A Bit of History

In December 2005 I joined the Anthracite Coal Forum (http://www.nepadigital.com/bb/index.php). I had self installed a coal boiler for heating my Central Maryland home a few years earlier. I was no stranger the coal heat, having grown up in a Northwestern New Jersey home heated with Pennsylvania Anthracite coal. What I found on the forum were many others that shared my interest in residential coal heat. I learned a lot about many different coal boilers. One in particular the Axeman-Anderson "Anthratube" was very similar to my Alternate Heating Systems boiler. I soon learned the U.S. Bureau of Mines tested the A-A boiler in the early 1950's. Forum member "mikeandgerry" was kind enough to send me a copy of report he obtained from A-A. Being an engineer I was impressed by the boiler evaluation and the completeness of the report. It's a timeless document. There is a very large table that summarizes two years of boiler evaluation data. In spite of my best efforts I have not been able to get the document from U. S. Bureau of Mines archives. I decided to transcribe the document and make it available on the Internet.

The principal author of the Report is J.F.Barkley. I did some research on the Mr. Barkley. He was born in 1888, a registered civil engineer, and at the time the report was published in 1953, Mr. Barkley was Chief, Fuels Utilization Branch, Bureau of Mines, Washington, D.C. In 1948 he received the prestigious Percy Nicholls Award. The American Society for Mechanical Engineers (ASME) and The American Institute of Mining Engineers (AIME) presents it jointly for notable scientific or industrial achievement in the field of solid fuels. The award commemorates the outstanding contributions that Mr. Nicholls had made in the science and technology of fuels utilization. In 1954 the award was presented to John Ferdinand Barkley.

I scanned the paper copy of report and used Optical Character Recognition and manual re-typing to re-create the document. Table I was manually re-created as an Excel spreadsheet. The recreated document is as close as possible to the original. I left the original spelling, grammar and punctuation errors. The photographs and charts were high resolution scanned to keep as much detail as possible. The individual parts were converted to Acrobat pdf format and combined into a single document. I created a self-extracting zip file to reduce the file size. Included is the Excel spreadsheet.

Many thanks to the members of the Anthracite Coal Forum that have review my translation. I take responsibility for any remaining errors. Please e-mail any you find to yanche@verizon.net. The original document is not copyright protected and I make no claims for any additional copyright protection.

John "Yanche" Dozsa

May 2007

TESTS OF THE ANTHRATUBE

BY J. F. BARKLEY, L. R. BURDICK, AND R. E. MORGAN

* * * * * * * * * **Report of Investigations 4936**

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary
BUREAU OF MINES
J. J. Forbes, Director

Work on manuscript completed October 1952. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Report of Investigations 4936."

January 1953

TESTS OF THE ANTHRATUBE

by

J.F.Barkley, [1/] L.R.Burdick, [2/] and R.E.Morgan [3/]

CONTENTS

TABLES

IIUSTRATIONS

1/ Chief, Fuels Utilization Branch, Bureau of Mines, Washington, D. C.
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3/ Fuel technologist, Fuels Utilization Branch, Bureau of Mines, Washington, D. C.

ILLUSTRATIONS (Cont.)

INTRODUCION

At the request of several Federal agencies, tests were conducted on a relatively recent type of Anthracite-burning equipment named the Anthratube. This device, rated at 130,000 B.t.u. per hour, was designed to burn Pea-size anthracite automatically for steam or hot-water house heating and for domestic hot-water supply.

ACKMOWLEDGEMENTS

The helpful cooperation of the Anthracite Institute and the manufacturers of the equipment, Axeman-Anderson Co., Williamsport, Pa., is gratefully acknowledged.

SUMMARY AND CONCLUSIONS

An Anthratube was installed in a nine-room, three-story house and tested for supplying hot water for house heating and for domestic use under regular house-service operating conditions for both winter and summer. The equipment operated under complete automatic control, the coal being fed from a storage bin and the ashes deposited into a container.

Although the equipment was designed to burn Pee -size anthracite, it was tested not only for Pea-size but also for Buckwheat- (No. 1) size anthracite,

To burn Buckwheat size satisfactorily, it was found necessary to admit more air over the fire by means of an air opening drilled in the cover of the fuel-bed inspection tube.

The exact B.t.u.-per-hour capacity of the Anthratube depends not only upon the size and characteristics, particularly the volatile end the ash content of the coal used, but also upon the fan speed and the grate setting chosen. An approximate method of determination, with the fan speed and grate setting used for winter operation, showed a B.t.u.-per-hour production of useful heat sf 123,000 with Pea coal and about 113,000 with Buckwheat coal. However, this could have been increased or decreased substantially to values above or below the 130,000 B.t.u. as rated by the manufacturer by varying the fan speed. The values also give the heat per hour that could be put into domestic hot water with no heat for house heating. The coal-burning rates were about 11.7 pounds per hour for Pea and about io.6 pounds per hour for Buckwheat.

The efficiency of the Anthratube - or its ability to make the heat in the fuel useful - when continuously running was found to be about 81.6 percent for Pea coal and about 84.0 percent for Buckwheat. If the heat radiated from the boiler and connecting piping is useful, these efficiencies would rise to about 84.0 percent for Pea and about 86.7 percent for Buckwheat. Operating on cycles of on and off, the average annual efficiency varies with the ratio of time on to time off.

The Kilowatt-hours used per ton of coal burned averaged about 4O for Pea size during the winter and about 34 during the summer; for Buckwheat size the average was about 46 during the winter and about 53 during the summer.

The Anthratube requires very little chimney draft, since its fan supplies most of the pressure differential needed.

The Anthratube is rugged, easy to maintain, and remarkably free from operating difficulties. Depositing the ash and refuse into a receiver and use of induced draft are two important cleanliness factors. Its control equipment, standard for various uses, should require the major part of any maintenance work.

The Anthratube should ordinarily be operated both summer and winter. If allowed to stand idle in such locations as an ordinary basement, dampness and condensation would cause corrosion, thus shortening the life of the boiler,

Heat radiated from such equipment installed in an ordinary basement will effectively eliminate any dampness nuisance without increasing the basement temperature appreciably.

There was little difference in house-service results when either Pea or Buckwheat was burned; however, the Anthratube would not feed Buckwheat when it was excessively wet. Choice of size of coal to use had best be determined for each individual installation.

The heating equipment as installed in the house under test resulted in essentially constant living-room temperatures, the variations from chosen temperatures being less than 1° F.

DESCRIPION OF EQUIPMENT

Figure 1 shows the front and side of the Anthratube as tested; figure 2 the rear; and figure 3, the coal-feeding tube entering the coal bin. An encasing jacket was available for this equipment but was not used for these tests. Figure 4 shows line sketches with explanatory notations and figure 5 a cut-away view.

The coal was fed by a feed tube (fig. 6) from the bin to a tube (fig. 7) that carried coal to the top of the fuel bed. The entire feed tube with its internal spiral rotated, guiding the coal up the tube by the spiral as it slid by gravity downward on the circumference of the tube. The speed of rotation was set so that somewhat more coal could be fed than could be burned. Since the tube spilling coal to the top of the fire could receive coal only at the rate taken by the fire, it was kept essentially full. This fullness, in turn, slowed the movement of the coal in the feed-tube and resulted

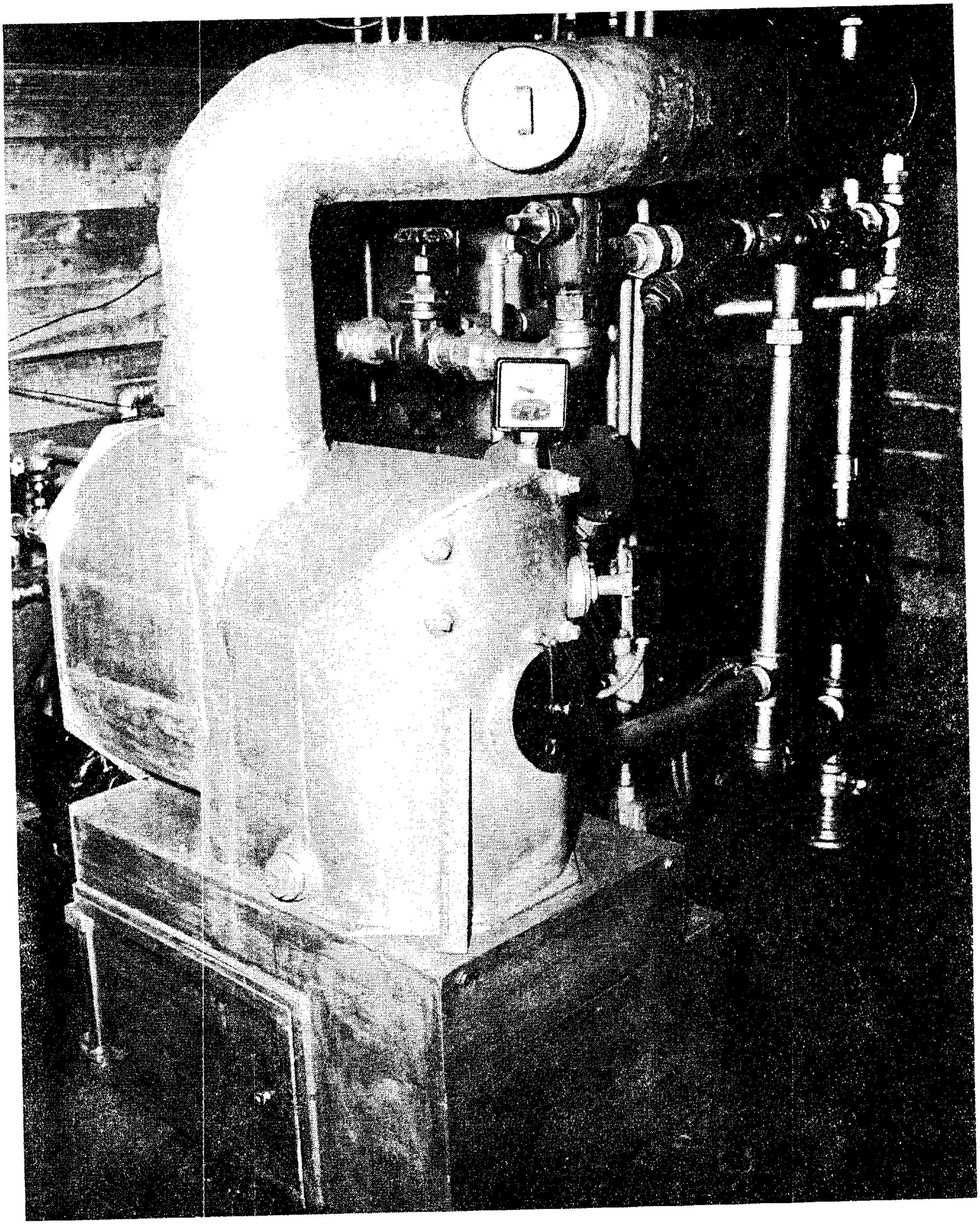


Figure 1. - View of front and side of Anthratube.

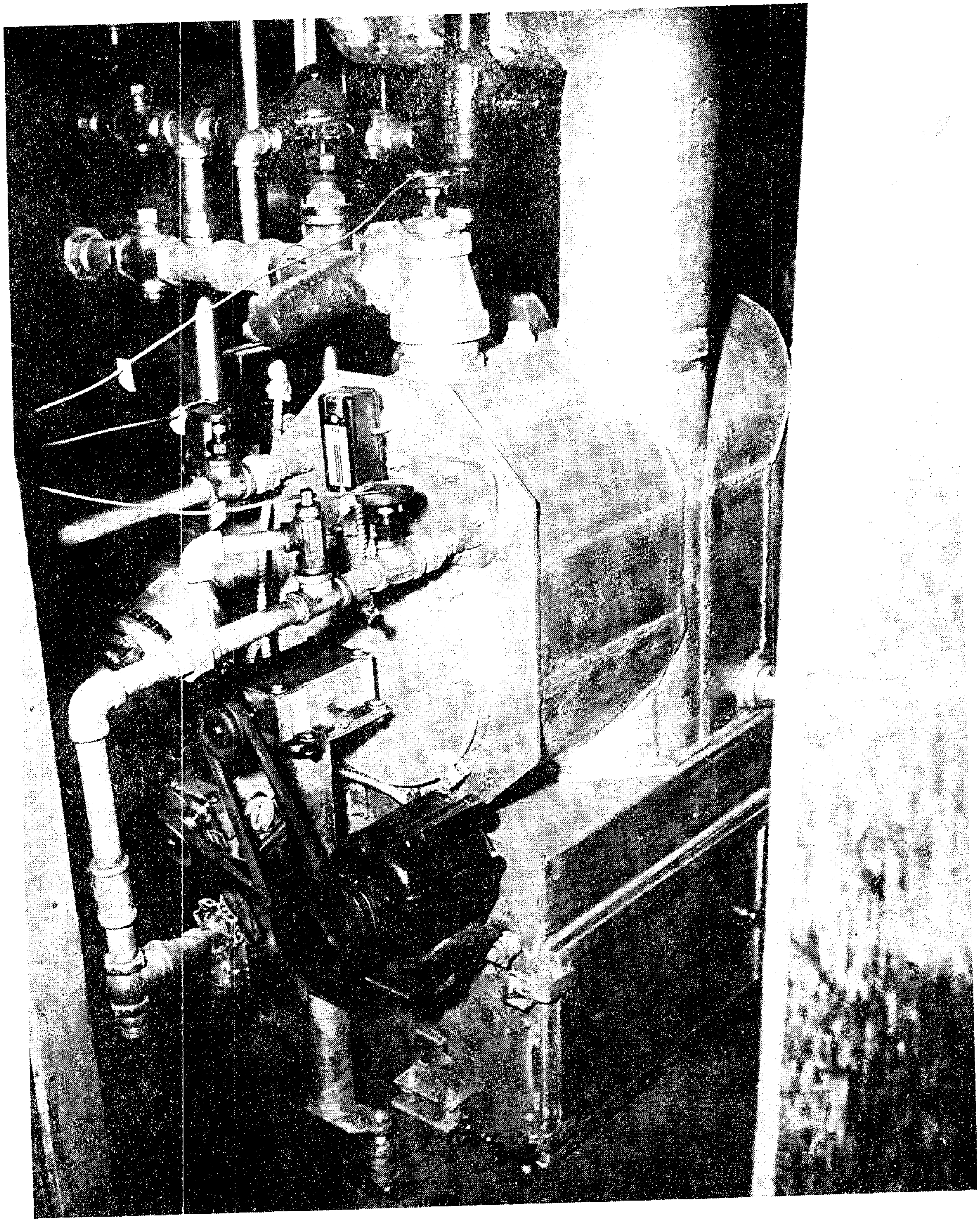


Figure 2. - View of rear of Anthratube.

