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* Jan. 1937
Remarks Gas at 1352 ft. Well completed Aug. 16, 1936, and went to salt water Jan. 1937.

Sample No. 37 *County* Cabell *District* McComas
Company or Operator DeJarnett Gas Co.
Farm J. H. DeJarnett
Location Guyandot River near Salt Rock 18 mi. E. of Huntington
Name of Sand Big Injun *Depth to top of Sand* 1418 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 2-13-37

Sample No. 38 *County* Calhoun *District* Sheridan
Company or Operator L. B. Carroll
Farm L. B. Carroll
Location Little Kanawha, 5 mi. W. of Grantsville
Name of Sand Moundsville *Depth to top of Sand* 62 *ft.*
Salt Water Horizon from 62 *ft. to* 68 *ft.*
Height Salt Water rose in Well 16 *ft.* *Time required for rise* * *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 2-24-37
Remarks This is the only sample obtained from this horizon. * Rate of flow 6 gal. per minute.

Sample No. 39 *County* Calhoun *District* Sherman
Company or Operator Logan McDonald
Farm Logan McDonald
Location Sycamore Creek, 6 mi. S. of Grantsville
Name of Sand 1st Salt *Depth to top of Sand* 1465 *ft.*
Salt Water Horizon from 1470 *ft. to* .... *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 11-20-35

Sample No. 40 *County* Calhoun *District* Sheridan
Company or Operator Richter Oil Co.
Farm Z. O. Cooper *Farm Well No.* 6
Location Threemile Run, 2 mi. E. of Hartley
Name of Sand Salt *Depth to top of Sand* 1690 *ft.*
Salt Water Horizon from 1803 *ft. to* 1806 *ft.*
Height Salt Water rose in Well 75 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 6 *inches.* *Date Sample Collected* 7-8-36

Sample No. 41 *County* Calhoun *District* Sheridan
Company or Operator Richter Oil Co.
Farm Emily McCray Heirs
Location Threemile Run, 2 mi. east of Brohard *Farm Well No.* 2
Name of Sand Salt *Depth to top of Sand* 1740 *ft.*
Salt Water Horizon from 1832 *ft. to* 1835 *ft.*
Height Salt Water rose in Well 30 *ft. Time required for rise* 24 *hours.*
Size of Hole 6 *inches.* *Date Sample Collected* 9-14-35

Sample No. 42 *County* Calhoun *District* Lee
Company or Operator Everett Starcher
Farm Tom Campbell
Location 1¼ mi. S. of Creston *Farm Well No.* 2
Name of Sand Salt *Depth to top of Sand* 1402 *ft.*
Salt Water Horizon from 1402 *ft. to* ------- *ft.*
Height Salt Water rose in Well 1402 *ft.*
Date Sample Collected 1937

Sample No. 43 *County* Calhoun *District* Lee
Company or Operator Mud Lick Oil & Gas Co.
Farm G. W. Bennington *Well No.* 3-11
Location Beech Run, 3 mi. S. W. of Arnoldsburg
Name of Sand Salt *Depth to top of Sand* 1710 *ft.*
Salt Water Horizon from 1778 *ft. to* 1789 *ft.*
Height Salt Water rose in Well 920 *ft. Time required for rise* 4½ *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 7-10-35

Sample No. 44 *County* Calhoun *District* Sheridan
Company or Operator W. A. Bickerstaff
Farm W. M. Cooper
Location Near corner of Wirt, Ritchie and Calhoun lines
Name of Sand Maxton *Depth to top of Sand* 1885 *ft.*
Salt Water Horizon from 1990 *ft. to* 1998 *ft.*
Size of Hole 6 *inches.* *Date Sample Collected* 5-24-34
Remarks This well produces oil. Will pump 100 bbls. brine in 4½ hours after a 24-hour shut-down.

Sample No. 45 *County* Calhoun *District* Sherman
Company or Operator Logan McDonald
Farm Logan McDonald
Location Sycamore Creek, 6 mi. S. of Grantsville *Farm Well No.* 1
Name of Sand Maxton *Depth to top of Sand* 1967 *ft.*
Salt Water Horizon from 2025 *ft. to* 2144 *ft.*
Height Salt Water rose in Well 1700 *ft. Time required for rise* 24 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 12-7-35

Sample No. 46 *County* Calhoun *District* Sherman
Company or Operator McIntosh & Grimm
Farm W. E. Stump *Farm Well No.* 1
Location Three Forks of Little Bear Fork, 8 mi. E. of Arnoldsburg
Name of Sand Maxton *Depth to top of Sand* 1835 *ft.*
Salt Water Horizon from 1875 *ft. to* 1885 *ft.*
Height Salt Water rose in Well 1675 *ft.* *Time required for rise* 48 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 2-11-35

Sample No. 47 *County* Clay *District* Henry
Company or Operator Virginian Gasoline & Oil Company *Well No.* 4593
Farm Brown, Goshorn, Swan & Geary
Location Waters of Summers Fork, 1 mi. W. of Ovapa
Name of Sand Salt *Depth to top of Sand* 1260 *ft.*
Salt Water Horizon from 1460 *ft. to* 1465 *ft.*
Height Salt Water rose in Well 300 *ft.* *Time required for rise* 2 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 1-11-36

Sample No. 48 *County* Clay *District* Henry
Company or Operator Virginian Gasoline & Oil Company *Well No.* 4592
Farm Brown, Goshorn, Swan & Geary
Location Waters of Summers Fork, 1 mi. W. of Ovapa P. O.
Name of Sand Salt *Depth to top of Sand* 1145 *ft.*
Salt Water Horizon from 1200 *ft. to* 1230 *ft.*
Height Salt Water rose in Well 500 *ft.* *Time required for rise* 1 *hour.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 1-4-36

Sample No. 49 *County* Clay *District* Union
Company or Operator Reed, Wheeler & Young
Farm Goshorn Heirs *Farm Well No.* 22
Location Waters of Little Sycamore Creek, 8 mi. S. W. of Clay
Name of Sand Salt *Depth to top of Sand* 1135 *ft.*
Salt Water Horizon from 1295 *ft. to* 1500 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 10-16-36
Remarks * 6½ barrels per hour.

Sample No. 50 *County* Clay *District* Henry
Company or Operator South Penn Oil Co.
Farm O. D. Stockly *Farm Well No.* 107
Name of Sand Salt Sand *Depth to top of Sand* 1250 *ft.*
Salt Water Horizon from 1445 *ft. to* 1465 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 10 *inches.* *Date Sample Collected* August 1934
Remarks * Salt Sand 1250′-1365′; break 1365′-1390′; sand 1390′-1590′; water 1445′ 10 bailers per hour in 10 inch. Hole full of water at 1465′.

Sample No. 51 *County* Doddridge *District* Central
Company or Operator Hope Construction & Refining Co. *Well No.* 983
Farm Olive Ellifritt
Location Gun Run, 1 mi. S. of Greenwood
Name of Sand Maxton *Depth to top of Sand* 1897 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 3-16-37
Remarks This well produces gas.

Sample No. 52 *County* Doddridge *District* Grant
Company or Operator Hope Construction & Refining Co. *Well No.* 143
Farm R. L. Roberts
Location ¼ mi. N. of Brush Run and 7½ mi. N. of West Union
Name of Sand Maxton *Depth to top of Sand* 2060 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 3-12-37
Remarks This well produces gas.

Sample No. 53 *County* Doddridge *District* Grant
Company or Operator Hope Natural Gas Company *Well No.* 4544
Farm E. Smith
Location 6 mi. N. W. of Salem on Big Flint
Name of Sand Big Injun *Depth to top of Sand* 1984 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* Spring 1937
Remarks Record shows no salt water in the Big Injun, but does show water at a depth of 1535 to 1565 in the 2nd Salt Sand. Produces gas.

Sample No. 54 *County* Doddridge *District* McClellan
Company or Operator Hope Natural Gas Co. *Well No.* 7469
Farm Smith & Wilson
Location Big Battle Creek, 8 mi. N. W. of Salem
Name of Sand Big Injun *Depth to top of Sand* 1896 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* Feb. 1937
Remarks Record shows water at a depth of 1765 ft. (Maxton). Well drilled by Godfrey L. Cabot, Inc. Well produces gas.

Sample No. 55 *County* Doddridge *District* McClellan
Company or Operator Hope Natural Gas Company *Well No.* 7481
Farm J. M. Mayfield
Location Big Battle Creek, 10 mi. N. W. from Salem
Name of Sand Big Injun *Depth to top of Sand* 1870 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* Spring 1937
Remarks This well produces gas. Record shows that salt water was found at 1430 ft.

Sample No. 56 *County* Doddridge *District* Grant
Company or Operator Hope Natural Gas Co. *Well No.* 7753
Farm W. A. Lawrence
Location Morgan Run, 10 mi. W. from Salem
Name of Sand Big Injun *Depth to top of Sand* 1964 *ft.*
Date Sample Collected Spring 1937
Remarks Record shows water at 1460 ft. in 3rd Salt Sand. Well produces gas.

Sample No. 57 *County* Doddridge *District* Central
Company or Operator Hope Construction & Refining Co. *Well No.* 104
Farm E. M. Jackson
Location ½ mi. W. of Long Run, 8 mi. N. W. of West Union
Name of Sand Squaw *Depth to top of Sand* 1938 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 3-15-37
Remarks This well produces gas.

Sample No. 58 *County* Doddridge *District* Grant
Company or Operator Manufacturers Light & Heat Co. *Well No.* 1397
Farm R. B. Ross
Location 7 mi. W. from Salem on Buckeye Creek
Name of Sand Squaw *Depth to top of Sand* 1908 *ft.*
Size of Hole 6 *inches.* *Date Sample Collected* Spring 1937
Remarks This is a gas well.

Sample No. 59 *County* Doddridge *District* McClellan
Company or Operator Clifton Oil & Gas Company
Farm Dallas Powell *Farm Well No.* 1
Location Israel Fork on Waters of Big Flint, 1 mi. N. E. of West Union
Name of Sand Big Dunkard *Depth to top of Sand* 1168 *ft.*
Salt Water Horizon from 1168 *ft. to* .... *ft.*
Height Salt Water rose in Well 400 *ft.* *Time required for rise* 3 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* November 1935

Sample No. 60 *County* Gilmer *District* DeKalb
Company or Operator The McCall Drilling Co. *Well No.* 97
Farm Wigner & Craddock *Farm Well No.* 2
Location Tanner Creek, 1½ mi. E. of White Pine
Name of Sand Maxton *Depth to top of Sand* 1760 *ft.*
Salt Water Horizon from 1775 *ft. to* 1800 *ft.*
Height Salt Water rose in Well 1200 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 6-25-35

Sample No. 61 *County* Gilmer *District* DeKalb
Company or Operator Hope Natural Gas Co. *Well No.* 7004
Farm Roseana Reaser
Location Upper Big Run of Sinking Creek, 1 mi. S. W. of Lucerne
Name of Sand Maxton *Depth to top of Sand* 1515 *ft.*
Height Salt Water rose in Well 100 *ft.* *Time required for rise* 1 *week.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 4-7-37
Remarks Well produces gas.

Sample No. 62 *County* Gilmer *District* Glenville
Company or Operator Hope Natural Gas Co. *Well No.* 6350
Farm Minerva Stump
Location Big Ellis, 3 mi. E. of Baldwin
Name of Sand Big Injun *Depth to top of Sand* 1848 *ft.*
Height Salt Water rose in Well 35 *ft.* *Time required for rise* 7 *days.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 3-22-37
Remarks This well produces gas.

Sample No. 63 *County* Gilmer *District* Troy
Company or Operator Hope Natural Gas Co. *Well No.* 5896
Farm Porter Maxwell
Location Crane Run of Big Cove, 2½ mi. N. E. of Coxs Mills
Name of Sand Big Injun *Depth to top of Sand* 2167 *ft.*
Height Salt Water rose in Well 50 *ft.* *Time required for rise* 14 *days.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 3-23-37
Remarks This well produces gas.

Sample No. 64 *County* Harrison *District* Eagle
Company or Operator V. L. & J. H. Hornor
Farm Ernest Robinson *Farm Well No.* 1
Location Jones Run, 2½ mi. W. of Lumberport
Name of Sand 1st Salt *Depth to top of Sand* 687 *ft.*
Salt Water Horizon from 715 *ft. to* 716 *ft.*
Height Salt Water rose in Well 550 *ft.* *Time required for rise* 1 *hour.*
Size of Hole 10 *inches.* *Date Sample Collected* 1-26-37

Sample No. 65 *County* Harrison *District* Eagle
Company or Operator Lumberport & Shinnston Gas Co.
Farm Jim Robinson *Farm Well No.* 1
Location 7 mi. S. W. of Lumberport
Name of Sand 2nd Salt *Depth to top of Sand* 760 *ft.*
Salt Water Horizon from 760 *ft. to* 895 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 10 *inches.* *Date Sample Collected* 8-4-36
Remarks * 350 gal. per hour of brine.

Sample No. 66 *County* Harrison *District* Eagle
Company or Operator Lumberport & Shinnston Gas Co.
Farm Guy Harbert *Farm Well No.* 3
Location Reese Run of Jones Run, 3 mi. W. of Lumberport
Name of Sand 2nd Salt *Depth to top of Sand* 840 *ft.*
Salt Water Horizon from 845 *ft. to* 855 *ft.*
Height Salt Water rose in Well 600 *ft. Time required for rise* 4 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 8-21-36

Sample No. 67 *County* Kanawha *District* Washington
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 453
Farm Siler Coal Land Co.
Location Little Coal River
Name of Sand 1st Salt *Depth to top of Sand* 804 *ft.*
Salt Water Horizon from 915 *ft. to* 960 *ft.*
Height Salt Water rose in Well 530 *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 10-10-36

Sample No. 68 *County* Kanawha *District* Elk
Company or Operator Columbian Carbon Co. *Well No.* GW-339
Farm W. L. Burdette *Farm Well No.* 1
Location Lick Branch of Little Sandy Creek, 14 mi. from Charleston
Name of Sand Salt *Depth to top of Sand* 1011 *ft.*
Salt Water Horizon from 1120 *ft. to* 1140 *ft.*
Height Salt Water rose in Well 700 *ft. Time required for rise* 7⅓ *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 10-30-35

Sample No. 69 *County* Kanawha *District* Elk
Company or Operator Columbian Carbon Co. *Well No.* GW-337
Farm Copenhaver Heirs *Farm Well No.* 2
Location Lick Branch of Little Sandy Creek
Name of Sand Salt *Depth to top of Sand* 975 *ft.*
Salt Water Horizon from 995 *ft. to* 1015 *ft.*
Height Salt Water rose in Well 800 *ft. Time required for rise* 6¼ *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 10-17-35

Sample No. 70 *County* Kanawha *District* Elk
Company or Operator Sandy-Elk Oil & Gas Co.
Farm Moles *Farm Well No.* 1
Location Little Sandy Creek of Elk River, 9 mi. N. 45° E. from Charleston
Name of Sand Salt *Depth to top of Sand* 880 *ft.*
Salt Water Horizon from 906 *ft. to* 1000 *ft.*
Height Salt Water rose in Well 700 *ft. Time required for rise* 8 *hrs.* 10 *min.*
Size of Hole 10 *inches.* *Date Sample Collected* 6-24-36

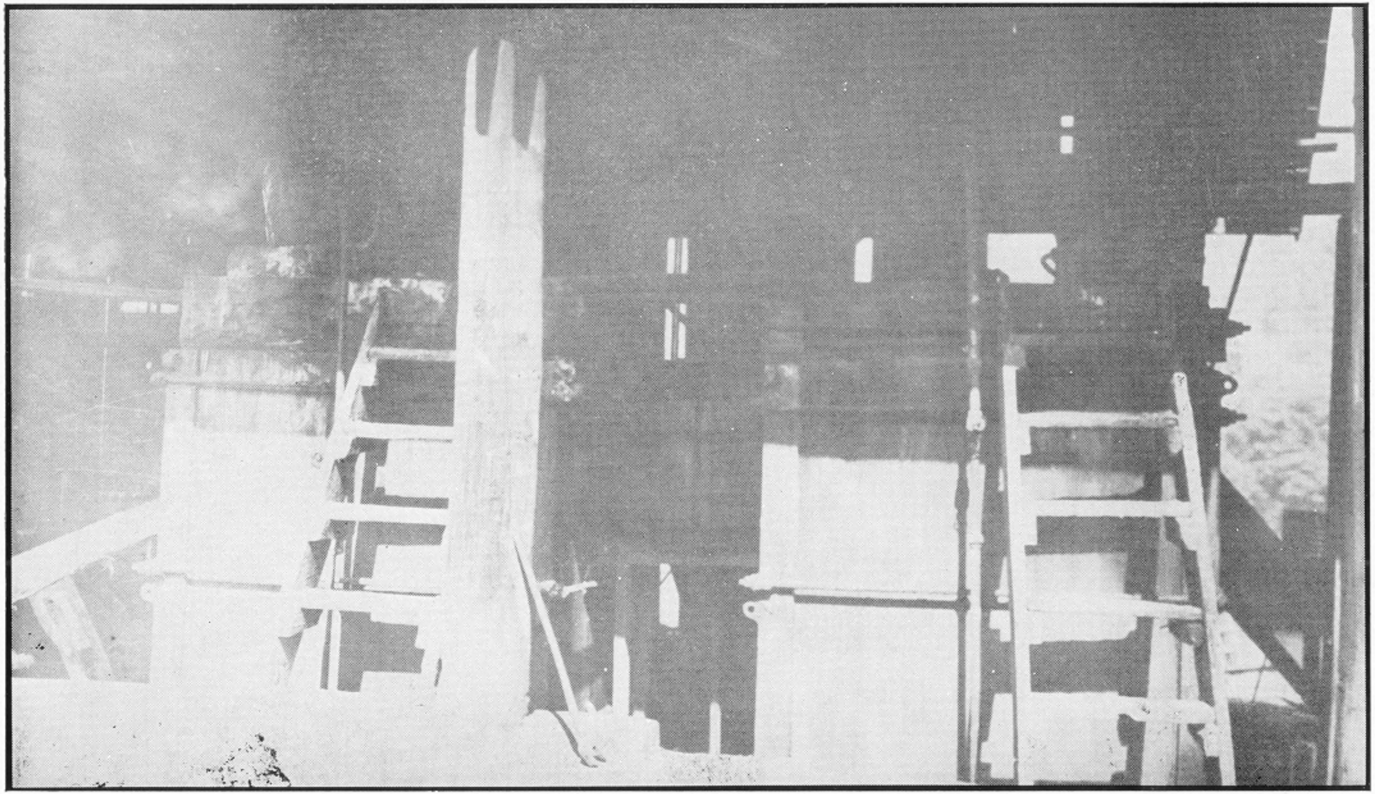


PLATE X.—New Bromine Stills at Malden, W. Va.—These are fashioned from slabs of sandstone bound together with iron clamps. Asbestos is used to pack the joints.--Photo by Hoskins, 1934.

Sample No. 71 *County* Kanawha *District* Elk
Company or Operator Columbian Carbon Co. *Well No.* GW-327
Farm W. F. Copenhaver Heirs *Farm Well No.* 1
Location Lick Branch of Little Sandy, 3 mi. N. of Copenhaver
Name of Sand Salt *Depth to top of Sand* 859 *ft.*
Salt Water Horizon from 895 *ft. to* 945 *ft.*
Height Salt Water rose in Well 850 *ft.* *Time required for rise* 6 *hours.*
Size of Hole 13 *inches.* *Date Sample Collected* 6-12-35

Sample No. 72 *County* Kanawha *District* Elk
Company or Operator Yoak Oil and Gas Co.
Farm Goshorn Heirs *Farm Well No.* 2
Location 0.6 mi. S. of Elk River, 1.1 mi. S. E. of Big Chimney
Name of Sand Salt *Depth to top of Sand* 630 *ft.*
Salt Water Horizon from 800 *ft. to* 805 *ft.*
Height Salt Water rose in Well 600 *ft.* *Time required for rise* * *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 4-13-36
Remarks * Hole already full of water.

Sample No. 73 *County* Kanawha *District* Malden
Company or Operator J. Q. Dickinson Salt Co. *Well No.* Upper
Farm J. Q. Dickinson
Location Malden, W. Va.
Name of Sand Salt *Depth to top of Sand* * *ft.*
Date Sample Collected 2-11-37
Remarks Well averages 25 gal. per minutue, 5.0° - 5.7° Bé.
* This is such an old well that no records are available, but produces brine used in salt plant.

Sample No. 74 *County* Kanawha *District* Malden
Company or Operator J. Q. Dickinson Salt Co. *Well No.* Gas
Farm J. Q. Dickinson
Location Malden, W. Va.
Name of Sand Salt *Depth to top of Sand* * *ft.*
Date Sample Collected 2-11-37
Remarks Well pumps 15 to 25 gal. per minute, 8½° Bé.
* This is such an old well that no records are available, but produces brine used in salt plant.

Sample No. 75 *County* Kanawha *District* Malden
Company or Operator J. Q. Dickinson Salt Co. *Well No.* Quincy
Farm J. Q. Dickinson
Location Malden, W. Va.
Name of Sand Salt and Big Injun *Depth to top of Big Injun Sand* 1700 *ft.*
Salt Water Horizon from 1000 *ft. to* 1700 *ft.*
Date Sample Collected 2-11-37
Remarks Well pumps 20 to 30 gal. per minuute, 10½° Bé.
Well produces brine used in salt plant. Oldest well at plant.
Was recently deepened to Big Injun; both sands utilized.

Sample No. 76 *County* Kanawha *District* Malden
Company or Operator Columbian Carbon Co. *Well No.* GW-338
Farm Canterbury, Dearien et al.
Location Spring Fork of Campbell Creek, 1.9 mi. E. of Malden
Name of Sand Salt *Depth to top of Sand* 652 *ft.*
Salt Water Horizon from 652 *ft. to* 775 *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 9-?-35
Remarks Worthless as a brine.

Sample No. 77 *County* Kanawha *District* Malden
Company or Operator South Penn Oil Co.
Farm Kate C. Scott *Farm Well No.* 2
Location Right Fork of Coal Fork of Campbell Creek, 2¼ mi. E. of Reed.
Name of Sand Salt *Depth to top of Sand* 640 *ft.*
Salt Water Horizon from 640 *ft. to* 697 *ft.*
Height Salt Water rose in Well 220 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 2-4-36

Sample No. 78 *County* Kanawha *District* Malden
Company or Operator Columbian Carbon Co. *Well No.* GW-328
Farm W. D. Lewis *Farm Well No.* 14
Location Campbell Creek, 3 mi. E. of Dana
Name of Sand Salt *Depth to top of Sand* 504 *ft.*
Salt Water Horizon from 650 *ft. to* 665 *ft.*
Height Salt Water rose in Well 500 *ft.* *Time required for rise* 2 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 6-4-35

Sample No. 79 *County* Kanawha *District* Loudon
Company or Operator Columbian Carbon Co. *Well No.* GW-334
Farm Kanawha City Co. *Farm Well No.* 12
Location Headwaters of Rush Creek, 1½ mi. W. of Malden Station
Name of Sand Salt *Depth to top of Sand* 734 *ft.*
Salt Water Horizon from 734 *ft to* 878 *ft.*
Height Salt Water rose in Well 450 *ft.* *Time required for rise* 10 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 6-29-35

Sample No. 80 *County* Kanawha *District* Loudon
Company or Operator United Carbon Co.
Farm C. C. Dickinson *Farm Well No.* 1
Location At head of N. W. Branch of Rush Creek, 2.2 mi. S. W. of Malden
Name of Sand Salt *Depth to top of Sand* 990 *ft.*
Salt Water Horizon from * *ft.*
Height Salt Water rose in Well 775 *ft.* *Time required for rise* 1½ *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 3-10-36
Remarks * 1st water at 990; hole full at 1075; this sample at 1105′

Sample No. 81 *County* Kanawha *District* Malden
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 828
Farm Plus R. Levi *Farm Well No.* 1
Location Along hill north of road between Malden and Heskett
Name of Sand Salt *Depth to top of Sand* 645 *ft.*
Height Salt Water rose in Well 400 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 5-18-35

Sample No. 82 *County* Kanawha *District* Malden
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 828
Farm Plus R. Levi *Farm Well No.* 1
Location Along hill north of road between Malden and Heskett
Name of Sand Salt *Depth to top of Sand* 645 *ft.*
Salt Water Horizon from 720 *ft. to* 910 *ft.*
Height Salt Water rose in Well 600 *ft.* *Time required for rise* 36 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 5-20-35

Sample No. 83 *County* Kanawha *District* Malden
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 828
Farm Plus R. Levi *Farm Well No.* 1
Location Along hill north of road between Malden and Heskett
Name of Sand Salt *Depth to top of Sand* 1050 *ft.*
Height Salt Water rose in Well 550 *ft.* *Time required for rise* 36 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 5-23-35
Remarks Nos. 81, 82, and 83 were taken from the same well as drilling progressed to ascertain if brine changed with depth.

Sample No. 84 *County* Kanawha *District* Loudon
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 827
Farm Edgewood Realty Co. *Farm Well No.* 1
Location Middle Fork of Davis Creek, 1.17 mi. S. 13° W. of mouth of Bays Branch
Name of Sand Salt *Depth to top of Sand* 670 *ft.*
Salt Water Horizon from 670 *ft. to* 680 *ft.*
Height Salt Water rose in Well 370 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 4-18-35

Sample No. 85 *County* Kanawha *District* Cabin Creek
Company or Operator The Winifrede Co. *Well No.* 16
Farm The Winifrede Co.
Location Log Camp of Fields Creek, 4 mi. S. E. of Marmet
Name of Sand Salt *Depth to top of Sand* 725 *ft.*
Salt Water Horizon from 780 *ft. to* 800 *ft.*
Height Salt Water rose in Well 550 *ft.* *Time required for rise* 9 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 1-24-35

Sample No. 86 *County* Kanawha *District* Cabin Creek
Company or Operator The Winifrede Co.
Farm McConihay *Farm Well No.* 23
Location Winifrede Branch of Kanawha River, 1.45 mi. S. of Quincy P. O.
Name of Sand Salt *Depth to top of Sand* 1415 *ft.*
Salt Water Horizon from 1445 *ft. to* 1470 *ft.*
Height Salt Water rose in Well 500 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 10-2-36

Sample No. 87 *County* Kanawha *District* Cabin Creek
Company or Operator The Pure Oil Co.
Farm Williams Coal Co. *Farm Well No.* 262
Location Coal Fork of Cabin Creek, 4¼ mi. S. W. of Dawes
Name of Sand Salt *Depth to top of Sand* 1702 *ft.*
Salt Water Horizon from 1790 *ft. to* 1800 *ft.*
Height Salt Water rose in Well 870 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 4-16-36

Sample No. 88 *County* Kanawha *District* Cabin Creek
Company or Operator The Pure Oil Co.
Farm Williams Coal Co. *Farm Well No.* **263**
Location Coal Fork of Cabin Creek, 4½ mi. S. W. of Dawes
Name of Sand Salt *Depth to top of Sand* 1600 *ft.*
Salt Water Horizon from 1700 *ft. to* 1713 *ft.*
Height Salt Water rose in Well 700 *ft.* *Time required for rise* 30 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 4-20-36

Sample No. 89 *County* Kanawha *District* Cabin Creek
Company or Operator Pure Oil Co.
Farm LaFollette, Robson & Prichard "C" tract *Farm Well No.* C-3
Location Coal Fork of Cabin Creek, 2¼ mi. S. of Mt. Hope
Name of Sand Salt *Depth to top of Sand* 1231 *ft.*
Salt Water Horizon from 1380 *ft. to* 1390 *ft.*
Height Salt Water rose in Well 980 *ft.* *Time required for rise* 7½ *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 6-25-35

Sample No. 90 *County* Kanawha *District* Cabin Creek
Company or Operator The Winifrede Co. *Well No.* 16
Farm The Winifrede Co.
Location Log Camp of Fields Creek, 4 mi. S. E. of Marmet
Name of Sand Maxton *Depth to top of Sand* 1350 *ft.*
Salt Water Horizon from 1380 *ft. to* 1390 *ft.*
Height Salt Water rose in Well 1100 *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 2-2-35

Sample No. 91 *County* Kanawha *District* Loudon
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 433
Farm L. A. Christy *Farm Well No.* 2
Location Kanawha River, 4½ mi. S. E. of Charleston
Name of Sand Big Lime *Depth to top of Sand* 1030 *ft.*
Salt Water Horizon from 1136 *ft. to* 1200 *ft.*
Height Salt Water rose in Well 360 *ft.* *Time required for rise* * *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 1936
Remarks * 1136′ - 330 gal. per hr. 1153′ - hole filled to 550′; 1182′ - hole filled to 360′.

Sample No. 92 *County* Kanawha *District* Big Sandy
Company or Operator United Carbon Co. *Well No.* 147
Farm J. A. and M. F. Osborne *Farm Well No.* 15
Location Mudlick Fork of Leatherwood Creek, 3.4 mi. S. W. of Clendenin
Name of Sand Oriskany *Depth to top of Sand* 5763 *ft.*
Salt Water Horizon from 5777 *ft. to* .... *ft.*
Height Salt Water rose in Well 500 *ft.* *Time required for rise* 20 *hours.*
Size of Hole 5-3/16 *inches.* *Date Sample Collected* 9-28-36
Remarks Well is 2⅝ mi. up Leatherwood Creek of Elk River.

Sample No. 93 *County* Kanawha *District* Malden
Company or Operator Godfrey L. Cabot, Inc. *Well No.* 863
Farm Wm. B. Tompkins Heirs *Farm Well No.* 8
Location Spring Fork, 3¼ mi. S. 40° E. of Malden
Name of Sand Oriskany *Depth to top of Sand* 5067 *ft.*
Salt Water Horizon from 5086 *ft. to* 5089 *ft.*
Height Salt Water rose in Well 39 *ft.* *Time required for rise* 5 *hours.*
Size of Hole 4¾ *inches.* *Date Sample Collected* 8-20-36

Sample No. 94 *County* Kanawha *District* Malden
Company or Operator Owens, Libbey-Owens Gas Dept. *Well No.* 365
Farm Caroline Q. Crockett *Farm Well No.* 7
Location 3.1 mi. E. of Heskett
Name of Sand Oriskany *Depth to top of Sand* 5249 *ft.*
Salt Water Horizon from 5249 *ft. to* .... *ft.*
Height Salt Water rose in Well No data.
Size of Hole 5 *inches.* *Date Sample Collected* 1936

Sample No. 95 *County* Kanawha *District* Elk
Company or Operator Benedum & Trees Oil Co.
Farm Mary C. Wingfield *Farm Well No.* 1
Name of Sand Oriskany?
Date Sample Collected 1936
Remarks Drip sample. Operator preferred not to release data requested.

Sample No. 96 *County* Kanawha *District* Elk
Company or Operator United Fuel Gas Co. (Submitted by) *Drip No.* 221
Location Aarons Fork
Name of Sand Oriskany *Depth to top of Sand* 5020 *ft.*
Salt Water Horizon from 5032 *ft. to* 5035 *ft.*
Size of Hole 5 *inches.* *Date Sample Collected* Jan. 1937
Remarks Drip sample. Operator preferred not to release data requested.

Sample No. 97 *County* Kanawha *District* Elk
Company or Operator Hand and Smith *Well No.* 5
Farm Matheny and Wertz (Gellatin Mining Co.)
Location Cooper Creek Island, Elk River
Name of Sand Newburg? *Depth to top of Sand* 5533 *ft.*
Height Salt Water rose in Well 25 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 5-12-36

Sample No. 98 *County* Lewis *District* Freemans Creek
Company or Operator Carnegie Natural Gas Co. *Well No.* 656
Farm J. S. Davis *Farm Well No.* 1
Location ½ mi. E. of Vadis on Walnut Fork
Name of Sand Dunkard?
Salt Water Horizon from 519 *ft. to* 527 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 2-8-37
Remarks Oil and water produced with gas.

Sample No. 99 *County* Lewis *District* Freemans Creek
Company or Operator Reserve Gas Co. *Well No.* 825
Farm James Jarvis
Location Polk Creek, 5 mi. W. of Weston
Name of Sand Salt *Depth to top of Sand* 1470 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 3-11-37
Remarks This well produces gas.

Sample No. 100 *County* Lewis *District* Freemans Creek
Company or Operator Hope Natural Gas Co. *Well No.* 4435
Farm Cullen Heirs
Location Back Fork, 3 mi. N. of Alum Bridge
Name of Sand Big Injun *Depth to top of Sand* 1855 *ft.*
Height Salt Water rose in Well 120 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 4-7-37
Remarks This well produces gas.

Sample No. 101 *County* Lincoln *District* Sheridan
Company or Operator Eustace Gas Co.
Farm Owen Bias *Farm Well No.* 1
Location Twomile Creek, 1 mi. E. of West Hamlin
Name of Sand Salt *Depth to top of Sand* 860 *ft.*
Salt Water Horizon from 900 *ft. to* 980 *ft.*
Height Salt Water rose in Well 600 *ft.* *Time required for rise* 6 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 10-15-36

Sample No. 102 *County* Lincoln *District* Sheridan
Company or Operator Kanawha Gas & Utilities Co. *Well No.* 201
Farm R. R. Sloan *Farm Well No.* 1
Location Onemile Creek, 3 mi. S. of West Hamlin
Name of Sand Salt *Depth to top of Sand* 575 *ft.*
Salt Water Horizon from 625 *ft. to* 635 *ft.*
Height Salt Water rose in Well 585 *ft.* *Time required for rise* 12 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 5-27-35

Sample No. 103 *County* Lincoln *District* Carroll
Company or Operator Kanawha Gas & Utilities Co. *Well No.* 202
Farm George A. Black
Location Trace Creek, 4 mi. N. E. of Hamlin
Name of Sand Salt *Depth to top of Sand* 1190 *ft.*
Salt Water Horizon from 1190 *ft. to* 1200 *ft.*
Height Salt Water rose in Well 600 *ft.* *Time required for rise* 10 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 1935
Remarks This is a sample of the upper part of the Salt Sand. (See below)

Sample No. 104 *County* Lincoln *District* Carroll
Company or Operator Kanawha Gas & Utilities Co. *Well No.* 202
Farm George A. Black
Location Trace Creek, 4 mi. N. E. of Hamlin
Name of Sand Salt *Depth to top of Sand* 1190 *ft.*
Salt Water Horizon from 1215 *ft. to* 1220 *ft.*
Height Salt Water rose in Well 600 *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 1935
Remarks Hole full of water from 1st Sand when 2nd was encountered, therefore this sample represents both parts of the sand.

Sample No. 105 *County* Lincoln *District* Jefferson
Company or Operator Owens, Libbey-Owens Gas Dept.
Farm Gordon Adkins *Farm Well No.* 1
Location Connelly Branch of Mud River
Name of Sand Salt
Salt Water Horizon from 1093 *ft. to* 1172 *ft.*
Height Salt Water rose in Well 600 *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 2-12-36

Sample No. 106 *County* Lincoln *District* Sheridan
Company or Operator Kanawha Gas & Utilities Co. *Well No.* 5
Farm Louisa Mitchell *Farm Well No.* 1
Location Twomile Creek, 2½ mi. E. of West Hamlin
Name of Sand Stray *Depth to top of Sand* 1730 *ft.*
Salt Water Horizon from 1740 *ft. to* .... *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 6-3-35
Remarks Water blown out. Well not allowed to fill up. This sand is seldom found.

Sample No. 107 *County* Lincoln *District* Sheridan
Company or Operator Kanawha Gas & Utilities Co. *Well No.* 201
Farm R. R. Sloan *Farm Well No.* 1
Location Twomile Creek, 2½ mi. E. from West Hamlin
Name of Sand Stray Salt? *Depth to top of Sand* 575 *ft.*
Salt Water Horizon from 625 *ft. to* 635 *ft.*
Height Salt Water rose in Well 585 *ft.* *Time required for rise* 12 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-11-35
Remarks Flow sample after gas was struck in Big Lime.

Sample No. 108 *County* Lincoln *District* Carroll
Company or Operator Kanawha Gas & Utilities Co. *Well No.* 202
Farm George A. Black
Location Trace Creek, 4 mi. N. E. of Hamlin
Name of Sand Big Injun *Depth to top of Sand* 1880 *ft.*
Salt Water Horizon from 1880 *ft. to* 1882 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 1935
Remarks * Hole full of water, when this water was encountered; this was an attempt to secure sample from bottom of hole.

Sample No. 109 *County* Logan *District* Logan
Company or Operator Boone County Coal Corp. *Well No.* "C"
Farm Boone County Coal Corp.
Location ¼ mi. N. W. of Mifflin
Name of Sand 2nd Salt *Depth to top of Sand* 1040 *ft.*
Salt Water Horizon from 1125 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 10 *inches.* *Date Sample Collected* 6-14-35
Remarks * 3 bbls. per hour of brine.

Sample No. 110 *County* Logan *District* Logan
Company or Operator Boone County Coal Corp. *Well No.* "A"
Farm Boone County Coal Corp.
Location Rockhouse Creek of Spruce Fork of Coal River, 1 mi. W. of Clothier
Name of Sand 2nd Salt *Depth to top of Sand* 1141 *ft.*
Salt Water Horizon from 1424 *ft.*
Height Salt Water rose in Well 30 *ft.* *Time required for rise* 2-5/6 *hours.*
Size of Hole 10 *inches.* *Date Sample Collected* 2-4-35
Remarks First Salt Sand was dry.

