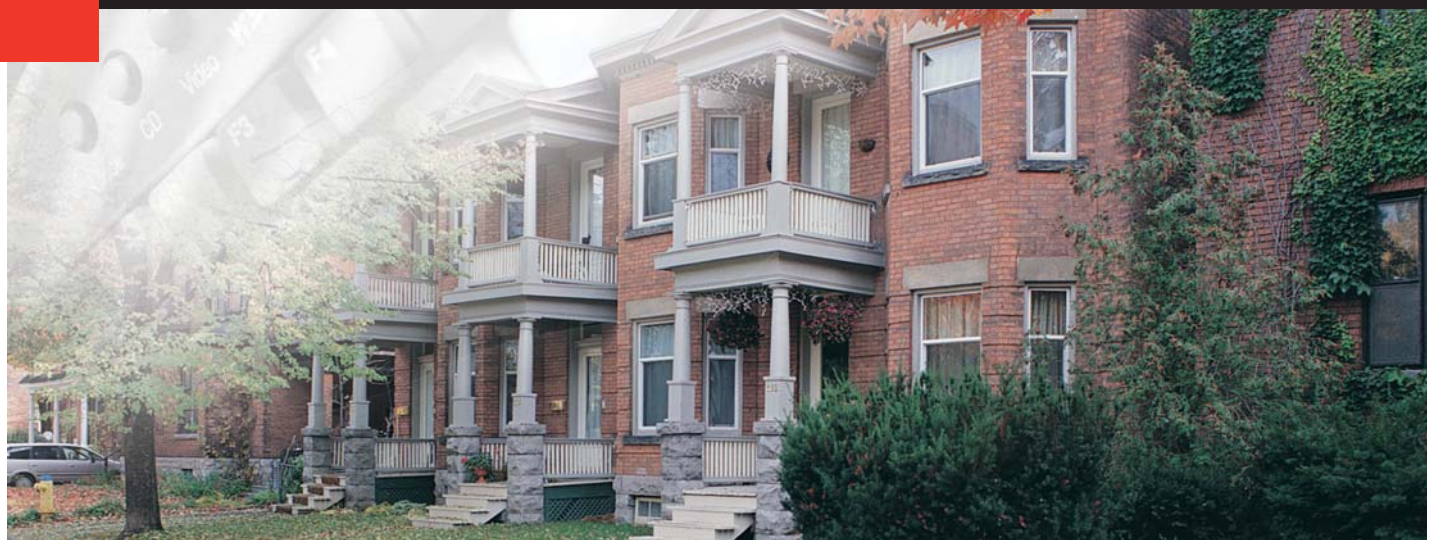
RESEARCH REPORT



Demonstration of Duct Installation in Houses Previously Without Ducting Appendices

Canada

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Appendices

Demonstration of Duct Installation in Houses Previously Without Ducting

R. Clarke Designs Ltd.
3 Sheffield Court
Oromocto, NB E2V 2N1

for
Don Fugler
CMHC Policy and Research Division

March 2004

HRAI **Load Short Form**
Entire House

Job: 23013a
Date: Apr. 29, 2003
By: R. Clarke

Cert.#: 001529(RHLG, RASD) **R. Clarke Designs Ltd.**

3 Sheffield Court, Oromocto, NB E2V 2N1 Phone: 506-357-3377 Fax: 506-357-3378 Email: rclarke@nbnet.nb.ca

Project Information

For: CMHC Test House #1

Design Information

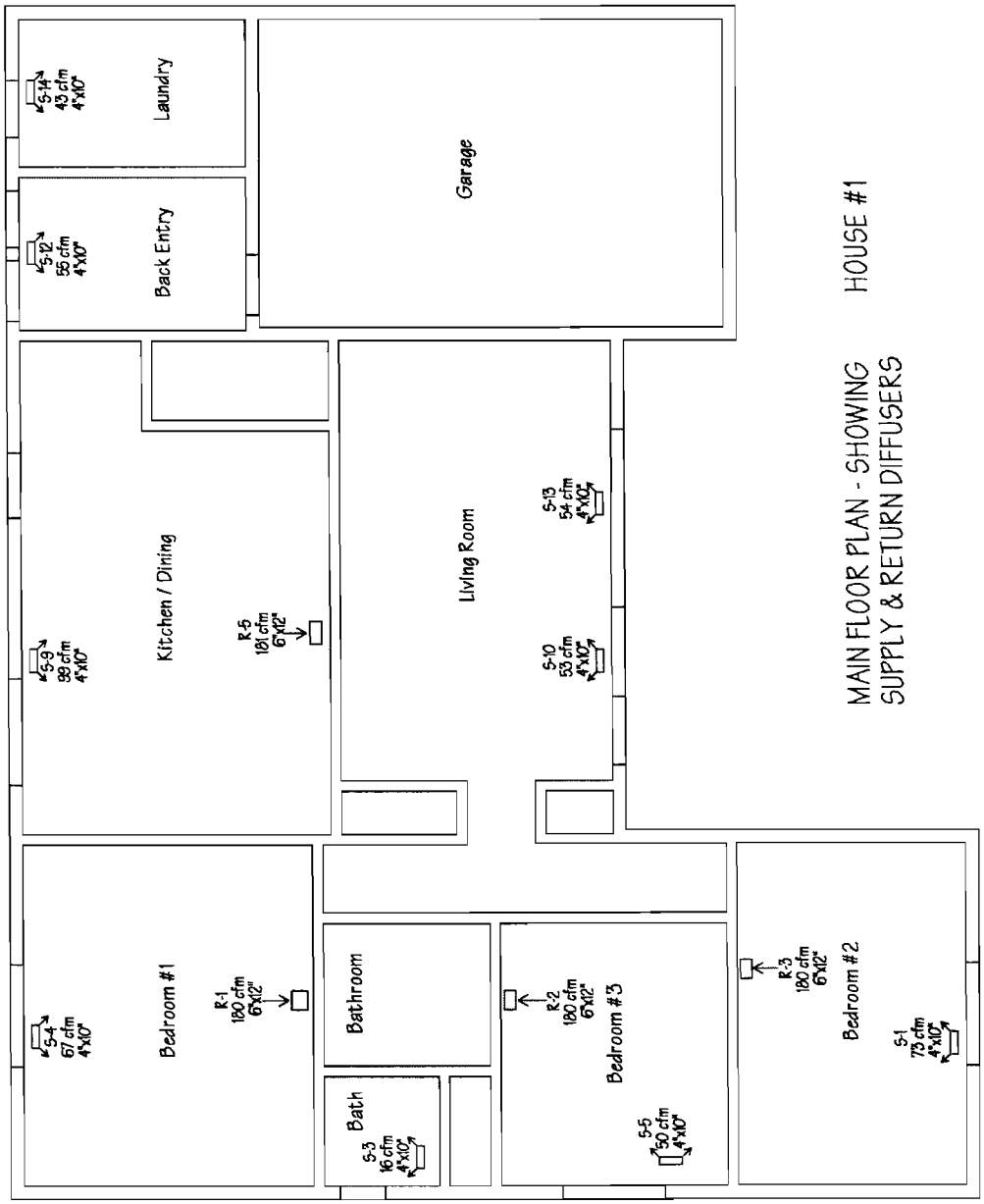
	Htg	Clg	Infiltration	
Outside db (°F)	-11	84	Method	F280
Inside db (°F)	72	75	Exposure category	Sheltered
Design TD (°F)	83	9	Construction category	Average
Daily range	-	M	Number of stories	1.0
Inside humidity (%)	-	50		
Moisture difference (gr/lb)	-	21		

HEATING EQUIPMENT		COOLING EQUIPMENT	
Make		Make	
Trade		Trade	
Model		Cond	
		Coil	
Efficiency	0 HSPF	Efficiency	0 EER
Heating input		Sensible cooling	0 Btuh
Heating output	0 Btuh @ 47°F	Latent cooling	0 Btuh
Temperature rise	0 °F	Total cooling	0 Btuh
Actual air flow	933 cfm	Actual air flow	933 cfm
Air flow factor	0.022 cfm/Btuh	Air flow factor	0.055 cfm/Btuh
Static pressure	0.50 in H2O	Static pressure	0.50 In H2O
Space thermostat		Load sensible heat ratio	77 %

ROOM NAME	Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Master Bdrm	197	3082	1455	67	79
Kitchen/Dining	303	4557	3175	99	173
Entry	75	2538	798	55	44
Laundry	67	1959	743	43	41
Living Rm.	270	4897	2786	107	152
Front Bdrm.	154	3339	1407	73	77
Mid-Bdrm.	158	2298	945	50	52
Bathroom	113	741	89	16	5
Family Room	337	5951	3397	130	185
Storage	158	2353	1213	51	66
Workshop	135	3647	1099	80	60
Basement	423	3925	0	86	0
Office	217	3458	0	75	0

Entire House	d	2604	42746	17107	933	933
Ventilation air			5020	1361		
Equip. @ 1.00	RSM			18468		
Latent cooling				5540		
TOTALS		2604	47766	24008	933	933

Appendix A
House One
Main Floor Plan Showing Supply & Return Diffusers



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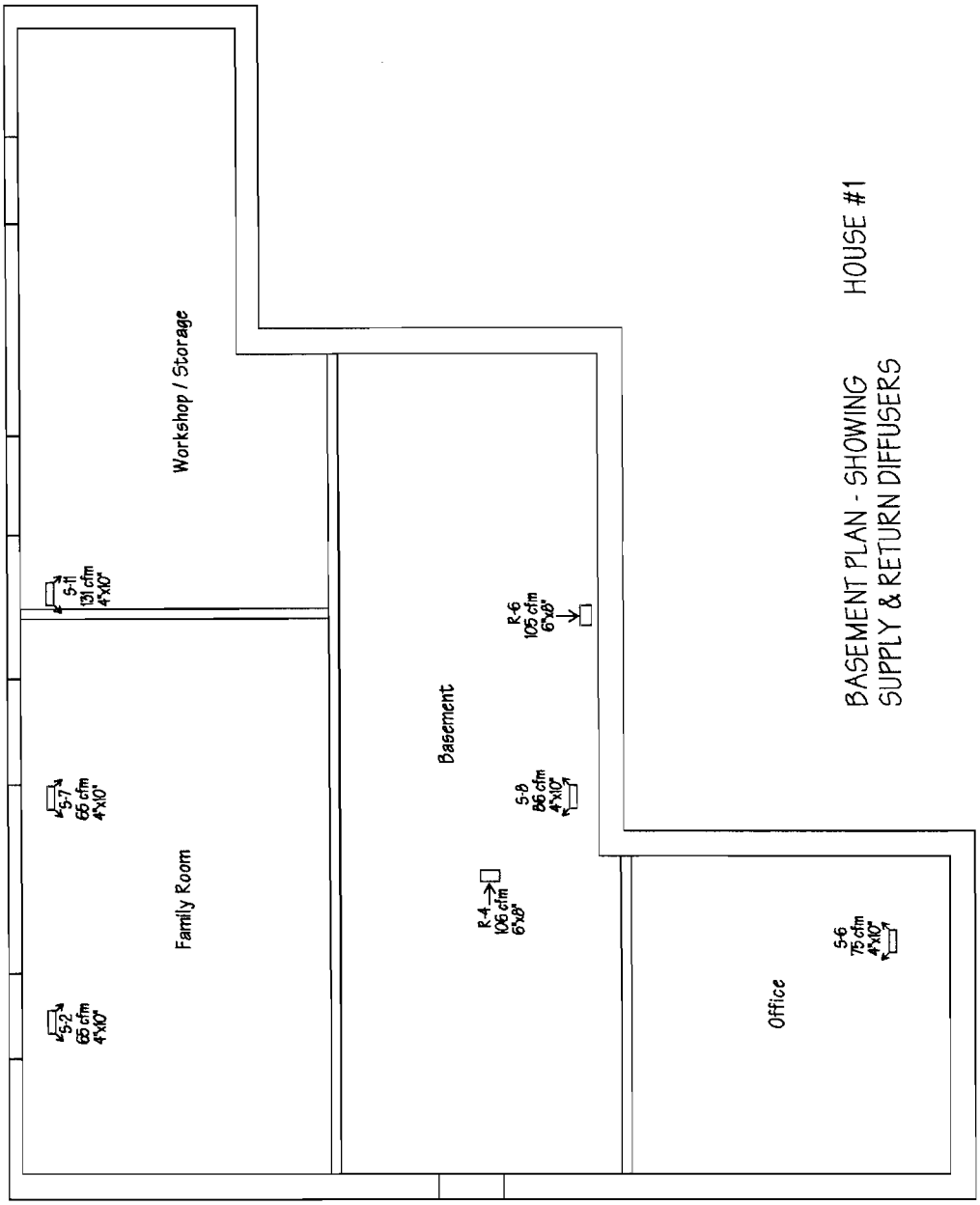
Appendix A
House One
Basement Plan Showing Supply & Return Diffusers



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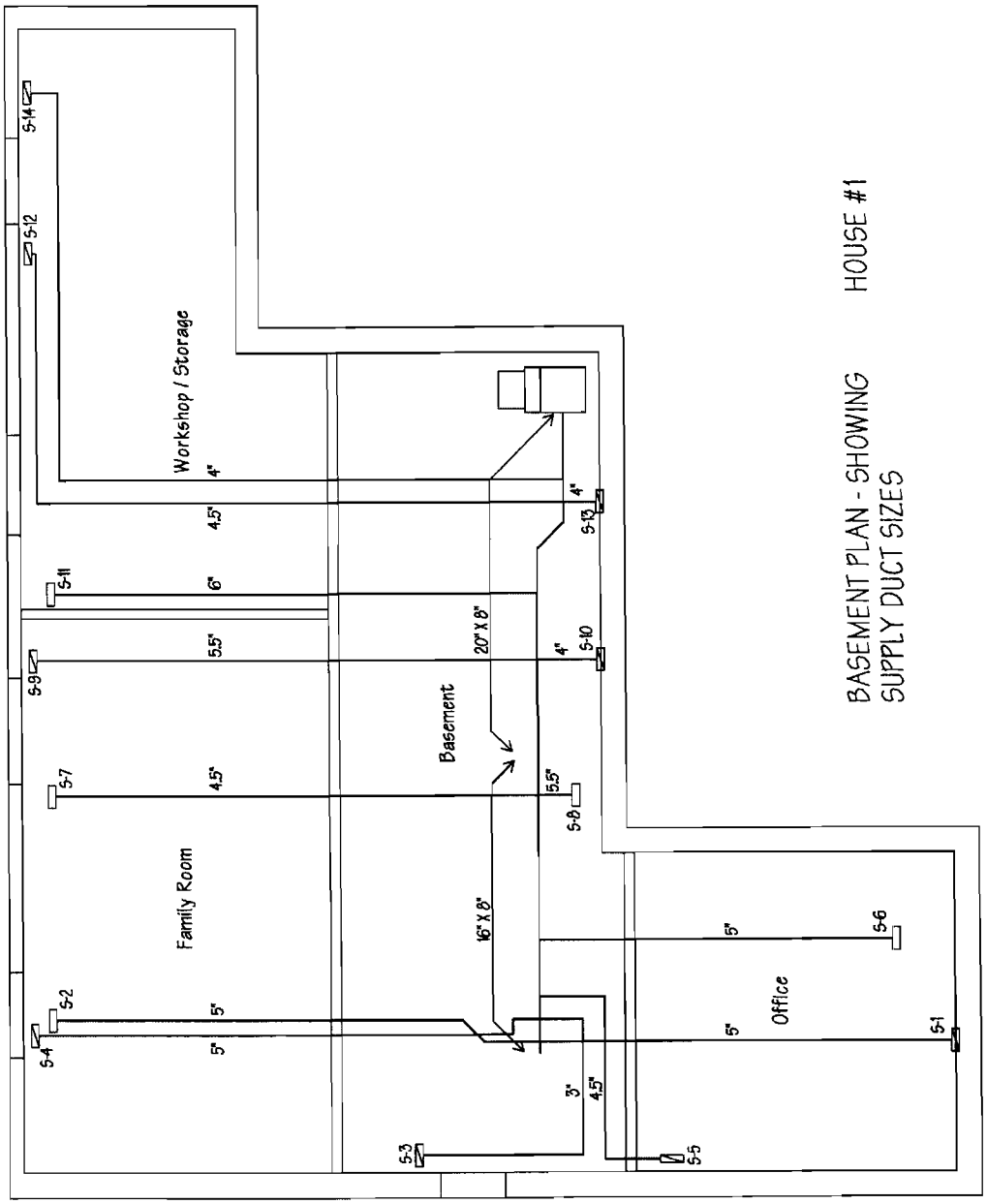
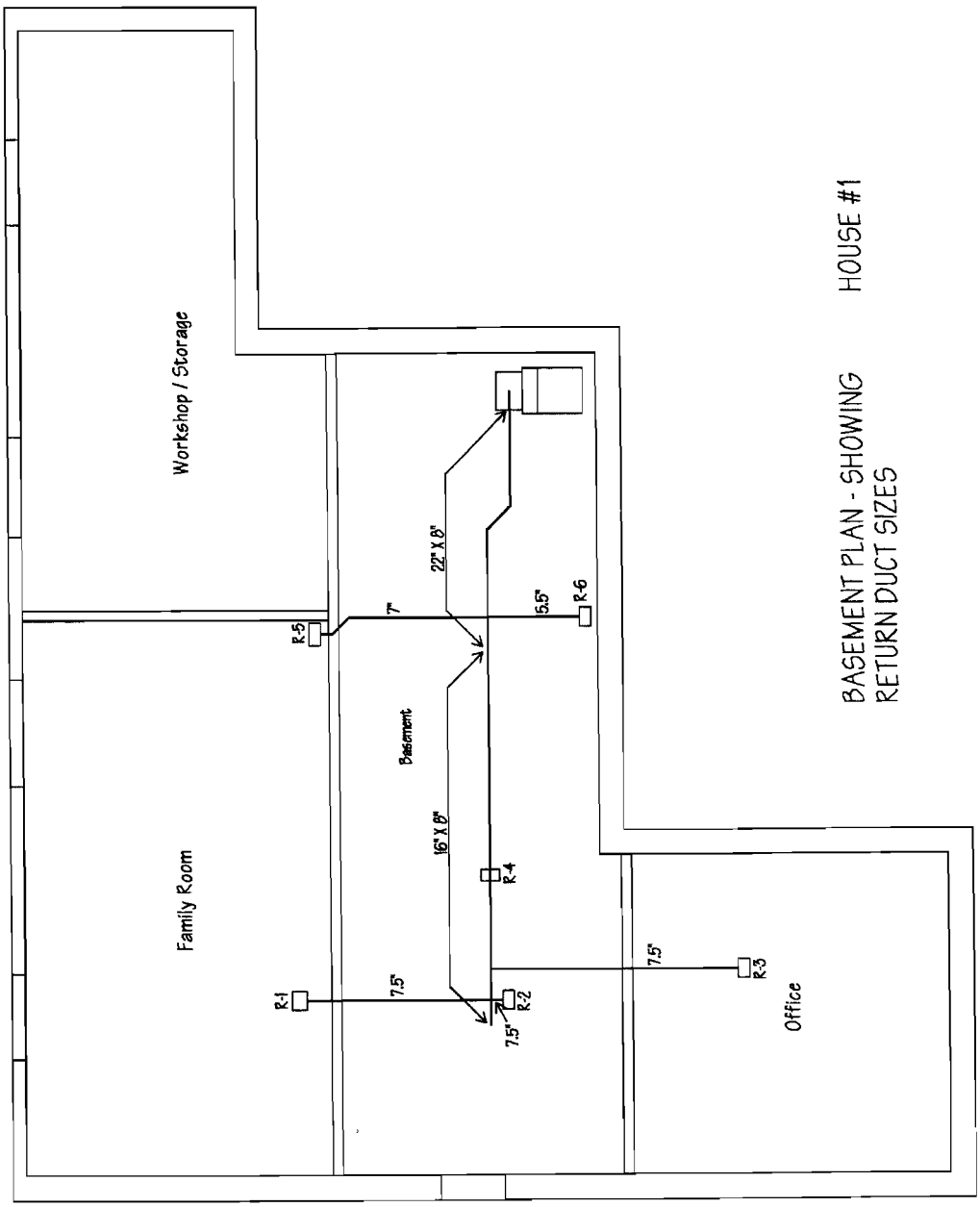
Appendix A
House One
Basement Plan Showing Supply Duct Sizes



Appendix A
House One
Basement Plan Showing Return Duct Sizes



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Appendix A
House One
Duct Size Calculations Page 1/6

PART A - DESIGN LOAD SPECIFICATIONS

page 2

A.1 Sub Total Heat Loss 42746 Btuh.

A.2 Ventilation Heat Loss 5020 Btuh.

A.3 Total Heat Loss 47766 Btuh.. (A.1 + A.2)

A.4 Sub Total Heat Gain 17107 Btuh.

A.5 Ventilation Heat Gain 1361 Btuh.

A.6 Total Heat Gain 18468 Btuh. (A.4 + A.5)

A.7 Volume of House 21483 cu ft.

A.8 Ventilation Flow Rate _____ cfm.

PART B - EQUIPMENT SELECTION

Heating Equipment:

Make _____ Model _____

Fuel Type: ☐ Gas ☐ Oil ☑ Electricity ☐ Other _____

B.1 Heating Output _____ Btuh.
(100% -140% of A.3)

B.2 Approved Temperature rise/ range .5 °F

B.3 Equipment External Static Pressure .933 in. W.C.

B.4 Heating Air Flow Rate. _____ cfm.
(when selected) _____ RPM/Speed.
(or when single temp rise) cfm = [B.1 ÷ (1.08 x B.2)]

Cooling Equipment:

Make _____ Model _____ (indoor coil)

Cooling Medium: ☐ DX ☐ Chilled water ☐ Other _____

B.5 Cooling output _____ (Btuh) _____ Tons.
(80% - 125% of A.6)

B.6 Manufacturers Flow Rate/Ton _____ (cfm/ton)

B.7 Coil Pressure Drop _____ in. W.C.

B.8 Cooling Air Flow Rate. _____ cfm.
(when selected) _____ RPM/Speed.
(or when calculated) cfm = B.5 (tons) x B.6

PART C - AIR DISTRIBUTION & PRESSURE

C.1 Circulation Air Flow Rate. _____ cfm.
(A.7 x .025)

C.2 System Design Air Flow Rate. 933 cfm.
(highest of B.4, B.8, C.1)

C.3 Cooling Air Flow Proportioning Factor (B.8 ÷ A.4)
(calculate to 4 decimal places) .0545 cfm/Btuh.

C.4 Heating Air Flow Proportioning Factor (C.2 ÷ A.1)
(calculate to 4 decimal places) .0218 cfm/Btuh.

C.5 Calculated Heating Temperature Rise _____ °F.
[B.1 ÷ (B.4 x 1.08)]

C.6 Filter Pressure Drop .0172 in. W.C.

C.7 Coil Pressure Drop (B.7) 0 in. W.C.

C.8 Total of Pressure Drop (C.6 + C.7) .0172 in. W.C.

C.9 Available Design Pressure (B.3 - C.8) .48 in. W.C.

Note: When furnace standard filter is replaced, subtract its pressure drop from the replacement filter and record on line C.6

Appendix A
House One
Duct Size Calculations Page 2/6

PART D - DETERMINING ROOM AND FLOOR DESIGN FLOW RATES								page 3
D.1 Floor	MAIN							
D.2 Room	BDRM #1	KITCHEN	BACK ENTRY	LAUNDRY	LIV. RM	BDRM #2	BDRM #3	BATH
D.3 Cooling load (Btuh)	1455	3175	798	743	2786	1407	945	89
D.4 Room cooling flow rate (D.3 x C.3)								
D.5 Heating load (Btuh)	3082	4557	2536	1959	4897	3339	2298	741
D.6 Room heating flow rate (D.5 x C.4)	67	99	55	43	107	73	50	16
D.7 Number of outlets per room	1	1	1	1	2	1	1	1
D.8 Floor supply air flow rates	510 cfm							

PART D - CONTINUED											
D.1	BASEMENT										
D.2	FAM. RM	STORAGE	WK SHOP	BASE'T	OFFICE						
D.3	3397	1213	1099	Ø	Ø						
D.4											
D.5	5951	2353	3647	3925	3458						
D.6	130	51	80	86	75						
D.7	2	1	1	1	1						
D.8	422 cfm										

PART E - INLET FLOW RATES					
Floor level (Location)	Basement (50% D.8 Max)	1st floor (Sum of D.8 Min)	2nd floor (Sum of D.8 Min)	Outside air (100% of A.8)	Total = (C.2) (System cfm)
E.1 Floor return air flow rate	211	510+211=721			933
E.2 Minimum number of openings					
E.3 Actual number of openings	2	4			
E.4 Actual cfm per opening (E.1 ÷ E.3)	105.5	180.25			

Note: After location of supply outlets and return inlets are determined, produce preliminary drawing.