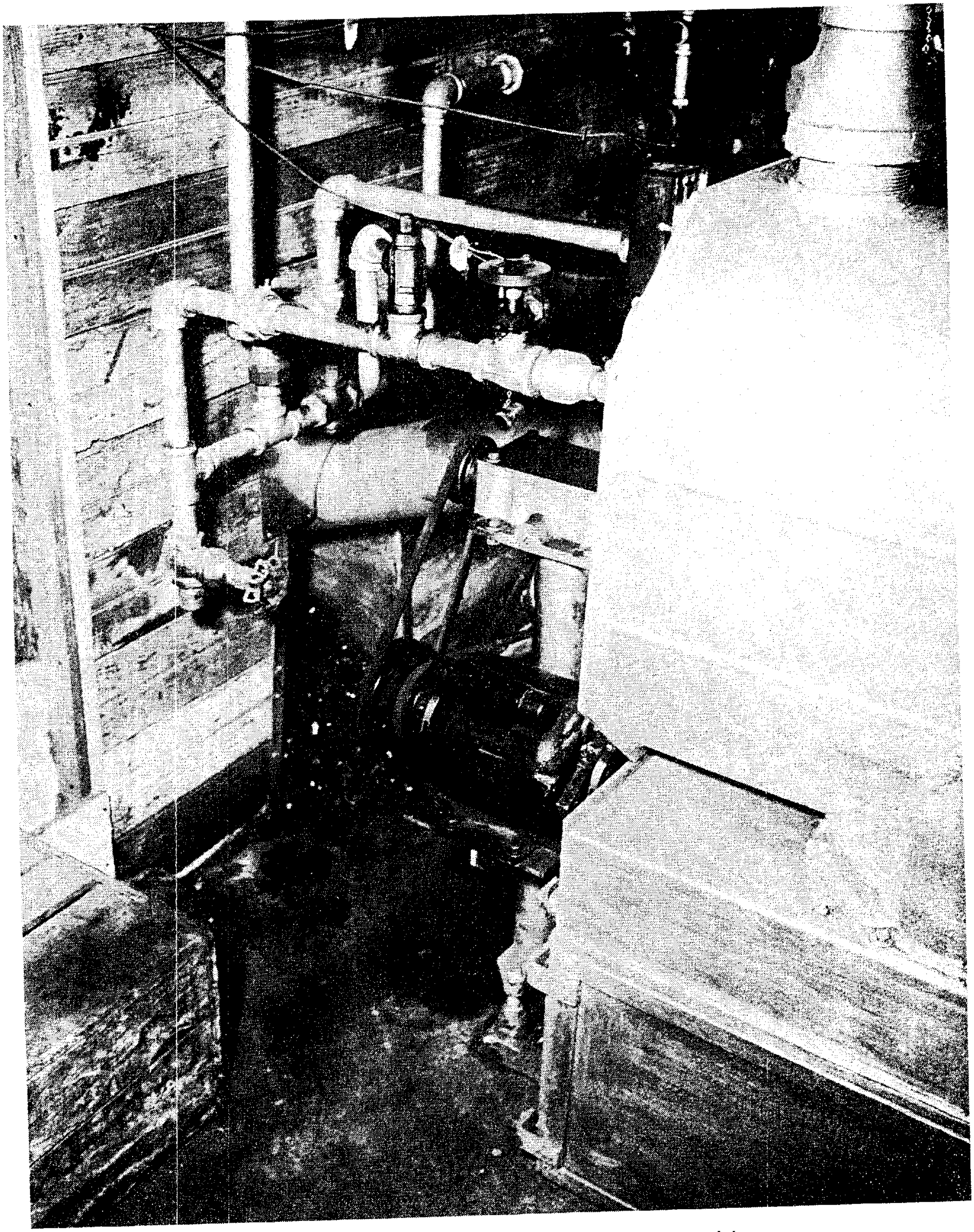
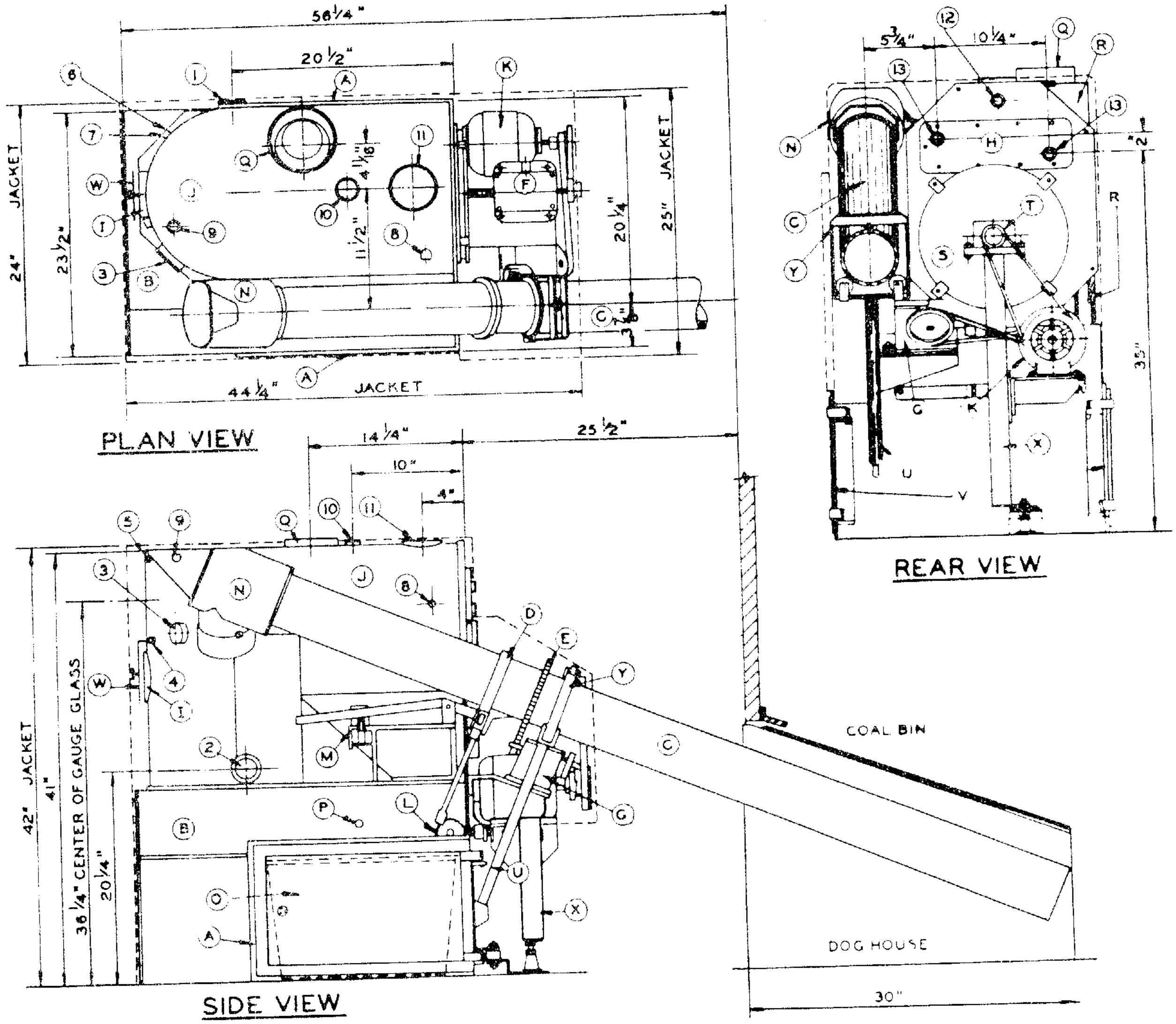


Figure 3. - View of coal-feeding tube entering coal bin.



COMPONENTS

A - ASH PIT DOOR
B - BASE
C - COAL TUBE
D - CAM
E - SPROCKET
F - FAN BEARING BOX
G - GEAR REDUCER
H - HOT WATER COIL
I - SIGHT TUBE
J - MAIN BOILER
K - MOTOR
L - RATCHET
M - SOLENOID
N - TRANSFER HEAD
O - BUSHEL ASH CAN
P - GRATE SWITCH OPENING
Q - 5" SMOKE COLLAR
R - CYCLONE
S - FAN PLATE
T - DRIVE (FAN)
U - COAL TUBE SUPPORT
V - HINGES
W - BALANCE PLATE
X - COMBINATION FAN AND MOTOR MOUNT
Y - COAL TUBE KEEPER

THREADED CONNECTIONS

1 - 2" RETURN
2 - 2" RETURN
* 3 - 2 1/2" LOW WATER CUT-OFF
4 - 1/2" GAUGE GLASS
5 - 1/2" GAUGE GLASS
6 - 3/8" TRI COCK
7 - 3/8" TRI COCK
8 - 1/2" DIRECT CONTROL
9 - 1/2" TEMP. OR PRESSURE GAUGE
10 - 1" SAFETY VALVE
11 - 3" OUTLET
12 - 3/4" HIGH LIMIT CONTROL OR PRESSURE SWITCH
13 HOT WATER COILS
* USED FOR LOW LIMIT CONTROL

Figure 4. - Line sketches of Anthratube with explanatory notations.

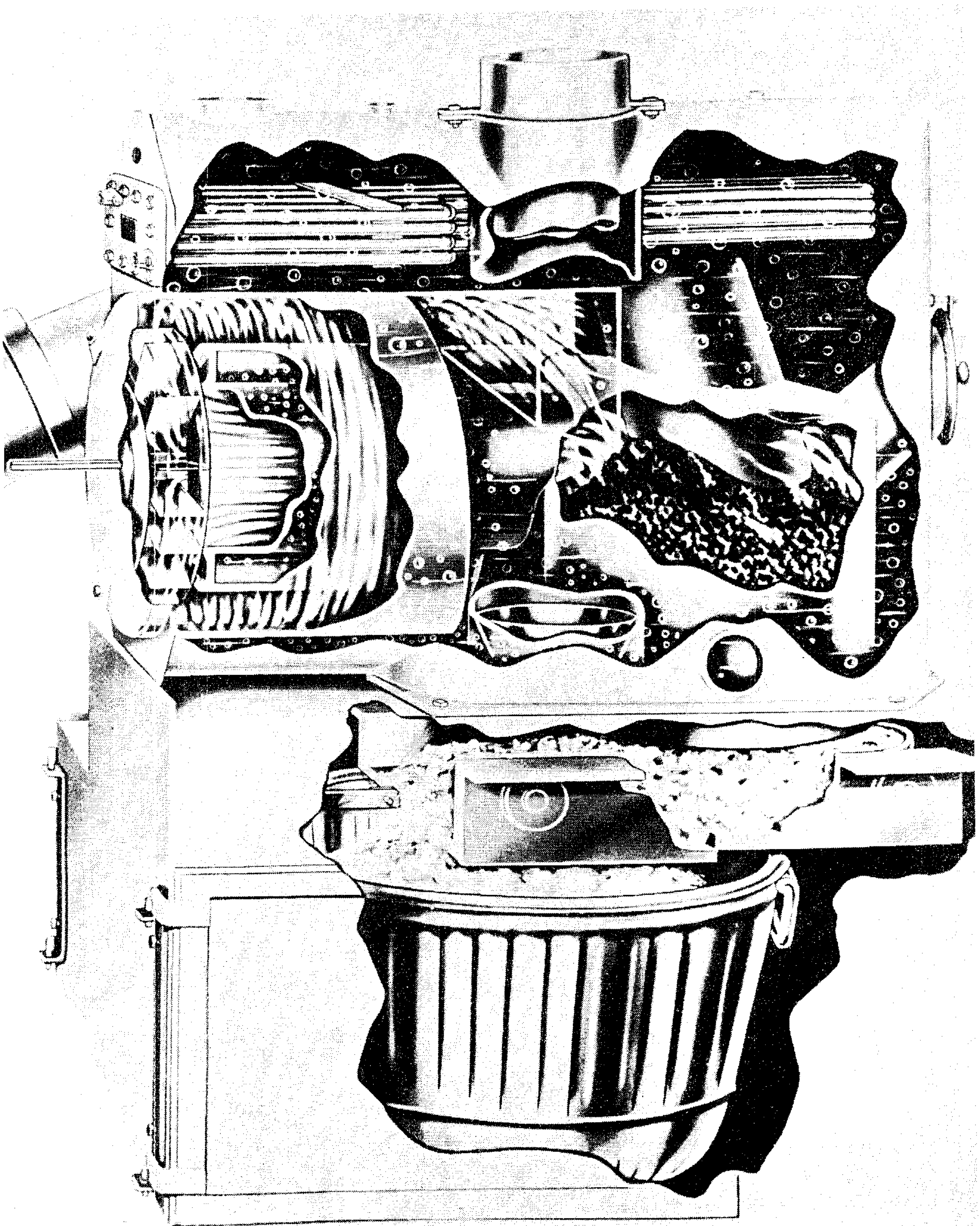


Figure 5. - Cut-away view of the Anthratube.

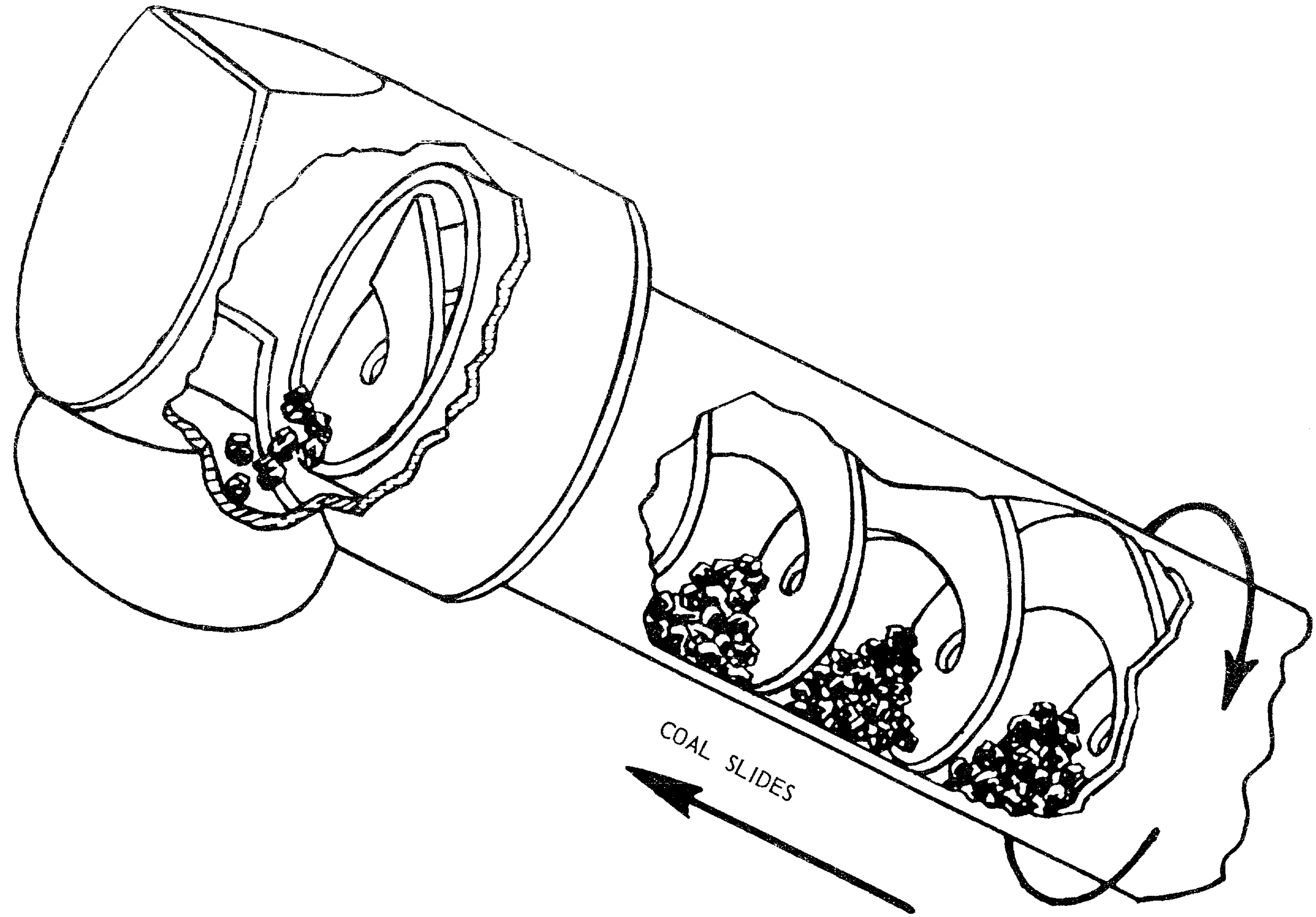


Figure 6. - Coal-feed tube of Anthratube.

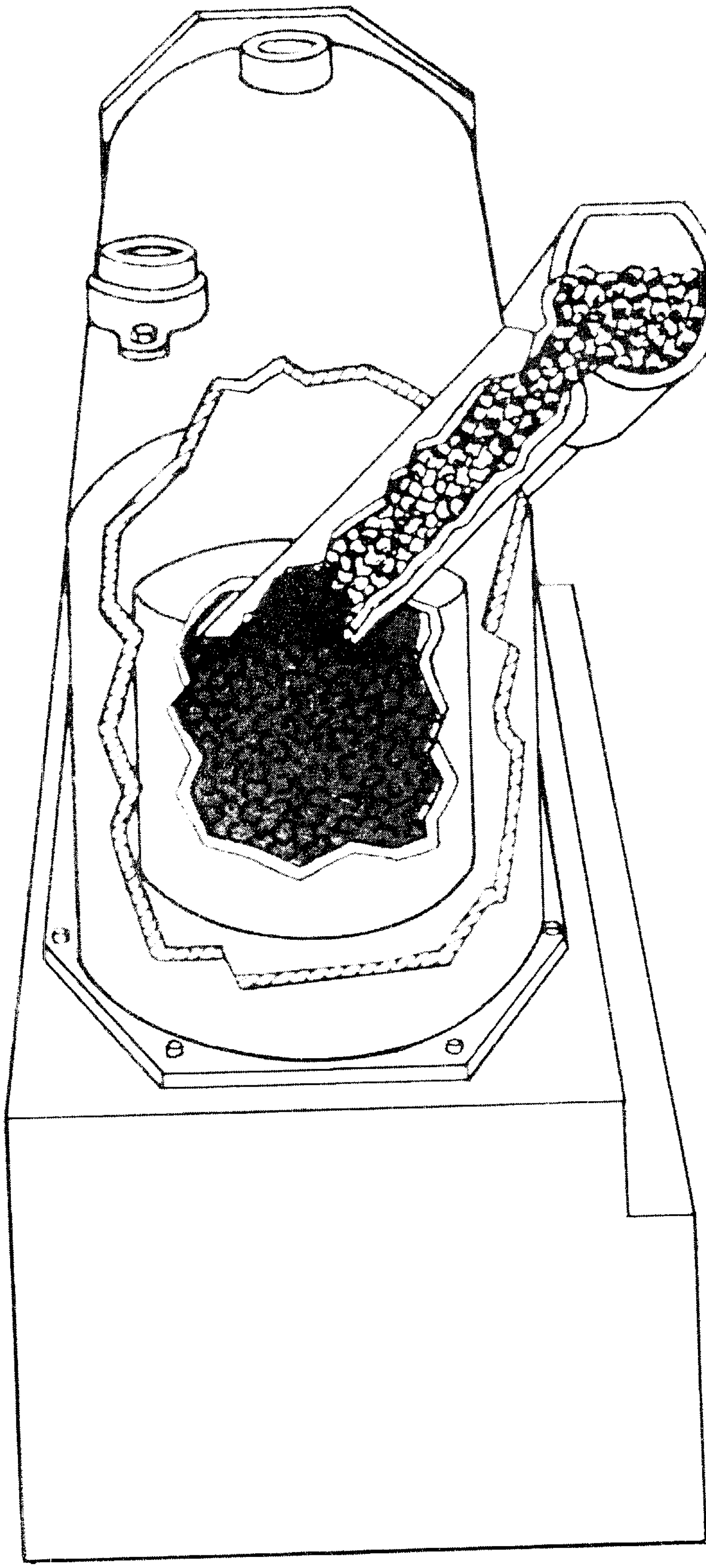


Figure 7. - Coal-spill tube for feeding coal to top of fuel bed.