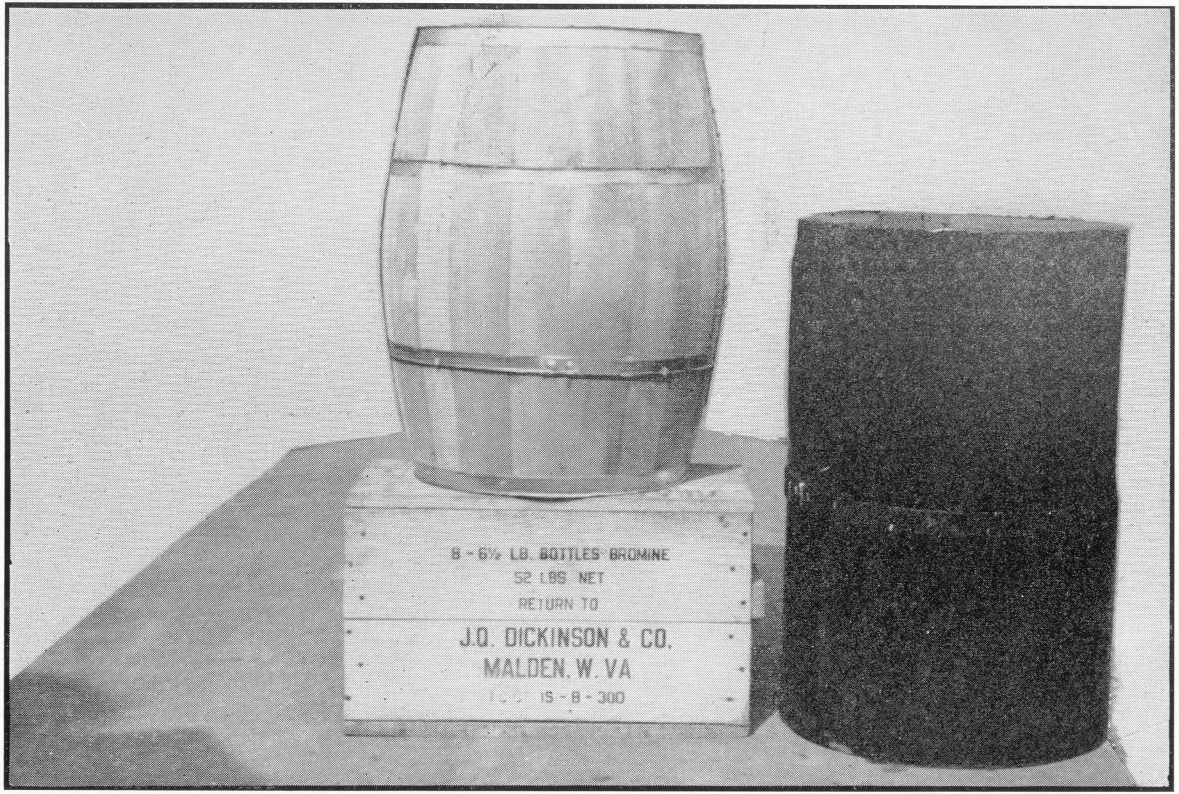


PLATE XI.—Shipping Packages for Brine Products.—Salt is shipped in barrels of 250 lbs. net; calcium chloride is shipped in steel drums of 600-700 lbs. net, and bromine is shipped in glass bottles of 6.5 lbs. net, packed eight to a case. Bags are now being used for both salt and calcium chloride.—Photo by Hoskins, 1937.

Sample No. 111 *County* Logan *District* Logan
Company or Operator Boone County Coal Corp. *Well No.* "H"
Farm Boone County Coal Corp.
Location Rockhouse Creek of Spruce Fork of Coal River, 1½ mi. W. of Mifflin
Name of Sand 2nd Salt *Depth to top of Sand* 1554 *ft.*
Salt Water Horizon from 1640 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-6-36
Remarks * Water was not permitted to build up and drilling continued.

Sample No. 112 *County* Logan *District* Logan
Company or Operator Boone County Coal Corp. *Well No.* "G"
Farm Boone County Coal Corp.
Location On ridge above Hewett Creek, 1¾ mi. W. from Mifflin
Name of Sand 2nd Salt *Depth to top of Sand* 1687 *ft.*
Salt Water Horizon from 1745 *ft. to* could not determine
Height Salt Water rose in Well * *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 4-13-36
Remarks * 2 bailers per hour. Well not permitted to fill up.

Sample No. 113 *County* Logan *District* Logan
Company or Operator Boone County Coal Corp. *Well No.* "F"
Farm Boone County Coal Corp.
Location At head of Anthony Branch of Rockhouse Creek, 1.36 mi. N. W. of Mifflin
Name of Sand 2nd Salt *Depth to top of Sand* 1592 *ft.*
Salt Water Horizon from 1622 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 2-13-36
Remarks * 3 bailers every hour and 20 minutes.

Sample No. 114 *County* Logan *District* Logan
Company or Operator Boone County Coal Corp. *Well No.* "D"
Farm Boone County Coal Corp.
Location 2nd Branch to right of Rockhouse Creek, ¾ mi. N. W. of Mifflin
Name of Sand 2nd Salt *Depth to top of Sand* 1010 *ft.*
Salt Water Horizon from 1047 * *ft.*
Height Salt Water rose in Well 1047 *ft.*
Size of Hole 10 *inches.* *Date Sample Collected* 8-21-35
Remarks * 3 bailers per hour.

Sample No. 115 *County* Logan *District* Logan
Company or Operator Boone County Coal Corp. *Well No.* "D"
Farm Boone County Coal Corp.
Location 2nd Branch to right of Rockhouse Creek, ¾ mi. N. W. of Mifflin
Name of Sand Salt *Depth to top of Sand* 1010 *ft.*
Salt Water Horizon from 1255 *ft.*
Height Salt Water rose in Well 1047 * *ft.*
Size of Hole 10 *inches.* *Date Sample Collected* 8-26-35
Remarks * Did not increase level of 1047—just filled up faster.

Sample No. 116 *County* Logan *District* Logan
Company or Operator The Southeastern Gas Co. *Well No.* 768
Farm G. W. Mitchell
Location On a branch of Hewett Creek, 2½ mi. S. W. of Hewett
Name of Sand Salt Sand *Depth to top of Sand* 904 *ft.*
Salt Water Horizon from 948 *ft. to* 1021 *ft.*
Size of Hole 10 *inches.* *Date Sample Collected* 7-27-35

Sample No. 117 *County* Logan *District* Logan
Company or Operator Boone County Coal Corp. *Well No.* "G"
Farm Boone County Coal Corp.
Location Between Rockhouse and Hewett Creeks, 1¾ mi. W. from Mifflin
Name of Sand 2nd Salt? *Depth to top of Sand* 1687 *ft.*
Salt Water Horizon from 1985 *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 4-13-36
Remarks This sample includes water coming from a higher sand. 2 bailers per hour increase at this point.

Sample No. 118 *County* Marion *District* Fairmont
Company or Operator Owens-Illinois Glass Co. *Well No.* 147
Farm A. T. Heck
Location Branch of Finches Run, between Barrackville and Grant Town, 2 mi. N. of Barrackville.
Name of Sand Salt *Depth to top of Sand* 1364 *ft.*
Salt Water Horizon from 1379 *ft. to* 1424 *ft.*
Height Salt Water rose in Well 675 *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 5-28-35

Sample No. 119 *County* Marion *District* Mannington
Company or Operator Hope Natural Gas Co. *Well No.* 365
Farm J. L. Hamilton
Location No data
Name of Sand Big Injun
Salt Water Horizon from 2309 *ft. to* 2313 *ft.*
Date Sample Collected 1934
Remarks This is a gas well; brine caught in a drip.

Sample No. 120 *County* Marion *District* Lincoln
Company or Operator Monongahela West Penn Public Service Co.
Farm H. T. Lough *Well No.* M-111
Location 2½ mi. N. E. of Farmington on Gilbow Fork of Bethel Run
Name of Sand Fifth *Depth to top of Sand* 2766 *ft.*
Salt Water Horizon from 2766 *ft. to* 2790 *ft.*
Height Salt Water rose in Well 24 *ft.*
Size of Hole 5 *inches* (2" tubing). *Date Sample Collected* 1937
Remarks 4 to 5 gals. per day.

Sample No. 121 *County* Marshall *District* Webster
Company or Operator Burleigh Wright
Farm Elmer Blake Heirs *Farm Well No.* 1
Location 6 mi. N. E. of Cameron
Name of Sand Salt (1st, 2nd, 3rd mixed) *Depth to top of Sand* 1530 *ft.*
Salt Water Horizon from 1560 *ft. to* 1700 *ft.*
Height Salt Water rose in Well 500 *ft.* *Time required for rise* 48 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 10-10-36

Sample No. 122 *County* Mason *District* Waggener
Company or Operator Liverpool Salt Company *Well No.* Fleetwood
Farm Plant site of Liverpool Salt Company
Location On site of Salt Plant, Ohio River, in Hartford, W. Va.
Name of Sand Salt *Depth to top of Sand* about 1100 *ft.*
Salt Water Horizon from approx. 1100 *ft. to* 1200 *ft.*
Height Salt Water rose in Well 600 *ft.*
Date Sample Collected 6-1-34
Remarks This is a very old well and mentioned in the Detailed Report for Jackson, Mason and Putnam Counties. Supplies brine to salt plant. Also produces gas used in salt works.

Sample No. 123 *County* Mason *District* Lewis
Company or Operator H. S. Johnson, et al.
Farm A. L. Neale *Farm Well No.* 1
Location Kanawha River at Pt. Pleasant
Name of Sand Salt
Date Sample Collected 1-11-37
Remarks Operator supplied no other data.

Sample No. 124 *County* Mason *District* Lewis
Company or Operator H. S. Johnson, et al.
Farm A. L. Neale *Farm Well No.* 1
Location Kanawha River at Pt. Pleasant
Name of Sand Salt and Big Injun
Salt Water Horizon from 1120 *ft.*
Date Sample Collected 1-11-37
Remarks Well flowed as soon as tools were pulled. Sample contaminated with Salt Sand water. No other data furnished.

Sample No. 125 *County* Mason *District* Lewis
Company or Operator H. S. Johnson, et al.
Farm A. L. Neale *Farm Well No.* 1
Location Kanawha River at Pt. Pleasant
Name of Sand Salt and Big Injun
Salt Water Horizon from 1120 *ft. to* 1140 *ft.*
Height Salt Water rose in Well flowed. *Time required for rise* at once.
Date Sample Collected 1-11-36
Remarks See remarks on Sample No. 124.

Sample No. 126 *County* Monongalia *District* Cass
Company or Operator L. J. Houze Convex Glass Co.
Farm Jesse L. Bowlby *Farm Well No.* 1
Location Wade Run, 9 mi. N. from Morgantown
Name of Sand Little Dunkard *Depth to top of Sand* 1125 *ft.*
Salt Water Horizon from 1257 *ft. to* .... *ft.*
Date Sample Collected Fall of 1935
Remarks 400 ft. below top of Pittsburgh Coal.

Sample No. 127 *County* Monongalia *District* Cass
Company or Operator Carnegie Natuural Gas Co. *Well No.* 1488
Farm Katherine R. Cooke *Farm Well No.* 1
Location Waters of Robinson Run, 10 mi. N. W. of Morgantown
Name of Sand Gas *Depth to top of Sand* 1055 *ft*
Salt Water Horizon from 1070 *ft. to* 1073 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-6-35
Remarks * 4 bailers per hr.

Sample No. 128 *County* Monongalia *District* Cass
Company or Operator L. J. Houze Convex Glass Co.
Farm Leonore Barrickman *Farm Well No.* 1
Location Waters of Wade Run, 1 mi. South of Union School
Name of Sand 1st Salt
Date Sample Collected 1934
Remarks This water is potable. Compare with Salt Sand brine in southern counties.

Sample No. 129 *County* Monongalia *District* Cass
Company or Operator L. J. Houze Convex Glass Co.
Farm Leonore Barrickman *Farm Well No.* 1
Location Waters of Wade Run, 1 mi. South of Union School
Name of Sand 2nd Salt *Depth to top of Sand* 1520 *ft.*
Salt Water Horizon from 1523 *ft.*
Date Sample Collected Summer 1934
Remarks This water also potable. See No. 128.

Sample No. 130 *County* Monongalia *District* Clay
Company or Operator Philadelphia Oil Co. *Well No.* 5407
Farm J. J. Moore
Location Days Run, 4 mi. N. of Fairview
Name of Sand 1st and 2nd Salt *Depth to top of Sand* 1730 *ft.*
Salt Water Horizon from 1800 *ft. to* 1810 *ft.*
Height Salt Water rose in Well 700 *ft.* *Time required for rise* 6 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 7-28-36

Sample No. 131 *County* Monongalia *District* Cass
Company or Operator Carnegie Natural Gas Co. *Well No.* 1488
Farm Katherine R. Cooke *Farm Well No.* 1
Location Waters of Robinson Run, 10 mi. N. W. of Morgantown
Name of Sand 2nd Salt *Depth to top of Sand* 1185 *ft.*
Salt Water Horizon from 1255 *ft. to* 1259 *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-10-35
Remarks * 5 bailers per hour. Compare with Nos. 128 & 129.

Sample No. 132 *County* Monongalia *District* Cass
Company or Operator L. J. Houze Convex Glass Co.
Farm Jesse L. Bowlby *Farm Well No.* 1
Location Wade Run, about 9 mi. N. from Morgantown
Name of Sand Salt *Depth to top of Sand* 1125 *ft.*
Salt Water Horizon from 1257 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 6-10-35
Remarks Compare with Nos. 128 & 129.

Sample No. 133 *County* Monongalia *District* Cass
Company or Operator Carnegie Natural Gas Co. *Well No.* 1488
Farm Katherine R. Cooke *Farm Well No.* 1
Location Waters of Robinson Run, 10 mi. N. W. of Morgantown
Name of Sand Salt *Depth to top of Sand* 1185 *ft.*
Salt Water Horizon from 1265 *ft. to* 1271 *ft.*
Height Salt Water rose in Well — filled in 8 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-12-35

Sample No. 134 *County* Monongalia *District* Cass
Company Carnegie Natural Gas Co. *Well No.* 1488
Farm Katherine R. Cooke *Farm Well No.* 1
Location Waters of Robinson Run, 10 mi. N. W. of Morgantown
Name of Sand All sands. *Depth to top of Sand* 1055 *ft.*
Salt Water Horizon from 1070 *ft. to* 1271 *ft.*
Height Salt Water rose in Well 800 *ft.*
Date Sample Collected 10-6-35
Remarks This sample is a mixture of all brines found in the well.

Sample No. 135 *County* Monongalia *District* Clay
Company Philadelphia Oil Co. *Well No.* 5407
Farm J. J. Moore
Location Days Run, 4 mi. N. of Fairview and 3 mi. S. W. of Daybrook
Name of Sand Salt *Depth to top of Sand* 1730 *ft.*
Salt Water Horizon from 1888 *ft. to* 1910 *ft.*
Height Salt Water rose in Well 1500 *ft.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 7-31-36

Sample No. 136 *County* Monongalia *District* Clay
Company Philadelphia Oil Co. *Well No.* 5407
Farm J. J. Moore
Location Days Run, 4 mi. N. of Fairview, same as 135
Name of Sand Big Injun *Depth to top of Sand* 2230 *ft.*
Salt Water Horizon from 2342 *ft. to* .... *ft.*
Height Salt Water rose in Well 1200 *ft. Time required for rise* 24 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 8-18-36

Sample No. 137 *County* Monongalia *District* Clay
Company or Operator J. I. Eddy & Co.
Farm H. C. Youst *Farm Well No.* 1
Location Big Indian Creek, ½ mi. N. W. of Hagans
Name of Sand Big Injun *Depth to top of Sand* 1742 *ft.*
Salt Water Horizon from 1742 *ft. to* .... *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 11-17-36
Remarks * Very small seepage — depth in sand not known.

Sample No. 138 *County* Nicholas *District* Jefferson
Company or Operator Hope Natural Gas Co. *Well No.* 6847
Farm Line Creek Coal Co.
Location Waters of Right Fork—2.4 mi. N. from Lockwood
Name of Sand Big Injun *Depth to top of Sand* 2570 *ft.*
Salt Water Horizon from 2570 *ft. to* 2657 *ft.*
Date Sample Collected 3-17-37
Remarks This well produces gas.

Sample No. 139 *County* Nicholas *District* Jefferson
Company or Operator Hope Construction & Refining Co. *Well No.* 1139
Farm Lewis Land & Coal Co.
Location Waters of Sugarcamp Branch of Twentymile, 2.5 mi. N. of Lockwood
Name of Sand Big Injun *Depth to top of Sand* 2549 *ft.*
Salt Water Horizon from 2549 *ft. to* 2577 *ft.*
Date Sample Collected 3-8-37
Remarks This is a gas well.

Sample No. 140 *County* Pleasants *District* Grant
Company or Operator All-in-One Producing & Refining Co.
Farm B. E. Coen *Farm Well No.* 1
Location About 50 ft. off road up Cow Creek, 5 mi. S. W. of St. Marys.
Name of Sand Gas Sand *Depth to top of Sand* 87 *ft.*
Salt Water Horizon from 90 *ft. to* 95 *ft.*
Height Salt Water rose in Well 24 *ft. Time required for rise* 24 *hours.*
Size of Hole 6¼ *inches.* *Date Sample Collected* 11-15-35

Sample No. 141 *County* Pleasants *District* Grant
Company or Operator K. M. Wishart
Farm Beeson *Farm Well No.* 1
Location Calf Creek, 3 mi. S. W. of Waverly (Burning Springs Anticline)
Name of Sand Big Injun *Depth to top of Sand* 750 *ft.*
Salt Water Horizon from 750 *ft. to* 790 *ft.*
Height Salt Water rose in Well 640 *ft. Time required for rise* 30 *minutes.*
Size of Hole 10 *inches.* *Date Sample Collected* 7-28-35

Sample No. 142 *County* Pleasants *District* Jefferson
Company or Operator Hope Natural Gas Co. *Well No.* 1759
Farm J. H. Ralston
Location Alum Cave Run, 4 mi. S. of St. Marys
Name of Sand Big Injun *Depth to top of Sand* 1777 *ft.*
Salt Water Horizon from 1778 *ft. to* 1780 *ft.*
Size of Hole 5½ *inches.* *Date Sample Collected* 3-24-37
Remarks This is a gas well.

Sample No. 143 *County* Pleasants *District* Jefferson
Company or Operator Hope Natural Gas Co. *Well No.* 3896
Farm S. C. Hammett
Location Sharps Run, 8 mi. S. W. of St. Marys
Name of Sand Big Injun *Depth to top of Sand* 1595 *ft.*
Salt Water Horizon from 1610 *ft. to* 1625 *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 3-21-37
Remarks This is a gas well.

Sample No. 144 *County* Pleasants *District* Jefferson
Company or Operator Hope Natural Gas Co. *Well No.* 6761
Farm D. R. Dunn
Location Sharps Run, 8 mi. S. W. of St. Marys
Name of Sand Squaw *Depth to top of Sand* 1857 *ft.*
Salt Water Horizon from 1862 *ft. to* 1870 *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 3-24-37
Remarks This is a gas well.

Sample No. 145 *County* Putnam *District* Scott
Company or Operator C. E. Krebs
Farm Robert L. Morris *Farm Well No.* 1
Location Headwaters of Morrison Fork, 2.3 mi. N. E. of Scott Depot
Name of Sand Big Injun *Depth to top of Sand* 1728 *ft.*
Salt Water Horizon from 1728 *ft. to* 1730 *ft.*
Date Sample Collected 1934
Remarks This is a gas well and the brine is produced with the gas.

Sample No. 146 *County* Ritchie *District* Murphy
Company or Operator W. H. Bickel
Farm Dewey Gibson *Farm Well No.* 1
Location South Fork of Hughes River, ¾ mi. S. W. of Smithville
Name of Sand Little Dunkard *Depth to top of Sand* 680 *ft.*
Salt Water Horizon from 695 *ft. to* 710 *ft.*
Height Salt Water rose in Well 500 *ft.* Time *required for rise* 18 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 1-21-36

Sample No. 147 *County* Ritchie *District* Union
Company or Operator Carnegie Natural Gas Co. *Well No.* 1484
Farm A. H. Tate *Farm Well No.* 2
Location Chevauxdefrise, 2 mi. S. W. of Pullman
Name of Sand 1st Salt *Depth to top of Sand* 1470 *ft.*
Salt Water Horizon from 1510 *ft. to* 1520 *ft.*
Height Salt Water rose in Well 200 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 4-13-36

Sample No. 148 *County* Ritchie *District* Murphy
Company or Operator W. H. Mossor
Farm W. K. Prunty *Farm Well No.* 1
Location Rock Run of Spruce Creek, 2 mi. N. E. of Thursday
Name of Sand First Salt *Depth to top of Sand* 1330 *ft.*
Height Salt Water rose in Well 160 *ft.* *Time required for rise* 7 *days.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 7-20-36

Sample No. 149 *County* Ritchie *District* Murphy
Company or Operator Smith & Hendershot
Farm Royston D. Law *Farm Well No.* 1
Location On Grass Run, 1.5 mi. E. of Burnt House
Name of Sand Salt *Depth to top of Sand* 1335 *ft.*
Date Sample Collected 6-15-35

Sample No. 150 *County* Ritchie *District* Murphy
Company or Operator Clem S. Morris
Farm George Mathers *Farm Well No.* 1
Location Waters of Grass Run, ¾ mi. S. W. of Thursday
Name of Sand Second Salt *Depth to top of Sand* 1707 *ft.*
Salt Water Horizon from 1758 *ft. to* 1797 *ft.*
Height Salt Water rose in Well 335 *ft.* *Time required for rise* 2 *days.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 7-15-37
Remarks ½ bailer every screw.

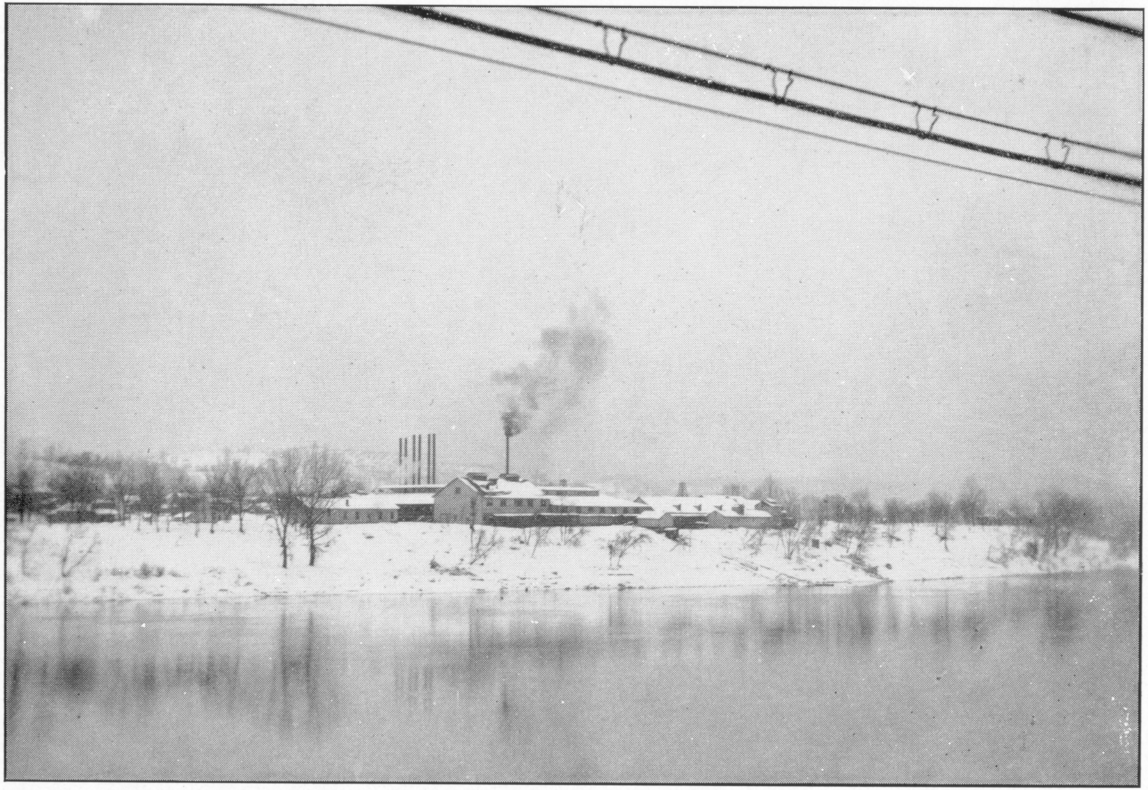


PLATE XII.—Dixie Plant, Ohio River Salt Corp., Mason City, W. Va.—This view was taken March 14, 1937 after a heavy snow.—Photo by courtesy Norman O. Wein.

Sample No. 151 *County* Ritchie *District* Murphy
Company or Operator South Penn Oil Company
Farm Georgia M. Haught *Farm Well No.* 2
Location Laurel Fork, 1½ mi. N. W. of Hartley
Name of Sand Salt *Depth to top of Sand* 1826 *ft.*
Salt Water Horizon from 1905 *ft. to* 1910 *ft.*
Height Salt Water rose in Well 400 *ft.* *Time required for rise* 48 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 11-18-35

Sample No. 152 *County* Ritchie *District* Murphy
Company or Operator Hope Natural Gas Co. *Well No.* 7735
Farm A. M. Scott
Location Hughes River, ½ mi. W. of Smithville
Name of Sand Salt *Depth to top of Sand* 1490 *ft.*
Salt Water Horizon from 1515 *ft. to* 1520 *ft.*
Height Salt Water rose in Well 65 *ft.* *Time required for rise* 80 *hours.*
Size of Hole 8 *inches.* *Date Sampe Collected* 7-28-36
Remarks This is a gas well.

Sample No. 153 *County* Ritchie *District* Grant
Company or Operator Hill & Kuhn
Farm G. B. Rosson *Farm Well No.* 2
Location Gillespie Run, 7 mi. S. W. of Cairo
Name of Sand Maxton *Depth to top of Sand* 1400 *ft.*
Salt Water Horizon from 1460 *ft. to* .... *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 8 *inches.* *Date Sample Collected* 4-1-36
Remarks * 60 gallons per hour — kept bailed out.

Sample No. 154 *County* Ritchie *District* Grant
Company or Operator Richards & Moats
Farm Stout & Jackson *Farm Well No.* 2
Location Bear Run, 11 mi. E. from Cairo
Name of Sand Maxton *Depth to top of Sand* 1587 *ft.*
Salt Water Horizon from 1607 *ft. to* 1617 *ft.*
Height Salt Water rose in Well 50 *ft.* *Time required for rise* 12 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 5-15-36

Sample No. 155 *County* Ritchie *District* Murphy
Company or Operator Patterson & Pope
Farm H. S. & R. Wilson *Farm Well No.* 1
Location Laurel Run, 1.6 mi. N. W. of Hartley
Name of Sand Maxton *Depth to top of Sand* 1769 *ft.*
Salt Water Horizon from 1800 *ft. to* 1852 *ft.*
Height Salt Water rose in Well 1000 *ft.* *Time required for rise* 10 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* Nov. 1935

Sample No. 156 *County* Ritchie *District* Murphy
Company or Operator E. E. Pope
Farm H. S. & R. Wilson *Farm Well No.* 1
Location Laurel Run, 1.3 mi. N. W. of Hartley
Name of Sand Maxton *Depth to top of Sand* 1572 *ft.*
Salt Water Horizon from 1602 *ft. to* 1610 *ft.*
Height Salt Water rose in Well 900 *ft.* Time *required for rise* 24 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 11-20-35

Sample No. 157 *County* Ritchie *District* Grant
Company or Operator F. R. Morrison
Farm A. F. Parks *Farm Well No.* 1
Location Layfield Fork, 1.4 miles S. of Ingram Church
Name of Sand Maxton *Depth to top of Sand* 1490 *ft.*
Salt Water Horizon from 1515 *ft. to* 1525 *ft.*
Height Salt Water rose in Well 825 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 1-17-36

Sample No. 158 *County* Ritchie *District* Murphy
Company or Operator W. R. Hayes
Farm J. W. Wince *Farm Well No.* 15
Location Dutchman Run, 3½ mi. S. W. from Macfarlan
Name of Sand Maxton *Depth to top of Sand* 1565 *ft.*
Salt Water Horizon from 1655 *ft. to* 1660 *ft.*
Height Salt Water rose in Well 60 *ft.* *Time required for rise* 3½ *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 1-9-36

Sample No. 159 *County* Roane *District* Curtis
Company or Operator K. M. Hunt
Farm Blaker & Moore Heirs *Farm Well No.* 1
Location 2 mi. W. of Peniel
Name of Sand Salt *Depth to top of Sand* 1773 *ft.*
Salt Water Horizon from 1773 *ft. to* .... *ft.*
Size of Hole 6 *inches.* *Date Sample Collected* 6-22-35
Remarks Salt water coming along with the oil.

Sample No. 160 *County* Roane *District* Curtis
Company or Operator Big Four Drilling Co.
Farm L. C. Burdette (Brown Farm) *Farm Well No.* 1
Location Tributary of Peniel Run, 1¼ mi. N. W. of Peniel
Name of Sand Salt *Depth to top of Sand* 1670 *ft.*
Salt Water Horizon from 1670 *ft. to* 1728 *ft.*
Height Salt Water rose in Well hole full.
Size of Hole 6 *inches.* *Date Sample Collected* 6-27-35

Sample No. 161 County Roane *District* Curtis
Company or Operator K. M. Hunt
Farm T. J. Murray *Farm Well No.* 3
Location Waters of Peniel Run, 1.5 mi. E. of Buffalo
Name of Sand Salt *Depth to top of Sand* 1612 *ft.*
Salt Water Horizon from 1612 *ft. to* .... *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 6-22-35
Remarks Salt water coming along with oil. Brine sample taken from bottom of tank.

Sample No. 162 *County* Roane *District* Curtis
Company or Operator Henderson Oil Co.
Farm J. C. Burdette *Farm Well No.* 1
Location Waters of Peniel Run, 1 mi. W. of Peniel
Name of Sand Salt *Depth to top of Sand* 1784 *ft.*
Salt Water Horizon from 1784 *ft. to* 1782 *ft.*
Date Sample Collected 8-7-35
Remarks Salt water coming along with oil. Well drilled 38 feet in the sand.

Sample No. 163 *County* Roane *District* Geary
Company or Operator Godfrey L. Cabot Inc. *Well No.* 879
Farm T. F. Smith *Farm Well No.* 1
Location Left Fork of Big Sandy Creek, 1000 feet north 45° E. of Uler
Name of Sand Oriskany *Depth to top of Sand* 5972 *ft.*
Salt Water Horizon from 5978 *ft. to* .... *ft.*
Height Salt Water rose in Well 120 *ft.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 2-19-37

Sample No. 164 *County* Roane *District* Curtis
Company or Operator United Fuel Gas Company *Well No.* 4053
Farm J. W. Heinzman
Location Headwaters of Frozencamp Creek, 0.3 mi. S. E. of Antioch Church
Name of Sand Ohio Clinton or White Medina
Salt Water Horizon from 7135 *ft. to* .... *ft.* *Depth to top of Sand* 7040 *ft.*
Height Salt Water rose in Well 315 *ft.* *Time required for rise* 15 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* August 1931
Remarks Special sample from the deepest well in West Virginia.

Sample No. 165 *County* Tyler *District* Union
Company or Operator E. C. Hartman
Farm W. M. Martin *Farm Well No.* 1
Location Branch of Buffalo Creek, 3 miles S. W. of Friendly
Name of Sand Second Salt *Depth to top of Sand* 1266 *ft.*
Salt Water Horizon from 1272 *ft. to* .... *ft.*
Height Salt Water rose in Well 300 *ft.* *Time required for rise* 72 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 7-1-36

Sample No. 166 *County* Tyler *District* Centerville
Company or Operator Kerns & Smith
Farm J. P. Ripley *Farm Well No.* 1
Location Wheeler Run, 2 mi. W. of Centerville
Name of Sand Salt *Depth to top of Sand* 1570 *ft.*
Salt Water Horizon from 1590 *ft. to* 1600 *ft.*
Height Salt Water rose in Well 500 *ft.* *Time required for rise* 20 *days.*
Size of Hole 6 *inches.* *Date Sample Collected* 3-20-35

Sample No. 167 *County* Tyler *District* Meade
Company or Operator Kerns & Smith
Farm E. A. Hill *Farm Well No.* 1
Location McKim Run, 3 mi. W. of Mole Hill
Name of Sand Salt *Depth to top of Sand* 1610 *ft.*
Salt Water Horizon from 1610 *ft. to* 1645 *ft.*
Height Salt Water rose in Well 500 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 3-30-35

Sample No. 168 *County* Tyler *District* Lincoln
Company or Operator Hope Natural Gas Co.
Farm Sutton Lot *Farm Well No.* Sutton Lot
Location on bank of Ohio River in Sistersville
Name of Sand Big Injun
Size of Hole 2″ tubing. *Date Sample Collected* 3-31-34
Remarks Brine is produced with the oil. Well is pumped. This is not a tank sample.

Sample No. 168 *County* Tyler *District* Centerville
Company or Operator American Oil Development Co.
Farm Leroy Pierpont *Farm Well No.* 1
Location Near Centerville (Alma P. O.)
Name of Sand Big Injun *Depth to top of Sand* 2159 *ft.*
Salt Water Horizon from 2159 *ft. to* .... *ft.*
Height Salt Water rose in Well 590 *ft.* *Time require for rise* * *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 2-5-37
Remarks * 250 bbls. of water per day. Elevation of surface is 1210 ft.

Sample No. 170 *County* Wayne *District* Ceredo
Company or Operator Ceredo Gas & Development Co.
Farm J. H. & H. J. Stark *Farm Well No.* 1
Location Twelvepole Creek, ½ mi. E. of Ceredo
Name of Sand Salt *Depth to top of Sand* 764 *ft.*
Salt Water Horizon from 770 *ft. to* 930? *ft.*
Height Salt Water rose in Well 730 *ft.* *Time required for rise* 20 *minutes.*
Size of Hole 10 *inches.* *Date Sample Collected* 10-7-36

Sample No. 171 *County* Wayne *District* Cerede
Company or Operator Ceredo Gas & Development Co.
Farm J. H. & H. J. Stark *Farm Well No.* 1
Location Twelvepole Creek, ½ mi. E. of Ceredo
Name of Sand Big Injun *Depth to top of Sand* 1026 *ft.*
Salt Water Horizon from 1036 *ft. to* .... *ft.*
Height Salt Water rose in Well 30 *ft.* *Time required for rise* 1 *hour.*
Size of Hole 8 *inches.* *Date Sample Collected* 10-17-36

Sample No. 172 *County* Wayne *District* Butler
Company or Operator Edward Oil & Gas Co. *Well No.* 1
Farm Edward Oil & Gas Co.
Location Patrick Creek, 5 mi. S. W. of Wayne
Name of Sand Big Injun *Depth to top of Sand* 1525 *ft.*
Salt Water Horizon from 1525 *ft. to* 1540 *ft.*
Height Salt Water rose in Well 1200 *ft.* *Time required for rise* 24 *hours.*
Size of Hole 8 *inches.* *Date Sample Collected* 6-5-35

Sample No. 173 *County* Wetzel *District* Church
Company or Operator Union Gasoline & Oil Co. *Well No.* 787
Farm George Sole
Location Long Drain, 3 mi. S. W. of Hundred
Name of Sand 1st Salt *Depth to top of Sand* 1710 *ft.*
Salt Water Horizon from 1710 *ft. to* 1715 *ft.*
Height Salt Water rose in Well 5 *ft.* *Time required for rise* 1 *hour.*
Size of Hole 8 *inches.* *Date Sample Collected* 12-11-36

Sample No. 174 *County* Wetzel *District* Green
Company or Operator O. T. Midcap
Farm Henry Elson *Farm Well No.* 2
Location Fluharty Run, 2 mi. S. of Porters Falls.
Name of Sand 3rd Salt *Depth to top of Sand* 1755 *ft.*
Salt Water Horizon from 1775 *ft. to* .... *ft.*
Size of Hole 6 *inches.* *Date Sample Collected* 3-6-36

Sample No. 175 *County* Wetzel *District* Church
Company or Operator Union Gasoline & Oil Co. *Well No.* 775
Farm E. P. Oliver
Location Long Drain, 2 mi. S. W. of Hundred
Name of Sand Salt *Depth to top of Sand* 1615 *ft.*
Salt Water Horizon from 1620 *ft. to* 1623 *ft.*
Height Salt Water rose in Well 17 *ft.* *Time required for rise* 1 *hour.*
Size of Hole 8 *inches* *Date Sample Collected* 7-10-36

Sample No. 176 *County* Wirt District Spring Creek
Company or Operator A. E. Mackintosh
Farm A. E. Mackintosh *Farm Well* No. 1
Location Petes Run, ¾ mi. S. W. of Creston
Name of Sand Salt *Depth to top of Sand* 1239 *ft.*
Salt Water Horizon from 1330 *ft. to* 1335 *ft.*
Height Salt Water rose in Well 1130 *ft.* *Time required for rise* 4 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 9-9-35

Sample No. 177 *County* Wirt *District* Spring Creek
Company or Operator A. E. Mackintosh
Farm A. E. Mackintosh *Farm Well No.* 1
Location Petes Run, ¾ mi. S. W. of Creston
Name of Sand Salt *Depth to top of Sand* 1239 *ft.*
Salt Water Horizon from 1330 *ft. to* 1335 *ft.*
Height Salt Water rose in Well 1130 *ft.* *Time required for rise* 4 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 9-9-35
Remarks Probably a duplicate of 176.

Sample No. 178 *County* Wirt *District* Burning Springs
Company or Operator J. B. & W. R. Busch
Farm McCauly *Farm Well No.* 1
Location Brushy Fork, 10 mi. E. of Elizabeth
Name of Sand Maxton *Depth to top of Sand* 1769 *ft.*
Salt Water Horizon from 1845 *ft. to* 1855 *ft.*
Height Salt Water rose in Well to 1200 *ft.* *Time required for rise* 12 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* 2-9-35

Sample No. 179 *County* Wirt *District* Burning Springs
Company or Operator Shannon Dawson
Farm Spencer Wilson *Farm Well No.* 1
Location Straight Creek, 1¼ mi. W. of Brohard
Name of Sand Maxton *Depth to top of Sand* 1870 *ft.*
Salt Water Horizon from 1945 *ft. to* 1950 *ft.*
Height Salt Water rose in Well 1300 *ft.* *Time required for rise* 2 *hours.*
Size of Hole 6⅝ *inches.* *Date Sample Collected* 4-11-36

Sample No. 180 *County* Wirt *District* Clay
Company or Operator Blauser Drilling Co.
Farm Zora Deem, 18½ acres *Farm Well No.* 1
Location Waters of Goose Creek, 2¾ mi. W. of Petroleum
Name of Sand Squaw *Depth to top of Sand* 562 *ft.*
Salt Water Horizon from 562 *ft. to* 566 * *ft.*
Height Salt Water rose in Well 475 *ft.* *Time required for rise* ½ *hour.*
Size of Hole 5-3/16 *inches.* *Date Sample Collected* 12-1-36
Remarks * Well not through sand when sample was taken.

