HARRY R. FRASER

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THS

THESIS

Design & Cost of Heating System For Farm House

HARRY R. FRASER
M. A. C. 1910

THESIS
cop. 1

Heating - Estimates

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[illegible] AND [illegible] OF COST OF
[illegible] ANNUAL GIFTS'D [illegible], FOR
[illegible], NON-[illegible] AND NON-[illegible]

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by

Larry L. Fraser

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THESIS

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Alfred Clifford's Farm Residence,
Flint Township,
Flint, Michigan.

96319

OBJECT OF THESIS

The object of this thesis is to design and estimate the cost of installation and operation, separately, of steam, hot-water, and hot-air systems for heating the farm house of Alfred Gifford, located near Flint, Michigan.

DESCRIPTION OF HOUSE

The house is located about five miles west of Flint in Flint Township. It is a frame house, built about thirty-five years ago. During the summer and fall of 1907 the house was remodeled at an expense of about two thousand five hundred dollars ($2500.00). A new roof was put on and the interior of the house completely changed, all the old lumber was used again, thus reducing the cost of remodeling. There is a cellar under all of the house except the kitchen, the walls are made of stone and eighteen inches in thickness. The walls of the house are built as follows: The studdings are 2"x6" with an inch sheathing next to the studding, then building paper with a matched sheathing over the paper, then clapboarded on the outside. The inside is lathed and plastered. All inside partitions are six inches thick with lath and plaster on both sides, except where it has been necessary to make the partitions thicker to keep the walls straight, as shown on the drawings. The first floor is all double-floored while the second is single-floored.

On the second floor are two tanks, one for hard water, the other for soft water. The hard water is pumped through the house to the barn by a windmill, while the soft water is pumped up by hand. The tanks being on the second floor give a gravity circulation of the water to the kitchen, bath-room, and cellar. The water for the bath-room is heated by a water-front in the kitchen range.

The house is lighted by acetylene gas, the gas apparatus being enclosed in a small room in the cellar. The plumbing and fixtures for the gas and water, together, cost about two hundred and sixty dollars ($260.00).

In the above costs no allowance is made for work done by Mr. Gifford or his men, nor is any allowance made for the boarding of the workmen: all the work being done by day's work.

[illegible] OF HEATING

The house is heated by means of a peninsular furnace with 5.2 square feet of grate surface as follows: All rooms down stairs except the kitchen are heated from the furnace, the kitchen being heated by a steel range. The bedrooms marked "A" and "B" upstairs are heated direct from the furnace. Bedroom marked "C" is heated by means of a floor register from the sitting room directly below it. The bed-room marked "D" and the trunk room are heated from the hall and the rooms below. In the fall and spring when the furnace is not running the sitting room is heated by a fire place.

Computation of Heat Losses

Constants used for heat losses	K
Windows	1.03
Outside walls, plastered, double sheathing, paper and clapboarded.	.18
Partitions, both sides plastered	.14
Ceilings, plastered	.62
Ordinary doors	.41
Ceiling single floor above, second floor	.45
Floor over cellar, double	.31

Allowance for Leakage

Formula $L = \frac{N C}{60}(t_m - t_o)$

L is the allowance for leakage in B.T.U. per hour.

N is the number of times air is changed per hour, taken as 1½ in this case.

C is the contents of room in cubic feet.

t_m is the mean room temperature.

t_o is the outdoor temperature.

Bed Room "A"
Contents 2027 cubic feet

No.	Exp.	Surf.	Dimensions	Area Sq.ft.	t_1-t_0 Deg.F	K	$K(t_1-t_0)$	B.T.U.	Total B.T.U.
1	N	Win.	6'6"x6'2"	12	60	1.03	61.8	742	
2	N	Wall	9"x13.5-12	10.5	60	.18	10.8	1474	
3	N	Win.	2--2'6"x6'2"	31	60	1.03	61.8	1404	
4	N	Wall	9"x17-24	127.75	60	.18	10.8	1406	5103
		10% Allowance for N. and W. exposure							817
5	W	Win.	9"x6.5	40.5	60	.18	10.8	835	5.5
6		Ceil.	6"x2.25	243.25	25	.02	1.5	9770	4779
			17 x 14.33						
7	Sing	le wall losses							93.9
8	Allowance for leakage by formula								5.17
9	Allowance for exposed location 25% of 7 and 8								1.36
10	B. T. U. required for continuous service								10081