Appendix A
House One
Duct Size Calculations Page 3/6

PART F - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR RETURN DUCTS									page 4	
Inlet No	Equipment Connection (Group 1)	Trunk To Drop Connection (Group 1)	Trunk Transitions (Group 2)	Trunk Fittings (Group 2)	Duct To Joist (Group 3)	Turbulence Effect	Stud To Joist (Group 4)	Grille Opening To Stud (Group 4)	Measured Length (ft)	Branch Effective Length (ft)
R1	C-10	B-35	K-15	GS+S	A-25	80	—	C-10	44	229
R2	C-10	B-35	K-15	GS+S	A-25	80	—	C-10	36	221
R3	C-10	B-35	K-15	GS+S	A-60	40	—	C-10	44.5	224.5
R4	C-10	B-35	K-15	GS+S	—	0	—	C-10	29.5	109.5
R5	C-10	B-35	—	GS+S	A-40	0	B-30	ES+S	25	160
R6	C-10	B-35	—	GS+S	A-40	0	—	D-10	23	128

PART G - DUCT DESIGN PRESSURE

G.1 (Return Branch Longest Effective Length 229 ft).

G.2 **R/A Plenum Pressure:**
Available Design Pressure (Line C.9) x Return Air Apportioning Factor (Appendix C (C3))

(.48) x (.5) = .24 in. W.C. (Record Line H.8)

G.3 **S/A Plenum Pressure:**
Available Design pressure (Line C.9) - R/A Plenum Pressure

(.48) - (.24) = .24 in. W.C. (Record Line J.7)

Appendix A
House One
Duct Size Calculations Page 4/6

PART H - SIZING OF RETURN GRILLES, BRANCHES AND MAIN TRUNK DUCTS - page 5										
H.1 Trunk Letter/No	A				B					
H.2 Inlet Location (Room)	BD #1	BD #3	BD #2	BASE'T	LIV.	BASE'T				
H.3 Inlet No (R)	R1	R2	R3	R4	R5	R6				
H.4 Inlet flow rate (cfm) (Line E.4 adjusted)	180.25	180.25	180.25	105.5	180.25	105.5				
H.5 Minimum required inlet free area (sq. in.) (Appendix C8)	65	65	65	40	65	40				
H.6 Inlet size (Appendix A)	6x12	6x12	6x12	6x8	6x12	6x8				
H.7 Inlet Pressure Loss (in. W.C.)	.02	.02	.02	.02	.02	.02				
H.8 R/A Plenum pressure (in. W.C.) (Line G.2)	.24	.24	.24	.24	.24	.24				
H.9 Adjusted duct design pressure (H.8 - H.7)	.22	.22	.22	.22	.22	.22				
H.10 Branch effective length (ft) (Part F)	229	221	224.5	109.5	160	128				
H.11 Loss/100 ft. of effective length [(H.9 x 100) ÷ H.10]	.09	.09	.09	.20	.13	.17				
H.12 Branch duct size (round) (H.4, H.11) (Appendix C4,5)	7.5	7.5	7.5	5.5	7	5.5				
H.13 Branch rectangular equivalent (Appendix C6)	14x3¼	14x3¼	14x3¼	10x3¼	14x3¼	10x3¼				
H.14 Joist to trunk opening size (2 x area H.13)	9.5x9.5	9.5x9.5	9.5x9.5		9.5x9.5					
H.15 Trunk flow rate (cfm) accumulation of H.4	180.25	360.5	540.75	646.25	826.5	932				
H.16 Lowest loss/100 ft encountered from duct end.	.09	.09	.09	.09	.09	.09				
H.17 Trunk duct size (round) (H.15, H.16) (Append C4,5)	7.5	9.5	11	12	13	14				
H.18 Trunk rectangular equivalent (Appendix C6)	6x8	9x8	13x8	16x8	18x8	22x8				
H.19 Installed Trunk size (Transitions)	←	—	—	16x8	←	22x8				
H.20 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area]				727		762				

Appendix A
House One
Duct Size Calculations Page 5/6

PART I - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR SUPPLY DUCTS page 6

Outlet No	Plenum Fitting (Group 5)	Trunk Transition (Group 6)	Trunk Fittings (Group 6)	Trunk To Branch Take offs (Group 7)	Aspiration Effect	Duct Flex Length (ft)	Branch Elbows (Group 8)	Boot Fitting (Group 8)	Measured Length (ft)	Branch Effective Length (ft)
S1	B-10	A-10+10	K-5	D-10	0		D-10+10	B-30	47	142
S2	B-10	A-10+10	K-5	A-40	0		E-5+5	B-30	51	166
S3	B-10	A-10+10	K-5	D-10	10		D-10+10	B-30	43	148
S4	B-10	A-10+10	K-5	D-10	10		D-10+10	B-30	51	156
S5	B-10	A-10+10	K-5	D-10	20		D-10+10+10	C-50	39.5	184.5
S6	B-10	A-10+10	K-5	D-10	30		D-10	B-30	40.5	155.5
S7	B-10	A-10+10	K-5	A-40	40		—	B-30	40.5	185.5
S8	B-10	A-10+10	K-5	A-40	40		—	B-30	20.5	165.5
S9	B-10	A-10+10	—	A-40	0		—	B-30	34.5	134.5
S10	B-10	A-10+10	—	A-40	0		—	B-30	16	116
S11	B-10	A-10+10	—	A-40	10		D-10	—	30	120
S12	B-10	—	—	A-40	20		D-10+10+10	B-30	38	168
S13	B-10	—	—	A-40	20		—	B-30	6	106
S14	B-10	—	—	A-40	30		D-10+10+10	B-30	42	182

Appendix A
House One
Duct Size Calculations Page 6/6

PART J - SIZING OF SUPPLY DIFFUSERS, BRANCHES AND MAIN TRUNK DUCTS page 7

J.1 Trunk Letter/No	A								B					
J.2 Outlet location (Room)	BD#2	FAM.R	BATH	BD#1	BD#3	OFFICE	FAM.R.	BASE'T	K/D	LIV.R.	STOR/WKSHOP	BACK ENTRY	LIV R.	LAUN.
J.3 Outlet No (S)	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
J.4 Outlet flow rate (cfm) (Line D.6 ÷ D.7)	73	65	16	67	50	75	65	86	99	53	131	55	54	43
J.5 Outlet size	4x10 →												→	
J.6 Outlet pressure loss (in. W.C.)	.01	.01	.005	.01	.01	.01	.01	.01	.02	.01	.04	.01	.01	.01
J.7 S/A Plenum pressure (in. W.C.) (Line G.3)	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24
J.8 Adjusted duct design pressure (J.7 - J.6)	.23	.23	.23	.23	.23	.23	.23	.23	.22	.23	.20	.23	.23	.23
J.9 Branch effective length (ft) (Part I)	142	166	148	156	184.5	155.5	185.5	165.5	134.5	116	120	168	106	182
J.10 Loss/100 ft of effective length [(J.8 x 100) ÷ J.9]	.16	.14	.15	.14	.12	.14	.12	.14	.16	.19	.16	.14	.20	.13
J.11 Branch duct size (round) (J.4, J.10) (Appendix C4,5)	5	5	3	5	4.5	5	4.5	5.5	5.5	4	6	4.5	4	4
J.12 Branch rectangular equivalent (Appendix C6)	10x3¼ →									→	12x3¼	10x3¼	→	→
J.13 Trunk flow rate (cfm) accumulation of J.4	73	138	154	221	271	346	411	497	596	649	780	835	889	932
J.14 Lowest loss/100 ft encountered from duct end.	.16	.14	.14	.14	.12	.12	.12	.12	.12	.12	.12	.12	.12	.12
J.15 Trunk duct size (round) (J.13, J.14) (Appendix C4,5)	5	6	6.5	7.5	8.5	9.5	10	10.5	11	11.5	12.5	13	13	13.5
J.16 Trunk rectangular equivalent (Appendix C6)								12x8						20x8
J.17 Installed Trunk size (Transitions)	←						←	16x8	←				←	20x8
J.18 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area]								559						839

Appendix A
House One
Supply-Air Flow Measurements

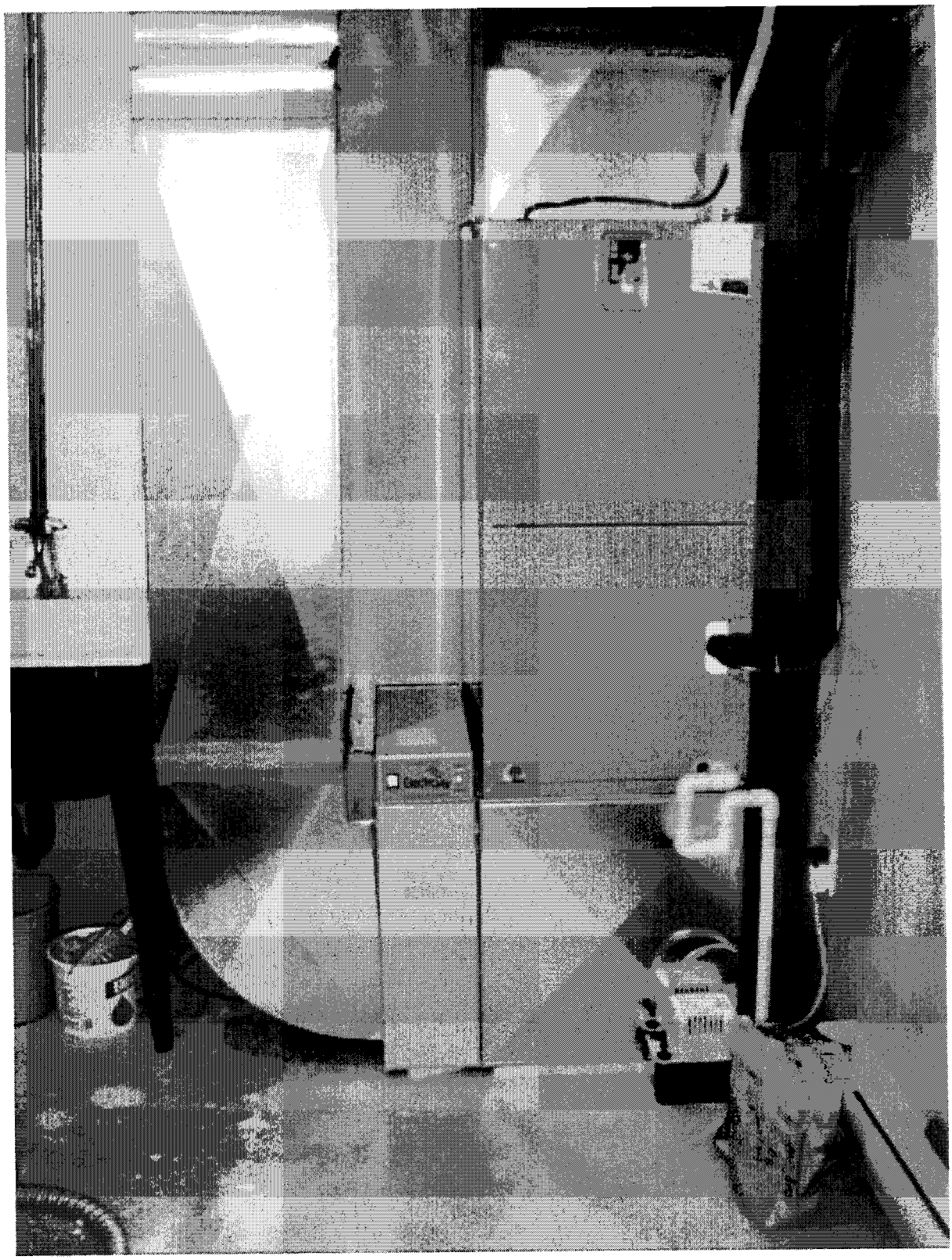
Supply Airflows Measurements

Measurements Method	Flow Collar In Duct			Hood At Grille			Branch	Design
Space	Pressure		Airflow	Pressure		Airflow		Airflow
	pa	"wc	cfm	pa	"wc	cfm		
Main Floor								
Master Bedroom	2.6	0.01	50	7.2	0.028	36	S-4	67
Bathroom	2.4	0.009	48	7	0.028	36	S-3	16
Mid. Bedroom	1.9	0.0076	44	5.7	0.022	32	S-5	50
Front Bedroom	4	0.016	64	9	0.036	41	S-1	73
Living Room (1)	could not measure			9.7	0.038	42	S-13	54
Living Room (2)	3.1	0.0124	57	15.6	0.062	53	S-10	53
Kitchen / Dining	6.6	0.026	82	12.9	0.0516	49	S-9	99
Back Entry	5.9	0.023	77	10.6	0.042	44	S-12	55
Laundry	2.6	0.01	51	4	0.016	27	S-14	43
Basement								
Family Room (1)	12.3	0.049	112	could not measure			S-2	66
Family Room (2)	10	0.04	101	could not measure			S-7	65
Storage	2	0.008	45	could not measure			S-11	131
Basement	0.9	0.0036	30	could not measure			S-8	86
Office	6.8	0.027	84	could not measure			S-6	75

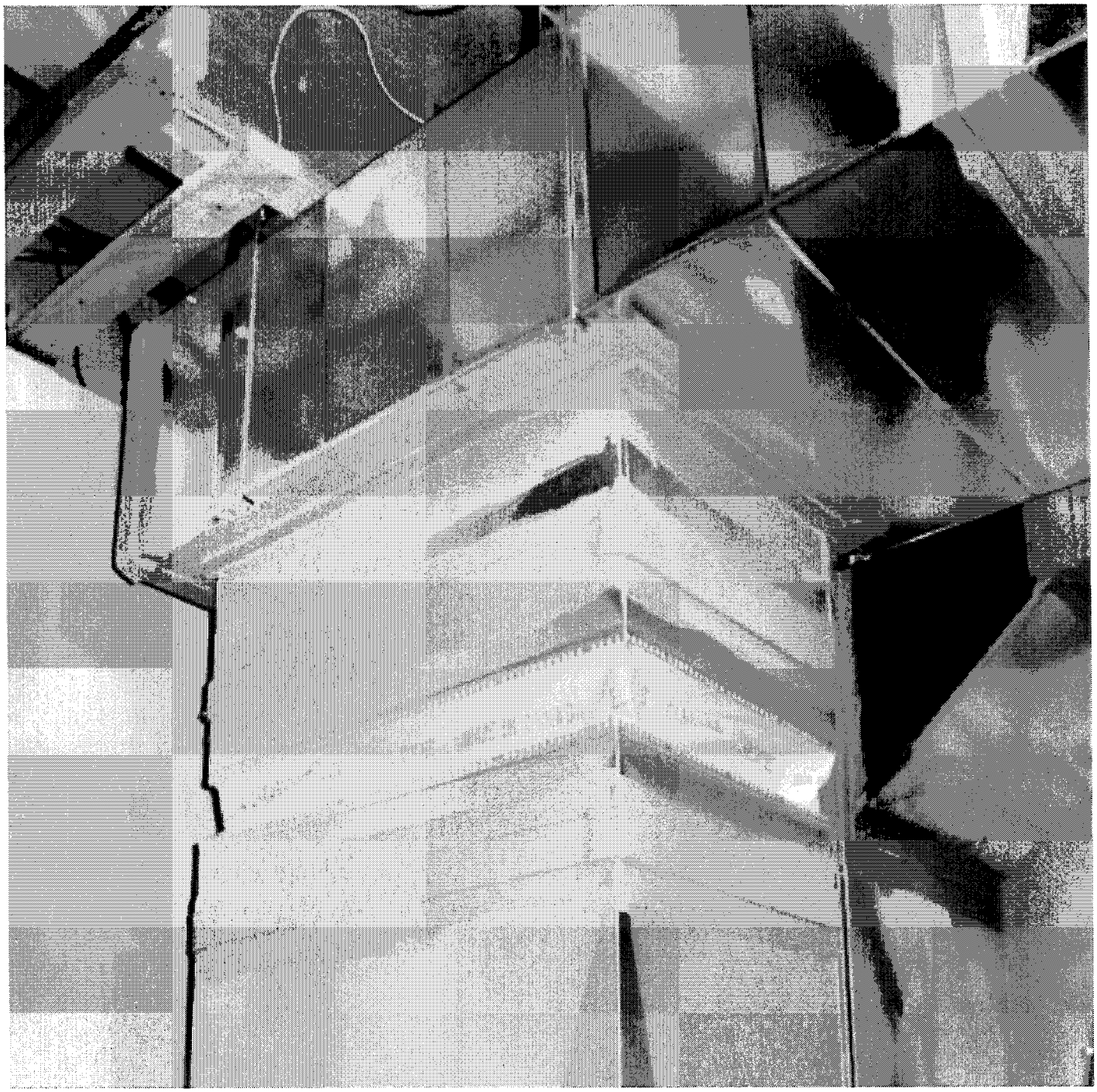
Notes:

* Measurements were recorded using a digital manometer
* Flow collar in duct, 6" dia. saddle style
* Hood equipped with 4" dia. Flow collar
* Some measurements not collected, no access to duct
* Some measurements not collected, no ceiling against which to place hood
* Joints of branch ducts were not sealed

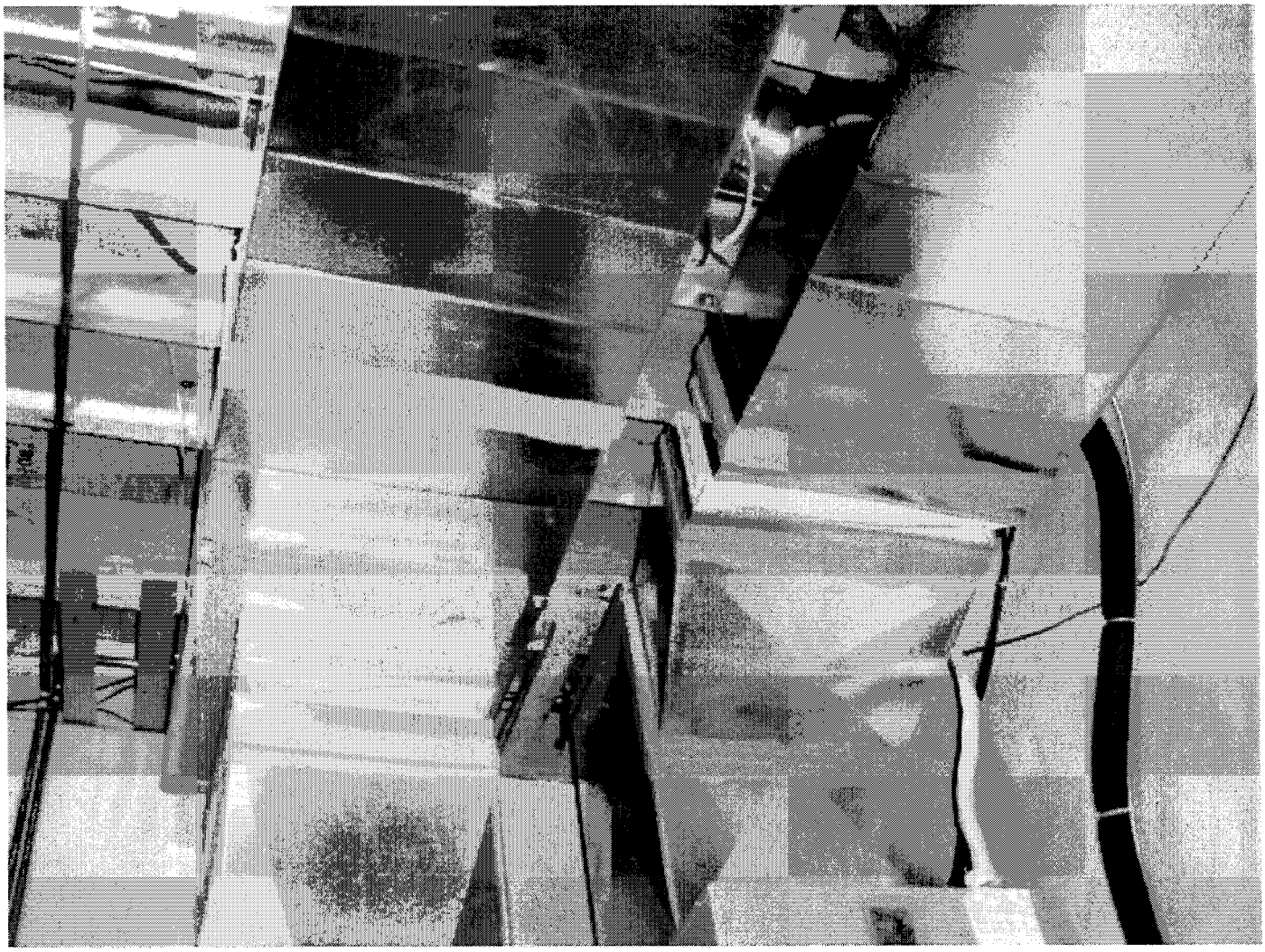
Appendix A
House One
Photographs of System 1 of 13
H1,001



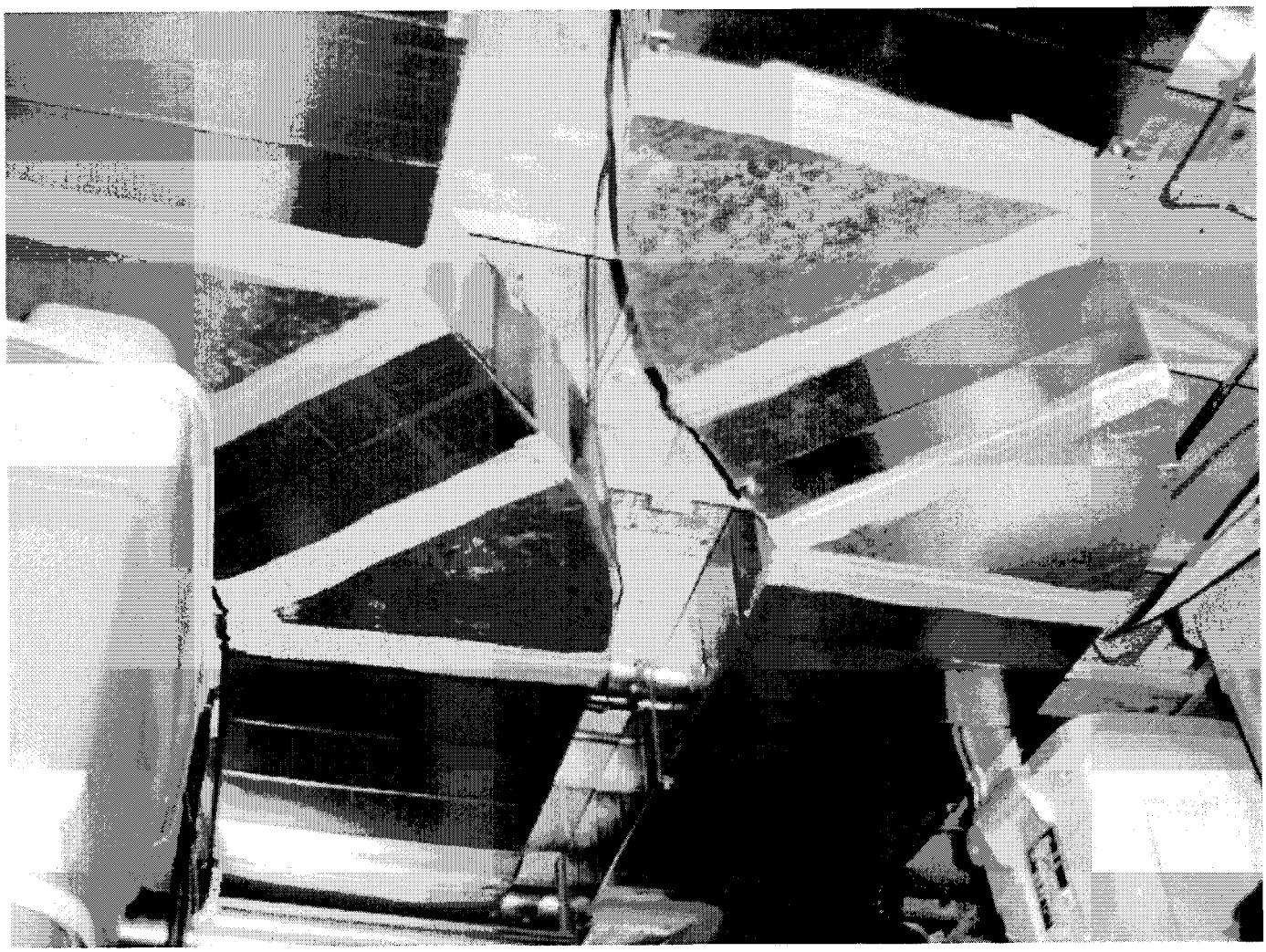
Appendix A
House One
Photographs of System 2 of 13
H1,002