Sample No. 181 *County* Wirt *District* Spring Creek
Company or Operator Glen W. Roberts *Well No.* 500
Farm J. A. and L. R. Roberts *Farm Well No.* 1
Location 1 mi. N. E. of Burning Springs
Name of Sand Oriskany *Depth to top of Sand* 4899 *ft.*
Salt Water Horizon from 4901½ *ft. to* 4903½ *ft.*
Height Salt Water rose in Well * *ft.*
Size of Hole 6 *inches.* *Date Sample Collected* Jan. 1937
Remarks * 1 bbl. per hour.

Sample No. 182 *County* Wirt *District* Spring Creek
Company or Operator Glen W. Roberts *Well No.* 500
Farm J. A. and L. R. Roberts *Farm Well No.* 1
Location 1 mi. N. E. of Burning Springs
Name of Sand Oriskany *Depth to top of Sand* 4899 *ft.*
Salt Water Horizon from 4901½ *ft. to* 4903½ *ft.*
Size of Hole 6 *inches.* *Date Sample Collected* 1-29-37
Remarks This sample collected while well was drilling at 4969. No increase in amount of water noted.

Sample No. 183 *County* Wood *District* Walker
Company or Operator Leeton & Flanagan
Farm E. G. Morehead *Farm Well No.* 1
Location 12 mi. from Cairo
Name of Sand Maxton *Depth to top of Sand* 1746 *ft.*
Salt Water Horizon from 1776 *ft. to* 1780 *ft.*
Height Salt Water rose in Well 600 *ft.* *Time required for rise* 168 *hours.*
Size of Hole 6 *inches.* *Date Sample Collected* 6-7-35

Sample No. 184 *County* Wood *District* Union
Company or Operator L. P. Bickel *Well No.* B-1
Farm Hendershot Heirs
Location Worthington Creek, 1.6 mi. N. of Dallison
Name of Sand Big Injun *Depth to top of Sand* 1761 *ft.*
Salt Water Horizon from 1761 *ft. to* .... *ft.*
Height Salt Water rose in Well 1461 *ft.* *Time required for rise* 12 *hours.*
Size of Hole 8¼ *inches.* *Date Sample Collected* July, 1935

Sample No. 185 *County* Tyler *District* Meade
Company or Operator W. H. Miller
Farm Myrtle Hadley *Farm Well No.* 1
Location Sancho Creek, 5 mi. S. W. of Middlebourne
Name of Sand Big Injun *Depth to top of Sand* 1705 *ft.*
Salt Water Horizon from 1742 *ft. to* .... *ft.*
Height Salt Water rose in Well 50 *ft.* *Time required for rise* 12 *hours.*
Size of Hole 5-3/16 *inches.* *Date Sample Collected* 5-10-37

Sample No. 186 *County* Gilmer *District* Troy
Company or Operator Hope Natural Gas Co. *Well No.* 4405
Farm F. T. Bush
Location Sinking Creek, 1 mi. E. Newberne
Name of Sand Big Injun *Depth to top of Sand* 2021 *ft.*
Salt Water Horizon from 2021 *ft. to* .... *ft.*
Height Salt Water rose in Well 75 *ft.* *Time required for rise* 10 *months.*
Size of Hole 6 *inches.* *Date Sample Collected* 4-20-37
Remarks This is a gas well.

Sample No. 187 *County* Gilmer *District* Troy
Company or Operator Hope Natural Gas Co. *Well No.* 6005
Farm H. I. Allman
Location Pike Fork of Camp Creek, 2 mi. W. from Coxs Mills
Name of Sand Maxton *Depth to top of Sand* 1710 *ft.*
Salt Water Horizon from 1710 *ft. to* .... *ft.*
Height Salt Water rose in Well 75 *ft.* *Time required for rise* 5 *months.*
Size of Hole 6 *inches.* *Date Sample Collected* 5-5-37
Remarks This is a gas well.

Sample No. 188 *County* Marion *District* Lincoln
Company or Operator Monongahela West Penn Public Service Co.
Farm H. T. Lough *Well No.* M-111
Location Gilbow Fork of Bethel Run, 2½ mi. N. E. from Farmington
Name of Sand Fifth *Depth to top of Sand* 2766 *ft.*
Salt Water Horizon from 2766 *ft. to* 2790 *ft.*
Height Salt Water rose in Well 188 *ft.* *Time required for rise* * *hrs.*
Size of Hole 5 *inches* (2″ tubing). *Date Sample Collected* 4-20-37
Remarks * 4 to 5 gals. per days — exact point in sand where water enters not known. This sample taken from top of fluid.

Sample No. 189 *County* Marion *District* Lincoln
Company or Operator Monongahela West Penn Public Service Co.
Farm H. T. Lough *Well No.* M-111
Location Gilbow Fork of Bethel Run, 2½ mi. N. E. from Farmington
Name of Sand Fifth *Depth to top of Sand* 2766 *ft.*
Salt Water Horizon from 2766 *ft. to* 2790 *ft.*
Height Salt Water rose in Well 24 *ft.* *Time required for rise* * *hours.*
Size of Hole 5 *inches.* (2″ tubing) *Date Sample Collected* 5-3-37
Remarks * 4 to 5 gals. per day—See No. 188.
This is last fluid taken from the well.

CHEMICAL ANALYSES BY COUNTIES.

The following table shows complete chemical analyses by counties. The 28 counties included have been arranged in alphabetical order in the table for convenience of reference. The grouping by counties for this table was adopted for the convenience of those readers who would be most interested in having together all data for each county even though parts of the data might pertain to different producing horizons.

PLATE XIII.—Brine Reservoir, Dixie Plant, Mason City, W. Va.—This reservoir was built after the Ohio River flood of 1861 and is still in use. Brine from all the wells is pumped to this tank, whence it flows by gravity to the first furnace pan.—Photo by Hoskins, 1937.

Table 10.—Chemical Analyses of Brines of West Virginia by Counties, in Parts per Million.

Sample No.	Producing Horizon	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
	BOONE COUNTY																	
1	2nd Salt	26.5	1.1048	146,300	75	12,690	313	266	2,113	39,300	606	53	6.6	89,700	64	0.75	145,188	HAH
2	Salt	22	1.1083	148,000	30	12,470	248	397	2,236	39,500	281	10	744	89,200	812	3	145,931	JBM
3	Salt	26	1.1103	150,900	4.5	12,700	387	412	2,279	40,610	338	6.3	1.0	92,300	540	40	149,618	HAH
4	Salt	25	1.1060	145,800	11	11,750	300	419	2,075	39,400	385	8.4	1.2	88,200	475	0.72	143,025	HAH
5	Salt	26	1.0999	139,060	60	10,680	225	678	1,724	38,900	300	4	3	84,400	546	4	137,524	JBM
6	Salt	26	1.1050	145,300	90	13,200	271	345	3,610	35,300	238	9.1	7.4	88,600	543	1.8	142,245	JBM
7	Salt	28	1.0880	125,800	135	9,690	tr.	244	1,555	34,800	286	acid	3.3	75,700	827	1.5	123,242	HAH
8	Salt	25	1.0160	32,100	0.45	1,607	60	141	267	8,780	116	46	6	17,300	103	0.35	28,427	HAH
9	Salt	24	1.0239	38,700	1	2,336	85	81	421	11,760	tr.	158	tr.	23,320	147	tr.	38,263	HAH
10	Salt?	27	1.0332	46,300	0.6	2,900	78	47	632	13,130	164	97	9.5	27,340	116	tr.	44,514	HAH
11	Salt	22	1.0051	11,390	1.4	345	tr.	127	197	3,620	104	296	4.9	6,740	12	tr.	11,447	HAH
12	Salt	26	1.0012	8,940	tr.	136	3	0	56	3,200	34	256	9	5,200	30	0.02	8,924	HAH
13	Salt?	25	0.9975	2,730	0.45	92	ND	ND	12	1,020	ND	413	7.8	1,470	120	0	3,135	JBM
14	Salt	26.5	0.9961	1,470	0.6	414	ND	ND	58	64	ND	243	3.8	781	3.8	tr.	1,568	JBM
15	Salt	25	1.0096	17,360	3	873	31	60	196	5,360	48	905	7.8	9,950	89	tr.	17,522	HAH
16	Salt	25	1.0105	18,660	1.2	934	28	82	234	5,880	94	847	8.6	11,040	30	tr.	19,179	JBM
17	Salt	23	1.0552	79,300	1	5,360	158	214	1,032	22,540	340	4.4	5.3	47,900	60	tr.	77,615	HAH
18	Salt	23	1.0415	63,000	0.5	4,470	129	120	761	18,060	240	51	tr.	37,900	240	tr.	61,972	HAH
19	Salt	25.5	1.0803	115,700	66	9,730	ND	384	1,753	30,600	215	65	0	69,800	92	2	112,707	HAH
20	Salt	28	1.0435	66,200	45	5,650	118	188	993	17,560	110	81	4.5	40,100	230	0.9	65,080	HAH
21	Maxton	28	1.1211	167,000	45	18,200	444	84	4,800	36,400	189	61	23	102,600	642	7.1	163,495	JBM
22	Salina	23	1.1533	196,400	0	20,470	363	700	4,080	48,800	2,100	190	595	122,000	1,500	59	202,057[1]	HAH
	BRAXTON COUNTY																	
23	Big Injun	27	1.0851	118,100	1,600	9,150	447	0	1,840	31,500	172	0	5.5	72,500	369	11	117,595	HAH
	CABELL COUNTY																	
24	Salt	27	1.0533	78,000	5.7	4,110	150	106	1,238	23,600	218	104	0	47,500	190	1.1	77,227	HAH
25	Salt	24	1.0243	39,200	0.45	1,686	79	127	421	12,620	249	150	5.3	23,590	88	tr.	39,016	JBM
26	Big Dunkard	23	1.0394	59,400	tr.	3,370	103	127	979	17,690	50	99	tr.	36,200	52	0.4	58,670	HAH
27	Salt	26	1.0578	86,900	tr.	5,490	158	298	1,424	24,760	15	62	19	52,200	194	2	84,622	HAH
28	Salt	26	1.0246	41,600	1	1,919	80	75	560	14,470	105	140	tr.	27,400	110	6	44,866	HAH
29	Salt	19.5	1.0093	13,930	2	592	16	tr.	210	4,300	184	323	0	8,250	50	0	13,927	HAH
30	Salt?	25	1.0199	33,200	4.5	1,277	62	57	383	10,580	142	152	0.82	19,760	117	0.78	32,536	JBM
31	Big Injun & Salt	24	1.0527	77,600	1	4,910	126	245	1,320	22,840	256	13	0	47,000	285	3.2	76,999	HAH
32	Big Injun	27	1.0729	109,200	45	5,460	174	340	1,688	31,600	400	0	0	63,800	280	2	103,789	HAH
33	Maxton	27	1.0391	59,400	50	3,160	237	155	902	17,780	136	85	0	35,900	193	1.1	58,599	HAH
34	Big Injun	22	1.0334	53,300	0	3,050	Pr.	132	822	15,500	96	152	0	32,000	210	2.7	52,059	HAH
35	Big Injun?	25	1.1198	163,200	6	11,990	206	551	2,780	42,000	280	25	10	98,200	1,252	4	157,304	HAH
36	Big Injun	24	1.1239	177,300	36	17,360	385	927	3,170	45,100	412	8.3	0	110,200	890	8.5	178,497	JBM
37	Big Injun	21	1.1278	172,000	114	13,610	ND	928	3,150	46,000	449	18	0	104,700	665	7	169,641	HAH

Table 10.—Chemical Analyses of Brines of West Virginia by Counties, in Parts per Million, (Continued).

Sample No.	Producing Horizon	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
	CALHOUN COUNTY																	
38	Moundsville	25.5	1.0021	8,860	0	1,172	0	0	231	1,663	tr.	163	31	5,190	10	0	8,460	HAH
39	1st Salt	30	1.0082	19,270	1.8	469	31	29	126	7,410	60	495	5.4	11,170	tr.	0.08	19,797	HAH
40	Salt	23	1.0666	91,300	65	6,140	225	1,295	1,392	25,700	150	39	9.4	55,400	337	6.8	90,759	HAH
41	Salt	22	1.0510	73,700	10	4,610	194	757	1,117	20,590	149	acid	0	44,200	300	4.7	71,932	HAH
42	Salt	24	1.0720	113,400	7	8,454	2,610	1,554	2,038	28,900	298	51	0	68,400	373	4	112,689	JBM
43	Salt	26	1.0732	105,100	1.1	6,070	168	1,843	1,730	29,900	300	50	7	63,000	400	6	103,475	HAH
44	Maxton	24	1.0729	103,800	0.25	6,790	221	1,500	1,711	28,600	40	65	0	62,100	326	tr.	101,353	HAH
45	Maxton	30	1.0605	89,490	92	5,990	196	1,290	1,332	25,100	476	167	3	54,200	283	3	89,132	JBM
46	Maxton	26	1.0694	99,100	ND	7,610	ND	344	1,919	26,900	306	72	ND	60,900	ND	ND	98,051	JBM
	CLAY COUNTY																	
47	Salt	30	1.0022	8,520	0.6	41	3.3	4	36	3,240	45	1,360	5.4	4,420	12	tr.	9,167	HAH
48	Salt	30	1.0028	9,170	0.3	31	3.1	6	39	3,510	70	1,534	8.2	4,750	18	tr.	9,969	HAH
49	Salt	24	1.0132	23,660	0.62	616	26	143	158	8,160	177	699	0	13,780	89	tr.	23,849	JBM
50	Salt	25	1.0045	11,750	0.15	49	4	6.7	71	2,870	17	1,062	16	4,470	tr.	0.1	8,566	HAH
	DODDRIDGE COUNTY																	
51	Maxton	27	1.0154	29,500	120	1,042	195	66	283	9,580	61	12	0	17,820	49	0.39	29,228	HAH
52	Maxton	27	1.0033	10,200	8	96	4	9.7	41	3,780	32	544	86	5,830	tr.	tr.	10,431	HAH
53	Big Injun	27.5	0.9934	221	77	29	ND	ND	1.8	36	ND	26	15	86	0	0	271	JBM
54*	Big Injun	27.5	0.9941	2,560	80	71	ND	ND	329	380	ND	1,573	14	708	0	0	3,188	JBM
55	Big Injun	27.5	1.0034	13,143	70	853	ND	ND	231	3,940	ND	42	3	8,210	50	1.5	13,401	JBM
56	Big Injun	27.5	0.9931	117	3.8	0.4	ND	ND	0.4	51	ND	14	2.3	70	0	0	142	JBM
57	Squaw	27	1.0799	112,500	250	8,920	67	0	1,800	30,700	344	0	8.4	68,700	695	9.3	111,494	HAH
58	Squaw	27.5	1.0060	18,600	22	633	ND	ND	196	6,290	ND	37	3	11,330	75	2	18,588	JBM
59	Big Dunkard	21.5	1.0064	10,690	35	141	4.8	tr.	39	3,590	46	695	159	5,420	10	tr.	10,140	HAH
	GILMER COUNTY																	
60	Maxton	25	1.0432	65,700	18	4,240	182	255	896	18,770	209	402	10	39,200	172	4	64,358	JBM
61	Maxton	27	1.0359	55,600	220	2,730	197	29	568	17,300	79	157	0	33,500	193	2	54,975	HAH
62	Big Injun	27	1.0171	28,100	240	2,065	43	0	360	7,790	56	46	6	17,030	98	2	27,736	HAH
63	Big Injun	27	1.0348	51,800	220	2,770	103	0	1,009	15,250	59	23	56	31,600	242	6	51,338	HAH
	HARRISON COUNTY																	
64	1st Salt	22	1.0076	13,120	0.3	247	15	57	98	4,690	45	878	0	7,490	2.5	tr.	13,523	HAH
65	2nd Salt	21	1.0020	7,410	tr.	134	5	0	58	2,670	22	705	63	4,090	6	0.05	7,753	HAH
66	2nd Salt	23	1.0012	7,580	tr.	84	5	9	47	2,800	25	773	18	4,160	9	tr.	7,930	HAH

Table 10.—Chemical Analyses of Brines of West Virginia by Counties, in Parts per Million, (Continued).

Sample No.	Producing Horizon	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
	KANAWHA COUNTY																	
67	1st Salt	21	1.0355	54,800	0	2,280	ND	226	771	17,440	264	360	0	33,300	19	1.2	54,661	HAH
68	Salt	25	1.0732	104,400	17	5,600	275	534	1,619	31,100	344	9	3.7	63,300	280	1.9	103,085	HAH
69	Salt	25	1.0738	104,500	90	5,620	151	1,390	1,663	31,100	264	57	9.5	63,700	335	3.4	104,483	HAH
70	Salt	24	1.0585	84,700	10	4,240	139	683	1,200	25,770	175	99	tr.	51,200	227	2.8	83,746	HAH
71	Salt	22	1.0747	104,800	7.5	5,440	179	1,005	1,658	31,100	356	36	3.7	63,200	503	3	103,312	HAH
72	Salt	26	1.0401	61,300	1.	2,940	109	330	786	19,100	105	184	10	37,100	173	1.9	60,840	HAH
73	Salt	21.5	1.0225	31,800	14	4,840	122	0	1,016	5,480	145	64	61	20,110	37	0.8	31,888	HAH
74	Salt	21	1.0514	72,200	5	4,870	107	489	1,110	19,220	208	157	0	41,900	59	2.3	68,127	HAH
75	Salt & Big Injun	21	1.0741	102,500	24	7,510	256	487	1,769	28,500	278	76	0	63,000	105	2.7	102,009	HAH
76	Salt	29	1.0000	564	2.1	13	ND	ND	10	ND	ND	438	56	ND	0	0	......[2]	HAH
77	Salt	30	1.0249	40,500	0.6	1,576	82	270	330	12,870	731	412	4.1	24,170	117	1.2	40,564	JBM
78	Salt	22	1.0415	60,200	1.5	2,860	115	562	681	18,760	120	402	7.4	36,000	480	2	59,991	HAH
79	Salt	26	1.0208	34,700	0.6	1.609	33	113	493	10,780	163	732	17	20,640	118	tr.	34,699	HAH
80	Salt	26	1.0316	50,800	7.5	2,341	92	137	756	15,780	110	743	9	30,500	174	1.5	50,651	HAH
81	Salt	28	1.0509	77,300	0.9	3,900	127	860	968	23,260	221	160	5.4	46,080	342	1.3	75,926	HAH
82	Salt	28	1.0491	74,700	1.2	5,140	147	764	1,248	20,250	230	209	5.8	44,400	343	1.3	72,739	HAH
83	Salt	28	1.0421	65,000	1.1	3,250	159	682	830	19,540	323	180	6.6	38,800	346	1.3	64,119	HAH
84	Salt	26.5	1.0095	19,720	1.65	463	28	20	220	6,840	73	732	6.6	11,650	64	0.5	20,098	HAH
85	Salt	25	1.0435	65,900	0.75	4,740	134	174	894	17,850	220	32	4.9	39,400	432	0.25	63,882	HAH
86	Salt	24	1.0325	49,500	29	3,450	83	110	561	14,400	232	acid	0	30,200	174	1	49,240	JBM
87	Salt	25	1.0268	42,100	9	2,458	63	154	440	12,500	197	73	7.4	25,200	88	1	41,192	JBM
88	Salt	25	1.0253	39,600	6	2,330	39	134	412	11,680	285	134	9	23,570	73	1.2	38,673	JBM
89	Salt	25	1.0085	19,000	0.45	814	36	58	160	6,290	42	272	9	11,520	38	tr.	19,239	HAH
90	Maxton	25	1.0398	57,600	3	4,010	107	146	764	16,050	160	27	7	34,500	362	0.75	56,130	HAH
91	Big Lime	26	1.0621	90,800	tr.	5,620	393	0	1,585	26,000	245	147	219	54,800	283	7.5	89,300	HAH
92	Oriskany	25	1.2097	267,000	75	22,600	1,574	0	2,407	69,600	4,850	100	68	159,900	990	tr.	262,164	HAH
93	Oriskany	24.5	1.1776	240,300	5	3,920	1,386	0	479	85,700	2,800	133	113	143,600	850	3.4	238,989	HAH
94	Oriskany	23	1.1746	235,100	26	4,540	1,331	20	2,580	81,100	689	266	62	141,400	1,532	34	233,580	JBM
95	Oriskany Drip	22	1.0025	6,700	10	410	28	tr.	41	1,870	214	244	126	3,710	5	tr.	6,658	HAH
96	Oriskany Drip	24	1.0151	29,200	74	3,669	22	6.6	201	6,830	372	16	21	17,900	99	1.6	29,213	JBM
97*	Newburg?	26	1.0426	63,400	4	8,040	0	0	tr.	15,600	340	748	1,675	36,700	230	2.7	63,436	HAH
	LEWIS COUNTY																	
98	Dunkard?	19.5	1.0102	17,580	2	499	12	0	175	5,800	156	334	2.8	10,270	49	0	17,300	HAH
99	Salt	27	1.0340	54,100	320	2,880	210	38	704	16,440	56	124	0	33,000	145	2.7	53,920	HAH
100	Big Injun	27	1.0011	7,920	560	600	5.7	tr.	54	1,583	14	445	0	4,130	tr.	tr.	7,392	HAH

Table 10.—Chemical Analyses of Brines of West Virginia by Counties, in Parts per Million, (Continued).

Sample No.	Producing Horizon	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
	LINCOLN COUNTY																	
101	Salt	25.5	1.0285	48,100	4	2,482	ND	88	566	14,860	123	138	0	29,000	58	0.4	47,319	HAH
102	Salt	29.5	1.0198	34,800	0.75	1,546	46	63	463	11,030	620	39	7.4	21,650	88	tr.	35,546	JBM
103	Salt	30	1.0203	36,600	0.9	1,323	41	42	399	12,160	350	156	6.6	22,500	79	1	37,058	JBM
104	Salt	30	1.0256	42,800	3	1,569	35	38	474	14,200	249	127	21	26,170	146	0.4	43,032	JBM
105	Salt	25.5	1.0134	26,200	0	1,458	ND	0	362	7,700	126	126	78	15,480	20	0	25,350	HAH
106	Stray	29	1.1219	169,600	45	14,400	489	710	4,590	41,300	290	acid	5.3	103,200	965	1	165,705	JBM
107	Stray & Salt	29	1.0433	67,000	0.9	3,950	126	0	1,083	19,480	60	81	4	40,200	183	1.5	65,170	HAH
108	Big Injun	30	1.0040	12,500	9	576	6.7	0	158	3,850	73	317	353	7,042	1	0	12,386	HAH
	LOGAN COUNTY																	
109	2nd Salt	22	1.0862	121,100	25	9,960	Pr.	292	1,730	32,800	496	acid	0	7[illegible],800	615	tr.	119,793	HAH
110	2nd Salt	24	1.1058	144,600	120	12,380	267	306	2,228	39,100	400	acid	2.5	87,900	542	0.75	143,246	HAH
111	2nd Salt	24	1.1094	153,500	81	19,330	439	458	2,255	35,000	300	4.2	0	95,200	865	2.2	153,934	JBM
112	2nd Salt	24	1.1051	157,300	72	20,100	347	499	2,286	35,800	286	8.4	0	97,800	869	2.2	158,070	JBM
113	2nd Salt	24	1.1056	154,100	27	16,370	354	464	2,217	37,400	301	11	0	93,500	814	1.4	151,459	JBM
114	2nd Salt	27	1.1080	150,900	18	12,920	347	281	2,620	38,900	1,333	30	5	92,000	45	1	148,500	HAH
115	Salt	28	1.1145	159,600	60	15,600	447	347	3,900	39,500	244	30	4.9	100,400	670	1.1	161,204	JBM
116	Salt	28	1.0971	137,100	0.45	11,080	369	266	1,837	37,300	228	76	5.8	82,800	493	1.1	134,456	HAH
117	2nd Salt?	24	1.1098	158,900	36	19,250	378	426	2,330	37,500	264	0	0	97,900	973	2.2	159,059	JBM
	MARION COUNTY																	
118	Salt	25.5	1.0011	6,078	0.15	151	tr.	0	76	1,998	92	58	89	3,550	6	tr.	6,020	HAH
119	Big Injun	24	1.1394	187,100	0.75	15,830	401	0	2,880	49,300	620	0	19	113,500	1,382	22	184,029	HAH
120	Fifth	24	1.0848	108,200	ND	10,000	ND	ND	1,800	31,052	ND	acid	ND	70,800	0	24	113,676	JBM
	MARSHALL COUNTY																	
121	Salt	24.5	1.0001	5,460	0.25	47	ND	ND	16	2,100	ND	811	35	2,870	tr.	tr.	5,879	JBM
	MASON COUNTY																	
122	Salt	25	1.0608	87,500	30	4,090	88	213	1,282	24,800	168	34	3.7	50,200	354	tr.	81,263	HAH
123	Salt	24.5	1.0620	88,800	7.1	5,290	ND	0	1,490	26,200	ND	55	45	55,000	339	2.3	88,428	JBM
124	Salt & Big Injun	24	1.0846	128,200	2.3	10,180	186	360	2,104	36,000	304	4.3	0	79,900	664	3.2	129,708	JBM
125	Salt & Big Injun	24	1.0832	127,300	2.3	10,090	188	313	2,089	35,800	299	61	0	79,500	369	0	128,711	JBM
	MONONGALIA COUNTY																	
126	Little Dunkard	26.5	1.0129	25,100	1.65	1,024	35	17	289	8,100	22	128	18	15,070	88	2	24,795	HAH
127	Gas	22	1.0128	22,600	39	369	10	40	285	7,550	45	501	12	12,900	0	0	21,751	JBM
128	1st Salt	25	0.9970	875	0.6	4	tr.	1	1	273	13	570	5	180	tr.	tr.	1,118[3]	HAH
129	2nd Salt	24	0.9973	955	0.55	12	0	48	3.4	358	9	606	3	223	1	0.32	1,264	HAH
130	1st & 2nd Salt	25	0.9981	2,390	0.37	20	ND	ND	5.6	951	ND	854	16	1,010	0	0	2,857	JBM
131*	2nd Salt	22	0.9964	755	3	8.8	ND	ND	2.7	601	ND	477	21	646	0	0	1,770	JBM

Table 10.—Chemical Analyses of Brines of West Virginia by Counties, in Parts per Million, (Continued).

Sample No.	Producing Horizon	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
	MONONGALIA COUNTY (continued)																	
32	Salt	24	1.0098	1,052	10	79	0.3	0.7	14	250	36	305	184	287	0	0	1,166	JBM
33	Salt	22	0.9971	722	1.2	21	ND	ND	2.8	268	ND	477	20	166	0	0	956	JBM
34	All Sands	22	0.9972	682	1.1	10	ND	ND	2.5	260	ND	393	49	161	0	0	877	JBM
35	Salt	21	0.9978	1,490	3.5	15	ND	ND	4.6	596	ND	855	51	424	tr.	tr.	1,949	JBM
36	Big Injun	25	1.1381	182,100	9	15,540	207	0	2,670	50,300	367	29	85	112,600	842	40	182,689	HAH
37	Big Injun	23.5	1.0601	87,800	22	9,000	69	44	1,474	20,770	352	22	184	54,100	453	0.19	86,490	JBM
	NICHOLAS COUNTY																	
38	Big Injun	27	1.1319	179,900	20	14,000	1,298	0	4,580	46,100	224	78	258	109,800	1,060	15	177,433	HAH
39	Big Injun	27	1.1267	181,400	180	13,980	826	0	4,590	43,600	244	60	214	105,900	888	11	170,493	HAH
	PLEASANTS COUNTY																	
40	Gas	24.5	1.0061	9,050	0.5	131	ND	ND	86	4,100	ND	1,320	323	5,790	tr.	tr.	11,751	JBM
41	Big Injun	29	1.0262	42,500	1.35	1,373	45	116	346	14,460	126	915	11	25,400	0.2	2.9	42,795	HAH
42	Big Injun	27	1.0835	119,400	250	9,180	80	260	1,513	33,500	268	71	0	72,650	692	9.2	118,473	HAH
43	Big Injun	27	1.0663	98,900	120	6,970	76	0	1,168	27,800	296	70	83	58,800	234	12	95,629	HAH
44	Big Injun	27	1.0861	119,800	1,200	10,210	82	186	1,648	31,600	288	36	0	73,300	460	12	119,022	HAH
	PUTNAM COUNTY																	
45	Big Injun	24	1.1325	177,700	60	12,710	305	294	2,950	50,200	500	0	2.9	108,400	927	5	176,354	HAH
	RITCHIE COUNTY																	
46	Little Dunkard or 1st Cow Run	22	1.0051	10,420	tr.	214	9.2	16	59	3,710	38	214	15	6,180	7.5	tr.	10,463	HAH
47	1st Salt	26	0.9983	4,990	1.5	45	ND	ND	12	1,834	ND	703	45	2,500	0	0	5,141	JBM
48	1st Salt	23	1.0131	22,190	0.94	643	21	0	154	7,420	48	598	236	12,540	41	1.6	21,704	JBM
49	Salt	22	1.0111	20,750	3	780	34	10	186	6,740	88	415	29	12,140	40	tr.	20,465	HAH
50	2nd Salt	27	1.0275	43,800	9	2,284	140	47	468	13,370	193	345	11	26,100	39	tr.	43,006	HAH
51	Salt	30	1.0717	99,400	4	6,800	166	1,573	1,608	27,300	289	52	tr.	59,900	196	7.5	97,895	JBM
52	Salt	24	1.0093	21,160	0.2	800	34	5	177	7,030	67	212	46	12,670	74	0.6	21,115	HAH
53	Maxton	25	1.0740	104,900	17	7,240	155	1,126	1,500	29,600	282	64	6.6	63,500	559	7.5	104,057	HAH
54	Maxton	24	1.0862	123,700	25	8,690	87	474	1,738	34,300	308	193	tr.	73,600	552	7.4	119,984	JBM
55	Maxton	25	1.0685	98,500	0.3	6,570	191	1,361	1,495	27,000	63	40	4.5	58,400	337	5.6	95,467	HAH
56	Maxton	25	1.0628	90,000	7.2	6,060	137	1,289	1,758	24,440	246	22	tr.	54,400	282	5.6	88,647	JBM
57	Maxton	24	1.0614	104,700	94	9,960	159	271	1,303	29,000	238	66	0	66,400	471	9	107,971	JBM
58	Maxton	22	1.0706	96,800	6	6,440	57	1,069	1,360	25,700	292	87	0	55,700	280	3.7	91,066	HAH
	ROANE COUNTY																	
59	Salt	22	1.0400	62,800	60	3,700	Pr.	244	925	18,440	236	199	0	38,000	430	3.7	62,238	HAH
60	Salt	22	1.0519	76,100	tr.	4,710	Pr.	640	1,055	21,980	416	143	0	45,900	1.5	6.1	74,852	HAH

Table 10.—Chemical Analyses of Brines of West Virginia by Counties, in Parts per Million, (Concluded).

No.	Producing Horizon	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
	ROANE COUNTY (Continued)																	
1	Salt	25	1.0077	14,270	800	1,187	23	133	456	2,890	124	acid	4.1	9,100	0	tr.	14,717	HAH
2	Salt	27	1.0842	122,400	1.8	7,170	242	5,530	2,064	33,700	224	93	4.1	73,700	354	7.4	123,090	HAH
3	Oriskany	21	1.1690	223,900	40	16,930	ND	0	2,097	63,500	2,820	34	1,587	135,100	642	5	222,755	HAH
4	Ohio Clinton or White Medina	31	1.1498	200,300	32	20,190	544	124	1,627	52,400	1,009	acid	355	122,000	1,000	40	199,321	HAH
	TYLER COUNTY																	
5	2nd Salt	25	1.0007	4,560	0.29	47	ND	ND	11	1,766	ND	377	21	2,600	6	0.4	4,829	JBM
6	Salt	26	1.1240	164,400	3	14,360	198	294	2,471	45,900	328	acid	18	103,600	800	18	167,990	HAH
7	Salt	26.5	0.9962	1,840	0.45	11	ND	ND	122	509	ND	744	1.8	727	tr.	tr.	2,115	JBM
8	Big Injun	25	1.0856	120,700	1.7	10,110	95	165	1,578	30,400	2,427	acid	6.2	72,300	1,105	11.7	118,199	HAH
9	Big Injun	21.5	1.1329	173,900	70	14,720	128	367	2,540	47,200	753	7	0	107,000	265	30	173,080	HAH
	WAYNE COUNTY																	
0	Salt	25	1.0401	61,200	tr.	3,290	115	158	947	18,630	150	94	tr.	37,500	144	1	61,029	HAH
1	Big Injun	24	1.0755	107,600	5.7	7,300	445	265	2,135	30,400	356	39	0	66,600	334	0.9	107,881	JBM
2	Big Injun	22	1.0408	60,200	14	7,500	382	52	767	13,300	329	34	6.2	36,200	1,000	tr.	59,584	HAH
	WETZEL COUNTY																	
3	1st Salt	24.5	1.0021	7,210	0.45	63	ND	ND	20	2,800	ND	716	127	3,970	tr.	tr.	7,696	JBM
4	3rd Salt	30	1.0581	86,700	14	6,590	129	0	1,184	24,090	229	83	40	52,300	400	17.4	85,076	HAH
5	Salt	24	1.0022	7,140	tr.	46	1.4	0	17	2,840	50	942	8	4,000	15	0.03	7,919	HAH
	WIRT COUNTY																	
6	Salt	27	1.0547	83,700	0.9	4,370	214	862	1,471	24,310	192	105	5.4	50,100	284	3.4	81,918	HAH
7	Salt	27	1.0549	84,000	0.9	4,410	204	833	1,470	24,380	135	102	5.4	50,200	284	3.8	82,028	HAH
8	Maxton	24	1.0718	101,100	75	7,190	271	1,252	1,763	27,700	300	4	5	61,000	560	5.0	100,125	HAH
9	Maxton	25	1.0765	108,200	5.7	7,180	183	1,685	1,934	30,000	292	156	0	65,600	446	5.6	107,487	JBM
0	Squaw	25	1.0137	27,000	2	1,027	24	0	238	8,740	116	414	0	15,820	89	1	26,471	HAH
1	Oriskany	24	1.2048	280,000	100	30,500	881	172	3,960	65,900	2,101	113	119	169,200	1,245	2.7	274,294	JBM
2	Oriskany	22	1.2259	270,000	115	27,200	889	0	4,110	68,100	3,400	114	101	168,000	1,550	21	273,600	HAH
	WOOD COUNTY																	
3	Maxton	22	1.0707	99,900	15	6,000	160	499	1,656	29,200	159	289	5	60,600	336	3	98,922	JBM
4	Big Injun	30	1.0765	110,500	60	6,120	178	347	1,898	32,500	252	61	7.8	67,000	5	tr.	108,429	HAH

[1]No. 22 contains 1200 ppm S — included in T. D. C.
[2]No. 76 contains 18 ppm SiO_2. Purity sample questioned — hence not completed. ND=Not determined. Pr.=Present. Tr.=Trace.
[3]No. 128 contains 71 ppm SiO_2 included in T. D. C.
*Those marked with asterisk contain CO_3 as follows: No. 54 — 33 ppm.; No. 97 — 96 ppm.; No. 131 — 10 ppm.; all others contain no CO_3.

CHEMICAL ANALYSES BY PRODUCING HORIZONS.

The following table shows complete chemical analyses by producing horizons. A total of 19 different horizons are included. In a considerable percentage of cases only one sample per horizon was available.

The four horizons best represented are Salt, Maxton, Big Injun and Oriskany. The Salt has been segregated into 1st Salt, 2nd Salt, etc., as reported by operators.

The data here included are the same as those in the preceding table arranged by counties. The rearrangement by horizons in the present table was adopted for the convenience of those wishing to see together all results for a given horizon. The county arrangement for each horizon is again alphabetical.

Average results per horizon are given in the table at the end of the group of analyses for that horizon. In the case of a single analysis, of course, no separate average is shown.