Bed Room "B"
Contents 1625 cubic feet

No.	Exp.	Surf.	Dimensions	Area Sq.ft.	t_1-t_0 Deg.F	K	$K(t_1-t_0)$	B.T.U.	Total
1	E	Win	6'6"x2'6"	12	60	1.03	61.8	742	
2	W	Wall	9"x11-12	87	60	.18	10.8	940	10.3
	10% Allowance for west exposure								
3	S	Win.	6'6"x6'2"	12	60	1.03	61.8	748	
4	S	Wall	9"x17.5-12	147.5	60	.18	10.8	1596	2.30
5	"	Wall	9"x6'	38.5	10	.34	3.4		199
6		Ceil	7.7'x3.25	196	25	.02	15.5		3038
			17'x10.5'						
7	Sing	le wall losses							74.5
8	Allowance for leakage by formula								3072
9	Allowance for exposed location 25% 7 and 8								2.34
10	B. T. U. required for continuous service								15081

Bed Room "C"
Contents 1117 cubic feet

No.	Exp. Surf.	Dimensions	Area Sq.ft.	t_1-t_o Deg.F	K	$K(t_1-t_o)$	B.T.U.	Total
1	N	Win.	8'6"x3'2"	12	60	1.03	61.8	742	
2	N	Win	8'6"x3'0"	8.8	60	1.03	61.8	556	
3	N	Wall	20'x9'-18	162	60	.18	10.8	175	2050
	10% Allowance for north exposure								205
4	E	Win.	8'6"x1'6"	12	60	1.03	61.8	742	
5	E	Wall	8.5'x9'-18	64.5	60	.18	10.8	696	1438
6		Ceil.	10.5'x11.5'	118	20	.63	15.5		1821
7	Simple wall losses								7304
8	Allowance for leakage by formula								2488
9	Allowance for exposed location #5, 7 and 8								2460
10	B. T.U. required for continuous service								12385

Bed Room "B"
Contents 1130 cubic feet

No.	Exp.	Surf.	Dimensions	Area Sq.ft.	t_1-t_o Deg.F	K	$K(t_1-t_o)$	B.T.U.	Total
1	E	Win.	22"x16"	11.3	70	1.03	61.8	882	
2	E	Wall	15'x9'-11.3	96.7	50	.18	9.	870	1452
3	S	Win.	26"x70"	12.6	50	1.03	51.5	669	
4	S	Wall	10.5'x9'-12.6	1[illegible]	50	.18	9.	1[illegible]	1892
5	S	Door	6'.10"x3'	11.7	10	.41	6.15	72	
6	S	Wall	6 x[illegible].5	37	15	.04	4.6	170	242
7		Ceil.	10'x11.5'	104	15	.02	3.3		1711
8	Simple wall losses								5317
9	Allowance for leakage by formula								1696
10	Allowance for exposed location #5, 7 and 8								1617
11	B. T. U. required for continuous service								9114

Bank Room and Lock Hallway
Contents 652.5 cubic feet

No.	Exp.	Surf.	Dimensions	Area Sq.ft.	t_1-t_o Deg.F	K	$K(t_1-t_o)$	B.T.U.	Total
1	S	Win.	28"x14"	10.5	80	1.03	81.6	841	
2	W	Wall	9"x5'-10.5	53	80	.18	9	371	8[illegible]
	10%	Allowance for west exposure							[illegible]
3	S	Wall	7.[illegible]x9	67.5	80	.18	9		[illegible]
4		Ceil.	6.7[illegible]x11.25	75.9	15	.08	9.5		7[illegible]
5	Single wall losses								[illegible]
6	Allowance for leakage by formula								[illegible]
7	Allowance for exposed location 25% 5 and 6								7.[illegible]
8	B. T. U. required for continuous service								[illegible]

Parlor
Contents 1012 cubic feet

No.	Exp. Surf.	Dimensions	Area sq. ft.	t_1-t_o deg. F.	K	(t_1-t_o)	B.t.u.	Total B.t.u.
1	[illegible]	in.	[illegible]	70	1.03	73.1	[illegible]	
2	[illegible]	Wall	14 x [illegible]	70	.18	12.6	[illegible]	
3	[illegible]	in.	[illegible]	70	1.03	73.1	[illegible]	
4	[illegible]	Wall	17.7[illegible]	70	.18	12.6	[illegible]	[illegible]
	10% allowance for north and west exposure							[illegible]
5	[illegible]	Wall	[illegible]	70	.18	12.6		[illegible]
6		Ceil	[illegible]	10	.41	4.5		[illegible]
7		Floor	[illegible]	30	.1	9.[illegible]		[illegible]
8	Single wall losses							[illegible]
9	Allowance for leakage by formula							1610
10	Allowance for exposed location 5% 6 and 9							[illegible]
11	B. t. u. required for continuous service							[illegible]