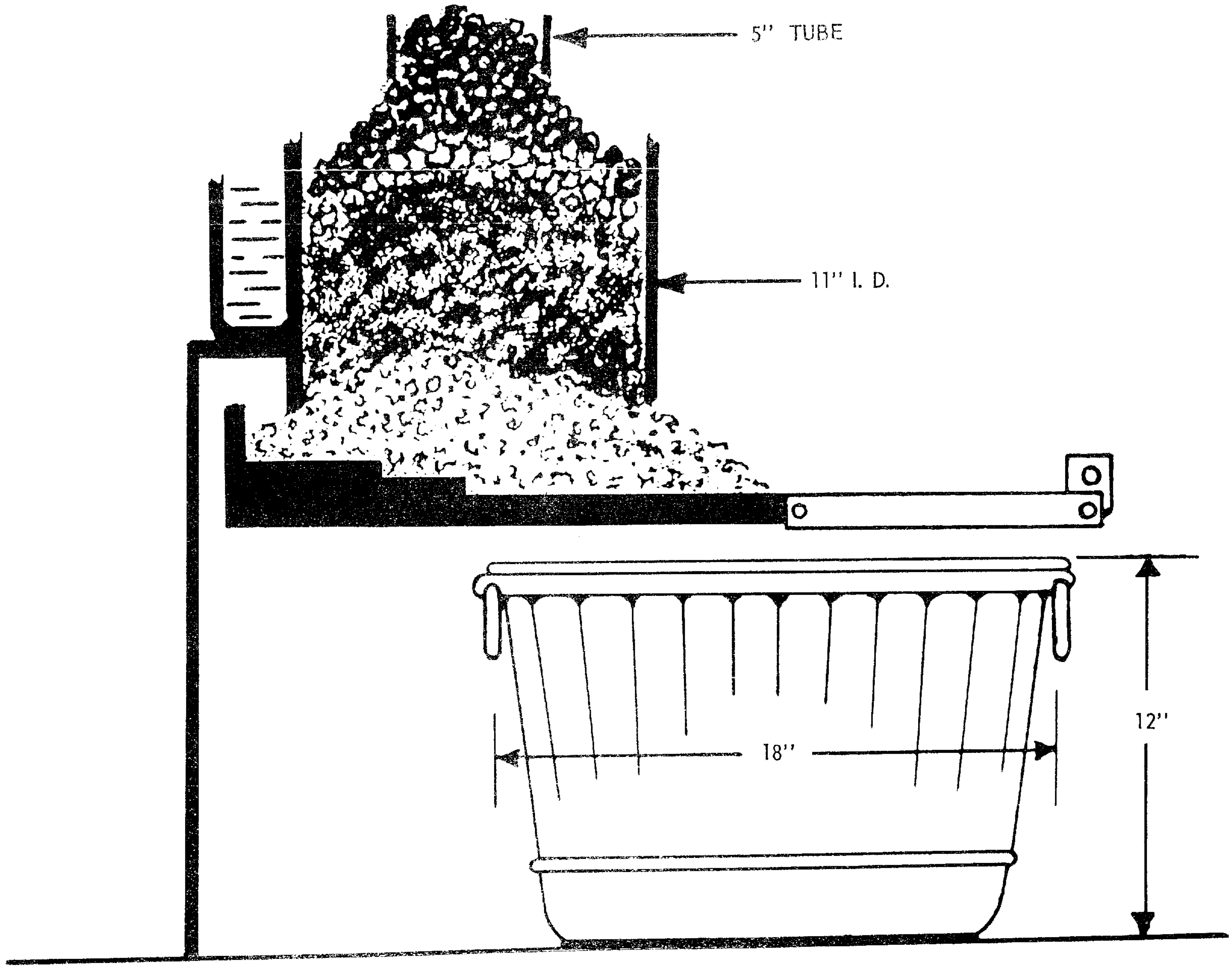


Figure 8. - Side view of reciprocating grates and ash-receiving can.

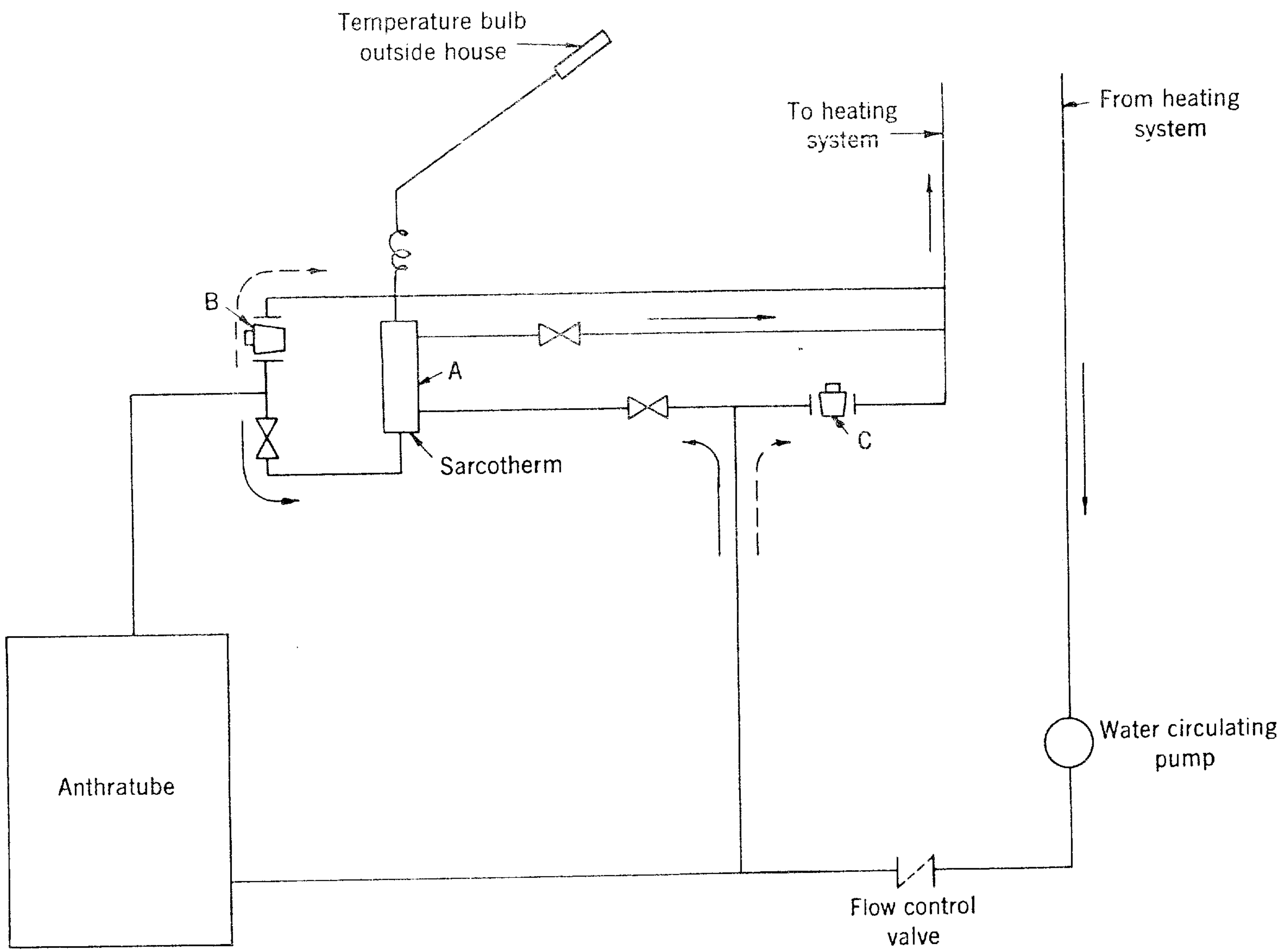


Figure 9. - Diagram of piping connecting Anthratube to house-heating system.

inherently in the correct rate of coal feed. The ash was removed from beneath the fuel bed by a reciprocating grate (fig. 8) and dropped into a 1-bushel ashcan. The movement of the grate was controlled by ratchet L (fig. 4); the time of a complete revolution of the ratchet wheel, as related to the revolving of the coal-feed tube, could be varied.

As shown in figure 5, an enclosed high-speed fan, about 2,900 r.p.m., induced draft over the fire, drawing the products of combustion against boiler-water heating surface, then forcing them at high speed against more heating surface, and on into a cyclone-type fly-ash separator, only partly shown in the center of figure 5; the gases finally went out the stack. The fly-ash trap was designed to drop its catch on the ash below it.

The domestic hot-water heating coil, mounted in the boiler-water space near the top of the boiler (fig. 5), was of the tankless or instantaneous type rated to heat 3.5 gallons of water per minute from 40° F. to l4O° F. when the boiler-water temperature was 180 F. No hot water-storage-tank was used in connection with this coil.

The Anthratube was installed in the basement of a nine-room, three-story brick house to supply hot water for radiator heating and for general domestic use. The test-coal bin was 42 inches long, 40 inches wide, and 36 inches high. For test-operating convenience, a few feet of the breeching from the boiler was insulated as shown in figure 1. There was 784 square feet of hot-water radiation plus the connecting piping. The house was in an area having about 4,100 degree-days a year (fig. 27, follows p. 8).

The hot-water heating system of the house had operated as a gravity system, but in piping up the Anthratube water-circulating pump was added. Figure 9 is a diagram of the piping lay-out. As indicated, the system could be operated by using special valve A, controlled by outside temperature, to proportion return water and boiler water to give varying temperatures of the water going to the radiators; or, with valve A isolated, valves B and C could be opened and adjusted to give any chosen constant proportion. Figures 1 and 2 show views of the piping as installed for experimental purposes. The piping of the domestic hot-water heating coil was arranged so that the hot water leaving the coil was proportioned with cold water by a thermostatic -type valve that could be set manually to obtain chosen temperatures. This piping is shown in figure 3.

The operation of the Anthratube was controlled primarily by a boiler-mounted thermostat that closed and opened the Anthratube motor circuit. This off-and-on control could be set to hold chosen boiler-water temperatures. A similar-type boiler-mounted secondary or safety control was used in the circuit of the motor of the motor-circulating pump of the house heating system; its function was to close the circuit at a chosen maximum boiler-water temperature, thus pumping water out of the Anthratube boiler into the heating system. This prevented excessive boiler-water temperature if the primary control failed to operate properly. A second similar-type control was used to open the circuit of the motor of the water-circulating pump at a chosen minimum boiler-water temperature, so that no water could then be pumped from the boiler. This was designed to prevent the circulating pump from causing a boiler-water temperature below that required for maintaining a supply of domestic hot water of satisfactory temperature. An adjustable hold-fire control (fig. 10, center right) also was installed in the Anthratube motor circuit for independent operation at chosen intervals to prevent possible loss of fire during such periods as summer operation. An adjustable thermostatic-type control was used to stop movement of the ash-dumping grate when the temperature of the ash about to be dumped was higher than chosen, thus improving combustible burn-out. The temperature in the house was controlled by a room thermostat in the hail of the house that, through a switch shown at extreme right (fig. 10), gave on-and-off operation of the water-circulating pump of the heating system, except when overruled by the control action resulting from high or low boiler-water temperature of the Anthratube.

INSTRUMENTATI0N

As shown in figure 1, an operating gage was mounted on the boiler to indicate the temperature and pressure of the boiler water. For testing purposes, 11 thermocouples were installed - 3 of which are shown with connecting wires in figure 2 - to determine the temperatures of the following:

1. Air outside house.
2. Water to radiators.
3. Return water from radiators.
4. Central hail of house.
5. Living room.
6. Boiler room.
7. Boiler water.
8. Flue gas.
9. Water to domestic water-heating coil.
10. Water from domestic water-heating coil.
11. Domestic water to house from tempering valve.

These temperatures were determined by means of a multipoint recording potentiometer shown at lower right in figure 11.

The stack draft was measured by an indicating, inclined-draft gage and a recording-draft gage shown at left in figure 11. Special draft measurements were made with a micrometer-type gage adjustable as to incline shown at the upper right in figure 11. The positioning in the stack of the flue-gas thermocouple and the draft tube is shown at extreme top, slightly left of center, in figure 1. Flue-gas samples were also taken at this position and analyzed by a laboratory-type Orsat. Integrating watt-hour meters, as shown at left in figure 10, gave the kilowatt-hours used by the circulating water pump and the total kilowatt-hours used. The kilowatt -hours used by the Anthratube were obtained by difference.

COALS USED

Although the Anthratube was designed for burning Pea-size anthracite, both Pea and Buckwheat (No, 1) sizes were used. These coals were Pennsylvania anthracites. The average analyses were as follows:

The next three pages of this document is the reproduction of Table I in the original document. Data was manually re-entered into an Excel spreadsheet and formatted to print as three pages. The three pages should be printed and taped together as left, middle and right of a large fold out page.

The table is also distributed as an Excel spreadsheet, “Bureau_of_Mines_4936_Table_I.xls”

I take responsibility for any errors in the reproduction.

“Yanche”

May 2007

Item No.	TABLE 1. Tabulation of test data				
1	Test No.		1	2	3
2	Date		10-05-49	10-24-49	11-04-49
			10-24-49	11-04-49	11-17-49
3	Duration	hours	455.8	264.4	311.6
4	Size of Coal Used		Pea	Pea	Pea
5	Control settings:				
	a. Main boiler-water thermostat	deg. F	170	170	170
	b. High-temperature safety control	deg. F	235	235	235
	c. Low-temperatrue cut-off	deg. F	160	160	160
	d. Hold-fire operation	time per hr.	1	1	1
	e. Do	minutes per hr.	1.12	1.12	1.12
	f. Grate movement	notches	1	1	1
	g. Thermostat to stop grate movement	indicator No.	3.1	3.1	3.1
	h. Position of flow-control valve. Circulating water pump not running	Closed	Closed	Closed	Closed
	i. Means of proportioning return water and boiler water		Hand	Hand	Hand
			valve	valve	valve
	Temperatures:				
6	Air outside house, average	deg. F	63	50	51
7	Water to radiators, maximum	deg. F	175	212	218
8	Return water from, maximum	deg. F	106	115	125
9	Central hall of house, average	deg. F	75	73	74
10	Living room, average	deg. F	76	74	74
11	Boiler room, average	deg. F	78	77	78
12	Boiler water, range	deg. F	153-212	154-222	150-227
13	Flue gas, range	deg. F	138-408	136-425	136-425
14	Water to domestic water-heating coil, average	deg. F	68	67	64
15	Domestic water to house from tempering valve, maximum	deg. F	163	141	141
16	Total weight of coal	lb.	-	701	820
17	Total weight of ash and refuse	lb.	120	112	125
18	Total electrical energy used	kw. Hr.	30.5	25.4	27.9
19	Electrical energy to water-circulating pump	kw. Hr.	15.6	10.7	11.2
20	Electrical energy to Antratube	kw. Hr.	14.9	14.7	16.7
21	Total domestic hot water (estimated)	gal.	2,130	1,230	1,450
22	Total degree-days (based on items 6 and 9)	degree-day	228	354	299
23	Coal burned per hour, total	lb.	-	2.65	2.63
24	Coal burned per hour for domestic hot water (estimated)	lb.	0.32	0.29	0.3
25	Coal burned per hour for heat radiated by boiler plus 25 feet of 1-1/2 -inch inlet and outlet piping	lb.	0.48	0.42	0.42
26	Coal burned per degree-day for house heating (estimated)	lb.	-	2.02	1.99
27	Ash and refuse per day	lb.	6.3	10.2	9.6
28	Cans of ash and refuse per week, approximately	No.	1.3	2.2	2.0
29	Cans of ash and refuse per pound of coal	lb.	-	0.16	0.15
30	Electrical energy per day (24 hours) total	kw. Hr.	1.60	2.30	2.15
31	Electrical energy per day (24 hours) for water-circulating pump	kw. Hr.	0.82	0.97	0.86
32	Electrical energy for water-circulating pump per degree-day	kw. Hr.	0.07	0.04	0.04
33	Electrical energy per day (24 hourd) for Antratube	kw. Hr.	0.78	1.33	1.29
34	Electrical energy for Antratube per ton of coal burned	kw. Hr.	-	42.0	40.7
35	Domestic hot water average per day (estimated)	gal.	112	112	112
36	Average degree-days per day	degree-day	12.0	23.0	23.0
37	Proximate analysis of coal as fired				
	a. Moisture	percent	2.8	2.8	2.8
	b. Volatile matter	percent	5.9	5.9	5.9
	c. Fixed carbon	percent	81.2	81.2	81.2
	d. Ash	percent	10.1	10.1	10.1
38	B.t.u. per pound of coal as fired	B.t.u.	13,110	13,110	13,110
39	Ash-softening temperature	deg F	2,840	2,840	2,840
40	Analysis of ash and refuse:				
	a. Combustible	percent	52.8	39.9	36.9
	b. Ash	percent	47.2	60.1	63.1

(1) 1/4 open 180.0 hrs. or 63% of total time
(2) 1/4 open 26.7 hrs. or 10% of the total time
(3) 1/4 open 49.2 hrs. or 23% of the time
(4) 1/4 open 218.1 hrs. or 90% of total time
(5) 1/4 open 234.3 hours or 91% of total time