Table 11.—Chemical Analyses of Brines of West Virginia by Producing Horizons, in Parts per Million

No.	Geological Horizon	County	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
38	Moundsville	Calhoun	25.5	1.0021	8,860	0	1,172	0	0	231	1,663	tr.	163	31	5,190	10	0	8,460	HAH
26	Little Dunkard or 1st Cow Run	Monongalia	26.5	1.0129	25,100	1.65	1,024	35	17	289	8,100	22	128	18	15,070	88	2	24,795	HAH
46	Little Dunkard or 1st Cow Run	Ritchie	22.	1.0051	10,420	tr.	214	9.2	16	59	3,710	38	214	15	6,180	7.5	tr.	10,463	HAH
..	Little Dunkard or 1st Cow Run	Average	24.3	1.0090	17,760	0.82	619	22.1	16.5	174	5,905	30	171	16.5	10,625	47.8	1	17,629	
26	Big Dunkard	Cabell	23	1.0394	59,400	tr.	3,370	103	127	979	17,690	50	99	tr.	36,200	52	0.4	58,670	HAH
59	Big Dunkard	Doddridge	21.5	1.0064	10,690	35	141	4.8	tr.	39	3,590	46	695	159	5,420	10	tr.	10,140	HAH
98	Dunkard?	Lewis	19.5	1.0102	17,580	2	499	12	0	175	5,800	156	334	2.8	10,270	49	0	17,300	HAH
..	Big Dunkard	Average	21.3	1.0187	29,223	12	1,337	40	42	398	9,027	84	376	54	17,296	37	0.1	28,703	
27	Gas	Monongalia	22	1.0128	22,600	39	369	10	40	285	7,550	45	501	12	12,900	0	0	21,751	JBM
40	Gas	Pleasants	24.5	1.0061	9,050	0.5	131	ND	ND	86	4,100	ND	1,320	323	5,790	tr.	tr.	11,751	JBM
..	Gas	Average	23.2	1.0095	15,825	20	250	5	20	185.5	5,825	22.5	910.5	167.5	9,345	0	0	16,751	
39	1st Salt	Calhoun	30	1.0082	19,270	1.8	469	31	29	126	7,410	60	495	5.4	11,170	tr.	0.08	19,797	HAH
64	1st Salt	Harrison	22	1.0076	13,120	0.3	247	15	57	98	4,690	45	878	0	7,490	2.5	tr.	13,523	HAH
67	1st Salt	Kanawha	21	1.0355	54,800	0	2,280	ND	226	771	17,440	264	360	0	33,300	19	1.2	54,661	HAH
28	1st Salt[3]	Monongalia	25	0.9970	875	0.6	4	tr.	1	1	273	13	570	5	180	tr.	tr.	1,118	HAH
47	1st Salt	Ritchie	26	0.9983	4,990	1.5	45	ND	ND	12	1,834	ND	703	45	2,500	0	0	5,141	JBM
48	1st Salt	Ritchie	23	1.0131	22,190	0.94	643	21	0	154	7,420	48	598	236	12,540	41	1.6	21,704	JBM
73	1st Salt	Wetzel	24.5	1.0021	7,210	0.45	63	ND	ND	20	2,800	ND	716	127	3,970	tr.	tr.	7,696	JBM
..	1st Salt	Average	24.6	1.0088	17,494	0.80	536	9.5	44.7	169	5,981	61.5	617.1	59.6	10,164.3	8.9	0.41	17,663	
30	1st & 2nd Salt	Monongalia	25	0.9981	2,390	0.37	20	ND	ND	5.6	951	ND	854	16	1,010	0	0	2,857	JBM
1	2nd Salt	Boone	26.5	1.1048	146,300	75	12,690	313	266	2,113	39,300	606	53	6.6	89,700	64	0.75	145,188	HAH
65	2nd Salt	Harrison	21	1.0020	7,410	tr.	134	5	0	58	2,670	22	705	63	4,090	6	0.05	7,753	HAH
66	2nd Salt	Harrison	23	1.0012	7,580	tr.	84	5	9	47	2,800	25	773	18	4,160	9	tr.	7,930	HAH
09	2nd Salt	Logan	22	1.0862	121,100	25	9,960	Pr.	292	1,730	32,800	496	acid	0	73,800	615	tr.	119,793	HAH
10	2nd Salt	Logan	24	1.1058	144,600	120	12,380	267	306	2,228	39,100	400	acid	2.5	87,900	542	0.75	143,246	HAH
11	2nd Salt	Logan	24	1.1094	153,500	81	19,330	439	458	2,255	35,000	300	4.2	0	95,200	865	2.2	153,934	JBM
12	2nd Salt	Logan	24	1.1051	157,300	72	20,100	347	499	2,286	35,800	286	8.4	0	97,800	869	2.2	158,070	JBM
13	2nd Salt	Logan	24	1.1056	154,100	27	16,370	354	464	2,217	37,400	301	11	0	93,500	814	1.4	151,459	JBM
14	2nd Salt	Logan	27	1.1080	150,900	18	12,920	347	281	2,620	38,900	1,333	30	5	92,000	45	1	148,500	HAH

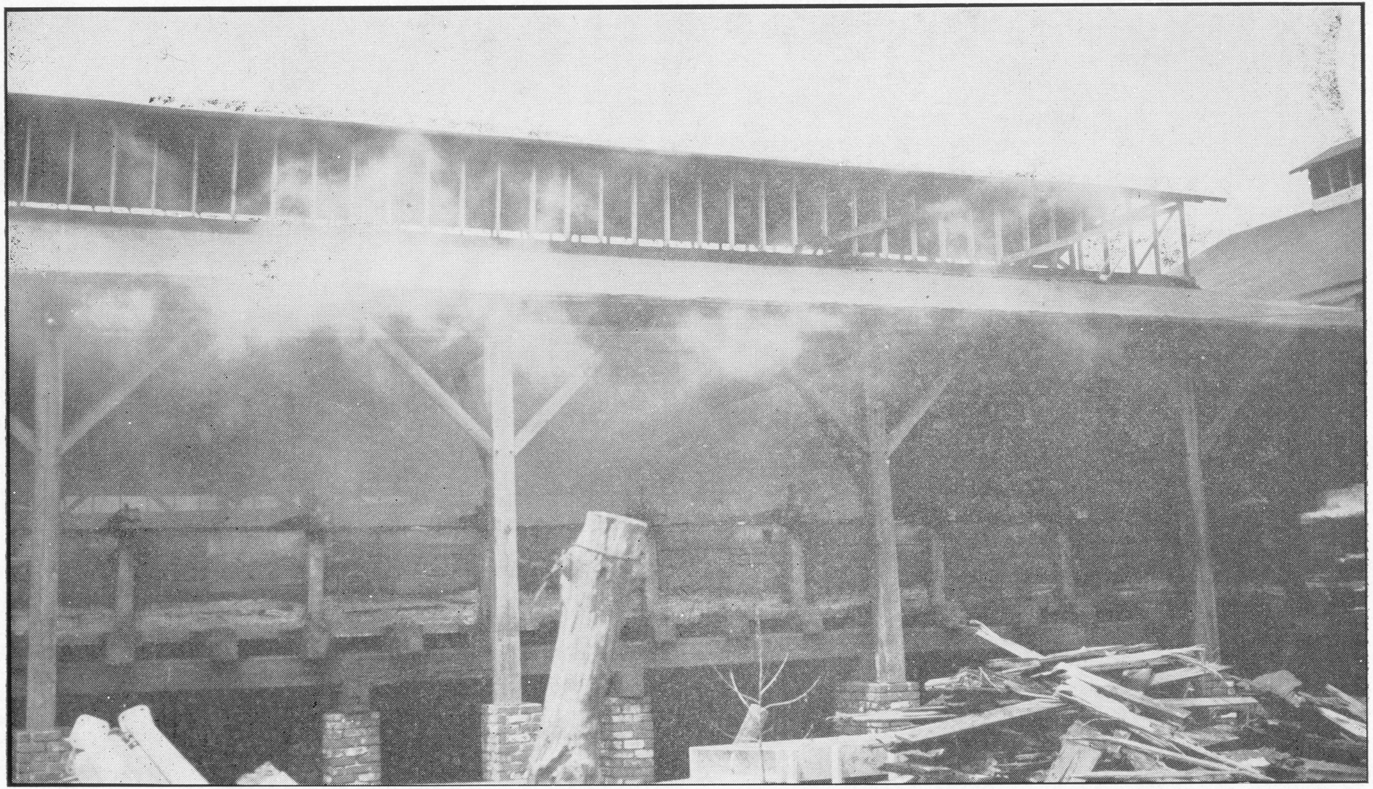


PLATE XIV.—Grainer Shed and First Vat, Mason City, W. Va.—This is the "grainer" which produces the first grade of salt. Note the keyed plank construction. The shed is open to permit ready escape of steam from the brine.—Photo by Hoskins, 1937.

Table 11.—Chemical Analyses of Brines of West Virginia by Producing Horizons, in Parts per Million, (Continued).

Sample No.	Geological Horizon	County	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
117	2nd Salt?	Logan	24	1.1098	158,900	36	19,250	378	426	2,330	37,500	264	0	0	97,900	973	2.2	159,059	JBM
129	2nd Salt	Monongalia	24	0.9973	955	0.55	12	0	48	3.4	358	9	606	3	223	1	0.32	1,264	HAH
131	2nd Salt[4]	Monongalia	22	0.9964	755	3	8.8	ND	ND	2.7	601	ND	477	21	646	0	0	1,770	JBM
150	2nd Salt	Ritchie	27	1.0275	43,800	9	2,284	140	47	468	13,370	193	345	11	26,100	39	tr.	43,006	HAH
165	2nd Salt	Tyler	25	1.0007	4,560	0.29	47	ND	ND	11	1,766	ND	377	21	2,600	6	0.4	4,829	JBM
...	2nd Salt	Average	24.1	1.0614	89,411	33.34	8,969	185.4	221	1,312	22,668	302.5	241.8	10.8	54,687	346	0.81	88,986	
2	Salt	Boone	22	1.1083	148,000	30	12,470	248	397	2,236	39,500	281	10	744	89,200	812	3	145,931	JBM
3	Salt	Boone	26	1.1103	150,900	4.5	12,700	387	412	2,279	40,610	338	6.3	1.0	92,300	540	40	149,618	HAH
4	Salt	Boone	25	1.1060	145,800	11	11,750	300	419	2,075	39,400	385	8.4	1.2	88,200	475	0.72	143,025	HAH
5	Salt	Boone	26	1.0999	139,060	60	10,680	225	678	1,724	38,900	300	4	3	84,400	546	4	137,524	JBM
6	Salt	Boone	26	1.1050	145,300	90	13,200	271	345	3,610	35,300	238	9.1	7.4	88,600	543	1.8	142,245	JBM
7	Salt	Boone	28	1.0880	125,800	135	9,690	tr.	244	1,555	34,800	286	acid	3.3	75,700	827	1.5	123,242	HAH
8	Salt	Boone	25	1.0160	32,100	0.45	1,607	60	141	267	8,780	116	46	6	17,300	103	0.35	28,427	HAH
9	Salt	Boone	24	1.0239	38,700	1	2,336	85	81	421	11,760	tr.	158	tr.	23,320	147	tr.	38,263	HAH
10	Salt?	Boone	27	1.0332	46,300	0.6	2,900	78	47	632	13,130	164	97	9.5	27,340	116	tr.	44,514	HAH
11	Salt	Boone	22	1.0051	11,390	1.4	345	tr.	127	197	3,620	104	296	4.9	6,740	12	tr.	11,447	HAH
12	Salt	Boone	26	1.0012	8,940	tr.	136	3	0	56	3,200	34	256	9	5,200	30	0.02	8,924	HAH
13	Salt?	Boone	25	0.9975	2,730	0.45	92	ND	ND	12	1,020	ND	413	7.8	1,470	120	0	3,135	JBM
14	Salt	Boone	26.5	0.9961	1,470	0.6	414	ND	ND	58	64	ND	243	3.8	781	3.8	tr.	1,568	JBM
15	Salt	Boone	25	1.0096	17,360	3	873	31	60	196	5,360	48	905	7.8	9,950	89	tr.	17,522	HAH
16	Salt	Boone	25	1.0105	18,660	1.2	934	28	82	234	5,880	94	847	8.6	11,040	30	tr.	19,179	JBM
17	Salt	Boone	23	1.0552	79,300	1	5,360	158	214	1,032	22,540	340	4.4	5.3	47,900	60	tr.	77,615	HAH
18	Salt	Boone	23	1.0415	63,000	0.5	4,470	129	120	761	18,060	240	51	tr.	37,900	240	tr.	61,972	HAH
19	Salt	Boone	25.5	1.0803	115,700	66	9,730	ND	384	1,753	30,600	215	65	0	69,800	92	2	112,707	HAH
20	Salt	Boone	28	1.0435	66,200	45	5,650	118	188	993	17,560	110	81	4.5	40,100	230	0.9	65,080	HAH
24	Salt	Cabell	27	1.0533	78,000	5.7	4,110	150	106	1,238	23,600	218	104	0	47,500	190	1.1	77,227	HAH
25	Salt	Cabell	24	1.0243	39,200	0.45	1,686	79	127	421	12,620	249	150	5.3	23,590	88	tr.	39,016	JBM
27	Salt	Cabell	26	1.0578	86,900	tr.	5,490	158	298	1,424	24,760	15	62	19	52,200	194	2	84,622	HAH
28	Salt	Cabell	26	1.0246	41,600	1	1,919	80	75	560	14,470	105	140	tr.	27,400	110	6	44,866	HAH
29	Salt	Cabell	19.5	1.0093	13,930	2	592	16	tr.	210	4,300	184	323	0	8,250	50	0	13,927	HAH
30	Salt?	Cabell	25.0	1.0199	33,200	4.5	1,277	62	57	383	10,580	142	152	0.82	19,760	117	0.78	32,536	JBM
40	Salt	Calhoun	23	1.0666	91,300	65	6,140	225	1,295	1,392	25,700	150	39	9.4	55,400	337	6.8	90,759	HAH
41	Salt	Calhoun	22	1.0510	73,700	10	4,610	194	757	1,117	20,590	149	acid	0	44,200	300	4.7	71,932	HAH
42	Salt	Calhoun	24	1.0720	113,400	7	8,454	2,610	1,554	2,038	28,900	298	51	0	68,400	373	4	112,689	HAH
43	Salt	Calhoun	26	1.0732	105,100	1.1	6,070	168	1,843	1,730	29,900	300	50	7	63,000	400	6	103,475	HAH
47	Salt	Clay	30	1.0022	8,520	0.6	41	3.3	4	36	3,240	45	1,360	5.4	4,420	12	tr.	9,167	HAH

Table 11.—Chemical Analyses of Brines of West Virginia by Producing Horizons, in Parts per Million, (Continued).

No.	Geological Horizon	County	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
48	Salt	Clay	30	1.0028	9,170	0.3	31	3.1	6	39	3,510	70	1,534	8.2	4,750	18	tr.	9,969	HAH
49	Salt	Clay	24	1.0132	23,660	0.62	616	26	143	158	8,160	177	699	0	13,780	89	tr.	23,849	JBM
50	Salt	Clay	25	1.0045	11,750	0.15	49	4	6.7	71	2,870	17	1,062	16	4,470	tr.	0.1	8,566	HAH
68	Salt	Kanawha	25	1.0732	104,400	17	5,600	275	534	1,619	31,100	344	9	3.7	63,300	280	1.9	103,085	HAH
69	Salt	Kanawha	25	1.0738	104,500	90	5,620	151	1,390	1,663	31,100	264	57	9.5	63,700	335	3.4	104,483	HAH
70	Salt	Kanawha	24	1.0585	84,700	10	4,240	139	683	1,200	25,770	175	99	tr.	51,200	227	2.8	83,746	HAH
71	Salt	Kanawha	22	1.0747	104,800	7.5	5,440	179	1,005	1,658	31,100	356	36	3.7	63,200	503	3	103,312	HAH
72	Salt	Kanawha	26	1.0401	61,300	1	2,940	109	330	786	19,100	105	184	10	37,100	173	1.9	60,840	HAH
73	Salt	Kanawha	21.5	1.0225	31,800	14	4,840	122	0	1,016	5,480	145	64	61	20,110	37	0.8	31,888	HAH
74	Salt	Kanawha	21	1.0514	72,200	5	4,870	107	489	1,110	19,220	208	157	0	41,900	59	2.3	68,127	HAH
76	Salt[2]	Kanawha	29	1.0000	564	2.1	13	ND	ND	10	ND	ND	438	56	ND	0	0		HAH
77	Salt	Kanawha	30	1.0249	40,500	0.6	1,576	82	270	330	12,870	731	412	4.1	24,170	117	1.2	40,564	JBM
78	Salt	Kanawha	22	1.0415	60,200	1.5	2,860	115	562	681	18,760	120	402	7.4	36,000	480	2	59,991	HAH
79	Salt	Kanawha	26	1.0208	34,700	0.6	1,609	33	113	493	10,780	163	732	17	20,640	118	tr.	34,699	HAH
80	Salt	Kanawha	26	1.0316	50,800	7.5	2,341	92	137	756	15,780	110	743	9	30,500	174	1.5	50,651	HAH
81	Salt	Kanawha	28	1.0509	77,300	0.9	3,900	127	860	968	23,260	221	160	5.4	46,080	342	1.3	75,926	HAH
82	Salt	Kanawha	28	1.0491	74,700	1.2	5,140	147	764	1,248	20,250	230	209	5.8	44,400	343	1.3	72,739	HAH
83	Salt	Kanawha	28	1.0421	65,000	1.1	3,250	159	682	830	19,540	323	180	6.6	38,800	346	1.3	64,119	HAH
84	Salt	Kanawha	26.5	1.0095	19,720	1.65	463	28	20	220	6,840	73	732	6.6	11,650	64	0.5	20,098	HAH
85	Salt	Kanawha	25	1.0435	65,900	0.75	4,740	134	174	894	17,850	220	32	4.9	39,400	432	0.25	63,882	HAH
86	Salt	Kanawha	24	1.0325	49,500	29	3,450	83	110	561	14,400	232	acid	0	30,200	174	1	49,240	JBM
87	Salt	Kanawha	25	1.0268	42,100	9	2,458	63	154	490	12,500	197	73	7.4	25,200	88	1	41,192	JBM
88	Salt	Kanawha	25	1.0253	39,600	6	2,330	39	134	412	11,680	285	134	9	23,570	73	1.2	38,673	JBM
89	Salt	Kanawha	25	1.0085	19,000	0.45	814	36	58	160	6,290	42	272	9	11,520	38	tr.	19,239	HAH
99	Salt	Lewis	27	1.0340	54,100	320	2,880	210	38	704	16,440	56	124	0	33,000	145	2.7	53,920	HAH
01	Salt	Lincoln	25.5	1.0285	48,100	4	2,482	ND	88	566	14,860	123	138	0	29,000	58	0.4	47,319	HAH
02	Salt	Lincoln	29.5	1.0198	34,800	0.75	1,546	46	63	463	11,030	620	39	7.4	21,650	88	tr.	35,546	JBM
03	Salt	Lincoln	30	1.0203	36,600	0.9	1,323	41	42	399	12,160	350	156	6.6	22,500	79	1.0	37,058	JBM
04	Salt	Lincoln	30	1.0256	42,800	3	1,569	35	38	474	14,200	249	127	21	26,170	146	0.4	43,032	JBM
05	Salt	Lincoln	25.5	1.0134	26,200	0	1,458	ND	0	362	7,700	126	126	78	15,480	20	0	25,350	HAH
07	Salt & Stray	Lincoln	29	1.0433	67,000	0.9	3,950	126	0	1,083	19,480	60	81	4	40,200	183	1.5	65,170	HAH
15	Salt	Logan	28	1.1145	159,600	60	15,600	447	347	3,900	39,500	244	30	4.9	100,400	670	1.1	161,204	JBM
16	Salt	Logan	28	1.0971	137,100	0.45	11,080	369	266	1,837	37,300	228	76	5.8	82,800	493	1.1	134,456	HAH
18	Salt	Marion	25.5	1.0011	6,078	0.15	151	tr.	0	76	1,998	92	58	89	3,550	6	tr.	6,020	HAH
21	Salt	Marshall	24.5	1.0001	5,460	0.25	47	ND	ND	16	2,100	ND	811	35	2,870	tr.	tr.	5,879	JBM
22	Salt	Mason	25	1.0608	87,500	30	4,090	88	213	1,282	24,800	168	34	3.7	50,200	354	tr.	81,263	HAH
23	Salt	Mason	24.5	1.0620	88,800	7.1	5,290	ND	0	1,490	26,200	ND	55	45	55,000	339	2.3	88,428	JBM
32	Salt	Monongalia	24	1.0098	1,052	10	79	0.3	0.7	14	250	36	305	184	287	0	0	1,166	JBM

Table 11.—Chemical Analyses of Brines of West Virginia by Producing Horizons, in Parts per Million, (Continued).

No.	Geological Horizon	County	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
33	Salt	Monongalia	22	0.9971	722	1.2	21	ND	ND	2.8	268	ND	477	20	166	0	0	956	JBM
34	All Salt Sands	Monongalia	22	0.9972	682	1.1	10	ND	ND	2.5	260	ND	393	49	161	0	0	877	JBM
35	Salt	Monongalia	21	0.9978	1,490	3.5	15	ND	ND	4.6	596	ND	855	51	424	tr.	tr.	1,949	JBM
49	Salt	Ritchie	22	1.0111	20,750	3	780	34	10	186	6,740	88	415	29	12,140	40	tr.	20,465	HAH
51	Salt	Ritchie	30	1.0717	99,400	4	6,800	166	1,573	1,608	27,300	289	52	tr.	59,900	196	7.5	97,895	JBM
52	Salt	Ritchie	24	1.0093	21,160	0.2	800	34	5	177	7,030	67	212	46	12,670	74	0.6	21,115	HAH
59	Salt	Roane	22	1.0400	62,800	60	3,700	Pr.	244	925	18,440	236	199	0	38,000	430	37	62,238	HAH
60	Salt	Roane	22	1.0519	76,100	tr.	4,710	Pr.	640	1,055	21,980	416	143	0	45,900	1.5	6.1	74,852	HAH
61	Salt	Roane	25	1.0077	14,270	800	1,187	23	133	456	2,890	124	acid	4.1	9,100	0	tr.	14,717	HAH
62	Salt	Roane	27	1.0842	122,400	18	7,170	242	5,530	2,064	33,700	224	93	4.1	73,700	354	7.4	123,090	HAH
66	Salt	Tyler	26	1.1240	164,400	3	14,360	198	294	2,471	45,900	328	acid	18	103,600	800	18	167,990	HAH
67	Salt	Tyler	26.5	0.9962	1,840	0.45	11	ND	ND	122	509	ND	744	1.8	727	tr.	tr.	2,115	JBM
70	Salt	Wayne	25	1.0401	61,200	tr.	3,290	115	158	947	18,630	150	94	tr.	37,500	144	1	61,029	HAH
74	3rd Salt	Wetzel	30	1.0581	86,700	14	6,590	129	0	1,184	24,090	229	83	40	52,300	400	17.4	85,076	HAH
75	Salt	Wetzel	24	1.0022	7,140	tr.	46	1.4	0	17	2,840	50	942	8	4,000	15	0.03	7,919	HAH
76	Salt	Wirt	27	1.0547	83,700	0.9	4,370	214	862	1,471	24,310	192	105	5.4	50,100	284	3.4	81,918	HAH
77	Salt	Wirt	27	1.0549	84,000	0.9	4,410	204	833	1,470	24,380	135	102	5.4	50,200	284	3.8	82,028	HAH
..	Salt	Average	25.2	1.0402	59,440	25.1	3,866	130	358	887	17,000	156	250	22	35,961	206	2.8	58,596	
06	Stray	Lincoln	29	1.1219	169,600	45	14,400	489	710	4,590	41,300	290	acid	5.3	103,200	965	1.0	165,705	JBM
21	Maxton	Boone	28	1.1211	167,000	45	18,200	444	84	4,800	36,400	189	61	23	102,600	642	7.1	163,495	JBM
33	Maxton	Cabell	27	1.0391	59,400	50	3,160	237	155	902	17,780	136	85	0	35,900	193	1.1	58,599	HAH
44	Maxton	Calhoun	24	1.0729	103,800	0.25	6,790	221	1,500	1,711	28,600	40	65	0	62,100	326	tr.	101,353	HAH
45	Maxton	Calhoun	30	1.0605	89,490	92	5,990	196	1,290	1,332	25,100	476	167	3	54,200	283	3	89,132	JBM
46	Maxton	Calhoun	26	1.0694	99,100	ND	7,610	ND	344	1,919	26,900	306	72	ND	60,900	ND	ND	98,051	JBM
51	Maxton	Doddridge	27	1.0154	29,500	120	1,042	195	66	283	9,580	61	12	0	17,820	49	39	29,228	HAH
52	Maxton	Doddridge	27	1.0033	10,200	8	96	4	9.7	41	3,780	32	544	86	5,830	tr.	tr.	10,431	HAH
60	Maxton	Gilmer	25	1.0432	65,700	18	4,240	182	255	896	18,770	209	402	10	39,200	172	4	64,358	JBM
61	Maxton	Gilmer	27	1.0359	55,600	220	2,730	197	29	568	17,300	79	157	0	33,500	193	2	54,975	HAH
90	Maxton	Kanawha	25	1.0398	57,600	3	4,010	107	146	764	16,050	160	27	7	34,500	362	0.75	56,130	HAH
53	Maxton	Ritchie	25	1.0740	104,900	17	7,240	155	1,126	1,500	29,600	282	64	6.6	63,500	559	7.5	104,057	HAH
54	Maxton	Ritchie	24	1.0862	123,700	25	8,690	87	474	1,738	34,300	308	193	tr.	73,600	552	7.4	119,984	JBM
55	Maxton	Ritchie	25	1.0685	98,500	0.3	6,570	191	1,361	1,495	27,000	63	40	4.5	58,400	337	5.6	95,467	HAH
56	Maxton	Ritchie	25	1.0628	90,000	7.2	6,060	137	1,289	1,758	24,440	246	22	tr.	54,400	282	5.6	88,647	JBM
57	Maxton	Ritchie	24	1.0614	104,700	94	9,960	159	271	1,303	29,000	238	66	0	66,400	471	9	107,971	JBM
58	Maxton	Ritchie	22	1.0706	96,800	6	6,440	57	1,069	1,360	25,700	292	87	0	55,700	280	3.7	91,066	HAH
78	Maxton	Wirt	24	1.0718	101,100	75	7,190	271	1,252	1,763	27,700	300	4	5	61,000	560	5	100,125	HAH

Table 11.—Chemical Analyses of Brines of West Virginia by Producing Horizons, in Parts per Million, (Continued).

Sample No.	Geological Horizon	County	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
79	Maxton	Wirt	25	1.0765	108,200	5.7	7,180	183	1,685	1,934	30,000	292	156	0	65,600	446	5.6	107,487	JBM
83	Maxton	Wood	22	1.0707	99,900	15	6,000	160	499	1,656	29,200	159	289	5	60,600	336	3	98,922	JBM
..	Maxton	Average	25.4	1.0597	87,642	42.2	6,274	168	679	1,459	24,063	204	132.3	7.9	52,934	318	3.72	86,288	
91	Big Lime	Kanawha	26	1.0621	90,800	tr.	5,620	393	0	1,585	26,000	245	147	219	54,800	283	7.5	89,300	HAH
23	Big Injun	Braxton	27	1.0851	118,100	1,600	9,150	447	0	1,840	31,500	172	0	5.5	72,500	369	11	117,595	HAH
31	Salt & Big Injun	Cabell	24	1.0527	77,600	1	4,910	126	245	1,320	22,840	256	13	0	47,000	285	3.2	76,999	HAH
75	Salt & Big Injun	Kanawha	21	1.0741	102,500	24	7,510	256	487	1,769	28,500	278	76	0	63,000	105	2.7	102,009	HAH
24	Salt & Big Injun	Mason	24	1.0846	128,200	2.3	10,180	186	360	2,104	36,000	304	4.3	0	79,900	664	3.2	129,708	JBM
25	Salt & Big Injun	Mason	24	1.0832	127,300	2.3	10,090	188	313	2,089	35,800	299	61	0	79,500	369	0	128,711	JBM
32	Big Injun	Cabell	27	1.0729	109,200	45	5,460	174	340	1,688	31,600	400	0	0	63,800	280	2	103,789	HAH
34	Big Injun	Cabell	22	1.0334	53,300	0	3,050	Pr.	132	822	15,500	96	152	0	32,000	210	2.7	52,059	HAH
35	Big Injun?	Cabell	25	1.1198	163,200	6	11,990	206	551	2,780	42,000	280	25	10	98,200	1,252	4	157,304	HAH
36	Big Injun	Cabell	24	1.1239	177,300	36	17,360	385	927	3,170	45,100	412	8.3	0	110,200	890	8.5	178,497	JBM
37	Big Injun	Cabell	21	1.1278	172,000	114	13,610	ND	928	3,150	46,000	449	18	0	104,700	665	7	169,641	HAH
53	Big Injun	Doddridge	27.5	0.9934	221	77	29	ND	ND	1.8	36	ND	26	15	86	0	0	271	JBM
54[4]	Big Injun	Doddridge	27.5	0.9941	2,560	80	71	ND	ND	329	380	ND	1,573	14	708	0	0	3,188	JBM
55	Big Injun	Doddridge	27.5	1.0034	13,143	70	853	ND	ND	231	3,940	ND	42	3	8,210	50	1.5	13,401	JBM
56	Big Injun	Doddridge	27.5	0.9931	117	3.8	0.4	ND	ND	0.4	51	ND	14	2.3	70	0	0	142	JBM
62	Big Injun	Gilmer	27	1.0171	28,100	240	2,065	43	0	360	7,790	56	46	6	17,030	98	2	27,736	HAH
63	Big Injun	Gilmer	27	1.0348	51,800	220	2,770	103	0	1,009	15,250	59	23	56	31,600	242	6	51,338	HAH
00	Big Injun	Lewis	27	1.0011	7,920	560	600	5.7	tr.	54	1,583	14	445	0	4,130	tr.	tr.	7,392	HAH
08	Big Injun	Lincoln	30	1.0040	12,500	9	576	6.7	0	158	3,850	73	317	353	7,042	1	0	12,386	HAH
19	Big Injun	Marion	24	1.1394	187,100	0.75	15,830	401	0	2,880	49,300	620	0	19	113,500	1,382	22	184,029	HAH
36	Big Injun	Monongalia	25	1.1381	182,100	9	15,540	207	0	2,670	50,300	367	29	85	112,600	842	40	182,689	HAH
37	Big Injun	Monongalia	23.5	1.0601	87,800	22	9,000	69	44	1,474	20,770	352	22	184	54,100	453	0.19	86,490	JBM
38	Big Injun	Nicholas	27	1.1319	179,900	20	14,000	1,298	0	4,580	46,100	224	78	258	109,800	1,060	15	177,433	HAH
39	Big Injun	Nicholas	27	1.1267	181,400	180	13,980	826	0	4,590	43,600	244	60	214	105,900	888	11	170,493	HAH
41	Big Injun	Pleasants	29	1.0262	42,500	1.35	1,373	45	116	346	14,460	126	915	11	25,400	0.2	2.9	42,795	HAH
42	Big Injun	Pleasants	27	1.0835	119,400	250	9,180	80	260	1,513	33,500	268	71	0	72,650	692	9.2	118,473	HAH
43	Big Injun	Pleasants	27	1.0663	98,900	120	6,970	76	0	1,168	27,800	296	70	83	58,800	234	12	95,629	HAH
44	Big Injun	Pleasants	27	1.0861	119,800	1,200	10,210	82	186	1,648	31,600	288	36	0	73,300	460	12	119,022	HAH
45	Big Injun	Putnam	24	1.1325	177,700	60	12,710	305	294	2,950	50,200	500	0	2.9	108,400	927	5	176,354	HAH
68	Big Injun	Tyler	25	1.0856	120,700	1.7	10,110	95	165	1,578	30,400	2,427	acid	6.2	72,300	1,105	11.7	118,199	HAH
69	Big Injun	Tyler	21.5	1.1329	173,900	70	14,720	128	367	2,540	47,200	753	7	0	107,000	265	30	173,080	HAH
71	Big Injun	Wayne	24	1.0755	107,600	5.7	7,300	445	265	2,135	30,400	356	39	0	66,600	334	0.9	107,881	JBM
72	Big Injun	Wayne	22	1.0408	60,200	14	7,500	382	52	767	13,300	329	34	6.2	36,200	1,000	tr.	59,584	HAH
84	Big Injun	Wood	30	1.0765	110,500	60	6,120	178	347	1,898	32,500	252	61	7.8	67,000	5	tr.	108,429	HAH
..	Big Injun	Average	25.6	1.0697	99,845	154.7	7,722	204.3	193.3	1,685	26,944	320	129.3	41	60,704	458.4	6.84	98,532	

Table 11.—Chemical Analyses of Brines of West Virginia by Producing Horizons, in Parts per Million, (Concluded).

Sample No.	Geological Horizon	County	Temperature °C.	Density	Solids after evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents	Analyst
57	Squaw	Doddridge	27	1.0799	112,500	250	8,920	67	0	1,800	30,700	344	0	8.4	68,700	695	9.3	111,494	HAH
58	Squaw	Doddridge	27.5	1.0060	18,600	22	633	ND	ND	196	6,290	ND	37	3	11,330	75	2	18,588	JBM
180	Squaw	Wirt	25	1.0137	27,000	2	1,027	24	0	238	8,740	116	414	0	15,820	89	1	26,471	HAH
...	Squaw	Average	26.5	1.0332	52,700	91.3	3,527	30.3	0	745	15,243	153	150	3.8	31,950	286.3	4.1	52,184	
120	Fifth	Marion	24	1.0848	108,200	ND	10,000	ND	ND	1,800	31,052	ND	acid	ND	70,800	0	24	113,676	JBM
92	Oriskany	Kanawha	25	1.2097	267,000	75	22,600	1,574	0	2,407	69,600	4,850	100	68	159,900	990	tr.	262,164	HAH
93	Oriskany	Kanawha	24.5	1.1776	240,300	5	3,920	1,386	0	479	85,700	2,800	133	113	143,600	850	3.4	238,989	HAH
94	Oriskany	Kanawha	23	1.1746	235,100	26	4,540	1,331	20	2,580	81,100	689	266	62	141,400	1,532	34	233,580	JBM
*95	Oriskany Drip	Kanawha	22	1.0025	6,700	10	410	28	tr.	41	1,870	214	244	126	3,710	5	tr.	6,658	HAH
*96	Oriskany Drip	Kanawha	24	1.0151	29,200	74	3,669	22	6.6	201	6,830	372	16	21	17,900	99	1.6	29,213	JBM
163	Oriskany	Roane	21	1.1690	223,900	40	16,930	ND	0	2,097	63,500	2,820	34	1,587	135,100	642	5	222,755	HAH
181	Oriskany	Wirt	24	1.2048	280,000	100	30,500	881	172	3,960	65,900	2,101	113	119	169,200	1,245	2.7	[illegible]74,2[illegible]4	JBM
182	Oriskany	Wirt	22	1.2259	270,000	115	27,200	889	0	4,110	68,100	3,400	114	101	168,000	1,550	21	273,600	HAH
...	Oriskany	Average	23.25	1.1936	252,717	60	17,615	1,010	32	2,606	72,317	2,777	127	342	152,870	1,135	11	[illegible]50,897	
22	Salina	Boone	23	1.1533	196,400	0	20,470	363	700	4,080	48,800	2,100	190	595	122,000	1,500	59	202,057[1]	HAH
97[4]	Newburg?	Kanawha	26	1.0426	63,400	4	8,040	0	0	tr.	15,600	340	748	1,675	36,700	230	2.7	63,436	HAH
164	White Medina or Ohio Clinton	Roane	31	1.1498	200,300	32	20,190	544	124	1,627	52,400	1,009	acid	355	122,000	1,000	40	199,321	HAH

*Omitted from Averages.

[1]No. 22 contains 1200 ppm. S—included in T. D. C.

[2]No. 76 contains 18 ppm. SiO_2.

[3]No. 128 contains 71 ppm. SiO_2 included in T. D. C.

[4]Those marked [4] contain CO_3 as follows: No. 54—33 ppm.; No. 97—96 ppm.; and No. 131—10 ppm. All others contain no CO_3.

Question mark after horizon indicates doubt as to identity.
ND=Not determined. Pr.=Present. Tr.=Trace.

CHEMICAL ANALYSES.

AVERAGE RESULTS BY HORIZONS.

The following table was prepared to show in condensed form average results for the principal four horizons. All the various subdivisions of the Salt Sand were grouped together for this table.

The main conclusion indicated by this table is that the concentration increases with deeper horizons. This conforms with the general observation resulting from other brine studies.

Table 12.—Summary of Averages of Chemical Analyses of Brines of West Virginia for Four Major Horizons, in Parts per Million.

Geological Horizon	Number of Samples in Average	Temperature °C.	Density	Solids After Evaporation	Fe	Ca	Sr	Ba	Mg	Na	K	HCO_3	SO_4	Cl	Br	I	Total of Determined Constituents
Salt	106	25.1	1.0221	60,089	215	4,284	128	316	888	16,840	167	279	23	3,6401	210	2.33	59,380
Maxton	19	25.4	1.0597	87,642	42	6,274	168	679	1,459	24,063	204	132.3	7.9	52,934	318	3.7	86,288
Big Injun	33	25.6	1.0697	99,845	155	7,722	204	193	1,685	26,994	320	129	41	60,704	458	6.8	98,532
Oriskany	6	23.3	1.1936	252,717	60	17,615	1,010	32	2,606	72,317	2,777	127	342	152,870	1,135	11	250,730

CORRELATION OF RESULTS OF CHEMICAL ANALYSES.

A general study has been made with the object of achieving a general correlation of results of chemical analysis. This study was successful to an exceptional degree. The two general conclusions derived are:

First, all of the brines of a given density both from a given horizon and from different horizons have approximately the same percentage composition of solid matter as regards the major constituents sodium, chloride, calcium, and magnesium.

Second, the brines in general increase in concentration with increasing depth of producing horizon.

In order to better study and compare the analyses, each constituent of all analyses from all horizons was plotted as ordinates against brine density as abscissa. In this way a set of curves was developed for each horizon showing, plotted against density, the following: Total solids after evaporation, iron, calcium, barium, magnesium, strontium, sodium, potassium, bicarbonate, sulfate, chloride, bromine, iodine. (See Figures 8 to 18).

It was found that for each horizon there were the following results:

Total solids gave a very smooth straight line.

Chloride gave a very smooth straight line.

Calcium gave a fairly smooth curve tipping upward for higher densities.

Sodium gave a very smooth curve tipping downward slightly for higher densities.

Magnesium gave a fairly smooth curve approximating a straight line.

Bromine increased in a general way with increasing density but did not give a very smooth straight line.

Barium, strontium, potassium, and iodine increased in a general way with density but did not give smooth curves. There was even greater variation from a fixed relationship than in the case of bromine.

Iron showed no relationship at all; carbonate was nonexistent for the most part; bicarbonate and sulfate showed no definite relationship.

PLATE XV.—Salt Storage, Dixie Plant at Mason City, W. Va.—Salt from the grainer is drained, then brought here by means of elevators and belt conveyors, and packaged for shipment.—Photo by Hoskins, 1937.

When the curves for the major constituents, total solids, Cl, Ca, Na, Mg, for different horizons were superimposed upon each other, it was found that they practically coincided. This proved that the waters from the different horizons had practically the same relative composition of major constituents for a given density.

The plotted data for the other constituents for different horizons were compared and were found to be generally very similar.