Bed Room Down Stairs
Contents 1200 cubic feet

No.	Exp.	Surf.	Dimensions	Area sq. ft.	t_1-t_o deg. F.	K	(t_1-t_o)	B.t.u.	Total B.t.u.
1	[illegible]	in.	[illegible]	[illegible]	70	1.03	73.1	[illegible]	
2	[illegible]	Wall	15.7[illegible]	116	70	.18	12.6	[illegible]	[illegible]
	10% allowance for west exposure								[illegible]
3	[illegible]	in.	[illegible]	[illegible]	70	1.03	73.1	[illegible]	
4	[illegible]	Wall	17.7[illegible]	116	70	.18	12.6	[illegible]	[illegible]
5		Ceil	17.[illegible]	[illegible]	10	.41	4.5		[illegible]
6		Floor	17.[illegible]	[illegible]	30	.31	9.3		[illegible]
7	Single wall losses								[illegible]
8	Allowance for leakage by formula								[illegible]
9	Allowance for exposed location 5% 7 and 8								[illegible]
10	B. t. u. required for continuous service								[illegible]

...arlor
Contents 1912 cubic feet

No.	Exp.	Surf.	Dimensions	Area sq.ft.	t_1-t_0 deg.F	K	$A(t_1-t_0)$	B.T.U.	Total B.T.U.
1	[illegible]	in.	25"x36"	12.0	70	1.03	72.1	[illegible]	
2	W	Wall	14 x 9.5-12.8	118.2	70	.18	12.6	1513	
3	[illegible]	in.	25--25"x36"	27.5	70	1.03	72.1	1983	
4	S	Wall	17.75 x 9.5-15.6	148	70	.18	12.6	1865	6361
	10% allowance for north and west exposure								636
5	[illegible]	Wall	5.5x9.5	52.2	70	.18	12.6		658
6		Ceil	15.5x13.25	214.6	10	.42	4.5		965
7		Floor	15.5x13.25	214.6	30	.1	9.3		1995
8	Single wall losses								10050
9	Allowance for leakage by formula								2010
10	Allowance for exposed location 25% 8 and 9								3015
11	B. T. U. required for continuous service								17076

Bed Room Room Stairs
Contents 1,500 cubic feet

No.	Exp.	Surf.	Dimensions	Area sq.ft.	t_1-t_0 deg.F	K	$A(t_1-t_0)$	B.T.U.	Total B.T.U.
1	[illegible]	in.	25"x36"	12.8	70	1.03	72.1	923	
2	W	Wall	15.75x9.5-13.8	118	70	.18	12.6	1487	2410
	10% allowance for west exposure								241
3	S	in.	25"x36"	12.8	70	1.03	72.1	923	
4	S	Wall	17.75x9.5-12.8	156	70	.18	12.6	1965	2888
5		Ceil	17.25x12.25	211.5	10	.42	4.5		1038
6		Floor	17.25x12.25	211.5	30	.31	9.3		2115
7	Single wall losses								6393
8	Allowance for leakage by formula								1814
9	Allowance for exposed location 25% 7 and 8								1207
10	B. T. U. required for continuous service								15634

Sitting Room

Contents 1973 cubic feet

No.	Exp.	Surf.	Dimensions	Area sq.ft.	t_1-t_o Deg.F	K	$K(t_1-t_o)$	B.T.U.	Total B.T.U.
1	N	Win	30"x66"	13.5	70	1.03	72.1	1190	
2	N	Win	2-30"x66"	27.0	70	1.03	72.1	1946	
3	N	Wall	18.5x13.5-43	119.5	70	.18	12.6	1506	4742
			10% Allowance for north exposure						
4	E	Door	4'x7'	28	10	.41	4.1	115	
5	E	Wall	15.75x9.5-28	120.5	10	.34	3.4	410	525
6		Ceil.	14'x15.25	213.5	10	.45	4.5		960
7		Floor	14'x15.25	213.5	10	.81	9.3		1985
8	Simple wall losses								8466
9	Allowance for leakage by formula								3700
10	Allowance for exposed location 25% 8 and 9								3033
11	B. T. U. required for continuous service								15899

