TEST OF A 25 H. P. TYPE "E" SMITH ANTHRACITE SUCTION GAS PRODUCER

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A THESIS

PRESENTED BY

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INTRODUCTION.

The accuracy of a test on a gas producer depends largely upon the duration of the test. The conditions in the producer, especially in a producer of the type tested, are constantly varying and difficult to control, so that accurate results cannot be obtained on short-period tests. An experiment of this nature must be of such duration that the errors arising from the irregularities inherent in the operation become negligible. It is hoped that the tests herein described will meet this requirement.

The writers are indebted to Professor H. McCormack and Mr. E. W. McMullen of the Chemical Engineering Department for the chemical analyses herein given. They are under obligation also to the instructors of the Mechanical Engineering Department for advice on the method of procedure, and to several fellow students for assistance in operation.

Object of the Tests.

The suction gas producer burning anthracite coal of the finer grades is thought to be well adapted for use in the field of small isolated power plants. That it is not being adopted more readily as a source of power is due to a great extent to the lack of impartial data on the efficiency, reliability, and cost of operation of this class of machine. The object of these tests is two-fold: to become familiar with the action of a suction gas producer of small size under continuous operation, and to obtain reliable data on the efficiency and reliability of such a producer. Two tests were made, of thirty-six and seventy-two hours' duration respectively, with the same kind of fuel, but under different conditions of operation.

THEORETICAL DISCUSSION

Simple Carbon Monoxide Producer.

In its simplest form, the gas producer consists of a closed retort in which carbon is burned in a limited supply of oxygen. Fig. 1 shows such a producer. Air enters at the base of the producer, passes

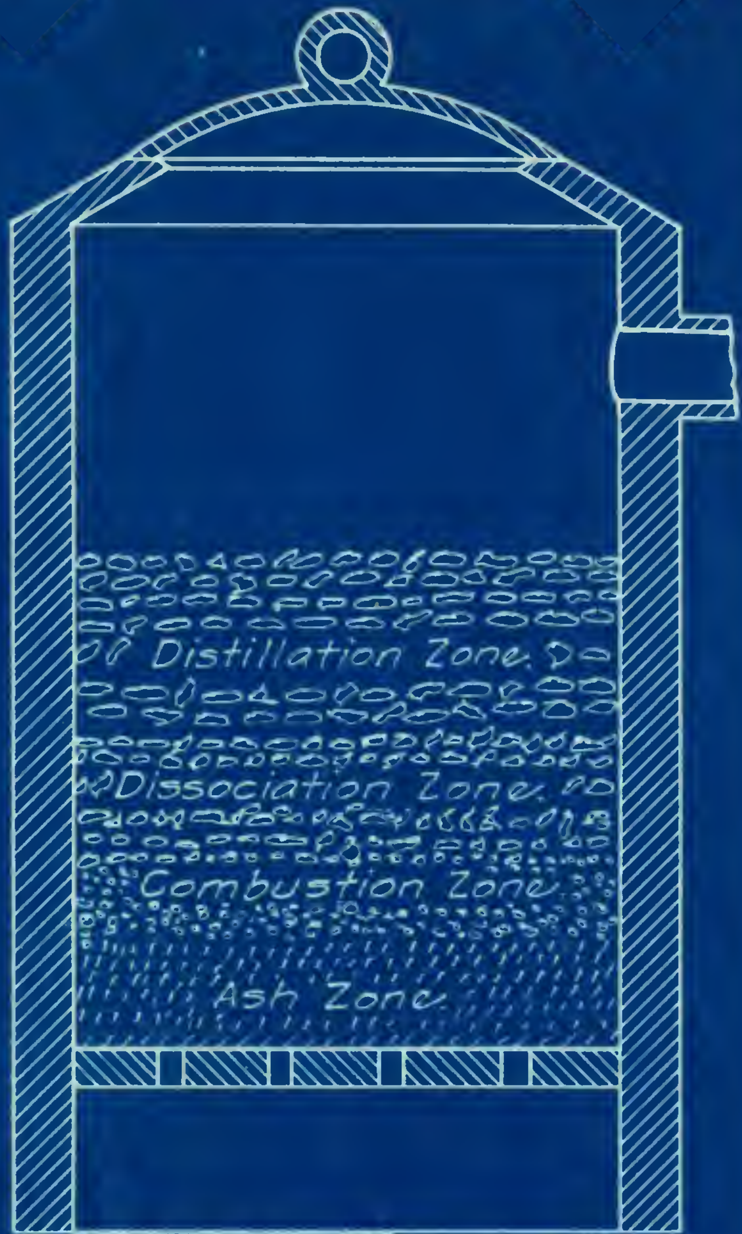

Fig. 1.

SIMPLE CARBON MONOXIDE
GAS PRODUCER.

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up through the ash zone and into the fuel bed. Here the oxygen of the air unites with the incandescent carbon to form carbon dioxide, as represented by the equation

$$C + O_2 = CO_2 \qquad (1)$$

This reaction is exothermic; i. e., it gives out heat. For every pound of carbon burned to CO_2 14,540 B. t. u. are liberated.

The carbon dioxide thus formed, in passing up through the incandescent fuel bed, begins to take up more carbon, and forms carbon monoxide, thus:

$$CO_2 + C = 2CO \qquad (2)$$

This reaction is reversible, the direction in which it takes place depending upon the temperature.

Reaction (2) is endothermic; i. e., it absorbs heat. For every pound of carbon used to form the monoxide, 10,100 B. t. u. are absorbed. This 10,100 B. t. u. is given up in the combustion of CO.

To sum up the interchange of heat in the formation of carbon monoxide:

1 lb. C burned to CO_2 evolves	14,540 B. t. u.
1 lb. C burned to CO evolves	4,440 B. t. u.
Available heat in the gas	10,100 B. t. u.

The theoretical efficiency of the carbon monoxide producer is thus shown to be

$$\frac{10,100}{14,540} \qquad 69.5\%$$

The remaining 30.5% is lost in radiation, conduction, and in the sensible heat leaving the producer.

Conditions in the Actual Producer.

Owing to this high heat loss, the simple carbon monoxide producer is now obsolete. In the commercial producer this heat loss is greatly reduced by using the available heat in the decomposition of some other agent, either water vapor or carbon monoxide. In the producer using water vapor, a mixture of steam and air is introduced at the base. In passing up through the incandescent fuel bed, the vapor is decomposed, according to either of the following reactions.

$$2H_2O + C = 2H_2 + CO \qquad (3)$$

$$H_2O + C = H_2 + CO \qquad (4)$$

It is considered that reaction (3) occurs in the regions of comparatively low temperature; i. e., between 1000° and 1600° F. Above 1600° F. reaction (4) predominates. The steam introduced in the producer thus not only adds a combustible con-

stituent to the gas formed, but also serves to eliminate many of the difficulties met with in the operation of the producer.

The formation of producer gas in the actual producer probably takes place in the following manner: The mixture of steam and air, comparatively cool, enters at the ash pit and passes up into the fuel bed, cooling down in its passage the first layer of fuel, termed the combustion zone. Here reactions (1) and (3) are considered to take place, part of the oxygen from the air uniting with the carbon to form CO_2, while part of the vapor decomposes into CO_2 and H_2. The CO_2 thus formed passes up into the hotter portions of the fuel bed and takes up more carbon, forming CO, according to reaction (2). The water vapor which has not been decomposed, and the oxygen which has not been combined in the combustion zone now pass up into the hotter decomposition zone, where the oxygen is converted into CO by reactions (1) and (2), and the moisture into CO by reaction (4).

The gas leaving the decomposition zone is thus seen to consist of H_2, CO, CO_2, and small quantities

of O_2. As this hot gas passes through the comparatively cool fuel in the distillation zone, it drives off and mixes with some of the volatile matter from the coal. In the case of anthracite coal, this volatile matter consists of small quantities H_2, H_2O, CH_4, C_2H_4, and condensible by hydrocarbons in the form of tar. Where bituminous coal is used, the volatile matter might form a large portion of the heating value of the gas.

There are many factors which influence the respective rates and extent of each of the reactions discussed. High temperatures in the producer tend toward the formation of CO and H_2.. A deep fuel bed usually yields a gas low in H_2 and high in CO, while a shallow fuel bed tends to produce a gas low in CO but high in CO_2 and H_2.

APPARATUS

The Producer

The producer used in these tests was manufactured by the Smith Gas Power Co., of Lexington, Ohio, and is known as their 25 H. P. Type "E" Suction Gas Producer. Fig. 2 shows a vertical section

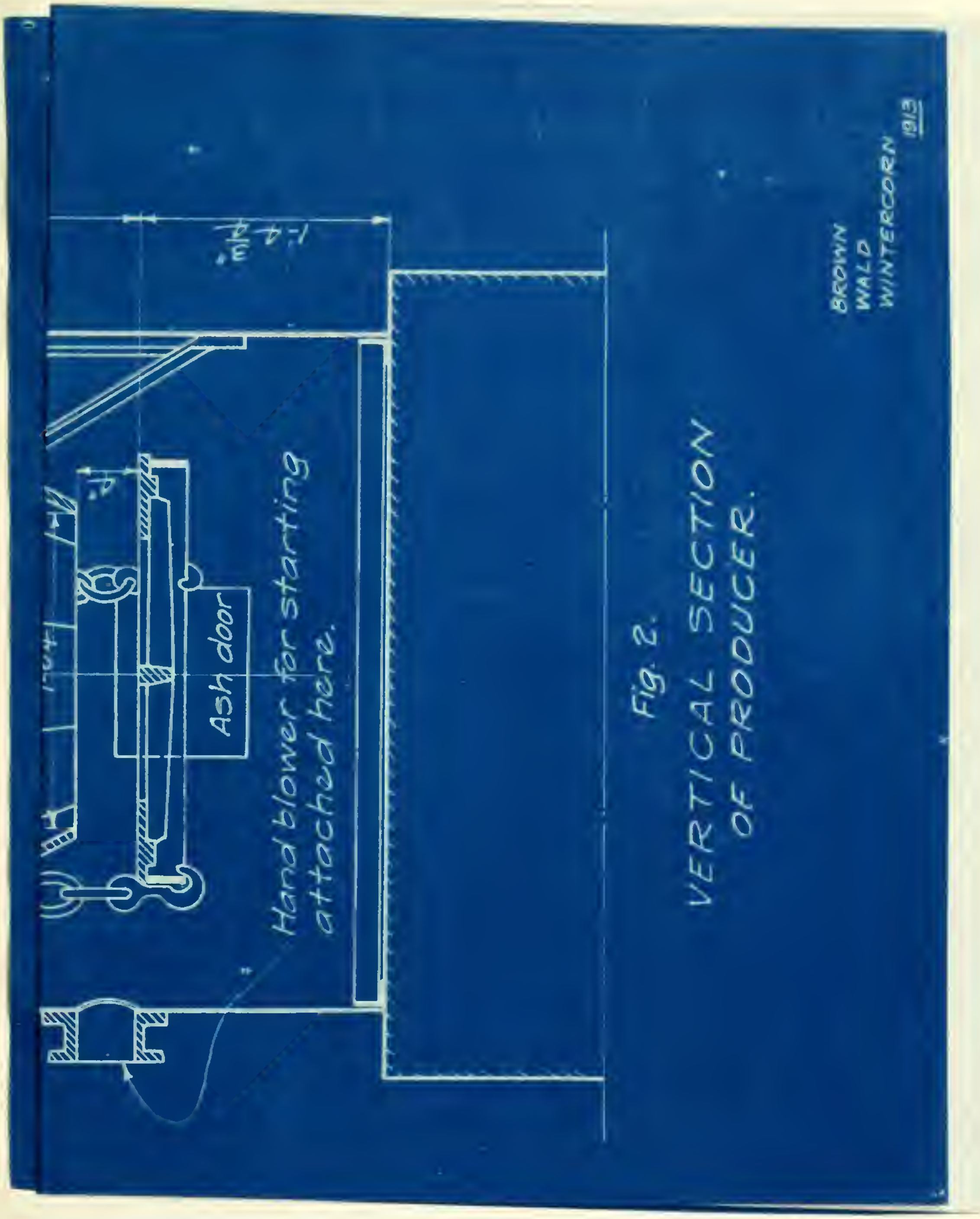

Fig. 2.
VERTICAL SECTION OF PRODUCER.

