THE EFFICIENCY OF A HORIZONTAL, RETURN, TUBULAR BOILER EQUIPPED WITH A BIGGS UNDERFEED STOKER

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A THESIS SUBMITTED FOR THE DEGREE OF
BACHELOR OF SCIENCE
ELECTRICAL ENGINEERING COURSE

The University of Tennessee

1928

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In the past two decades more and more attention has been given to the proper combustion of fuels. Modern science with the use accurate measuring instruments and chemicals have made a close and intelligent study of the phenomenon of burning. Coal, being the chief supply of fuel and the principal expense in the operation of power plants, has been especially studied with regards to its most efficient combustion. The Mechanical Stoker, a development of this research, has brought about the regulation of certain factors in the burning of coal which has heretofore been impossible or impractical with hand fired furnaces.

A stimulation of interest in fuel combustion has been made recently in the vicinity of Knoxville due to the passage of a municipal ordinance regulating smoke.

The Biggs Stoker, which is of the underfeed type, meets the requirements of the municipal ordinance and it is adapted for installations in old settings. This type stoker may be used efficiently in moderately size boilers rangeing from fifty to four hundred boiler horse power.

As a test had not been previously made on the operation of these stokers, this thesis was chosen to obtain the facts regarding their operation in a practical installation.

The writer wishes to acknowledge the suggestions and aid of Mr. W. E. Biggs, Mr. John Callon, and Mr. H. E. Ayres of the W.E.Biggs Engineering Company, the cooperation of Mr. E. Waldron, chief engineer of The Sanitary Laundry and Dry Clean-

ing Company, and to the assistance of the following students who aided in preparing and running the tests: William Fowler, Elam, Gaston Summers, Clyde Winters, Clyde Keltner, and William Crawford. The writer also wishes to state his appreciation for the help and criticism given by Prof. W. R. Woolrich, Professor of Mechanical Engineering, under whom the thesis was taken.

B. M. G.

MECHANICAL STOKERS IN POWER PLANT OPERATION:

With the scientific study made upon the combustion of coal during the past several decades engineers have discovered that certain factors must be closely regulated to obtain the greatest efficiency in heating from the fuel. The day of the old-fashioned fireman,who judged the efficiency of his plant by the gage, has long since past. The proper burning of fuel, the costliest expense in the operation of a boiler, cannot be left unnoticed. The Mechanical Stoker has been developed to give a uniform control of the different factors of combustion.

The main advantages of the mechanical stoker are: the efficient combustion of coal with the proper control of the air supply, the elimenation of smoke by completely burning all volatile matter and gases, the ability to drive the boilers at much higher ratings than could be accomplished by the use of hand-fired stokers, use of lower grades of coal, and the elimenation of a great deal of labor. The requirements below, necessary for efficient combustion, are achieved by the mechanical stoker, as:

(1) The coal must be fed continuously without the continual opening of the firedoors, permitting cold air to cool the furnace.

(2) Volatiles must be distilled in such a manner that they may be burned with proportionate amounts of air.

(3) The amount of air must be controlled.

(4) The fire-bed must be kept uniform and the ashes dumped

as they are formed.

The general assumption[1] is that one man can care for water, coal,and ashes for a 200 h.-p. boiler with a hand-fired furnace. With a mechanical stoker and suitable coal and ash handling equipment one man may take care of 2000 to 5000 h.-p. of boilers.

The most commonly used stokers are divided into four classes: chain grates, inclined or overfeed stokers, underfeed stokers, and combinations of the above.

The chain grate stoker has as its principal moving part a chain with links that serve as grate bars. The coal is fed unto the chain from a hopper at the front, the depth of the coal on the chain being regulated by an adjustabl gate. As the green coal is carried into the fire upon the chain, it is first coked and then burned. The ashes are dumped at the rear sprocket wheel.

In the inclined or overfeed stoker the coal is generally burnt upon sloping grates. Sections of the inclined grates move with a reciprocating motion, working the green from a hopper at the top downward.

In the underfeed stoker the fresh coal is fed from underneath the fuel bed by some plunger or pushing device. The fuel bed consists of three layers, a lower layer of green coal,

1. Hershfeld and Ulbricht, Steam Power, p.339.

the middle layer being partially coked, and the upper layer is composed of incandescent burning coke and gases. The air is fed from underneath the coal thus forcing all distillation products through the incandescent zone of the fuel bed. The fuel is gradually worked either to the back or to the side (depending upon the particular style) where the ashes accumulate and may be dumped. A forced draft is found to be best with these kind of stokers. The boilers which were tested are equipped with this kind of stoker. (See Figs. 1, 2, and 3).

