The efficiency of the Kerruish Smoke Consumer and Coal Economizer

Arthur F. Truex
Gilbert F. Metz

Follow this and additional works at: http://scholarsmine.mst.edu/bachelors_theses

Part of the Mining Engineering Commons
Department: Mining and Nuclear Engineering

Recommended Citation
The Efficiency of the Kerruish Smoke Consumer
and
Coal Economizer
by
Arthur F. Truex and Gilbert F. Metz.
A
Thesis
Submitted to the faculty of the
SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI
In partial fulfillment of the work required for the
Degree of
Engineer of Mines ~ ~ ~ ~ ~ ~ ~ ~ Arthur F. Truex
Bachelor of Science in Mine Engineering ~ ~ Gilbert F. Metz.
Rolla, Mo.
1914

Approved by... A. L. McRae.....
Professor of Physics.
1. Table of Contents.

1- Scope of this thesis.
2- Description of the Kerruish Smoke Consumer.
3- Installation at the School of Mines and Rolla City Power Plants.
4- Description of boiler tests
5- Data on boiler tests
6- Flue gas analyses.
7- Summary
8- Drawings.
1- SCOPE OF THE THESIS-

The Kerruish Smoke Consumer is the invention of Mr. H. B. Kerruish and is patented in the United States under the Patent Number 1,046,196.

The tests herein shown were made for the purpose of determining the practical value of the device as a smoke consumer, and as a fuel economizer. Many forms of these devices have been put on the market, some using a steam spray, and others using air in a manner similar to the Kerruish apparatus.

2- DESCRIPTION OF THE APPARATUS-

The apparatus in itself is very simple, consisting of an iron pipe set either in the bridge wall or immediately back of it. This pipe is fitted with a series of copper nozzles or jets protruding from it as shown by the accompanying sketch. In a water tube boiler this pipe is placed preferably in the bridge wall itself, and in a fire tube boiler, about half way between the front of the furnace and the first row of tubes.

This pipe is connected with a source of air supply, either a fan or a compressed air receiver the pressure does not exceed eight (8) ounces; hence a small fan equipment is advisable because of the constant pressure it maintains.
3.

In addition to the pipe and air jets, a wall is built 30 inches back of the bridge wall. This wall is 9 inches thick and has arched openings at its base 14 inches wide and varying in height from 14 to 18 inches.

3- INSTALLATION OF SCHOOL OF MINES AND ROLLA CITY POWER PLANT-

The plant at the Missouri School of Mines and Metallurgy consists of four 135 H.P. Haime water-tube boilers. The Kerruish Consumer was installed there under boilers No.1 and 2.

At the Rolla City power plant the installation was made under a 250 H.P. Wangler fire-tube boiler.

4- DESCRIPTION OF BOILER TESTS-

Two short preliminary tests at the school plant were first made, but it was found that under the conditions which obtained, average results could not be secured, so several larger runs were made over periods of nine to fifteen hours.

The first test was made of the two boilers with the consumer, and then on the other two boilers of like type and horse power without the apparatus. In this way it was hoped to secure a comparison of the efficiency of the two sets of boilers.
One series of tests was run by testing each boiler separately, and another by testing two boilers as a unit. The latter method proved more satisfactory as the fireman was enabled better to maintain average conditions. It was possible to throttle the feed water valve so that both boilers were taking water continuously during the entire run, while in the first test one boiler had to be cut out when the other was taking water.

Tests No. 1 and 2, were run on boilers No. 3 and 4, without the smoke consumer, and tests No. 3 and 4, were on boilers No. 1 and 2, with the installation. The tests of these latter boilers show a gain in efficiency of ten percent, and the evaporation is about one pound of water more per pound of coal than in test No. 1 and 2. This is marked saving, but the conditions during the test were somewhat abnormal for the plant, as the load was very heavy and above average.

Tests No. 7 and 8, on numbers 1 and 2, 3 and 4, boilers were made to determine the relative economical results and to discover whether the smoke consumer actually saved coal and consequently evaporated more water. The coal used on these two tests was from the same supply and ran nearly the same in analysis.
5.