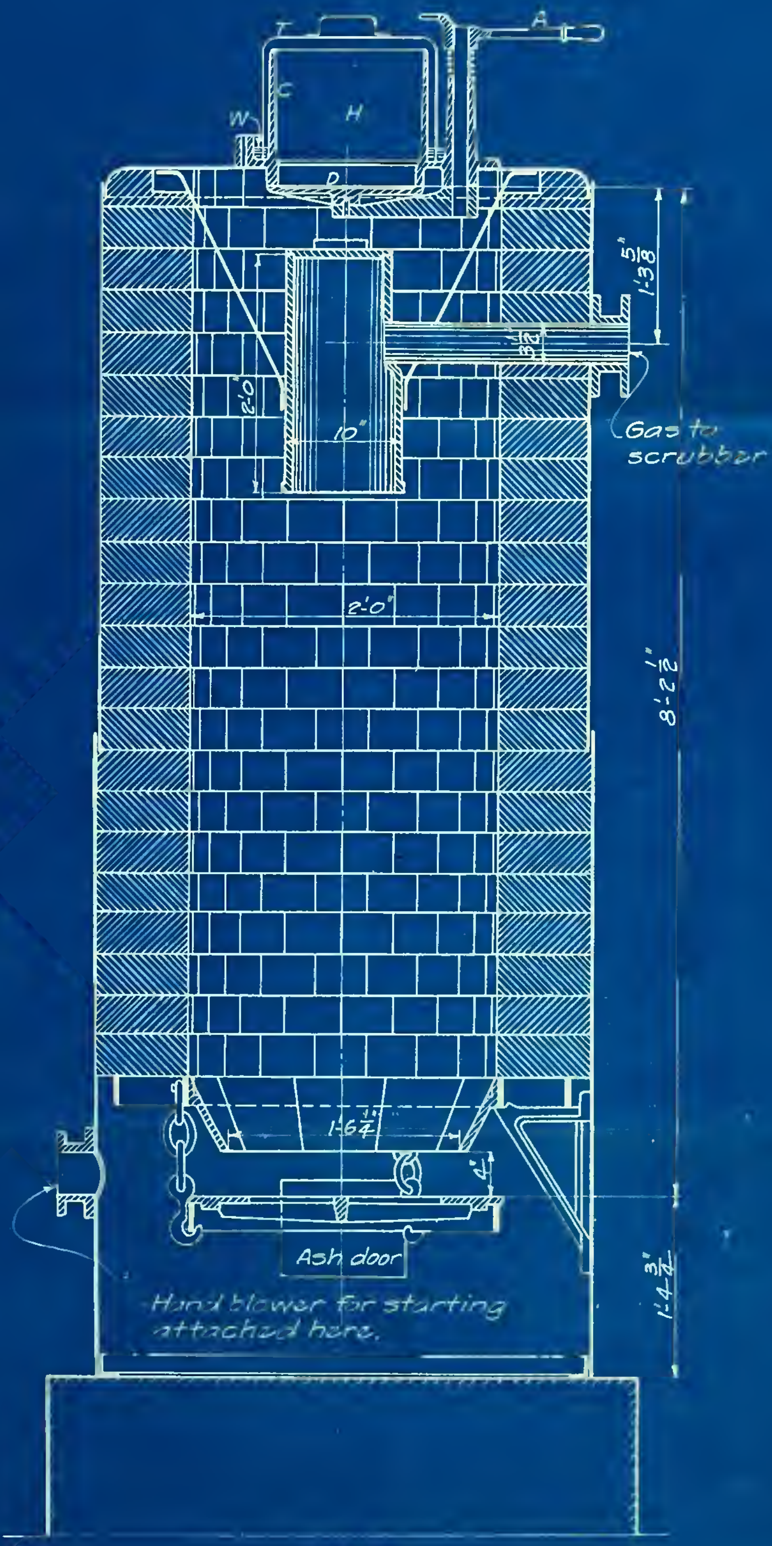

Fig. 2.

VERTICAL SECTION OF PRODUCER.

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through the producer, with the principal dimensions indicated.

The producer consists of steel shell lined with fire brick. The fuel is supported by a flat, shaking grate, which is suspended by chains from the steel ring supporting the brick lining. The charging hopper H (Fig. 2) is designed with special attention to keeping the producer air-tight at all times. It consists of a hollow cylinder C, about 16 in. in diameter and 14 in. deep, which is closed at the bottom by the circular door D. This door is pivoted at O, and can be slid across either side of the opening by means of the arm A. A tin cover T fits around the hopper, and dips into the water-seal W, thus effectually insuring the producer against leakage of air from above.

The Plant.

The complete installation for generating the gas and testing is shown in Fig. 3. The generating equipment consists of the producer A, the wet scrubber B, the dry scrubber C, and the water regulator G.

The wet scrubber is a device for cleaning and cooling the gas, and consists of a pipe fitted with

GENERAL DRAWING

OF

GAS PRODUCER INSTALLATION.

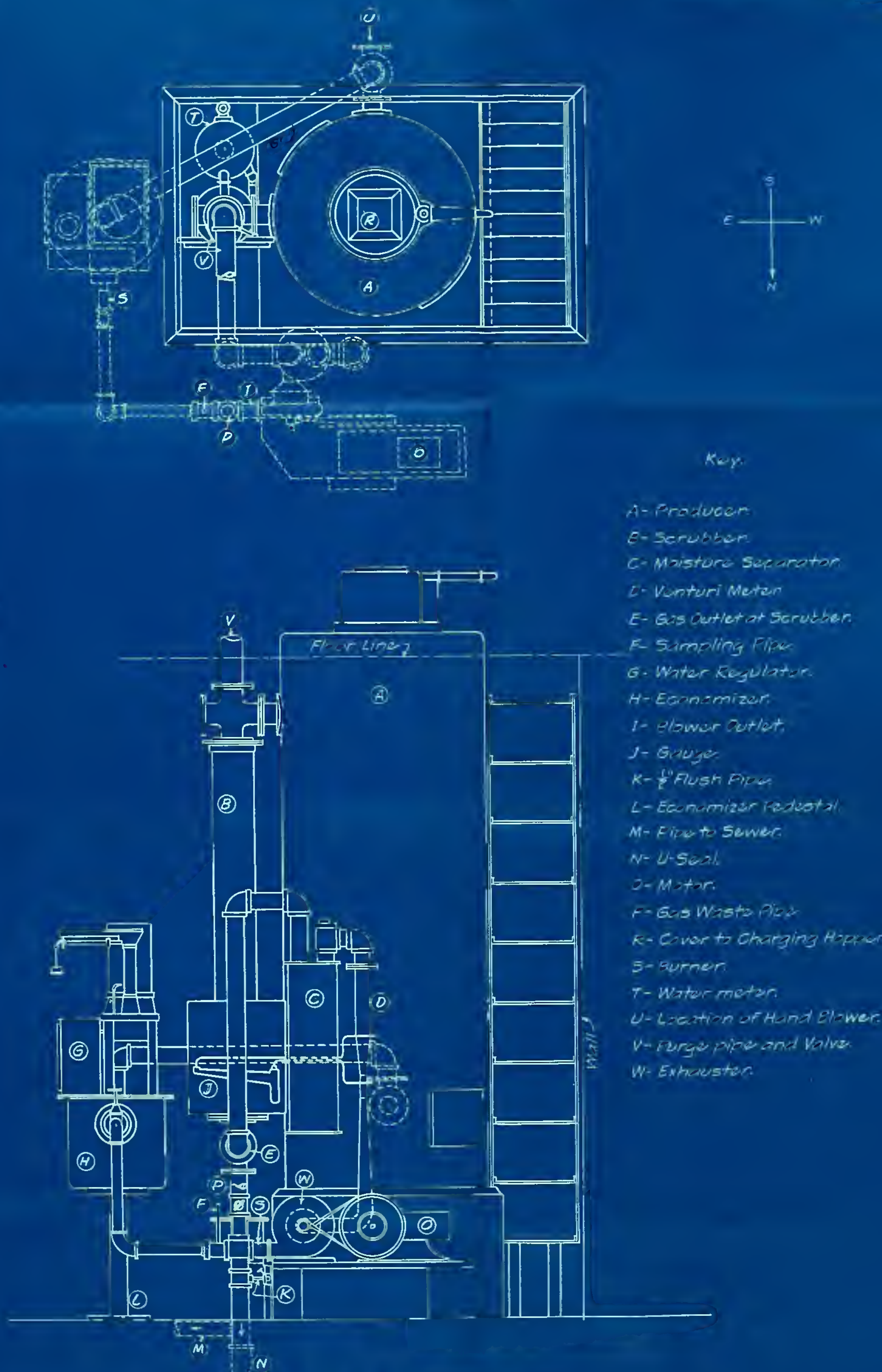

Fig. 3.

INSTALLATION OF SMITH SUCTION GAS PRODUCER.

baffles over which water is sprinkled. The gas is drawn through the scrubber; and, in winding its way through the baffles, comes into contact with the water, and is thus cleaned.

The dry scrubber or moisture separator is a steel tank of sufficient cross-sectional area to decrease the velocity of the gas to the point where the entrapped water particles drop out. The water is then drained off. In order to insure thorough cleaning of the gas, the writers placed a series of baffles of wire gauze and excelsior in this pipe.