OBJECT OF THE EXPERIMENT:

This work was undertaken to supply some concrete data on a practical installation of this particular stoker, The Biggs Underfeed Stoker.

GENERAL THEORY:

The tests upon the boilers were made according to the A. S.M.E. Test Code for Stationary Steam Boilers as near as could be practically followed. The efficiency of the boiler is defined as the ratio of the available heat in the steam line as it leaves the boiler to the heat supplied by the coal.

METHOD OF PERFORMANCE AND APPARATUS USED:

If boiler tests are to be depended upon for reliable data, which might be used in comparison with tests upon other boilers then the test must be run according to some standard. The A.S. M.E. Test Code for Stationary Boilers was followed as closely

as practicable.

The plant which was tested is typical, medium size plant. It is of a size in which the Biggs stoker was designed to operate. The load varies with different days, but in the run of ten hours it is fairly constant. From a very heavy load at the beginning of the week the load usually drops off toward the end of the week. The steam is used for heating and pressing appliances in the laundry and is not used for prime movers. It has been found possible to operate at a very much higher rating with the use of the stokers and with a forced draft than with hand-fired grates as was previously used.

Boiler testing at best is subject to numerous errors some of which are very difficult to estimate. The personal equation is accountable for a large variance between tests. Any test of a technical nature, and this applies especially to a boiler test, should be run by men who are skilled to read, manipulate, and appreciate the accuracy of the instruments used. Another factor which should be given considerable weight is the enthusiasm and faithfulness of the men performing the test.

There are a number of technical computations which are very difficult to determine the probable error or limits of errors. One source of error is the sampling of coal. The sampling must be representative of the coal used in the test.

Probably the largest source of error or unreliable data was obtained on metering the feedwater. It was found impractical to weigh the water, hence a meter was used and calibrated. At best a water meter is very fickle. The meter in question was closely calibrated at the end of the test with a series of readings and an average correction factor was used. Although the sample taken of the coal was kept in a sealed jar, a variable amount of moisture might have been lost when the coal was pulverized. The results that are tabulated are not carried out to absurd fractions, but, rather, are given thru the last significant digit.

Having determined the object of the test a rough survey was made of the plant, and the operating conditions. While it is better to run a twenty four hour test, only a ten hour test could be run at this plant as they close down every night. The average load at a laundry varies from a peak at the beginning of the week to a lighter load at the end of the week. It happened that the two days, Tuesday and Thursday, on which the test were made demanded very nearly the same load. It was the intention to obtain the efficiencies at two different loads.

Measurements were made of the various elements effecting the test, including:

(a) Area of heating surfaces

(b) Grate surface

(c) Furnace volume and dimensions

(d) Average steam pressure

(e) Steam temperature

(f) Flue temperature

(g) Feedwater temperature

(h) Fuel weight

(i) Refuse weight

The instruments used included: a platform scales; a tank used in calibrating the water meter; a Worthington, hot water, high pressure water meter,#1238563; an Orsat flue gas analyzer; three 0-600°F. thermometers; a throttling calorimeter; and steam pressure gages.

The coal was weighed on the platform scales in a steel wheelbarrow. The refuse was weighed in the same manner. The total weight of the wheelbarrow and fuel was recorded each time.

The water glass was marked where the liquid stood at the beginning of the test, and it was brought back to the same level at the end of the test.

The water meter was calibrated at the same pressure, temperature, and rate as the average test conditions ran. The meter was tapped into the feed water line between the pumps and the boilers. No attempt was made measure the water into each separate boiler.

A sampling apparatus was rigged up by which the flue gas

was drawn into a bottle displacing water. A glass tube was inserted into the breeching through which the sample was drawn. Each sample was drawn over a period of about three minutes. The chemicals in the Orsat apparatus were freshly made. Care was exercised in excluding all air before drawing the sample and allowing none to mix with it while making the analysis.

The pressure gage was the regular power house gage. It was not calibrated, but it was noted that it read zero while the pressure was off.

The feedwater temperature was taken by drawing off a small amount in a can. Care was taken to allow the water to warm the pipes. The temperature being so low the limits of error were not very great.

A throttling calorimeter was mounted over one boiler with a sampling tube inserted into the vertical feeder from the boiler. A thermometer in the thermometer well of the calorimeter served to give the temperature.

Before running the test all the apparatus was placed in operation and several "mock" readings were observed to accustom the operators with their necessary duties. The grates, ashpits, and furnace lining were carefully cleaned previous to running the test.