It was thus concluded that for all horizons the waters are generally similar as regards percentage composition of major constituents in the dissolved solid matter for waters of a given density. It was further concluded that for waters of different densities the same rule holds except that for the higher densities or higher concentrations the percentage of calcium tends to increase and the percentage of sodium to correspondingly decrease.

This conclusion is considered one of the most important results of the brine study because it not only indicates a similar general source of the waters but from a practical viewpoint makes it possible to quickly estimate the composition of our brines by taking the density and then consulting the curves on which have been plotted the compositions of brines analyzed. This procedure will yield a fairly correct approximation of the major constituents such as total solids, chloride, sodium, calcium, magnesium. If a correct statement of minor constituents is also desired the brine will have to be analyzed.

Accompanying is a set of curves for illustrative purposes plotted for the Big Injun Sand. They include:

Group 1, total solids, sodium, chloride.
Group 2, calcium, magnesium, bromine.
Group 3, barium, strontium, potassium, bicarbonate, iodine.

It will be noted: that group 1 gives smooth curves; that group 2 gives definite curves but with the points somewhat more scattered than in the case of group 1; that in group 3 there is no smooth curve possible because there is either only a very general relationship or else no relationship at all.

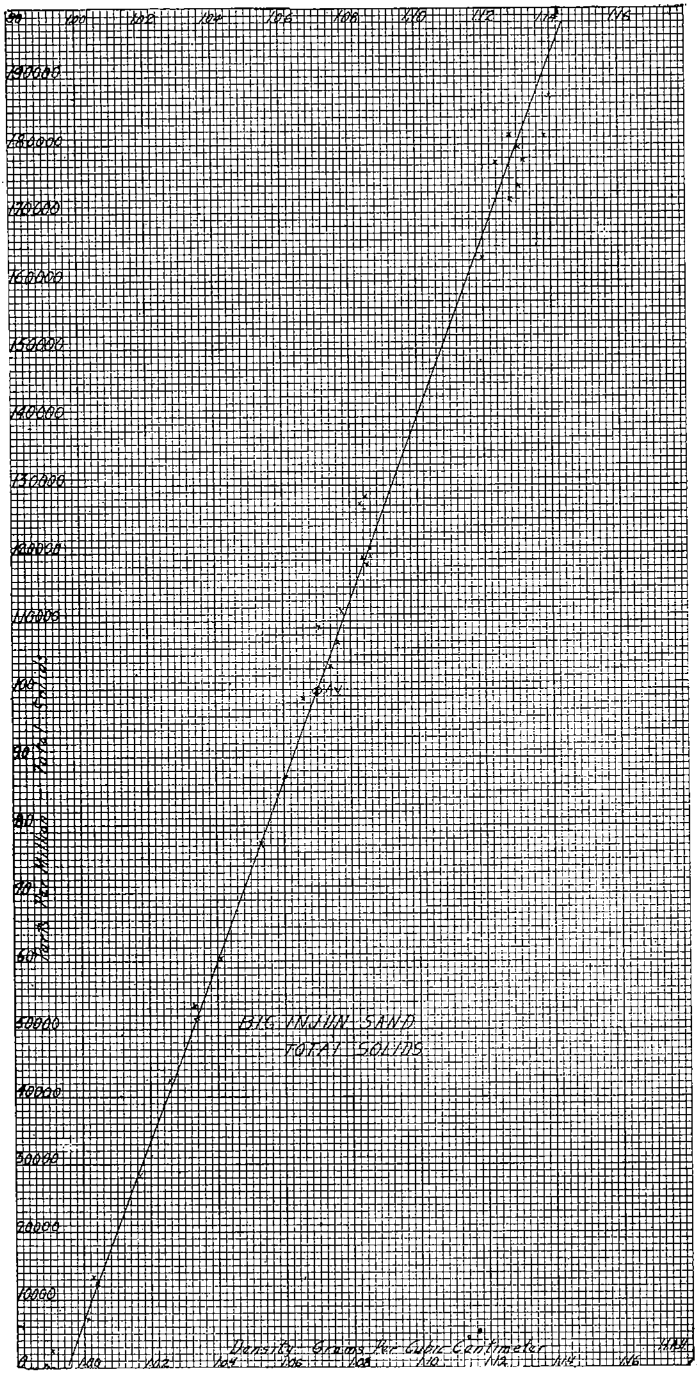


Figure 8.—Relation between Total Solids and Density—Big Injun Sand.

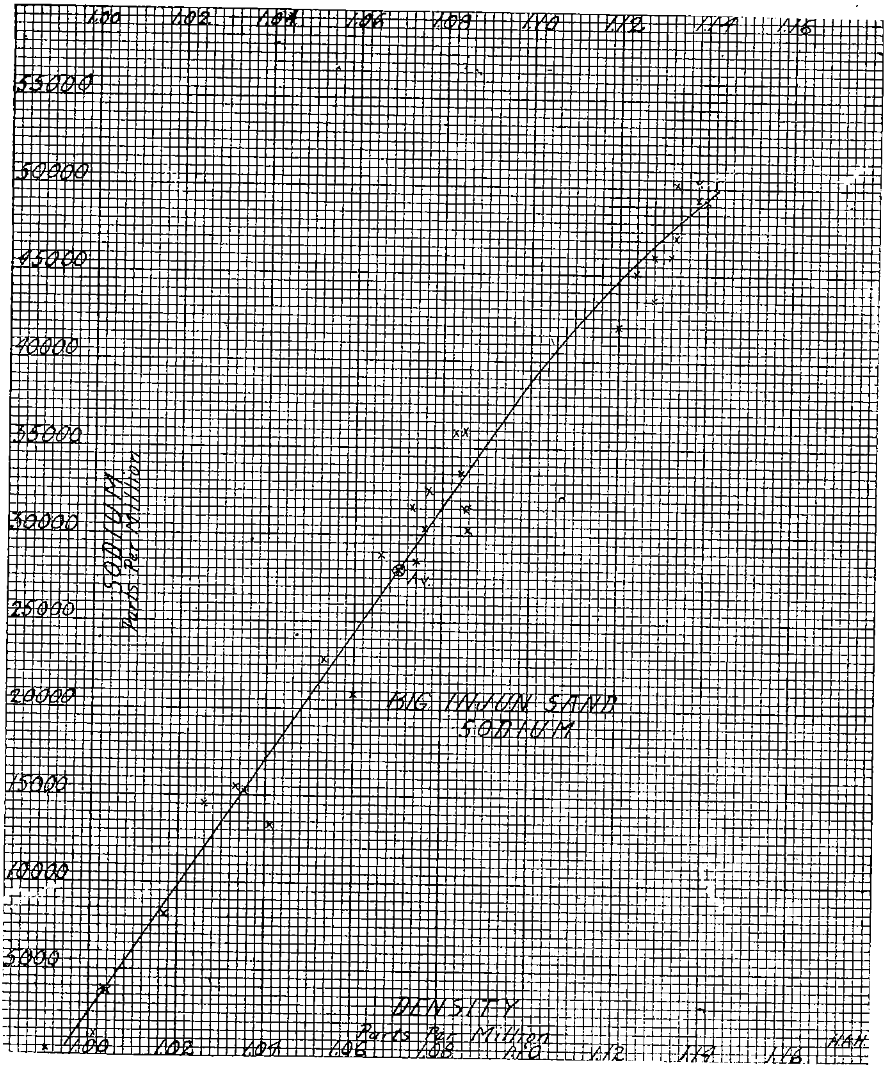


Figure 9.—Relation between Sodium and Density—Big Injun Sand.

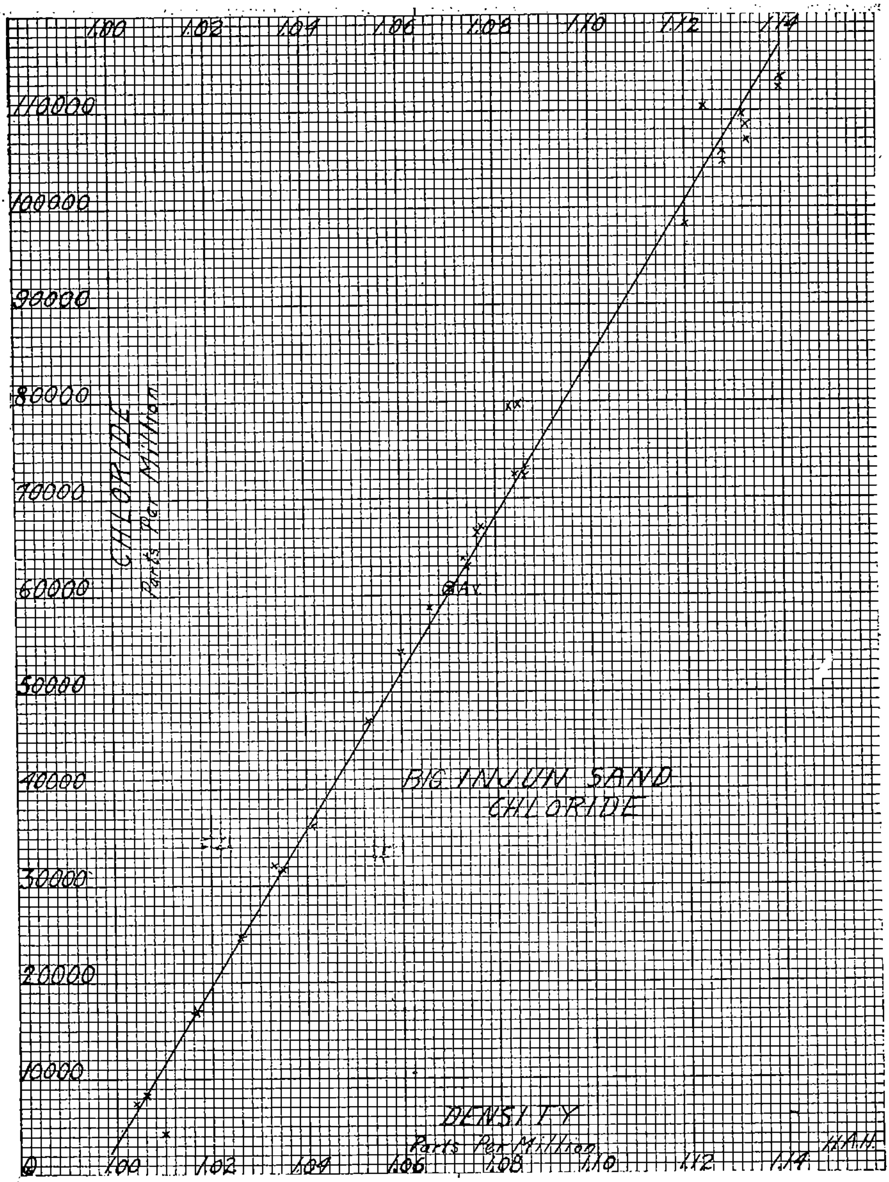


Figure 10.—Relation between Chloride and Density—Big Injun Sand.

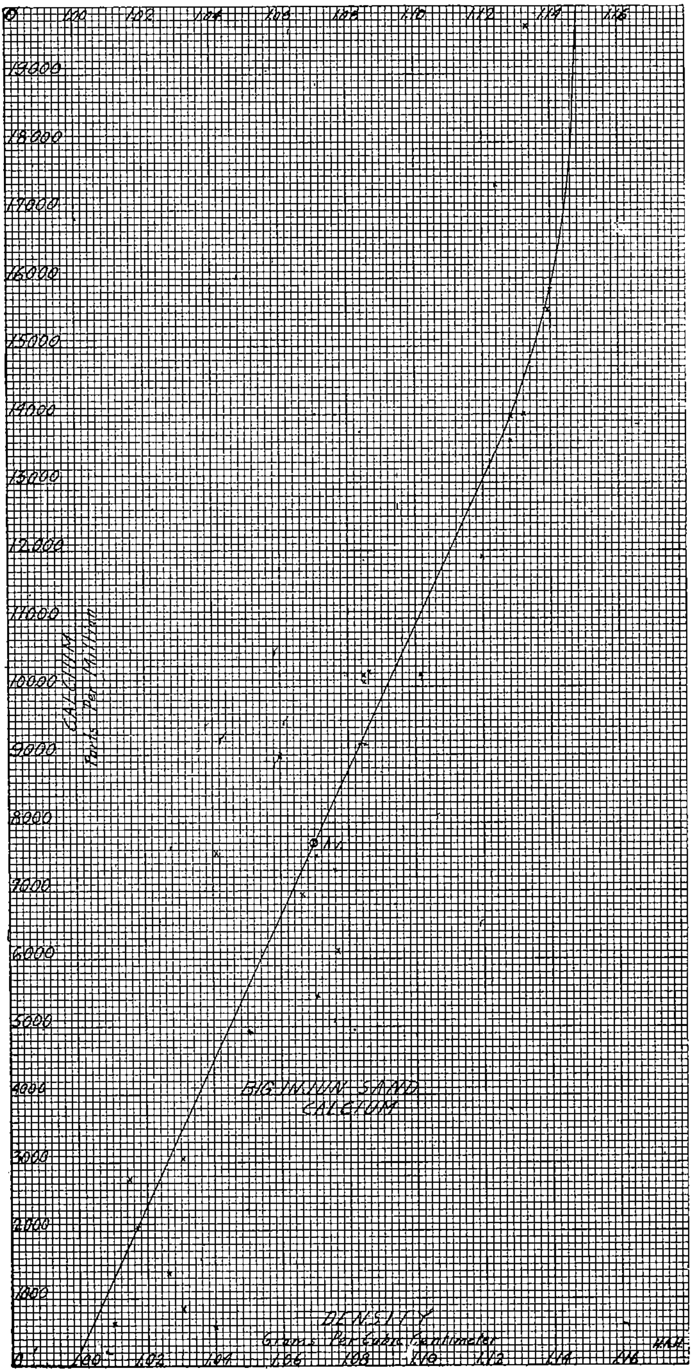


Figure 11.—Relation between Calcium and Density—Big Injun Sand.

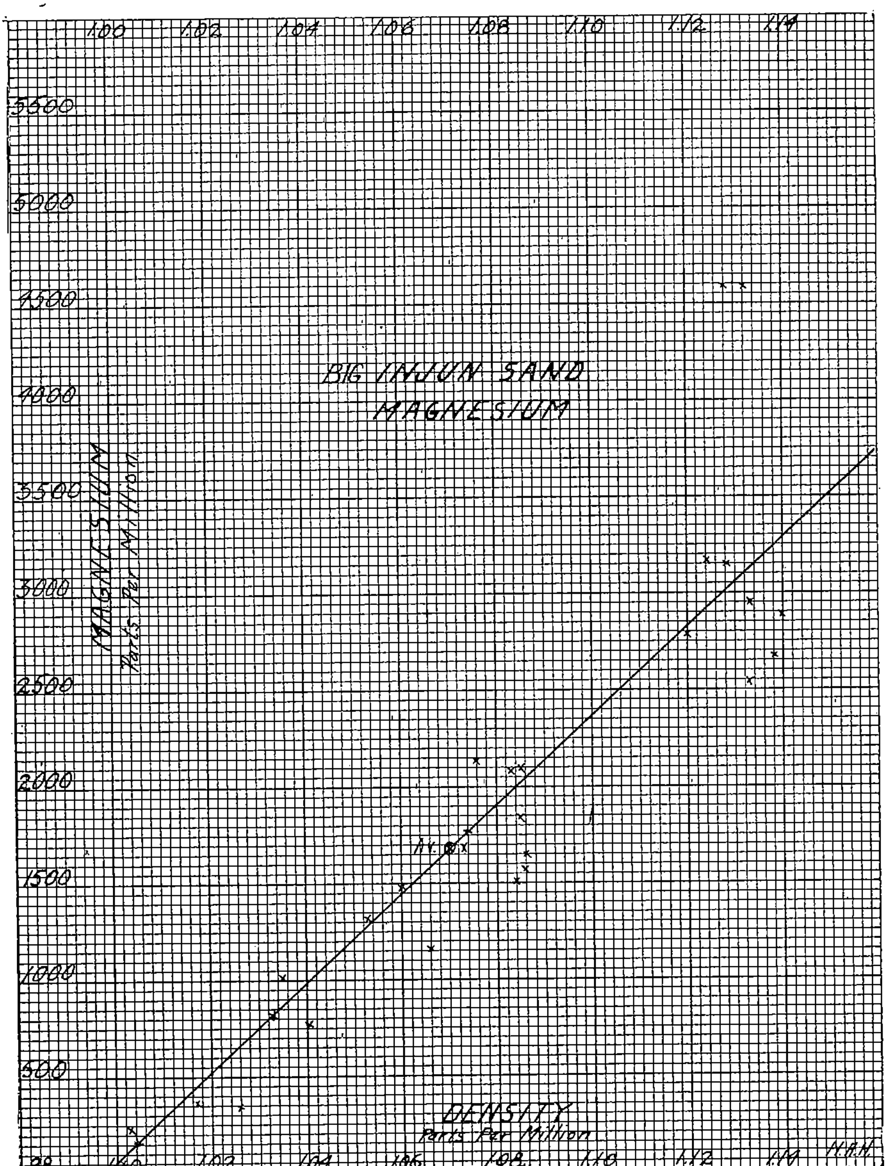


Figure 12.—Relation between Magnesium and Density—Big Injun Sand.

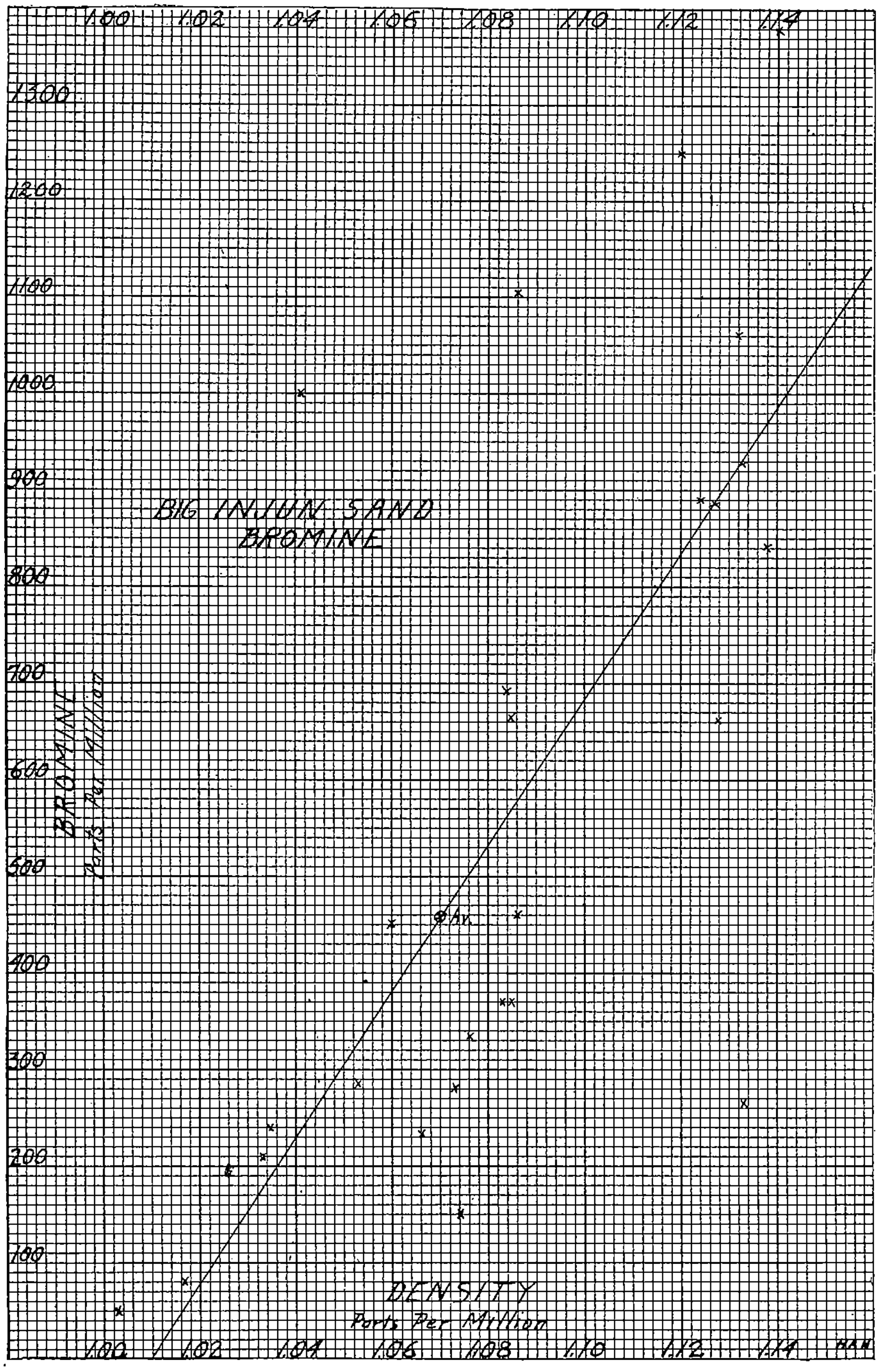


Figure 13.—Relation between Bromine and Density—Big Injun Sand.

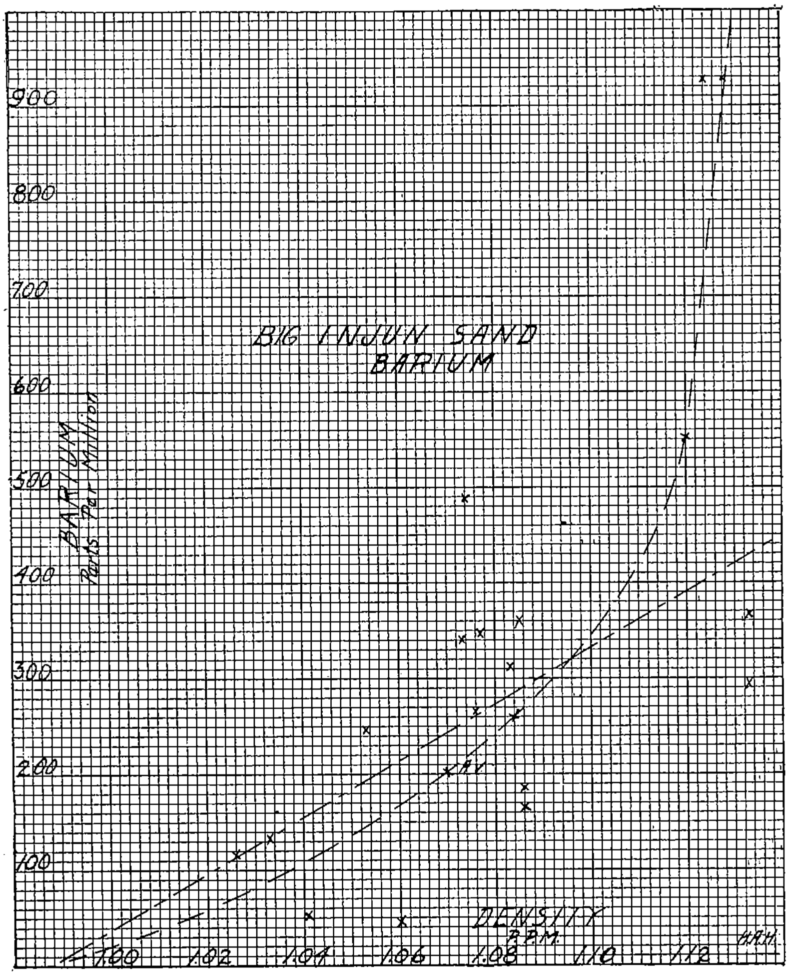


Figure 14.—Relation between Barium and Density—Big Injun Sand.

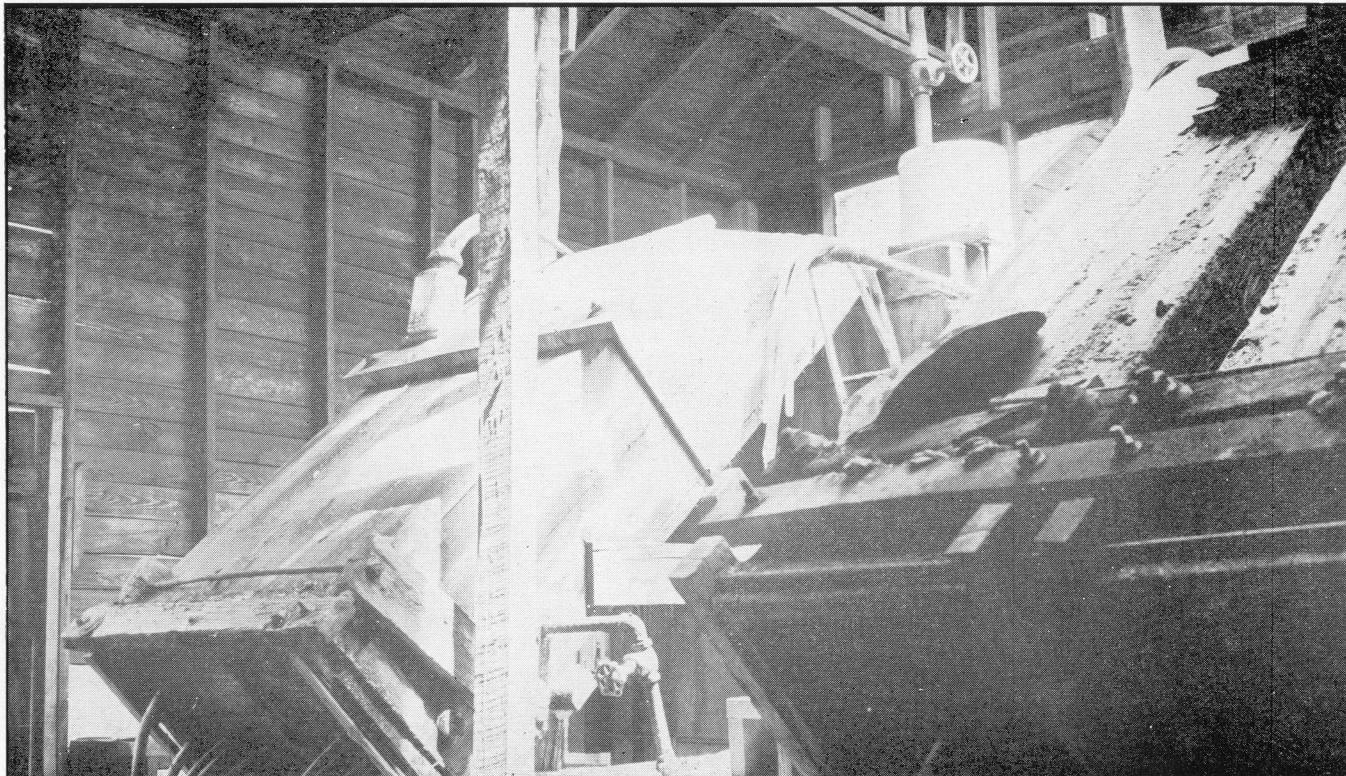


PLATE XVI.—New Bromine Stills, Dixie Plant, Mason City, W. Va.—Brine bittern is poured in at upper end and steam is admitted through iron pipe. Lead pipe is used to convey bromine vapor and liquid. These stills are constructed of sandstone slabs.—Photo by Hoskins, 1937.

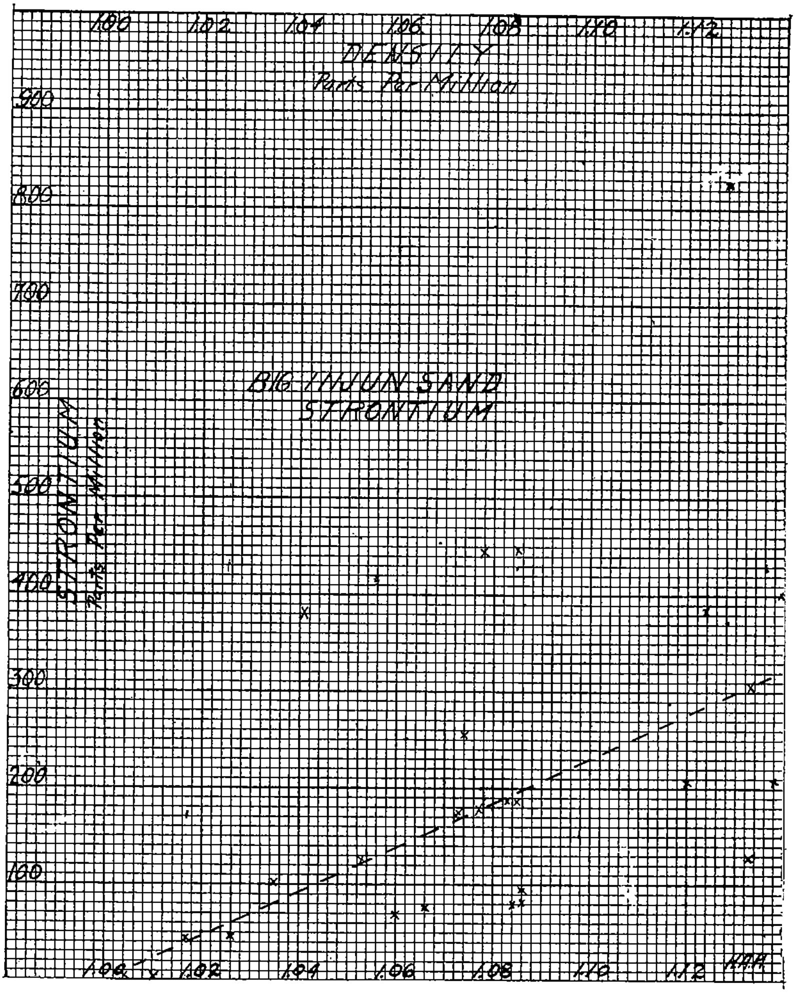


Figure 15.—Relation between Strontium and Density—Big Injun Sand.

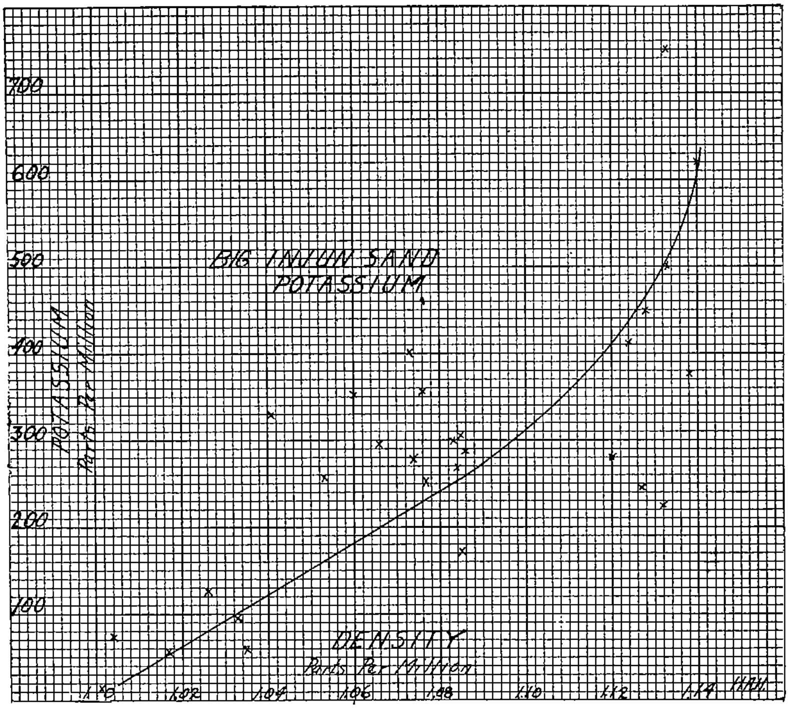


Figure 16.—Relation between Potassium and Density—Big Injun Sand.

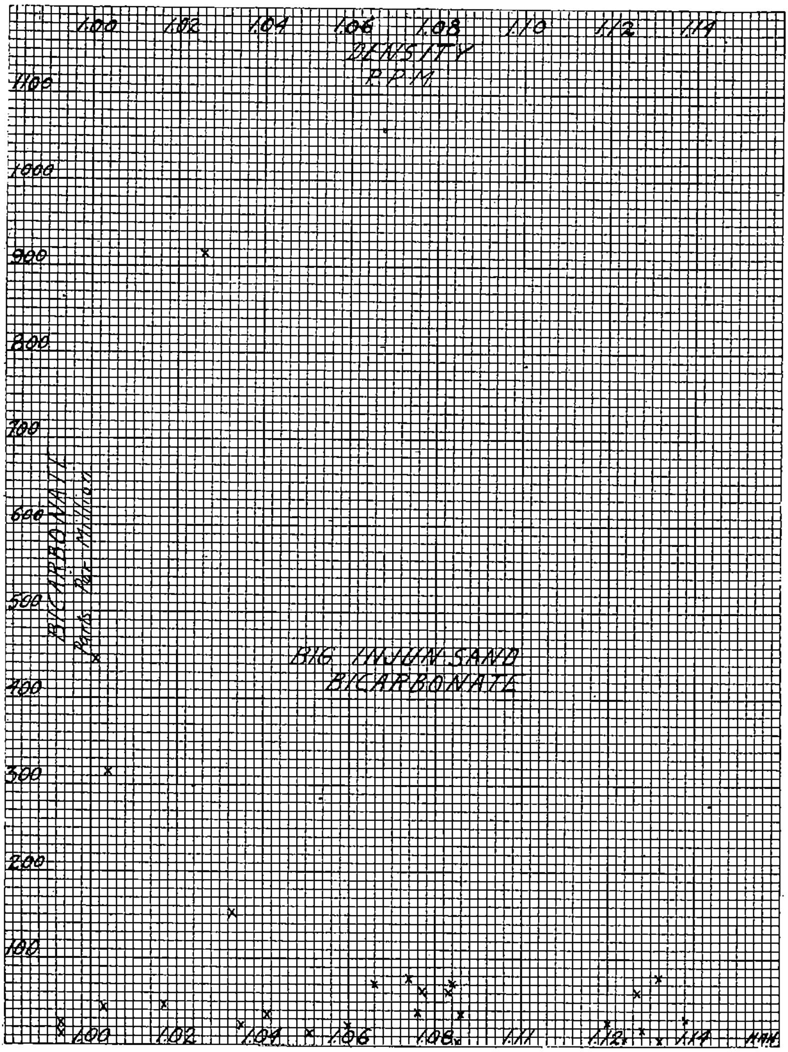


Figure 17.—Relation between Bicarbonate and Density—Big Injun Sand.

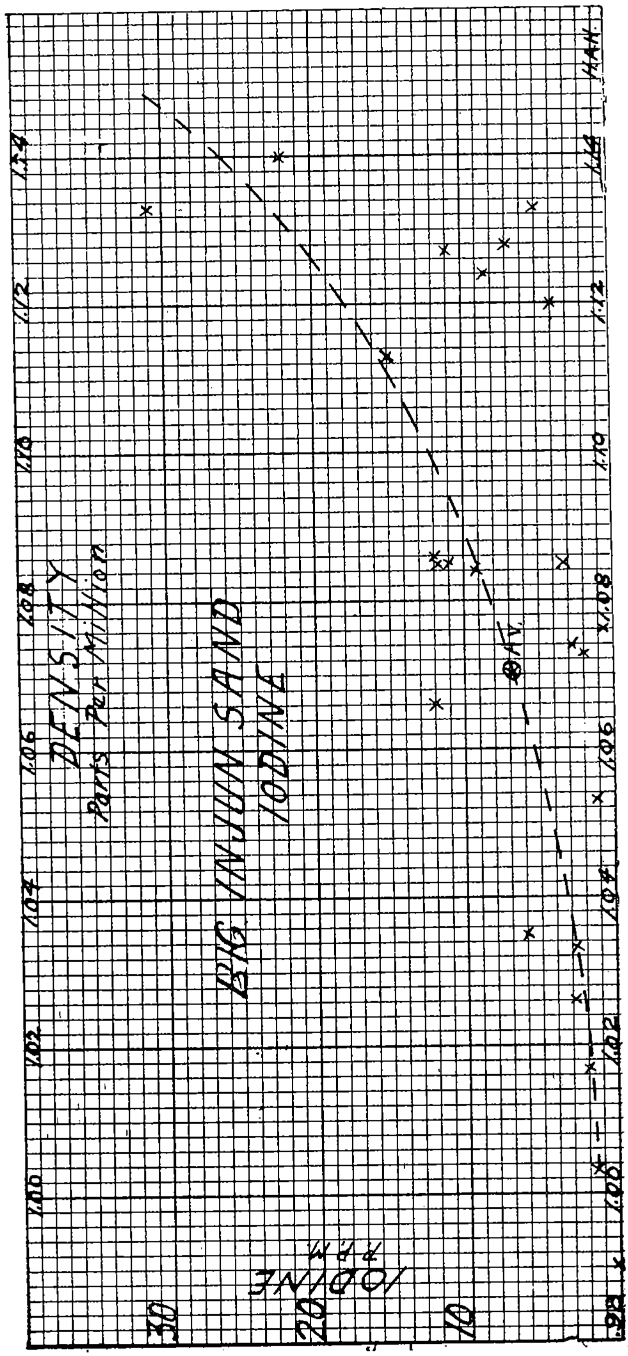


Figure 18.—Relation between Iodine and Density—Big Injun Sand.

CHAPTER V.

ECONOMIC UTILIZATION OF BRINES.

INTRODUCTION.

Salt deposits both in the form of rock salt and as salt brines are widely distributed throughout the world. Salt is produced from many sources in various countries, including the sea, salt lakes, rock salt mines, and brine wells. The total estimated annual world production of salt is roughly 20,000,000 tons. Of this, the United States produces nearly one-third. There are only 4 or 5 other large producing countries led by Russia with approximately 3,000,000 tons per year.

West Virginia has been producing salt from brines for over a hundred years. Current annual production is roughly 70,000 tons.

SALT RESERVES.

Aside from the ocean which of course constitutes by far the greatest reservoir for sodium chloride and other salts, there are other vast deposits in various parts of the world which for all practical purposes may be considered as unlimited sources for sodium chloride and various associated salts. These deposits include underground brines and rock salt layers. They also include surface deposits of rock salts in arid countries and salt lakes.