4	5	6	7	8	9	10	11	12	13	14
11-17-49	11-26-49	12-05-49	12-15-49	12-25-49	1-07-50	1-18-50	10-14-50	10-28-50	11-13-50	11-24-50
11-26-49	12-05-49	12-15-49	12-25-49	1-07-50	1-18-50	1-30-50	10-28-50	11-13-50	11-24-50	12-03-50
208	224.3	240	240.8	311.1	263.5	288	339.4	385.7	266.7	213.9
Pea	Pea	Pea	Pea	Pea	Pea	Pea	Buck.#1	Buck.#1	Buck.#1	Buck.#1
170	170	170	170	170	170	170	170	170	170	170
235	235	235	235	235	235	235	235	235	235	235
160	160	160	160	160	160	160	160	160	160	160
1	1	1	1	1	1	1	1	1	1	1
1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.00	1.00	1.00	1.00
1	1	1	1	1	1	1	1	1	1	1
3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Closed	Closed	Closed	Closed	Closed	Closed	Closed (1)	Closed	Closed	Closed (2)	Closed
						1/4 Open			1/4 Open	
Hand	Hand	Hand	Hand	Therma	Therma	Therma	Therma	Therma	Therma	Therma
valve	valve	valve	valve	valve	valve	valve	valve	valve	valve	valve
40	39	37	40	47	41	44	58	57	45	35
212	216	216	214	198	183	183	158	173	178	164
127	119	117	125	122	122	121	116	120	120	122
73	73	72	73	72	72	73	75	75	75	73
74	73	73	73	73	73	74	75	75	75	73
77	76	74	74	74	75	76	79	78	78	76
147-221	150-219	151-224	148-222	155-220	147-215	115-218	154-203	138-201	116-208	114-206
140-432	140-423	136-414	137-437	140-434	142-438	125-446	129-385	131-419	154-426	150-433
57	53	51	50	50	50	51	68	65	57	53
137	135	135	133	136	137	137	142	141	139	138
770	924	996	935	932	991	962	822	862	909	957
104	129	126	138	127	129	125	120	130	115	119
25.8	28.9	30.3	30.5	33.2	39.5	23.1	27.7	29.9	23.1	27.4
9.7	10.3	10.5	11.2	15.6	20.3	5.1	9.8	10.3	4.0	6.2
16.1	18.6	19.8	19.3	17.6	19.2	18.0	17.9	19.6	19.1	21.2
970	1,050	1,120	1,120	1,450	1,230	1,340	1,580	1,800	1,240	1,000
286	318	350	331	324	340	348	240	289	333	339
3.70	4.12	4.02	3.88	2.99	3.76	3.34	2.42	2.24	3.41	4.47
0.32	0.33	0.34	0.34	0.35	0.34	0.34	0.31	0.32	0.33	0.34
0.41	0.41	0.40	0.41	0.42	0.41	0.41	0.46	0.45	0.42	0.41
2.17	2.38	2.25	2.28	2.14	2.33	2.14	2.34	1.95	2.13	2.35
12.0	13.8	12.6	13.8	9.8	11.7	10.4	8.5	8.1	10.3	13.4
2.5	2.9	2.7	2.9	2.1	2.5	2.2	1.8	1.7	2.2	2.8
0.13	0.14	0.13	0.15	0.14	0.13	0.13	0.15	0.15	0.13	0.12
2.98	3.09	3.03	3.04	2.56	3.60	1.93	1.96	1.86	2.08	3.08
1.12	1.10	1.05	1.12	1.20	1.85	0.43	0.69	0.64	0.36	0.70
0.03	0.03	0.03	0.03	0.05	0.06	0.01	0.04	0.04	0.01	0.02
1.86	1.99	1.98	1.92	1.36	1.75	1.5	1.27	1.22	1.72	2.38
41.8	40.4	41.0	41.3	37.8	38.7	37.5	43.6	45.5	42.0	44.3
112	112	112	112	112	112	112	112	112	112	112
33.0	34.0	35.0	33.0	25.0	31.0	29.0	17.0	18.0	30.0	38.0
2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
5.9	5.9	5.9	5.9	5.9	5.9	5.9	6.7	6.7	6.7	6.7
81.2	81.2	81.2	81.2	81.2	81.2	81.2	79.5	79.5	79.5	79.5
10.1	10.1	10.1	10.1	10.1	10.1	10.1	11.0	11.0	11.0	11.0
13,110	13,110	13,110	13,110	13,110	13,110	13,110	12,890	12,890	12,890	12,890
2,840	2,840	2,840	2,840	2,840	2,840	2,840	3,000	3,000	3,000	3,000
27.1	28.9	28.7	33.9	26.6	24.1	24.4	28.9	27.5	13.6	11.0
72.9	71.1	71.3	66.1	73.4	75.9	75.6	71.1	72.5	86.4	89.0

(1) 1/4 open 180.0 hrs. or 63% of total time
(2) 1/4 open 26.7 hrs. or 10% of the total time
(3) 1/4 open 49.2 hrs. or 23% of the time
(4) 1/4 open 218.1 hrs. or 90% of total time
(5) 1/4 open 234.3 hours or 91% of total time

15	16	17	18	19	20	21	22	23	24	25
12-03-50	12-13-50	12-22-50	12-31-50	1-10-51	1-21-51	1-30-51	5-22-50	6-08-50	8-06-50	9-01-50
12-13-50	12-22-50	12-31-50	1-10-51	1-21-51	1-30-51	2-07-51	6-08-50	7-01-50	9-01-50	9-17-50
239.7	217.2	212.7	242.1	258.3	217.4	196.2	408.3	542.5	621.5	378.3
Buck.#1	Buck.#1	Buck.#1	Buck.#1	Buck.#1	Buck.#1	Buck.#1	Pea	Pea	Buck.#1	Buck.#1
170	170	170	170	170	170	170	170	170	170	170
235	235	235	235	235	235	235	235	235	235	235
160	160	160	160	160	160	160	160	160	160	160
1	1	1	1	1	1	1	1	1	1	1
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1	1	1	1	1	1	1	1	1	1	1
3.1	3.1	3.1	3.1	3.1	3.1	3.1				
Closed	Closed (3)	1/4 Open	Closed (4)	Closed (5)	1/4 Open	1/4 Open	Closed	Closed	Closed	Closed
	1/4 Open		1/4 Open	1/4 Open						
Therma	Therma	Therma	Therma	Therma	Therma	Therma	-	-	-	-
valve	valve	valve	valve	valve	valve	valve	-	-	-	-
38	30	31	37	43	34	29	-	-	-	-
169	183	185	183	181	176	177	-	-	-	-
114	146	134	-	-	-	-	-	-	-	-
75	74	74	75	74	74	74	-	-	-	-
75	73	75	75	75	74	74	-	-	-	-
76	75	75	76	76	75	75	-	-	-	-
115-209	121-205	128-194	108-209	-208	117-203	116-206	144-207	153-203	152-200	151-203
149-424	146-478	153-467	118-459	129-427	126-455	148-478	140-389	149-394	144-364	143-351
51	50	50	50	50	50	50	62	68	68	68
140	141	137	138	138	134	138	146	145	142	142
1,005	1,121	1,062	1,091	1,038	985	1,056	386	445	546	363
117	137	134	141	136	134	128	78	110	138	108
28.8	37.9	29.1	31.0	28.0	29.5	32.3	6.8	7.4	14.1	9.8
6.2	8.4	5.0	5.5	3.5	5.1	7.2	0.0	0.0	0.0	0.0
22.6	29.5	24.1	25.5	24.5	24.4	25.1	6.8	7.4	14.1	9.8
1,120	1,010	990	1,130	1,210	1,010	920	2,520	2,600	2,100	1,620
370	398	381	383	334	362	368	-	-	-	-
4.19	5.16	4.99	4.51	4.02	4.53	5.43	0.95	0.82	0.88	0.96
0.35	0.34	34	0.35	0.36	0.34	0.35	0.47	0.34	0.29	0.37
0.41	0.41	0.41	0.41	0.42	0.41	0.41	0.48	0.48	0.59	0.59
2.22	2.41	2.37	2.37	2.51	2.27	2.49	-	-	-	-
11.7	15.1	15.1	14.0	12.6	14.8	15.6	4.6	4.9	5.3	6.9
2.5	3.2	3.2	3.0	2.7	3.1	3.3	0.8	0.9	1.0	1.3
0.12	0.12	0.13	0.13	0.13	0.14	0.12	0.20	0.25	0.25	0.30
2.88	4.19	3.28	3.08	2.61	3.25	3.95	0.40	0.33	0.54	0.62
0.62	0.93	0.56	0.55	0.33	0.56	0.88	-	-	-	-
0.02	0.02	0.01	0.01	0.01	0.01	0.02	-	-	-	-
2.26	3.26	2.72	2.53	2.28	2.69	3.07	0.40	0.33	0.54	0.62
45.0	52.6	45.4	46.7	47.2	49.5	47.1	35.2	33.3	51.7	54.0
112	112	112	112	112	112	112	148	115	81	103
37.0	44.0	43.0	38.0	31.0	40.0	45.0	-	-	-	-
2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	3.7	3.7
6.7	6.7	6.7	6.7	6.7	6.7	6.7	5.9	5.9	6.6	6.6
79.5	79.5	79.5	79.5	79.5	79.5	79.5	81.2	81.2	78.1	78.1
11.0	11.0	11.0	11.0	11.0	11.0	11.0	10.1	10.1	11.6	11.6
12,890	12,890	12,890	12,890	12,890	12,890	12,890	13,110	13,110	12,610	12,610
3,000	3,000	3,000	3,000	3,000	3,000	3,000	2,840	2,840	2,750	2,750
12.3	12.0	13.6	14.4	21.1	21.7	13.9	53.7	62.3	59.4	64.2
87.7	88.0	86.4	85.6	78.9	78.3	86.1	46.3	37.7	40.6	35.8

(1) 1/4 open 180.0 hrs. or 63% of total time
(2) 1/4 open 26.7 hrs. or 10% of the total time
(3) 1/4 open 49.2 hrs. or 23% of the time
(4) 1/4 open 218.1 hrs. or 90% of total time
(5) 1/4 open 234.3 hours or 91% of total time

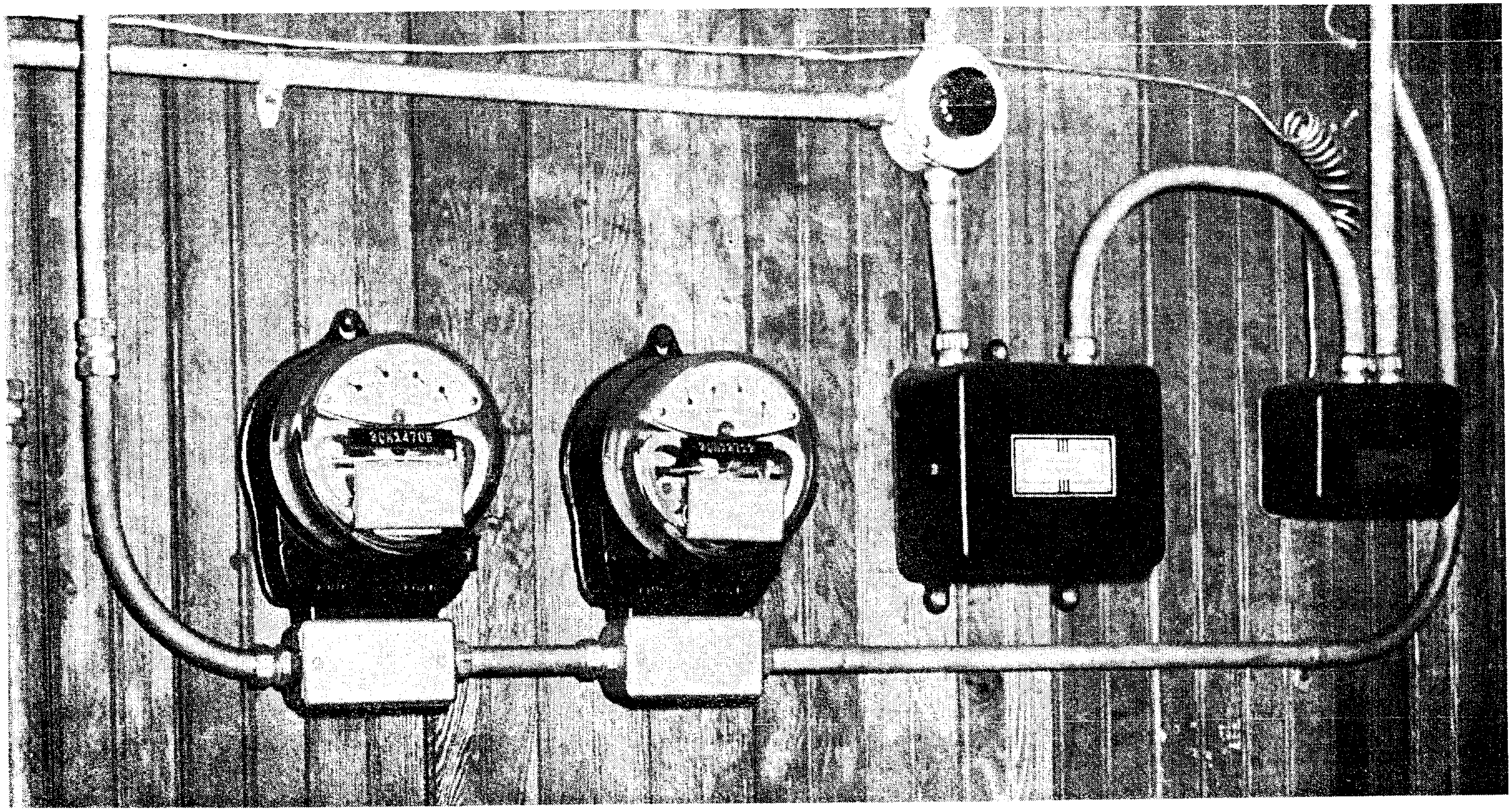


Figure 10. - Kilowatt-hour meters, hold-fire control box, and switch box for water-circulating pump.

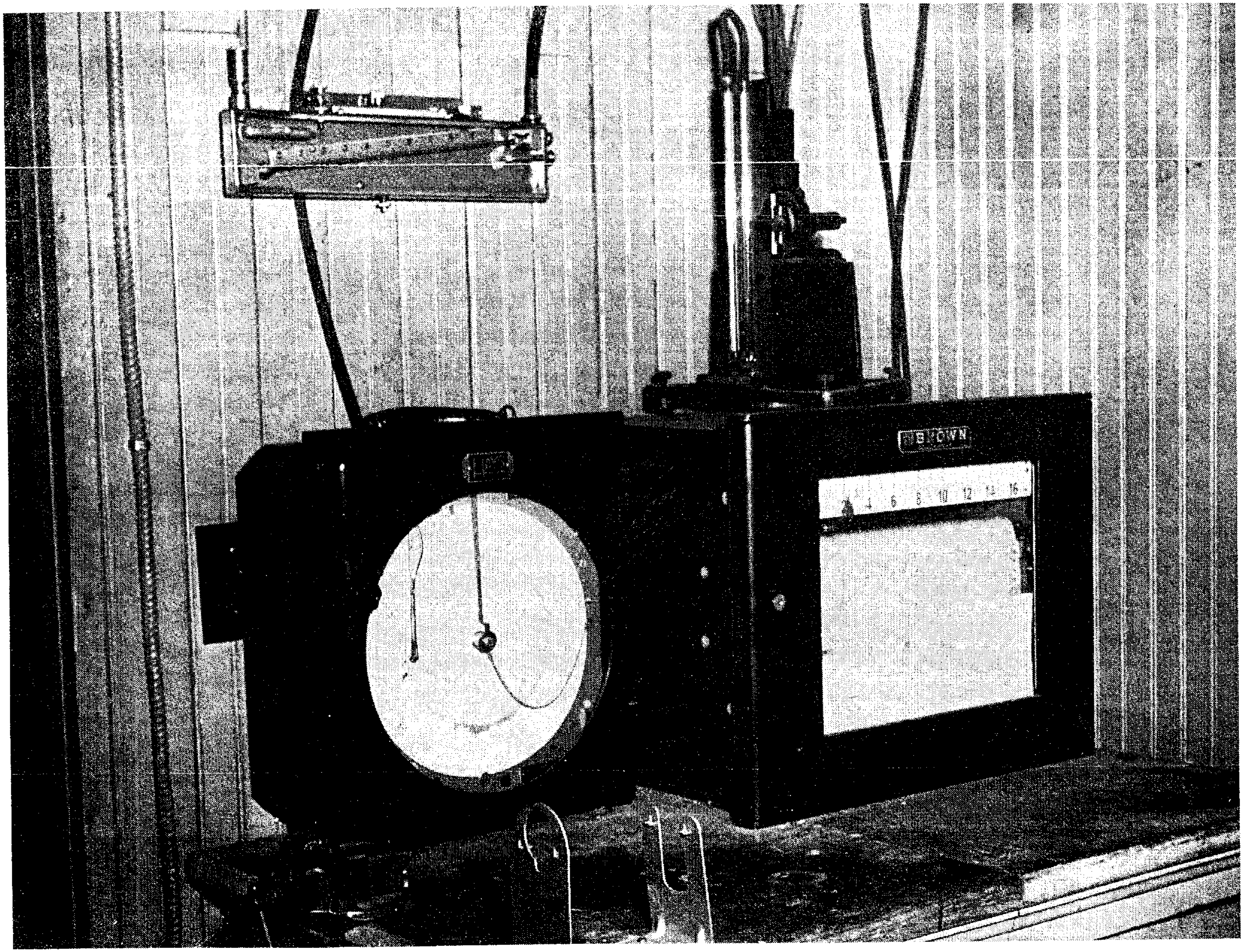


Figure 11. - Draft-indicating gages, draft-recording gage, and multi-point recording potentiometer.