Halls and Vestibule

Contents 2210 cubic feet

No.	Exp.	Surf.	Dimensions	Area Sq.Ft.	t -t Deg.F	K	K(t1-t0)	B.T.U.	Total B.T.U.
1	N	Win	30"x30"	5.8	60	1.03	61.8	358	
2	N	Wall	8.75'x9'-5.8	28	60	.18	10.8	302	
3	N	Glass	30"x36"	6.5	60	1.03	61.8	402	
4	N	Door	3'x7'-6.5	14.5	60	.41	24.6	357	
5	N	Wall	8.75'x20.5'-21	62.1	60	.18	10.8	671	2090
		10% Allowance for north exposure							209
6	E	Win.2--30"x38"		11	60	1.03	61.8	680	
7	E	Wall	10'x9.5-11	141	60	.18	10.8	1523	2203
8	E	Door	10"x3'.6"	17	10	.41	4.1	70	
9	E	Wall	10'x9.5-17	112.25	10	.04	0.4	691	761
10		Ceil	8.75'x30'	66	0	.45	0	0	
11		Ceil	30'.9"x8.25' 8.75'x13.5	114.75	20	.62	15.5	1780	1780
12		Floor	10.25x8	132	20	.1	6.2		713
13	Single wall losses								7782
14	Allowance for leakage by formula								5518
15	Allowance for exposed location 12, 13 and 14								1560
16	B.T.U. required for continuous service								14850

Lining Room
Contents 1500 cubic feet

No.	Exp. Surf.	Dimensions	Area sq. ft.	t_1-t_0 deg. F.	K	$K(t_1-t_0)$	B.T.U.	Total B.T.U.
1	E	Win. 36"x36"	16.6	70	1.03	72.1	1190	
2	E	Win. 2--36"x36"	25.6	70	1.03	72.1	1846	
3	E	Wall 7'-9"x8'-4"	60.25	70	.18	12.6	1087	4183
4	E	Door 6'-6"x3'0"	16.6	20	.41	8.2	136	
5	E	Wall 6.75x8.5-16.6	66.5	20	.34	6.8	452	588
6	E	Wall 7½ 9.5	66.5	70	.18	12.6		838
7		Ceil 16'x11.25	180	20	.45	9		1620
8		Floor 16'x11.25	180	20	.31	9.3		1674
9	Simple wall losses							8943
10	Allowance for leakage by formula							1807
11	Allowance for exposed location 25% 9 and 10							3618
12	B. T. U. required for continuous service							15368

Bath Room
Contents 264 cubic feet

No.	Exp. Surf.	Dimensions	Area sq. ft.	t_1-t_0 deg. F.	K	$K(t_1-t_0)$	B.T.U.	Total B.T.U.
1	E	Win. 20"x30"	11.6	70	1.03	72.1	963	
2	E	Wall 5.5x8.5-11.6	35.6	70	.18	12.6	487	1470
		10% allowance for west exposure						147
3		Ceil 11.25'x7'-4"x3'	66.75	20	.45	9		600
4		Floor 11.25'x7'-4"x3'	66.75	20	.31	9.3		620
5	Simple wall losses							2837
6	Allowance for leakage by formula							1115
7	Allowance for exposed location 25% 5 and 6							988
8	B. T. U. required for continuous service							4940

Kitchen

Contents 1810 cubic feet

No.	Exp. Surf.	Dimensions	Area Sq. ft.	t_1-t_0 Deg. F	K	$K(t_1-t_0)$	B.t.u.	Total B.t.u.
1	N	Win.2--28"x70"	27.2	70	1.03	72.1	1961	
2	N	Wall 18.25'x9.5'-27.2	98.7	70	.18	12.6	1244	3205
		10% Allowance for west exposure						
3	S	Door 6'.10"x30"	17	70	.41	28.7	486	
4	S	Wall 17'x9.5'-17	144.5	70	.18	12.6	1820	2306
5	E	Glass 6'-10"x14"	6	70	1.03	72.1	433	
6	E	Door 30"x82"-6	12.25	70	.41	28.7	352	
7	E	Wall 17'x9.5'-18.25	143.25	70	.18	12.6	1805	2590
8		Ceil 18.25'x13.75'	207	35	.62	21.7		4493
9		Floor 18.25'x13.75'	207	30	.45	17.1		3540
10	Simple wall losses							10434
11	Allowance for leakage by formula							5415
12	Allowance for exposed location 25% 10 and 11							4077
13	B. t. u. required for continuous service							24087

Radiating Surface Needed, for Steam

Steam pressure in radiator 5 pounds per square inch.

Temperature of steam 227° F.

Temperature of room 70° F.

Difference in temperature between radiator and room 157° F.

Factor per heat lost from two column cast iron radiator 1.65

B. T. U. per degree difference in temperature per hour

157 x 1.65 = 259 B. T. U. per square foot per hour.