In the United States extensive deposits, representing all these various classes of sources, occur. Among various States having important deposits may be mentioned the following: California, Kansas, Louisiana, Michigan, New York, Ohio, Texas, Utah, and West Virginia.

In West Virginia the salt deposits are mainly in the form of brines. These have been found in large quantities in the western half of the State in the zone paralleling the Ohio River. Samples from 28 counties in this zone have been analyzed. Based on these analyses there has been prepared a rough estimate of the possible minimum quantities of salt contained in the brines of this area. Only four producing horizons have been included. The total reserve was calculated as nearly 800 million tons. It is believed that this estimate is quite conservative. Even so, such a reserve could, at the rate of 20,000,000 tons per year, supply the world for about 40 years. It is thus obvious that West Virginia has salt reserves adequate for even a much expanded West Virginia industry for generations to come.

The following table shows the derivation of the estimate. It is based on brine analyses from the present report and on the best opinion in the Survey concerning probable extent, thickness, and porosity of the brine-bearing areas of the various producing horizons included.

Table 13.—Estimated Salt Reserves of West Virginia.

Producing Horizon.	Salt.	Maxton.	Big Injun.	Oris-kany.
Total area included, sq. mi.	11,500	11,500	11,500	11,500
Porosity, %	13	13	13	8
Thickness of pay sands, feet	20	5	10	4
% of area bearing brine	50	15	30	5
Volume of brine, sq. mi.—ft.	14,950	1,122	4,490	184
Weight brine, millions of tons	13,000	975	3,900	160
% salt in brine	5	8	9	20
Weight salt, millions of tons	650	78	35	32

PRODUCTS FROM BRINES.

The various raw products derived from brines may be briefly listed as follows:

Sodium chloride	$NaCl$
Calcium chloride	$CaCl_2$
Magnesium chloride	$MgCl_2$
Bromine	Br_2
Iodine	I_2

These have been listed in order of their abundance in the brines. There are other constituents present but they have no economic significance except as impurities.

Sodium chloride is consumed directly in large quantities for agricultural and household use, and is also used as the raw material for manufacture of several chemical derivatives such as:

Sodium bicarbonate	$NaHCO_3$
Soda ash (sodium carbonate)	Na_2CO_3
Caustic soda (sodium hydroxide)	$NaOH$
Bleaching compound (calcium hypochlorite)	$Ca(OCl)_2$
Chlorine	Cl_2
Hydrochloric acid	HCl

Calcium chloride is used in increasing quantities in road treatment and for dust laying in mines.

Magnesium chloride is used as a dust depressant and magnesium from brines is also produced in metallic form and used in light metal alloys.

Bromine and iodine are both used for several purposes including notably the preparation of pharmaceuticals. The chief present use of bromine, however, is in the manufacture of anti-knock gasoline.

Sodium Chloride.—The following tables taken from U. S. Department of the Interior Minerals Yearbook for 1936 show interesting statistics relating to salt:

Table 14.—Salt sold or used by producers in the United States 1931-35.

Year.	Short tons.				Value[1]	
	Manufactured (evaporated).	In brine.	Rock salt.	Total.	Total.	Average.
1931	2,203,690	3,300,210	1,854,170	7,358,070	$21,541,012	$2.93
1932	2,053,421	2,769,821	1,584,731	6,407,973	19,938,830	3.11
1933	2,358,954	3,461,026	1,784,992	7,604,972	22,318,086	2.93
1934	2,281,453	3,417,439	1,913,182	7,612,074	22,850,797	3.00
1935[2]	2,345,000	3,860,000	1,800,000	8,005,000	22,226,000	2.78

[1]The values are f. o. b. mine or refinery and do not include cost of cooperage or containers.

[2]Subject to revision.

Table 15.—Salt sold or used by producers in the United States, 1933-35, by States.

State	1933		1934		1935[1]	
	Short tons	Value	Short tons	Value	Short tons	Value
California	331,009	$ 2,018,694	341,893	$ 2,026,376	357,000	$ 2,183,000
Kansas	732,947	3,039,343	768,133	2,949,930	651,000	2,517,000
Louisiana	532,569	2,345,208	567,289	2,854,785	578,800	2,582,000
Michigan	2,090,254	5,679,737	2,012,370	5,470,684	2,110,000	5,348,000
New York	1,847,696	5,120,846	1,866,280	5,263,394	2,104,000	5,429,000
Ohio	1,382,294	2,599,055	1,432,292	2,721,167	1,487,000	2,699,000
Texas	165,603	560,085	208,979	612,586	269,000	565,000
Utah	56,305	141,330	--------[2]	---------[2]	57,900	164,000
West Virginia	63,818	329,051	66,766	384,342	67,900	434,000
Undistributed[3]	402,477	484,737	348,072	567,533	323,300	305,000
	7,604,972	22,318,086	7,612,074	22,850,797	8,005,000	22,226,000

[1]Subject to revision.
[2]Included under "Undistributed".
[3]1933 and 1935, Nevada, New Mexico, Oklahoma, Puerto Rico, and Virginia; 1934, Nevada, New Mexico, Oklahoma, Puerto Rico, Utah, and Virginia.

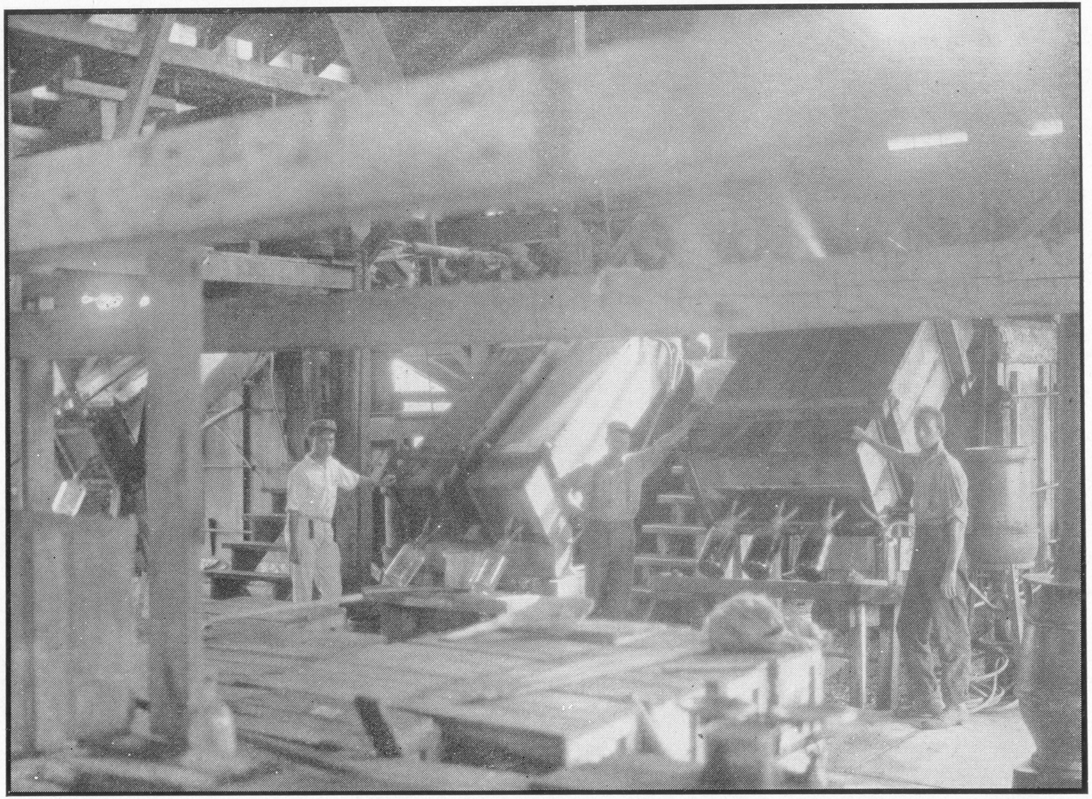


PLATE XVII.—Bromine Stills and Condenser Boxes, Ohio River Salt Corporation, Mason City, W. Va.—This is a wider view of stills shown in Plate XVI.—Photo by courtesy Norman O. Wein.

Table 16.—Salt sold or used by producers in the United States, 1934-35, by methods of manufacture.

Method of manufacture	1934		1935[1]	
	Short tons	Value	Short tons	Value
Evaporated in open pans or grainers	541,392	$ 4,410,641	470,000	$ 3,780,000
Evaporated in vacuum pans	1,267,157	8,190,797	1,400,000	8,845,000
Solar evaporated	333,459	1,170,894	347,000	1,300,000
Pressed blocks from evaporated salt	139,445	999,170	128,000	925,000
Rock	1,883,838	6,139,826	1,773,000	5,620,000
Pressed blocks from rock salt	29,344	166,269	27,000	146,000
Salt in brine (sold or used as such)	3,417,439	1,773,200	3,860,000	1,610,000
	7,612,074	22,850,797	8,005,000	22,226,000

[1]Subject to revision.

Table 17.—Evaporated salt sold or used by producers in the United States, 1934-35, by States.

State	1934		1935[1]	
	Short tons	Value	Short tons	Value
California	333,098	$ 1,986,964	351,000	$ 2,156,000
Kansas	277,075	1,885,952	244,000	1,652,000
Michigan	722,183	4,023,633	733,000	3,843,000
New York	344,961	3,345,416	376,000	3,396,000
Ohio	333,299	2,135,708	386,000	2,444,000
West Virginia[2]	66,766	384,342	67,000	434,000
Undistributed[3]	204,071	1,009,487	188,000	925,000
	2,281,453	14,771,502	2,345,000	14,850,000

[1]Subject to revision.

[2]Includes a quantity of salt content of brine for chemical use reported as evaporated salt with value as evaporated salt.

[3]Includes Louisiana, New Mexico, Oklahoma, Puerto Rico, Texas, and Utah.

Table 18.—Rock salt sold by producers in the United States, 1931-35.

Year	Short tons	Value
1931	1,854,170	$5,735,207
1932	1,584,731	5,100,779
1933	1,784,992	5,570,352
1934	1,913,182	6,306,095
1935[1]	1,800,000	5,766,000

[1]Subject to revision.

Salt content of brine.—The quantity of salt in brine sold or used by producers for the manufacture of chemicals in 1935 was 3,860,000 short tons, an increase of 13 per cent. over 1934. This class of salt represented 48 per cent. of the total output and was produced at 10 plants — in Louisiana in Cameron Parish, near Orange, Tex., and in Iberville Parish, La.; Detroit and Wyandotte, Mich. (2 plants); Barberton and Painesville, Ohio; Tully, N. Y.; Benavides, Tex.; and Saltville, Va.

There was also some salt brine used direct from wells in West Virginia not included in that listed by the foregoing paragraph.

The following table shows estimated consumption of salt in the process industries in 1933:

Table 19.—Consumption of Salt in Process Industries.
(Data compiled by H. A. Hoskins).

Products.	Short tons.
Soda ash and caustic soda	3,006,000
Electro Chemicals	175,000
Coal Tar Products	300,000
Fine Chemicals	10,000
Fertilizers	5,000
Leather	100,000
Soap	100,000
Glass and Ceramics	50,000
Pulp and Paper	50,000
Textiles	40,000
Vegetable Oils	10,000

The following table shows tonnage and value of salt produced from brines in West Virginia over a twenty-year period:

Table 20.—Salt Production and Value in West Virginia.
(Data compiled by H. A. Hoskins).

Year	Tons	Value	Year	Tons	Value
1916	33,389	$122,669	1926	23,180	$170,953
1917	24,844	191,044	1927	22,600	167,155
1918	26,077	251,668	1928	18,700	149,421
1919	18,599	167,529	1929	20,290	153,477
1920	29,802	348,556	1930	28,670	184,327
1921	27,964	320,537	1931	35,480	218,672
1922	25,188	283,257	1932	49,629	243,185
1923	31,589	284,196	1933	63,818	329,051
1924	37,561	258,089	1934	66,766	384,342
1925	25,870	180,053	1935	67,000	434,000

Calcium chloride.—The following discussion and tables are quoted from Minerals Yearbook 1936:

"The calcium chloride reported in the following table occurs as an original constituent of the natural brine produced in connection with the extraction of salt or salt and bromine from mineral raw materials only. A large output of calcium chloride made by manufacturing processes is not included. The calcium chloride reported includes mixed calcium and magnesium chlorides and other salts.

"Production in 1935 was reported as 83,546 short tons, valued at $1,039,103, an increase of 9 per cent. in quantity but a decrease of 10 per cent. in value compared with 1934.

"Producers in the United States of calcium chloride from natural brines are the California Rock Salt Co. (address, 2465 Hunter Street, Los Angeles), Saltus, Calif.; The Dow Chemical Co., Midland, Mich.; Saginaw Salt Products Co., Saginaw, Mich.; Pomeroy Salt Corporation (address, Pomeroy, Ohio), Minersville, Ohio; Excelsior Salt Works, Inc., Pomeroy, Ohio; Texaco Salt Products Co., Tulsa, Okla.; J. Q. Dickinson & Co., Malden, W. Va.; Liverpool Salt Co., Hartford, W. Va.; Ohio River Salt Corporation, Mason, W. Va.; and Westvaco Chlorine Products, Inc., South Charleston, W. Va."

Table 21.—Calcium (calcium-magnesium) chloride from natural brines sold by producers in the United States, 1931-35.

Year	Short tons	Value	Year	Short tons	Value
1931	86,156	$1,687,166	1934	76,719	$1,153,159
1932	66,286	1,163,385	1935	83,546	1,039,103
1933	57,813	893,442			

Table 22.—Calcium chloride imported for consumption in the United States, 1931-35.

Year	Short tons	Value	Year	Short tons	Value
1931	4,916	$74,546	1934	1,975	$26,271
1932	3,569	48,865	1935	2,003	26,987
1933	3,583	48,115			

Table 23.—Calcium chloride exported from the United States, 1931-35.

Year	Short tons	Value	Year	Short tons	Value
1931	24,351	$566,573	1934	30,715	$566,189
1932	17,747	378,130	1935	30,735	525,179
1933	15,710	312,309			

Bromine.—The following discussion and tables are quoted from Minerals Yearbook for 1936:

"The figures for bromine production in this report comprise the quantity of bromine recovered by the producers from natural brines and the bromine content of bitterns used by producers in the manufacture of bromine compounds. The larger part of the bromine output reported is not sold as bromine but as ethylene dibromide, potassium and sodium bromide, and other bromine compounds. In 1935 the bromine produced amounted to 16,428,533 pounds, valued at $3,483,239, an increase of 7 per cent. in quantity and 8 per cent. in value over 1934.

"The Ethyl-Dow Chemical Co., which began to extract bromine directly from sea water at Wilmington, N. C., in 1934, is the largest producer of bromine in the United States. Other companies that produced bromine in 1935 were the California Chemical Co. (address, Newark), Chula Vista, Calif.; Morton Salt Co. (address, 208 West Washington Street, Chicago, Ill.), Manistee, Mich.; The Dow Chemical Co., Midland, Mich.; Pomeroy Salt Corporation (address, Pomeroy, Ohio), Minersville, Ohio; Excelsior Salt Works, Inc., Pomeroy, Ohio; Texaco Salt Products Co. (address, care of the Texas Co., Houston, Tex.), Tulsa, Okla.; J. Q. Dickinson & Co., Malden, W. Va.; Liverpool Salt Co., Hartford, W. Va.; Ohio River Salt Corporation, Mason, W. Va.; and Westvaco Chlorine Products, Inc., South Charleston, W. Va."

Table 24.—Bromine and bromine in compounds sold or used by producers in the United States, 1931-35.

Year	Pounds	Value	Year	Pounds	Value
1931	8,935,330	$1,854,650	1934	15,344,290	$3,227,425
1932	5,727,561	1,182,569	1935	16,428,533	3,483,239
1933	10,147,960	2,040,352			

Bromine production in West Virginia (data by Hoskins) over the 13-year period 1890-1902, ranged from a minimum of 80,852 lbs. valued at 25c lb. in 1893 to a maximum of 118,888 lbs. in 1898 valued at 28c lb.

Iodine.—The following discussion and tables are quoted from Minerals Yearbook for 1936:

"Until 1932 little naturally occurring iodine had been produced commercially in the United States. During the war there was a small output of iodine from kelp at plants on the Pacific coast, which are no longer active. Extensive experimental work during recent years on processes for the extraction of iodine from brines and oil-well waters has resulted in the establishment of three plants recovering iodine from oil-well brines in Los Angeles County, Calif. These plants were operated in 1934 by the Deepwater Chemical Co., Ltd., Compton, Calif.; the General Salt Co., Ltd., Long Beach, Calif.; and the Io-Dow Chemical Co., Midland, Mich. In 1935 the only plant reported in operation was the Io-Dow Chemical Co., but sales were made from stock by the other companies.

"The sales of domestic production in 1935 were 245,696 pounds valued at $248,654, a decrease of 14 per cent. in quantity and 27 per cent. in value. Imports of iodine, which have been held at least partly responsible for restricted production of domestic iodine, decreased 75 per cent. in quantity and 80 per cent. in value in 1935 from 1934, and the average unit value decreased from $1.44 in 1934 to $1.12 in 1935.

"The United States has imported its supply of iodine chiefly from Chile, where it is obtained as a by-product of the nitrate plants. Virtually all the iodine enters the United States in crude form, with occasional small shipments of resublimed material. A small part of the imports in 1934 came from Japan, but in 1935 all the iodine imported was from Chile. Crude iodine enters free of duty. The resublimed product is subject to a duty of 10 cents a pound under the Tariff Act of 1930; before June 1930 the duty was 20 cents a pound."

Table 25.—Iodine Produced in the United States, 1933-35.

Year	Pounds	Value
1933	401,525	$669,289
1934	284,604	342,957
1935	245,696	248,654

Table 26.—Iodine imported for consumption in the United States, 1931-35.

Year	Crude		Resublimed	
	Pounds	Value	Pounds	Value
1931	278,713	$ 998,079	---	---
1932	631,669	2,225,661	100	$269
1933	1,411,687	2,936,489	200	493
1934	1,481,123	2,134,979	---	---
1935	375,819	420,793	---	---

Sodium Chloride Derivatives.—The following table shows statistics relating to quantity and value of certain heavy chemical manufactures using salt as a raw material. The data apply to the United States as a whole.

Table 27.—Sodium Chloride Derivatives.

[Data for first four items from reference (45)]

Material	Year	Total Tons	Produced for Sale	
			Tons	Value $
Sodium bicarbonate	1929	--------	140,234	---------
	1931	--------	127,533	$ 3,696,000
	1933	--------	140,234	3,586,000
Soda Ash	1929	2,682,216	--------	---------
	1931	2,275,416	1,508,679	22,493,000
	1933	2,317,011	1,654,028	24,183,000
Caustic Soda	1929	761,792	--------	---------
	1931	658,889	634,213	26,565,000
	1933	686,983	644,731	24,478,000
Hydrochloric Acid (100% basis)	1929	81,307	--------	---------
	1931	54,889	40,687	2,422,000
	1933	62,628	44,895	2,387,000
Liquid Chlorine*	1931	230,000	--------	---------
Chlorine gas*	1931	45,000	--------	---------

*Data from reference (46)

Distribution of Consumption of Liquid Chlorine.

Pulp and Paper	65%	Sanitation	10%
Textiles	20%	Miscellaneous	5%

Uses of Soda Ash and Caustic Soda.—From the foregoing table it will be noted that the sodium compounds of greatest economic importance are soda ash or sodium carbonate, Na_2CO_3, and caustic soda. The following tables (46) show estimated distribution of sales of each for 1932 and 1931.

Table 28.—Estimated distribution of soda ash sales in the United States in 1932 and 1931.

Consuming Industries.	1932 Short tons.	1931 Short tons.
Glass	380,000	508,000
Soap	160,000	175,000
Chemicals	370,000	375,000
Cleansers and Modified sodas	87,000	95,000
Pulp and Paper	72,000	87,000
Water softeners	45,000	50,000
Petroleum refining	8,000	9,000
Textiles	27,000	31,000
Exports	14,000	28,000
Miscellaneous	37,000	42,000

Table 29.—Estimated distribution of Caustic Soda sold in the open market (U. S.) in 1931 and 1932.

	1931 Short tons	1932 Short tons
Rayon	108,000	88,000
Petroleum refining	103,000	93,000
Chemicals	98,000	81,000
Soap	90,000	82,000
Pulp and Paper	36,500	31,000
Textiles	32,000	28,000
Lye	22,000	20,000
Rubber reclaiming	14,000	8,000
Vegetable oils	8,500	9,000
Exports	66,000	52,000
Miscellaneous	42,000	33,000

Sodium bicarbonate is used mainly in the manufacture of baking powders. Hydrochloric acid is used in connection with the manufacture of iron and steel products, in dye manufacture, and for a multitude of minor purposes.

Other Sodium Compounds.—There are a few other sodium compounds of highly specialized use which deserve mention. They are shown in the following summary:

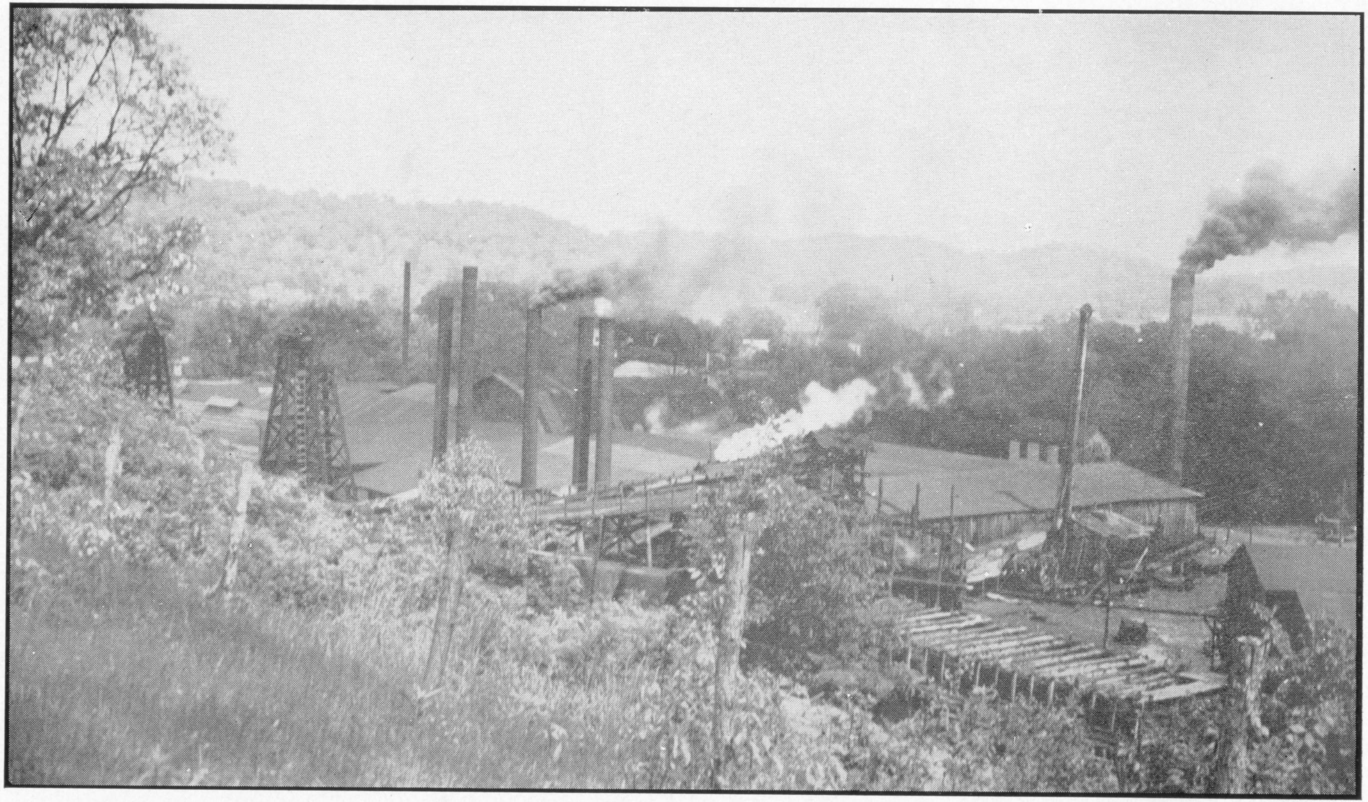


PLATE XVIII.—Liverpool Salt Co., Salt Works, Hartford City, W. Va.—Note the old, but still used, brine reservoir in foreground. The furnace pan is under the roof just beyond it, and the grainers are under the roof beneath the white steam. At extreme left are brine wells, one of which is the old "Fleetwood"; a new well, just completed, beyond reservoir.—Photo by Hoskins, 1937.

Table 30.—Other Sodium Compounds.

Name	Formula	Uses
1. Sodium sulfide ----	NaS	As a depilatory (hair remover). In manufacture of sulfur dyes. As a solvent for sulfur dyes.
2. Sodium Thiosulfate -------	$Na_2S_2O_35H_2O$	In photography for dissolving silver salts. In textile mills as an "antichlor".
3. Sodium Bisulfite ----------	$NaHSO_3$	Dye manufacture. Dye application. Sterilization of beer casks, etc. In Chile for reduction of iodine in iodine manufacture.
4. Sodium Hyposulfite or Hydrosulfite ------	$Na_2S_2O_4$	As an "antichlor". In reduction of certain dyes.

Salt Prices.—Salt is so cheaply produced that the usual price at point of production is of the order of three dollars per ton. Freight charges, therefore, play a very large part in fixing the price at which salt reaches the consumer. Where salt is used in large quantities local or near-by production naturally gives the lowest total cost.

In brines there are considerable amounts of calcium and magnesium chlorides that must be removed. Sodium chloride is considered the main product and other substances such as the calcium and magnesium chlorides, bromine, and iodine, are considered by-products.

It happens that considerable calcium chloride comes from sources other than salt brines which increases the competitive problem of disposal of calcium chloride from brines.

Utilization of Chlorine and Bromine.

The production and consumption of chlorine have increased very rapidly in recent years. One of the chief sources of demand for **chlorine** is as a bleaching agent in the manufacture of paper from southern slash pine. The demand from this and other sources may be expected to increase still more.

Although the demand for **bromine** is increasing, the larger part of the total amount used is likely to continue to be produced from sea water because that source contains the greatest quantity of it. Bromine will, however, continue to be a profitable by-product from the processing of brines treated primarily for the extraction of other constituents.

Notes on Technology of Salt Industry. (39)

"The processes of salt making in the United States are of two kinds:

"1. The mining of rock salt and its purification and separation into marketable sizes, and,

"2. The production of salt by evaporation from brines, bitterns, and other solutions containing it.

"The processes employed in the manufacture of salt by evaporation may be classified as follows:

1. Solar Evaporation
2. Direct heat evaporation
    (a) In open kettles
    (b) In open pans
3. Steam evaporation
    (a) In jacketed kettles
    (b) In grainers
4. Vacuum pan evaporation."

The use of solar evaporation is confined mainly to regions which have an exceptionally sunny climate and relatively little rainfall such as certain arid or semi-arid regions of western United States. The brine is evaporated in large ponds and the salt is later harvested from them. One of the important economies of this method is that it requires practically no fuel.

The use of direct heat evaporation, while still practiced in some places, is of decreasing importance. It requires relatively simple equipment and was the earliest method developed using heat from fuels.

The use of steam evaporation in jacketed kettles and grainers, while still practiced somewhat extensively, is also of relatively less importance than formerly. It represents a very considerable advance over the previously mentioned method using direct heat.

Vacuum pan evaporation is the latest and most modern method for salt production from brines. With it the capital costs of plant construction are greater but the costs of fuel and labor are less than with the other methods. The vacuum pans are arranged in what is known as multiple effect which permits the regeneration and re-use of steam for evaporation in such a way as to achieve a very great fuel economy.

Notes on Technology of Manufacture of Chemicals using Salt as Raw Material.

Sodium bicarbonate and soda ash are made by the famous Solvay process. A strong salt brine is treated with ammonia and carbon dioxide in such a way as to precipitate sodium bicarbonate as a white salt. A part of this is purified and sold direct. Soda ash is made by heating the bicarbonate to expel water and carbon dioxide.

Caustic soda may be made by treating soda ash with lime or by electrolysis of a salt brine solution. Both methods are used. After formation the water is expelled by evaporation and the caustic is poured molten into steel drums in which it solidifies.

By-products from the electrolysis of brine to produce caustic soda are chlorine and hydrogen gases. The chlorine gas may be used as a gas or it may be liquefied by pressure and refrigeration. Most of it is sold in liquid form either in tank car or one ton tank lots.

Hydrochloric acid may be made by burning chlorine gas in excess hydrogen or by fusing together salt and sodium acid sulfate, $NaHSO_4$. Both methods are used. It forms as a gas and must be absorbed in water in order that it may be shipped.

Bromine is made by several methods. One of the more important consists of electrolysis of brines containing bromine. It is electrolyzed at a lower voltage than chlorine and hence may be stripped from a brine leaving the chlorine behind. Another method consists of treating the concentrated bitterns or mother liquors from brines used in salt making with sulfuric acid and sodium chlorate. This is the oldest method. Still another method consists in using chlorine direct to liberate the bromine.

CHEMICAL INDUSTRIES IN WEST VIRGINIA USING SALT BRINES OR BRINE PRODUCTS.

During the period May 23 to May 25 inclusive, 1937, the writers made a tour of the Ohio and Kanawha River Valleys visiting certain plants processing salt brines or using brine products. A brief description of these plants is given below following the order in which the plants were visited.

PLANT OF THE OHIO RIVER SALT CORPORATION.

This plant is located at Mason City along the Ohio River. The president of the corporation is Mr. H. F. Smith. The person who supplied the information herewith included was Mr. Norman O. Wein who is treasurer and general manager of the company. (See Plates XII to XVII).

The plant is of the grainer type steam heated throughout. It regularly employs about 50 men. It pumps brine from its own wells and processes it for various products.

Materials Produced.—Following is a discussion of the various materials produced, methods of manufacture and packaging, rates of production, etc.

Salt is produced in two grades. The first grade, known as "Ohio River Salt," comprises the major part of the salt production. It is sold mostly in the southern States and is used largely in meat curing. Last year the State of Tennessee alone took about 25% of the plant's production. The other grade of salt, known as "low grade," is high in barium. It is sold mostly for use as a glazing material in the manufacture of brick and tile. Salt is packed in barrels and also in cotton bags of 25, 50, and 100 pounds capacity. About 50 tons of salt are produced per day. It is all produced by the grainer process.

After salt is removed from the brine the residual liquor, known as bittern, is treated for extraction of bromine. The method used is to first add to the bittern sulfuric acid and sodium chlorate to liberate the bromine. The bromine is then distilled out of the bittern, condensed, and caught in glass bottles. In this way there is produced what is known as a commercial grade of liquid bromine. The bottles hold roughly 6 pounds each. About 250 pounds per day of bromine is produced.

The liquor resulting from bromine extraction is then neutralized with lime and further treated to recover calcium and magnesium chlorides. The method of treatment consists in evaporating by use of steam coils until the hot residue attains a thick viscous consistency. The residue is then run into sheet iron drums which will hold about 600 pounds. Upon cooling it becomes solid. The bulk of the calcium and magnesium chloride is sold in this form. A part of the production, however, is flaked by a special process and sold packed in 100-pound burlap bags with moisture proof lining. About 11 tons of calcium and magnesium chloride are produced per day. These chlorides are used for use both in treating coal and in treating roads. Mr. Wein reported that a considerable quantity is sold in Ohio for the latter purpose.

The salt produced at this plant is known as non-hardening salt. This property results from the presence in the salt of small amounts of calcium and magnesium chlorides.

The plant operates about 300 days per year.

Raw Materials.—The main raw material used is salt brine. Other raw materials used in much smaller amounts are sulfuric acid, lime, and sodium chlorate.

The brine is obtained from two wells drilled in 1914. These wells are about 1000 feet deep. The brine-producing horizon is the Salt Sand. The brine is pumped by air lifts at the rate of about 150 gallons per minute for both wells together. The brine has a density of about 9° Bé. Mr. Wein stated that the producing capacity of the wells depends altogether on their diameter. There seems to be a very plentiful supply of brine in the sand.

Coal is used for fuel in the plant. The daily consumption is about 60 tons for combined power and evaporation purposes. All power is generated in the local steam plant.

General Comments.—The present plant was built in 1913-14. It was purchased by its present owner in 1929. It was stated that there is a ready sale for all of the different products made. The great flood in January of 1937 caused very high losses including about 125 car-loads of salt and 25 car-loads of calcium and magnesium chloride.

This plant is unique, in one respect, for a grainer plant. There is no direct heating of the brine by fire. The main heating is done by steam generated in the boiler plant and the secondary heating is performed by steam generated from the brine first heated by power-plant steam.

PLANT OF THE LIVERPOOL SALT COMPANY.

This plant is located at Hartford, West Virginia. The informant who supplied the data herewith included was Mr. D. A. Smith, Manager. The plant is of the grainer type direct fired. It regularly employs about 40 men. This plant is in general quite similar to that of the Ohio River Salt Corporation just described. (See Plate XVIII).

Materials Produced.—Following is a discussion of the various materials produced, methods of manufacture and packaging, rates of production, etc.

Salt is produced in three grades. The first and second grades are for human nad animal consumption. The main use of the these grades is for meat curing and livestock salting. The third grade is known as "low grade" and is high in barium. It is sold for use as glaze in brick and tile manufacture. Salt is packed in barrels, and in cotton bags of 25, 50, and 100 pounds capacity. Salt is produced at the rate of about 40 tons per day.

The bittern resulting from salt extraction is treated for bromine by the sulfuric acid-sodium chlorate process. The residual bittern is then evaporated to produce mixed calcium and magnesium chloride.

The bromine is sold as liquid bromine of commercial grade. The amount produced is about 185 pounds per day. The calcium and magnesium chloride are sold in sheet-iron drums of about 600 pounds capacity. The amount produced is about 8 tons per day. It is reported that the demand for calcium and magnesium chlorides is very poor.

Transportation includes both rail and river traffic.

The plant operates about 300 days per year.

Raw Materials.—The principal raw material used is, of course, salt brine. Other raw materials used in smaller amounts are sulfuric acid, lime, and sodium chlorate.

The brine is obtained from five wells. Four of them are approximately 50 years old. The other was drilled in 1936. They have an elevation of about 570 feet and are about 1200 feet deep. The rate of flow is 90 gallons per minute on four wells combined. The brine density is about 9.5° Bé.

Fuel and Power.—Coal is used for fuel. About 40 tons per day is burned for combined power and evaporation purposes.

General Comments.—A steam jet is used at the fire-box to reduce the size of clinkers produced. The furnace is hand-fired.

The coal mine of the Hartford Coal Company is adjacent to the plant.

The primary concentration in the brine takes place in a direct fired evaporator with a steam chest. This provides steam for secondary use in the settling tanks and grainers.

The great flood of 1937 did considerable damage including the wrecking of several grainer vats which have not as yet been replaced.

PLANT OF THE J. Q. DICKINSON SALT COMPANY.

This plant is located at Malden, West Virginia and is owned by the J. Q. Dickinson Salt Company. Information was supplied mainly by Mr. G. R. Pyle, Managing Chemist. The plant is of the grainer type. It has a direct fired furnace for primary evaporation. The number of men employed is about 40 for the salt plant proper or 85 to 90 for all operations including the salt plant. (See Plates VI to X).

Materials Produced.—Following is a discussion of the various materials produced, methods of manufacture and packaging, rates of production, etc.

Salt is produced in four grades, namely, dairy and table grade, medium fine grade, coarse grade, off grade. The first three grades are used for human consumption and for livestock salting. The fourth grade, containing considerable barium, is sold for special industrial purposes. It is reported that 85% of the salt is recovered from the brine. The salt is packed in 280-pound barrels and in 25, 50, and 100-pound cotton bags. The rate of production is reported as approximately 500 tons per month. The salt market is said to be mainly in Kentucky, Virginia, and West Virginia. It is reported that this salt is in great demand for meat curing. All of the salt is manufactured by the regular grainer process.

The bittern from salt production is then treated for bromine extraction by the standard sulfuric acid-sodium chlorate process. The rate of bromine production was stated to be about 3000 pounds per month. The bromine is redistilled and a part of it sold as chemically pure bromine. Part is also used locally for manufacture of alkali bromides. Bromine extraction from brine is said to be 90 per cent. The bromine is sold in bottles of about 6 pounds capacity.

After bromine extraction the residual bittern is evaporated to produce mixed calcium and magnesium chlorides. The rate of production is stated as about 100 tons per month. It is sold in 600-pound drums and also in 100-pound moisture proof bags.

The alkali bromides manufactured include sodium, potassium, and ammonium bromide. The rate of production was not stated. The method of manufacture is secret. These bromides are shipped in lined barrels. (See Plate XI).

Raw Materials.—The principal raw material is, of course, salt brine. Other raw materials used in smaller amounts are sulfuric acid, sodium chloride, lime, caustic soda, caustic potash, and ammonium hydroxide.

The brine is obtained from 6 wells. The age and elevation of wells were not given. Depth of wells was stated to range from 800 feet to 1200 feet. The rate of flow for all wells combined was given as 80 gallons per minute. Brine density was 8.5 to 9° Bé. (See Plate I).