	Pea	Buckwheat
H_2O .... percent	2.8	3.3
Volatile matter .... dry basis	6.1	6.9
Fixed carbon .... do	83.5	81.4
Ash .... do	10.4	11.7
Total .... do	100.0	100.0
B.t.u. (as received)	13,110	12,180
B.t.u. (dry)	13,490	13,180
Ash-softening temperature ....°F	2,840	2,880

TEST DATA

The equipment was tested under regular house-service operating conditions. To use Buckwheat in the Anthratube it was found necessary, owing to its more compact fuel bed, to drill a 7/l6-inch-diameter hole in balance plate W (fig. 4), so that more air could be provided over the fire. Without this air, the CO in the products of combustion would frequently, during start-up periods, build up to some 13 percent or enough to create an explosive mixture. The mixture would ignite and cause a “bump” or small explosion.

Table 1 shows the settings of the controls and the test data taken. For tests 1 to 7, inclusive, the return water from the radiators and the boiler water were proportioned for water to the radiators by the hand valves; for tests 8 to 21, inclusive, the proportioning was done automatically by the special valve controlled by outside temperature. Item 7 shows that higher maximum temperatures occurred for the first series. Although the control by outside temperature is the better method, there was in this case no noticeable difference in constancy of house temperature, as shown by test readings or in general house-heating comfort.

Item 9 shows the temperatures carried in the hall. The differences came essentially from different settings of the hall control thermostat. No change was made in the thermostat setting for the night hours.

Item 12 shows the momentary highest and lowest temperatures of the boiler water for each test. For the winter tests, both the high and low temperatures when using Pea coal were, in general, higher than when using Buckwheat coal. This was caused by the quicker "pick-up" of the Pea coal, the smaller-size Buckwheat responding more slowly to the fan draft. During the colder winter months, the fire is maintained in much more active condition than in the warmer fall and spring months, and there is a quicker response in heating up the boiler water. The boiler-water temperature at the boiler outlet can drop appreciably lower than the setting of the low-water temperature cut-off control, item 5c, because there is a temperature lag at the control point and also after the circulating-water-pump motor is cut off a flow of cold return water continues momentarily into the boiler. When the boiler-water temperature near the top of the boiler drops below about l40° F. for any length of time, satisfactory domestic hot water would not be available unless a properly sized storage tank was used with the heating coil. On these tests, temperatures below 140° F. were noted for only one test with Pea coal, but on all except one with Buckwheat coal. Since these low temperatures were of only short duration, no inconvenience was noticed from lack of hot domestic water except on two occasions with Buckwheat coal during warmer months. Raising the temperature setting of item 5c somewhat would have improved, this situation; item 5a could also have been carried, higher. Higher boiler-water temperatures than the setting of 5a occurred from continuing activity of the fuel bed after the Anthratube motor was cut off by the main thermostat and whenever the hold-fire running period happened to follow immediately the end of a running period under main thermostat control. This overrun was never enough, however, to cause the safety control to operate.

Item 13 shows the range of flue-gas temperature for each test. These temperatures are low. Flue-gas temperatures lower than boiler-water temperatures are shown, because when the Anthratube fan is not running, balance plate W (fig. 4), is no longer held against I the sight or inspection tube, and an air flow over the top of the fuel bed and through the boiler to the stack results from natural draft. In passing through the boiler the air is not heated as high as boiler-water temperature. This balance-plate action also lowers fuel-bed activity when no heat is required. The amount of heat, produced by the fuel bed during off periods, that goes into the boiler water must be lost from the boiler by radiation, conduction, or convection to prevent undesirably high boiler-water temperatures.

Item 15 shows the various temperatures used for domestic hot water, A setting to obtain about 142° to l45° F. gave best satisfaction. The tempering valve held this maximum satisfactorily. It was not possible to record accurately possible instances when the temperature fell below that desired, as the demand for hot water was usually relatively short and between demands the temperature of the piping dropped at times even to room temperature. Often, enough hot water was obtained to meet the need before the maximum temperature was reached.

Item 28 indicates approximately the number of cans of ash per week. The weight of ash per can varied somewhat, say from 28 to 38 pounds, depending on the specific gravity of the ash and on the fullness of the can when removed.

Item 32 shows the kilowatt-hours per degree-day used by the water-circulating pump. The amount of pumping can be decreased for a heating system if some natural circulation of the water can occur. The flow-control valve (fig. 9) prevents such circulation. If the flow-control valve is adjusted so that it does not close completely when the circulating pump is not running, some continuous natural circulation of the water will result. This gives a more nearly constant heating effect. In using such a scheme, it is necessary to adjust the flow-control valve so that the resulting natural circulation will not quite heat the house, the water-circulating pump making up the deficiency. This scheme is most applicable during continuously cold weather, when there is less chance of overheating the house during unexpected mild weather. Item 5h,together with item 32, shows the appreciable decrease in kilowatt-hours, used per degree-day for the pump when the flow-control valve is opened a little. During these tests it was frequently necessary to close the valve owing to erratic weather conditions. For heating systems having enough natural or gravity circulation for the coldest weather conditions, the type of valve that is opened and closed under the control of a room thermostat could be considered as a substitute for the circulating-water pump with the flow-control valve. There would be some lag in the natural circulation as compared to that induced by a pump; this should not be serious for most cases because of the general flywheel effect of the heat of the house, Where the pump is relied upon as a safety device to prevent high temperatures in the heater as arranged for the Anthratube, its elimination might be questionable, unless enough natural circulation is assured.

Item 35 shows the estimated use of domestic hot water per day. For tests 22, 23, 24, and 25 the amount used was calculated from the coal used and the heat losses. Much variation in the amount of hot water used from time to time is indicated. An average of these figures was used for the remaining tests.

Figures 12 to 17, inclusive, show some correlations of the test data. Figure 12 shows the pounds of coal per degree-day for house heating plotted against the outside temperatures. The amount of Buckwheat coal used per degree-day is shown to have been about the same as that of the Pea coal, although there is some evidence that more Buckwheat than Pea was used during the higher outside temperatures. Figure 13 shows the kilowatt-hours used per 24 hours by the Anthratube for various outside temperatures. Less electrical energy was required, to burn Pea than to burn Buckwheat. Figure 14 shows the kilowatt-hours used per ton of coal burned; again the kilowatt-hours used for Pea was less, particularly in the summer months. The more compact fuel bed of the Buckwheat gives more resistance to the flow of air. It is slower in reaching a full fire. The great difference in the kilowatt-hour use of the Pea from that of the Buckwheat in summer is not only due to the slowness of the Buckwheat in responding to the draft but also to the greater amount of Pea coal burned by natural draft during the long off-periods of Operation.

Figure 15 shows the percentage of combustible in the refuse related to outside temperature and figure 16 related to the pounds of coal burned per hour. Better burn -out of combustible was obtained when the Anthratube operated more nearly continuously. Better burn-out was also obtained with Buckwheat than with Pea during house-heating periods; for summer operation it was

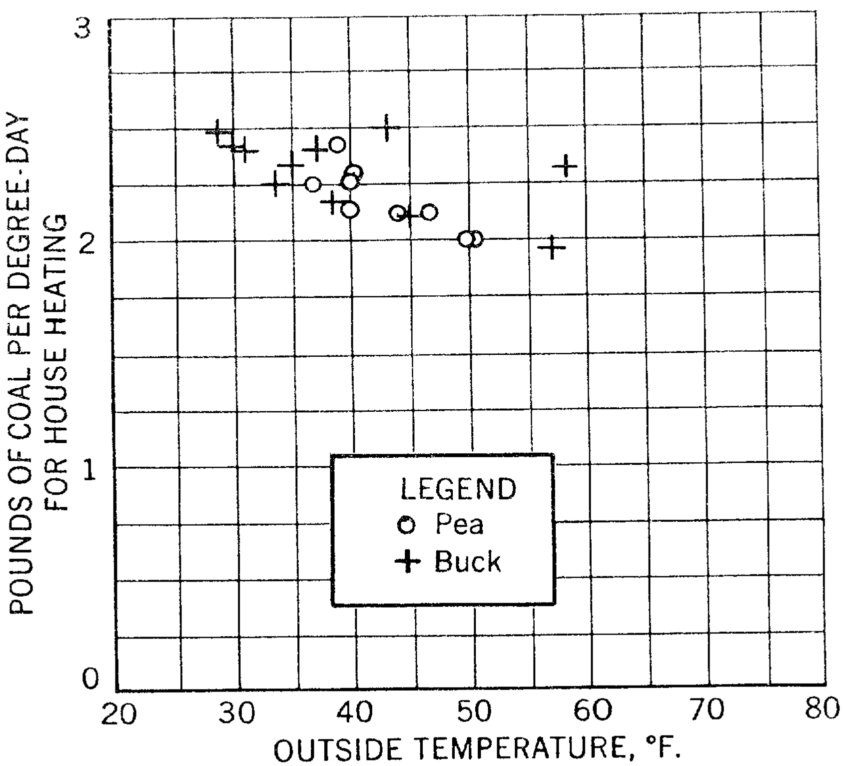


Figure 12. - Pounds of coal used per degree day by the Anthratube for house heating for various outside temperatures.

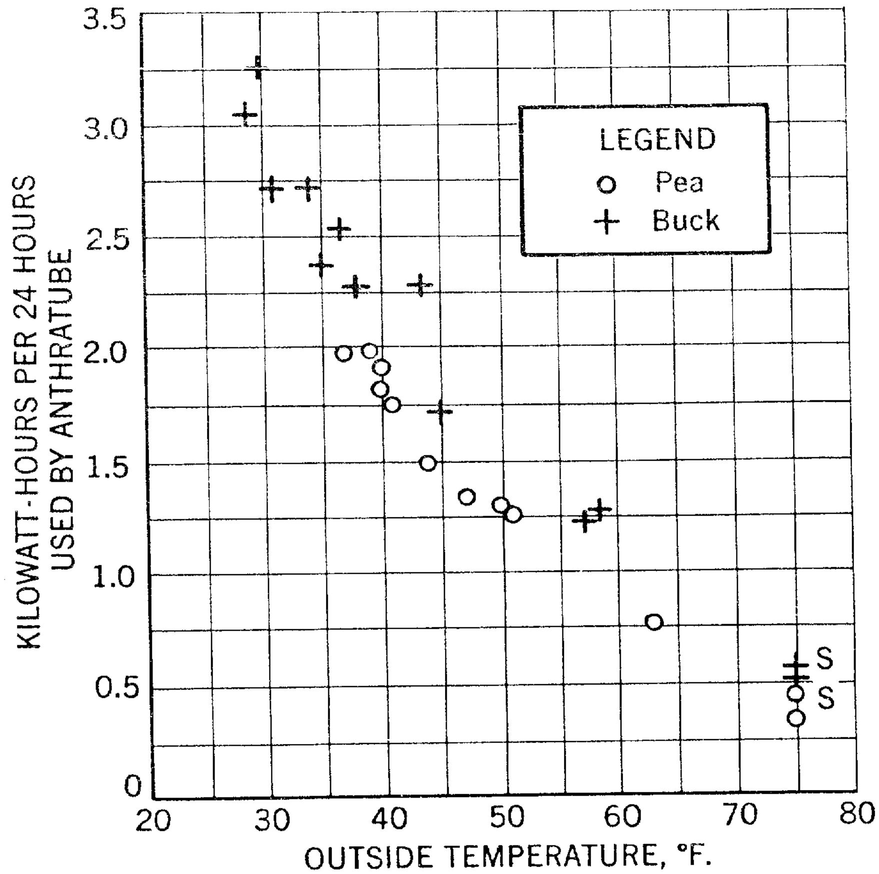


Figure 13. - Kilowatt-hours per day used by the Anthratube for various outside temperatures. S designates summer operation.

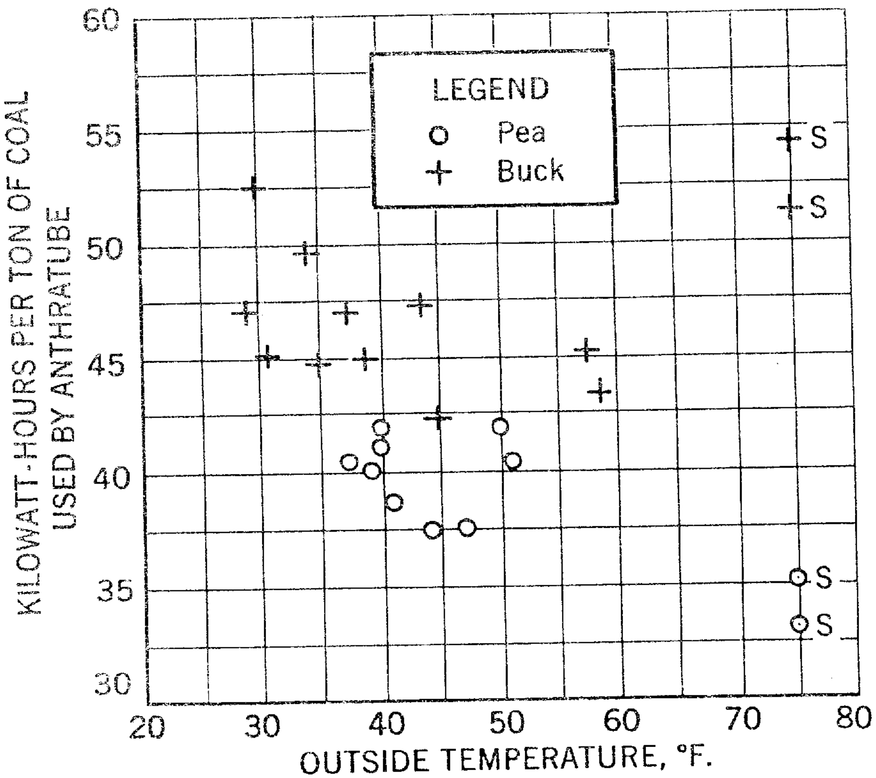


Figure 14. - Kilowatt-hours per ton of coal used by the Anthratube for various outside temperatures. S designates summer operation.

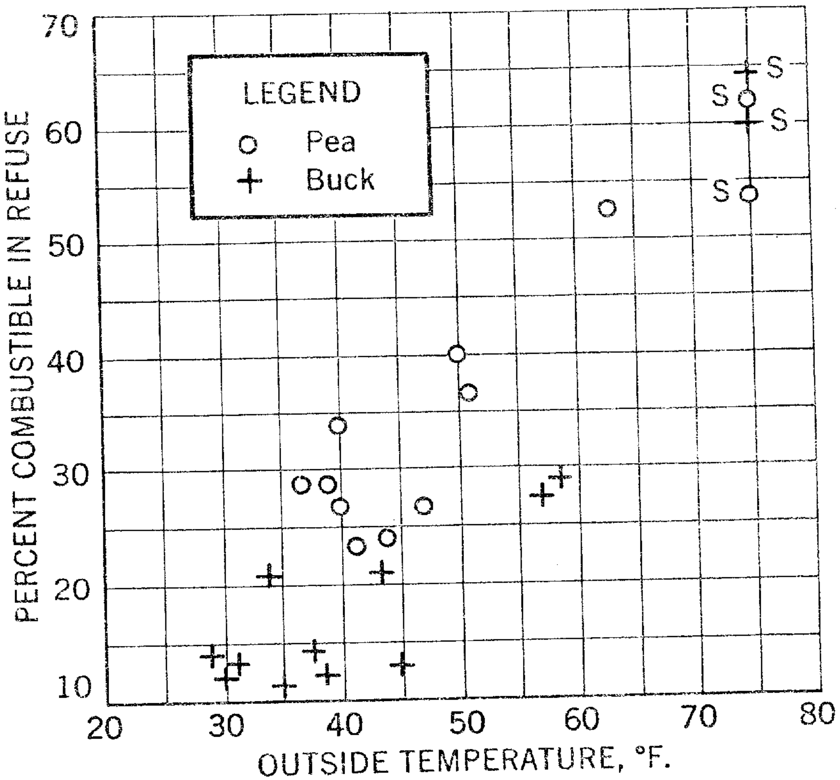


Figure 15. - Percent combustible in refuse for various outside temperatures. S designates summer operation.