The test was begun promptly at scheduled time. Note was

made of the height of the water in the water glasses, the pressures,and various temperatures. The water meter was read. The stoker hoppers were started full, all additional coal being weighed. The fires were allowed to burn down before the test was begun. The ashpits were empty. At ten o'clock the conditions of the boiler were brought back to those at starting, as nearly as possible. Ashes were dumped once during this period. Readings were carefully noted at ten o'clock as if starting the test over. Conditions were again brought back to those at starting when the test closed at five o'clock.

As the readings later proved, over 250 pounds of coal were burned per square foot of grate surface during the ten hour run. This amount is considered minimum for standard tests.

Records were kept of the fuel burned, and hourly readings were made of the water meter. Feedwater temperature, calorimeter temperature, and steam pressure were recorded at fifteen minute intervals. Flue gas temperature and analysis were made hourly.

A sample was taken from each wheelbarrow of coal and saved for analysis. This final, rather bulky, sample was quartered and divided down to a half-gallon. This was placed in an air-tight fruit jar. The ashes were sampled in a similar way. The moisture in the ashes was estimated by drying

a sample over the boilers.

The coal sample was pulverized until it would pass a sixty mesh screen. A sample was tested in an oxygen calorimeter for the heat content of the coal, as fired. Another sample was tested for moisture, volatile, fixed carbon, and ash.

The stack was watched with regards to the emission of smoke. There was no apparent smoke except when the fireman raked the fires. This was done about once an hour. Although the stokers were equipped with an automatic regulator, the fireman regulates the stokers by hand, running them intermittently.

The data and results follow the A.S.M.E. form as near as necessary to obtain the object of the test.

DATA AND RESULTS: of Stationary Steam Boiler Test.

Solid Fuels - As Fired

General Information

1 Date of Test: May 8 and 10, 1928.

2 Location: North Broadway, Knoxville, Tenn.

3 Firm: Sanitary Laundry and Dry Cleaning Company

4 Maker and type of boiler: Casey-Hedges 66" H.R.T.Boiler

5 Maker and type of fuel burning equippment: Biggs Underfeed Stoker

6 Test conducted by: B.M.Gallaher

7 Object of test: To test the performance of a H.R.T.Boiler equipped with a Biggs Underfeed Stoker.

Description, Dimensions, etc.

8 Boiler heating surface: 2 boilers, each 1030, 2060 sq.ft.

9 Grate surface: " grates, " 24, 48 sq.ft.

10 Fuel burning equippment: single retort, underfeed stokers

11 Draft: fan draft

12 Fuel: nut and slack, 1" and less, bituminous

13 Volume of combustion space: 2 boilers, each 333, 666 cu.ft.

14 Furnace, center of grate to nearest heating surface: 2.8ft.

15 Furnace volume per sq.ft. boiler heating surface: .324cu.ft.

Fuel and Gas Analysis Data

16 Volatile matter	31.9	per cent
17 Fixed carbon	58.8	per cent

18 Ash			8.5	per cent
19 Moisture-as fired			.8	per cent
20 Heating value of the coal - as fired			13,175	B.t.u.
21 Heating value of the coal - dry			13,300	B.t.u.
Flue Gas Analysis				
22 Boiler Breeching:	(1)*	(2)	(3)	(4)
Carbon dioxide (CO_2)	7.1	7.1	6.3	6.3
Oxygen (O_2)	12.6	12.6	14.7	14.7
Carbon monoxide (CO)	**	**	**	**
Pressure and drafts				
23 Steam pressure (abs.)	140.4	140.0	139.0	139.0
24 Moisture in the steam	2.94	2.21	1.21	1.41
25 Temperature of boiler room	80	80	80	80
26 Temperature of flue gases	445	445	425	425
27 Temperature of feedwater	127	127	130	129
Hourly Quantities				
28 Duration of test	7	10	7	10
29 Fuel, as fired, per hour	1235	1221	1260	1241
30 Dry fuel, per hour	1246	1232	1273	1252
31 Fuel,as fired,per sq.ft.grate	25.7	25.5	26.2	25.9
32 Fuel,as fired,per retort,per hour	617	610	630	620
33 Combustion space per lb. of coal, as fired	.54	.54	.53	.54
34 Refuse per hour	105	105	109	109
35 Actual water evaporated,per hour	9600	10120	10150	9900
36 Factor of evaporation	1.13	1.13	1.13	1.13

37 Equivalent evaporation per hour	10850	11430	11450	11200
38 Units of evaporation, U.E.	10550	11100	11120	10900
(a) Boiler horsepower, aver.	315	332	332	324
Refuse				
39 Refuse, as fired, percent fuel	8.4	8.5	8.6	8.7
40 Percentage of combustible				
41 Actual evaporation per lb. fuel, as fired	7.7	8.3	8.0	8.0
42 Equivalent evaporation per lb. fuel, as fired	8.78	9.36	9.10	8.96
43 Equivalent evaporation per sq. ft. heating surface, per hour	5.27	5.55	5.56	5.43
44 Units of evaporation absorbed per sq. ft. per hour	5.12	5.40	5.39	5.29
(a) Percentage rating	153	161	161	157
45 Efficiency of boiler, furnace, and grate	64.8	69.0	67.1	66.2

* Columns (1), (2), (3), (4) are data and results on the 7 and 10 hour test on May 8 and the 7 and 10 hour test on May 10, respectively.