		Sq.Ft.Use
Bed room "A"	16631 ÷ 259 = 64.5	64
Bed room "B"	12021 ÷ 259 = 46.5	46
Bed room "C"	12145 ÷ 259 = 47.5	48
Bed room "D"	9184 ÷ 259 = 35.5	36
Bath room and hall	4048 ÷ 259 = 15	16
Parlor	17150 ÷ 259 = 66	66
Bed room down stairs	15554 ÷ 259 = 60	60
Sitting room	15540 ÷ 259 = 60	60
Halls and vestibule	14520 ÷ 259 = 55	55
Dining room	15062 ÷ 259 = 58	60
Bath room	4940 ÷ 259 = 19	20
Kitchen	24987 ÷ 259 = 96	96

Total square feet of radiating surface 630 [17] 643 sq.ft.

Size of Circulating Main for Steam.

Total B. T. U. supplied per hour 163,240

163240 ÷ 966 = 168 pounds steam circulated per hour.

168 x 20.25 = 3402 cubic feet of steam per hour.

Allow a velocity of 20 feet per second in pipe.

3402 ÷ 60 = 56.7 cubic feet per minute.

56.7 ÷ 60 = .945 cubic feet per second

(.945 x 1728) ÷ (20 x 12) = 6.8 square inches of main area

$\frac{1}{4}d^2$ 3.1416 = 6.8 $\quad d^2 = \frac{6.8 \times 4}{3.1416} = 8.6$

d = 2.94 inches in diameter use a 3 inch pipe.

Boiler, Pipe and Fittings for Steam

Ideal sectional boiler rated at 900 square feet

632 square feet of radiator surface, standard

38" cast iron radiators four square feet per section

4 - 1" and 4 - 1½" brass angle valves, with union

3 - 1½" and 1 - 1 " brass globe valves. All valves are to be rough body, plated all over.

165 feet 3 inch wrought iron pipe.

25 feet 2 inch " " "

65 feet 1½ " " " "

35 feet 1" " " " "

9 - 3" standard cast iron elbows, screwed.

4 - 1" and 6 - 1½" cast iron elbows, screwed.

2 reducing elbows from 2" to 1"

4 " " " 1½" to 1"

3 " tees " 3 " to 2 "

5 " " " 3" to 1½"

3 " " " 1½" to 1"

1 " " " 1½" to 1 "

15 Brass floor plates, nickel plated 6 - 1 " and 7 - 1½"

5 patent two-piece ceiling plates 2 - 1" and 3 - 1½"

2 - 1" and 6 - 1¼" wrought iron nipples

9 - 3" pipe hangers

12 radiator air valves

90 feet of 3" pipe covering.

33 feet of 2" pipe covering.

10 feet of 1¼" pipe covering.

9 - 3" moulded elbow covers.

8 - 3" moulded reducing tee covers.

Pipe covering to be 85% magnesia.

Cost of Boiler, Pipe and Fittings for Steam.

Ideal Sectional Boiler	$148.00
602 square feet radiator surface	112.80
12 brass globe and angle valves	36.50
Wrought iron pipe required	34.00
Cast iron elbows	5.00
Cast iron reducing tees	5.48
Floor and ceiling plates	1.22
Wrought iron nipples	.62
Pipe hangers	2.52
Radiator air valves, wood, wheel, with rods	9.00
Pipe covering	31.60
Moulded elbows and tees	3.02
12 day's work for plumber and helper(60 cents hr.)	64.80
Total Cost For Steam	446.56

Radiating Surface Needed For Hot Water

Temperature of water 170° F as maximum

Temperature of room 70° F

Difference 170 - 70 = 100° F

Cast iron radiators 1.58 B. T. U. per degree difference in temperature.

1.58 x 100 = 158 B. T. U. per hour per sq. ft.

		Act. Use
Bed room "A"	16001 ÷ 158 = 105	104
Bed room "B"	12641 ÷ 158 = 80	80
Bedroom "C"	12345 ÷ 158 = 78	80
Bed room "D"	9184 ÷ 158 = 84.5	86
Bath room and Hall	8960 ÷ 158 = 85	88
Parlor	17380 ÷ 158 = 110	108
Bedroom down stairs	11074 ÷ 158 = 99	100
Sitting room	15330 ÷ 158 = 97	96
Halls and vestibule	14220 ÷ 158 = 90	92
Dining room	14502 ÷ 158 = 91.5	96
Bath room	4340 ÷ 158 = 21	22
Kitchen	24187 ÷ 158 = 147	150
Actual square feet radiating surface	1082	1092

Size of Circulating Mains For Hot Water

Use two separate mains with the radiating surface divided between them as follows:

Circulating main No. 1

Bedroom "C"	8[illegible] Sq.Ft.
Bedroom "D"	83 " "
Sitting Room	96 " "
Halls and Vestibule	[illegible] " "
Dining Room	96 " "
Kitchen	13[illegible] " "
Total radiating surface on main	670 Sq.Ft.