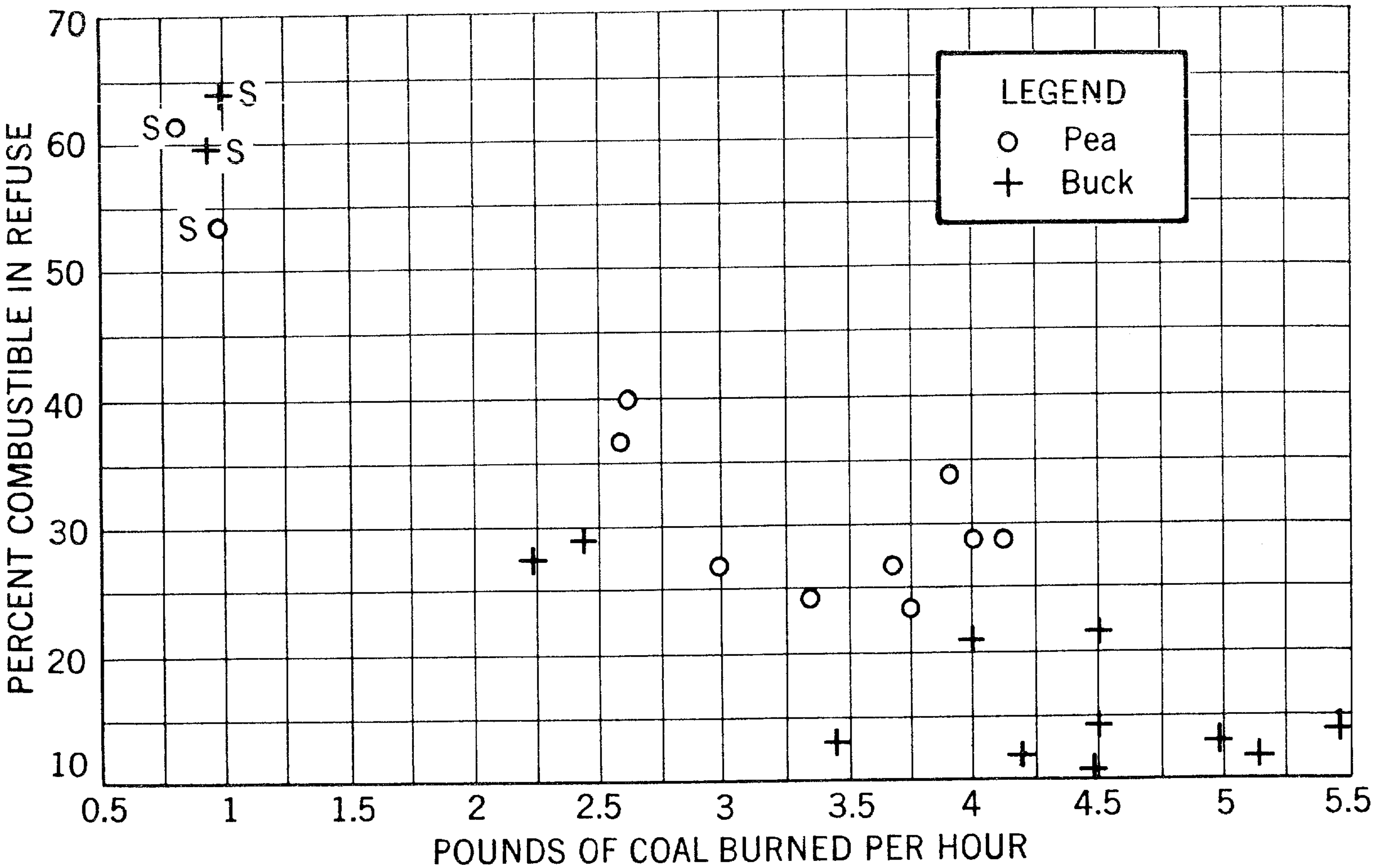


Figure 16. - Percent combustible in refuse related to pounds of coal burned per hour. S designates summer operation.

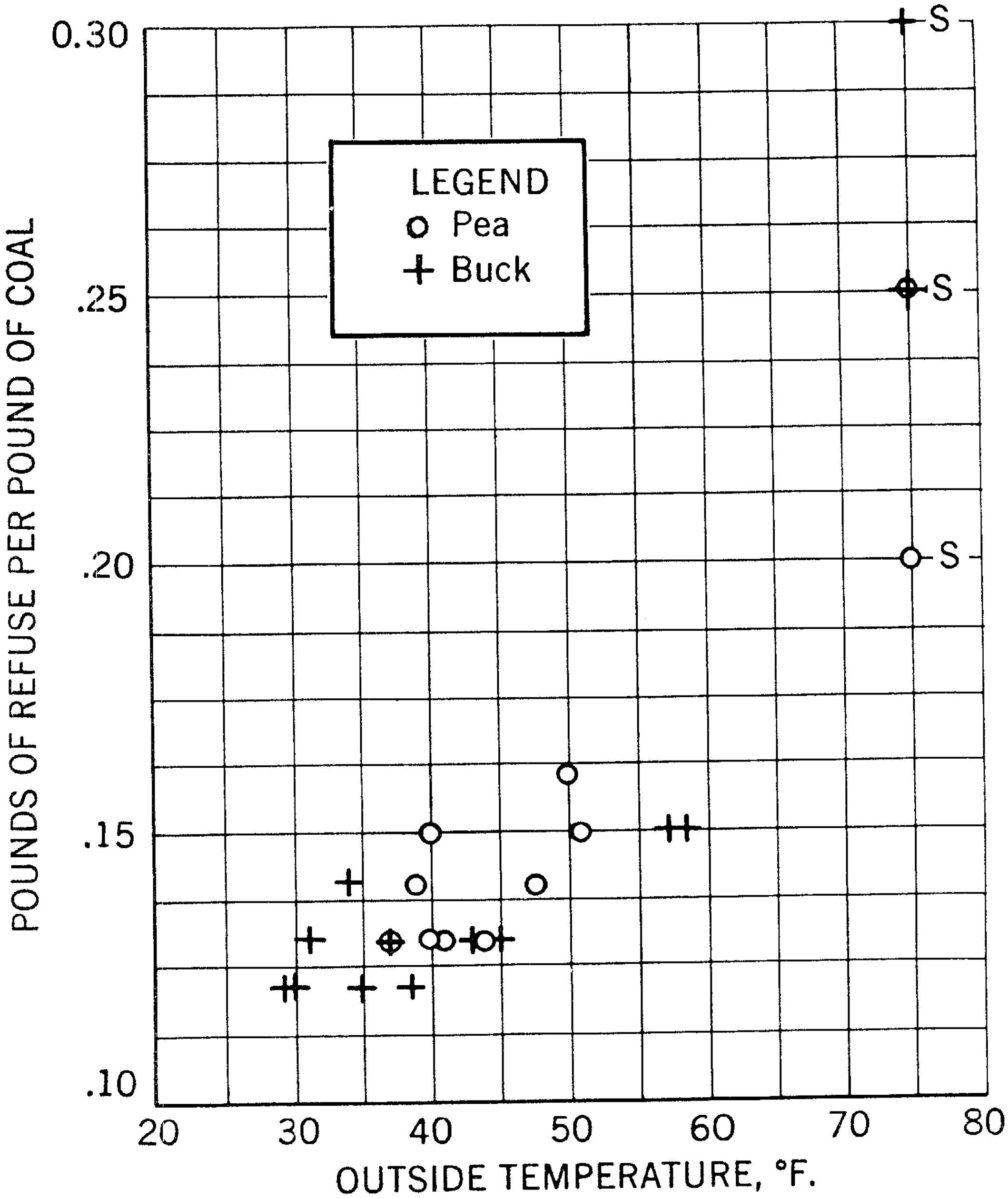


Figure 17. - Pounds of refuse per pound of coal for various outside temperatures. S designates summer operation.

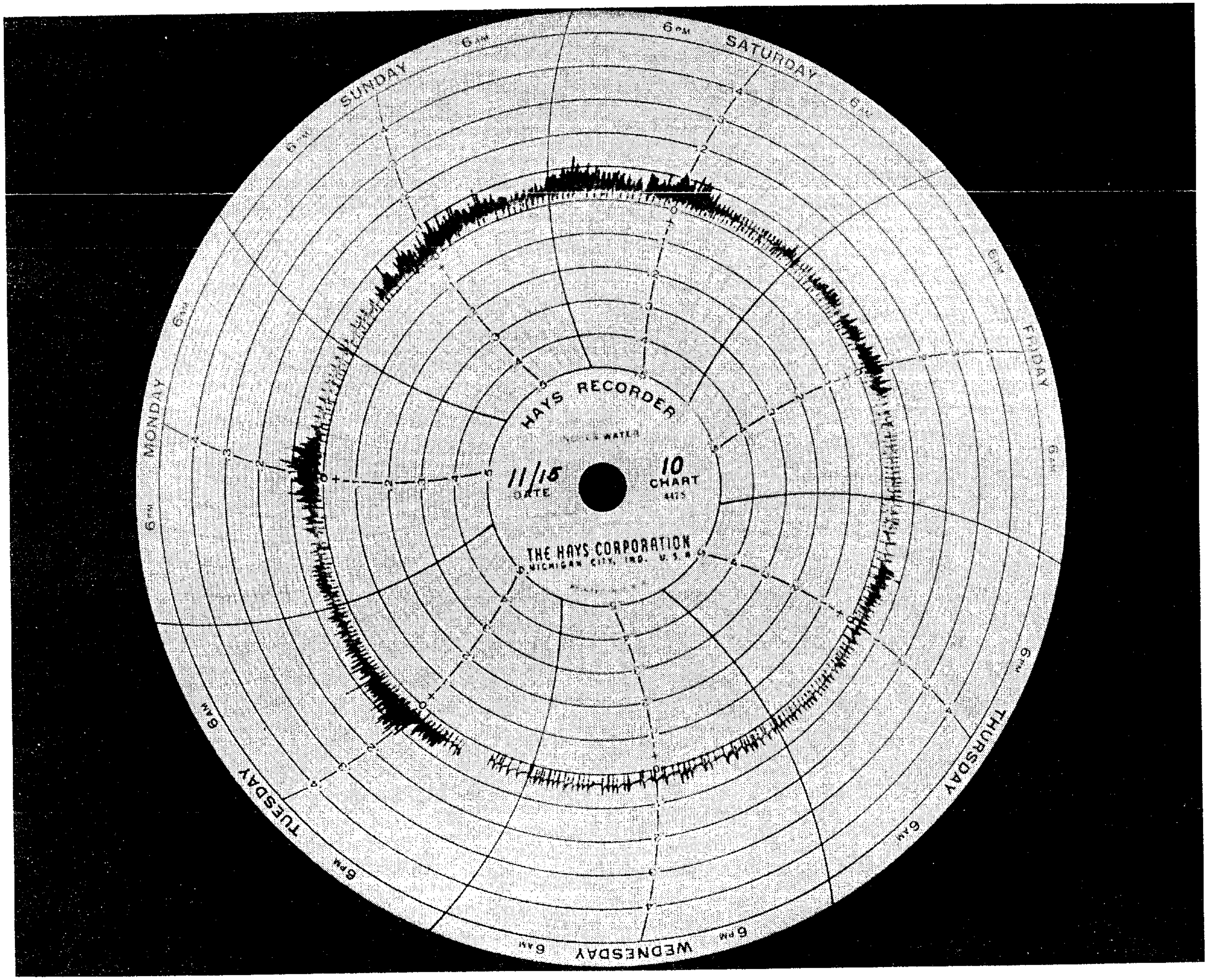


Figure 18. - Typical chart of draft in breeching of Anthratube for winter operation with Pea coal.

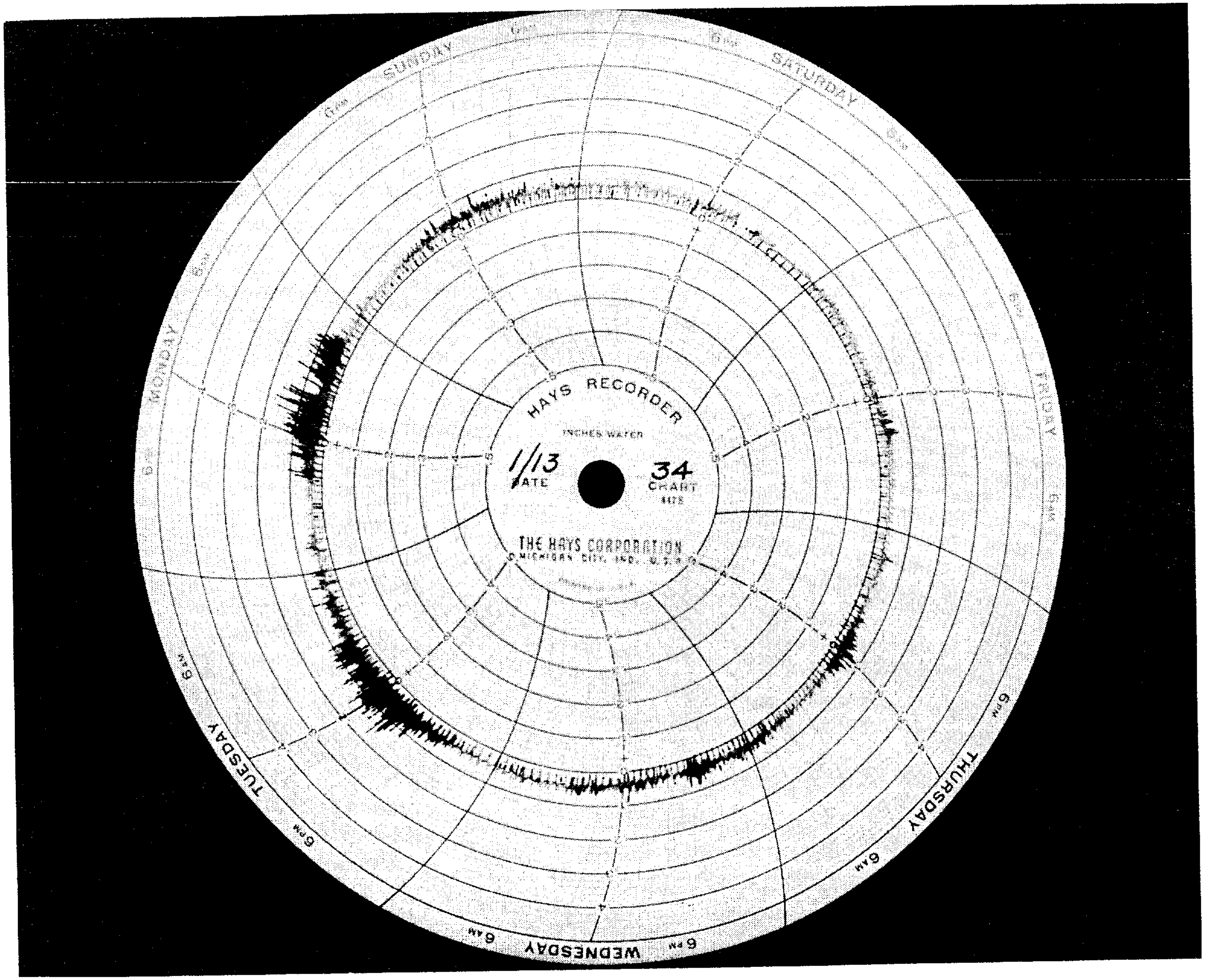


Figure 19. - Typical chart of draft in breeching of Anthratube for winter operation with Buckwheat coal.

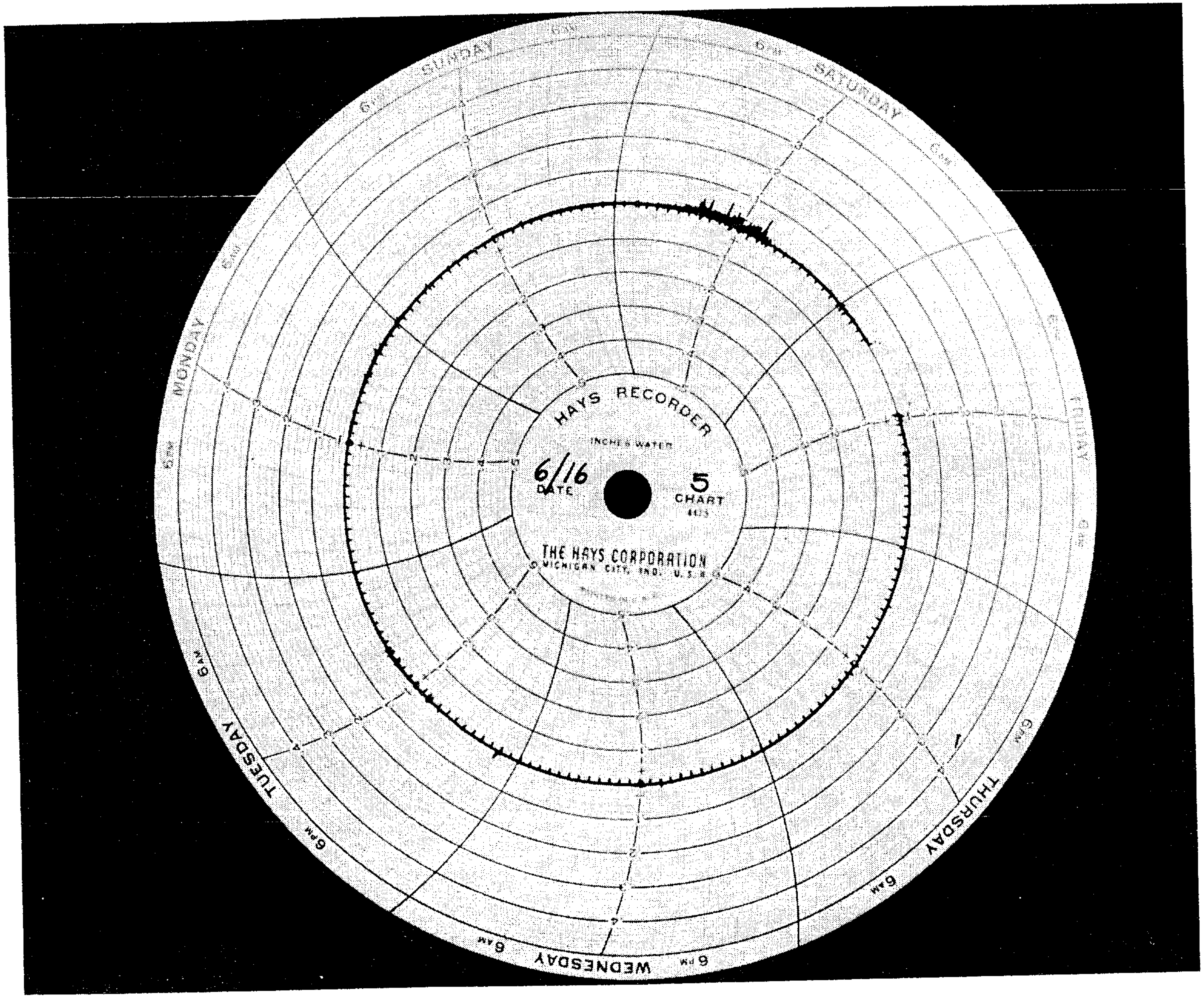


Figure 20. - Typical chart of draft in breeching of Anthratube for summer operation with Pea coal.