The water regulator is a vital part of the generating equipment, and deserves special mention. Fig. 4 shows the regulator together the economizer, or heater, for vaporizing the water and preheating the air introduced into the producer. A portion of the producer gas generated was piped to the heater and burned in a torch at A. The hot gases from this flame encircle the interior of the heater B, and heat in their passage the thin, flat disks C, through which the air and steam pass. The gases, considerably cooled, finally pass out to the atmosphere at D. Where the producer is connected to an

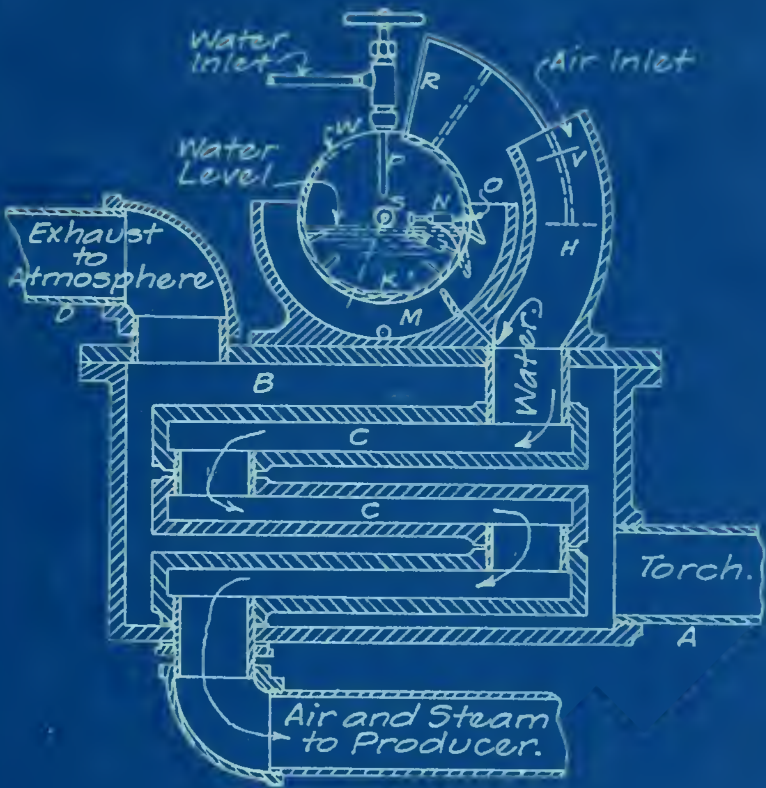

Fig. 4.

SMITH WATER REGULATOR.

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engine the exhaust gases are used in place of the torch.

The regulator consists of a weighing vessel W pivoted upon a shaft S. The rod R connects the vane G with this vessel. The water enters the container W through the inlet valve E and pipe P. N is a small needle valve by means of which the amount of water flowing through the orifice O can be regulated. If more water is supplied to W than can pass out through O, the excess is drained off to M by an opening not shown in the figure, and passes out through the drain M. K is a counter weight to aid in bringing W back into position. The operation is as follows:

The suction in the producer causes a rush of air through H, and a consequent deflection of the vane G to the position indicated by the dotted lines. This allows the water to flow out through the orifice O. This water is swept down to the hot disks C and is vaporized and usually superheated. If an engine is coupled to the producer, the vane is deflected with every suction stroke of the engine, and is brought back to the original position by means of the counterweight.

The suction was produced by a small exhauster

operated by a $\frac{1}{2}$ H. P. variable speed motor. The producer is equipped with a hand blower for starting, but its use was not found necessary in the tests. When the producer is run with an engine, however, this blower is indispensable.

Testing Apparatus.

The testing apparatus consisted of a Venturi meter for determining the volume of gas generated, a water meter for measuring the water supplied the scrubber, platform scales for weighing the water supplied the regulator and the ash removed from and the coal fed the producer, a Junker gas calorimeter, a gasometer, and thermometers for measuring the various temperatures, as explained below.

The Venturi meter used for measuring the gas is 3 in. in diameter upstream and 1 in. in diameter at the throat. The upstream taper is 3 in. to 1 ft., and the downstream taper is 1 in. to 1 ft. The total length of the meter is 2 ft. 9 in. All parts except the throat are made of heavy tin with soldered joints. The throat is of brass, accurately turned to a diameter of 1 in. Four leads to draft gauges

are tapped both at the throat and upstream. It was thought that a number of openings such as those used would eliminate errors due to current disturbances. In order to keep these leads free from any soot and tar that might collect at the throat, a number of holes for cleaning were tapped in the tubes. These holes were kept closed with suitable screws and washers.

The water supplied the scrubber was measured by a 1½ in. Empire disk meter. The temperatures of the inlet and outlet water were obtained.

The weight of water vaporized was measured by weighing both the water supplied the regulator and the overflow. As the mixture of air and steam left the coils of the heater, it was swept through the lagged pipe G′ (Fig. 3) to the ash pit. The temperature of the mixture was indicated by a 400° thermometer placed at the elbow of this pipe just at the entrance to the producer.

The blower drew the gas from the producer through the wet scrubber, the moisture separator, the Venturi meter, and discharged it into the pipe I (Fig. 3). The temperature of the gas was measured

just as the gas issued from the wet scrubber, and again after it had passed through the Venturi meter.

After passing through the blower, the gas was discharged into the horizontal pipe I, as noted above. From this pipe a portion of the gas was discharged to waste, part to the gasometer and Junker calorimeter, and the remainder was utilized at the heater to vaporize the water supplied the producer.

The waste pipe was placed near the outlet of the blower, and rose vertically to within about 2 ft. of the ceiling and then passed through the window and continued upward about 2 ft. to the free air. This pipe was at first equipped with a butterfly valve for regulating the amount of gas supplied the burner. The regulation of the flame at the burner proved to be highly important, and this valve was not sufficient for this purpose. A gate valve was put in its place for the second test, and this proved satisfactory.

The sampling pipe was screwed into the supply main about 5 in. beyond the waste pipe. In order to give sufficient velocity to the gas, an elbow was screwed to the end of the pipe inside the supply,

and was turned upstream. This pipe had a lead for the continuous sample at the gasometer, and another for a Bunson burner, and finally ended at the Junker gas calorimeter. It was 3/8 in. in diameter and about 60 ft. long, and had 5 right angle bends before it terminated at the calorimeter.

That portion of the gas which was not discharged to waste or used in sampling was burned at the heater below the water regulator, and served to vaporize the water fed the producer. It was burned in a long, torch-like flame that impinged against the coils of the vaporizer. A valve at the nozzle of the burner served to regulate the amount of gas burned.

Calibration of Apparatus.

In calibrating the Venturi meter an effort was made to duplicate in the calibration as far as possible the conditions in the test. A large gas meter which had previously been calibrated and had been found correct to within 1%, was connected to the outlet of the exhauster. The waste ~~in~~ and sampling pipes were then closed, and the blower was started. It

maintained a uniform flow of air through the meter, and thus greatly simplified the calibration. This calibration was made after the tests had been run, with the conditions of flow exactly similar to those of the gas in the tests. .

Five runs of 15 minutes duration each were made and the head between the upstream and throat of the venturi was varied for each run. The temperatures of the inlet and outlet air, the barometer reading, and the relative humidity were obtained. The quantity of air delivered was calculated from the equation

$$Q = CA\sqrt{2g(h_1-h_2)};$$

where C is a coefficient determined by experiment,

A is the area at the throat in sq. ft.,

$h_1 - h_2$ is the head in feet of air.

Q is the volume of gas in cu. ft. per sec.

The following results were obtained:

No. run	Head in in. water	Vol. del. cu. ft./hr.	Coef. C.
1	1.5	1524-	0.938
2	2.55	1988	0.938
3	4.75	2816	0.940
4	8.17	3684	0.992
5	9.85	4136	0.994

The coefficient C was obtained by comparing the calculated values of the volume delivered with the meter readings. The calibration curve was plotted with the square root of the head in ins. water as abscissa, so as to obtain a straight line.

The water meter was calibrated before and after testing by passing water through it into weighing tanks, and comparing the volumes read on the meter with the true calculated volumes. The meter used was old, and showed a slip of 11.5% before the tests and 13.75% after the tests. The slip in a meter is a variable error; but, for this purpose, it is sufficiently accurate to take the mean of the two results as the error in the meter during the tests.

Thermometers.

All the thermometers used at the producer were calibrated at several temperatures against a standard thermometer. They were found practically correct. The thermometers used on the inlet and outlet water at the Junker gas calorimeter were calibrated against each other, and were found to read very nearly the same.

METHOD OF TESTING.

Building up the Fire Bed.

The fire was built by igniting a layer of kindling which had been placed upon the grate, and, when this had well begun to burn, by adding a layer of coke. The coke was allowed to become incandescent before any coal was added. As the fire increased in strength, coal was gradually added until a bed of the desired depth was reached. Gas was obtained in each case about an hour after the fire was built, but it took as long as twelve hours to build up the bed to the proper depth. The exhauster was used from the very beginning, and this greatly accelerated the process.

Before the gas became rich enough to burn, it was found necessary to use a jet of illuminating gas to vaporize the water introduced into the scrubber. This jet was maintained throughout the tests, for the gas generated was not of uniform strength, and became sometimes too weak to burn well, or again, came with such pressure that the flame blew out.

Starting and Closing the Tests.

After the fuel bed had been built up to the desired depth, and conditions in the generator had become somewhat uniform, the work of preparing the producer for the test was begun. The fire was thoroughly cleaned, the ash shaken down, and the clinkers broken up and removed. The ash pit was then quickly cleaned of the refuse. As this process usually lowered the level of the fuel bed, enough green coal was added to bring the level up to the original height. The producer was then ready for the test.

The tests were closed in a similar manner. The fuel bed was thoroughly cleaned of ash and clinkers, and green fuel was added to make the depth of the fuel bed the same as at the beginning of the test. The ash was then quickly removed and weighed. This method of starting and closing a test is strongly to be advocated, for it eliminates the errors frequently made in determining the amount of fuel gasified.

Conditions in the Tests.

A diffcrent set of conditions was maintained in each of the tests; and it is partly the purpose of this thesis to ascertain which set of conditions is the more favorable for operation with this type of producer. In the first test the fuel bed was maintained about 4 ft. high, which is comparatively shallow, and the exhauster was run at a low speed. These two factors, a shallow fuel bed and a low suction, make the conditions of operation definite. In the second test the fuel bed was kept 8 ft. deep and the blower was operated at a very much higher speed. An effort was made to keep each set of conditions constant throughout the tests.

Observations.

The following observations were taken every half hour:

Venturi meter reading.

Water meter reading.

Temperature of water entering scrubber.

Temperature of water leaving scrubber.

Temperature of gas leaving scrubber.

Temperature of gas leaving Venturi meter.

Temperature of mixture of air and vapor at ashpit.

The weights of coal fired and ash removed were recorded whenever a quantity was added or removed. Besides these items, analyses of the heat value of the gas were made with the Junker calorimeter at frequent intervals, and determinations were frequently made of the rate at which water was supplied the regulator.

Sampling Coal, Ash, and Gas.

Great care was taken to secure average samples of coal, ash, and gas. The coal and ash were sampled in the same way. A sample was taken from each charge and put aside. At the end of the run the entire quantity was thoroughly mixed and quartered, and a quarter was placed in a jar for analysis. This was again thoroughly mixed and ground, and was then given to the Chemical Department to be analyzed.

A continuous sample of gas was collected in a gasometer. The sample for the first test was allowed to run about twelve hours, and that for the second test about eighteen hours. Inasmuch as the gas was running freely through the sampling pipe all this time, the samples obtained might well be considered representative of the gas generated.