** Traces of carbon monoxide were found. Leaky pipette gave inaccurate results.

CALCULATIONS:

Item 8 = the surface exposed to the gases being cooled and the fluid being heated. The surface is measured on the side next to the hot gases.

Item 9 = The horizontal projected area within the four walls surrounding the furnace.

Item 13 = The cubic space provided for the combustion of fuel before the products of combustion pass through any heating surface.

Items 16 to 19 = These values were found by standard methods.

Item 20= Heating value found by use of oxygen bomb calorimeter.

Item 24 = $\frac{H - 1151.7 - .46(t_s - 212)}{L}$, where H is total heat of steam at high pres.; t_s is temp. in calorimeter; L is the latent heat at high pres.

Item 35 = cu.ft.recorded x 61.8 x correction factor of meter divided by hours duration

Item 36 = $\frac{H - q}{970.4}$

Item 37 = Item 35 x Item 36

Item 38 = $\frac{\text{Item 37 x 970.4}}{1000}$

(a) = $\frac{\text{Item 37}}{34.5}$

Item 39 = Item 34 + Item 29

Item 30 = Item 29 + (100 - Item 19)

Item 31 = Item 29 + Item 9

Item 33 = Item 29 + Item 13

Item 41 = Item 35 + Item 29

Item 42 = Item 37 + Item 29

Item 43 = Item 37 + Item 8

Item 44 = Item 38 + Item 8

(a) = Item 38a x 1000 x Item 8

Item 45 = $\frac{\text{Item 42 x 970.4}}{\text{Item 20}}$, as fired.

CONCLUSIONS:

a. It was found that by the use of the stoker and the forced draft that a very much higher capacity could be obtained than could be expected from hand firing.

b. The efficiency was considerable higher than that which could be obtained from most hand fired furnaces. A great number of hand fired H.R.T. Boilers operate at less than fifty per cent efficiency. This boiler operated as high as sixty nine per cent.

c. The stokers were found suitable in regards to the municipal smoke ordinance, if properly fired.

d. The control of firing may be easily and carefull made.

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3. Heine Safety Boiler Company, Steam Boiler Engineering, Saint Louis, 1920.

4. Hirshfeld, C. F., Ulbricht, T. C., Steam Power, New York, 1922.

5. Power Test Codes, Test Code for Stationary Boilers, A.S. M.E., Series 1923.

May 8,1928
Bar. Pres.: 29.9"

Test by: Gallaher, Elam, Summers
Boiler Room Temp.: 80°F.

Time	Meter Reading	Feedwater Temp. °F.	Calorimeter Gage Pres.	Calorimeter Temp.	Remarks
7:00	39511	125	120	229	
:15		120	115	254	
:30		130	115	248	
:45		132	128	256	
8:00	39676	136	120	248	
:15		110	136	259	
:30		128	117	250	
:45		127	120	250	
9:00	39800	134	118	253	
:15		131	125	253	
:30		135	140	258	
:45		129	132	254	
10:00	40149	126	133	253	All readings noted as if starting.
:15		126	133	254	
:30		125	125	257	
:45		129	129	255	
11:00	40275	120	130	254	
:15		127	107	250	
:30		130	126	254	
::45		128	125	250	
12:00	40477	124	124	254	
:15		126	145	251	
:30		137	114	249	
:45		130	119	239	

May 8, 1928. (2)

Time	Meter Reading	Feedwater Temp. °F.	Calorimeter Gage Pres.	Calorimeter Temp.	Remarks
1:00	40646	122	100	243	
:15		130	125	241	
:30		134	125	238	
:45		128	142	242	
2:00	40837	118	120	228	
:15		118	135	248	Boiler Room T.=
:30		126	127	242	80°F.
:45		124	120	240	
3:00	41052	128	125	239	
:15		128	125	239	
:30		127	137	211	
:45		119	125	211	
4:00	41230	116	125	259	
:15		130	127	267	
130		124	127	273	
:45		133	130	275	
5:00	41417	124	120	265	
	1268 Cu.Ft. (7)	126.7°(7)	125.7 (7)	248 (7)	
	1906 " " (10)	126.7(10)	125.0(10)	248.2 (10)	

(3)

May 8, 1928.