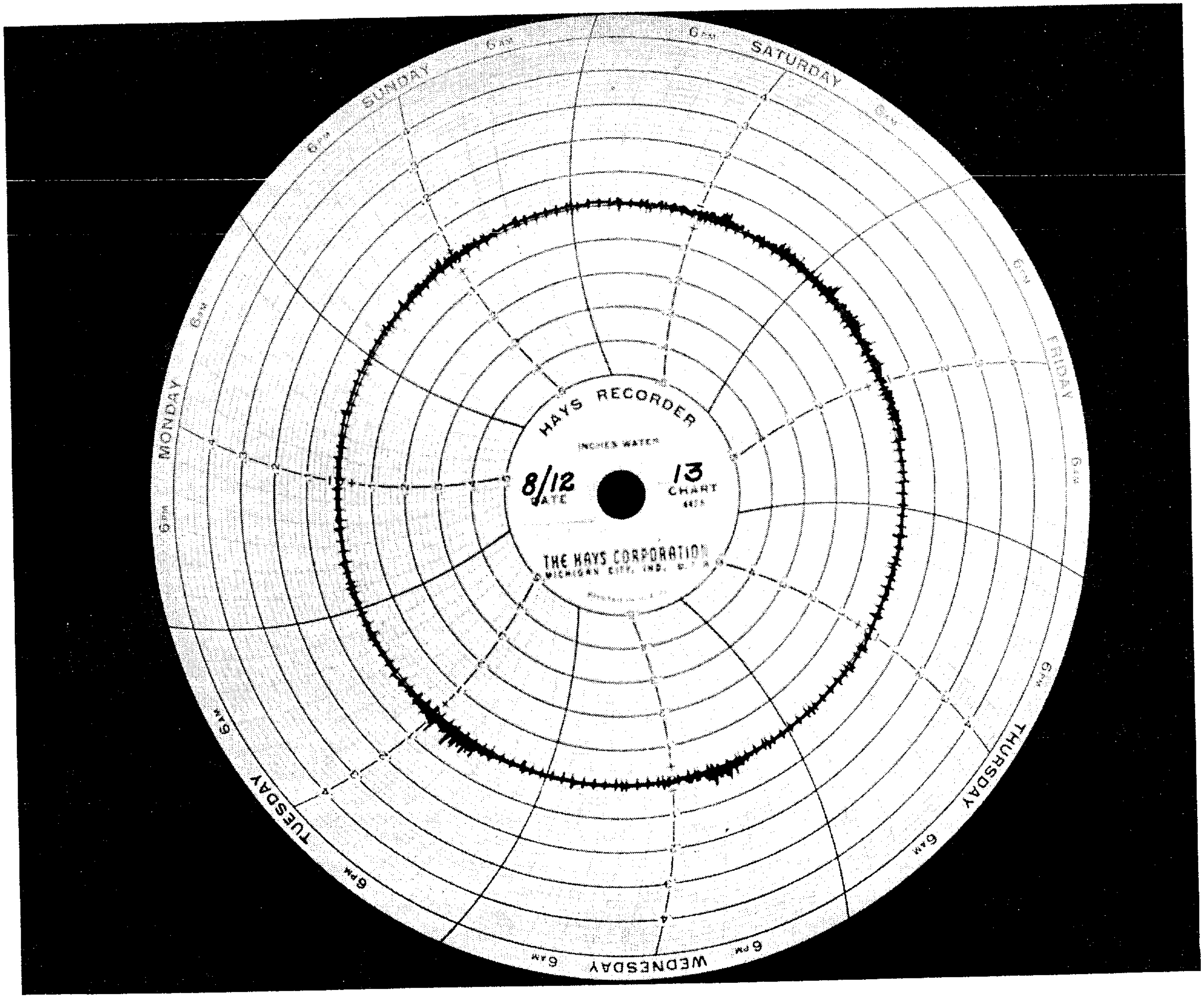


Figure 21. - Typical chart of draft in breeching of Anthratube for summer operation with Buckwheat coal.

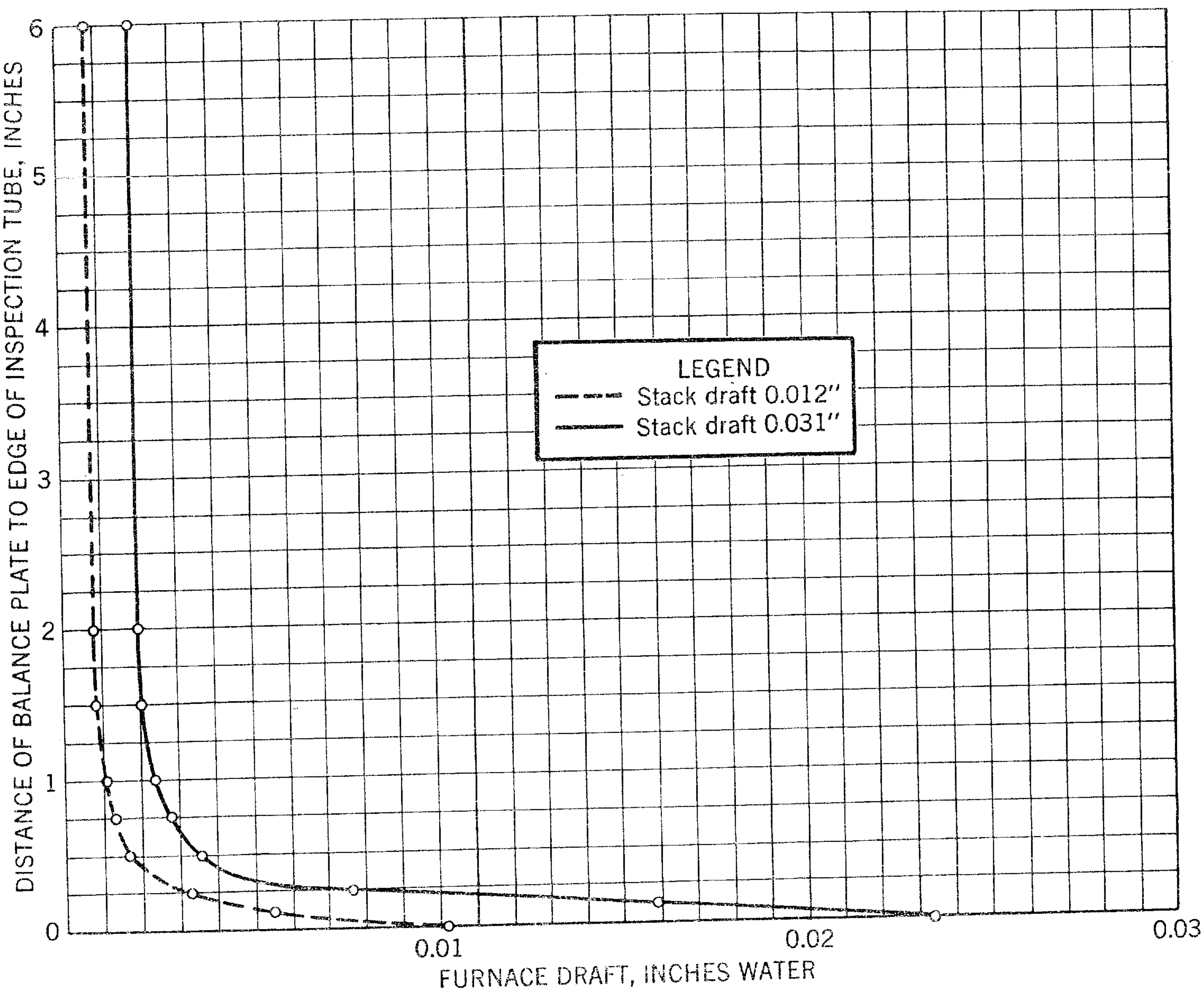


Figure 22. - Effect of distance of balance plate from edge of inspection tube during off periods.

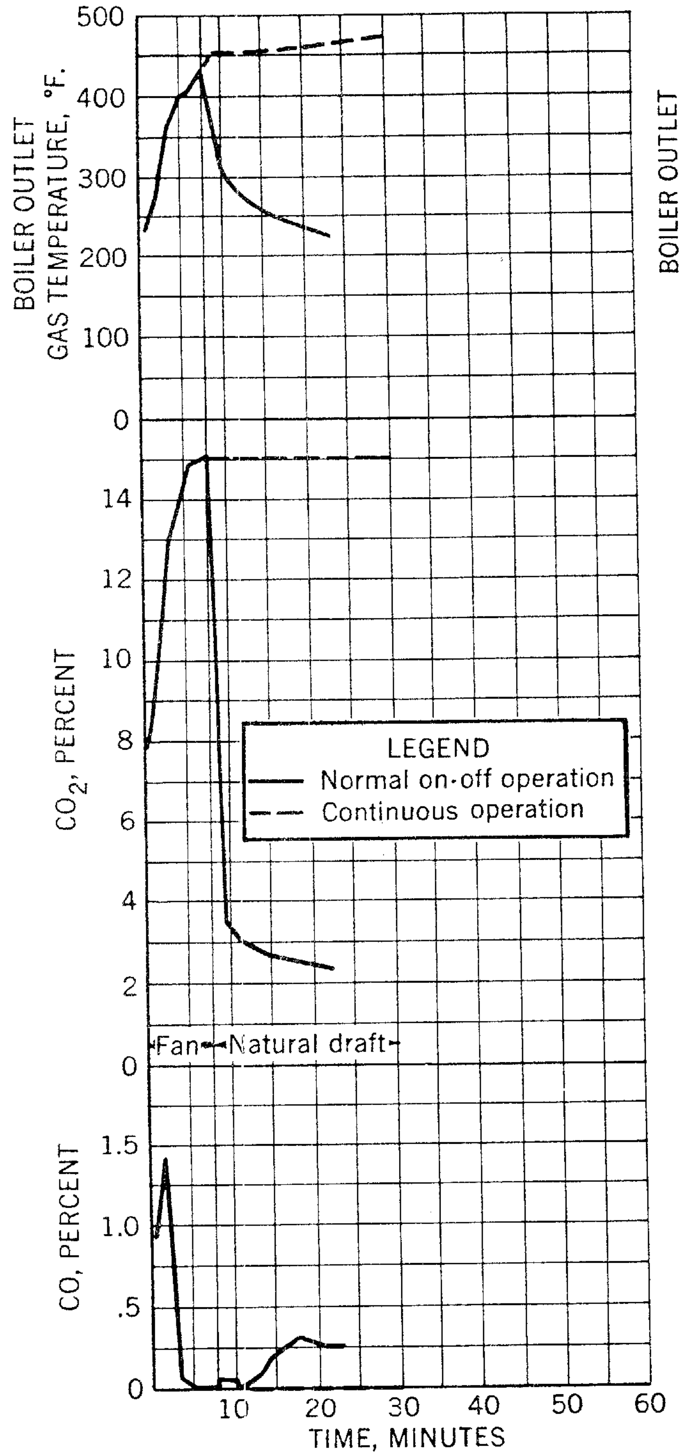


Figure 23. - Winter operation with Pea coal - typical boiler-outlet gas temperatures and percentages of CO_2 and CO.

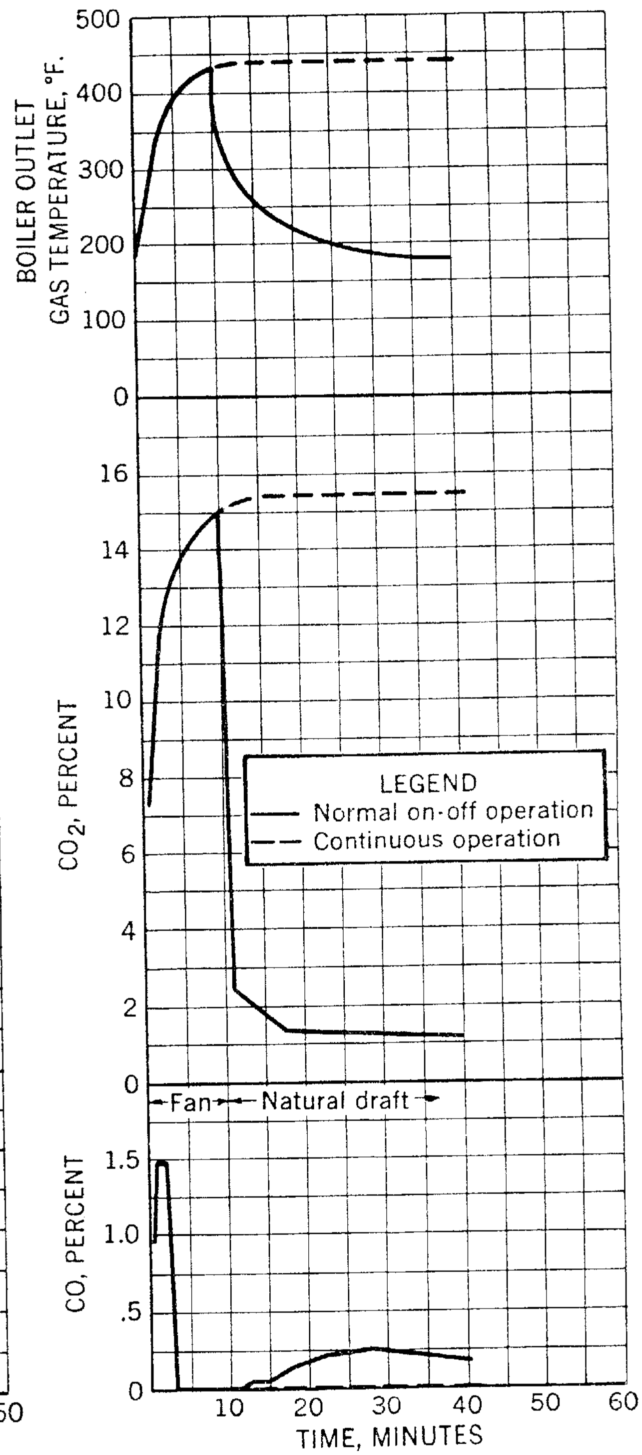


Figure 24. - Winter operation with Buckwheat coal - typical boiler-outlet gas temperatures and percentages of CO_2 and CO.

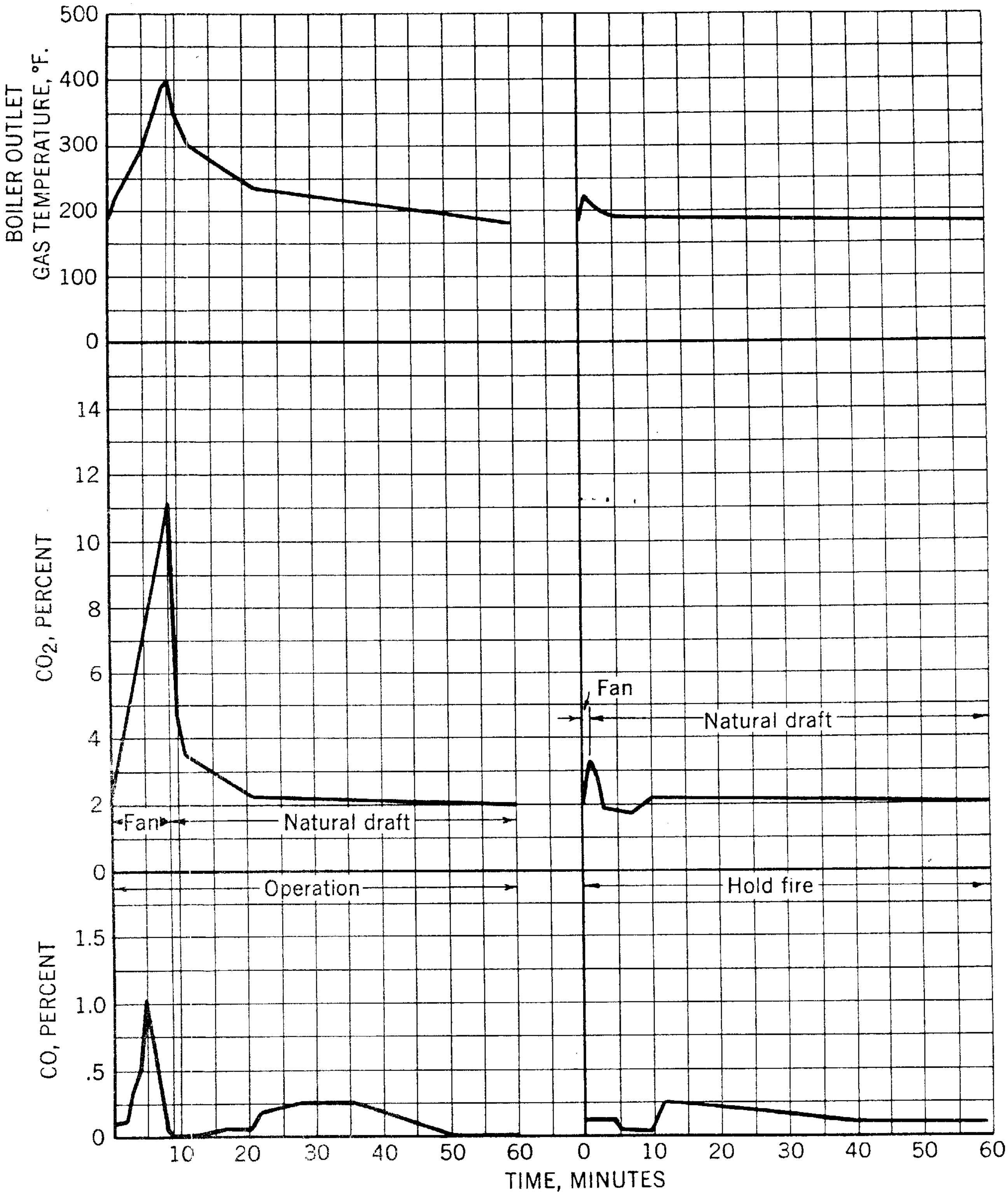


Figure 25. - Summer operation with Pea coal - typical boiler-outlet gas temperatures and percentages of CO_2 and CO.