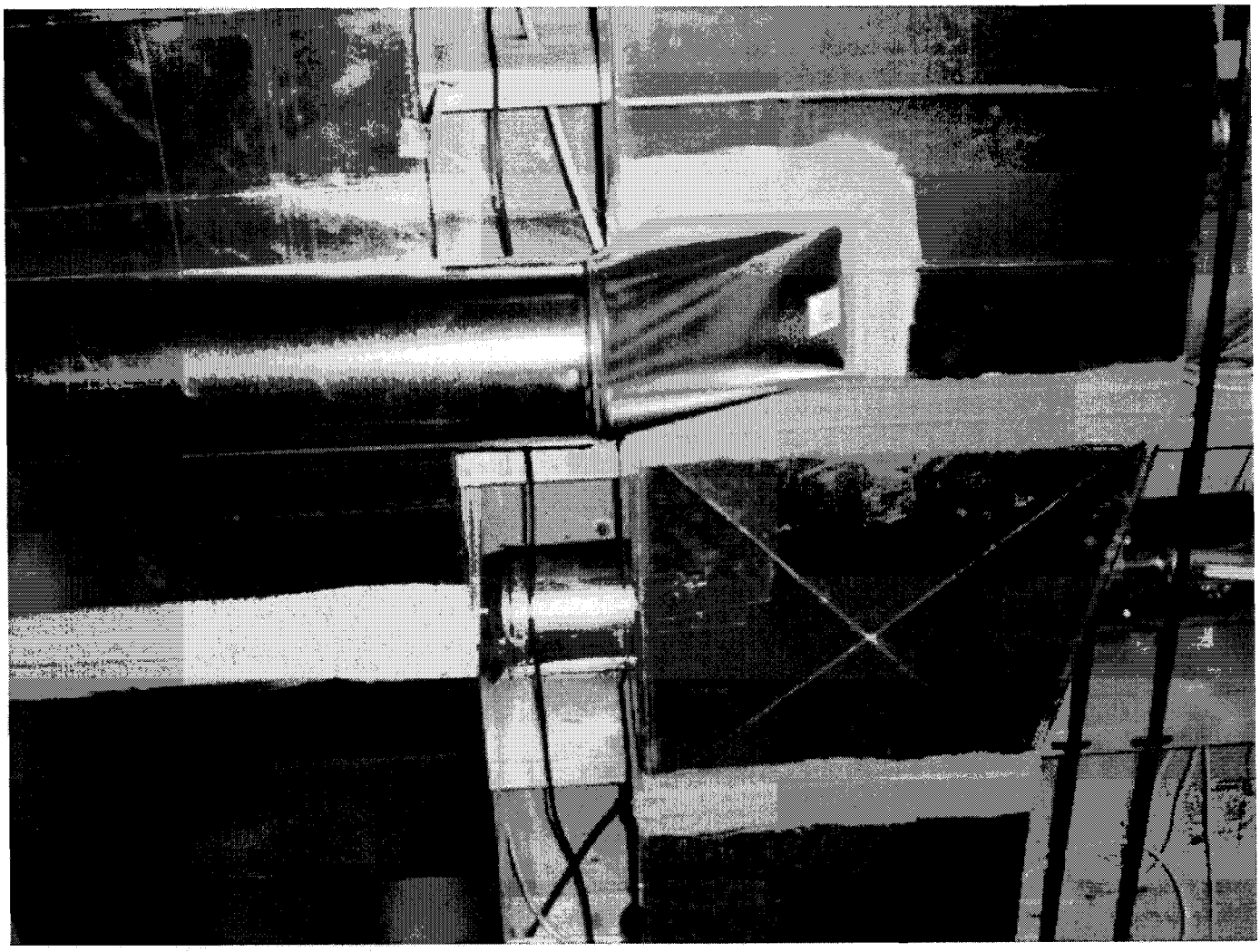
Appendix A
House One
Photographs of System 3 of 13
H1,003



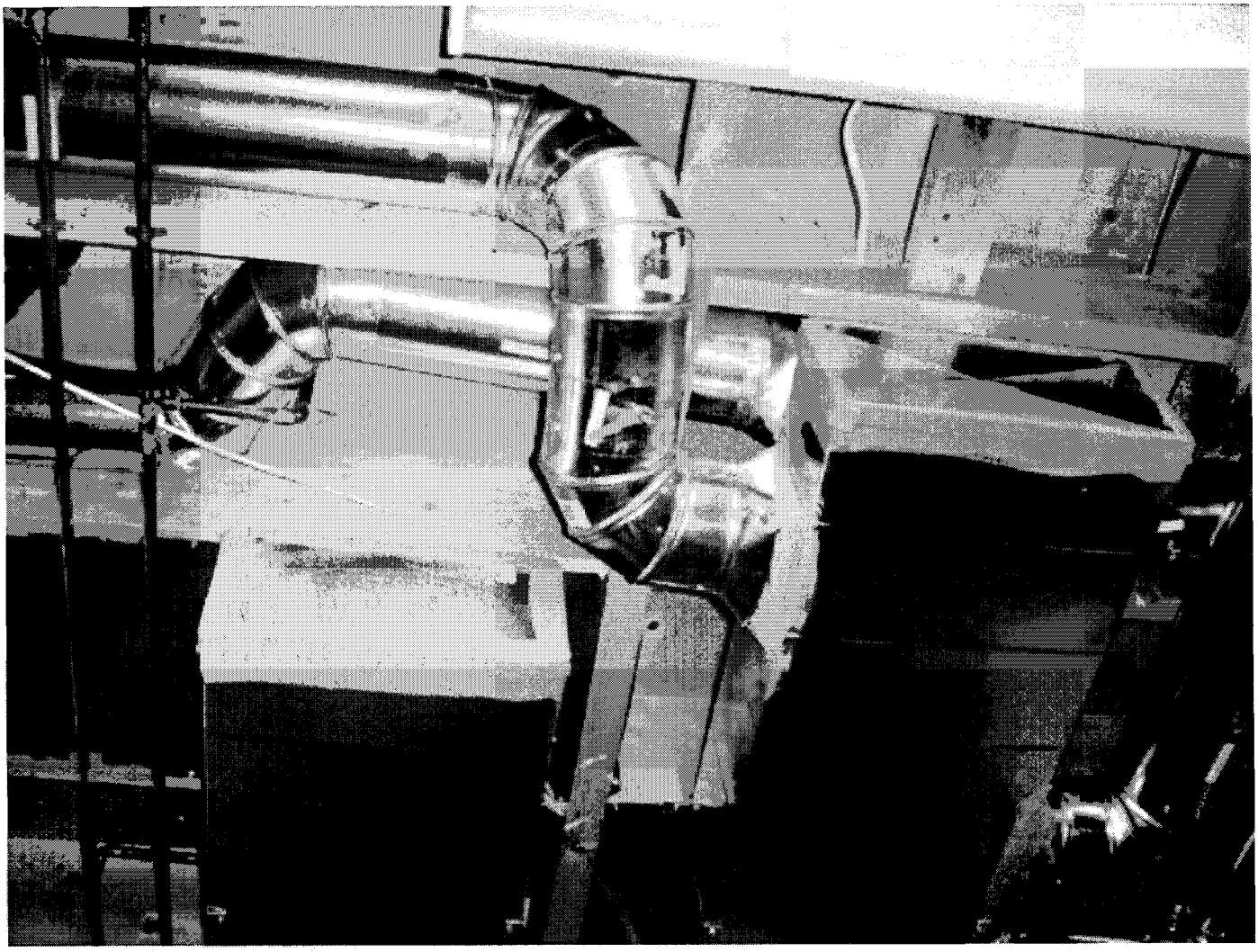
Appendix A
House One
Photographs of System 4 of 13
H1,004



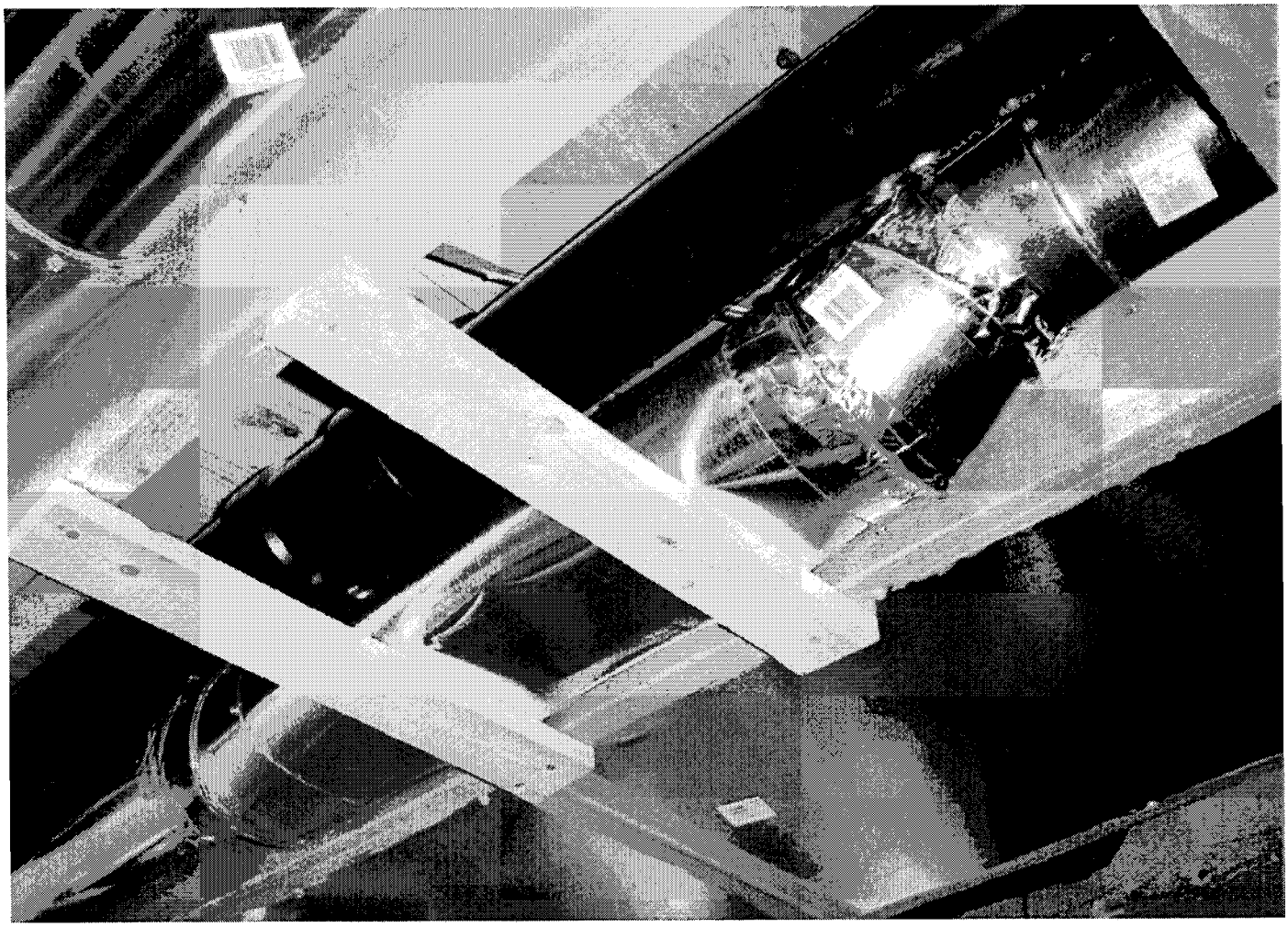
Appendix A
House One
Photographs of System 5 of 13
H1,005



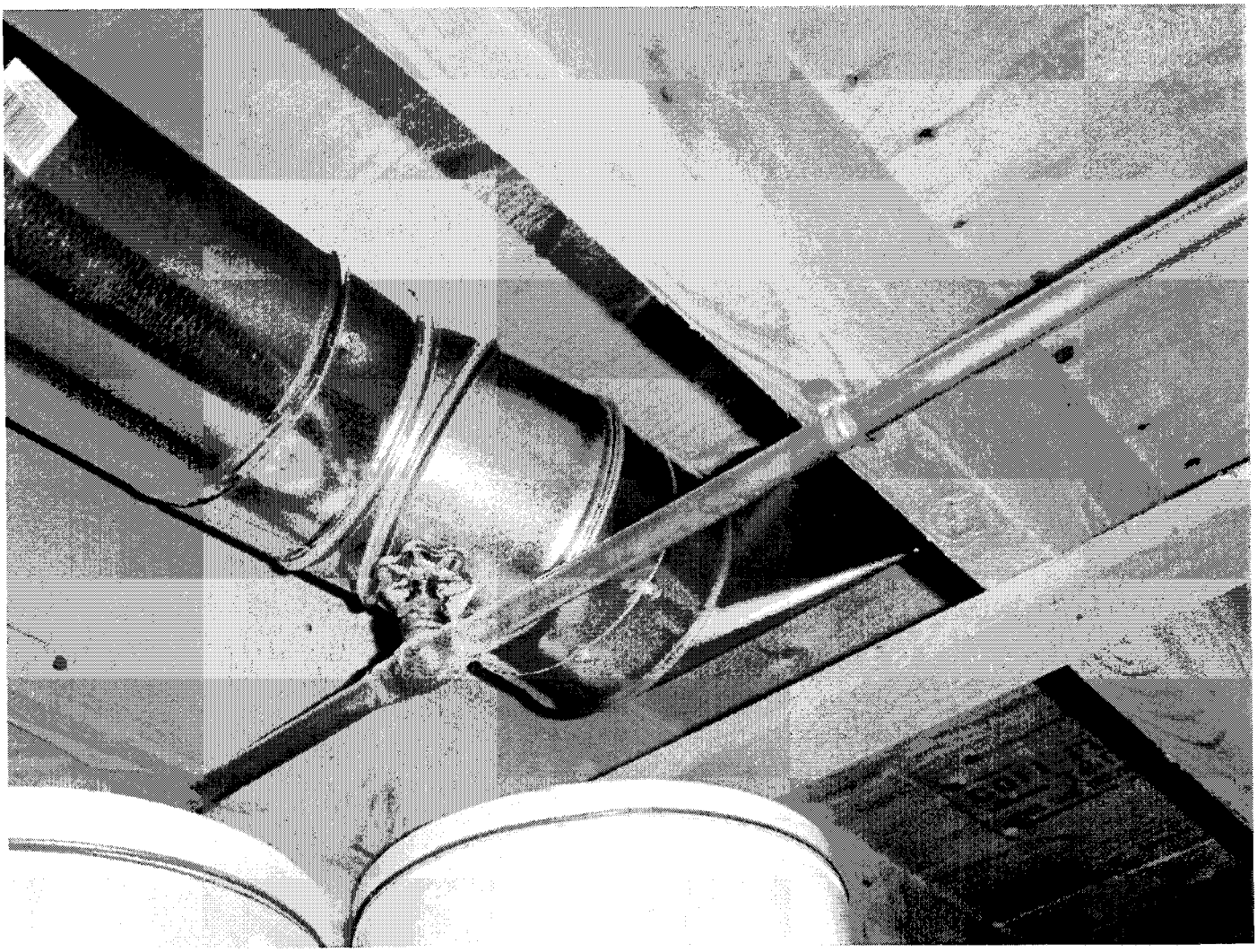
Appendix A
House One
Photographs of System 6 of 13
H1,006



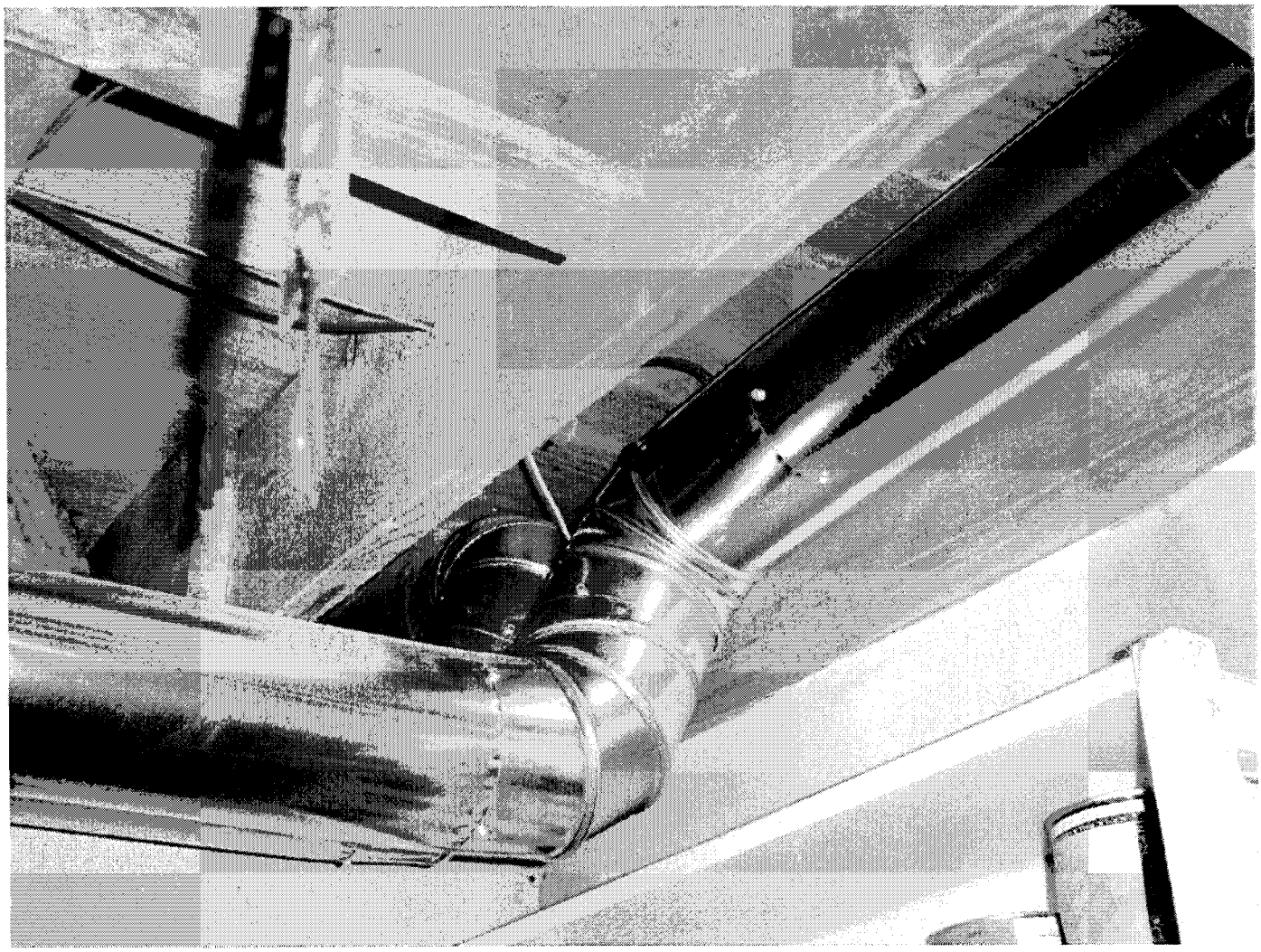
Appendix A
House One
Photographs of System 7 of 13
H1,007



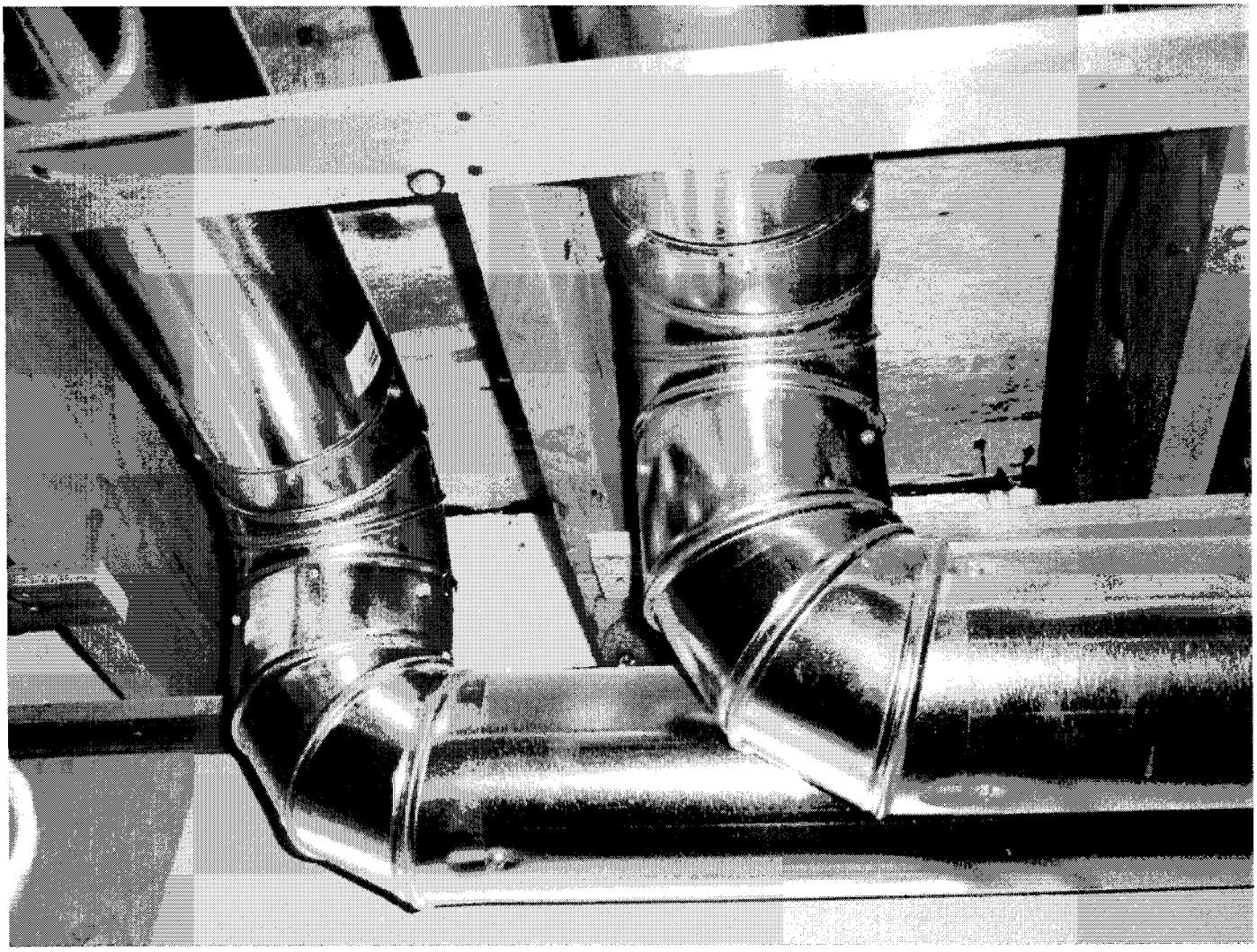
Appendix A
House One
Photographs of System 8 of 13
H1,008