Circulating Main No.2

Bedroom "A"	104 Sq.Ft.
Bedroom "B"	80 "
Bank room and back hall	2[illegible] "
Parlor	100 "
Bedroom down stairs	100 "
Bathroom	1[illegible] "
Total radiating surface on main	432 Sq.Ft.

As the kitchen will probably not be heated by hot water the radiating surface is divided about equally between the two circulating mains.

Size of Circulating Mains for Hot Water

Temperature difference between water in the radiator and room, 100° F.

Unit radiation 1.58 B.T.U. per square foot per hour for one degree difference in temperature.

1.58 x 100 = 158 B. T. U. per hour per square foot.

One pound of water circulating through the system loses 10 B. T. U. per hour.

158 ÷ 10 = 15.8 water circulated per hour per square foot of radiation.

15.8 x 452 = 7141.6 water circulated per hour in main.

7141.6 ÷ 3600 = 1.984 water circulated per second

1.984 ÷ 62.5 = .03174 cubic feet water per second

.03174 ÷ .54 = .0588 cubic feet cross sectional area of circulating main

.0588 x 144 = 8.47 square inches area of pipe.

8.47 = d^2 3.1416 (8.47 x 4) ÷ 3.1416 = d^2

d^2 = 10.79 d = 3.28 inches Use a 3.5 inch pipe

Boiler, Pipes and Fittings for Hot Water

Ideal sectional boiler rated at 1250 square feet.

1028 square feet of radiator surface, standard.

38" cast iron, two column radiators.

4 - 1"; 2 - 1¼" and 18 - 1½" brass angle valves with unions.

12 radiator air valves with wood wheel.

125' - 5" wrought iron pipe for circulating mains.

250' - 1½" " " " " risers

40' - 1¼" " " " " "

40' - 1 " " " " " "

30' - ¾ " " " " to expansion tank

14 - 5" cast iron elbows

26 - 1½" " " "

4 - 1¼" " " "

6 - 1 " " " "

5 - ¾ " " " "

12 - 5" Durham cast iron reducing tees

12 - 5" pipe hangers, sectional

6 - 1"; 4 - 1¼"; and 24 - 1½" nickel plated floor plates

2 - 1": 2 - 1¼" and 6 - 1½" patent two piece ceiling plates.

One expansion tank, galvanized iron.

135' - 3" pipe covering

100' - 1½" " "

10' - 1¼" " "

14 - 3½" molded elbow covers

15 - 1½" " " "

12 - 3½" Eureka reducing tee covers

All pipe covering to be 85% magnesia.

Cost of Boiler, Pipe, and Fittings for Hot Water.

Ideal Sectional Boiler, 1200 square feet	$132.00
1080 square feet radiator surface	162.40
24 Brass angle valves	84.00
12 radiator air valves	6.00
Wrought iron pipe	50.17
Cast iron elbows	9.70
12 - 3½" cast iron Eureka tees	11.96
12 - 3½" pipe hangers	4.20
Floor plates, nickel plated	1.00
Patent two pieces ceiling plates	1.26
Expansion tank, galvanized iron	2.00
Pipe covering, 85% magnesia	21.60
Molded elbow covers	3.36
Eureka reducing tee covers	3.12
14 days work for plumber and helper	75.00
Total cost for hot water	666.67

Size of Hot Air Furnace to Heat House

Total heat required 102542 B. T. U. per hour.

One pound of anthracite coal containing 9.1% of ash gives up 13189 B. T. U. (Kent)

Allowing 75% efficiency for furnace

13189 x 75% = 9892 B. T. U. converted into heat by combustion of one pound of coal.

102542 ÷ 9892 = 10.4 pounds of coal burned per hour to heat house.

Allowing 2½ pounds of coal per square foot of grate surface to be burned per hour.

10.4 ÷ 2½ = 4.7 square feet of grate surface necessary in furnace

Use a hot air furnace with a 20" fire pot giving a grate surface of 4.38 square feet, as this is the largest size furnace that can be gotten through the cellar door.

Size of Hot Air Pipes

Divide the volume of the room by 20 and the square root of the quotient will be the diameter of the pipe for first-floor rooms. For second floor rooms divide the volume by 25 and the square root of the quotient will be the diameter of furnace pipe.