Test No. 7 shows only about 0.2 pounds more on the "equivalent evaporation" and the efficiency of the boiler alone shows a 2.5 percent increase. These results do not show any great advantage for the consumer, but the test was made after the boilers were on the load for a month without cleaning, while test No. 8 was run with clean boilers. It is probable that there would be a greater saving if the conditions of the boilers had been alike.

Tests No. 5 and 6, on the Wangler boiler at the City power plant differ from the others in that the only data taken were the weights of coal, ash, feed water and load conditions during a twenty-four hour run. The load at this plant is carried by one 250 H. P. boiler working up to capacity most of the time. Only at one time did the load drop off, and it was due to this fact that the evaporation showed a corresponding decrease. The results show a saving of 3871 pounds of coal in 24 hours, and an increase in evaporation of 1.7 pounds of water per pound of coal burned. The coal used on these tests was about the same quality, the B. T. U. values agreeing
Data and Results of Evaporative Test on Heine Boiler No. 3. Without smoke consumer.

I. S. M. Station.

No. of test...1....Made by A. F. Truex and G. F. Metz.
Grate surface....27.5 sq. ft. ........................................

TOTAL QUANTITIES.

Day of month..........................Jan. 5, 1914
Time of test..........................2 P.M. to 10.45 P.M.
Duration, hours........................8 hr. 45 Min.
Weight of coal as fired, Ibs................4914 #
Weight of coal dropped thru grate, Ibs...........
Weight of coal actually burned, Ibs............4914
Percentage of surface moisture in coal........7.0%
Total weight of dry coal consumed, Ibs........4570
Total ash and refuse, Ibs..................632
Percent of ash and refuse to dry coal......13.8%
Percent of combustible in the ash...........
Total weight of water, Ibs..................26217
Quality of steam, %..........................97.8%
Water actually evaporated, Ibs.............25640
Factor of evaporation.....................1.141
Equivalent water evaporated from and at
212 deg., lbs..........................29255

HOURLY QUANTITIES.

Coal consumed per hour, Ibs..............561.6
Dry coal consumed per hour, Lbs..........522.3
Coal consumed per hour per square foot grate surface, Ibs........20.4
Dry coal consumed per hour per square foot grate surface, Lbs.......19.0
Apparent water evaporated per hour, Ibs......2996
Water evaporated per hour corrected for quality of steam, Ibs........2930
Equivalent evaporation dry steam per hour from and at 212 degs., Ibs...........3343

AVERAGE PRESSURES, TEMPERATURES, ETC.

Steam pressure gague....................93.6
Temp. of feed water......................112.7°
Temp. of escaping flue gases..............585°
Draft in breeching, inches of water
(stack draft)........................................56
Temp. of steam from table................333.4
CO₂ in flue gas.........................9.7 = 13.3 Q. = 4.5
Calorific value of coal in B.T.U...........................12136

HORSE POWER.

Horse power developed.......................................84.8
Builder's rated H.P.............................................135
Percent of rated H.P. developed..............................63%

ECONOMIC RESULTS.

Actual evap. per lb. coal as fired............................5.31
Equivalent evap. per lb. coal as fired.........................5.95
Equivalent evap. per lb. coal dry.............................6.40
Equivalent evap. per lb. combustible........................7.43
Efficiency of boiler and grate, based on dry coal....51.17
Efficiency of boiler alone....................................51.18

CONDITION OF BOILER:

Condition of bridge wall______________________________

CONDITION OF FIRE:

Thickness__about_4"_Speed of grate___Hand fired
General color_____Bright yellow_____________________
Weather__________________Fair and cold________________

COAL:

From________Illinois______________________________
Kind________Mine run______________________________

Proximate Analysis:

Moisture____7.0%____
Ash________13.87_____
MISSOURI SCHOOL OF MINES.
ROLLA, MO.

Data and results of Evaporative test on Heine Boiler No. 3
Without smoke consumer.

M. S. M. Station.

No. of test---1
made by A. F. Trueck and G. E. Metz.

Grate surface---27.5 $sq. Ft.

TOTAL QUANTITIES.