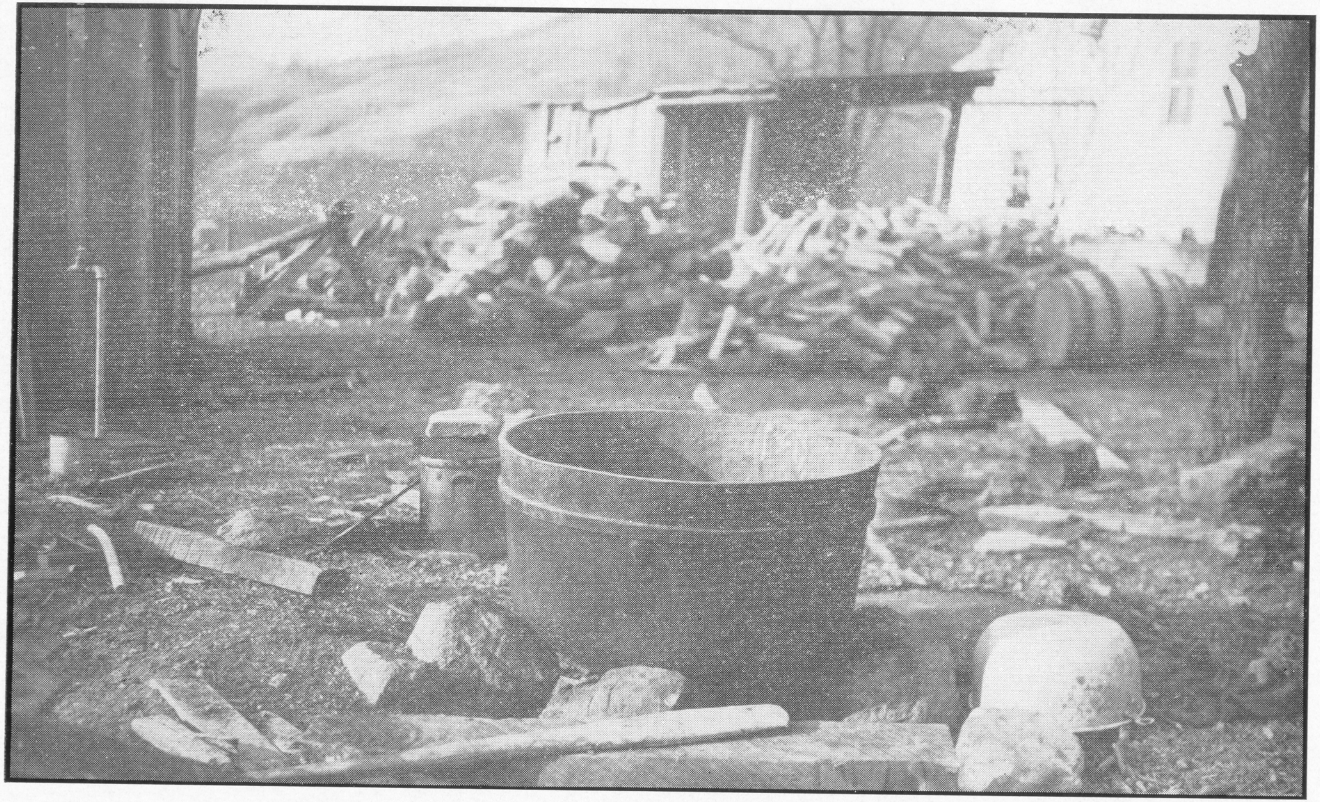


PLATE XIX.—Old Salt Kettle, Bulltown, Braxton Co., W. Va.—Two sizes of iron kettles were used at the Bulltown Salines. This is one of the large ones. It is now used for domestic purposes.—Photo by Hoskins, 1937.

Fuel and Power.—The fuel used is coal. All fuel is burned in the main furnace which serves both to heat the primary brine evaporator and also a power boiler which is installed in the furnace setting. This boiler provides steam for power purposes. The furnace is provided with a chain grate stoker. Ashes are recovered and sold. This installation also has a good dust separating system.

General Comments.—The Malden plant has had a long and interesting history. An excellent historical write-up of it appeared in Industrial and Engineering Chemistry for the months of October, November, and December, 1935.

It is one of the oldest manufacturing plants in West Virginia and is said to be the oldest in point of continuous operation.

PLANT OF CARBIDE AND CARBON CHEMICALS CORPORATION.

This plant is located at South Charleston, West Virginia.

Information was provided by Mr. S. W. Pickering, II, Assistant Superintendent. This plant is a large modern plant built for the manufacture of many different products including synthetic organic chemicals. The area occupied is 170 to 180 acres. About 2500 men are regularly employed. (See Plates XXII and XXIII).

Materials Produced.—Following is a discussion of the various materials produced in so far as information is available.

The plant produces over a hundred different materials. These include a considerable number of synthetic organic chemicals, activated carbon, and various hydrocarbon gases of high purity.

Among the more important synthetic organic chemicals may be mentioned the following: ethylene glycol, better known as prestone, acetone, ethyl alcohol, acetic acid, acetic esters. Information is not available as to rates of production but it is obvious that in a plant of this size the total volume of production of the more important materials must be very great.

Raw Materials.—Mr. Pickering stated that the principal raw materials are chlorine, natural gas, and lime. The chlorine is obtained in gaseous form at about 30 pounds pressure from the Westvaco Chlorine Products Corporation whose plant is near by. It is piped direct from the Westvaco plant to the consuming plant. No brine is used.

PLANT OF THE WESTVACO CHLORINE PRODUCTS CORPORATION.

This is a large modern plant located at South Charleston, West Virginia. The resident manager is Mr. M. G. Geiger. The information was obtained from Mr. E. V. Norton, Assistant Manager.

This is a large modern industrial plant covering about 40 acres and employing about 600 men. (See Plates XXII and XXIII).

It pumps brine from its own wells and makes a number of direct brine products and also chlorine derivatives of various organic chemicals. (See Plate XXI).

Materials Produced.—The chief product is chlorine gas. Two large by-products are caustic soda and calcium and magnesium chlorides. In addition the following are produced, bromine, ethylene dibromide, carbon tetrachloride, carbon bisulphide, acetylene tetrachloride, trichlorethylene, sulphur chloride.

The main features of the production scheme are as follows: brine is pumped from the company's wells to the concentrating plant. It is first concentrated in a quintuple effect vacuum pan system using steam heat. In this section it is concentrated to a point where it is just ready to deposit salt crystals. It is then transferred to a double effect vacuum pan system using steam heat and here the salt crystals are deposited. The crystals then pass to rotary salt filters including both Swenson and Dorroco makes. The salt from these filters, containing perhaps 10 or 15 per cent. moisture is then redissolved and subjected to a purification process. It then goes to the electrolytic cells as a pure salt solution and is there treated to produce chlorine and hydrogen gases and caustic soda solution. The chlorine gas is for the most part shipped as a gas by pipe line to the neighboring Carbide and Carbon Chemicals Corporation. Small amounts are liquefied and sold as liquid. The hydrogen gas produced is used mainly as a fuel in the plant. The caustic soda in the solution from the cells is concentrated and marketed.

The bittern from the second evaporation plant and salt filters is treated for extraction of bromine and for final production of calcium and magnesium chlorides.

The rate of production was not stated for any of the plant's products. Mr. Norton did state, however, that the Westvaco Chlorine Plant was the largest in the world and that it was running to capacity. The production of chlorine, therefore, is very large and the production of caustic soda, bromine, and calcium and magnesium chlorides are correspondingly large.

Raw Materials.—Brine is of course the primary raw material for the various brine products. There are various other organic raw materials which were not listed.

The brine is obtained from 17 different wells having an average age of about 5 years. Depth of wells was stated as about 1800 feet and the producing horizon was stated to be the Big Injun Sand. The brines are pumped by deep well centrifugal pumps. The rate of flow of brine was stated as 40 gallons per minute per well. Density of brine was given as 1.093 at 15° Bé. An analysis of the brine was also given as follows:

Analysis of Brine, Per Cent.:

$NaCl$	8.95
$CaCl_2$	2.22
$MgCl_2$	0.66
$BaCl_2$	0.06
Br_2	0.034
Iron	0.037

Fuel and Power.—Aside from the use of hydrogen for fuel above mentioned the principal fuel burned in the plant is coal. The daily consumption is about 850 tons. The rate of power generation is 32,000 kilowatts. This power is generated at 2300 volts. For cell room use it is transformed to a lower voltage and then converted to direct current both by rotary converters and also mercury arc rectifiers.

PLANT OF THE BELLE ALKALI COMPANY.

This plant is located at Belle, West Virginia. The resident manager is Mr. D. W. Stubblefield; the operating superintendent is Mr. W. A. Borror. It was he who supplied information for this report. The plant was built about 1923. It is devoted mainly to the manufacture of chlorine and caustic soda. It processes a pure grade of salt rather than salt brines.

Materials Produced.—Following is a discussion of materials produced, methods of manufacture and packaging, rates of production, etc.

The following table shows a list of materials produced and the rates of production.

Table 31.—Materials Produced.

	Product.	Rate of Production.
1.	Chlorine	14 tons per day
2.	Caustic Soda	16 tons per day
3.	Methyl chloride	313,000 lbs. in 1936
4.	Methylene chloride	121,000 lbs. in 1936
5.	Hydrochloric acid	1,379,000 lbs in 1936
6.	Minor products, including chloroform	282,000 lbs. in 1936

The company does not use salt brine. It purchases a pure grade of salt as the starting raw material for chloride and caustic soda. It dissolves this salt to form a pure brine and then electrolyzes it to produce chlorine and hydrogen gases and caustic soda. The chlorine is liquefied and shipped. The chlorine is shipped mostly as liquid, in tank cars, one ton tanks, and small containers of about 100 pounds capacity. The caustic soda is concentrated by evaporation to 50% strength and sold as a 50% solution mostly in tank car lots.

Methyl chloride is produced by a secret process based on chlorination of natural gas which is also purchased. Methylene chloride is made in connection with the process mentioned for methyl chloride.

Hydrochloric acid is made as a by-product of the methyl and methylene chloride operations. It is absorbed in water and sold as a strong aqueous solution mostly in tank car lots.

The various minor products including chloroform are made mostly in connection with the methyl and methylene chloride process.

Raw Materials.—The principal raw material is a very pure grade of salt purchased from the Wadsworth Salt Company of Wadsworth, Ohio. The other important raw material is natural gas.

No brines are used although the company has four brine wells. These wells were operated for a period. The following data were obtained during that time.

Rates of flow was as follows: 2 wells gave 5 gallons per minute each, 1 well gave 20 gallons per minute, 1 well gave 35 gallons per minute. Densities for the four different wells were as follows in °Bé: 13.7, 13, 12, 7.5. An analysis of the brines was supplied which is here reproduced.

Constituent.	Per Cent.
Silica	.0010
Ferrous bicarbonate	.0108
Manganous bicarbonate	.0088
Calcium bicarbonate	.0027
Calcium phosphate	.0004
Magnesium bromide	.0534
Ammonium chloride	.0072
Potassium chloride	.0630
Lithium chloride	.0145
Sodium chloride	6.4636
Strontium chloride	.0188
Barium chloride	.0248
Magnesium chloride	.5702
Calcium chloride	2.1877
Water	90.5731

Fuel and Power.—The chief fuel used is coal. About 130 tons are burned per day. The plant generates its own power at the rate of nearly 3000 kilowatts.

General Comments.—The plant as originally built included a small plant for making salt from salt brines. This plant used small steam heated evaporating pans each of which was provided with a pair of salt boxes, or chests, below for the removal of crystallized salt. Brine from the wells was pumped through this plant for salt making.

Now, however, neither the wells nor salt making plant are in operation since the company prefers to purchase salt.

FUTURE OF WEST VIRGINIA BRINE INDUSTRY.

As shown by the study of the salt brine industry in this State, West Virginia already produces a substantial part of the nation's total salt brine derivatives. Her relative production as well as her total tonnage production may be expected to increase. Not only does she have vast reserves of brine but she is also possessed of even greater reserves of fuel, chiefly coal, and of other raw materials all of which can be used in the upbuilding of integrated local industries.

The already great developments in the Kanawha Valley may be taken as only indicative of the still greater industrial expansion which is likely to develop on the basis of the fuel, salt brine, and other resources available within the State.

DETAILED BRINE REPORTS.

In this section will be found analyses representative of each horizon; tables of all brines analyzed appear elsewhere both by counties and by producing horizons, or sands. The order of arrangement here is the descending order of the sands and the north to south order of the counties in order that one may get a birdseye view of each horizon in any part of the State, and to show how the brines from the several sands compare along the trend of the major axis of the oil and gas fields of the State.

For this purpose, two First Salt brines, two Second Salt brines, seventeen Salt Sand brines (one from each county, because most abundant), six Maxton brines, twelve Big Injun brines, six Oriskany brines, and all the brines of which the Survey had but one or two samples are included. For convenience of reference, the following index is appended:

Index to Detailed Brine Reports.

Horizon	No.	County	Horizon	No.	County
L. Dunkard	126	Monongalia	Maxton	153	Ritchie
Dunkard	59	Doddridge	Maxton	60	Gilmer
Big Dunkard	26	Cabell	Maxton	187	Gilmer
Gas	127	Monongalia	Maxton	21	Boone
Gas	140	Pleasants	Big Lime	91	Kanawha
1st Salt	128	Monongalia	Big Injun	136	Monongalia
1st Salt	67	Kanawha	Big Injun	185	Tyler
2nd Salt	129	Monongalia	Big Injun	143	Pleasants
2nd Salt	114	Logan	Big Injun	184	Wood
Salt	121	Marshall	Big Injun	63	Gilmer
Salt	132	Monongalia	Big Injun	186	Gilmer
Salt	174	Wetzel	Big Injun	32	Cabell
Salt	118	Marion	Big Injun	145	Putnam
Salt	166	Tyler	Big Injun	138	Nicholas
Salt	151	Ritchie	Big Injun	108	Lincoln
Salt	177	Wirt	Big Injun	171	Wayne
Salt	99	Lewis	Big Injun	23	Boone
Salt	42	Calhoun	Squaw	57	Doddridge
Salt	122	Mason	Fifth	120	Marion
Salt	C.D.H.	Mason	Fifth	188	Marion
Salt	160	Roane	Fifth	189	Marion
Salt	82	Kanawha	Oriskany	92	Kanawha
Salt	48	Clay	Oriskany	93	Kanawha
Salt	104	Lincoln	Oriskany	94	Kanawha
Salt	170	Wayne	Oriskany	163	Roane
Salt	115	Logan	Oriskany	181	Wirt
Salt	2	Boone	Oriskany	182	Wirt
Maxton	51	Doddridge	Salina	22	Boone
Maxton	183	Wood	Wh. Medina	164	Roane

Sample No. 126 *Analyst* Hoskins
Company Name L. J. Houze Convex Glass Co. *Well*
Farm Name Jesse L. Bowlby *Farm Well No.* 1
County Monongalia *District* Cass *Producing Horizon* Little Dunkard
Location Wade Run about 9 miles N. from Morgantown
Depth to top of Sand 1125 *ft.* *Salt water horizon from* 1257 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 26.5 *Density at given temperature* 1.0129

Analysis in parts per million.

Total solids after evaporation (TS) 25,100

Iron (Fe)	1.65	*Carbonate (CO_3)*	.....
Calcium (Ca)	1024	*Bicarbonate (HCO_3)*	128
Strontium (Sr)	35	*Sulfate (SO_4)*	18
Barium (Ba)	17	*Chloride (Cl)*	15070
Magnesium (Mg)	289	*Bromine (Br)*	88
Sodium (Na)	8100	*Iodine (I)*	2
Potassium (K)	22	*Total of determined constituents*	24,795

Sample No. 59 *Analyst* Hoskins
Company Name Clifton Oil & Gas Co. *Well*
Farm Name Dallas Powell *Farm Well No.* 1
County Doddridge *District* McClellan *Producing Horizon* Big Dunkard
Location Israel Fork on waters of Big Flint, 1 mile N. E. of West Union
Depth to top of Sand 1168 *ft.* *Salt water horizon from* 1168 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 21.5 *Density at given temperature* 1.0064

Analysis in parts per million.

Total solids after evaporation (TS) 10,690

Iron (Fe)	35	*Carbonate (CO_3)*	.....
Calcium (Ca)	141	*Bicarbonate (HCO_3)*	695
Strontium (Sr)	4.8	*Sulfate (SO_4)*	159
Barium (Ba)	Tr	*Chloride (Cl)*	5420
Magnesium (Mg)	39	*Bromine (Br)*	10
Sodium (Na)	3590	*Iodine (I)*	Tr
Potassium (K)	46	*Total of determined constituents*	10,140

Sample No. 26 *Analyst* Hoskins
Company Name An old Artesian Well *Well*
Farm Name Cole & Crane ''40 Acre'' Farm *Farm Well No.* 1
County Cabell *District* Guyandot *Producing Horizon* Big Dunkard
Location Gunpowder Branch, 1¼ miles south from Guyandot
Depth to top of Sand 160 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 23 *Density at given temperature* 1.0394

Analysis in parts per million.

Total solids after evaporation (TS) 59,400

Iron (Fe)	Tr	*Carbonate (CO_3)*	.....
Calcium (Ca)	3370	*Bicarbonate (CHO_3)*	99
Strontium (Sr)	103	*Sulfate (SO_4)*	Tr
Barium (Ba)	127	*Chloride (Cl)*	36200
Magnesium (Mg)	979	*Bromine (Br)*	52
Sodium (Na)	17690	*Iodine (I)*	0.4
Potassium (K)	50	*Total of determined constituents*	58,670

Remarks: This is an Artesian well that has flowed since sometime between 1885 and 1890, therefore it should give a fairly true picture of the Salt Sand constituents. The Berea Sand is 1900 feet deep here.

PLATE XX.—The Old Brine Well, Sago, Upshur Co., W. Va.—Drilled by a "sweep" about 1847 and supplied brine for salt for some time. Later was deepened and oil was encountered; finally plugged off below a "flow" of fresh water. In domestic use ever since.—Photo by Hoskins, 1937.

Sample No. 127 *Analyst* McCue
Company Name Carnegie Nat. Gas Co. *Well—Company No.* 1488
Farm Name Katherine R. Cooke *Farm Well No.* 1
County Monongalia *District* Cass *Producing Horizon* Gas
Location Waters of Robinson Run, 10 miles N. W. from Morgantown
Depth to top of Sand 1055 *ft.* *Salt water horizon from* 1070 *ft. to* 1073 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 22 *Density at given temperature* 1.0128

Analysis in parts per million.

Total solids after evaporation (TS) 22,600

Iron (Fe)	39	*Carbonate (CO_3)*	......
Calcium (Ca)	369	*Bicarbonate (HCO_3)*	501
Strontium (Sr)	10	*Sulfate (SO_4)*	12
Barium (Ba)	40	*Chloride (Cl)*	12900
Magnesium (Mg)	285	*Bromine (Br)*	......
Sodium (Na)	7550	*Iodine (I)*	......
Potassium (K)	45	*Total of determined constituents*	21,751

Remarks: 4 bailers per hour.

Sample No. 140 *Analyst* McCue
Company Name All-in-One Producing & Ref. Co. *Well*
Farm Name B. E. Coen *Farm Well No.* 1
County Pleasants *District* Grant *Producing Horizon* Gas Sand
Location Cow Creek, 5 miles S. W. of St. Marys
Depth to top of Sand 87 *ft.* *Salt water horizon from* 90 *ft. to* 95 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24.5 *Density at given temperature* 1.0061

Analysis in parts per million.

Total solids after evaporation (TS) 9,050

Iron (Fe)	0.5	*Carbonate (CO_3)*	......
Calcium (Ca)	131	*Bicarbonate (HCO_3)*	1320
Strontium (Sr)	N.D.	*Sulfate (SO_4)*	323
Barium (Ba)	N.D.	*Chloride (Cl)*	5790
Magnesium (Mg)	86	*Bromine (Br)*	Tr
Sodium (Na)	4100	*Iodine (I)*	Tr
Potassium (K)	N.D.	*Total of determined constituents*	11,751

Sample No. 128 *Analyst* Hoskins
Company Name L. J. Houze Convex Glass Company *Well*
Farm Name Leonore Barrickman *Farm Well No.* 1
County Monongalia · *District* Cass *Producing Horizon* 1st Salt
Location Approximately 11 miles north of Morgantown

Detailed Chemical Analysis.

Temperature of sample °C 25 *Density at given temperature* 0.9970

Analysis in parts per million.

Total solids after evaporation (TS) 875

Silica (SiO_2)	71	*Carbonate (CO_3)*	......
Iron (Fe)	0.6	*Bicarbonate (HCO_3)*	570
Calcium (Ca)	4	*Sulfate (SO_4)*	5
Strontium (Sr)	Tr	*Chloride (Cl)*	180
Barium (Ba)	1	*Bromine (Br)*	Tr
Magnesium (Mg)	1	*Iodine (I)*	Tr
Sodium (Na)	273	*Total of determined constituents*	1,118
Potassium (K)	13		

Sample No. 67 *Analyst* Hoskins
Company Name Owens, Libbey-Owens Gas Dept. *Well—Company No.* 453
Farm Name Siler Coal Land Company
County Kanawha *District* Washington *Producing Horizon* 1st Salt
Location Little Coal River
Depth to top of Sand 804 *ft.* *Salt water horizon from* 915 *ft. to* 960 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 21 *Density at given temperature* 1.0355

Analysis in parts per million.

Total solids after evaporation (TS) 54,800

Iron (Fe)	.....	*Carbonate (CO_3)*	.....
Calcium (Ca)	2280	*Bicarbonate (HCO_3)* ..	360
Strontium (Sr)	N.D.	*Sulfate (SO_4)*	.....
Barium (Ba)	226	*Chloride (Cl)*	33300
Magnesium (Mg)	771	*Bromine (Br)*	19
Sodium (Na)	17440	*Iodine (I)*	1.2
Potassium (K)	264	*Total of determined constituents*	54,661

Sample No. 129 *Analyst* Hoskins
Company Name L. J. Houze Convex Glass Company *Well*
Farm Name Leonore Barrickman *Farm Well No.* 1
County Monongalia *District* Cass *Producing Horizon* 2nd Salt
Location Approximately 11 miles north of Morgantown
Depth to top of Sand 1520 *ft.* *Salt water horizon from* 1523 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24 *Density at given temperature* 0.9973

Analysis in parts per million.

Total solids after evaporation (TS) 955

Iron (Fe)	0.55	*Carbonate (CO_3)*	.....
Calcium (Ca)	12	*Bicarbonate (HCO_3)* ..	606
Strontium (Sr)	.....	*Sulfate (SO_4)*	3
Barium (Ba)	48	*Chloride (Cl)*	223
Magnesium (Mg)	3.4	*Bromine (Br)*	1
Sodium (Na)	358	*Iodine (I)*	0.32
Potassium (K)	9	*Total of determined constituents*	1,264

Remarks: Water is potable.

Sample No. 114 *Analyst* Hoskins
Company Name Boone County Coal Corp. *Well—Company No.* "D"
Farm Name Boone County Coal Corp.
County Logan *District* Logan *Producing Horizon* 2nd Salt
Location 2nd Branch to right of Rockhouse Creek, ¾ mi. N. W. from Mifflin
Depth to top of Sand 1010 *ft.* *Salt water horizon from* 1047 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.1080

Analysis in parts per million.

Total solids after evaporation (TS) 150,900

Iron (Fe)	18	*Carbonate (CO_3)*	.....
Calcium (Ca)	12920	*Bicarbonate (HCO_3)* ..	30
Strontium (Sr)	347	*Sulfate (SO_4)*	5
Barium (Ba)	281	*Chloride (Cl)*	92000
Magnesium (Mg)	2620	*Bromine (Br)*	45
Sodium (Na)	38900	*Iodine (I)*	1
Potassium (K)	1333	*Total of determined constituents*	148,500

Remarks: 3 bailers per hour.

Sample No. 121 *Analyst* McCue
Company Name Burleigh Wright *Well*
Farm Name Elmer Blake Heirs *Farm Well No.* 1
County Marshall *District* Webster *Producing Horizon* Salt
Location 6 miles N. E. of Cameron
Depth to top of Sand 1530 *ft.* *Salt water horizon from* 1560 *ft. to* 1700 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24.5 *Density at given temperature* 1.0001

Analysis in parts per million.

Total solids after evaporation (TS) 5,460

Iron (Fe)	0.25	*Carbonate (CO_3)*	......
Calcium (Ca)	47	*Bicarbonate (CHO_3)*	811
Strontium (Sr)	N.D.	*Sulfate (SO_4)*	35
Barium (Ba)	N.D.	*Chloride (Cl)*	2870
Magnesium (Mg)	16	*Bromine (Br)*	Tr
Sodium (Na)	2100	*Iodine (I)*	Tr
Potassium (K)	N.D.	*Total of determined constituents*	5,879

Remarks: Not completely analyzed because of such low density, but included to show variation in density, by counties.

Sample No. 132 *Analyst* McCue
Company Name L. J. Houze Convex Glass Company *Well*
Farm Name Jesse L. Bowlby *Farm Well No.* 1
County Monongalia *District* Cass *Producing Horizon* Salt
Location Wade Run, about 9 miles N. of Morgantown
Depth to top of Sand 1125 *ft.* *Salt water horizon from* 1257 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24 *Density at given temperature* 1.0098

Analysis in parts per million.

Total solids after evaporation (TS) 1,052

Iron (Fe)	10	*Carbonate (CO_3)*	......
Calcium (Ca)	79	*Bicarbonate (HCO_3)*	305
Strontium (Sr)	0.3	*Sulfate (SO_4)*	184
Barium (Ba)	0.7	*Chloride (Cl)*	287
Magnesium (Mg)	14	*Bromine (Br)*	......
Sodium (Na)	250	*Iodine (I)*	......
Potassium (K)	36	*Total of determined constituents*	1,166

Sample No. 174 *Analyst* Hoskins
Company Name O. T. Midcap *Well*
Farm Name Henry Elson *Farm Well No.* 2
County Wetzel *District* Green *Producing Horizon* 3rd Salt
Location Fluharty Run, 2 miles south from Porters Falls
Depth to top of Sand 1775 *ft.* *Salt water horizon from* 1775 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 30 *Density at given temperature* 1.0581

Analysis in parts per million.

Total solids after evaporation (TS) 86,700

Iron (Fe)	14	*Carbonate (CO_3)*	......
Calcium (Ca)	6590	*Bicarbonate (CHO_3)*	83
Strontium (Sr)	129	*Sulfate (SO_4)*	40
Barium (Ba)	......	*Chloride (Cl)*	52300
Magnesium (Mg)	1184	*Bromine (Br)*	400
Sodium (Na)	24090	*Iodine (I)*	17.4
Potassium (K)	229	*Total of determined constituents*	85,076

Sample No. 118 *Analyst* Hoskins
Company Name Owens-Illinois Glass Company *Well—Company No.* 147
Farm Name A. T. Heck
County Marion *District* Fairmont *Producing Horizon* Salt
Location Branch of Finches Run, between Barrackville and Grant Town
Depth to top of Sand 1364 *ft.* *Salt water horizon from* 1379 *ft. to* 1424 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 25.5 *Density at given temperature* 1.0011

Analysis in parts per million.

Total solids after evaporation (TS) 6,078

Iron (Fe)	0.15	*Carbonate* (CO_3)	......
Calcium (Ca)	151	*Bicarbonate* (CHO_3)	58
Strontium (Sr)	Tr	*Sulfate* (SO_4)	89
Barium (Ba)	......	*Chloride (Cl)*	3550
Magnesium (Mg)	76	*Bromine (Br)*	6
Sodium (Na)	1998	*Iodine (I)*	Tr
Potassium (K)	92	*Total of determined constituents*	6,020

Sample No. 166 *Analyst* Hoskins
Company Name Kerns & Smith *Well*
Farm Name J. P. Ripley *Farm Well No.* 1
County Tyler *District* Centerville *Producing Horizon* Salt
Location Wheeler Run, 2 miles west from Centerville
Depth to top of Sand 1570 *ft.* *Salt water horizon form* 1590 *ft. to* 1600 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 26 *Density at given temperature* 1.1240

Analysis in parts per million.

Total solids after evaporation (TS) 164,400

Iron (Fe)	3	*Carbonate* (CO_3)	......
Calcium (Ca)	14360	*Bicarbonate* (HCO_3)	Acid
Strontium (Sr)	198	*Sulfate* (SO_4)	18
Barium (Ba)	294	*Chloride (Cl)*	103600
Magnesium (Mg)	2471	*Bromine (Br)*	800
Sodium (Na)	45900	*Iodine (I)*	18
Potassium (K)	328	*Total of determined constituents*	167,990

Sample No. 151 *Analyst* McCue
Company Name South Penn Oil Co. *Well*
Farm Name Georgia M. Haught *Farm Well No.* 2
County Ritchie *District* Murphy *Producing Horizon* Salt
Location Laurel Fork, 1½ miles northwest from Hartley
Depth to top of sand 1826 *ft.* *Salt water horizon from* 1905 *ft. to* 1910 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 30 *Density at given temperature* 1.0717

Analysis in parts per million.

Total solids after evaporation (TS) 99,400

Iron (Fe)	4	*Carbonate* (CO_3)	......
Calcium (Ca)	6800	*Bicarbonate* (CHO_3)	52
Strontium (Sr)	166	*Sulfate* (SO_4)	Tr
Barium (Ba)	1573	*Chloride (Cl)*	59900
Magnesium (Mg)	1608	*Bromine (Br)*	196
Sodium (Na)	27300	*Iodine (I)*	7.5
Potassium (K)	289	*Total of determined constituents*	97,895

Remarks: This sample had exceedingly large amount of Barium.

Sample No. 177 *Analyst* Hoskins
Company Name A. E. Mackintosh *Well—Company No.* 1
Farm Name A. E. Mackintosh *Farm Well No.* 1
County Wirt *District* Spring Creek *Producing Horizon* Salt
Location Petes Run, ¾ mile southwest from Creston
Depth to top of Sand 1239 *ft.* *Salt water horizon from* 1330 *ft. to* 1335 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.0549

Analysis in parts per million.

Total solids after evaporation (TS) 84,000

Iron (Fe)	0.9	*Carbonate (CO_3)*	.....
Calcium (Ca)	4410	*Bicarbonate (CHO_3)*	102
Strontium (Sr)	204	*Sulfate (SO_4)*	5.4
Barium (Ba)	833	*Chloride (Cl)*	50200
Magnesium (Mg)	1470	*Bromine (Br)*	284
Sodium (Na)	24380	*Iodine (I)*	3.8
Potassium (K)	135	*Total of determined constituents*	82,028

Sample No. 99 *Analyst* Hoskins
Company Name Reserve Gas Co. *Well—Company No.* 825
Farm Name James Jarvis
County Lewis *District* Freemans Creek *Producing Horizon* Salt
Location Polk Creek, 5 miles west from Weston
Depth to top of Sand 1470 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.0340

Analysis in parts per million.

Total solids after evaporation (TS) 54,100

Iron (Fe)	320	*Carbonate (CO_3)*	.....
Calcium (Ca)	2880	*Bicarbonate (CHO_3)*	124
Strontium (Sr)	210	*Sulfate (SO_4)*	.....
Barium (Ba)	38	*Chloride (Cl)*	33000
Magnesium (Mg)	704	*Bromine (Br)*	145
Sodium (Na)	16440	*Iodine (I)*	2.7
Potassium (K)	56	*Total of determined constituents*	53,920

Remarks: This sample rrom a gas well tubed with steel pipe which probably accounts for high iron content.

Sample No. 42 *Analyst* McCue
Company Name Everett Starcher *Well*
Farm Name Tom Campbell *Farm Well No.* 2
County Calhoun *District* Lee *Producing Horizon* Salt
Location 1¼ miles south from Creston
Depth to top of Sand 1402 *ft.* *Salt water horizon from* 1402 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24 *Density at given temperature* 1.0720

Analysis in parts per million.

Total solids after evaporation (TS) 113,400

Iron (Fe)	7	*Carbonate (CO_3)*	.....
Calcium (Ca)	8454	*Bicarbonate (HCO_3)*	51
Strontium (Sr)	2610	*Sulfate (SO_4)*	.....
Barium (Ba)	1554	*Chloride (Cl)*	68400
Magnesium (Mg)	2038	*Bromine (Br)*	373
Sodium (Na)	28900	*Iodine (I)*	3.9
Potassium (K)	298	*Total of determined constituents*	112,689

Remarks: Included because of the peculiar amounts of Strontium and Barium which are rather high.

Sample No. 122 *Analyst* Hoskins
Company Name Liverpool Salt Company *Well—Company No.* Fleetwood
Farm Name Plant site Liverpool Salt Company
County Mason *District* Waggener *Producing Horizon* Salt
Location On the site of the Salt plant in Hartford
Depth to top of Sand about 1100 *ft.*
Salt water horizon from approx. 1100 *ft. to* 1200 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 25 *Density at given temperature* 1.0608

Analysis in parts per million.

Total solids after evaporation (TS) 87,500

Iron (Fe)	30	*Carbonate (CO_3)*	......
Calcium (Ca)	4090	*Bicarbonate (HCO_3)*	34
Strontium (Sr)	88	*Sulfate (SO_4)*	3.7
Barium (Ba)	213	*Chloride (Cl)*	50200
Magnesium (Mg)	1282	*Bromine (Br)*	354
Sodium (Na)	24800	*Iodine (I)*	Tr
Potassium (K)	168	*Total of determined constituents*	81,263

Remarks: This is one of the original wells drilled for brine on the Ohio River. It also produces a large amount of gas which is used in the salt works. This well is mentioned in the detailed report of Jackson, Mason, and Putnam Counties.

Sample No. ...... *Analyst* C. D. Howard
Company Name One of the Salt Companies *Well*
Farm Name Not given
County Mason *District* *Producing Horizon* Salt Sand
Location Hartford City. Does not state which salt works nor well.
**Depth to top of Sand* 1050 *ft.* *Salt water horizon from* 1050 *ft. to* 1200 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 15.5 *Sp. Gr. at given temperature* 1.0732

Analysis in parts per million.

Total solids after evaporation (TS) .... Not Stated

Ammonia (NH_3)	41	*Carbonate (CO_3)*	......
Calcium (Ca)	4580	*Bicarbonate (HCO_3)*	129
Strontium (Sr)	Present	*Sulfate (SO_4)*	......
Barium (Ba)	225	*Chloride (Cl)*	54500
Magnesium (Mg)	4050	*Bromine (Br)*	N.D.
Sodium (Na)	29500	*Iodine (I)*	N.D.
Potassium (K)	218	*Total of determined*	
Lithium (Li)	2	*constituents*	93,245

Remarks:

NH_3 is found in this brine. It is also present in brine at Mason City to-day (1937, Mr. Norman O. Wein) which is a peculiar feature not met elsewhere.

Lithium was determined, but strontium was not.

This analysis taken from p. 338 W. Va. Geol. Survey Report on Iron Ores, Salt, Limestone (1909), made in 1904.

*Taken from same article; is general statement for all wells in this area.

Sample No. 160 *Analyst* Hoskins
Company Name Big Four Drilling Co. *Well*
Farm Name Burdette (Brown Farm) *Farm Well No.* 1
County Roane *District* Curtis *Producing Horizon* Salt
Location Tributary of Peniel Run, 1¼ miles N. W. from Peniel
Depth to top of Sand 1670 *ft.* *Salt water horizon from* 1670 *ft. to* 1728 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 22 *Density at given temperature* 1.0519

Analysis in parts per million.

Total solids after evaporation (TS) 76,100

Iron (Fe)	Tr	*Carbonate (CO_3)*	-----
Calcium (Ca)	4710	*Bicarbonate (HCO_3)*	143
Strontium (Sr)	Present	*Sulfate (SO_4)*	-----
Barium (Ba)	640	*Chloride (Cl)*	45900
Magnesium (Mg)	1055	*Bromine (Br)*	1.5
Sodium (Na)	21980	*Iodine (I)*	6.1
Potassium (K)	416	*Total of determined constituents*	74,852

Remarks: A curious feature is that the Iodine is four times the Bromine; it also has rather large amount of Barium.
Drilled 58 feet in the sand. Hole full of water.

Sample No. 82 *Analyst* Hoskins
Company Name Godfrey L. Cabot, Inc. *Well—Company No.* 828
Farm Name Plus R. Levi *Farm Well No.* 1
County Kanawha *District* Malden *Producing Horizon* Salt
Location Along hill north of road between Malden and Heskett
Depth to top of Sand 645 *ft.* *Salt water horizon from* 720 *ft. to* 910 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 28 *Density at given temperature* 1.0491

Analysis in parts per million.

Total solids after evaporation (TS) 74,700

Iron (Fe)	1.2	*Carbonate (CO_3)*	-----
Calcium (Ca)	5140	*Bicarbonate (HCO_3)*	209
Strontium (Sr)	147	*Sulfate (SO_4)*	5.8
Barium (Ba)	764	*Chloride (Cl)*	44400
Magnesium (Mg)	1248	*Bromine (Br)*	343
Sodium (Na)	20250	*Iodine (I)*	1.3
Potassium (K)	230	*Total of determined constituents*	72,739

Sample No. 48 *Analyst* Hoskins
Company Name Virginian Gasoline & Oil Co. *Well—Company No.* 4592
Farm Name Brown, Goshorn, Swan and Geary
County Clay *District* Henry *Producing Horizon* Salt
Location Summers Fork, 1 mile west from Ovapa P. O.
Depth to top of Sand 1145 *ft.* *Salt water horizon from* 1200 *ft. to* 1230 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 30 *Density at given temperature* 1.0028

Analysis in parts per million.

Total solids after evaporation (TS) 9,170

Iron (Fe)	0.3	*Carbonate (CO_3)*	......
Calcium (Ca)	31	*Bicarbonate (CHO_3)* ..	1534
Strontium (Sr)	3.1	*Sulfate (SO_4)*	8.2
Barium (Ba)	6	*Chloride (Cl)*	4750
Magnesium (Mg)	39	*Bromine (Br)*	18
Sodium (Na)	3510	*Iodine (I)*	Tr
Potassium (K)	70	*Total of determined constituents*	9,969

Remarks: The pecularity of this sample is the high Bicarbonate, yet it is an average sample as to density.

Sample No. 104 *Analyst* McCue
Company Name Kanawha Gas & Utilities Co. *Well—Company No.* 202
Farm Name Geo. A. Black
County Lincoln *District* Carroll *Producing Horizon* Salt
Location Trace Creek, 4 miles N. E. of Hamlin
Depth to top of Sand 1190 *ft.* *Salt water horizon from* 1215 *ft. to* 1220 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 30 *Density at given temperature* 1.0256

Analysis in parts per million.

Total solids after evaporation (TS) 42,800

Iron (Fe)	3	*Carbonate (CO_3)*	......
Calcium (Ca)	1569	*Bicarbonate (HCO_3)* ..	127
Strontium (Sr)	35	*Sulfate (SO_4)*	21
Barium (Ba)	38	*Chloride (Cl)*	26170
Magnesium (Mg)	474	*Bromine (Br)*	146
Sodium (Na)	14200	*Iodine (I)*	0.39
Potassium (K)	249	*Total of determined constituents*	43,032

Remarks: The pecularity of this sample is that the Barium and Strontium are almost equal.