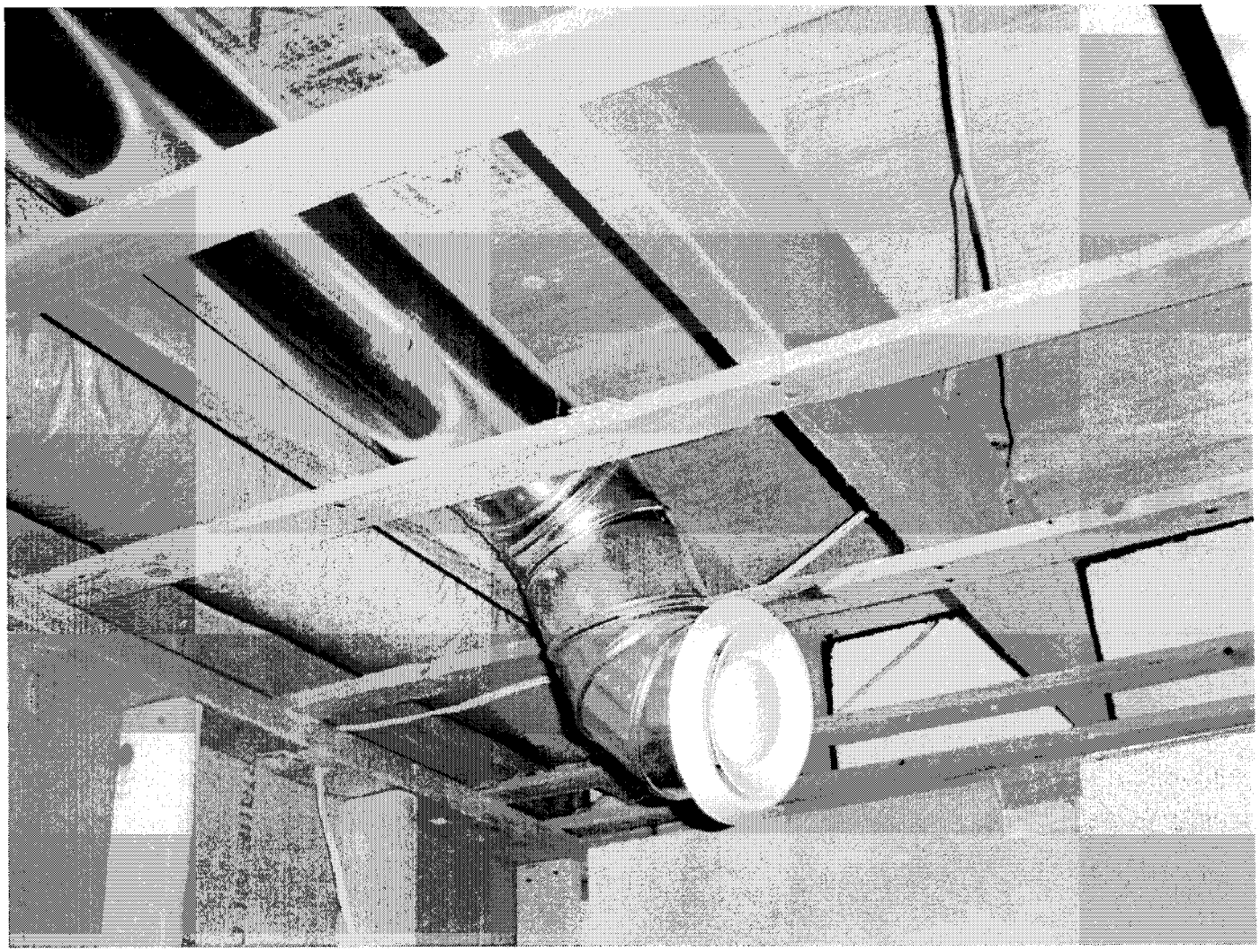
Appendix A
House One
Photographs of System 9 of 13
H1,009



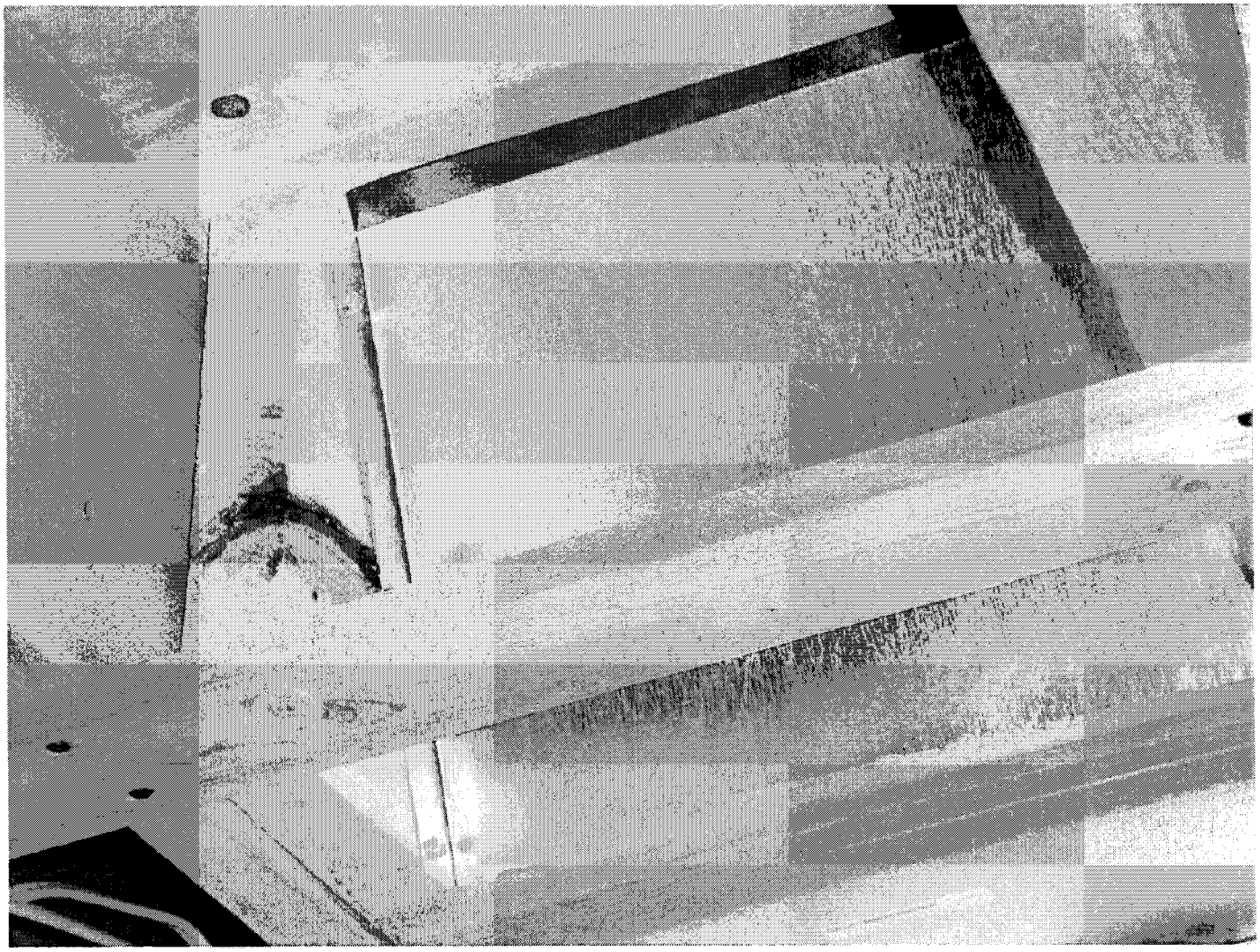
Appendix A
House One
Photographs of System 10 of 13
H1,010



Appendix A
House One
Photographs of System 11 of 13
H1,011



Appendix A
House One
Photographs of System 12 of 13
H1,012



Appendix A
House One
Photographs of System 13 of 13
H1,013

Load Short Form
Entire House

Job: 23013b
Date:
By: Bob Clarke

Cert.#: 001529

R. CLARKE Designs Ltd.

3 Sheffield Court, Oromocto, NB E2V 2N1 Phone: 506-357-3377 Fax: 506-357-3378 Email: rclarke@nbnet.nb.ca

Project Information

For: CMHC Test House #2

Design Information

	Htg	Clg
Outside db (°F)	-11	84
Inside db (°F)	72	75
Design TD (°F)	83	9
Daily range	-	M
Inside humidity (%)	-	50
Moisture difference (gr/lb)	-	21

Infiltration

Method	F280
Exposure category	Sheltered
Construction category	Average
Number of stories	2.0

HEATING EQUIPMENT		COOLING EQUIPMENT	
Make		Make	
Trade		Trade	
Model		Cond	
		Coil	
Efficiency	0 HSPF	Efficiency	0 SEER
Heating input		Sensible cooling	0 Btuh
Heating output	0 Btuh @ 47°F	Latent cooling	0 Btuh
Temperature rise	0 °F	Total cooling	0 Btuh
Actual air flow	900 cfm	Actual air flow	***900*** cfm
Air flow factor	0.022 cfm/Btuh	Air flow factor	0.058 cfm/Btuh
Static pressure	0.40 in H2O	Static pressure	0.40 in H2O
Space thermostat		Load sensible heat ratio	77 %

ROOM NAME	Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Bedroom #1	132	3299	1586	72	93
Bedroom #2	117	2821	1551	62	91
Upper Hall	101	359	86	8	5
Bathroom	80	682	69	15	4
Attic Storage	254	2229	386	49	23
Unfin. Attic Rom	396	3386	654	74	38
Laundry	127	3229	1148	70	67
Entry	66	1690	95	37	6
Powder Room	52	1717	502	37	29
Kitchen	118	2449	1030	53	60
Dining	147	4143	2814	90	165
Living Room	193	4089	1606	89	94
Parlor	133	4363	2254	95	132
Front Hall	100	858	14	19	1
Master Bedroom	258	5234	1576	114	92
Main Bath	111	714	17	16	1

Bold/Italic values have been manually overridden

Printout certified by HRAI to meet all requirements of CAN/CSA-F280-M90

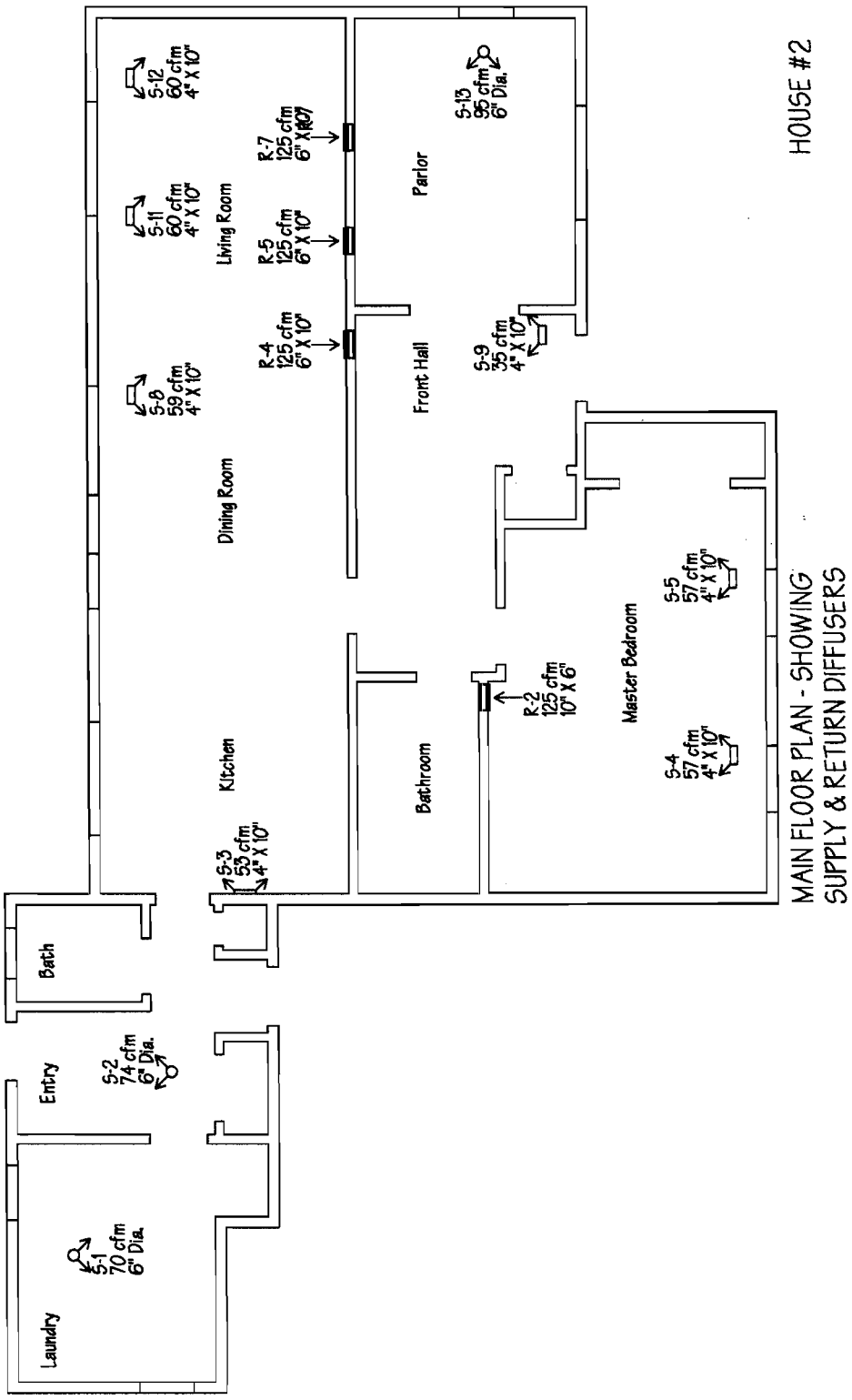
Entire House	d	2363	41262	15388	900	***900***
Ventilation air			10757	1166		
Equip. @ 1.00	RSM			16554		
Latent cooling				4966		
TOTALS		2363	52019	21520	900	***900***

Bold/Italic values have been manually overridden

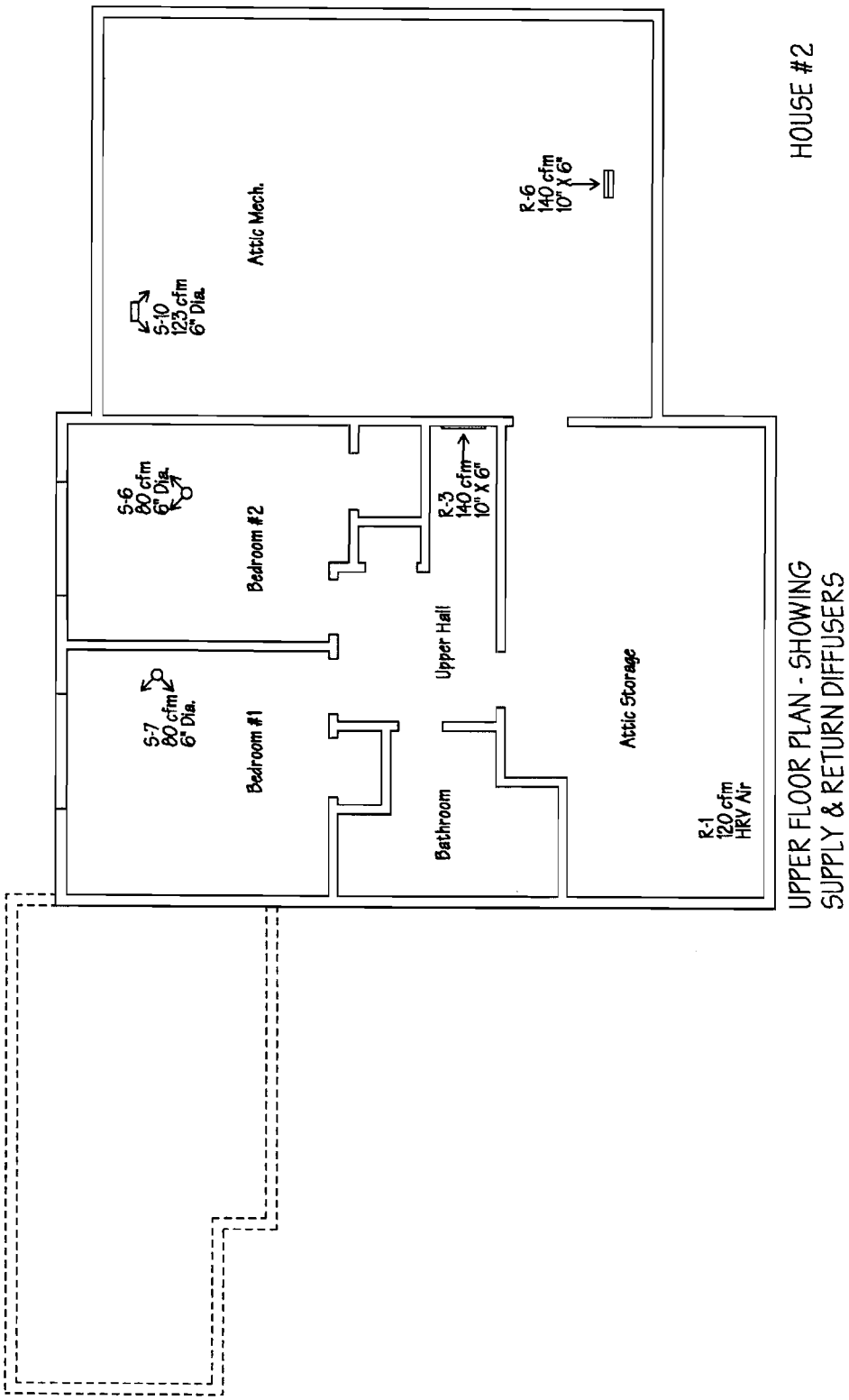
Printout certified by HRAI to meet all requirements of CAN/CSA-F280-M90

Appendix B
House Two
Design Heating / Cooling Load Calculations

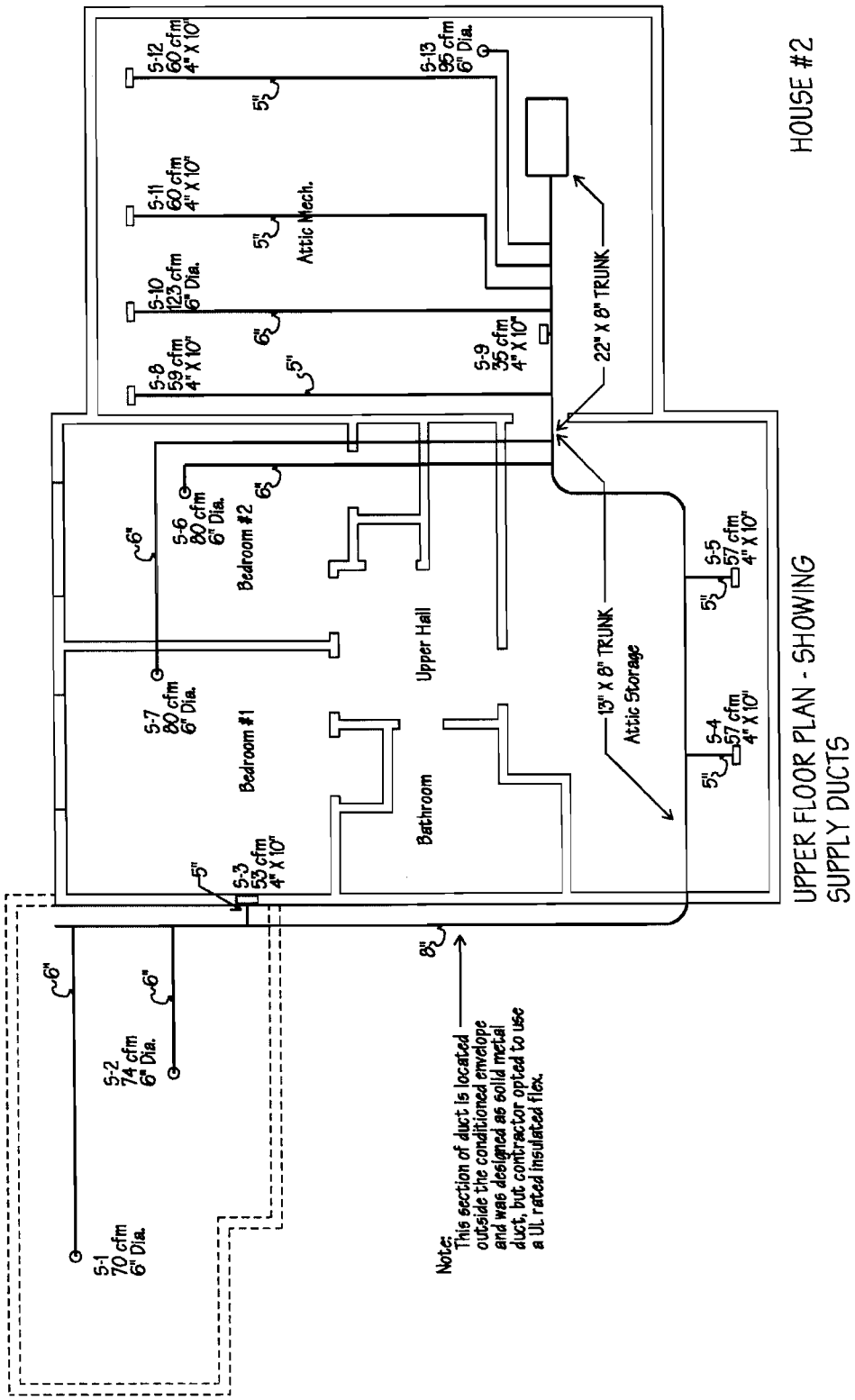
Appendix B
House Two
Main Floor Plan Showing Supply & Return Diffusers



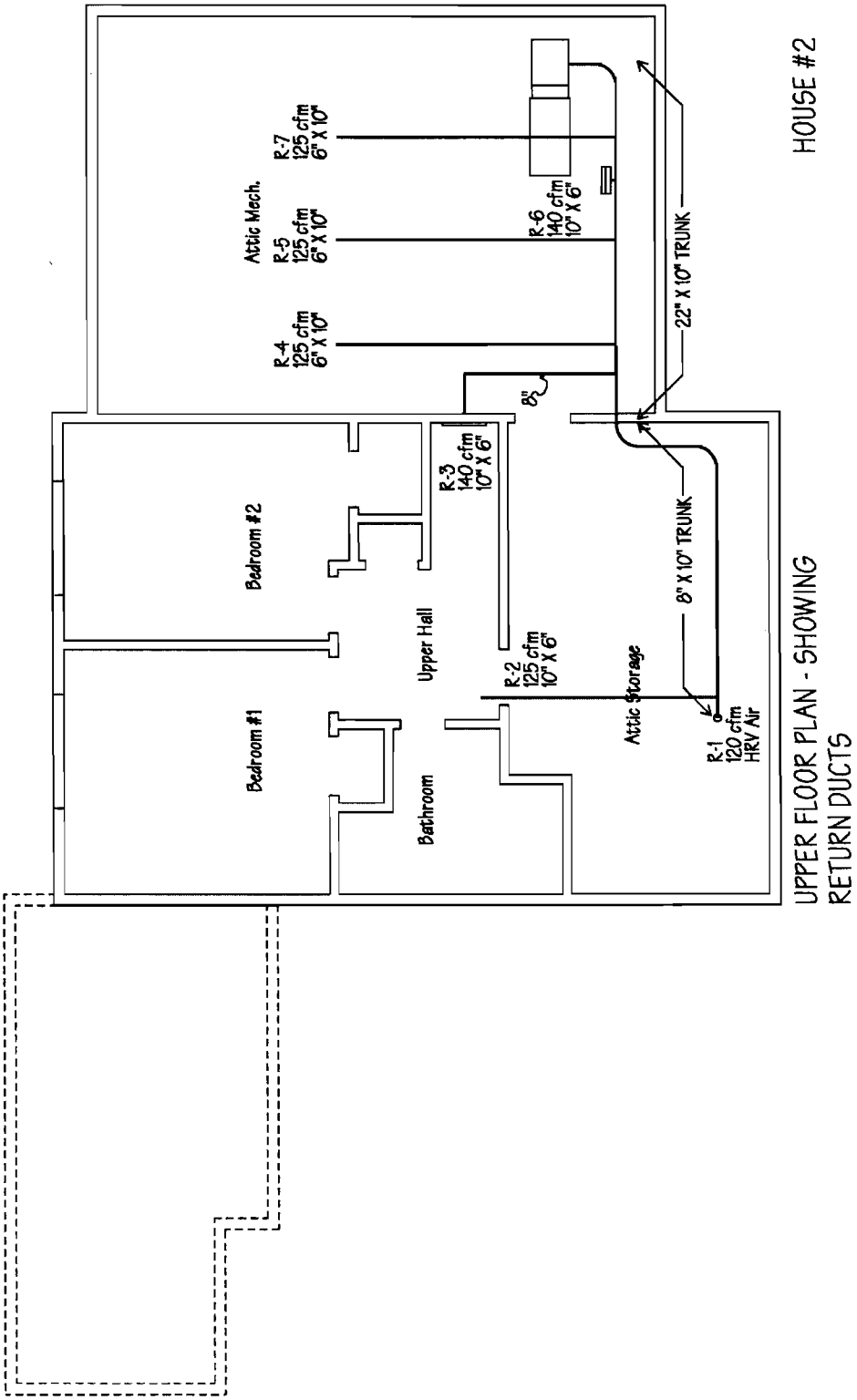
Appendix B
House Two
Upper Floor Plan Showing Supply & Return Diffusers



Appendix B
House Two
Upper Floor Plan - Showing Supply Ducts



Appendix B
House Two
Upper Floor Plan - Showing Return Ducts



Appendix B
House Two
Duct Size Calculations Page 1/6

PART A - DESIGN LOAD SPECIFICATIONS

page 2

A.1 Sub Total Heat Loss 41262 Btuh.