Flue Gas Analysis

Time	Temp. °F.	CO_2	O_2	CO	Remarks
7:00	442	7.0	15.5	6.5*	
8:00	448	8.5	12.5		
9:00	460	8.5	11.5		
10:00	423	5.0	10.5		
11:00	450	6.5	10.5		
12:00	464	6.4	16.8		
		5.5	10.7		
1:00	476	10.5	11.3		
2:00	408	8.5	9.9		
		7.4	12.4		
3:00	476	5.5	14.3		
4:00	402	6.0	15.0		
5:00					
	Aver. 444.9%	7.10%	12.57%		

* Due to the leaky pipettes, CO readings were not accurate.

(4)

May 8, 1928.

Coal and Ash — Wheelbarrow wt. = 111 lb.

Time	Coal plus wheelbarrow								
7:00	342	392				293			
	352	348				331			
	309	360				303			
	325	250	Total 5341			Total 927			
	329	327	-1775 (16 x 111)			-333 (3 x 111)			
	297	182	3566 net lb. coal			594 net refuse			
	370	144							
	344	-129							
	341								
10:00	366	327				302			
	336	363				318			
	330	341				244			
	337	356				864	Total		
	346	340				-333			
	326	365				531	net	refuse	7 hr
	332	335				594	"	"	3 "
	354	335				1125	"	"	10 "
	375	320							
	340	358							
	339	360							
	352								
	332								
	333								
	329								
	306								
	312								
	360								
	344								
	330		Total for 7 hr.		12,861				
	330		(38 x 111)		-4,220				
	342		Net for 7 hr.		8,641				
	348		" " 13 "		3,566				
	338		" " 10 "		12,207				
	350								

APPENDIX

May 10,1928. (5) Test by: Gallaher,
Boiler Room temp. 80° Fowler, Winters, Crawford,
Bar. Pressure: 29.93" and Keltner.

Time	Meter Reading	Feedwater Temp. °F.	Calorimeter Gage Pres.	Calorimeter Temp.	Remarks
7:00	42286	136	112	237	
:15		103	142	254	
:30		115	125	253	
:45		124	120	232	
8:00	42442	112	130	235	
:15		132	123	248	
:30		140	120	274	
:45		122	125	276	
9:00	42642	134	123	274	
:15		138	123	276	
:30		134	123	273	
:45		126	130	253	
10:00	42818	122	127	275	All readings made here
:15		116	118	272	
:30		127	120	270	
:45		131	123	272	
11:00	43013	126	130	276	
:15		130	122	274	
:30		130	127	275	
:45		132	128	276	

APPENDIX

May 10,1928. (6)

Time	Meter Reading	Feedwater Temp. °F.	Calorimeter Gage Pres.	Calorimeter Temp.	Remarks
12:00	43280	138	125	274	
:15		130	115	272	
:30		128	120	270	
:45		132	127	276	
1:00	43445	142	115	273	
:15		138	130	269	
:30		138	140	232	
:45		134	132	278	
2:00	43587	134	121	277	
:15		140	123	276	
:30		131	140	278	
:45		129	123	278	
3:00	43762	126	125	276	
:15		124	125	274	
:30		130	132	277	
:45		127	122	275	
4:00	43959	136	117	274	
:15		130	125	277	
:30		124	125	278	
:45		125	118	273	
5:00	44163	133	123	275	
For 7 hr.	1345 cu.ft	130.5° aver.	124.7#	273°	
" 10 "	1877 " "	129.3°	124.7#	268°	

APPENDIX

May 10,1928 (7)

Flue Gas Analysis

Time	Temp.°F.	CO_2	O_2	CO	Remarks
7:00	430*	3.0	18.2	***	
8:00	422	6.4	14.8		
9:00	424	5.4	15.4		
10:00	400	4.8	17.0		
11:00	426	4.8	17.6		
12:00	422	8.0	11.8		
1:00	452	7.7	13.7		
2;00	---**	---	---		Sampling tube was broken.
3:00	---	7.0	14.6		
4;00	---	9.5	8.9		
5:00					
Aver.7&10 hr.	425°	6.28%	14.7%		

* Only the bulb of the thermometer was inserted into the breeching. Temperatures are apparently too low.

**Thermometer broken.

***Leaky pipette, trace of CO indicated.

APPENDIX

May 10,1928. (8)

Coal and ash Wheelbarrow wt. = 111 lb.