The calorific value of the gas was determined at frequent intervals with the Junker calorimeter. The analysis of the continuous sample was considered the more accurate, however, and the heat value figured from this was used in calculating the results.

An attempt to obtain hourly analyses of the gas for the constituents CO_2, CO, and O_2 was made with the Hayes apparatus. The magnitude of the constituents, however, was beyond the capacity of the instrument, and the attempt had to be abandoned.

The Coal.

The coal used in the tests was a pea-sized anthracite. It had a high percentage of ash and a low heat value. It gave the following results on analysis:

Moisture	Ash	B. t. u.
1.10%	18.65%	10,188

Although the producer was designed for this grade of coal, yet the coal gave considerable trouble. It had a tendency to clinker and to form arches. (See notes on operation). The pea-sized coal is too small for the type of grate with which the producer

is equipped, and a great deal of the coal dropped through unburned to the ash pit.

The Ash.

Owing to the presence of large quantities of coal in the ash, difficulty was encountered in getting an average sample. The ash that was obtained was of a grayish color, with evidence of clinker. In the first test the ash ran 8366 B. t. u., and in the second, 6041 B. t. u.

The Gas.

Two samples of gas were taken from the gasometer for analysis. The analyses are given below:

Composition of Gas by Volume.

Constituent.	Per cent.			
	Test #1.		Test #2.	
	Sample 1.	Sample 2.	Sample 1.	Sample 2.
CO_2	2.9	2.8	2.6	2.2.
Illuminants.	0.2	0.2	0.2	0.4
O_2	2.0	2.0	1.4	2.2
CO	16.6	16.2	24.0	23.8
H	8.1	6.6	1.3	2.0
CH_4	0.4	0.4	3.0	2.2
N_2	69.8	71.8	67.5	67.4
B. t. u.	84.7	78.9	115.4	109.0

The gas burned with a clear non-luminous flame. It appeared to be perfectly free from soot and dust. It burned with a steady flame in a Bunsen burner, except when air was introduced at the base of the burner, when the flame at once went out.

Venturi Meter Readings.

The accuracy of the recorded volume of gas generated depends upon the accuracy with which the difference in pressure between the upstream and throat of the Venturi could be read. In the first trial these readings were recorded on a 3-in. Ellison differential gauge. In this test, too, the low suction made it possible to maintain the head on the Venturi practically constant. The 3-in. gauge was too small for use in the second test, and U-gauges had to be substituted. In this test it was a difficult matter to keep the head on the Venturi constant, and this fact may account for the erroneous results obtained. (See Discussion).

Attention is here called to the unusual construction of the U-gauge at the upstream. One of the scales alongside the tube was inverted, as shown in Fig. 5. This will serve to explain the

peculiarity of the upstream readings in the second test.

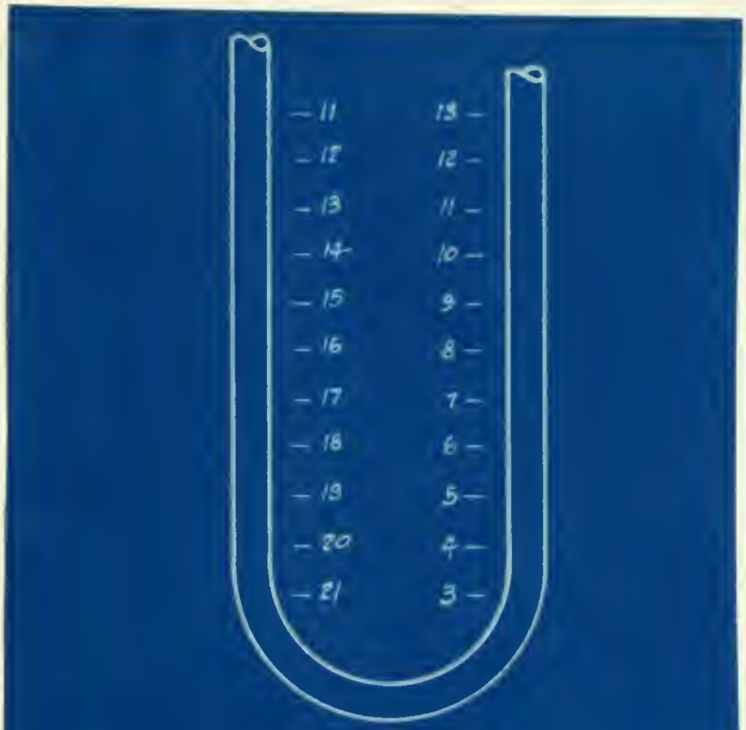


Fig. 5.

SKETCH OF U-GAUGE AT UPSTREAM.

<u>Determination of the Rate of Flow of Water into the Regulator</u>.

The rate at which the economizer was supplying water to the producer was determined very frequently, for it was impossible to keep this quantity constant. Whenever the irregularities in the fuel bed caused a change in the suction, and this

was constantly occuring, the rate of flow of water through the regulator was changed. By determining the rate of flow at frequent intervals, and averaging these determinations, a fairly close average rate couldbe obtained.

A determination was made by weighing both the water supplied the regulator and the overflow for a run of ten or fifteen minutes. The difference between these two weights was the weight vaporized during the time of the observation. The result was recorded in pounds per hour.

Cleaning the Fire.

The formation of a clinker could easily be detected by a weakening of the gas generated, Clinkers were broken up by opening the door of the charging the hopper and slicing the fire with an iron rod from above. This method, of course, admitted a large excess of air and diluted the gas to the point where it would no longer burn. This condition lasted for only a few minutes, however, and invariably good gas was obtained after the fire had been sliced.

RESULTS OF TEST NO. 1.

1. Duration of test in hours............ 36

Average Temperatures, degrees F.

2. Air and vapor entering producer......333
3. Gas leaving scrubber................. 46.4
4. Gas leaving Venturi.................. 73.1
5. Water entering scrubber.............. 34.0
6. Water leaving scrubber............... 37.4

Average Pressures.

7. Barometer, in. mercury............... 29.41
8. Diff. in pressure betw. throat and upstream in Venturi, in.water.. 1.77

Water.

9. Used in vaporizer, lbs. per hr....... 6.04
10. Total weight used in test............217.4
11. Used in vaporizer per lb. of fuel charged in producer........... 0.28
12. Used in wet scrubber, cu. ft........5659.
13. Used in wet scrubber per rated horsepower of producer per hr..... 6.28
14. Used in wet scrubber per 1000 cu. ft. of gas produced........... 91.9

Composition of Fuel by weight.

15. Moisture............................. 1.10%
16. Ash.................................. 18.65%

17.	Calorific value..............	10,188
Composition of Gas by Volume.		
18.	Carbon dioxide (CO_2).........	2.9%
19.	Illuminants..................	0.2
20.	Oxygen (O_2).................	2.0
21.	Carbon Monoxide (CO).........	16.4
22.	Hydrogen (H_2)...............	7.4
23.	Methane (CH_4)................	0.4
24.	Nitrogen (N_2)...............	70.7
25.	Calorific value, B. t. u.....	81.8
Fuel.		
26.	Total fuel charged in producer,lbs.	786.2
27.	Total dry fuel charged in producer.	777.55
28.	Percent of ash in dry fuel.........	18.89
29.	Total ash in fuel, lbs.............	146.9
30.	Total refuse from producer, lbs....	354.05
31.	Total combustible charged in producer, lbs....................	630.65
32.	Total combustible in refuse, lbs...	207.15
33.	Percent of total combustible consumed.........................	67.05
34.	Fuel as fired per hour, lbs........	21.85
35.	Dry fuel per hour, lbs.............	21.6
36.	Combustible per hour, lbs..........	17.51

37. Fuel as fired per sq.ft. of fuel bed area per hour, lbs.............. 6.95

38. Dry fuel per sq. ft. of fuel bed area per hour, lbs.............. 6.88

39. Combustible per sq. ft. of fuel bed area per hour, lbs.............. 5.58

Gas. (Standard at 62°F. and 29.92 in. mercury.)

40. Total cu. ft. produced................61,632

41. Cu. ft. per hour...................... 1,712

42. Cu. ft. per lb. of fuel as fired....... 78.45

43. Cu. ft. per lb. of dry fuel........... 79.45

44. Cu. ft. per lb. of combustible........ 99.1

Heat, B. t. u.

45. Per lb. of fuel as fired..............10,188.

46. Per lb. of dry fuel...................10,300.

47. Per lb. of ash........................ 8,366

48. From fuel as fired per hour...........222,608.

49. From refuse per hour.................. 82,238.

50. Supplied per hour.....................140,370.

51. Per cu. ft. of standard gas 81.8

52. From gas per hour.....................140,042.

Percent Efficiency.

53. Of producer and grate................ 62.95.

54. Of producer.......................... 99.8

Gas Producer Operator's Notes on Test #1.

Time.	Note.
Feb. 20, 11:00 A. M.	Beginning of test; gas too weak to burn at Junker calorimeter.
11:50	Poked fire and added 33.7 lbs. coal.
12:45	Poked fire; all running smoothly; gas still weak.
1:15 P. M.	Sliced fire from above to break up arch; gas becoming weaker.
3:40	Sliced fire.
5:25	Gas still weak.
5:45	Forced fire and opened waste pipe wide; gas becoming richer.
7:00	Closed waste pipe; gas richer and coming with a roar.
9:30	Sliced fire and added 62.5 lbs. coal.
10:00	Change of shift.
Feb. 21, 12:20 A. M.	Fired 100 lbs. coal.
3:00 A. M.	Fired 400 lbs. coal; level of fuel bed above starting level.
3:20	Good gas.
6:00	Gas burning well.
8:30	Change of shift.

Notes on Test #1 Contin'd.

10:50	Gas burning well.
1:30 P. M.	Gas good and burning steadily.
4:00	Fired 131 lbs. of coal.
6:00	All running smoothly; gas burning well.
8:00	Fired 59 lbs. of coal.
8:20	Sliced fire. Gas weakened and then improved.
10:45	Fuel bed at exactly the same level as at beginning of test; gas burning well.
11:00	Test closed; removed 354.05 lbs. of ashes.

Notes on Test #2.

Time.	Note.
Mar. 3, 10:00 P. M.	Beginning of test; gas good.
Mar. 4, 12:30 A. M.	Fired 65.1 lbs. of coal.
3:00	Added 65 lbs. of coal; gas burning well.
5:30	Fired 50 lbs. coal; gas weakening.
8:30	Change of shift; gas growing weaker.
9:00	Broke up arch and clinkers and thoroughly cleaned fire. Added 100 lbs. coal.
12:00	Added 50 lbs. coal and removed 108.4 lbs. ash.
2:00 P. M.	Poked fire and added 100 lbs. coal.
4:30	Sliced fire and added 50 lbs. coal.
5:45	Sliced fire on account of weakening gas; gas improved soon after.
7:00	Fired 50 lbs. coal.
8:15	Fired 100 lbs. coal.
10:00	Change of shift.
Mar. 5, 1:00 A. M.	Sliced fire and added 128 lbs. of coal.
1:30	Gas good.