A.2 Ventilation Heat Loss 10757 Btuh.

A.3 Total Heat Loss 52019 Btuh.. (A.1 + A.2)

A.4 Sub Total Heat Gain 20354 Btuh.

A.5 Ventilation Heat Gain 1166 Btuh.

A.6 Total Heat Gain 21520 Btuh. (A.4 + A.5)

A.7 Volume of House 17163 cu ft.

A.8 Ventilation Flow Rate 120 cfm.

PART B - EQUIPMENT SELECTION

Heating Equipment:

Make _____ Model _____

Fuel Type: ☐ Gas ☐ Oil ☐ Electricity ☐ Other _____

B.1 Heating Output 52019 Btuh.
(100% -140% of A.3)

B.2 Approved Temperature rise/ range _____ °F

B.3 Equipment External Static Pressure _____ in. W.C.

B.4 Heating Air Flow Rate. 900 cfm.
(when selected) _____ RPM/Speed.
(or when single temp rise) cfm = [B.1 ÷ (1.08 x B.2)]

Cooling Equipment:

Make _____ Model _____ (indoor coil)

Cooling Medium: ☐ DX ☐ Chilled water ☐ Other _____

B.5 Cooling output 24000 (Btuh) 2 Tons.
(80% - 125% of A.6)

B.6 Manufacturers Flow Rate/Ton _____ (cfm/ton)

B.7 Coil Pressure Drop _____ in. W.C.

B.8 Cooling Air Flow Rate. 900 cfm.
(when selected) _____ RPM/Speed.
(or when calculated) cfm = B.5 (tons) x B.6

PART C - AIR DISTRIBUTION & PRESSURE

C.1 Circulation Air Flow Rate. 429 cfm.
(A.7 x .025)

C.2 System Design Air Flow Rate. 900 cfm.
(highest of B.4, B.8, C.1)

C.3 Cooling Air Flow Proportioning Factor (B.8 ÷ A.4)
(calculate to 4 decimal places) .0442 cfm/Btuh.

C.4 Heating Air Flow Proportioning Factor (C.2 ÷ A.1)
(calculate to 4 decimal places) .0218 cfm/Btuh.

C.5 Calculated Heating Temperature Rise _____ °F.
[B.1 ÷ (B.4 x 1.08)]

C.6 Filter Pressure Drop .01 in. W.C.

C.7 Coil Pressure Drop (B.7) ✓ in. W.C.

C.8 Total of Pressure Drop (C.6 + C.7) .01 in. W.C.

C.9 Available Design Pressure (B.3 - C.8) .4 in. W.C.

Note: When furnace standard filter is replaced, subtract its pressure drop from the replacement filter and record on line C.6

Appendix B
House Two
Duct Size Calculations Page 2/6

PART D - DETERMINING ROOM AND FLOOR DESIGN FLOW RATES								page 3
D.1 Floor	MAIN FLOOR							
D.2 Room	LAUN.	ENTRY	P.RM.	KIT.	DIN	LIV	PARLOR	FT. HALL 3674
D.3 Cooling load (Btuh)	1148	95	502	1036	2814	1606	2254	31
D.4 Room cooling flow rate (D.3 x C.3)	50	4	22	46	124	71	100	2
D.5 Heating load (Btuh)	3229	1690	1717	2449	4143	4089	4363	1572
D.6 Room heating flow rate (D.5 x C.4)	70	37	37	53	90	89	95	35
D.7 Number of outlets per room	1	1		1	3		1	1
D.8 Floor supply air flow rates	SA = 620			RA = 500				

PART D - CONTINUED											
D.1		UPPER FLOOR									
D.2	M.BDRM	BD#1	BD#2	ATTIC ST.	ATTIC MEN						
D.3	1576	1672	1620	386	654						
D.4	70	74	72	17	29						
D.5	5234	3658	3503	2229	3386						
D.6	114	80	77	49	74						
D.7	2	1	1	1							
D.8		SA = 280		RA = 280 + 120 = 400 cfm							

PART E - INLET FLOW RATES					
Floor level (Location)	Basement (50% D.8 Max)	1st floor (Sum of D.8 Min)	2nd floor (Sum of D.8 Min)	Outside air (100% of A.8)	Total = (C.2) (System cfm)
E.1 Floor return air flow rate		500	280	120	
E.2 Minimum number of openings		4.16	2		
E.3 Actual number of openings		4			
E.4 Actual cfm per opening (E.1 ÷ E.3)		125	140	120	

Note: After location of supply outlets and return inlets are determined, produce preliminary drawing.

Appendix B
House Two
Duct Size Calculations Page 3/6

PART F - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR RETURN DUCTS page 4

Inlet No	Equipment Connection (Group 1)	Trunk To Drop Connection (Group 1)	Trunk Transitions (Group 2)	Trunk Fittings (Group 2)	Duct To Joist (Group 3)	Turbulence Effect	Stud To Joist (Group 4)	Grille Opening To Stud (Group 4)	Measured Length (ft)	Branch Effective Length (ft)
R1	E20	B35	K15	B15 B10+10	—	40	—	—	41	186
R2	↓	↓	K15	B15 B10+10	A25	0	A15	C10	58	213
R3	↓	↓	—	B15	A60	160	F5 E10	↓	29	344
R4	↓	↓	—	↓	A60	120	A15	↓	37	312
R5	↓	↓	—	↓	A60	80	A15	↓	32	267
R6	↓	↓	—	↓	A60	40	—	↓	12	192
R7	↓	↓	—	↓	A60	∅	A15	↓	27	182

PART G - DUCT DESIGN PRESSURE

G.1 (Return Branch Longest Effective Length 344 ft).

G.2 **R/A Plenum Pressure:**
Available Design Pressure (Line C.9) x Return Air Apportioning Factor (Appendix C (C3))

(.4) x (.5) = .2 in. W.C. (Record Line H.8)

G.3 **S/A Plenum Pressure:**
Available Design pressure (Line C.9) - R/A Plenum Pressure

(.4) - (.2) = .2 in. W.C. (Record Line J.7)

Appendix B
House Two
Duct Size Calculations Page 4/6

PART H - SIZING OF RETURN GRILLES, BRANCHES AND MAIN TRUNK DUCTS										page 5
H.1 Trunk Letter/No										
H.2 Inlet Location (Room)	VENT	MAST BDRM	UPPER HALL	LIV	LIV	ATTIC MECH	LIV			
H.3 Inlet No (R)	R1	R2	R3	R4	R5	R6	R7			
H.4 Inlet flow rate (cfm) (Line E.4 adjusted)	120	125	140	125	125	140	125			
H.5 Minimum required inlet free area (sq. in.) (Appendix C8)	43	47	50	47	47	50	47			
H.6 Inlet size (Appendix A)		10X6	10X6	10X6	10X6	10X6	10X6			
H.7 Inlet Pressure Loss (in. W.C.)		.04	→							
H.8 R/A Plenum pressure (in. W.C.) (Line G.2)	.2	.2	→							
H.9 Adjusted duct design pressure (H.8 - H.7)		.16	→							
H.10 Branch effective length (ft) (Part F)		213	344	312	267	192	182			
H.11 Loss/100 ft. of effective length [(H.9 x 100) ÷ H.10]		.07	.04	.05	.06	.08	.09			
H.12 Branch duct size (round) (H.4, H.11) (Appendix C4,5)		6	8	7.5	7.0	7	6.5			
H.13 Branch rectangular equivalent (Appendix C6)		12x3¼	7x8	14x3¼	14x3¼	14x3¼	12x3¼			
H.14 Joist to trunk opening size (2 x area H.13)		7x7	10x10	9.5x9.5	9x9	9x9	9x9			
H.15 Trunk flow rate (cfm) accumulation of H.4	120	245	385	510	635	775	900			
H.16 Lowest loss/100 ft encountered from duct end.	—	.07	.04	→						
H.17 Trunk duct size (round) (H.15, H.16) (Append C4,5)		9	11.5	13	14	15	16			
H.18 Trunk rectangular equivalent (Appendix C6)		8x8	11x10	14x10	17x10	19x10	22x10			
H.19 Installed Trunk size (Transitions)		8x10	←			↘	22x10			
H.20 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area]										

Appendix B
House Two
Duct Size Calculations Page 5/6

PART I - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR SUPPLY DUCTS page 6

Outlet No	Plenum Fitting (Group 5)	Trunk Transition (Group 6)	Trunk Fittings (Group 6)	Trunk To Branch Take offs (Group 7)	Aspiration Effect	Duct Flex Length (ft)	Branch Elbows (Group 8)	Boot Fitting (Group 8)	Measured Length (ft)	Branch Effective Length (ft)
S1	G15 + B10	K15	B15+15 B10	J50	0		D10	B30	82	252
S2					10				69	249
S3					20				61	251
S4			B15+15	D10	0			A5	34	129
S5			— " —	— " —	10			— " —	26	131
S6				A40	20		E5 + 5 D10	B30	30	180
S7				— " —	30		— " —		40	200
S8				D10	0		D10		28	103
S9					10		—	A5	9	59
S10					20		D10	B30	24	119
S11					30		D10+10+10		26	151
S12					40				30	165
S13					50				14	159

Appendix B
House Two
Supply-Air Flow Measurements

Supply Airflows Measurements

Measurements Method	Flow Collar In Duct			Hood At Grille			Branch	Design
Space	Pressure		Airflow	Pressure		Airflow		Airflow
	pa	"wc	cfm	pa	"wc	cfm		
Main Floor								
Laundry	could not measure			5	0.02	30.4	S-1	70
Side Entry	could not measure			4.4	0.017	66.5	S-2	74
Kitchen	could not measure			6.2	0.025	33.9	S-3	53
Living Room (1)	7.7	0.03	88.3	19.7	0.079	60.3	S-8	59
Living Room (2)	4.4	0.017	65.5	11.2	0.045	45.5	S-11	60
Living Room (3)	4	0.016	64.5	8.4	0.034	39.5	S-12	60
Parlor	5	0.02	72.1	7.8	0.031	89.8	S-13	95
Front Hall	1.3	0.005	36	3.1	0.012	23.5	S-9	35
Master Bedroom (1)	8.8	0.035	95.4	14.1	0.056	50.8	S-4	57
Master Bedroom (2)	7.2	0.028	85.3	11.7	0.47	46.5	S-5	57
Upper Floor								
Bedroom	4.9	0.019	70.3	6.1	0.024	79	S-7	80
Computer Room	5.9	0.023	77.3	7.8	0.031	89.8	S-6	80
Hall	6.3	0.025	80.6	8.4	0.034	94	S-6a	0
Attic Mech.	4.5	0.018	68.4	12.6	0.05	48	S-10	123

Notes:

* Measurements were recorded using a digital manometer
* Flow collar in duct, 6" dia. saddle style
* Hood equipped with 4" or 6" dia. Flow collar
* Some measurements not collected, no access to duct
* Joints of branch ducts were not sealed

Appendix B
House Two
Return-Air Flow Measurements

Return Airflows Measurements

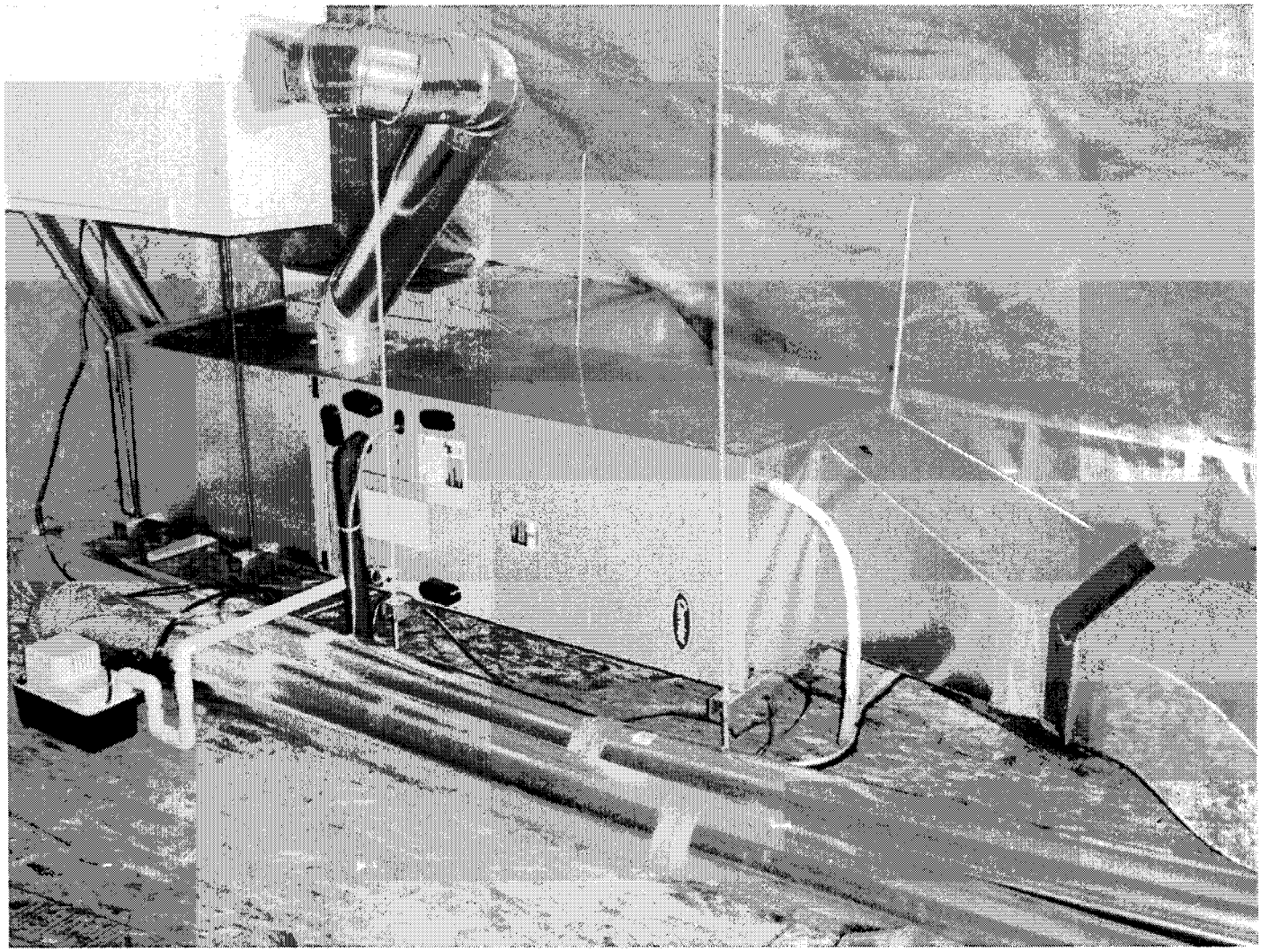
Measurements Method	Flow Collar In Duct			Hood At Grille			Branch	Design
Space	Pressure		Airflow	Pressure		Airflow		Airflow
	pa	"wc	cfm	pa	"wc	cfm		
Main Floor								
Living Room (1)	could not measure			7.7	0.03	88.3	R-4	125
Living Room (2)	could not measure			4.7	0.018	68.4	R-5	125
Living Room (3)	could not measure			4.7	0.018	68.4	R-7	125
Parlor	could not measure			6.5	0.026	82.2	R	0
Master Bedroom	could not measure			2.4	0.009	48.4	R-2	125
Upper Floor								
Stairwell	could not measure			9.5	0.038	99.4	R-3	140
Attic Mech.	not installed			not installed			R-6	140

Notes:

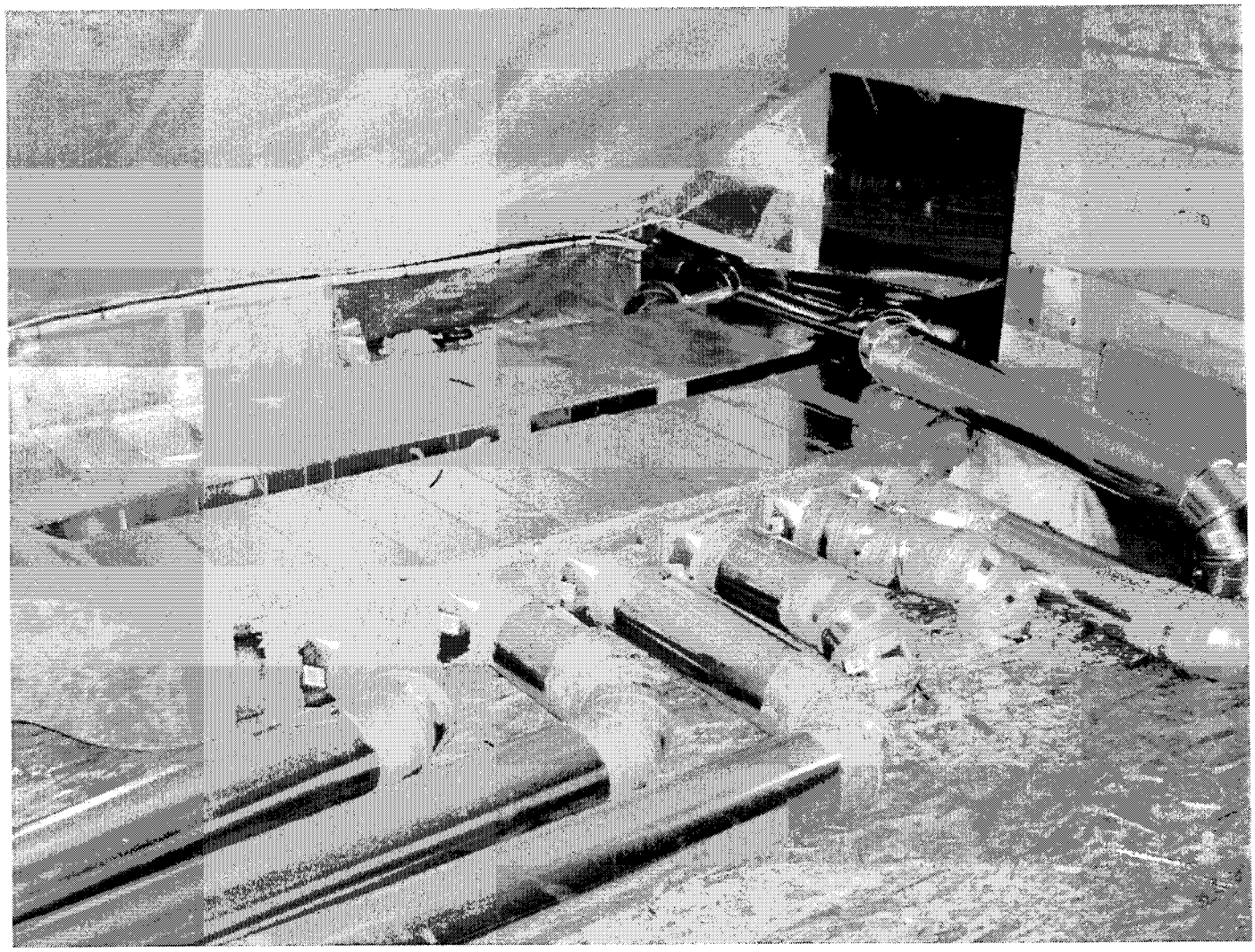
* Measurements were recorded using a digital manometer
* Hood equipped with 4" or 6" dia. Flow collar
* Some measurements not collected with flow collar, joists were panned

Appendix B
House Two
Photographs of System 1 of 15
H2, 001

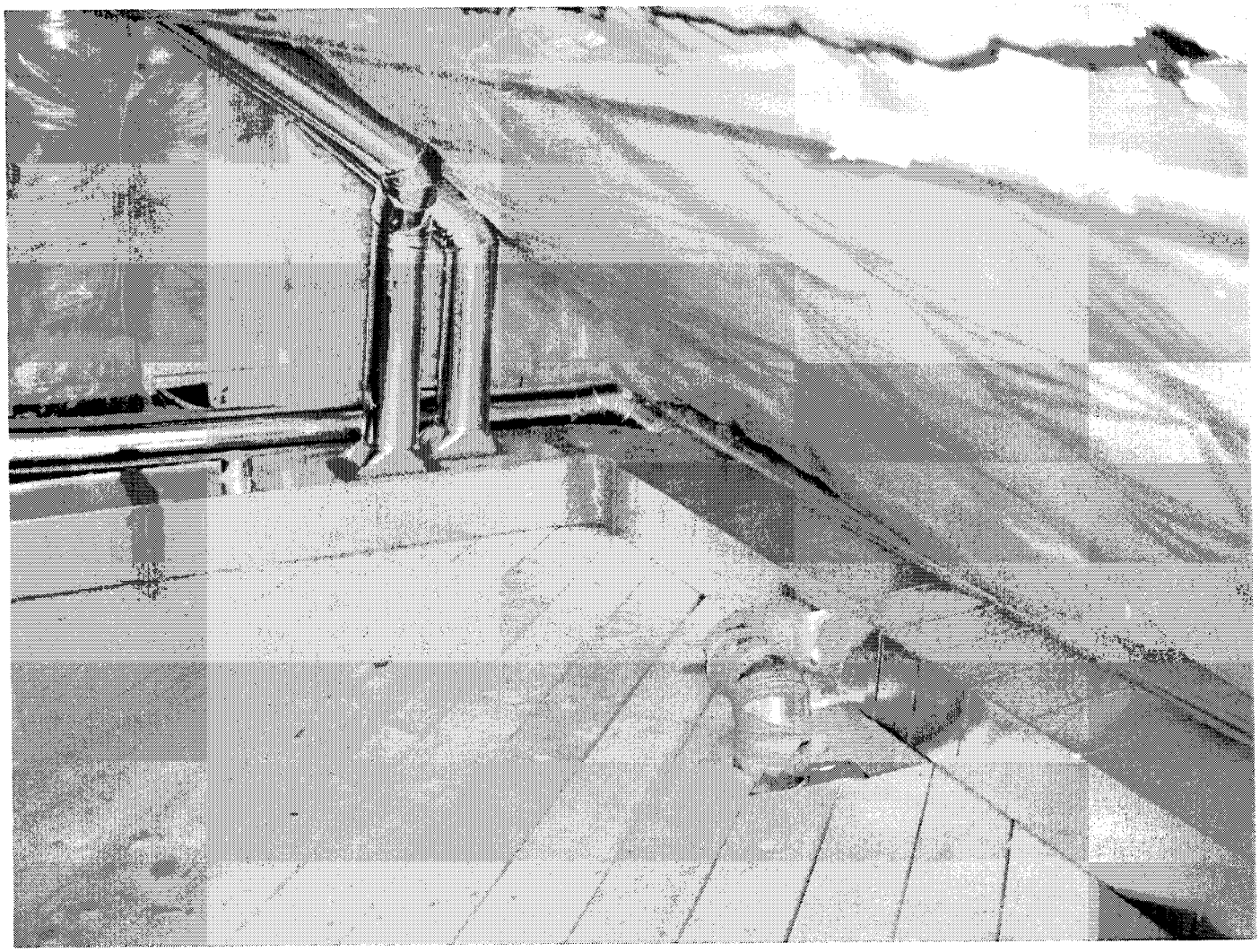
Appendix B
House Two
Photographs of System 2 of 15
H2, 002