Day of month.............................................Jan. 5, 1914.
Time of test..........................................................2.00 P.M. to 10.45
Duration, hours...................................................8.45 Min.
Weight of coal as fired, lbs...................................4730
Weight of coal actually burned, lbs............................4730
Percentage of surface moisture in coal..............7.0%
Total weight of dry coal consumed, lbs..............4399
Total ash and refuse, lbs........................................541
Percent of ash and refuse to dry coal.............11.43
Total weight of water, lbs.................................26031.0
Quality of steam, %................................................98.4
Water actually evaporated, lbs.............................25094.0
Factor of evaporation...........................................1.1402
Equivalent water evaporated from and at 212
deg., lbs..........................................................28612

HOURLY QUANTITIES.

Coal consumed per hour, lbs..............................440.6
Dry coal consumed per hour, lbs......................503.0
Coal consumed per hour per square foot grate surface, lbs...........19.6
Dry coal consumed per hour per square foot grate surface, lbs...........18.3
Apparent water evaporated per hour, lbs.............2975.0
Water evaporated per hour corrected for quality of steam, lbs...............2868.0
Equivalent evaporation dry steam per hour from and at 212 degs., lbs...............3270.0

AVERAGE PRESSURES, TEMPERATURES, ETC.

Steam pressure, gage......................................88.1
Temp. of feed water........................................112.7
Temp. of escaping flue gases..............................580
Draft in breeching, inches of water
(stack draft)....................................................46
Temp. of steam from table...................................329.9
### ECONOMIC RESULTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees of superheat.</td>
<td>None</td>
</tr>
<tr>
<td>CO$_2$ in flue gas.</td>
<td>4.6%</td>
</tr>
<tr>
<td>Colorific value of coal in B.T.U.</td>
<td>12136</td>
</tr>
<tr>
<td>Colorific value of combustible.</td>
<td>14090</td>
</tr>
<tr>
<td>Horse power developed.</td>
<td>82.9</td>
</tr>
<tr>
<td>Builder's rated horse power</td>
<td>135.0</td>
</tr>
<tr>
<td>Percent of rated H.P. developed</td>
<td>61.4</td>
</tr>
<tr>
<td>Actual evap. per lb. coal as fired.</td>
<td>5.50</td>
</tr>
<tr>
<td>Equivalent evap. per lb. coal as fired.</td>
<td>6.04</td>
</tr>
<tr>
<td>Equivalent evap. per lb. coal dry.</td>
<td>6.50</td>
</tr>
<tr>
<td>Equivalent evap. per lb. combustible.</td>
<td>7.55</td>
</tr>
<tr>
<td>Efficiency of boiler and grate, based on dry coal.</td>
<td>51.97</td>
</tr>
<tr>
<td>Efficiency of boiler alone.</td>
<td>52.00</td>
</tr>
</tbody>
</table>

### CONDITION OF BOILER:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition of bridge wall</td>
<td>O</td>
</tr>
<tr>
<td>Condition of setting</td>
<td>O</td>
</tr>
</tbody>
</table>

### CONDITION OF FIRE:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>about 4&quot;</td>
</tr>
<tr>
<td>Speed of grate</td>
<td>Hand fired</td>
</tr>
<tr>
<td>General color</td>
<td>Bright yellow</td>
</tr>
</tbody>
</table>

### COAL:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>Illinois</td>
</tr>
<tr>
<td>Kind</td>
<td>Mine run</td>
</tr>
</tbody>
</table>

### Proximate Analysis:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>7.0%</td>
</tr>
<tr>
<td>Ash</td>
<td>13.87%</td>
</tr>
</tbody>
</table>
Data and results of Evaporative Test on Heine, Boiler No. 1 without smoke consumer.

--- MISSOURI SCHOOLS OF MINES ---

ROLLA, MO.

No. or test: 3 Made by: A. F. Trues and G. F. Metz

Grate surface: 27.5 sq. ft. boiler. Total = 55 sq. ft.