Notes on Test #2 Contin'd.

Time.	Note.
2:30 A. M.	Gas burning well.
4:10	Sliced fire; gas uniform and good.
5:50	Sliced fire and added 61 lbs. of coal; gas good.
7:20	Broke up arch, and added 59 lbs. coal.
7:30	Gas weakening.
8:30	Change of shift.
10:15	Sliced fire and added 100 lbs. of coal.
12:30 P. M.	Cleaned fire of clinkers.
12:45	Removed 250.8 lbs. ash.
1:30	Fired 350.8 lbs. coal.
2:00	Fired 100 lbs. coal.
4:00	Very good gas.
6:30	Extra fine gas.
9:00	Gas burning well.
10:00	Change of shift.
10:20	Sliced fire and added 133 lbs. coal; gas very good.
Mar.6, 12:30 A. M.	Gas burning well.
2:20	Sliced fire and broke up arch. Fired 200 lbs. coal.

Notes on Test Contin'd.

Time.	Note.
5:40 A. M.	Sliced fire; gas good.
6:30	Sliced fire and added 65 lbs. of coal.
8:30	Change of shift.
9:00	Gas burning well.
9:30	Sliced fire and removed 342.2 lbs. ash. Gas poor.
10:30	Fired 350 lbs. coal.
12:00	Gas burning well.
3:30 P. M.	Gas very good.
6:00	Sliced fire.
6:45	Fired 100 lbs. coal.
8:25	Sliced fire; gas burning well.
10:00	Test closed. Added 225 lbs. coal to bring level of fuel bed to starting point. Removed 408.5 lbs. ashes.

DISCUSSION OF RESULTS.

It is seen from the results obtained that the gas generated in the second test was much richer than that of the first test. This is as might be expected. The deep fuel bed maintained throughout the test was favorable to the formation of CO, which is the most important constituent of producer gas. Considerably more methane, too, was obtained in the second trial, and this greatly added to the calorific value of the gas.

It is peculiar that the hydrogen content of the gas generated in the first test should be so much higher than that of the second, when more water was fed the producer. It is possible that the extremely high suction in this run swept the vapor through the fuel bed before it was broken up.

The writers have not calculated the results of the second test because they are uncertain of the volume of gas generated. This is not due to an incorrect calibration of the Venturi,--the writers have reason to believe that item correct,- but it is due undoubtedly to the high velocity of the gas, and the difficulty experienced in keeping the head

on the Venturi constant. Another source of error might have been the moisture content in the gas. With the gas flowing at the high velocity ~~the high~~ that it did during the test, the dry scrubber probably was unable to perform its function, and the gas may have come through very wet. Although the efficiency in the second run cannotbe obtained, the test is still valuable as a study of the conditions to be maintained in the operation of a producer of this type.

The frequent formation of clinkers which characterized the second test is a serious obstacle in the way of successful operation. It would undoubtedly be more desirable to operate the producer with a high suction and a deep fuel bed; but, under these conditions, the fuel has a greater tendency to clinker and to arch across the bed. With proper care in the operation, however, this difficulty could be lessened, and this set of conditions be maintained.

The efficiency of the producer as obtained in the first test is extremely high. This high value is undoubtedly due to an error in sampling the ash.

CONCLUSION.

The tests herein discussed show a gas producer of the type and size tested to be a practical piece of apparatus, which, with proper attention, can be operated with but little trouble and fairly high efficiency. The investigations carried on, however, were not, and could not well be, of sufficient scope to cover many of the problems incidental with the operation of a gas producer; and reference is here made to the results of a series of tests conducted at the University of Illinois on a producer somewhat larger than, but of a similar type to the one tested. These show:

1. The efficiency of a producer is, within wide limits, practically independent of the rate of gasification.

2. The efficiency of a producer is but little affected by the relative percentages of CO and H_2 in the gas generated.

These results would show the efficiency in each of the tests carried on here to be about the same.

APPENDIX.

Outline of Computations.

Item 1 - 9 (incl.). Observed.

10. Item 9 x item 1 = 6.04 x 36 = 217.4

11. $\frac{\text{Item 11}}{\text{Wt. coal used}} = \frac{217.4}{786.2} = 0.276$

12. Observed.

13. $\frac{\text{Item 12}}{\text{Rated H. P. x item 1}} = \frac{5659}{25 \times 36} = 6.28$

14. $\frac{\text{Item 12 x 1000}}{\text{Vlo. gas generated}} = \frac{5659 \times 1000}{61632} = 91.9$

15. - 24 (incl.) From analysis.

35. Figured from heat values as given in Richards "Metallurgical Calculations".

26. Observed.

27. $\frac{\text{Item 26 x (100-item 15)}}{100} = \frac{786.2\ (100-1.1)}{100}$
$= 777.55$

28. $\frac{\text{100 x item 16}}{\text{100 - item 15}} = \frac{100 \times 18.65}{100 - 1.1} = 18.89$

29. Item 16 x item 26 = 18.65 x 786.2 = 146.9

30. Observed.

31. Item 27 - item 29 = 777.55 - 146.9 = 630.65

32. Item 30 - item 29 = 354.05 - 146.9 = 207.15

33. $\frac{\text{Item 31 - item 32}}{\text{Item 31}}$ x100 = $\frac{630.65 - 207.15}{630.65}$ 100
$= 67.05$

Item 34. $\frac{\text{Item 26}}{\text{Item 1}} = \frac{786.2}{36} = 21.85$

35. $\frac{\text{Item 27}}{\text{Item 1}} = \frac{777.55}{36} = 21.6$

36. $\frac{\text{Item 31}}{\text{Item 1}} = \frac{630.65}{36} = 17.51$

37. $\frac{\text{Item 34}}{\text{Area fuel bed}} = \frac{21.85}{3.14} = 6.95$

38. $\frac{\text{Item 38}}{\text{Area fuel bed}} = \frac{21.6}{3.14} = 6.88$

39. $\frac{\text{Item 36}}{\text{Area fuel bed}} = \frac{17.51}{3.14} = 5.58$

40. Item 41 x 36 = 1712 x 36 = 61,632

41. Observed.

42. $\frac{\text{Item 40}}{\text{Item 26}} = \frac{61632}{786.2} = 78.45$

43. $\frac{\text{Item 40}}{\text{Item 27}} = \frac{61632}{777.55} = 79,45$

44. $\frac{\text{Item 40}}{\text{Item 31}} = \frac{61632}{630,65} = 99.1$

45. From analysis.

46. $\frac{\text{Item 45 x 100}}{\text{100 - item 15}} = \frac{10188 \text{ x } 100}{100 - 1.1} = 10,300$

47. From analysis

48. Item 45 x 34 = 10188 x 21.85 = 222,608

49. $\frac{\text{Item 30 x item 47}}{\text{Item 1}} = \frac{354.05 \text{ x } 8366}{36} = 82,238$

50. Item 48 - item 49 = 222608 - 82238 = 140,370

Item 51. Observed.

52. Item 41 x item 51 = 1712 x 81.8 = 140,042

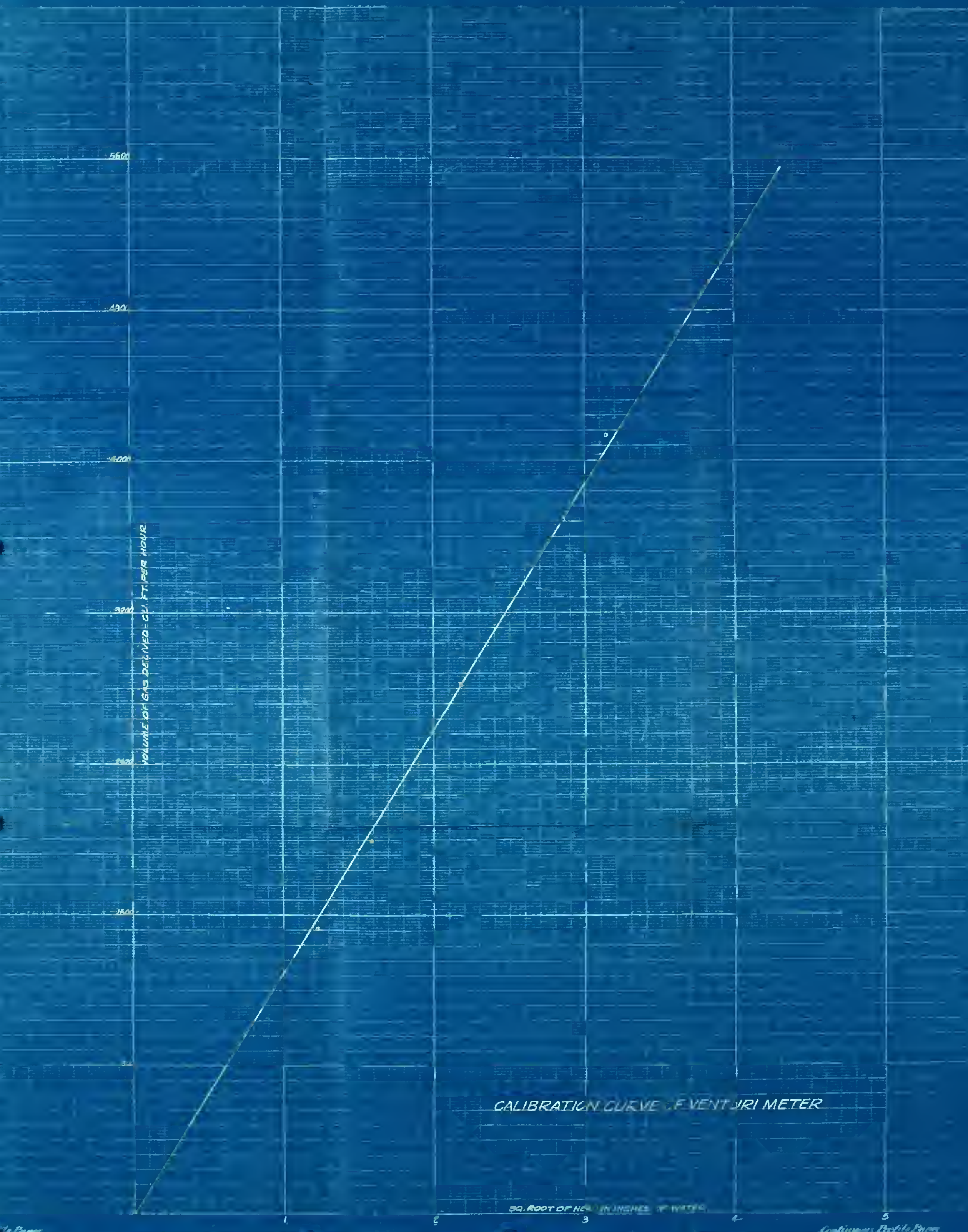
53. $\frac{\text{Item 52}}{\text{Item 48}} \times 100 = \frac{140042}{222608} \times 100 = 62.95$