Appendix B
House Two
Photographs of System 3 of 15
H2, 003



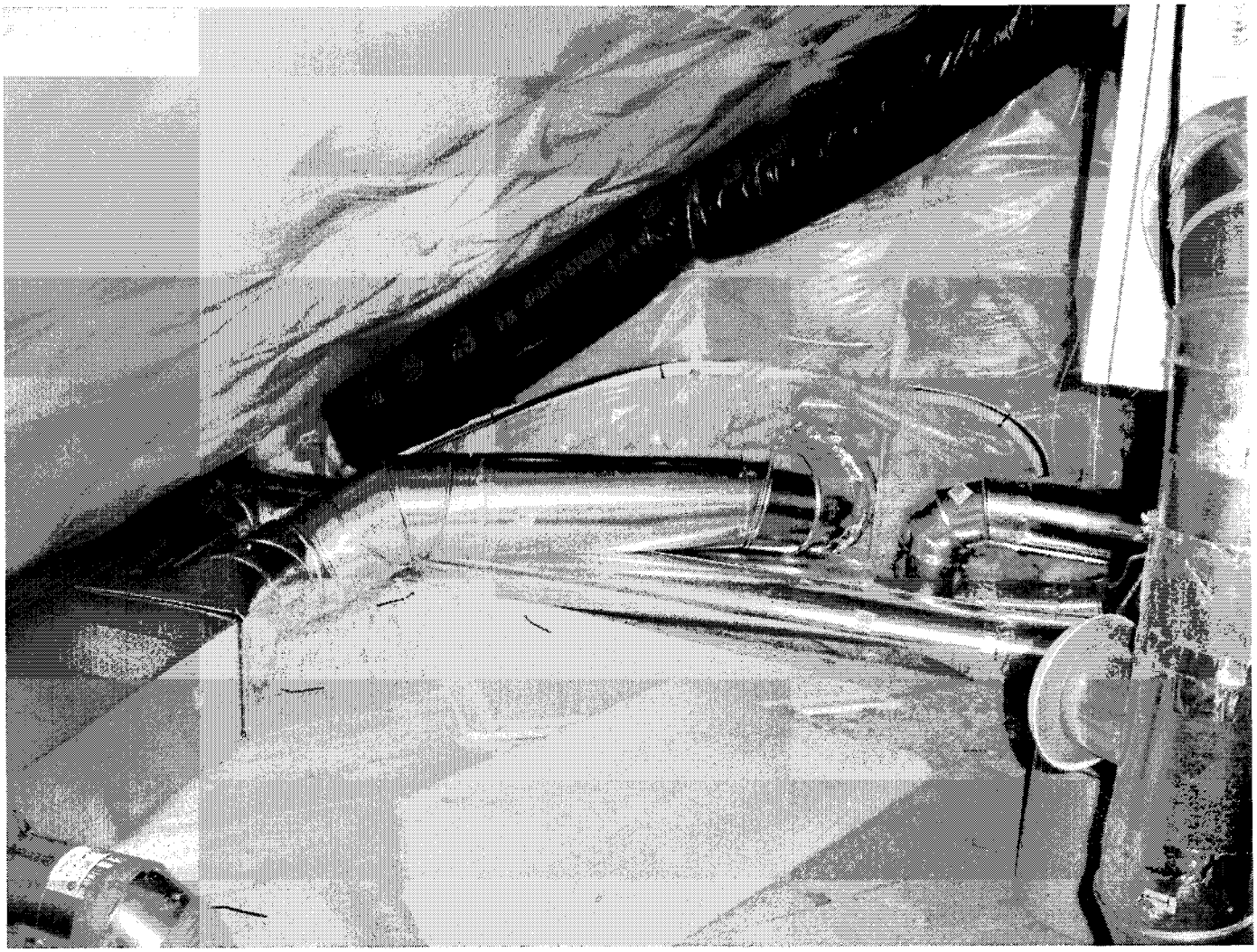
Appendix B
House Two
Photographs of System 4 of 15
H2, 004



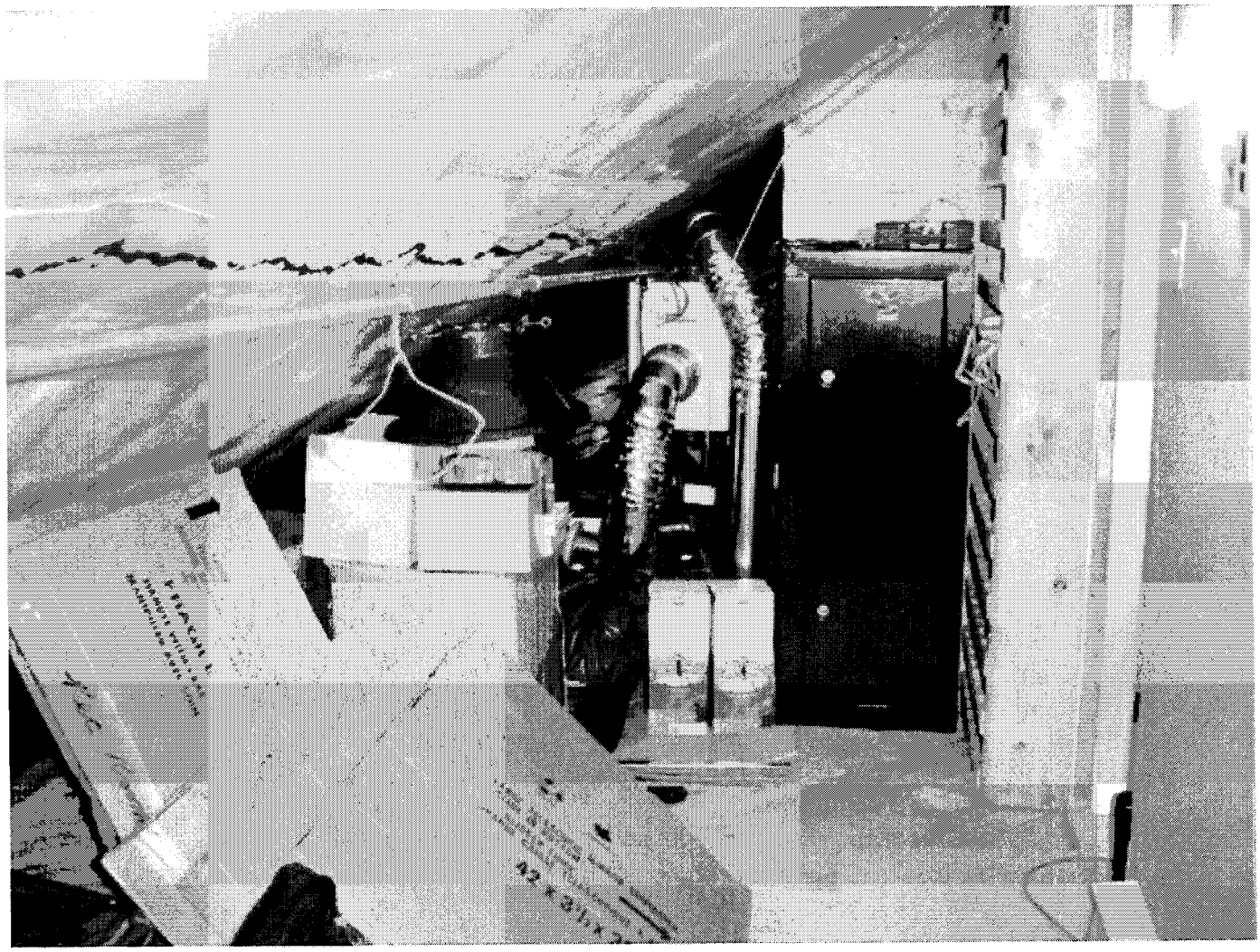
Appendix B
House Two
Photographs of System 5 of 15
H2, 005

Appendix B
House Two
Photographs of System 6 of 15
H2, 006

Appendix B
House Two
Photographs of System 7 of 15
H2, 007



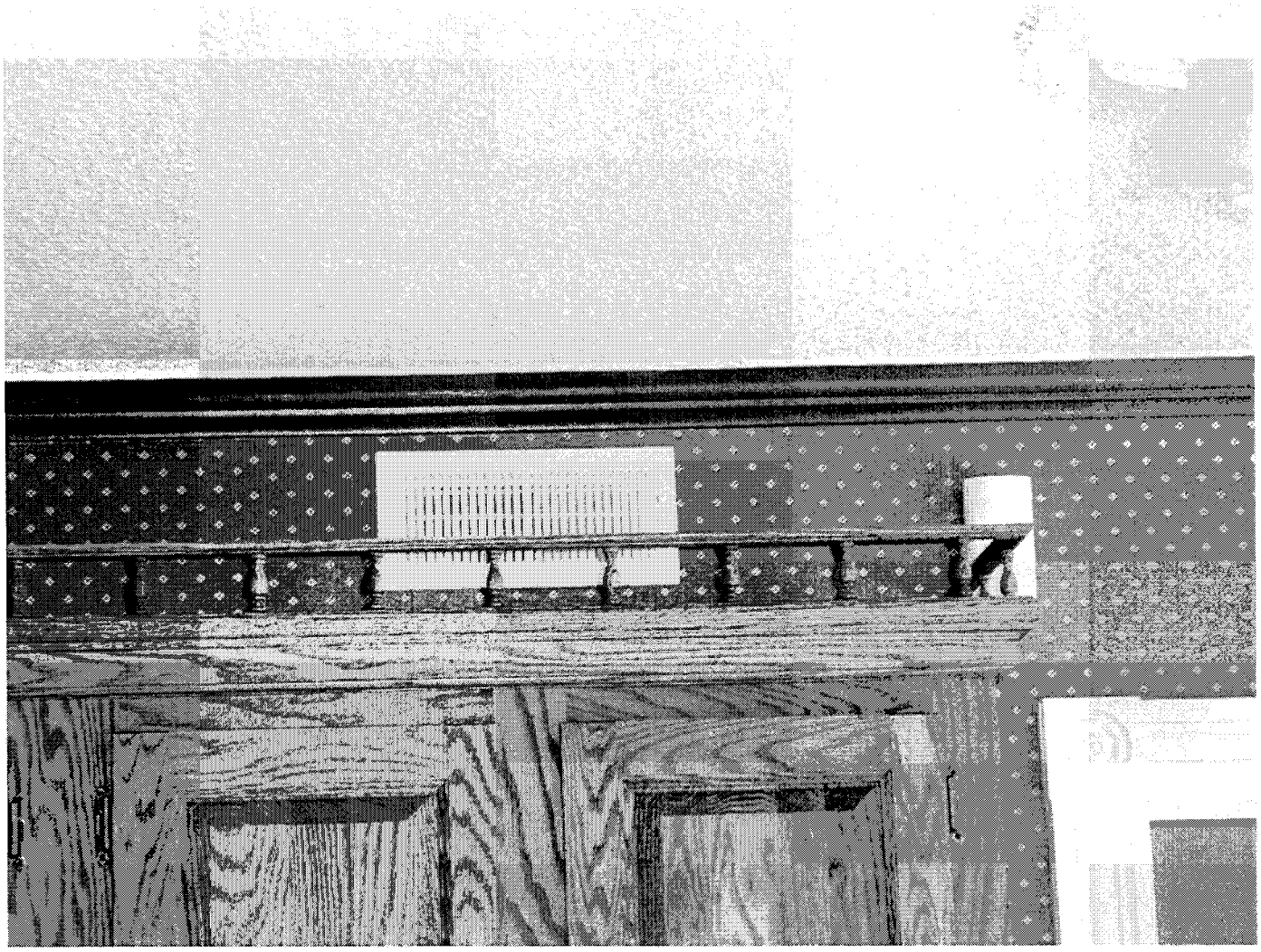
Appendix B
House Two
Photographs of System 8 of 15
H2, 008



Appendix B
House Two
Photographs of System 9 of 15
H2, 009

Appendix B
House Two
Photographs of System 10 of 15
H2, 010

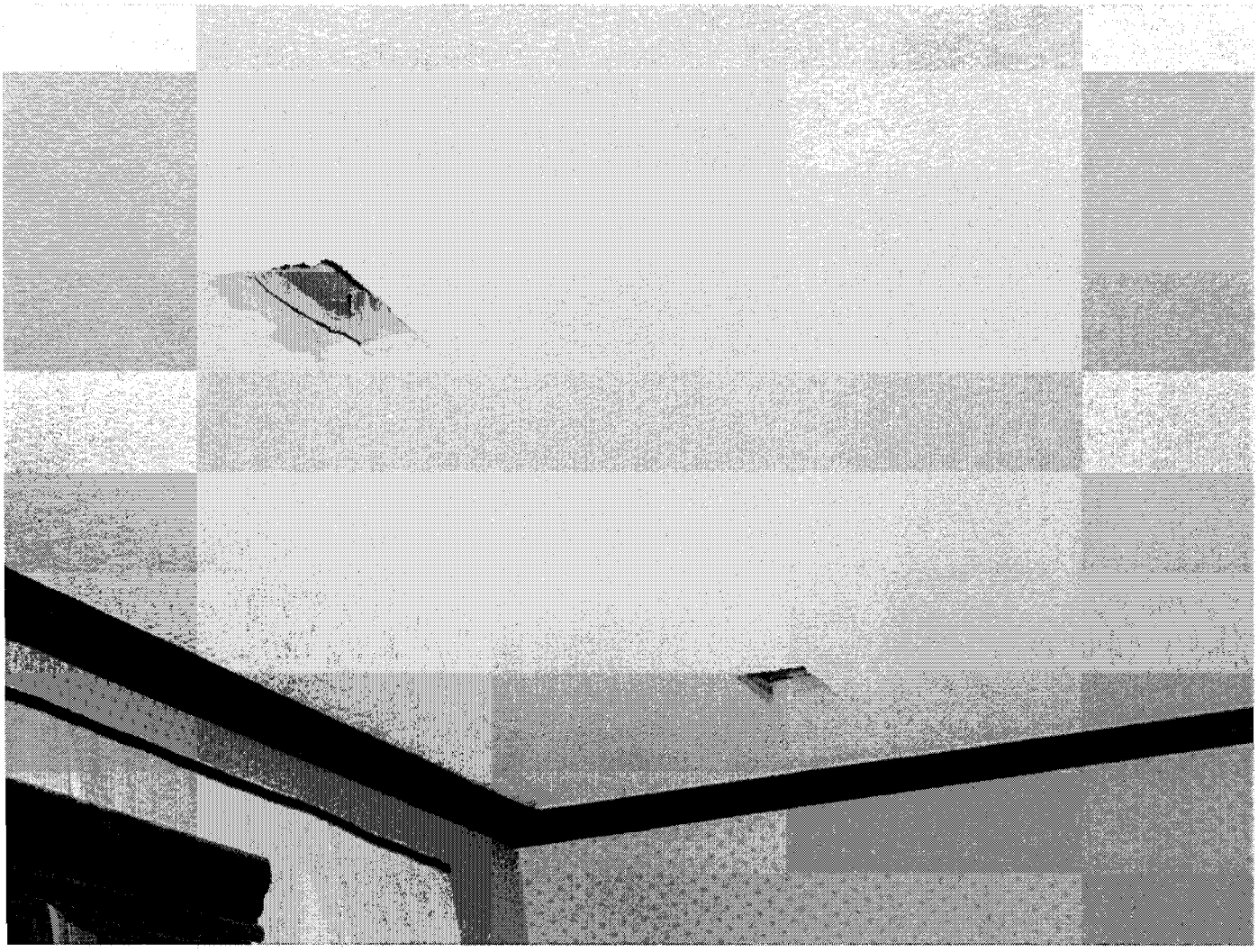
Appendix B
House Two
Photographs of System 11 of 15
H2, 011



Appendix B
House Two
Photographs of System 12 of 15
H2, 012

Appendix B
House Two
Photographs of System 13 of 15
H2, 013

Appendix B
House Two
Photographs of System 14 of 15
H2, 014



Appendix B
House Two
Photographs of System 15 of 15
H2, 015

Load Short Form
Entire House

Job: 23013d
Date: Aug.22, 2003
By: R. Clarke

Cert.#: 001529(RHLG, RASD) **R. Clarke Designs Ltd.**

3 Sheffield Court, Dromedo, NB E2V 2N1 Phone: 506-357-3377 Fax: 506-357-3378 Email: rclarke@nbnet.nb.ca

Project Information

For: CMHC Test House "4"

Design Information

	Htg	Clg	Infiltration	
Outside db (°F)	-11	84	Method	F280
Inside db (°F)	72	75	Exposure category	Sheltered
Design TD (°F)	83	9	Construction category	Average
Daily range	-	M	Number of stories	1.0
Inside humidity (%)	-	50		
Moisture difference (gr/lb)	-	21		

HEATING EQUIPMENT		COOLING EQUIPMENT	
Make		Make	
Trade		Trade	
Model		Cond	
		Coil	
Efficiency	0 HSPF	Efficiency	0 EER
Heating Input		Sensible cooling	0 Btuh
Heating output	0 Btuh @ 47°F	Latent cooling	0 Btuh
Temperature rise	0 °F	Total cooling	0 Btuh
Actual air flow	900 cfm	Actual air flow	*900* cfm
Air flow factor	0.018 cfm/Btuh	Air flow factor	0.052 cfm/Btuh
Static pressure	0.50 in H2O	Static pressure	0.50 in H2O
Space thermostat		Load sensible heat ratio	77 %

ROOM NAME	Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Front Bdrm	138	3600	1539	66	80
Kitchen	160	2452	1174	45	61
Dining Room	100	5131	4388	93	229
Living Room	273	6533	4267	119	222
Back Entry	58	1078	657	20	34
Laundry	28	67	23	1	1
Hall	91	223	75	4	4
Mid-Bdrm.	112	2406	1157	44	60
Bathroom	78	982	290	18	15
Master Bdrm.	251	6467	3698	118	193
Base't #1	227	3980	0	72	0
Base't #2	227	3980	0	72	0
Base't #3	283	4594	0	84	0
Base't #4	172	1807	0	33	0
Base't #5	266	8142	0	112	0

Bold/Italic values have been manually overridden

Printout certified by HRAI to meet all requirements of CAN/CSA-F280-M90

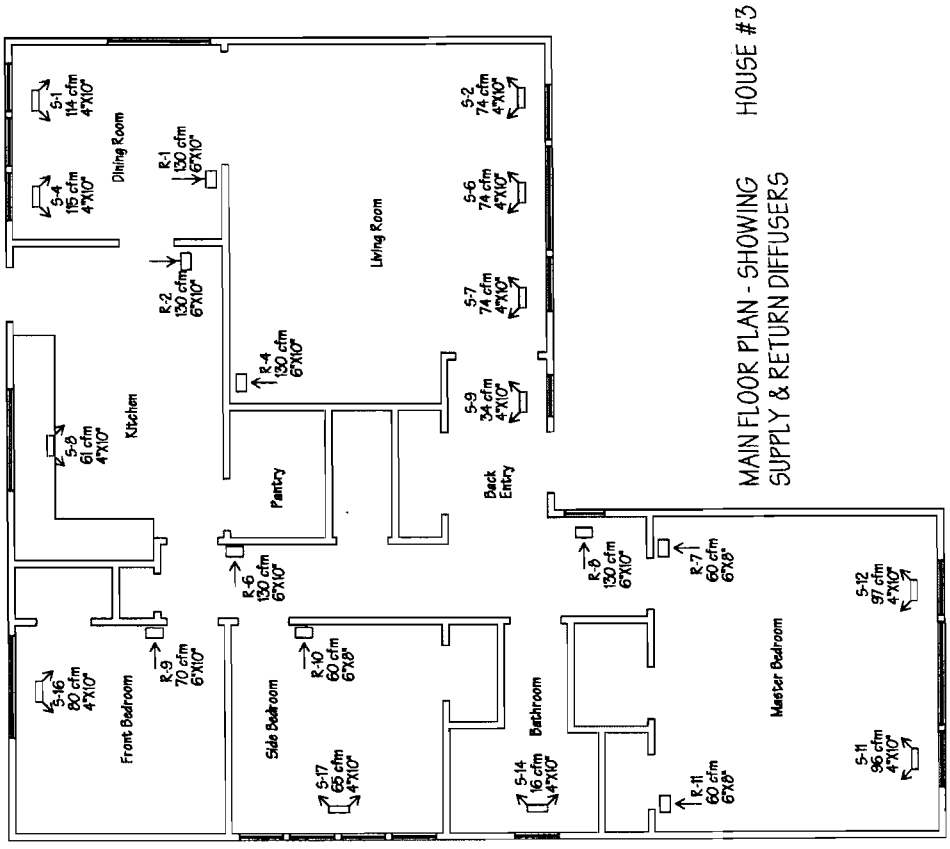
Entire House	d	2461	49460	17265	900	*900*
Ventilation air			10757	1166		
Equip. @ 1.00	RSM			18431		
Latent cooling				5529		
TOTALS		2461	60216	23961	900	*900*

Bold/Italic values have been manually overridden

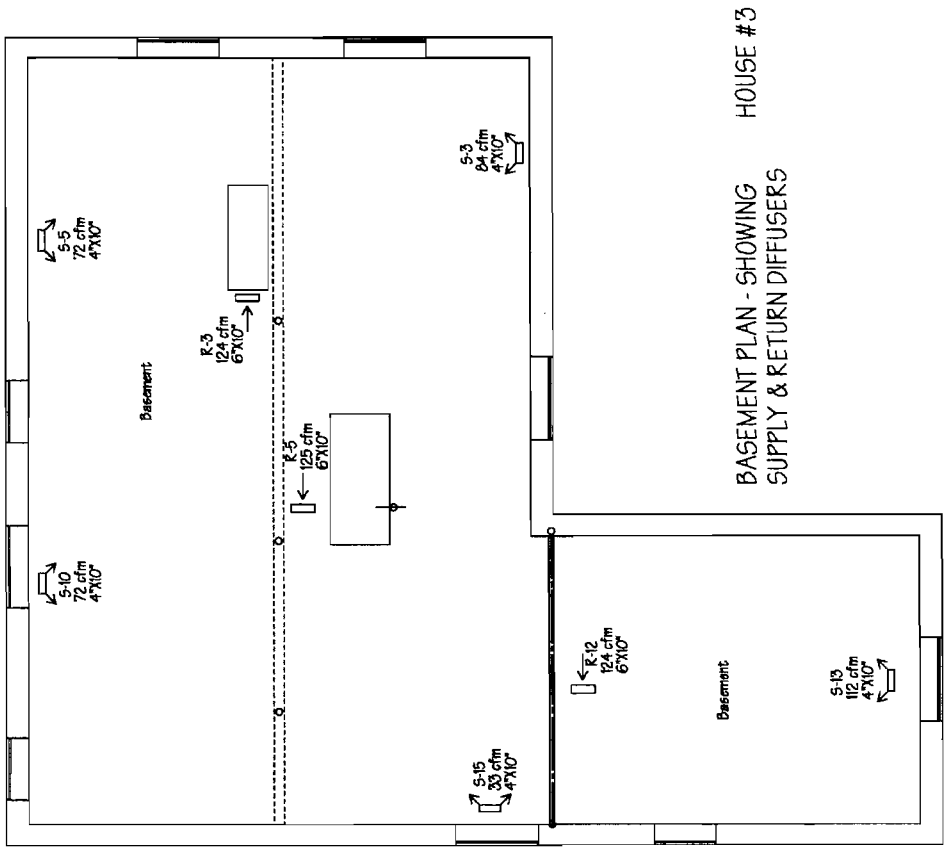
Printout certified by HRAI to meet all requirements of CAN/CSA-F280-M90