### TOTAL QUANTITIES

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day of month</td>
<td>Jan. 9, 1914</td>
</tr>
<tr>
<td>Time of test</td>
<td>8:30 A.M. to 11:50 P.M.</td>
</tr>
<tr>
<td>Duration, hours</td>
<td>15 Hrs., 20 Min.</td>
</tr>
<tr>
<td>Weight of coal as fired, lbs.</td>
<td>7830</td>
</tr>
<tr>
<td>Weight of coal dropped thru grate, lbs.</td>
<td>7830</td>
</tr>
<tr>
<td>Weight of coal actually burned, lbs.</td>
<td>7830</td>
</tr>
<tr>
<td>Percentage of surface moisture in coal</td>
<td>7.20%</td>
</tr>
<tr>
<td>Total weight of dry coal consumed, lbs.</td>
<td>7266</td>
</tr>
<tr>
<td>Total ash and refuse, lbs.</td>
<td>1294</td>
</tr>
<tr>
<td>Percent of ash and refuse to dry coal</td>
<td>17.6% (21.6)</td>
</tr>
<tr>
<td>Total weight of water, lbs.</td>
<td>52292</td>
</tr>
<tr>
<td>Quality of steam (%)</td>
<td>97% dry</td>
</tr>
<tr>
<td>Water actually evaporated, lbs.</td>
<td>50723</td>
</tr>
<tr>
<td>Factor of evaporation</td>
<td>1.0988</td>
</tr>
<tr>
<td>Equivalent water evaporated from and at 212 deg., lbs.</td>
<td>55734</td>
</tr>
</tbody>
</table>

### HOURLY QUANTITIES

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal consumed per hour, lbs.</td>
<td>510.8</td>
</tr>
<tr>
<td>Dry coal consumed per hour, lbs.</td>
<td>474.0</td>
</tr>
<tr>
<td>Coal consumed per hour per square foot grate surface, lbs.</td>
<td>284.7</td>
</tr>
<tr>
<td>Dry coal consumed per hour per square foot grate surface, lbs.</td>
<td>264.2</td>
</tr>
<tr>
<td>Apparent water evaporated per hour, lbs.</td>
<td>3411</td>
</tr>
<tr>
<td>Water evaporated per hour corrected for quality of steam, lbs.</td>
<td>3308.7</td>
</tr>
<tr>
<td>Equivalent evaporation dry steam per hour from and at 212 deg., lbs.</td>
<td>3635.6</td>
</tr>
<tr>
<td>AVERAGE Pressures, Temperatures, ETC.</td>
<td>92.7</td>
</tr>
</tbody>
</table>
Temp. of feed water...........................................153.4°
Temp. of escaping flue gases............................... 638°
Draft in breeching, inches of water
(stack draft)..............................................57
Temp. of steam................................................. 333.0°
CO₂ in flue gas...O₂ = 14.6 CO₂ = 0.11.............. 4.8%
Calorific value of coal in B.T.U.......................... 12186

**HORSE POWER.**
Horse power developed....................................... 105.4
Builder's rated H.P........................................ 135
Percent of rated H.P. developed............................. 78%

**ECONOMIC RESULTS.**
Actual evap. per lb. coal as fired......................... 6.48
Equivalent evap. per lb. coal as fired................... 7.12
Equivalent evap. per lb. coal dry........................ 7.67
Equivalent evap. per lb. combustible..................... 9.33
Efficiency of boiler and grate, based on dry coal........ 61.1%
Efficiency of boiler alone.................................. 63.9%

Moisture...........7.2%  
Ash............... 14.0%
MISSOURI OF SCHOOL MINES

ROLLA, MO.

Data and Result of Evaporative Test on Heine, Boiler No. 2 without smoke consumer.

Station.

No of test----4----Made by A.F. Truex and G.F. Metz.
Grate surface---27.5 sq. ft.

TOTAL QUANTITIES.