Time	Coal plus wheelbarrow		Ash plus Wheelbarrow
7:00	272		304
	387		325
	285		358 dumped at 10:00
	389		
	402		
	440		
	383		
	441		
	440		
	421		
	430		
	435		
	(100)*		
10:00	358		339
	417		347
	441		362
	410		
	440		948
	447		-333 (3 x 111)
	451		615 net refuse 7hr.
	409		
	439		1835
	423		-666 (6 x 111)
	370		1169 net refuse 10hr.
	446	317	
	445	390	7% moisture
	452	440	
	456	490	1090 lb. dry refuse
	412		10 hrs.
	425	12,031	
	384	-3,220 (111 x 29)	
	400	8,811 lb.coal 7 hr.	
	383		
	386	16,956	
	3666	-4,550 (111 x 41)	
	400	12,406 lb. coal 10 hr.	
	397		
	410		
	317		

APPENDIX

(9)

Calibration of water meter

Type: Worthington, hot water, #1238563

Temperature: 130°F.(cu.ft. water weighs 61.8 #)*

Pressure: 140 # gage, as in actual use of meter

Meter Reading Begin	End	cu.ft.	lbs.	Weighed lbs.	Rate lb./hr	Correction Factor
3.0	8.8	5.8	359	300	12,400	.835
3.2	9.3	6.1	378	300	12,000	.793
9.3	5.7	6.4	396	300	9,000	.758
8.8	6.0	7.2	446	400	9,600	.898
3.1	1.3	8.2	507	400	6,000	.788
1.2	8.0	6.8	421	400	6,850	.950
8.0	5.0	7.0	433	400	12,000	.924
0.3	7.5	7.2	446	400	14,000	.896

8) 6.842

Correction factor, Aver .855

* Wt. of gallon of water, 70° = 8.33#

" " " " " 130° = 8.23#

" " cu.ft. " " = 62.4#

" " " " " " 130° = $\frac{62.4 \times 8.23}{8.33}$

= 61.8#

APPROVAL

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.

Name W. P. Woodrich

Title Prof. M.E.