54. $\frac{\text{Item 52}}{\text{Item 50}} = \frac{140042}{140370} = 99.8$

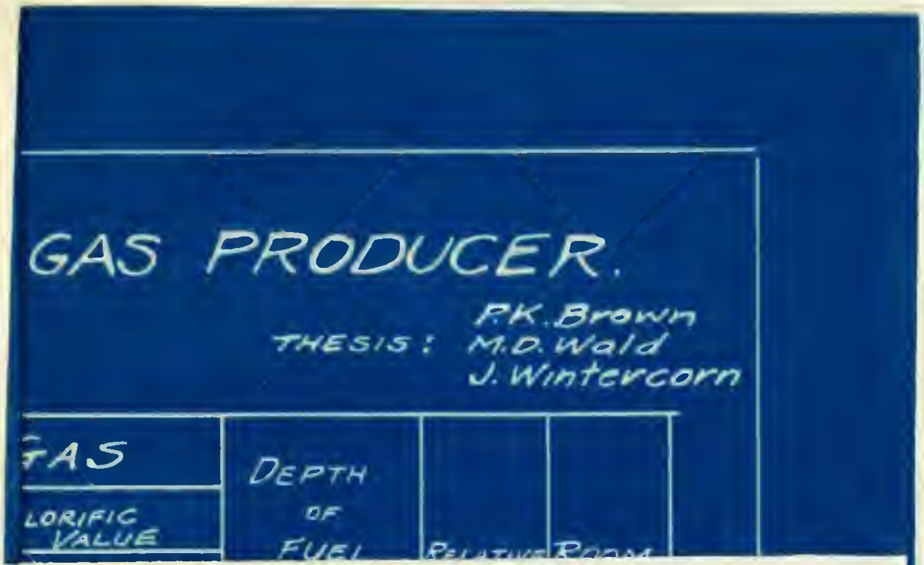
CALIBRATION CURVE

OF

VENTURI METER.



CALIBRATION CURVE OF VENTURI METER
VOLUME OF GAS DELIVED - CU. FT. PER HOUR
5600
4800
4000
3200
1600
1
3
4
5



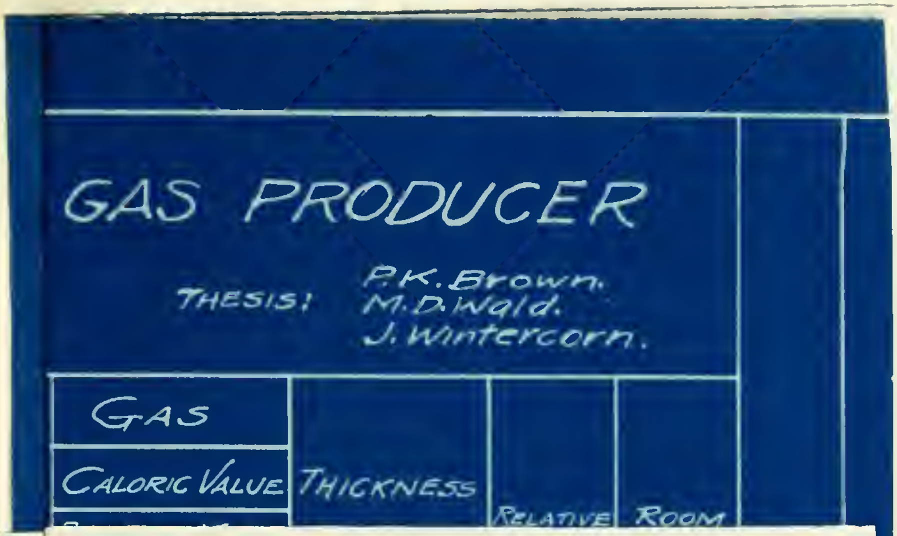
LOG SHEET #1

TEST #1.

TEST OF A 25 H.P. TYPE "E" SMITH SUCTION GAS PRODUCER.

Date Feb. 20 & 21, 1913 TEST #1. THESIS: P.K. Brown, M.D. Wald, J. Wintercorn

TIME Feb. 20-21, 1913.	PRESSURES Bar. Inches of Hg.	PRESSURES Venturi Diff. of Press. in Inches of Water	TEMPERATURES Water Entering Scrubber	TEMPERATURES Water Leaving Scrubber	TEMPERATURES Mixture of Steam and Air at Ash Pit.	TEMPERATURES Gas Leaving Wet Scrubber	TEMPERATURES Gas Leaving Venturi Meter	WEIGHTS Coal Fired	WEIGHTS Ash Removed	WEIGHTS Water Supplied to Regulator	Meter Readings (Water)	Weight of Water Supplied to Scrubber	GAS Calorific Value Determination by Junker	GAS Calorific Value Determination by Chemical Analysis	Depth of Fuel Bed Thickness of Fire	Relitive Humidity	Room Temp.
11:00		.72	34	38	319.5	17	78				28456				4 ft.		58
11:30		.75	34	38	321.0	17	78				28519						58
12:00		.72	34	38	332.0	18	78	33.7*			28588						59
12:30		.72	34	37	350.0	18	78				28657						58
1:00		.72	34	38	355.0	20	80.5				28723						60
1:30		.72	34	38	369.0	20	81				28790						60
2:00			34	No Rea	dings	taken	at this	time.			28857						
2:30		.63	34	37	316.0	17	83				28927						59
3:00		.71	34	38	318.0	18	83				28995						58
3:30		.76	34	38	324.0	19	84.5				29063						59
4:00		.70	34	38	324.0	18	83				29132						58
4:30		.68	34	38	335.0	19	83				29203						39
5:00		.68	34	37	352.0	19	83				29276						60
5:30		.70	34	38	350.0	19	82				29342						59
6:00		1.60	34	38	345.0	17	74				29412						57
6:30		1.80	34	37	344.0	15	75				29486						56
7:00	29.46	1.65	34	37	324.0	14	71			3.60	29557				4 ft.	29.86	55
7:30		1.95	34	37	318.0	19	79			4.68	29630						53
8:00		2.20	34	37	318.0	19	77			2.40	29705						51
8:30		2.33	34	36	314.0	18	76			3.72	29781						51
9:00		1.61	34	36	298.0	17	75				29858						51
9:30		2.85	34	37	284.0	13	69	62.5*			29929						50
10:00		2.05	34	36	274.0	15	71				30010						49
10:30		2.08	34	36	274.0	17	69			3.28	30086						48
11:00		1.88	34	39	281.0	15.5	73				30172		107.7				52
11:30		1.90	34	36	309.0	15	73				30245						50
12:00		1.88	34	38	322.0	16	75				30319						48
12:30		1.90	34	38	326.0	16	75	100*			30392						47
1:00		1.98	34	38	342.0	15	74			8.56	30463						48
1:30		1.95	34	37	368.0	16	72				30537				4 ft.		50
2:00		1.98	34	38	358.0	16	72			3.60	30611						45
2:30		2.04	34	38.5	344.0	14	68				30685						46
3:00		2.01	34	38	363.0	16	73	400*		10.32	30758						45
3:30		2.50	34	38	369.0	40	68				30833						45
4:00		2.50	34	38	338.0	40.5	63				30910						45
4:30		2.30	34	38.5	295.0	41.	63				30983						45



LOG SHEET #2

TEST #1.

TEST OF A 25 H.P. TYPE "E" SMITH SUCTION GAS PRODUCER

TEST #1

②

Date Feb. 20 & 21, 1913.

THESIS: R.K. Brown.
M.D. Wald.
J. Wintercorn.

TIME	PRESSURES		TEMPERATURES					WEIGHTS			METER	WEIGHT OF WATER	GAS		THICKNESS	RELATIVE	ROOM
	BAR.	VENTURI	WATER		MIXTURE OF STEAM AND AIR AT ASH PIT	GAS		COAL	ASH	WATER			CALORIC VALUE DETERMINATION BY				
FEB. 21, 1913.		DIFF. OF PRESSURE IN INCHES OF WATER	ENTERING SCRUBBER	LEAVING SCRUBBER		LEAVING WET SCRUBBER	LEAVING THE VENTURI METER	FIRED	REMOVED	SUPPLIED TO REGULATOR	READINGS (WATER)	SUPPLIED TO SCRUBBER	JUNKER	CHEMICAL ANALYSIS	OF FIRE IN (FEET)	HUMIDITY	TEMP.
5:00		2.40	34	38	305	42	62				31059						45
5:30		2.55	34	38	280	40.5	62				31130				4		44
6:00		2.03	34	38	263	44	68			8.16#	31198						44
6:30		2.01	34	38	314	45	76				31271		145.1				45
7:00	29.41	1.98	34	38	320	45	76				31341						45
7:30		1.93	34	38	318	45	77				31406						45
8:00		1.94	34	38	322	46	77				31466						45
8:30		1.92	34	38	323	45	77				31523						46
9:00		1.92	34	38	312	44.5	78			7.5#/hr.	31592						45
9:30		1.94	34	37	311	44.5	78				31642				4		44.5
10:00		1.93	34	37	308	45	75			6.84#/hr.	31709						44.5
10:30		1.96	34	37	343	45	73				31768						45
11:00		2.05	34	37	353	45	73			9.78#/hr.	31830						45
11:30		2.05	34	37	364	45	73				31904						45
12:00		2.05	34	37	366	44	72			9.00#/hr.	31969						43
12:30		2.04	34	37	359	43	72				32022						43
1:00		2.04	34	38	354	43	72			12.18#/hr.	32085				4		43
1:30		2.02	34	37	352	45	70				32158						42
2:00		2.01	34	37	349	46	71			7.08#/hr.	32218						43
2:30		2.00	34	37	345	45	73				32274						43
3:00		2.00	34	37	378	46	74	131#			32336		92.3				43
3:30		2.00	34	37	348	46	74.5			7.32#/hr.	32401						43
4:00		2.00	34	38	348	46	76				32456						42
4:30		2.00	34	37	351	46	76				32519						42
5:00		2.00	34	37	350	46	80			8.30#/hr.	32586						43
5:30		2.00	34	37	356	46	82				32653						43
6:00		2.01	34	37	357	46.5	82.5				32718						42
6:30		2.02	34	37	362	46.5	82.5			7.32#/hr.	32789						42
7:00	29.07	2.00	34	37	360	46.5	82				32858		89.8		4		42
7:30		2.00	34	38	364	46	82	59#		6.24#/hr.	32941						41
8:00		2.00	34	37	360	46	84				33002						41
8:30		2.00	34	37	356	46	86				33069						41
9:30		2.00	34	37	340	46	85				33210						40.5
10:00		2.00	34	37	340	47	85			6.96#/hr.	33284						40.5
10:30		2.00	34	37	342	47	85				33349		104.8				41.
11:00		2.00	34	37	336	47	85		354.05		33402				4		41.
AVERAGE	29.41	1.77	34	37.4	232	46.4	73.1			6.04			102.2	81.9	4		
TOTAL								786.2	354.05		4946						
CORRECT											5659	352558					

N GAS PRODUCER.

Thesis: P.K. Brown
M.D. Wald.
J. Wintercorn.

ts-Lbs.		Water Supl'd Scrubber		B.T.U. Value of Gas.			
on moved	ater porized per hr.	ter ding- Ft.	eight.	om ker. alysis	om. emical alysis.	elative umidity.	pth of el Bed.