Appendix C
House Three
Design Heating / Cooling Load Calculation

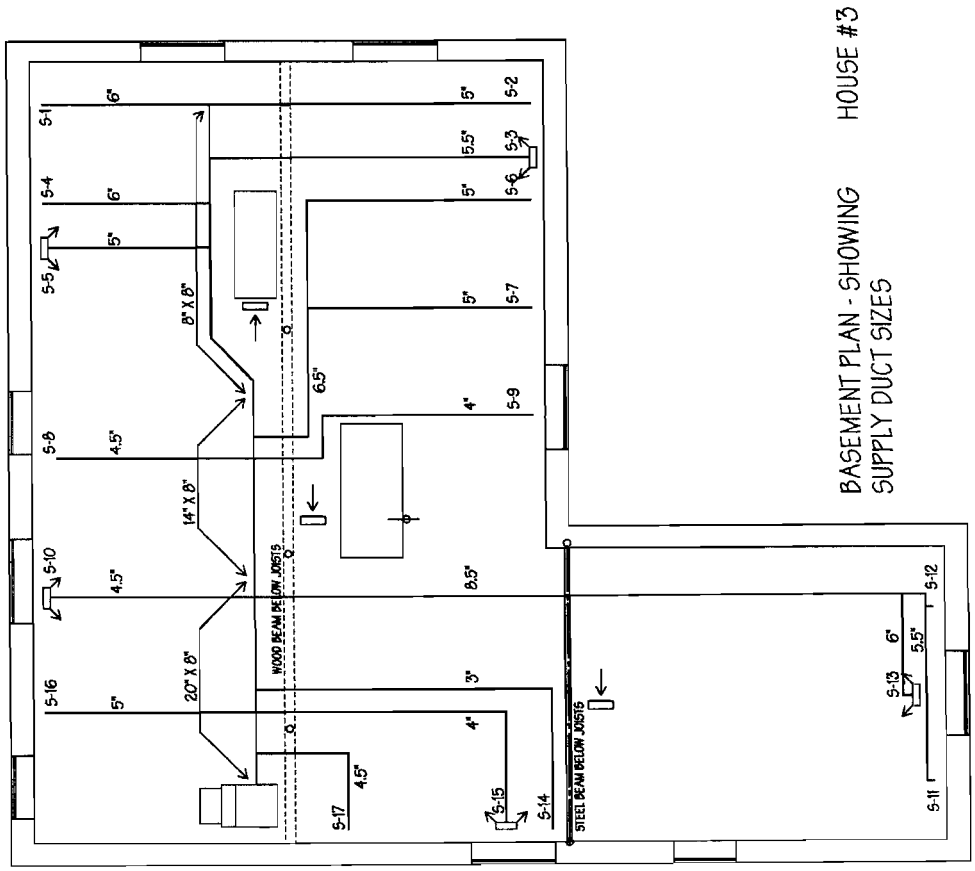
Appendix C
House Three
Main Floor Plan Showing Supply & Return Diffusers



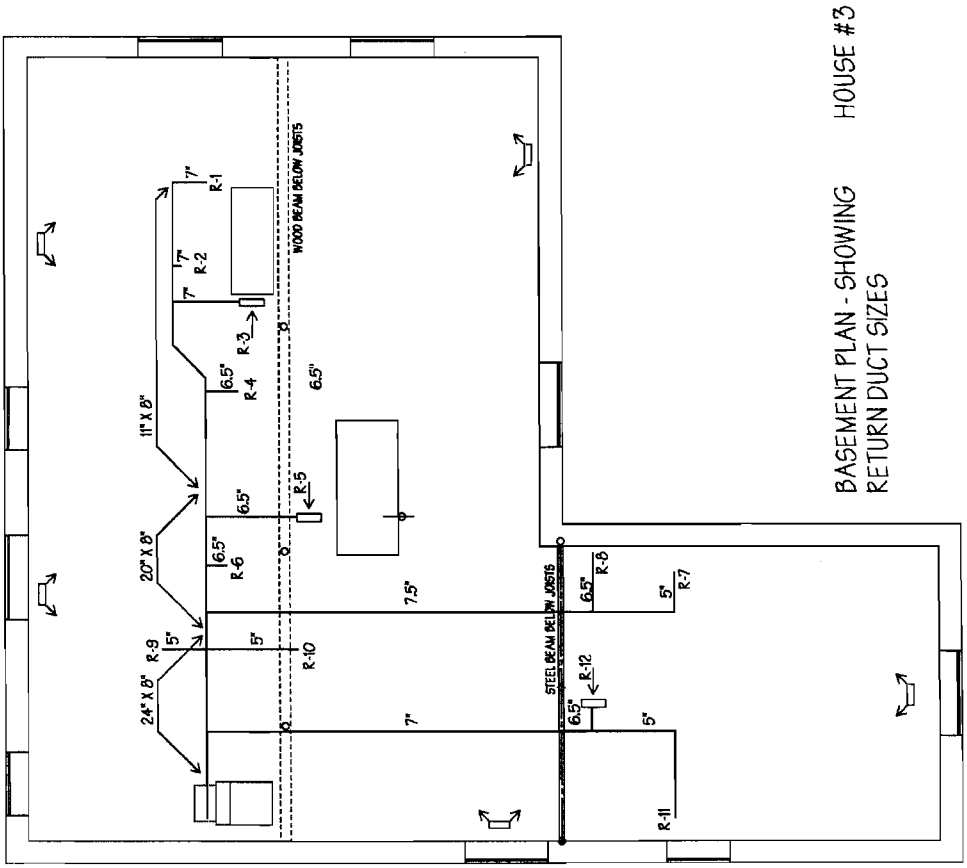
Appendix C
House Three
Basement Plan Showing Supply & Return Diffusers



Appendix C
House Three
Basement Plan Showing Supply Duct Sizes



Appendix C
House Three
Basement Plan Showing Return Duct Sizes



Appendix C
House Three
Duct Size Calculations Page 1/6

PART A - DESIGN LOAD SPECIFICATIONS — page 2

A.1 Sub Total Heat Loss 49611 Btuh.

A.2 Ventilation Heat Loss 10757 Btuh.

A.3 Total Heat Loss 60368 Btuh.. (A.1 + A.2)

A.4 Sub Total Heat Gain 22795 Btuh.

A.5 Ventilation Heat Gain 1166 Btuh.

A.6 Total Heat Gain 23961 Btuh. (A.4 + A.5)

A.7 Volume of House 23701.6 cu ft.

A.8 Ventilation Flow Rate 120 cfm.

PART B - EQUIPMENT SELECTION

Heating Equipment:

Make _____ Model _____

Fuel Type: ☐ Gas ☐ Oil ☐ Electricity ☐ Other _____

B.1 Heating Output 68260 Btuh.
(100% -140% of A.3)

B.2 Approved Temperature rise/ range _____ °F

B.3 Equipment External Static Pressure .5 in. W.C.

B.4 Heating Air Flow Rate. 900 cfm.
(when selected) _____ RPM/Speed.
(or when single temp rise) cfm = [B.1 ÷ (1.08 x B.2)]

Cooling Equipment:

Make _____ Model _____ (indoor coil)

Cooling Medium: ☐ DX ☐ Chilled water ☐ Other _____

B.5 Cooling output 24000 (Btuh) 2 Tons.
(80% - 125% of A.6)

B.6 Manufacturers Flow Rate/Ton 450 (cfm/ton)

B.7 Coil Pressure Drop — in. W.C.

B.8 Cooling Air Flow Rate. 900 cfm.
(when selected) _____RPM/Speed.
(or when calculated) cfm = B.5 (tons) x B.6

PART C - AIR DISTRIBUTION & PRESSURE

C.1 Circulation Air Flow Rate. 597.5 cfm.
(A.7 x .025)

C.2 System Design Air Flow Rate. 900 cfm.
(highest of B.4, B.8, C.1)

C.3 Cooling Air Flow Proportioning Factor (B.8 ÷ A.4)
(calculate to 4 decimal places) .0394 cfm/Btuh.

C.4 Heating Air Flow Proportioning Factor (C.2 ÷ A.1)
(calculate to 4 decimal places) .0181 cfm/Btuh.

C.5 Calculated Heating Temperature Rise 70 °F.
[B.1 ÷ (B.4 x 1.08)]

C.6 Filter Pressure Drop — in. W.C.

C.7 Coil Pressure Drop (B.7) — in. W.C.

C.8 Total of Pressure Drop (C.6 + C.7) — in. W.C.

C.9 Available Design Pressure (B.3 - C.8) .5 in. W.C.

Note: When furnace standard filter is replaced, subtract its pressure drop from the replacement filter and record on line C.6

Appendix C
House Three
Duct Size Calculations Page 2/6

PART D - DETERMINING ROOM AND FLOOR DESIGN FLOW RATES								page 3
D.1 Floor	MAIN FLOOR							
D.2 Room	F.BD.	KIT	DIN	LIV	B.ENTRY	LAUN.	HALL	MID.BD
D.3 Cooling load (Btuh)	1539	1174	4388	4267	657	23	75	1157
D.4 Room cooling flow rate (D.3 x C.3)	80	61	229	222	34	1	4	60
D.5 Heating load (Btuh)	3611	2459	5146	6553	1081	67	224	2413
D.6 Room heating flow rate (D.5 x C.4)	65	45	93	119	20	1	4	44
D.7 Number of outlets per room	1	1	2	3	1	0	0	1
D.8 Floor supply air flow rates	SA = (H) 527 cfm (C) 900 cfm RA = 900 cfm							

PART D - CONTINUED											
D.1	MAIN FL.		BASEMENT								
D.2	BATH	M.BD.	BASE!	#2	#3	#4	#5				
D.3	270	3696	Ø	Ø	Ø	Ø	Ø				
D.4	15	193									
D.5	985	6506	3992	3992	4808	1812	6161				
D.6	18	118	72	72	84	33	112				
D.7	1	2	1	1	1	1	1				
D.8			SA = 373 cfm			RA = 373					

PART E - INLET FLOW RATES					
Floor level (Location)	Basement (50% D.8 Max)	1st floor (Sum of D.8 Min)	2nd floor (Sum of D.8 Min)	Outside air (100% of A.8)	Total = (C.2) (System cfm)
E.1 Floor return air flow rate	373	900			900
E.2 Minimum number of openings	4	8			
E.3 Actual number of openings	3	9			
E.4 Actual cfm per opening (E.1 ÷ E.3)	124.3	100			

Note: After location of supply outlets and return inlets are determined, produce preliminary drawing.

Appendix C
House Three
Duct Size Calculations Page 3/6

PART F - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR RETURN DUCTS page 4

Inlet No	Equipment Connection (Group 1)	Trunk To Drop Connection (Group 1)	Trunk Transitions (Group 2)	Trunk Fittings (Group 2)	Duct To Joist (Group 3)	Turbulence Effect	Stud To Joist (Group 4)	Grille Opening To Stud (Group 4)	Measured Length (ft)	Branch Effective Length (ft)
R1	C 10	B 35	K15+15	A 10+10	A_1 25	120	—	C 10	40.5	290.5
R2					A_2 60	80	—		35.5	280.5
R3						40	B 25		43.5	273.5
R4						0			29.5	174.5
R5			K15			80			26.5	236.5
R6			— 4 —			40			20.5	190.5
R7			K15+15		A_1 25 A_2 60	40			41.5	251.5
R8			K15		A_2 60 A_2 60	0			38.5	228.5
R9			—		A_2 60	40			17	172
R10			—		A_2 60	40			19.5	174.5
R11			K15		A_1 25 A_2 60	40			37.5	232.5
R12			—		A_2 60 A_2 60	0			31.5	206.5

PART G - DUCT DESIGN PRESSURE

G.1 (Return Branch Longest Effective Length 290.5 ft).

G.2 **R/A Plenum Pressure:**
Available Design Pressure (Line C.9) x Return Air Apportioning Factor (Appendix C (C3))

(.5) x (.5) = 0.25 in. W.C. (Record Line H.8)

G.3 **S/A Plenum Pressure:**
Available Design pressure (Line C.9) - R/A Plenum Pressure

(.5) - (.25) = 0.25 in. W.C. (Record Line J.7)

Appendix C
House Three
Duct Size Calculations Page 4/6

PART H - SIZING OF RETURN GRILLES, BRANCHES AND MAIN TRUNK DUCTS	N TRUNK DUCTS												page 5
H.1 Trunk Letter/No	A				B				C				
H.2 Inlet Location (Room)	DIN	KIT	BASE'T	LIV	BASE'T	HALL	M.BD.	HALL	F.BD	MID.BD	M.BD	BASE'T	BASE'T
H.3 Inlet No (R)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	VENT
H.4 Inlet flow rate (cfm) (Line E.4 adjusted)	130	130	124	130	125	130	60	130	70	60	60	124	120
H.5 Minimum required inlet free area (sq. in.) (Appendix C8)	47	47	47	47	47	47	36	47	36	36	36	47	
H.6 Inlet size (Appendix A)	6X10 →					→	6X8	6X10 →	→	6X8 →	→	6X10	
H.7 Inlet Pressure Loss (in. W.C.)	.02 →											→	
H.8 R/A Plenum pressure (in. W.C.) (Line G.2)	0.25 →											→	
H.9 Adjusted duct design pressure (H.8 - H.7)	0.23 →											→	
H.10 Branch effective length (ft) (Part F)	290.5	280.5	273.5	174.5	236.5	190.5	251.5	228.5	172	174.5	232.5	206.5	
H.11 Loss/100 ft. of effective length [(H.9 x 100) ÷ H.10]	.08	.08	.08	.13	.10	.12	.09	.10	.13	.13	.10	.11	
H.12 Branch duct size (round) (H.4, H.11) (Appendix C4,5)	7	7	7	6.5	6.5	6.5	5	6.5	5	5	5	6.5	
H.13 Branch rectangular equivalent (Appendix C6)	14X3¼ →		→	12X3¼ →		→	10X3¼	12X3¼	10X3¼ →		→	12X3¼	
H.14 Joist to trunk opening size (2 x area H.13)	9.5X9.5 →		→	9X9 →		→	8X8	9X9	8X8 →		→	9X9	
H.15 Trunk flow rate (cfm) accumulation of H.4	130	260	260	390	390	520	580	710	780	840	900	900	
H.16 Lowest loss/100 ft encountered from duct end.	.08 →											→	
H.17 Trunk duct size (round) (H.15, H.16) (Append C4,5)	7	9	9	10	10	12	12	13	13.5	14	14	14	
H.18 Trunk rectangular equivalent (Appendix C6)	5X8	8X8	8X8	11X8	11X8	16X8	16X8	18X8	20X8	22X8	22X8	22X8	
H.19 Installed Trunk size (Transitions)				11X8				20X8				24X8	
H.20 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area]				638				639				675	

Appendix C
House Three
Duct Size Calculations Page 5/6

PART I - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR SUPPLY DUCTS										page 6
Outlet No	Plenum Fitting (Group 5)	Trunk Transition (Group 6)	Trunk Fittings (Group 6)	Trunk To Branch Take offs (Group 7)	Aspiration Effect	Duct Flex Length (ft)	Branch Elbows (Group 8)	Boot Fitting (Group 8)	Measured Length (ft)	Branch Effective Length (ft)
S1	B10	K5+5	A10+10	A40	0			B30	42	142
S2					0				49	149
S3					10				46.5	166.5
S4					20				37.5	167.5
S5					30				35.5	175.5
S6		K5	F10	—	10		10+10		41.5	126.5
S7			—	J50	10+10		10		36.5	171.5
S8				A40	20		—		25.5	130.5
S9					20		10+10		31.5	156.5
S10					0		0		19	99
S11			F10	—	0		10+5+5+5+5		51	131
S12				J50	10		10+5+5+5+5		42	182
S13				—	20		5+5+5+5		45	185
S14				A40	10		10		25.5	125.5
S15					20		—		19.5	129.5
S16					20		—		10.5	110.5
S17					30		10		10.5	130.5

Appendix C
House Three
Duct Size Calculations Page 6/6

PART J - SIZING OF SUPPLY DIFFUSERS, BRANCHES AND MAIN TRUNK DUCTS page 7																	
J.1 Trunk Letter/No	A					B				C							
J.2 Outlet location (Room)	DIN	LIV	BT3	DIN	BT2	LIV	LIV	KIT	B.ENTRY	BT1	M.BD	M.BD	BT5	BATH	BT4	F.BD	M.BD
J.3 Outlet No (S)	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17
J.4 Outlet flow rate (cfm) (Line D.6 ÷ D.7)	114	74	84	115	72	74	74	61	34	72	96	97	112	16	33	80	65
J.5 Outlet size	4x10 →						→	2½x10	4x10 →								→
J.6 Outlet pressure loss (in. W.C.)	.03	.01	.01	.03	.01	.01	.01	.01	.005	.01	.02	.02	.03	.005	.005	.01	.01
J.7 S/A Plenum pressure (in. W.C.) (Line G.3)	.25 →															→	
J.8 Adjusted duct design pressure (J.7 - J.6)	.22	.24	.24	.22	.24	.24	.24	.24	.245	.24	.23	.23	.22	.245	.245	.24	.24
J.9 Branch effective length (ft) (Part I)	142	149	166.5	167.5	175.5	126.5	171.5	130.5	156.5	99	131	182	185	125.5	129.5	110.5	130.5
J.10 Loss/100 ft of effective length [(J.8 x 100) ÷ J.9]	.15	.16	.14	.13	.13	.19	.14	.18	.16	.24	.17	.13	.12	.19	.19	.22	.18
J.11 Branch duct size (round) (J.4, J.10) (Appendix C4,5)	6	5	5½	6	5	5	5	4½	4	4½	5½	5½	6	3	4	5	4½
J.12 Branch rectangular equivalent (Appendix C6)	12x3¼	10x3¼ →		12x3¼	10x3¼							→	12x3¼	10x3¼			→
J.13 Trunk flow rate (cfm) accumulation of J.4	114	188	188	303	303	377	451	512	546	546	642	739	739	755	755	835	900
J.14 Lowest loss/100 ft encountered from duct end.	.15	.15	.14	.13	.13	.13	.13	.13	.13	.13	.13	.13	.12	.12	.12	.12	.12
J.15 Trunk duct size (round) (J.13, J.14) (Appendix C4,5)	6	7	7	8½	8½	9	10	10	10½	10½	11½	12	12	12	12	13	13
J.16 Trunk rectangular equivalent (Appendix C6)	12x3¼	14x3¼ →		8x8 →			11x8 →		12x8 →		14x8	16x8 →				18x8 →	
J.17 Installed Trunk size (Transitions)	←				8x8	←			14x8	←							20x8
J.18 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area]					681				702								810

Appendix C
House Three
Supply-Air Flow Measurements

Supply Airflows Measurements

Measurements Method	Flow Collar In Duct			Hood At Grille			Branch	Design
Space	Pressure		Airflow	Pressure		Airflow		Airflow
	pa	"wc	cfm	pa	"wc	cfm		
Main Floor								
Master Bedroom (1)	7.8	0.0312	89.02	3.1	0.0124	56.12	S-11	96
Master Bedroom (2)	10.3	0.0412	102.3	4.1	0.0164	65.54	S-12	97
Mid. Bedroom	17.5	0.07	133.34	2.1	0.0084	46.19	S-17	65
Front Bedroom	6.7	0.0268	82.5	2.6	0.0104	51.39	S-16	80
Kitchen	6.7	0.0268	82.5	2.6	0.0104	51.39	S-8	61
Dining Room (1)	8.2	0.0328	91.27	2.4	0.0096	49.38	S-4	115
Dining Room (2)	9.4	0.0376	97.72	3.4	0.0136	58.77	S-1	114
Back Entry	12.1	0.0484	110.88	3.7	0.0148	61.31	S-9	74
Living Room (1)	8.2	0.0328	91.27	2.8	0.0112	53.33	S-2	74
Living Room (2)	not installed			not installed			S-6	74
Living Room (3)	8.3	0.0332	91.83	3.2	0.0128	57.02	S-7	74
Bathroom (5" dia.)	5.9	0.0236	48.71	1.5	0.006	39.03	S-14	16
Basement								
Basement (1)	6.9	0.0276	83.73	could not measure			S-10	72
Basement (2)	not installed			not installed			S-5	72
Basement (3)	11.5	0.046	108.09	could not measure			S-3	84
Basement (4)	11	0.044	105.71	could not measure			S-13	112
Basement (5)	not installed			not installed			S-15	112

Notes:

* Measurements were recorded using a digital manometer
* Flow collar in duct, 5" & 6" dia. saddle style
* Hood equipped with 6" dia. Flow collar
* Some measurements not collected, no ceiling against which to place hood

Appendix C
House Three
Return-Air Flow Measurements

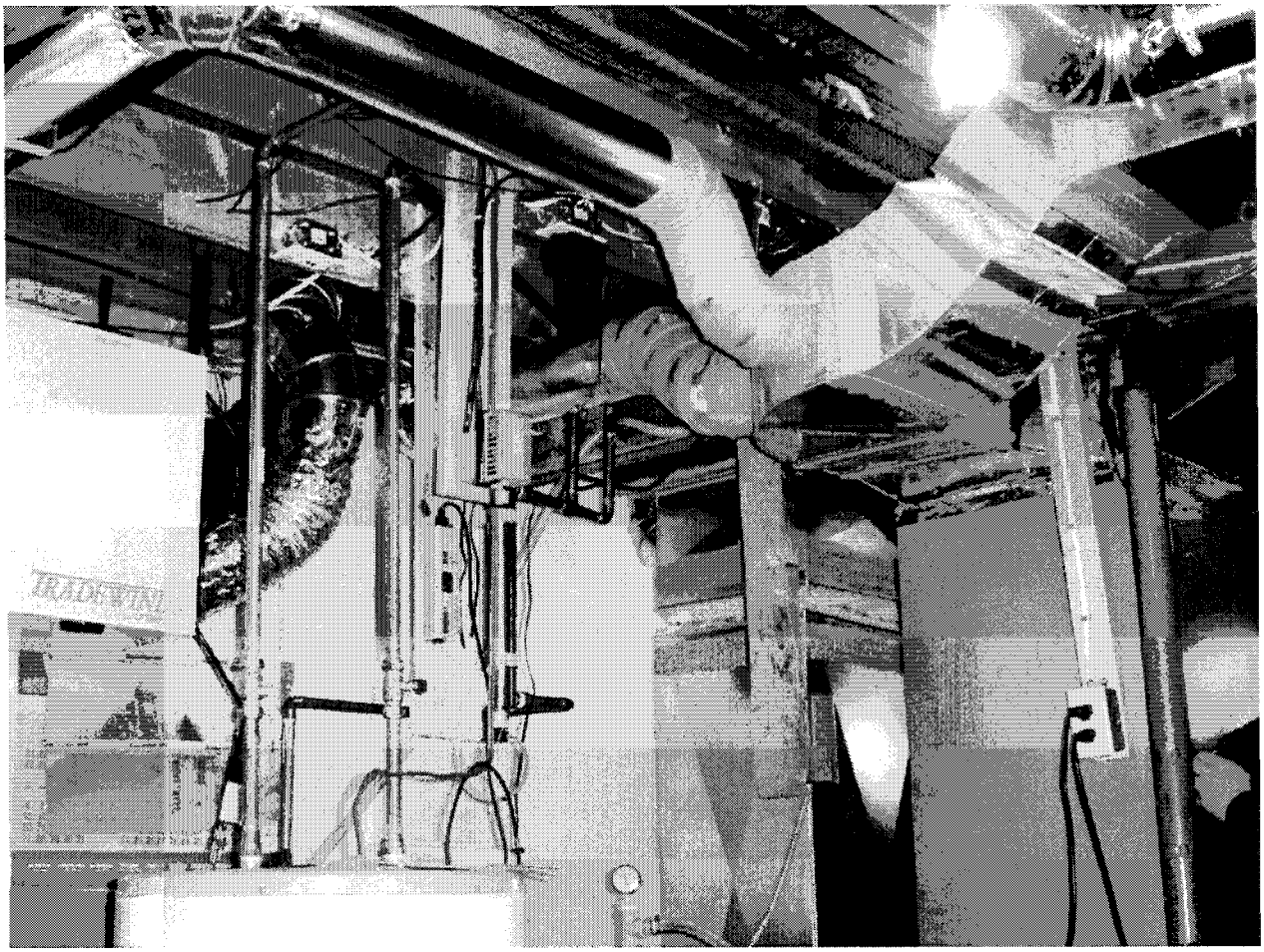
Return Airflows Measurements

Measurements Method	Flow Collar In Duct			Hood At Grille			Branch	Design
Space	Pressure		Airflow	Pressure		Airflow		Airflow
	pa	"wc	cfm	pa	"wc	cfm		
Main Floor								
Master Bedroom	0.8	0.0032	28.51	0.6	0.0025	24.69	R-7	60
Master Bedroom	not installed			not installed			R-11	60
Main Hall	could not measure			5.1	0.0204	71.98	R-6	130
Main Hall	not installed			not installed			R-8	130
Mid-Bedroom	could not measure			7.3	0.0292	86.12	R-10	60
Front Bedroom	could not measure			7.9	0.0316	89.59	R-9	70
Kitchen	could not measure			2.1	0.0084	46.19	R-2	130
Dining Room	not installed			not installed			R-1	130
Living Room	could not measure			6.9	0.0276	83.73	R-4	130
Basement								
Basement	not installed			not installed			R-3	124
Basement	not installed			not installed			R-5	125
Basement	not installed			not installed			R-12	124