		Size of Pipe
Pipe for Bedroom "A"	2027 ÷ 25 = 101	10"
" " " "B"	1393 ÷ 25 = 61	9"
" " " "C"	1217 ÷ 25 = 61	8"
" " " "D"	1[illegible] ÷ 25 = 61	8"

		Size of Pipe
Pipe for tank room and back hall	6[illegible] ÷ 25 = 25	5"
" " parlor	1[illegible]3 ÷ 30 = 96	10"
" " bedroom downstairs	1[illegible]9[illegible] ÷ 10 = 100	10"
" " sitting room	1[illegible]7[illegible] ÷ 30 = 99	10"
" " halls and vestibule	[illegible]10 ÷ 20 = 110	10"
" " dining room	1[illegible]0 ÷ 30 = 84	9 "
" " bath room	[illegible]4 ÷ 20 = 29	5 use 6"
" " Kitchen	1[illegible]10 ÷ 20 = 90.5	10"

Use one 10" pipe for bedroom "B" and tank room.

Use one 14" pipe for parlor and bed room down stairs.

Size of Registers Necessary for Rooms.

Calculations for Bedroom "A"

Temperature of air entering room 160° F.

Temperature of air in room 60° F.

Difference in temperature (160 - 60) = 100° F.

.2375 B. t. u. is the specific heat of air at a constant pressure, atmospheric pressure.

.2375 x 100 = 23.75 B. t. u. per pound of air

16631 ÷ 23.75 = 700.2 pounds of air per hour.

700.2 x 13 = 9102.6 cubic feet of air per hour.

9102.6 ÷ 3600 = 2.528 cubic feet per second.

Allowing a velocity of 4 feet per second to the second floor.

2.528 ÷ 4 = .632 square feet.

.632 x 144 = 91 square inches effective area to which 1/3 more must be added to get area register.

91 ÷ 30 = 121 square inches.

Register for the room	10" x 12"
Bedroom "B"	9" x 12"
Bedroom "C"	8" x 12"
Bedroom "D"	8" x 12"
Bath room and back hall	8" x 10"
Parlor	10" x 12"
Bedroom down stairs	10" x 12"
Sitting room	10" x 12"
Halls and vestibule	10" x 12"
Dining room	9" x 12"
Bath room	8" x 10"
Kitchen	10" x 14"

Elbows and Length of Tin Pipe for Hot Air Flues

Length of 8" pipe, 15'
" " 9" " 10'
" " 10" " 50'
" " 14" " 10'
" " 20" " for ventilation 15'
" " 3 1/8" x 12" pipe in partition 50'

No. of 8" elbows, 8
" " 9" " , 8
" " 10" " , 10
" " 14" " , 2

9 dampers for hot air flues

Cost of Furnace, Pipe and Elbows for Hot Air

One Peis Furnace, 28" fire-pot with casing	$130.00
12 Hot air registers	10.00
2 Ventilating pipe face plates	5.00
Tin pipe for flues, made up	14.55
Elbows made up 25 cents each	4.25
Regulator and chains	3.50
6 dampers for flues	1.00
Asbestos paper covering for flues	2.00
Cost of labor for installation	30.00
Total cost for hot air - - - - - - - - - - - - - - -	200.50

Ventilation of House

For ventilation of house use two cold air flues each 20" in diameter. One to be placed in the hall down stairs and one at the east wall of the sitting room, both pipes to be carried down to a conduit under the cellar floor to the base of the furnace.

Coal Necessary to Heat the House

The heat loss from the walls of the house during zero weather is 16[illegible]48 B. T. U. per hour. One pound of commercial coal containing 9.1, ash contains 13189 B. T. U.

Allowing an efficiency of 75% for furnace the amount of coal necessary to heat the house for one hour in zero weather would be 16[illegible]48 ÷ (13189 x .75) = 16.4 pounds.
16.4 x 24 = 393.6 pounds of coal for twenty-four hours. As the average heat loss from a house during the heating season is about 60% of the loss during zero weather, (Authority, J. M. Allen)

the amount of coal necessary for one hundred and fifty days would be 393.6 x 150 x .5 ÷ 2000 = 14.76 tons for the hot air system of heating.

The American Radiator Company consider that commercial coal contains 12000 B. T. U. per pound and that one pound of coal will evaporate eight and one-half pounds of water from and at 212° F. 966 x 8½ = 8211 B. T. U. per pound of coal 15[illegible] ÷ 8211 = 1[illegible].77 pounds of coal per hour during zero weather.

1[illegible].77 x 24 = 474.48 pounds per day.

474.48 x 1[illegible] x .5 ÷ 2000 = 17.7[illegible] tons of coal for steam or hot water heating per year.

Authorities for information used in thesis; notes on Heating and Ventilation by Prof C. L. Russell. Notes on Heating and Ventilation by J. [illegible] Allen. Michigan Supply Co. of Lansing, Mich., for heaters, pipes and cast iron fittings. Murry and Avery for hot-air furnace and flues. American Radiator Co. for radiators and efficiency of heaters.