LOG SHEET #1

TEST # 2.

TEST OF A 25 H.P. TYPE "E" SMITH SUCTION GAS PRODUCER.

TEST #2

Date: March 3, 4, 5, & 6, 1913

(1)

Thesis: P.K. Brown, M.D. Wald, J. Wintercorn

Time	Pressures.								Temperatures - °F.					Weights - Lbs.			Water Supl'd Scrubber		B.T.U. Value of Gas.			
March 3-4	Barometer	Venturi Gas Meter - Inches Water. Upstream* Left	Upstream* Right	Upstream* Diff. h_2	Throat Left	Throat Right	Throat Diff. h_1	Head $h_1 - h_2$	Water Entering Scrubber	Water Leaving Scrubber	Gas Leaving Scrubber	Gas Leaving Venturi	Mixture Air & Steam at Ash Pit	Coal Fired	Ash Removed	Water Vaporized Lbs. per hr.	Meter Reading - Cu. Ft.	Weight	From Junker Analysis	From Chemical Analysis	Relative Humidity	Depth of Fuel Bed
10:00 P.M.		-14.00	+14.19	4.19	-3.1	+8.9	12.0	7.81	33	35	40	52.5	308				35214					8
10:30		13.75	13.94	2.69	2.5	8.4	10.9	7.21	33	35	40	52.5	306				272					
11:00		14.13	14.06	4.19	3.5	9.5	13.0	8.81	34	36	41	52	218			12.36	338					
11:30		13.75	14.00	3.75	3.6	9.6	13.2	9.45	34	36	41	52	176				385					
12:00		13.88	14.13	4.01	3.8	10.1	13.9	9.89	33	36	39	53	174	65.1			434		105.5			
12:30 A.M.		13.63	13.75	3.38	3.7	9.7	13.4	9.02	34	36	39	53	182			3.72	483					
1:00		13.5	13.75	3.25	3.6	9.6	13.2	9.95	34	36	37	55	174				532		110.0			8
1:30		13.25	13.5	2.75	3.0	9.0	12.0	9.25	34	36	38	61	153			6.30	588					
2:00		13.13	13.38	2.51	2.8	8.8	11.6	9.09	34	38	40	60	194				634		149.5			
2:30		13.38	13.63	3.01	3.9	10.0	13.9	10.89	34	38	40	59	256			7.38	705					
3:00		13.25	13.5	2.75	3.9	10.1	14.0	11.25	34	38	40	59	246	65.			739		110.1			
3:30		13.13	13.38	2.51	3.8	9.8	13.6	11.09	34	38	39	59	228				805					
4:00		13.0	13.25	2.25	3.3	9.3	12.6	10.35	33	37	39	59	260			9.30	846		152.0			8
4:30		13.0	13.25	2.25	3.1	9.1	12.2	9.95	34	37.5	39	59	188				907					
5:00		12.63	12.75	1.38	1.9	7.8	9.7	8.32	34	38	39	62	178	50			949		132.9			
5:30		12.88	13.13	2.01	3.5	9.5	13.0	10.99	34	37	39	62	176				36003					
6:00		12.88	13.13	2.01	3.1	9.1	12.2	10.19	34	38	39	62	176				049					
6:30		12.5	12.75	1.25	1.0	7.0	8.0	6.75	34	38	39	62	176				105		133.1			
7:00	29.47	12.88	13.25	2.13	2.9	8.9	11.8	9.67	34	39	43	68	182			11.28	138				83	8
7:30		12.75	13.0	1.75	2.9	8.9	11.8	9.85	34	39	39	68	196				176		114.9			
8:00		12.75	13.0	1.75	3.1	9.1	12.2	10.45	34	38	40	68	214				214					
8:30		12.75	13.06	1.81	3.1	9.0	12.2	10.39	34	37.5		64	243				279					
9:00		12.88	13.0	1.88	3.4	9.3	12.7	10.82	33	38		67	240	100			345					
9:30									34				210									8
10:00									34				200			4.68						
10:30									34				190	100					114.0			
11:00									34				185									
11:30									34				183									
12:00									34				250	50	108.4							
12:30 P.M.		18.63	9.0	3.63	3.1	9.0	12.1	8.47	34	36.5		66	354			8.04	765		156.0			8
1:00		18.13	9.69	3.82	2.2	7.8	10.0	6.18	33	36.5	41	66	341				828					
1:30		18.13	9.69	3.82	2.1	7.7	9.8	5.98	34	37	39	65	346				891					
2:00		18.0	8.56	2.56	2.0	7.5	9.5	6.94	33	36.5	39	65.5	345	100		8.0	952		102.0			
2:30		17.88	9.19	3.07	2.1	7.6	9.7	5.63	34	37	39	60	311				37016					
3:00		17.75	9.06	2.81	1.9	7.5	9.4	6.59	33	36	38	60	328				083		138.5			
3:30		17.63	9.06	2.69	2.2	7.3	9.5	6.81	33.5	36	42	63	340				135					8

* See p. 25 for description of gauge.

AS PRODUCER.

P.K. Brown
Thesis: M.D. Wald.
J. Wintercorn.

ts-Lbs.	Water Supl'd Scrubber.	B.T.U. Value of Gas.		

LOG SHEET #2

TEST #2.

TEST OF A 25 H.P. TYPE "E" SMITH SUCTION GAS PRODUCER.

TEST #2

②

Date: March 3, 4, 5, & 6, 1913.

P. K. Brown
Thesis: M. D. Wald.
J. Wintercorn

Time March 4-5	Barometer	Pressures. Venturi Gas Meter-Inches Water. Upstream Left	Upstream Right	Upstream Diff. h_2	Throat. Left	Throat Right	Throat Diff. h_1	Head $h_1 - h_2$	Temperatures-°F. Water Entering Scrubber	Water Leaving Scrubber	Gas. Leaving Scrubber	Gas Leaving Venturi	Mixture Air & Steam at Ash Pit	Weights-Lbs. Coal Fired	Ash Removed	Water Vaporized Lbs. per hr.	Meter Reading Cu. Ft.	Water Supplied Scrubber. Weight	B.T.U. Value of Gas. From Junker Analysis	From Chemical Analysis	Relative Humidity.	Depth of Fuel Bed.
4:00 P.M.		-17.63	+8.88	2.51	-2.4	+7.0	9.4	6.89	33	36	39	63	336			7.74	37191					
4:30		17.63	8.88	2.51	1.5	7.0	8.5	5.99	33	36	38.5	63	321	50			252					
5:00		17.5	8.88	2.38	1.2	6.6	7.8	5.42	33	37	39	64.5	295				330		139.8			
5:30		17.88	9.0	2.88	2.5	7.0	9.5	6.62	33	35.5	42	68.	282				386					
6:00		17.5	9.5	3.0	4.0	10.0	14.0	11.00	33	37	39	66	302				454					8
6:30		17.13	9.13	2.26	2.3	7.9	10.2	7.94	33	36	39	66	324				522		124.9			
7:00	29.56	17.0	9.0	2.0	2.1	7.7	9.8	7.80	33	36	40	66	336	50			591				58	
7:36		17.32	9.32	2.64	3.8	9.7	13.5	10.86	33.5	36.5	43	68	376				673					
8:04		17.25	9.25	2.50	3.8	9.7	13.5	11.00	33	36	41	66	364			8.04	738					
8:30		17.19	9.19	2.38	3.5	9.4	12.9	10.52	33	36	42	67	347	100			798					
9:00		17.13	9.13	2.26	3.5	9.5	13.0	10.74	33	36.5	40	66	327				869					8
9:30		17.32	9.32	2.64	1.6	7.1	8.7	6.06	33	35.5	41	67	311				940					
10:00		17.25	9.38	2.63	1.7	7.3	9.0	6.37	33	36	39	66	296				38002					
10:30		17.19	9.32	2.51	1.2	6.8	8.0	5.49	34	36	41	64	286			5.74	076					
11:00		17.50	9.5	3.00	2.5	8.5	11.0	8.00	34	37	39	66	280				146					
11:30		17.13	9.38	2.51	2.2	8.0	10.2	7.69	34	37.5	40	66	267			7.34	203					
12:00		17.13	9.38	2.51	2.1	7.9	10.0	7.49	34	37.5	40	69	260				252					
12:30 A.M.		17.13	9.25	2.38	2.7	9.0	11.7	9.32	34	36	40	69	260				307					8
1:00		17.13	9.25	2.38	2.0	7.9	9.9	7.52	34	36	40	69	258	128			366					
1:30		17.25	9.38	2.63	2.5	8.4	10.9	8.27	34	36	40	69	251			6.70	417					
2:00		17.19	9.32	2.51	2.4	8.2	10.6	8.09	34	37	40	70	256				477					
2:30		17.13	9.25	2.38	2.5	8.0	10.5	8.22	34	36	40	68	260				530					
3:00		17.13	9.25	2.38	2.4	8.0	10.4	8.02	34	37	40	68	270			7.20	594		110.9			
3:30		17.13	9.25	2.38	2.0	8.0	10.0	7.62	34	37	40	66	272				640					
4:00		17.13	9.25	2.38	2.5	8.0	10.5	8.12	34	37	40	66.5	272			7.74	697					
4:30		17.25	9.38	2.63	3.0	8.9	11.9	9.27	34	36.5	39	66	276				756					8
5:00		17.25	9.38	2.63	2.8	8.9	11.7	9.07	34	37	40	66	280				825		118.8			
5:30		17.25	9.38	2.63	2.9	8.9	11.8	9.17	34	37	40	67	280				907					
6:00		17.13	9.25	2.38	3.0	9.0	12.0	9.62	34	37	40	67	280	61		8.0	971					
6:30		17.13	9.25	2.38	3.1	9.1	12.2	9.82	34	37	40	67	284				39036					
7:00	29.38	17.13	9.19	2.32	3.0	9.0	12.0	9.68	34	37	40	69	290				105				83	
7:30		17.13	9.38	2.51	3.1	9.1	12.2	9.69	34	37	41	75	288	59			160		126.6			
8:00		17.0	9.13	2.13	3.1	9.1	12.2	10.07	34	37	40	75	298				219					
8:30		17.0	9.13	2.13	3.0	9.0	12.0	9.87			41	78	296			7.68	276		142.2			8
9:00		17.0	9.0	2.0	3.1	9.5	12.6	10.60	34	37	49	80	284				345		105.8			
9:30		16.0	8.0	0.	2.1	3.1	6.2	6.20	34	36.5	42	72	278				399					
10:00		17.0	9.0	2.0	2.6	8.5	11.1	9.10	33	36.	40	72	280	100			465					

GAS PRODUCER.

Thesis: P.K. Brown.
M.D. Wald.
J. Wintercorn.

-Lbs.		Water Suppl'd. Scrubber.		B.T.U. Value of Gas.			
	ater porized per hr.	ater ding Ft.	eight.	om ker alysis.	om emical alysis.	Relative umidity.	pth of el Bed.

LOG SHEET #3

TEST #2.