<table>
<thead>
<tr>
<th>Day of month</th>
<th>Jan. 9, 1914</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of test</td>
<td>8.30 A.M. to 11.50 P.M.</td>
</tr>
<tr>
<td>Duration, hours</td>
<td>15 hrs. 20 min.</td>
</tr>
<tr>
<td>Weight of coal as fired, lbs.</td>
<td>7873</td>
</tr>
<tr>
<td>Weight of coal actually burned, lbs.</td>
<td>7873</td>
</tr>
<tr>
<td>Percentage of surface moisture in coal</td>
<td>7.2%</td>
</tr>
<tr>
<td>Total weight of dry coal consumed, lbs.</td>
<td>7306</td>
</tr>
<tr>
<td>Total ash and refuse, lbs.</td>
<td>1332</td>
</tr>
<tr>
<td>Percent of ash and refuse to dry coal</td>
<td>18.23%</td>
</tr>
<tr>
<td>Total weight of water, lbs.</td>
<td>50518</td>
</tr>
<tr>
<td>Quality of steam, %</td>
<td>97.40%</td>
</tr>
<tr>
<td>Water actually evaporated, lbs.</td>
<td>49205</td>
</tr>
<tr>
<td>Factor of evaporation</td>
<td>1.0986</td>
</tr>
<tr>
<td>Equivalent water evaporated from and at 212 deg., lbs.</td>
<td>54057</td>
</tr>
</tbody>
</table>

HOURLY QUANTITIES.

| Coal consumed per hour, lbs. | 513.5 |
| Dry coal consumed per hour, lbs. | 475.5 |
| Coal consumed per hour per square foot grate surface, lbs. | 18.6 |
| Dry coal consumed per hour per square foot grate surface, lbs. | 17.3 |
| Apparent water evaporated per hour, lbs. | 3295 |
| Water evaporated per hour corrected for quality of steam, lbs. | 3210 |
| Equivalent evaporation dry steam per hour from and 212 degs., lbs. | 3526 |

AVERAGE Pressures, Temperatures, Etc.

| Steam pressure gage | 90.4 |
| Temp. of feed water | 153.4° |
| Temp. of escaping flue gases | 50.9° |
Draft in breeching, inches of water
(stack draft) ......................... 6.64
Temp. of steam .......................... 331.4°F
Degrees of superheat ...................... None
CO₂ in flue gas ....5.06 0 = 13.4 CO = 0.1
Calorific value of coal in B.T.U ............... 12186

HORSE POWER.

Horse power developed ........................................... 102.2
Builder's rated H.P ............................................. 135.0
Percent of rated H.P. developed ...................... 75.7

ECONOMIC RESULTS.

Actual evap. per lb. coal as fired ............... 6.24
Equivalent evap. per lb. coal as fired .............. 6.86
Equivalent evap. per lb. coal dry ................... 7.39
Equivalent evap. per lb. combustible .............. 9.04
Efficiency of boiler and grate, based on dry coal .......... 58.84
Efficiency of boiler alone ......................... 61.93

COAL:

Kind Mine Run

Proximate Analysis:

Moisture ___ 7.2 _______%
Ash ______ 14.0 _______
MISSOURI SCHOOL OF MINES.

ROLLA, MO.

Data and result of Evaporative Test on Heine, Boilers No. 1 and 2.

--- M. S. M. Station ---

No. of test.................. 7
Made by...................... A. F. Truxx and C. F. Wetz
Grate surface................ 54 sq. ft. (Total)

TOTAL QUANTITIES.

Day of month.................. Feb. 14, 1914
Time of test.................. 6.00 A.M. to 5 P.M.
Duration, hrs.................. 11
Weight of coal as fired, lbs. 14726
Weight of coal actually burned, lbs. 14726
Percentage of surface moisture in coal......... 7.19
Total weight of dry coal consumed, lbs........ 13667
Total ash and refuse, lbs........ 2047
Percent of ash and refuse to dry coal........ 14.97
Total weight of water, lbs........ 83557
Quality of steam, %............ 97.5% dry
Water actually evaporated, lbs........ 81468.4
Factor of evaporation........... 1.0963
Equivalent water evaporated from and at 212 deg., lbs........ 89313.8

HOURLY QUANTITIES.

Coal consumed per hour, lbs........ 1336.7
Dry coal consumed per hour, lbs........ 2142.4
Coal consumed per hour per square foot grate surface, lbs........ 24.34
Dry coal consumed per hour per square foot grate surface, lbs........ 22.58
Apparent water evaporated per hour, lbs........ 7596.0
Water evaporated per hour corrected for quality of steam, lbs........ 7406.2
Equivalent evaporation dry steam per hour from and at 212 degs., lbs........ 8119.4

AVERAGE Pressures, Temperatures, Etc.