Hole full of water from 1st Sand when 2nd was encountered.

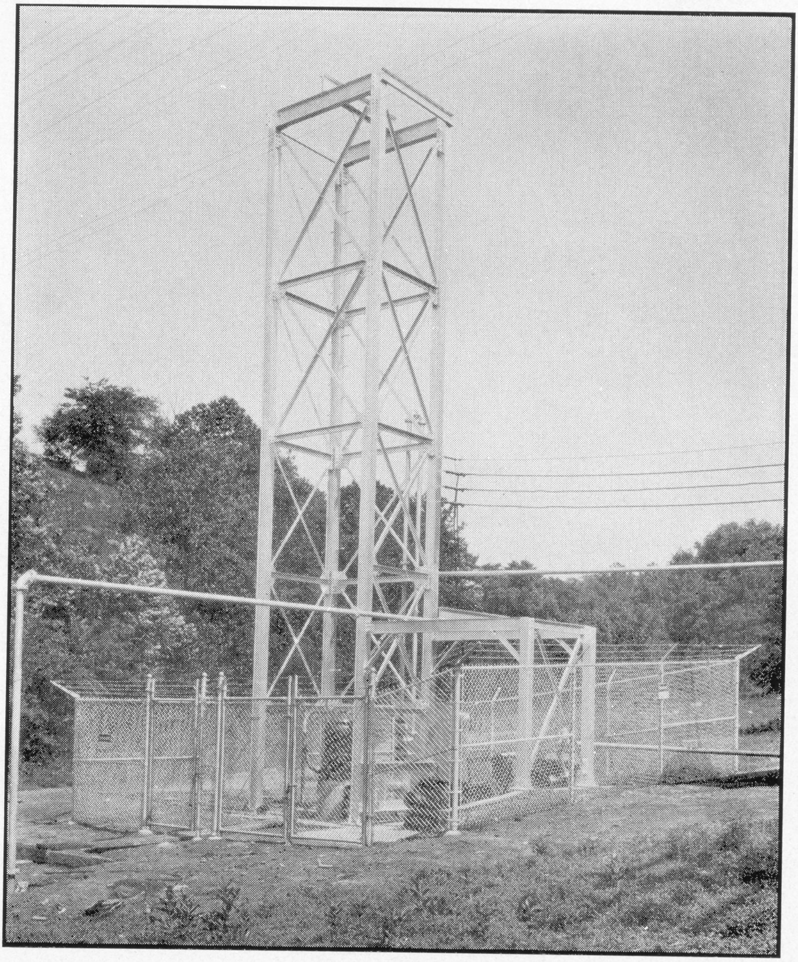


PLATE XXI.—Modern Brine Well, Westvaco Chlorine Products Co., Charleston, W. Va.—This well is pumped with an electric motor-driven deep well turbine.—Photo by Bollinger.—By courtesy of E. T. Crawford, Jr.

Sample No. 170 *Analyst* Hoskins
Company Name Ceredo Gas & Dev. Co. *Well*
Farm Name J. H. & H. J. Stark *Farm Well No.* 1
County Wayne *District* Ceredo *Producing Horizon* Salt
Location Twelvepole Creek, ½ mile east from Ceredo
Depth to top of Sand 764 *ft.* *Salt water horizon from* 770 *ft. to* 930. *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 25 *Density at given temperature* 1.0401

Analysis in parts per million.

Total solids after evaporation (TS) 61,200

Iron (Fe)	Tr	*Carbonate (CO_3)*	.....
Calcium (Ca)	3290	*Bicarbonate (HCO_3)*	94
Strontium (Sr)	115	*Sulfate (SO_4)*	Tr
Barium (Ba)	158	*Chloride (Cl)*	37500
Magnesium (Mg)	947	*Bromine (Br)*	144
Sodium (Na)	18630	*Iodine (I)*	1
Potassium (K)	150	*Total of determined constituents*	61,029

Sample No. 115 *Analyst* McCue
Company Name Boone County Coal Corp. *Well—Company No.* "D"
Farm Name Boone County Coal Corp.
County Logan *District* Logan *Producing Horizon* Salt
Location 2nd Branch to right of Rockhouse Creek, ¾ mile N. W. from Mifflin

Depth to top of Sand 1010 *ft.* *Salt water horizon from* 1255 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 28 *Density at given temperature* 1.1145

Analysis in parts per million.

Total solids after evaporation (TS) 159,600

Iron (Fe)	60	*Carbonate (CO_3)*	.....
Calcium (Ca)	15600	*Bicarbonate (HCO_3)*	30
Strontium (Sr)	447	*Sulfate (SO_4)*	4.9
Barium (Ba)	347	*Chloride (Cl)*	100400
Magnesium (Mg)	3900	*Bromine (Br)*	670
Sodium (Na)	39500	*Iodine (I)*	1.1
Potassium (K)	244	*Total of determined constituents*	161,204

Remarks: Note that Strontium and Barium are almost equal amounts. Did not increase level of 1047—just filled up faster.

Sample No. 2 *Analyst* McCue
Company Name Owens, Libbey-Owens Gas Dept. *Well—Company No.* 376
Farm Name Peytona Coal Land Co.
County Boone *District* Sherman *Producing Horizon* Salt
Location On Three Fork of Sandlick Creek of Laurel Fork
Depth to top of Sand 1455 *ft.* *Salt water horizon from* 1725 *ft. to* 1744 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 22 *Density at given temperature* 1.1083

Analysis in parts per million.

Total solids after evaporation (TS) 148,000

Iron (Fe)	30	*Carbonate (CO_3)*	------
Calcium (Ca)	12470	*Bicarbonate (HCO_3)*	10
Strontium (Sr)	248	*Sulfate (SO_4)*	744
Barium (Ba)	397	*Chloride (Cl)*	89200
Magnesium (Mg)	2236	*Bromine (Br)*	812
Sodium (Na)	39500	*Iodine (I)*	3
Potassium (K)	281	*Total of determined constituents*	145,931

Remarks: An odd feature of this brine is that the sulfate is quite high in spite of large amounts of Barium and Strontium.

Sample No. 51 *Analyst* Hoskins
Company Name Hope Construction & Refining Co. *Well—Company No.* 983
Farm Name Olive Ellifritt
County Doddridge *District* Central *Producing Horizon* Maxtom
Location Gun Run, 1 mile S. from Greenwood
Depth to top of Sand 1897 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.0154

Analysis in parts per million.

Total solids after evaporation (TS) 29,500

Iron (Fe)	120	*Carbonate (CO_3)*	------
Calcium (Ca)	1042	*Bicarbonate (HCO_3)*	12
Strontium (Sr)	195	*Sulfate (SO_4)*	------
Barium (Ba)	66	*Chloride (Cl)*	17820
Magnesium (Mg)	283	*Bromine (Br)*	49
Sodium (Na)	9580	*Iodine (I)*	0.39
Potassium (K)	61	*Total of determined constituents*	29,228

Sample No. 183 *Analyst* McCue
Company Name Leeton & Flanagan *Well*
Farm Name E. G. Morehead *Farm Well No.* 1
County Wood *District* Walker *Producing Horizon* Maxton
Location 12 miles from Cairo
Depth to top of Sand 1746 *ft.* *Salt water horizon from* 1776 *ft. to* 1780 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 22 *Density at given temperature* 1.0707

Analysis in parts per million.

Total solids after evaporation (TS) 99,900

Iron (Fe)	15	*Carbonate (CO_3)*	------
Calcium (Ca)	6000	*Bicarbonate (HCO_3)*	289
Strontium (Sr)	160	*Sulfate (SO_4)*	5
Barium (Ba)	499	*Chloride (Cl)*	60600
Magnesium (Mg)	1656	*Bromine (Br)*	336
Sodium (Na)	29200	*Iodine (I)*	3
Potassium (K)	159	*Total of determined constituents*	98,922

Sample No. 153
Company Name Hill & Kuhn
Farm Name G. B. Rosson
County Ritchie *District* Grant
Location Gillespie Run, 7 miles S. W. Cairo
Depth to top of Sand 1400 *ft.*

Analyst Hoskins
Well
Farm Well No. 2
Producing Horizon Maxton
Salt water horizon from 1460 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 25 *Density at given temperature* 1.0740

Analysis in parts per million.

Total solids after evaporation (TS) 104,900

Iron (Fe)	17	*Carbonate (CO_3)*	......
Calcium (Ca)	7240	*Bicarbonate (HCO_3)*	64
Strontium (Sr)	155	*Sulfate (SO_4)*	6.6
Barium (Ba)	1126	*Chloride (Cl)*	63500
Magnesium (Mg)	1500	*Bromine (Br)*	559
Sodium (Na)	29600	*Iodine (I)*	7.5
Potassium (K)	282	*Total of determined constituents*	104,057

Remarks: This sample contains very large amount of Barium.
Rate of brine flow, 60 gallons per hour.

Sample No. 60
Company Name McCall Drilling Co.
Farm Name Wigner & Craddock
County Gilmer *District* DeKalb
Location Tanner Creek, 1½ miles East from White Pine
Depth to top of Sand 1760 *ft.*

Analyst McCue
Well—Company No. 97
Farm Well No. 2
Producing Horizon Maxton
Salt water horizon from 1775 *ft. to* 1800 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 25 *Density at given temperature* 1.0432

Analysis in parts per million.

Total solids after evaporation (TS) 65,700

Iron (Fe)	18	*Carbonate (CO_3)*	......
Calcium (Ca)	4240	*Bicarbonate (HCO_3)*	402
Strontium (Sr)	182	*Sulfate (SO_4)*	10
Barium (Ba)	255	*Chloride (Cl)*	39200
Magnesium (Mg)	896	*Bromine (Br)*	172
Sodium (Na)	18770	*Iodine (I)*	4
Potassium (K)	209	*Total of determined constituents*	64,358

Sample No. 187 *Analyst* Hoskins
Company Name Hope Natural Gas Co. *Well—Company No.* 6005
Farm Name H. I. Allman
County Gilmer *District* Troy *Producing Horizon* Maxton
Location Pike Fork of Camp Creek, 2 miles W. of Coxs Mills
Depth to top of Sand 1710 *ft.* *Salt water horizon from* 1710 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 28½ *Density at given temperature* 1.0115

Analysis in parts per million.

Total solids after evaporation (TS) 21,550

Iron (Fe)	275	*Carbonate (CO_3)*	.....
Calcium (Ca)	740	*Bicarbonate (HCO_3)*	Acid
Strontium (Sr)	31	*Sulfate (SO_4)*	.....
Barium (Ba)	24	*Chloride (Cl)*	12990
Magnesium (Mg)	205	*Bromine (Br)*	49
Sodium (Na) } *Potassium (K)* }	7000	*Iodine (I)*	4
		Total of determined constituents	21,318

Remarks: Na and K were determined as Na. This well produces gas.

Sample No. 21 *Analyst* McCure
Company Name Boone County Coal Corp. *Well—Company No.* "E"
Farm Name Boone County Coal Corp.
County Boone *District* Washington *Producing Horizon* Maxton
Location Rockhouse Creek of Spruce Fork, 1¼ miles N. W. of Mifflin
Depth to top of Sand 1950 *ft.* *Salt water horizon from* 1955 *ft. to* 1965 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 28 *Density at given temperature* 1.1211

Analysis in parts per million.

Total solids after evaporation (TS) 167,000

Iron (Fe)	45	*Carbonate (CO_3)*	.....
Calcium (Ca)	18200	*Bicarbonate (HCO_3)*	61
Strontium (Sr)	444	*Sulfate (SO_4)*	23
Barium (Ba)	84	*Chloride (Cl)*	102600
Magnesium (Mg)	4800	*Bromine (Br)*	642
Sodium (Na)	36400	*Iodine (I)*	7
Potassium (K)	189	*Total of determined constituents*	163,495

Sample No. 91 *Analyst* Hoskins
Company Name Owens, Libbey-Owens Gas Dept. *Well—Company No.* 433
Farm Name L. A. Christy *Farm Well No.* 2
County Kanawha *District* Loudon *Producing Horizon* Big Lime
Location Kanawha River, 4½ miles S. E. from Charleston
Depth to top of Sand 1030 *ft.* *Salt water horizon from* 1136 *ft. to* 1200 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 26 *Density at given temperature* 1.0621

Analysis in parts per million.

Total solids after evaporation (TS) 90,800

Iron (Fe)	Tr	*Carbonate (CO_3)*	.....
Calcium (Ca)	5620	*Bicarbonate (HCO_3)*	147
Strontium (Sr)	393	*Sulfate (SO_4)*	219
Barium (Ba)	.....	*Chloride (Cl)*	54800
Magnesium (Mg)	1585	*Bromine (Br)*	283
Sodium (Na)	26000	*Iodine (I)*	7.5
Potassium (K)	245	*Total of determined constituents*	89,300

Remarks: 1136′—300 gal. per hr. 1153′—hole full to 550′; 1182′—hole full to 360′.

Sample No. 136 *Analyst* Hoskins
Company Name Philadelphia Oil Co. *Well—Company No.* 5407
Farm Name J. J. Moore
County Monongalia *District* Clay *Producing Horizon* Big Injun
Location Days Run, 4 miles N. from Fairview
Depth to top of Sand 2230 *ft.* *Salt water horizon from* 2342 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 25 *Density at given temperature* 1.1381

Analysis in parts per million.

Total solids after evaporation (TS) 182,100

Iron (Fe)	9	*Carbonate (CO_3)*	......
Calcium (Ca)	15540	*Bicarbonate (HCO_3)*	29
Strontium (Sr)	207	*Sulfate (SO_4)*	85
Barium (Ba)	......	*Chloride (Cl)*	112600
Magnesium (Mg)	2670	*Bromine (Br)*	842
Sodium (Na)	50300	*Iodine (I)*	40
Potassium (K)	367	*Total of determined constituents*	182,689

Sample No. 185 *Analyst* Hoskins
Company Name W. H. Miller *Well*
Farm Name Myrtle Hadley *Farm Well No.* 1
County Tyler *District* Meade *Producing Horizon* Big Injun
Location Waters of Sancho Crek, 5 miles S. W. of Middlebourne
Depth to top of Sand 1705 *ft.* *Salt water horizon from* 1742 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 28½ *Density at given temperature* 1.0938

Analysis in parts per million.

Total solids after evaporation (TS) 131,300

Iron (Fe)	27	*Carbonate (SO_3)*	......
Calcium (Ca)	10345	*Bicarbonate (HCO_3)*	14
Strontium (Sr)	95	*Sulfate (SO_4)*	145
Barium (Ba)	None	*Chloride (Cl)*	79600
Magnesium (Mg)	1670	*Bromine (Br)*	686
Sodium (Na) / *Potassium (K)*	36800	*Iodine (I)*	11
		Total of determined constituents	129,393

Sample No. 143 *Analyst* Hoskins
Company Name Hope Natural Gas Co. *Well—Company No.* 3896
Farm Name S. C. Hammett
County Pleasants *District* Jefferson *Producing Horizon* Big Injun
Location Sharps Run, 8 miles S. W. from St. Marys
Depth to top of Sand 1595 *ft.* *Salt water horizon from* 1610 *ft. to* 1625 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.0663

Analysis in parts per million.

Total solids after evaporation (TS) 98,900

Iron (Fe)	120	*Carbonate (CO_3)*	......
Calcium (Ca)	6970	*Bicarbonate (HCO_3)*	70
Strontium (Sr)	76	*Sulfate (SO_4)*	83
Barium (Ba)	......	*Chloride (Cl)*	58800
Magnesium (Mg)	1168	*Bromine (Br)*	234
Sodium (Na)	27800	*Iodine (I)*	12
Potassium (K)	296	*Total of determined constituents*	95,629

Sample No. 184 *Analyst* Hoskins
Company Name L. P. Bickel *Well—Company No.* B-1
Farm Name Hendershot Heirs
County Wood *District* Union *Producing Horizon* Big Injun
Location Worthington Creek, 1.6 miles North from Dallison
Depth to top of Sand 1761 *ft.* *Salt water horizon from* 1761 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 30 *Density at given temperature* 1.0765

Analysis in parts per million.

Total solids after evaporation (TS) 110,500

Iron (Fe)	60	*Carbonate (CO_3)*	------
Calcium (Ca)	6120	*Bicarbonate (HCO_3)* ..	61
Strontium (Sr)	178	*Sulfate (SO_4)*	7.8
Barium (Ba)	347	*Chloride (Cl)*	67000
Magnesium (Br)	1898	*Bromine (Br)*	5
Sodium (Na)	32500	*Iodine (I)*	Tr
Potassium (K)	252	*Total of determined constituents*	108,429

Sample No. 63 *Analyst* Hoskins
Company Name Hope Natural Gas Company *Well—Company No.* 5896
Farm Name Porter Maxwell
County Gilmer *District* Troy *Producing Horizon* Big Injun
Location Crane Run of Big Cove, 2½ miles N. E. of Coxs Mills
Depth to top of Sand 2167 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.0348

Analysis in parts per million.

Total solids after evaporation (TS) 51,800

Iron (Fe)	220	*Carbonate (CO_3)*	------
Calcium (Ca)	2770	*Bicarbonate (HCO_3)* ..	23
Strontium (Sr)	103	*Sulfate (SO_4)*	56
Barium (Ba)	------	*Chloride (Cl)*	31600
Magnesium (Mg)	1009	*Bromine (Br)*	242
Sodium (Na)	15250	*Iodine (I)*	6
Potassium (K)	59	*Total of determined constituents*	51,338

Remarks: Well producing gas and tubed with steel pipe which probably accounts for the high iron content.

Sample No. 186 *Analyst* Hoskins
Company Name Hope Natural Gas Co. *Well—Company No.* 4405
Farm Name F. T. Bush
County Gilmer *District* Troy *Producing Horizon* Big Injun
Location Waters of Sinking Creek, 1 mile E. of Newberne
Depth to top of Sand 2021 *ft.* *Salt water horizon from* 2021 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 28½ *Density at given temperature* 1.0172

Analysis in parts per million.

Total solids after evaporation (TS) 29,900

Iron (Fe)	138	*Carbonate (CO_3)*	......
Calcium (Ca)	1515	*Bicarbonate (HCO_3)*	115
Strontium (Sr)	31	*Sulfate (SO_4)*	2.5
Barium (Ba)	9.4	*Chloride (Cl)*	17840
Magnesium (Mg)	287	*Bromine (Br)*	49
Sodium (Na) } *Potassium (K)* }	9200	*Iodine (I)*	2
		Total of determined constituents	29,189

Remarks: This is a gas well that makes very little brine. When not blown off, water rises but 75 ft. in ten months.

Sample No. 32 *Analyst* Hoskins
Company Name Sure Shot Torpedo Co. *Well*
Farm Name Clyde Porter *Farm Well No.* 1
County Cabell *District* Union *Producing Horizon* Big Injun
Location Ohio River, 1.25 miles North from Lesage
Depth to top of Sand 1290 *ft.* *Salt water horizon from* 1290 *ft. to* 1470 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.0729

Analysis in parts per million.

Total solids after evaporation (TS) 109,200

Iron (Fe)	45	*Carbonate (CO_3)*	......
Calcium (Ca)	5460	*Bicarbonate (HCO_3)*	......
Strontium (Sr)	174	*Sulfate (SO_4)*	......
Barium (Ba)	340	*Chloride (Cl)*	63800
Magnesium (Mg)	1688	*Bromine (Br)*	280
Sodium (Na)	31600	*Iodine (I)*	2
Potassium (K)	400	*Total of determined constituents*	103,789

Remarks: Striking feature of this sample is the absence of both bicarbonate and sulfate as well as carbonate.

Sample No. 145 *Analyst* Hoskins
Company Name Sent in by C. E. Krebs, Charleston, W. Va. *Well*
Farm Name Robert L. Morris *Farm Well No.* 1
County Putnam *District* Scott *Producing Horizon* Big Injun
Location Headwaters of Morrison Fork, 2.3 miles N. E. of Scott Depot
Depth to top of Sand 1728 *ft.* *Salt water horizon from* 1728 *ft. to* 1730 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24 *Density at given temperature* 1.1325

Analysis in parts per million.

Total solids after evaporation (TS) 177,700

Iron (Fe)	60	*Carbonate (CO_3)*	-----
Calcium (Ca)	12710	*Bicarbonate (HCO_3)*	-----
Strontium (Sr)	305	*Sulfate (SO_4)*	2.9
Barium (Ba)	294	*Chloride (Cl)*	108400
Magnesium (Mg)	2950	*Bromine (Br)*	927
Sodium (Na)	50200	*Iodine (I)*	5
Potassium (K)	500	*Total of determined constituents*	176,354

Remarks: The Barium in this sample is one tenth the magnesium approximately and note that carbonate and bicarbonate are lacking. This brine is from a well producing gas.

Sample No. 138 *Analyst* Hoskins
Company Name Hope Natural Gas Co. *Well—Company No.* 6847
Farm Name Line Creek Coal Co.
County Nicholas *District* Jefferson *Producing Horizon* Big Injun
Location Waters of Right Fork, 2.4 miles N. from Lockwood
Depth to top of Sand 2570 *ft.* *Salt water horizon from* 2570 *ft. to* 2657 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.1319

Analysis in parts per million.

Total solids after evaporation (TS) 179,900

Iron (Fe)	20	*Carbonate (CO_3)*	-----
Calcium (Ca)	14000	*Bicarbonate (HCO_3)*	78
Strontium (Sr)	1298	*Sulfate (SO_4)*	258
Barium (Ba)	-----	*Chloride (Cl)*	109800
Magnesium (Mg)	4580	*Bromine (Br)*	1060
Sodium (Na)	46100	*Iodine (I)*	15
Potassium (K)	224	*Total of determined constituents*	177,433

Remarks: Note the high bromine and iodine content.

PLATE XXII.—Aerial View of South Charleston Chemical Plants, Looking Down the Kanawha River.—The Carbide & Carbon Chemicals Corporation is building a new plant on cleared area, lower left of picture; its present plant covers the island and part of the mainland between the bridges. Westvaco Chlorine Products plant is on mainland just beyond farthest bridge.—Photo by Bollinger, by courtesy Carbide & Carbon Chemicals Corporation.

Sample No. 108 *Analyst* Hoskins
Company Name Kanawha Gas & Utilities Co. *Well—Company No.* 202
Farm Name Geo. A. Black
County Lincoln *District* Carroll *Producing Horizon* Big Injun
Location Trace Creek, 4 miles N. E. from Hamlin
Depth to top of Sand 1880 *ft.* *Salt water horizon from* 1880 *ft. to* 1882 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 30 *Density at given temperature* 1.0040

Analysis in parts per million.

Total solids after evaporation (TS) 12,500

Iron (Fe)	9	*Carbonate (CO_3)*	......
Calcium (Ca)	576	*Bicarbonate (HCO_3)* ..	317
Strontium (Sr)	6.7	*Sulfate (SO_4)*	353
Barium (Ba)	......	*Chloride (Cl)*	7042
Magnesium (Mg)	158	*Bromine (Br)*	1
Sodium (Na)	3850	*Iodine (I)*	......
Potassium (K)	73	*Total of determined constituents*	12,386

Remarks: Hole full of water, when this water was encountered.

Sample No. 171 *Analyst* McCue
Company Name Ceredo Gas & Development Co. *Well*
Farm Name J. H. & H. J. Stark *Farm Well No.* 1
County Wayne *District* Ceredo *Producing Horizon* Big Injun
Location Twelvepole Creek, ½ mile East from Ceredo
Depth to top of Sand 1026 *ft.* *Salt water horizon from* 1036 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24 *Density at given temperature* 1.0755

Analysis in parts per million.

Total solids after evaporation (TS) 107,600

Iron (Fe)	5.7	*Carbonate (CO_3)*	......
Calcium (Ca)	7300	*Bicarbonate (HCO_3)* ..	39
Strontium (Sr)	445	*Sulfate (SO_4)*	......
Barium (Ba)	265	*Chloride (Cl)*	66600
Magnesium (Mg)	2135	*Bromine (Br)*	334
Sodium (Na)	30400	*Iodine (I)*	0.9
Potassium (K)	356	*Total of determined constituents*	107,880

Sample No. 23 *Analyst* Hoskins
Company Name Hope Natural Gas Compaany *Well—Company No.* 4044
Farm Name Hudson Mick
County Braxton *District* Salt Lick *Producing Horizon* Big Injun
Location Rocky Fork, 4 miles N. E. of Orlando
Depth to top of Sand 2136 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.0851

Analysis in parts per million.

Total solids after evaporation (TS) 118,100

Iron (Fe)	1600	*Carbonate (CO_3)*	......
Calcium (Ca)	9150	*Bicarbonate (HCO_3)* ..	......
Strontium (Sr)	447	*Sulfate (SO_4)*	5.5
Barium (Ba)	......	*Chloride (Cl)*	72500
Magnesium (Mg)	1840	*Bromine (Br)*	369
Sodium (Na)	31500	*Iodine (I)*	11
Potassium (K)	172	*Total of determined constituents*	117,594

Sample No. 57 *Analyst* Hoskins
Company Name Hope Construction & Refg. Co. *Well—Company No.* 104
Farm Name E. M. Jackson
County Doddridge *District* Central *Producing Horizon* Squaw
Location ½ mile W. of Long Run, 8 miles N. W. of West Union
Depth to top of Sand 1938 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 27 *Density at given temperature* 1.0799

Analysis in parts per million.

Total solids after evaporation (TS) 112,500

Iron (Fe)	250	*Carbonate (CO_3)*	......
Calcium (Ca)	8920	*Bicarbonate (HCO_3)* ..	......
Strontium (Sr)	67	*Sulfate (SO_4)*	8.4
Barium (Ba)	......	*Chloride (Cl)*	68700
Magnesium (Mg)	1800	*Bromine (Br)*	695
Sodium (Na)	30700	*Iodine (I)*	9.3
Potassium (K)	344	*Total of determined constituents*	111,494

Sample No. 120 *Analyst* McCue
Company Name Monongahela West Penn Public Service Co.
Farm Name H. T. Lough *Well—Company No.* M-111
County Marion *District* Lincoln *Producing Horizon* Fifth
Location 2½ miles N. E. from Farmington on Gilbow Fork of Bethel Run
Depth to top of Sand 2766 *ft. Salt water horizon from* 2766 *ft. to* 2790 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24 *Density at given temperature* 1.0848

Analysis in parts per million.

Total solids after evaporation (TS) 108,200

Iron (Fe)	N.D.	*Carbonate (CO_3)*	......
Calcium (Ca)	10000	*Bicarbonate (HCO_3)* ..	Acid
Strontium (Sr)	N.D.	*Sulfate (SO_4)*	N.D.
Barium (Ba)	N.D.	*Chloride (Cl)*	70800
Magnesium (Mg)	1800	*Bromine (Br)*	......
Sodium (Na)	31052	*Iodine (I)*	24
Potassium (K)	N.D.	*Total of determined constituents*	113,676

Sample No. 188 *Analyst* Hoskins
Company Name Monongahela West Penn Public Service Co.
Farm Name H. T. Lough *Well—Company No.* M-111
County Marion *District* Lincoln *Producing Horizon* Fifth
Location 2½ miles N. E. of Farmington on Gilbow Fork of Bethel Run
Depth to top of Sand 2766 *ft. Salt water horizon from* *2766 *ft. to* 2790 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 28½ *Density at given temperature* 1.0804

Analysis in parts per million.

Total solids after evaporation (TS) 108,900

Manganese (Mn)	138	*Carbonate (CO_3)*	......
Iron (Fe)	5800	*Bicarbonate (HCO_3)* ..	32
Calcium (Ca)	8340	*Sulfate (SO_3)*	44
Strontium (Sr)	25	*Chloride (Cl)*	69300
Barium (Ba)	Trace	*Bromine (Br)*	......
Magnesium (Mg)	1820	*Iodine (I)*	28
Sodium (Na)	27100	*Total of determined*	
Potassium (K)	160	*constituents*	112,787

Remarks: * It is not known at just what point the brine enters.

This brine presents three peculiarities—it has a very high iron and manganese content, and contains no determinable bromine. This sample was taken from the top of the fluid in the well. See No. 189, from same well.

Sample No. 189 *Analyst* Hoskins
Company Name Monongahela West Penn Public Service Co.
Farm Name H. T. Lough *Well—Company No.* M-111
County Marion *District* Lincoln *Producing Horizon* Fifth
Location 2½ miles N. E. of Farmington on Gilbow Fork of Bethel Run
Depth to top of Sand 2766 *ft. Salt water horizon from* *2766 *ft. to* 2790 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 28½ *Density at given temperature* 1.0874

Detailed Chemical Analysis.

Total solids after evaporation (TS) 113,600

Manganese (Mn)	78	*Carbonate (CO_3)*	......
Iron (Fe)	5780	*Bicarbonate (HCO_3)* ..	257
Calcium (Ca)	8570	*Sulfate (SO_4)*	29
Strontium (Sr)	38	*Chloride (Cl)*	72800
Barium (Ba)	......	*Bromine (Br)*	......
Magnesium (Mg)	1815	*Iodine (I)*	28
Sodium (Na)	29200	*Total of determined*	
Potassium (K)	72	*constituents*	118,667

Remarks: * The place in sand where brine enters is not known. This is thickness of the sand. This sample is the last fluid taken from bottom of the well.

Sample No. 92 *Analyst* Hoskins
Company Name United Carbon Company *Well—Company No.* 147
Farm Name J. A. & M. F. Osborne *Farm Well No.* 15
County Kanawha *District* Big Sandy *Producing Horizon* Oriskany
Location Mudlick Fork of Leatherwood Creek, 3.4 miles S. W. of Clendenin
Depth to top of Sand 5763 *ft.* *Salt water horizon from* 5777 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 25 *Density at given temperature* 1.2097

Analysis in parts per million.

Total solids after evaporation (TS) 267,000

Iron (Fe)	75	*Carbonate* (CO_3)	------
Calcium (Ca)	22600	*Bicarbonate* (HCO_3)	100
Strontium (Sr)	1574	*Sulfate* (SO_4)	68
Barium (Ba)	------	*Chloride (Cl)*	159900
Magnesium (Mg)	2407	*Bromine (Br)*	990
Sodium (Na)	69600	*Iodine (I)*	Tr
Potassium (K)	4850	*Total of determined constituents*	262,164

Remarks: Well is 2⅝ miles up Leatherwood Creek of Elk River.

Sample No. 93 *Analyst* Hoskins
Company Name Godfrey L. Cabot, Inc. *Well—Company No.* 863
Farm Name Wm. B. Tompkins Heirs *Farm Well No.* 8
County Kanawha *District* Malden *Producing Horizon* Oriskany
Location Spring Fork, 3¼ miles S. 40° E. of Malden
Depth to top of Sand 5067 *ft.* *Salt water horizon from* 5086 *ft. to* 5089 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24.5 *Density at given temperature* 1.1776

Analysis in parts per million.

Total solids after evaporation (TS) 240,300

Iron (Fe)	5	*Carbonate* (CO_3)	------
Calcium (Ca)	3920	*Bicarbonate* (HCO_3)	133
Strontium (Sr)	1386	*Sulfate* (SO_4)	113
Barium (Ba)	------	*Chloride (Cl)*	143600
Magnesium (Mg)	479	*Bromine (Br)*	850
Sodium (Na)	85700	*Iodine (I)*	3.4
Potassium (K)	2800	*Total of determined constituents*	238,989

Sample No. 94 *Analyst* McCue
Company Name Owens, Libbey-Owens Gas Dept. *Well—Company No.* 365
Farm Name Caroline Q. Crockett *Farm Well No.* 7
County Kanawha *District* Malden *Producing Horizon* Oriskany
Location 3.1 miles E. of Heskett
Depth to top of Sand 5249 *ft.* *Salt water horizon from* 5249 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 23 *Density at given temperature* 1.1746

Analysis in parts per million.

Total solids after evaporation (TS) 235,100

Iron (Fe)	26	*Carbonate* (CO_3)	------
Calcium (Ca)	4540	*Bicarbonate* (HCO_3)	266
Strontium (Sr)	1331	*Sulfate* (SO_4)	62
Barium (Ba)	20	*Chloride (Cl)*	141400
Magnesium (Mg)	2580	*Bromine (Br)*	1532
Sodium (Na)	81100	*Iodine (I)*	34
Potassium (K)	689	*Total of determined constituents*	233,580

Sample No. 163 *Analyst* Hoskins
Company Name Godfrey L. Cabot, Inc. *Well—Company No.* 879
Farm Name T. F. Smith *Farm Well No.* 1
County Roane *District* Geary *Producing Horizon* Oriskany
Location Left Fork of Big Sandy Creek, 1000 ft. No. 45° E. of Uler
Depth to top of Sand 5972 *ft.* *Salt water horizon from* 5978 *ft. to* .... *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 21 *Density at given temperature* 1.1690

Analysis in parts per million.

Total solids after evaporation (TS) 223,900

Iron (Fe)	40	*Carbonate (CO_3)*	......
Calcium (Ca)	16930	*Bicarbonate (HCO_3)*	34
Strontium (Sr)	N.D.	*Sulfate (SO_4)*	1587
Barium (Ba)	......	*Chloride (Cl)*	135100
Magnesium (Mg)	2097	*Bromine (Br)*	642
Sodium (Na)	63500	*Iodine (I)*	5
Potassium (K)	2820	*Total of determined constituents*	222,755

Sample No. 181 *Analyst* McCue
Company Name Glen W. Roberts *Well—Company No.* 500
Farm Name J. A. & L. R. Roberts *Farm Well No.* 1
County Wirt *District* Spring Creek *Producing Horizon* Oriskany
Location 1 mile N. E. of Burning Springs
Depth to top of Sand 4899 *ft.* *Salt water horizon from* 4901½ *ft. to* 4903½ *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 24 *Density at given temperature* 1.2048

Analysis in parts per million.

Total solids after evaporation (TS) 280,000

Iron (Fe)	100	*Carbonate (CO_3)*	......
Calcium (Ca)	30500	*Bicarbonate (HCO_3)*	113
Strontium (Sr)	881	*Sulfate (SO_4)*	119
Barium (Ba)	172	*Chloride (Cl)*	169200
Magnesium (Mg)	3960	*Bromine (Br)*	1245
Sodium (Na)	65900	*Iodine (I)*	2.7
Potassium (K)	2101	*Total of determined constituents*	274,294

Remarks: Brine flow, 1 barrel per hour.

Sample No. 182 *Analyst* Hoskins
Company Name Glen W. Roberts *Well—Company No.* 500
Farm Name J. A. & L. R. Roberts *Farm Well No.* 1
County Wirt *District* Spring Creek *Producing Horizon* Oriskany
Location 1 mile N. E. of Burning Springs
Depth to top of Sand 4899 *ft.* *Salt water horizon from* 4091½ *ft. to* 4093½ *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 22 *Density at given temperature* 1.2259

Analysis in parts per million.

Total solids after evaporation (TS) 270,000

Iron (Fe)	115	*Carbonate (CO_3)*	......
Calcium (Ca)	27200	*Bicarbonate (HCO_3)*	114
Strontium (Sr)	889	*Sulfate (SO_4)*	101
Barium (Ba)	......	*Chloride (Cl)*	168000
Magnesium (Mg)	4110	*Bromine (Br)*	1550
Sodium (Na)	68100	*Iodine (I)*	. 21
Potassium (K)	3400	*Total of determined constituents*	273,600

Remarks: This sample collected while well was drilling at 4969. No increase in amount of water noted.

Sample No. 22 *Analyst* Hoskins
Company Name Pond Fork Oil & Gas Co. *Well*
Farm Name Cole & Crane *Farm Well No.* 22
County Boone *District* Washington *Producing Horizon* Salina
Location Spruce Fork of Coal River 3½ miles S. of Madison
Depth to top of Sand 4257 *ft.* *Salt water horizon from* 4559 *ft. to* 4566 *ft.*

Detailed Chemical Analysis.

Temperature of sample °C 23 *Density at given temperature* 1.1533

Analysis in parts per million.

Total solids after evaporation (TS) 196,400

Sulphur (S)	1200	*Carbonate (CO_3)*	......
Iron (Fe)	......	*Bicarbonate (HCO_3)*	190
Calcium (Ca)	20470	*Sulfate (SO_4)*	595
Strontium (Sr)	363	*Chloride (Cl)*	122000
Barium (Ba)	700	*Bromine (Br)*	1500
Magnesium (Mg)	4080	*Iodine (I)*	59
Sodium (Na)	48800	*Total of determined*	
Potassium (K)	2100	*constituents*	202,057

Remarks: Well shut down for 4 days, and water was in hole when drilling was resumed.

Sample No. 164 *Analyst* Hoskins
Company Name United Fuel Gas Company *Well—Company No.* 4053
Farm Name J. W. Heinzman
County Roane *District* Curtis *Producing Horizon* Ohio Clinton Wh. Medina
Location Frozencamp Creek, 3 miles S. E. of Antioch Church
Depth to top of Sand 7040 *ft.* *Salt water horizon from* 7135 *ft. to* ....*ft.*

Detailed Chemical Analysis.

Temperature of sample °*C* 31 *Density at given temperature* 1.1498

Analysis in parts per million.

Total solids after evaporation (TS) 200,300

Iron (Fe)	32	*Carbonate (CO_3)*	......
Calcium (Ca)	20190	*Bicarbonate (HCO_3)*	Acid
Strontium (Sr)	544	*Sulfate (SO_4)*	355
Barium (Ba)	124	*Chloride (Cl)*	122000
Magnesium (Mg)	1627	*Bromine (Br)*	1000
Sodium (Na)	52400	*Iodine (I)*	40
Potassium (K)	1009	*Total of determined constituents*	199,321

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PLATE XXIII.—Aerial View of South Charleston, Looking up the Kanawha River. —Westvaco Chlorine Production plant in foreground; Carbide & Carbon Chemicals Corporation plant just beyond and on island. Famous Indian Mound at right, in circle. —Photo by courtesy Carbide & Carbon Chemicals Corporation.

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NOTE: The figures in parentheses throughout this report refer to the figures above.

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