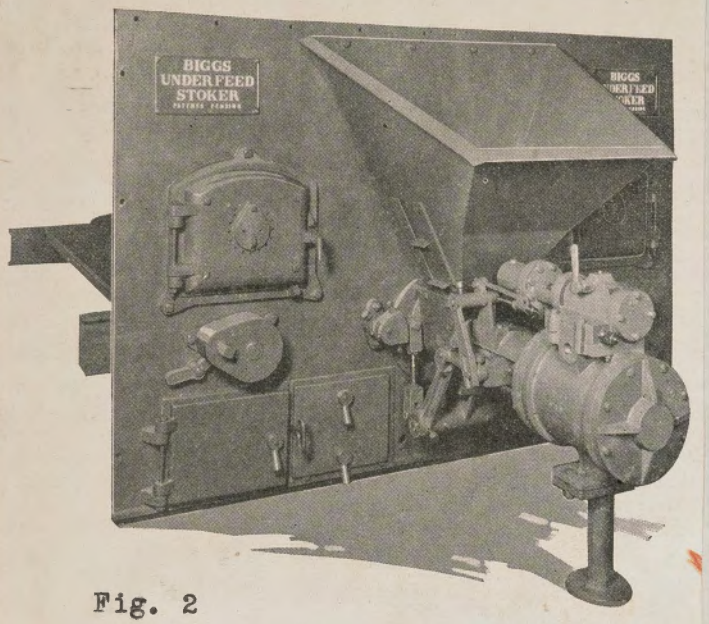


Fig. 2
Outside View of Steam Actuated Stoker

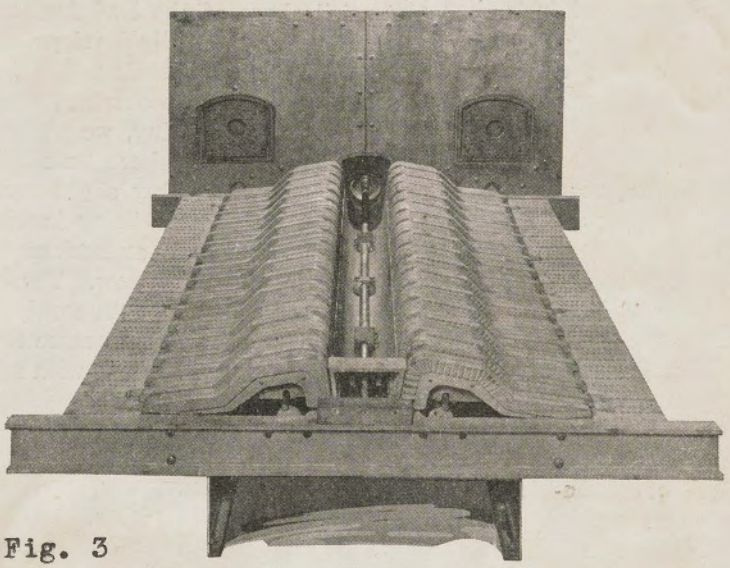
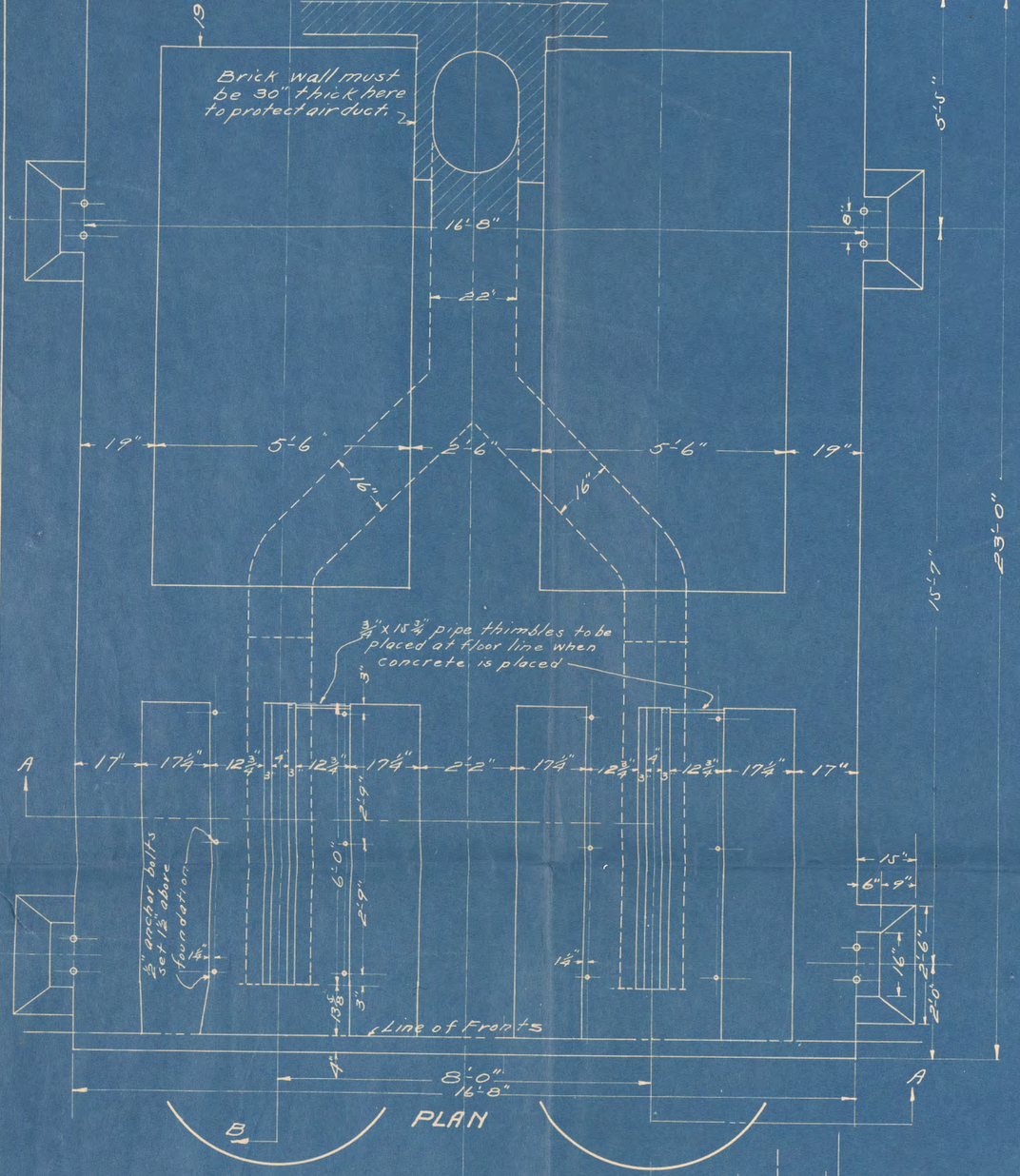
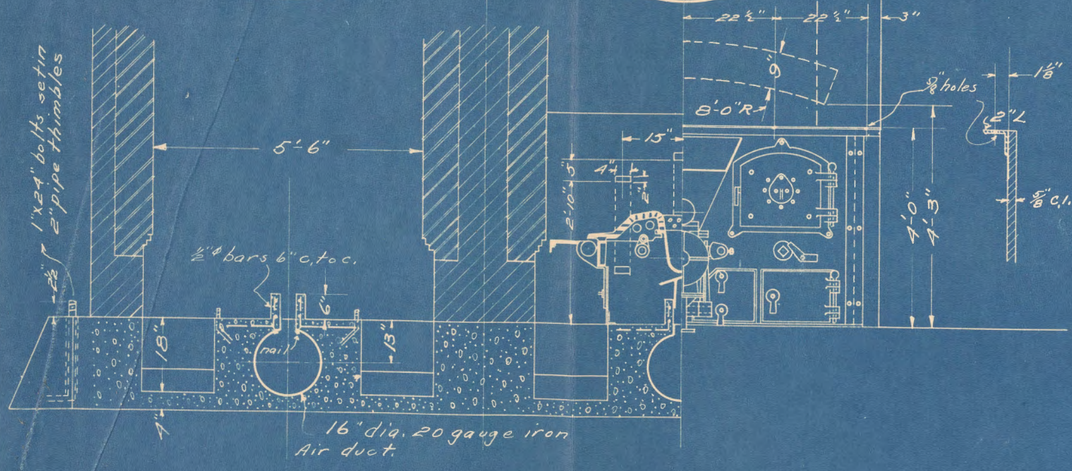
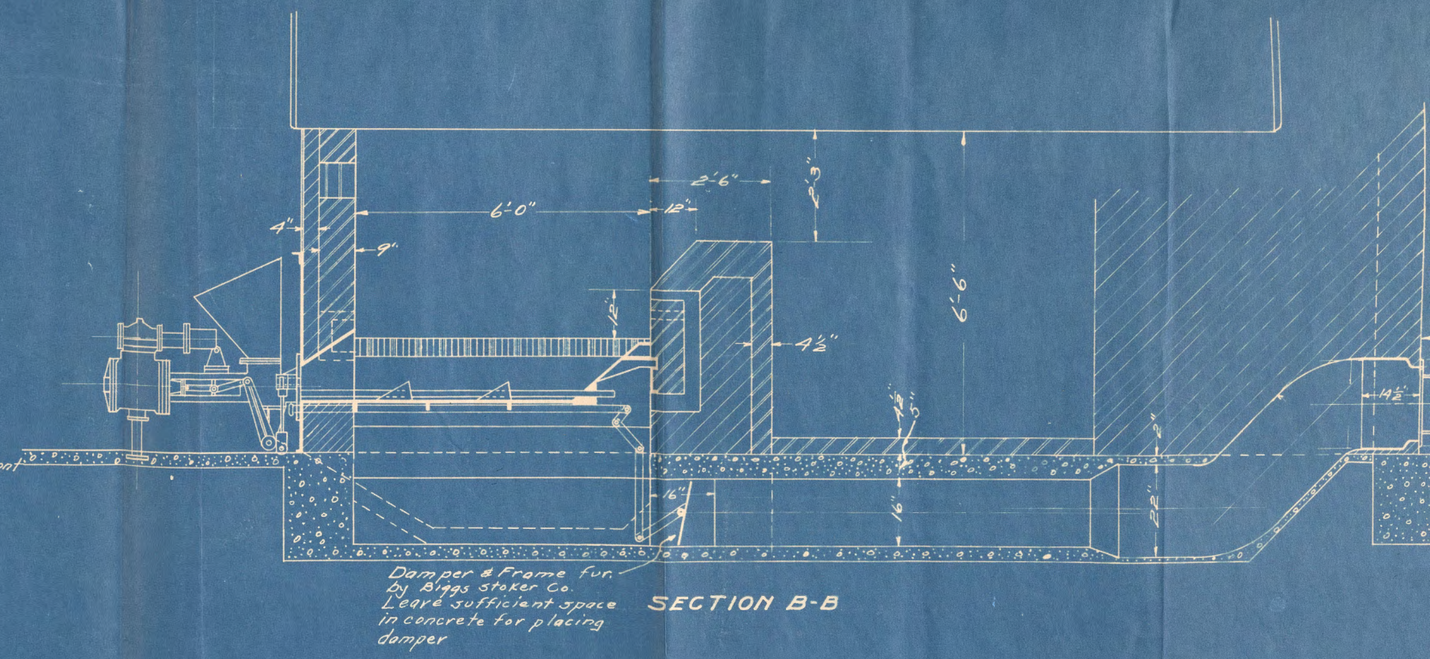


Fig. 3
Inside View Showing Coal Plunger, Coal Retort, and Grates







BIGGS STOKER COMPANY
KNOXVILLE TENNESSEE

BIGGS UNDER FEED STOKER APPLIED TO 2-66" X 20' WALSH & WEIDNER H.R.T. BOILERS

N. C. & ST. L. RAILWAY
CHATTANOOGA

Date: 9-3-27 Scale: 1/2" = 1'-0"

Drawn By A Apprv'd W.E.B. 1020