Steam pressure, gage.......................... 87.8
Temp. of feed water.......................... 155
Temp. of escaping flue gases..............#1. Boiler 655.5°
                                           #2. Boiler 570.6°
Draft over fires, inches of water........ 34
Draft in breeching, inches of water
(stock draft).............................. 58
CO₂ in flue gas. #1 = 7.2%, #2 = 5.9% - 00, #1 = 0.1%
                                           #2 = 0.2%.
Calorific value of coal in B.T.U........... 12086
Calorific value of 1# combustible... 13781

HORSE POWER.

Horse power developed.......................... 235.3
Builder's rated H.P.............................. 270.0
Perent of rated H.P. developed............... 87.1%

ECONOMIC RESULTS.
Actual evap. per lb. coal as fired........ 5.73
Equivalent evap. per lb. coal as fired...... 6.06
Equivalent evap. per lb. coal dry........... 6.53
Equivalent evap. per lb. combustible...... 7.68
Efficiency of boiler and grate, based on
dry coal........................................ 52.43
Efficiency of boiler alone.................... 54.07

CONDITION OF BOILER:

Tubes blown _______ January 13, 1914 _______

Condition of bridge wall----------------
Condition of setting_________ O. K. ______

CONDITION OF FIRE:

Thickness _______ about 4 in. ______ Speed of grate _______ Head fired
Long or short flame_________ Long flame_________
Working of fire ___________ Spreading system of firing.
Weather ___________ Cold and Fair
16.

COAL:

From _______ Illinois ____________

Kind ________ Wipe_Burn ____________

Proximate Analysis:

Moisture _____ 7.19
Volatile _____ 38.80
Fixed Carbon _____ 41.78
Sulphur ________ 4.13
Ash ______ 12.23

Note: In this test both boilers were run as one unit, water being fed to both boilers all the time.
MISSOURI SCHOOL OF MINES.

ROLLA, MO.

Data and Result of Evaporative Test on Heine, Boiler No. 3 and 4.

M. S. E. Station.

No. of test 3--made by A. F. Truex and C. F. Metz.

Grate surface 55 sq. ft. (total)

TOTAL QUANTITIES.

Day of month .................................. Feb. 21, 1914
Time of test .................................. 6.00 A.M. to 5.00 P.M.

Duration, hours ................................ 11
Weight of coal as fired, lbs .................. 15849
Weight of coal actually burned, lbs .......... 15849
Percentage of surface moisture in coal ...... 7.03
Total weight of dry coal consumed, lbs ...... 14735
Total ash and refuse, lbs .......................... 2219
Percent of ash and refuse to dry coal ....... 15.05
Total weight of water, lbs ................... 87225
Quality of steam, % ............................ 98.4% dry.
Water actually evaporated, lbs .............. 85829.4
Factor of evaporation ........................... 1.0972
Equivalent water evaporated from and at 212
deg., lbs ....................................... 94172

HOURLY QUANTITIES.

Coal consumed per hour, lbs .................. 1441
Dry coal consumed per hour, lbs ............. 1339.5
Coal consumed per hour per square foot grate
surface, lbs ..................................... 26.2
Dry coal consumed per hour per square foot
grate surface, lbs ................................ 24.3
Apparent water evaporated per hour, lbs ...... 7929.5
Water evaporated per hour corrected for
quality of steam, lbs ............................ 7348
Equivalent evaporation dry steam per hour from
and at 212 deg., lbs ............................ 8561

AVERAGE PRESSURES, TEMPERATURES, ETC.

Steam pressure, gage .......................... 92.4
Temp. of feed water ............................ 154.8°
18.

Temp. of escaping flue gases.... #3 Boiler 635°
#4 boiler 651°

Draft over fire, inches of water.... Did not get
Draft in breeching, inches of water
(Stock draft).................... .57 - .40

Temp. of steam from table................ 33°.7° F.