Summary of Thesis

Estimate cost of boiler, pipes, fittings and labor of installation for steam heating complete $[illegible]6.50.

Estimate cost of boiler, pipes, fittings, and labor of installation for hot water heating, $[illegible]6.67.

Estimate cost of furnace and labor of installation for hot air heating, $[illegible]0.00.

Estimated amount of coal to heat the house by hot air twenty-four hours in zero weather, 333.6 pounds. For heating season of one hundred and fifty days, 14.75 tons. Estimated amount of coal to heat house by steam or hot water for twenty-four hours in zero weather, 474.48 pounds. For heating season of one hundred and fifty days, 17.766 tons.

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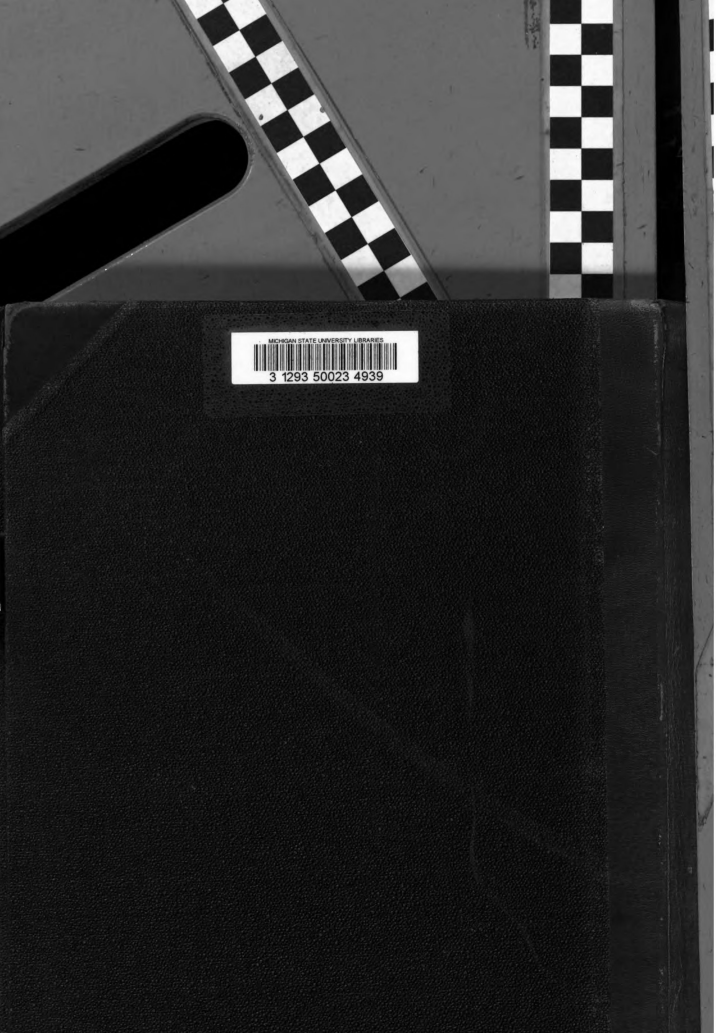
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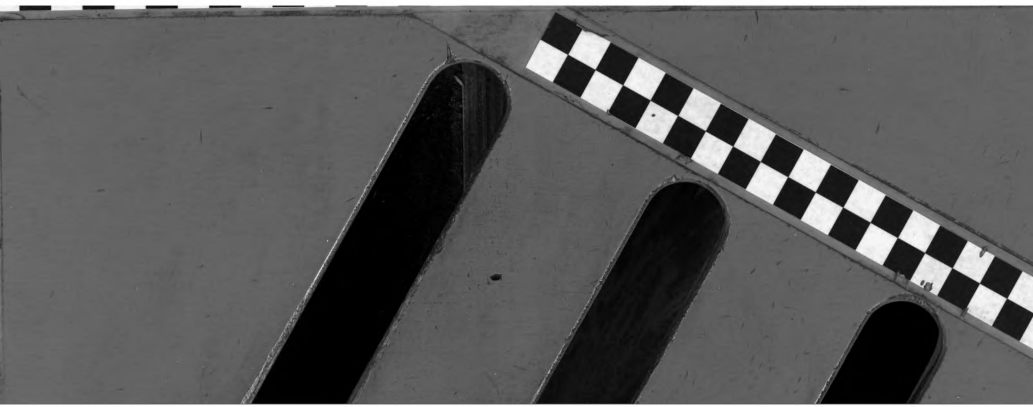


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