TEST OF A 25 H.P. TYPE "E" SMITH SUCTION GAS PRODUCER.

TEST #2.

Date: March 5,6, 1913

③

P.K. Brown
Thesis: M.D. Wald.
J. Wintercorn.

Time. March 5-6	Pressures. Barometer.	Venturi Gas Meter - Inches Water. Upstream. Left.	Upstream. Right.	Upstream. Diff. h_2	Throat. Left.	Throat. Right.	Throat. Diff. h_1	Head h_1-h_2	Temperatures-°F. Water. Entering Scrubber.	Water. Leaving Scrubber.	Gas. Leaving Scrubber.	Gas. Leaving Venturi.	Mixture Air & Steam at Ash Pit.	Weights-Lbs. Coal Fired.	Ash Removed.	Water Vaporized Lbs. per hr.	Water Supply Scrubber. Meter Reading Cu. Ft.	Weight.	B.T.U. Value of Gas. From Junker Analysis.	From Chemical Analysis.	Relative Humidity.	Depth of Fuel Bed.
10:30AM		-17.13	+9.00	2.13	-2.15	+8.00	10.15	8.02	33.5	36	43	69.5	264				39526		78.4			
11:00		16.75	8.88	1.63	2.10	8.00	10.10	8.47	33	36	48	74.0	241			6.70	594					
11:30		16.75	8.63	1.38	2.55	8.50	11.05	9.67	33	36	42	72.0	232				662					8
12:00		16.75	8.75	1.50	3.50	9.80	13.30	11.80	33.5	36	41	750	220				730					
12:30PM		16.88	8.88	1.76	3.10	9.20	12.30	10.54	33.5	36.5	42	80	246				795					
1:00		16.63	8.63	1.26	4.90	12.00	16.90	15.64	33	37	46	90	245		250.8		856					
1:30		17.13	9.13	2.26	2.00	8.40	10.40	8.14	33	37	46.5	90	290	350			929		123.9			
2:00		17.0	9.00	2.00	1.10	7.80	8.90	6.90	33.8	37.5	46.5	85	304	100			989					
2:30		18.5	10.38	3.88	4.70	11.20	15.90	12.02	33	37	40	70	305				40069					
3:00		17.88	9.88	3.76	3.20	9.30	12.50	8.74	33.5	37	44	72	340			7.20	130					
3:30		17.88	9.88	3.76	3.30	9.40	12.70	8.94	33	37	44	71	364				197		100.0			
4:00		17.88	9.88	3.76	3.15	9.15	12.30	8.54	33.5	37	41	70	370			5.28	267					
4:30		17.88	9.88	3.76	3.30	9.40	12.70	8.74	34.0	37	38	68	367				332					8
5:00		17.88	9.88	3.76	3.40	9.40	12.80	9.04	33	36	40	70	385			7.20	404					
5:30		17.88	9.88	3.76	3.40	9.40	12.80	9.04	33	36	40	69	392				471		163.1			
6:00		17.88	9.88	3.76	3.20	9.10	12.30	8.54	33.5	36	41.5	70	391				539					
6:30		17.88	9.88	3.76	3.20	9.10	12.30	8.54	33	37	40	68	371			11.61	611					
7:00	29.38	17.88	9.88	3.76	3.30	9.20	12.50	8.74	33.5	36	42.5	67	370				682				83	
7:30		17.75	9.63	3.38	3.60	9.50	13.10	9.72	33	37	40	66	365				746		132.1			
8:00		17.88	9.88	3.76	3.40	9.30	12.70	8.94	33	35	36	68	373			11.70	824					
8:30		17.88	9.88	3.76	3.50	9.50	13.00	9.24	33	36	41	66	376				888					
9:00		17.75	9.75	3.50	3.20	9.00	12.20	8.70	33	36	40	66	377				950					
9:30		17.75	9.63	3.38	3.30	9.20	12.50	9.12	33	36	39	66	378				41028					
10:00		17.63	9.75	3.38	3.30	9.30	12.60	9.22	33	36	39	66	372				115					
10:30		17.63	9.75	3.38	3.60	9.60	13.20	9.82	33	36	40	66	356	133			188					8
11:00		17.63	9.63	3.26	3.40	9.40	12.80	9.54	34	36	40	65	348			3.64	264					
11:30		17.63	9.63	3.26	3.80	10.00	13.80	10.67	34	36	40	65	360				343					
12:00		17.50	9.63	3.13	3.50	9.80	13.30	10.17	34	36	39	65	378				391					
12:30AM		17.25	9.50	2.75	3.30	9.30	12.60	9.72	34	36	40	67	384				447					
1:00		17.38	9.50	2.88	3.30	9.30	12.60	9.72	34	36	40	68	382				564		100.2			
1:30		17.25	9.38	2.63	3.40	9.40	12.80	10.17	34	36	40	68	381			4.74	558					
2:00		17.13	9.38	2.51	3.00	9.00	12.00	9.49	34	36	44	68	380				617					
2:30		17.38	9.50	2.88	3.30	9.20	12.50	9.62	34	36	41	69	382	200			669		106.5			
3:00		17.13	9.25	2.38	3.50	9.50	13.00	10.62	34	36	42	69	376				729					
3:30		17.13	9.25	2.38	3.50	9.50	13.00	10.62	34	36	42	70	376				787					8
4:00		17.13	9.38	2.51	3.60	9.80	13.40	10.89	34	37	42	70	374				840					

GAS PRODUCER

Thesis: P.K. Brown.
M.D. Wald.
J. Wintercorn.

-Lbs.		Water Suppl'd Scrubber.		B.T.U. Value of Gas.		Relative Humidity.	Depth of Fuel Bed.
Removed.	Water Vaporized Lbs. per hr.	Meter Reading Cu. Ft.	Weight	From Junker Analysis.	From Chemical Analysis.		

LOG SHEET #4

TEST #2.

TEST OF A 25 H.P. TYPE "E" SMITH SUCTION GAS PRODUCER

TEST #2.

④

Date: March 5, 6, 1913.

Thesis: R.K. Brown. M.D. Wald. J. Wintercorn.

Time.	Pressures.								Temperatures – °F.					Weights – Lbs.			Water Suppl'd Scrubber.		B.T.U. Value of Gas.		Relative Humidity.	Depth of Fuel Bed.
		Venturi Gas Meter – Inches Water.							Water.		Gas.											
		Upstream.			Throat.																	
March 6.	Barometer.	Left.	Right.	Diff. h_2	Left.	Right.	Diff. h_1	Head h_1-h_2	Entering Scrubber.	Leaving Scrubber.	Leaving Scrubber.	Leaving Venturi.	Mixture Air & Steam at Ash Pit.	Coal Fired.	Ash Removed.	Water Vaporized Lbs. per hr.	Meter Reading Cu. Ft.	Weight	From Junker Analysis.	From Chemical Analysis.		
4:30 AM.		-17.13	+9.25	2.38	-3.60	+9.80	13.40	11.02	34	37	42	74	374				41900					
5:00		17.13	9.25	2.38	3.00	9.20	12.20	9.82	34	37	42	74	374			8.08	950		84.3			
5:30		17.00	9.13	2.13	3.20	9.20	12.40	10.27	34	36	42	74	372				42008					8
6:00		17.13	9.25	2.38	3.30	9.40	12.70	10.32	34	37	43	74	370				061					
6:30		17.13	9.25	2.38	3.50	9.50	13.00	10.62	34	37	43	74	390	65			118					
7:00	29.19	17.13	9.00	2.13	3.50	9.50	13.00	10.87	34	37	43	74	400				151				58	
7:30		17.00	9.13	2.13	3.50	9.30	12.80	10.67	34	37	41	75	386				197					
8:00		17.00	9.00	2.00	3.20	9.20	12.40	10.40	34	36.5	41	75	320			12.0	242		96.2			8
8:30		16.75	8.88	1.63	3.20	9.20	12.40	10.77	34	36.5	41	74	324				307					
9:00		17.25	8.75	2.00	3.10	9.05	12.15	10.15	33	36	42	74	301				356					
9:30		16.75	8.75	1.50	3.15	9.10	12.25	10.75	33	36.5	39	71	283		342.2		423					
10:00		17.13	9.25	2.38	2.60	9.40	12.00	9.62	33	38	45	86	313				545					
10:30		17.25	9.38	2.63	2.90	9.50	12.40	9.77	33	38	43	82	334	350		8.16	607					
11:00		17.38	9.50	2.88	3.40	10.00	13.40	10.52	33	37	42	82	352				670					
11:30		17.50	9.56	3.06	3.30	9.90	13.20	10.14	33.5	38	42	82.5	370				736					
12:00		17.50	9.56	3.06	3.35	9.95	13.30	10.24	33.5	38	46	84	397				800					
12:30 PM.		17.50	9.56	3.06	3.40	10.00	13.40	10.34	33	37	41	80	392				845					
1:00		17.38	9.25	2.63	3.20	9.20	12.40	9.77	33	36.5	41.5	80.5	389			5.98	903					
1:30		17.25	8.75	2.00	4.00	10.20	14.20	12.20	33	37	41	79	399				956					
2:00		17.00	9.19	2.19	3.40	9.50	12.90	10.71	33	36.5	44	79.5	393				43023					8
2:30		17.00	9.19	2.19	3.20	9.30	12.50	10.31	33	37	43	79	377				083					
3:00		17.00	9.19	2.19	3.20	9.30	12.50	10.31	33	37.5	41.5	76.5	346				146					
3:30		17.00	9.00	2.00	4.00	10.20	14.20	12.20	33.5	36.5	42	78	368	100			209					
4:00		17.00	9.00	2.00	4.50	11.10	15.60	13.60	33.5	36	41	78.5	388			4.88	273					
4:30		17.13	9.25	2.38	5.30	11.90	17.20	14.82	33.5	36	41	79	392				337					
5:00		17.13	9.25	2.38	5.10	11.70	16.80	14.42	33.5	36	41	79	374				402					
5:30		17.13	9.25	2.38	4.50	11.20	15.70	13.32	33	38	41	79	348				493					
6:00		14.00	14.00	4.00	6.00	12.60	18.60	14.60	33.5	38	41	78	341				545					
6:30		13.75	13.75	3.50	5.80	12.40	18.20	14.70	33	37.5	40	78.5	374				614					8
7:00	29.50	13.75	13.75	3.50	6.10	13.00	19.10	15.60	33	36.5	40.5	77	390	100		9.44	679				64	
7:30		13.50	13.50	3.00	5.80	12.50	18.30	15.30	33.5	36.5	40	78	357				721					
8:00		13.38	13.38	2.76	5.60	12.20	17.80	15.04	33	36.5	42	79	354				765					
8:30		13.25	13.25	2.50	5.50	12.10	17.60	15.10	33	37	41	83	363				828					
9:00		13.13	13.13	2.26	5.50	12.10	17.60	15.34	33	37	42	83	342			5.04	901		113.3			
9:30		13.13	13.13	2.26	6.00	12.90	18.90	16.64	33	37	42	78	348				972					
10:00		13.13	13.13	2.26	6.30	12.90	19.20	16.94	33	37	42	78	348	225	408.5		44035					8