CO₂ in flue gas. #3 = 6.4% #4 = 7.0%, 0#3 = 11.5%
#4 = 10.80% CO #3 = 0.3%

Calorific value of coal in B.T.U....... 11961
Calorific value 1# of combustible..... 13368

Horse power developed.................. 247.8
Builder's rated H.P..................... 270.0
Percent of rated H.P. developed....... 91.8

ECONOMIC RESULTS.
Actual evap. per lb. coal as fired......... 5.50
Equivalent evap. per lb. cal as fired....... 5.94
Equivalent evap. per lb. coal dry.......... 6.39
Equivalent evap. per lb. combustible...... 7.14
Efficiency of boiler and grate, based on dry
coal....................................... 51.84
Efficiency of boiler alone................ 51.83

CONDITION OF BOILER:
Condition of bridge wall............... Q. K.
Condition of setting.................. Q. K.

CONDITION OF FIRE:
Thickness......... 4 In. Speed of grate........ Hand fired
Long or short flame........ Long flame.
General color........ Bright Orange Yellow.
Weather............... Fair.
Condition of wind...... South wind.

COAL:
From............. Illinois
19.

Kind: Mine Run,  

Proximate Analysis:

Moisture: 7.03

Volatile: 38.17

Fixed Carbon: 44.27

Sulphur: 4.36

Ash: 10.53
20.

Test No. 5 - ROLLA CITY PLANT - Wangler Five Tube Boiler.
January 26, 1914.

Total coal burned / 24 Hrs. ......................... 16,754 lbs.
Percent surface moisture in coal ..................... 7.0 %
Total ash ........................................... 2185 lbs.
Total water evaporated / 24 Hrs. ................. 73495.8 lbs.

EVAPORATION

Lbs. of water per lbs. of coal as fired .......... 4.3
Lbs. of water evaporated per lb. of dry coal .. 4.7
Average Feed Water Temperature .................. 134°
Dry coal burned / 24 Hrs. .......................... 15581 lbs.
Lbs. of water evaporated per lb. of combustible 5.4

COAL ANALYSIS:

<table>
<thead>
<tr>
<th>Ash</th>
<th>15.18</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.T.U.</td>
<td>12178</td>
</tr>
</tbody>
</table>

Test No. 6 - ROLLA CITY PLANT - Wangler Five Tube Boiler.

Total coal burned / 24 Hrs. , lbs. ............... 12859
Total percent of surface moisture ................. 7.5
Total lbs. of dry coal burned ...................... 11895 lbs.
Total Ash lbs. .................................... 2447 lbs.
Total water evaporated in 24 Hrs. ............... 782801 lbs.

EVAPORATION:

Lbs. of water per lb. of coal as fired .......... 6.09
Lbs. of water per lb. of dry coal as fired .... 6.58
Average Feed Water Temperature .................. 144°
Lbs. of water evaporated per lb. of combustible 8.27

COAL ANALYSES:

<table>
<thead>
<tr>
<th>Ash</th>
<th>12.63%</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.T.U.</td>
<td>12583</td>
</tr>
</tbody>
</table>
SUMMARY

The value of the apparatus as a smoke consumer is doubtful. The term is perhaps unfortunate, as observations of the smoke showed that it was cut down but slightly. This, however, may have been due to poor firing.

But as a coal economizer, the apparatus evidently possesses considerable value. While the results of the tests are in a way contradictory, they are in the main, satisfactory. The first set showed a saving of from 15 to 20 percent percent of fuel, but the last set show only a slight saving. There was an increase in evaporation of about 0.2 pounds of water per pound of coal.

The low efficiency of the boilers may be explained by noting the capacity at which they are being operated. To attain its highest efficiency a boiler should be run at from 125 to 150 percent of its rated H.P. The reason given for this practise is that in winter one boiler will not convey the load. This statement, however, is open to question.

The air supply was from a receiver and its pressure varied from 80 lbs. to 30 lbs. This variation
caused considerable fluctuation of the temperature in the combustion chamber, and may account for some apparent discrepancies. With a fan installation a supply of air at constant pressure may be maintained.

At the City plant, the tests show that the device makes quite an appreciable saving. Here a fire-tube boiler is used, and it seems as if better results are obtained than under a water-tube boiler, possibly due to better combustion or to the use of a blower fan for the air supply.

Many improvements might be made to increase the efficiency of the smoke consumer, notably the construction of the bridge wall and the fire arches, the size and construction of the air pipe and the regulation of air supply. One great detriment is that the excessive heat melts the air nozzles, buckles the boiler tubes and cracks the fire bricks.