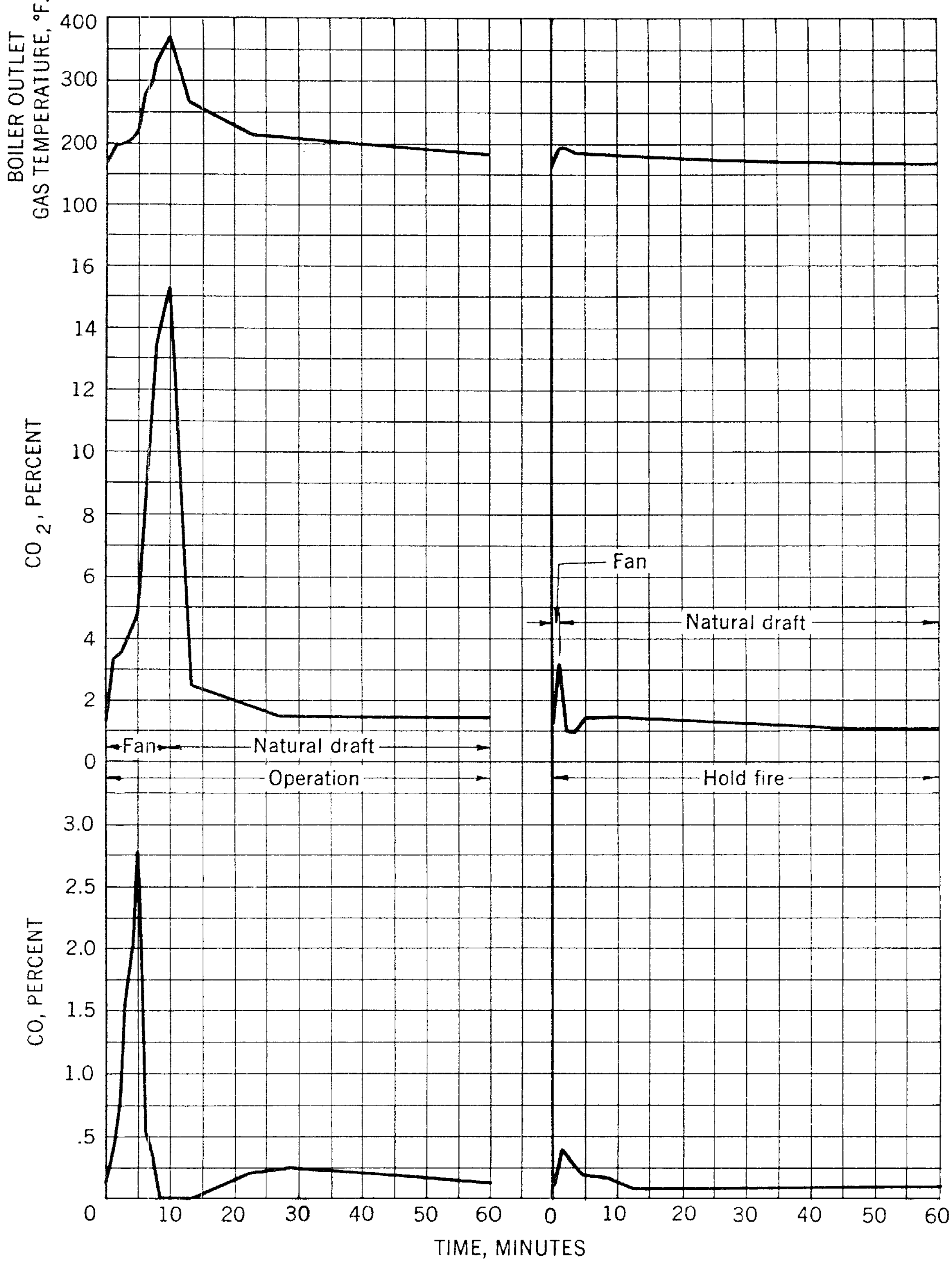


Figure 26. - Summer operation with Buckwheat coal - typical boiler-outlet gas temperatures and percentages of CO_2 and CO.

Figure 27. - View of dwelling in which Anthratube was installed.

about the same for both coals. For test 22, somewhat better burn-out (see item 40a of table 1) was obtained than for test 23, both tests of summer operation with pea. The first half of test 22 was run with a grate movement of one notch (see item 5f) and. the last half with three notches. It was found necessary to increase the grate movement during the test to prevent a build-up of ash that was about to extinguish the fire. Figure 17 shows the pounds of refuse per pound of coal.

Figures 18, 19, 20, and 21 show typical charts of the draft in the breeching near the Anthratube. When an on period begins there is a momentary decrease of draft caused by the quick action of the fan-air pressure, as shown by the low points of the draft record. As chimney draft is reestablished, the draft increases with the increase of the temperature of the flue gases until the Anthratube cuts off. The draft then decreases to some essentially constant value or until the next on period, begins. Since each on period was relatively short, the draft record for the period took the form of a line perpendicular to the draft lines of the chart for its lower part, its upper part being very slightly curved. Most such lines on the summer charts show hourly hold-fire runs of 1 minute each. Without the house-heating load, the Anthratube ran from about 25 to 90 minutes per day other than the hold-fire runs. Although there was pressure momentarily in the breeching at the point of draft measurement, particularly during the summer months, the breeching was free from leaks, and there was not 1eakge of products of combustion into the basement. The draft charts also show the changes of the natural draft from erratic winds passing the top of the chimney. Winds are indicated whore the chart-record line becomes a solid mass having erratic and various unusually high draft points. See Tuesday of charts in figures 18, 19, and 21, for examples. A barometric-typo damper could have smoothed this out but was not considered necessary.

Figure 22 shows the effect on the furnace draft over the fuel bed of different open positions of the balance plate during off-periods. The amount of this draft is a factor in the rate of burning of fuel during these periods. It shows that the balance plate should ordinarily hang about 1 inch from the edge of inspection tube I (fig. 4).

Figures 23, 24, 25, and 26 show typical temperatures of the products of combustion leaving the boiler and their percentages of CO_2 and CO. Figure 23, for Pea coal, winter operation, shows that when operation begins after an off-period the gas temperature rises for about *9* minutes and then tends to level off under continuous operation; the CO_2 quickly reaches about 8 percent, continues to rise until after about 8 minutes a constant 15 percent CO_2 ±5 held; the CO rises for about 2 minutes, then drops sharply to 0 percent and remains there. If the Anthratube shuts off 8 minutes after starting, the gas temperature drops sharply, then more slowly to some 200° F. after 22 minutes from the cut-off; the CO drops to about 2 percent; the CO begins to increase and rises to about 0.25 percent. Figure 24, for Buckwheat coal, winter operation, shows about the same general action. As compared to the Pea coal, the final CO_2 for continuous operation is a little higher, about 15-1/2 percent. After the cut-off the CO_2 for Buckwheat drops somewhat farther than for Pea, going to about 1.2 percent; the CO percent shows a little lower. Figure 25 for Pea coal, summer operation, and figure 26 for Buckwheat coal, summer operation, show running cycles and the 1-minute hold-fire cycles. The effects of the colder, less active, fuel bed is shown on all items, particularly during the running period.

CAPACITY OF EQUIPMENT

The Anthratube was rated at 130,000 B.t.u. per hour. Its exact capacity depends not only upon the size and characteristics, particularly the volatile and. the ash content of the coal used, but also upon the fan speed and the grate setting chosen. To check, at least approximately, the capacity with the two coals available on these tests, domestic hot water was drawn at a rate that kept the Anthratube running continuously. The B.t.u. per hour into the water was determined from the amount of water heated and its rise in temperature. With the Pea coal, about 123,000 B.t.u. per hour of useful heat was produced with the fan speed and grate setting used for winter operation; with the Buckwheat about 113,000 B.t.u. per hour. The rate with the Buckwheat, with its more compact fuel bed, was about 92 percent of that of the Pea coal. These rates could have been substantially increased or decreased to values above or below the 130,000 B.t.u. as rated by the manufacturer by varying the fan speeds. The coal-burning rates were about 11.5 pounds per hour for Pea coal and about 10.6 pounds per hour for Buckwheat. Either of the ratings was well above that actually required on the average for this installation, For en average outside temperature of about 29° F., the coldest average for any test period, the Anthratube operated on the average only about 35 percent of the time with Buckwheat coal. Had Pea coal been used, the operating time average would have been about 30 percent of the total time.

The B.t.u.-per-hour values of 123,000 and 113,000 also give the B.t.u. that could be put into domestic hot water with no heat for house hasting. The actual gallons per minute of hot water at, say, 140° F. that could be drawn depends upon the temperature of the cold water to be heated and the temperature of the boiler water in the Anthratube surrounding the heating coil. The value of 123,000 B.t.u. is equivalent to about 2.5 gallons per minute of water heated from 140° to 140° F., or 3.1 gallons from 60° to 140° F. The 113,000 B.t.u. value is equivalent to about 2.3 gallons per minute from 40° to 140° F., or 2.9 gallons from 60° to 140° F.

EFFICENCY OF EQUIPMENT

Table 2 shows an approximate heat balance when stabilized burning conditions have been reached after starting (fig. 23 and 24). The number of minutes before such conditions are reached after starting depends to an appreciable extent upon the condition of the fuel bed or the length of time of the off-period just before the start, For the conditions shown in figures 23 and 24, an efficiency, as related, to heat for space heating and domestic hot water, of about 76.5 percent is reached after about 1 minute. The efficiency continues to rise for about 4 minutes and then levels to about the figures shown in table 2, item f, or 81.6 percent for Pea and 84.0 for Buckwheat. The chief reason for the somewhat better efficiency of the Buckwheat coal is the better burn-out of combustib1e in the ash. If the heat radiated from the boiler and connecting piping is useful, the efficiency, as related to heat to water in the boiler, is expressed by item h in table 2, or 84.0 percent for Pea and 86.7 percent for Buckwheat.

TABLE 2. - Approximate heat balance for continuous running conditions

	Pea		Buckwheat No. 1	
	B.t.u.	Percent	B.t.u.	Percent
Heat balance, based on coal as fired: a. Loss due to heat carried away by steam in flue gasses	309	2.24	296	2.3
b. Loss due to heat carried away by dry flue gasses	1,198	9.1	1,139	8.8
c. Loss due to carbon monoxide	20	.2	0	0
d. Loss due to combustible in ash and refuse	564	4.3	279	2.2
e. Loss due to radiation	318	2.4	345	2.7
f. Heat available for space heating and domestic hot water	10,701	81.6	10,831	84.0
g. Heat in coal	13,110	100.0	12,890	100.0
h. Heat to water in boiler	11,019	84.0	11,176	86.7

For a summer day, assuming no hot water is used, the efficiency as related to heat for space heating and hot water drops to zero, all of the heat of the burning coal being used to make up losses while the equipment is held in readiness with water in the boiler at its usual temperature. For summer operation for this installation it was estimated that as related to heat to domestic hot water the efficiency was about 23.6 percent for Pea and about 18.4 percent for Buckwheat. There was better CO_2 and less CO for the Pea than for the Buckwheat. As related to heat to the boiler water these efficiencies become about 65.3 percent for Pea end about 55.6 percent for Buckwheat. It was found that the heat radiated to the basement was beneficial and worth paying for in coal used. Before the Anthratube was installed, dampness of varying amounts was a nuisance in the basement throughout the summer. The relatively small amount of heat radiated caused all dampness to disappear, although the temperature of the basement was not appreciably higher. Clothes from the washer hung in the basement on rainy days dried readily, and the housewife stored foods, such as cereals, near the Anthratube. Removing insulation from any basement hot-water heater could well solve dampness difficulties in many basements.

The over-all efficiency for a given installation depends upon the proportion of the time the equipment actually is running. As the running periods increase in relation to the total time, the over-all efficiency increases; also, the efficiency when using Buckwheat, although lower for summer operation, rises to equal and pass the efficiency with Pea. As far as the total amount of coal used a year is affected, the low efficiencies apply only when coal is being burned at very low rates.

GENERAL OPERATION

The Anthratube, completely automatic in its operation, is rugged and remarkably free from operating difficulties. Properly installed and inspected and the proper settings of its controls determined, the equipment requires little or no further mechanical or electrical attention, Its control equipment, standard for various uses, should require the major part of any operating maintenance. A general inspection once a year should he given the equipment. A careful inspection ordinarily requires about 2 hours. It includes checking all set-screws of pulleys, nuts, and bolts for tightness; examination of the two belts for cleanliness, wear, and running tightness; proper lubrication; checking and cleaning of contact points of controls; and checking control action.

An imperfect feature of the Anthratube is that the fly-ash collector does not deposit all of its catch in the refuse. A small part reaches the floor near the ashcan within the base. The fly ash accumulates, and in time some of it will be dragged out onto the basement floor when the can is removed. It is then desirable to clean out the base. If this fly ash ceases to fall, it is evidence that the spill hole at the bottom of the collector is plugged. This occurred once, but it was readily opened by opening the door at the left of the base, reaching up over the grate, and dislodging the accumulation with a short rod.

The Anthratube requires very little chimney draft, since its fan supplies most of the pressure differential needed.

The Anthratube ordinarily should be operated both summer and winter. If allowed to stand idle in locations such as the ordinary basement, dampness and condensation would cause rusting and corrosion, thus shortening the life of the boiler.

The entire heating equipment as installed in the house under test gave essentially constant hall and living-room temperature. For the several temperatures chosen, item 9, table 1, the variations from that chosen could not he satisfactorily recorded by the potentiometer. Occasional readings of hall thermometers appeared to indicate the variations to be less than 1° F. This closeness of control has much bearing on the total amount of coal used for heating, particularly when outside temperatures are milder. The amount of he at required for heating or that lost from the house is roughly proportional to the difference between the outside and inside temperatures. For example, if the outside is 58° F. and. the inside 70° F., the difference is 12° F.; if the inside is allowed to rise to 74° F the difference becomes 16° F., and for stabilized conditions about one-third more heat is leaving the house.

There was little difference in house service results when either Pea or Buckwheat was used. Somewhat more fly ash accumulated in the breeching and in the base of the chimney with the Buckwheat. The chief difference was in the action of the feed tube in feeding the coal when very wet. In order to feed, the coal must slide on the side of the tube. When Buckwheat is very wet the film of water on the coal pieces, particularly the smaller ones, will cause them to adhere to the tube and not slide so as to follow the spiral guide upward. For Pea coal, however, the pieces are large enough so that feeding will be accomplished. Many anthracite dealers wet the coal to allay dust during delivery. Frequently this is greatly overdone, and. much water settles to the floor of the bin a short time after coal has been stored. This can cause considerable trouble when Buckwheat is being used. Applying heat to the lower part of the tube with an ordinary electric radiant heater is helpful. To keep the Anthratube operating under such conditions, it might be necessary to remove the plate at the top of the feed tube and manually feed coal until that near the floor of the bin becomes dry enough to be fed by the tube. Removing this plate also permits visual inspection with a flashlight of conditions within and at the base of the tube. The base of the tube may be reached by pushing a rod through the central hole of the tube or it may be reached from beneath it near the bottom of the “dog house” (fig. 4). During operation, coal fines will accumulate in time near the end of the feed tube. This will not affect the feeding unless excessive moisture reaches the fines; a wet gob then is formed that even may prevent feeding Pea coal. In this case, pulling the fines out through the dog house by poker or small hoe is desirable. Any very wet Buckwheat had best be delivered on top of considerable coal that has become dry in storage.

The decision as to which size of coal to use for a given installation is an individual matter; items requiring consideration include the cost per ton of each size, the B.t.u. content per pound as received, the amount of ash, the problem of excessive wetness, the availability of each size, the proportion of the total time the equipment will run, and the cost of electric current.