Notes:

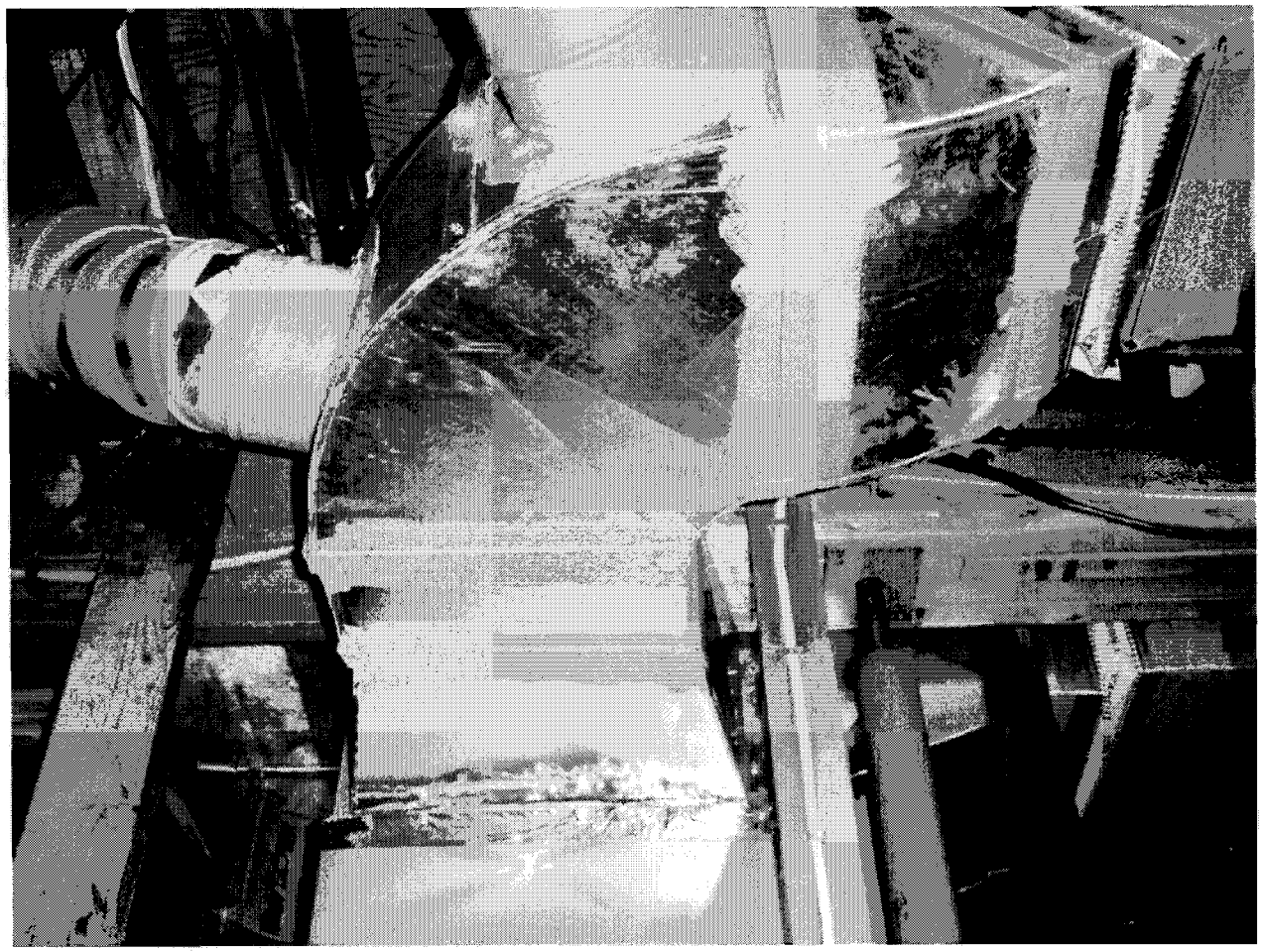
* Measurements were recorded using a digital manometer
* Flow collar in duct, 6" dia. saddle style
* Hood equipped with 4" dia. Flow collar
* Some measurements not collected with flow collar, joists were panned
* Some measurements not collected, no ceiling against which to place hood

Appendix C
House Three
Photographs of System 1 of 11
H3,001



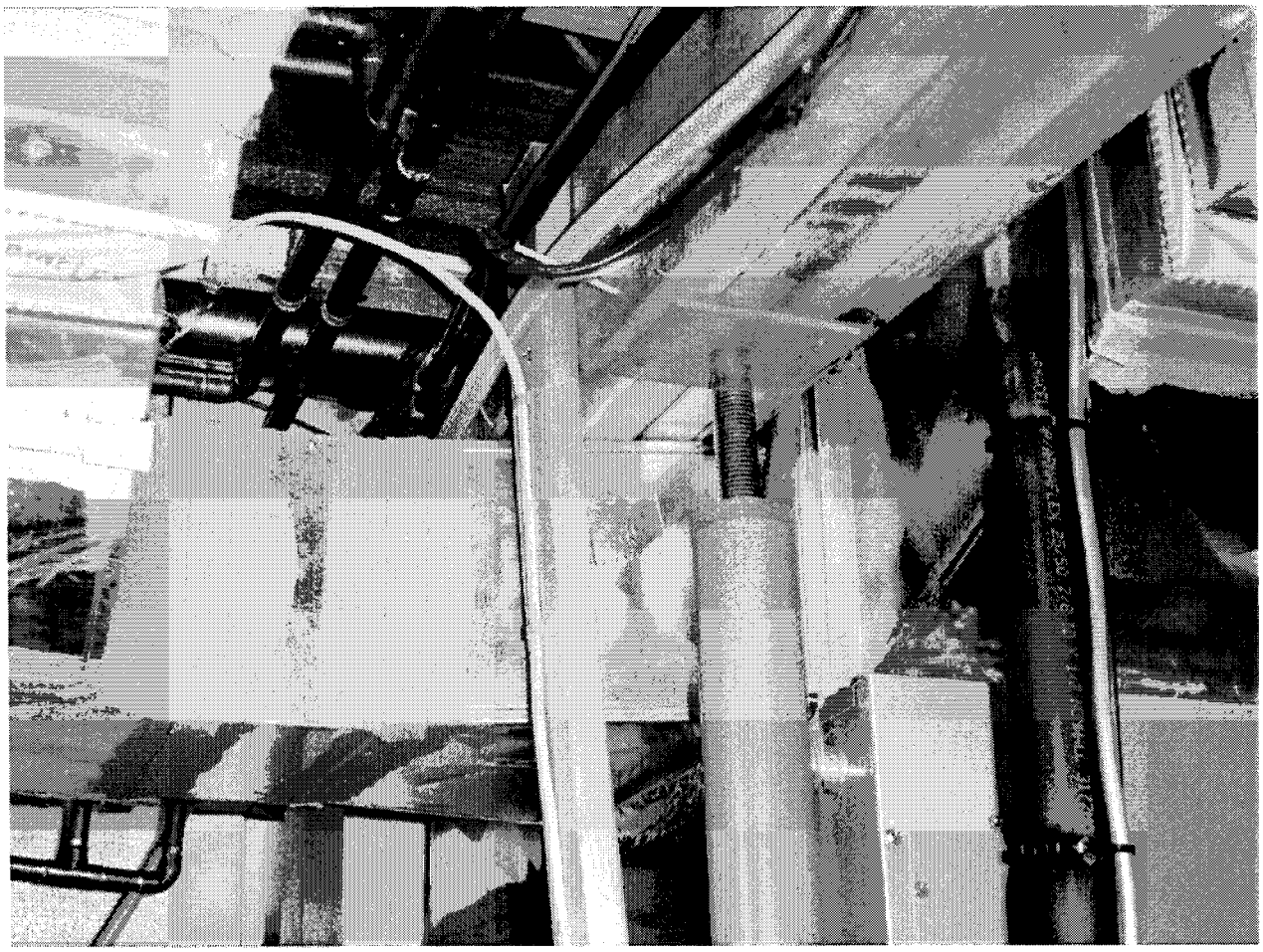
Appendix C
House Three
Photographs of System 2 of 11
H3,002

Appendix C
House Three
Photographs of System 3 of 11



H3,003

Appendix C
House Three
Photographs of System 4 of 11



H3,004

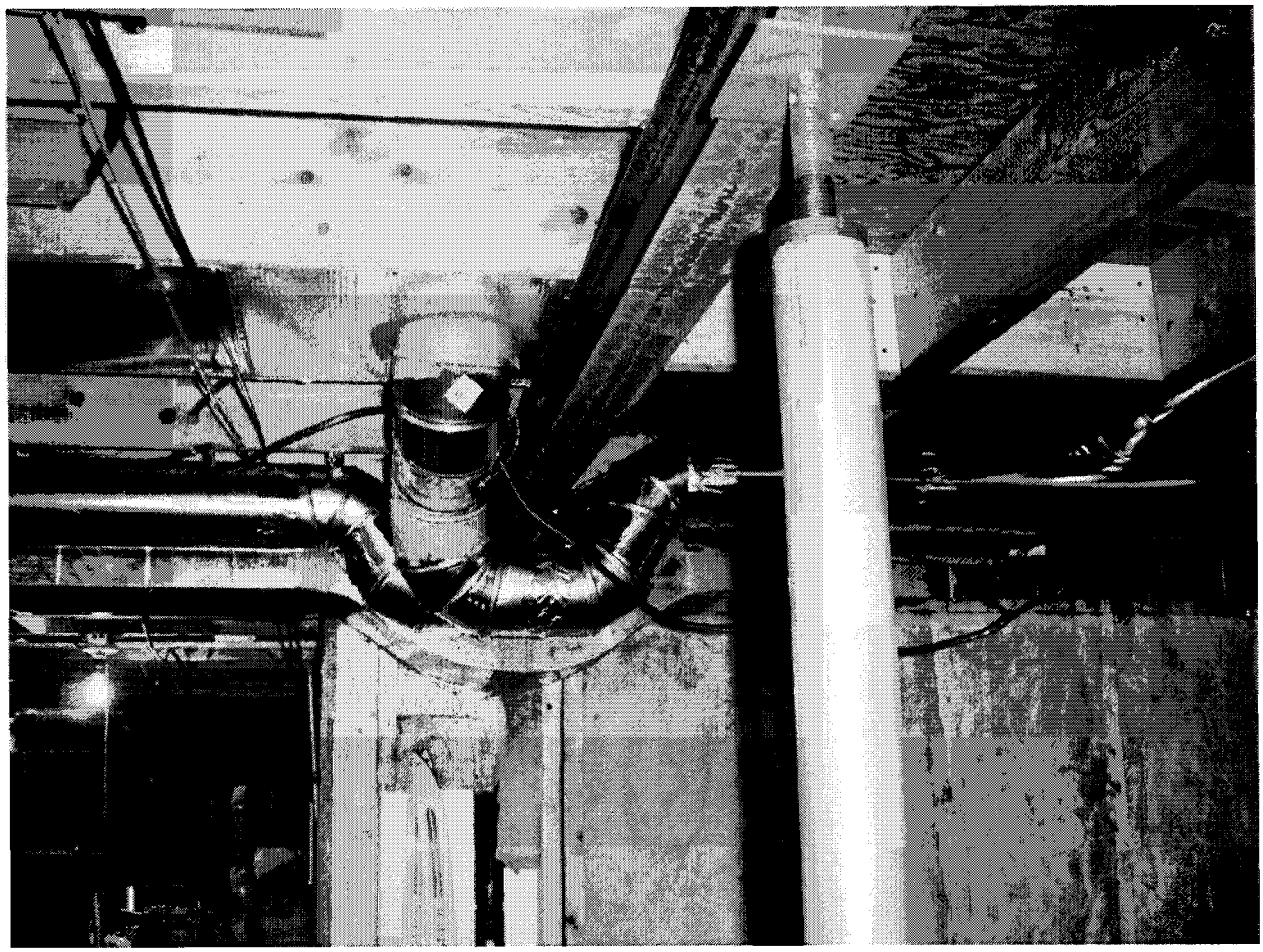
Appendix C
House Three
Photographs of System 5 of 11

H3,005

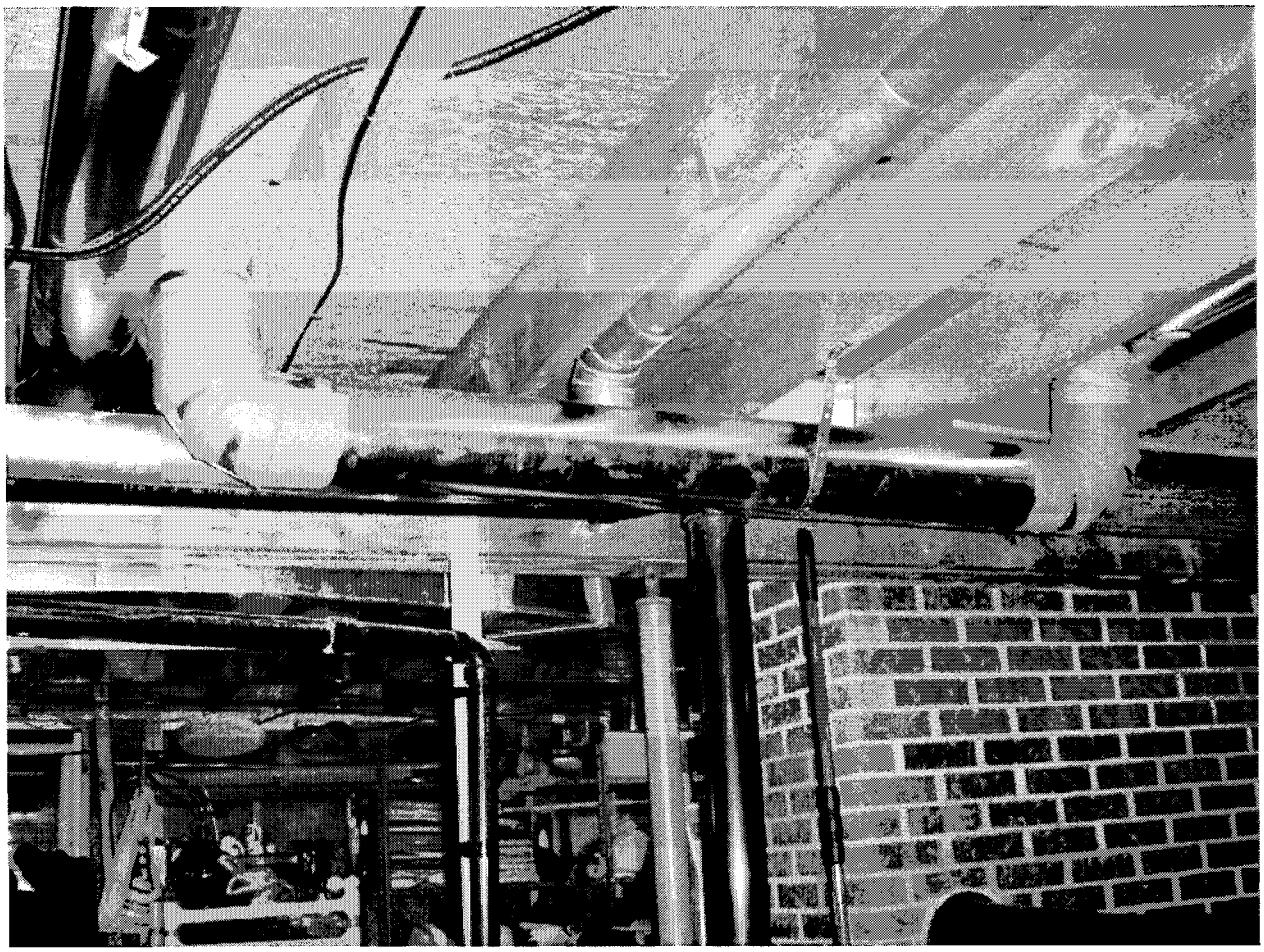
Appendix C
House Three
Photographs of System 6 of 11

H3,006

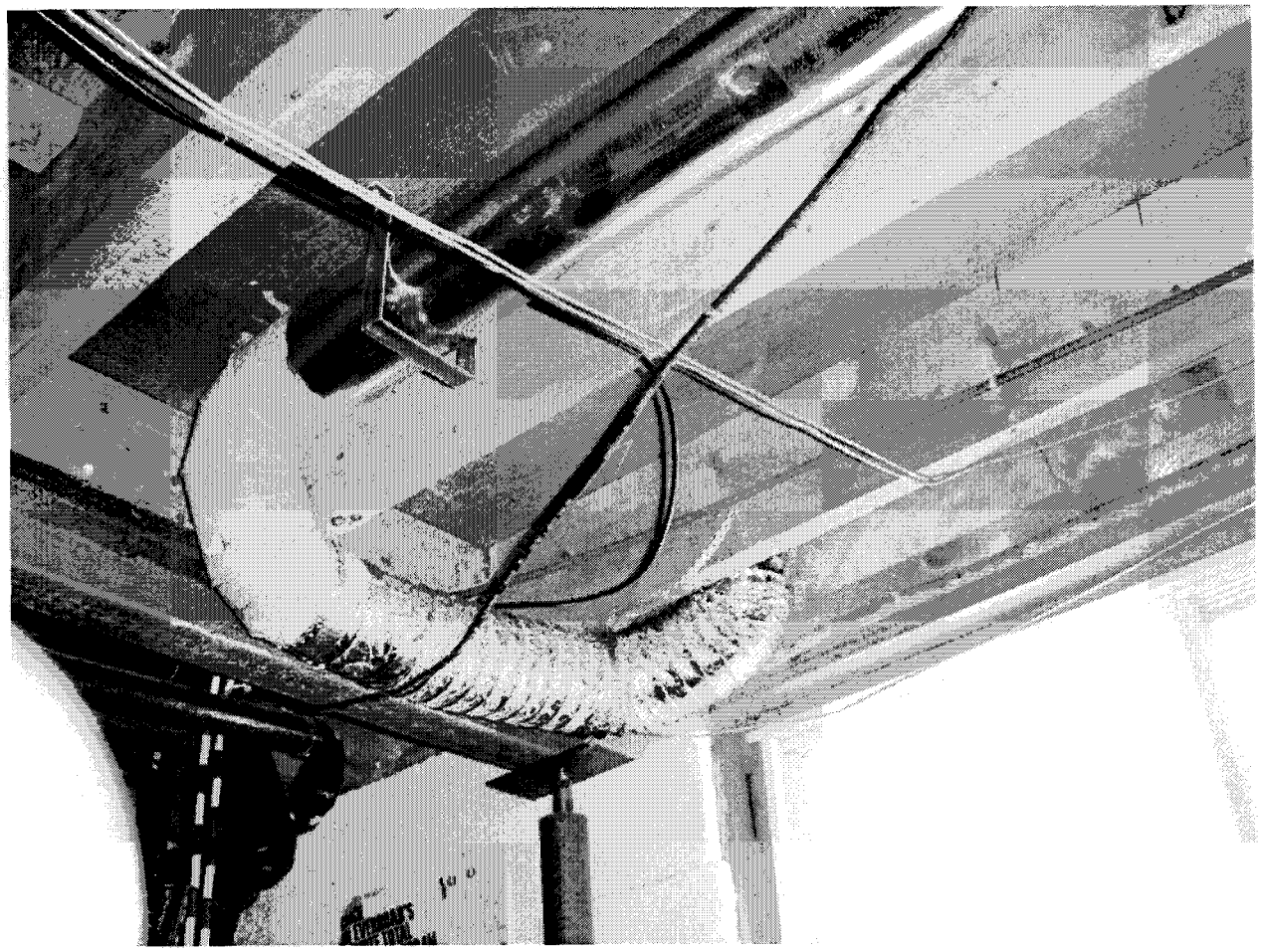
Appendix C
House Three
Photographs of System 7 of 11
H3,007



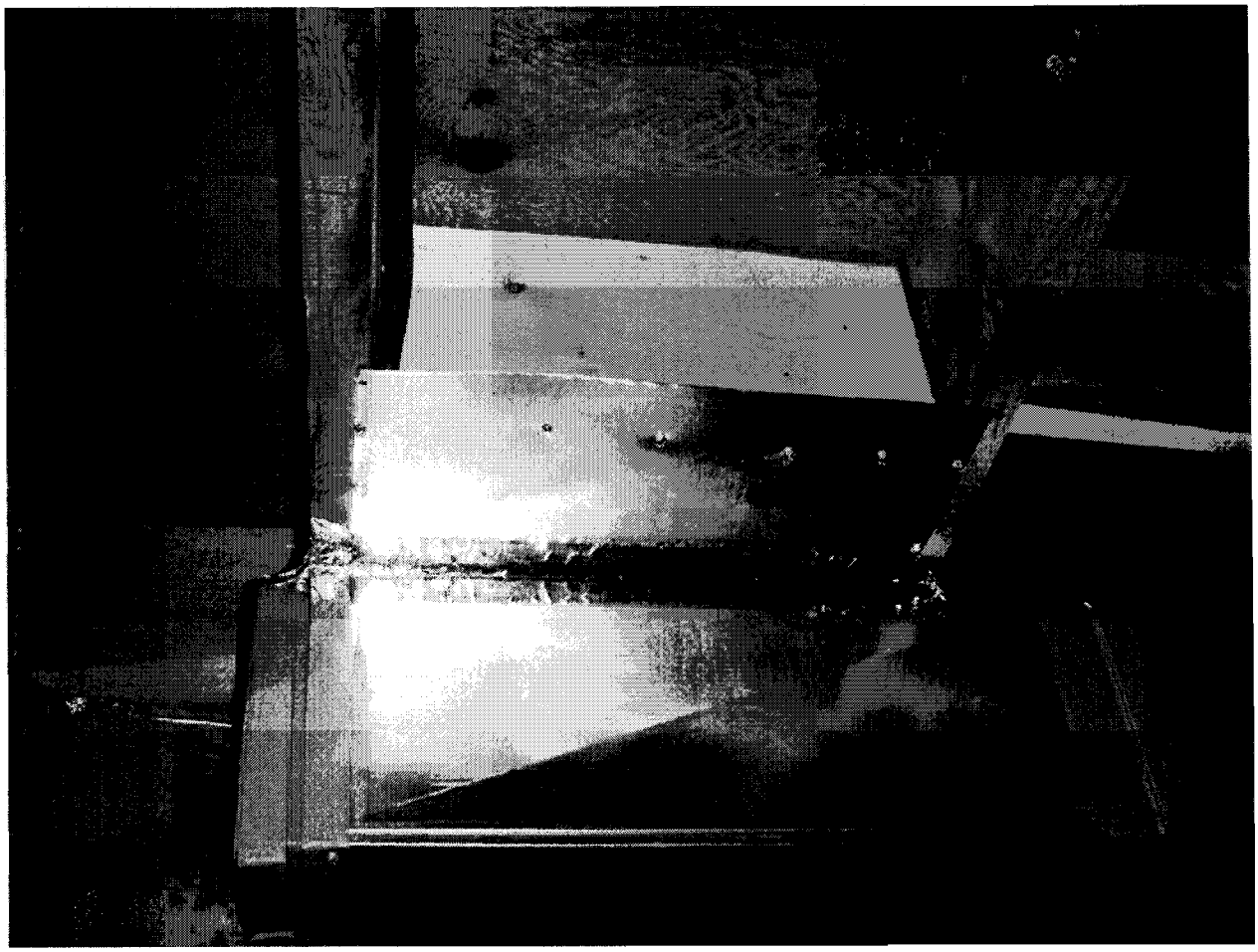
Appendix C
House Three
Photographs of System 8 of 11
H3,008



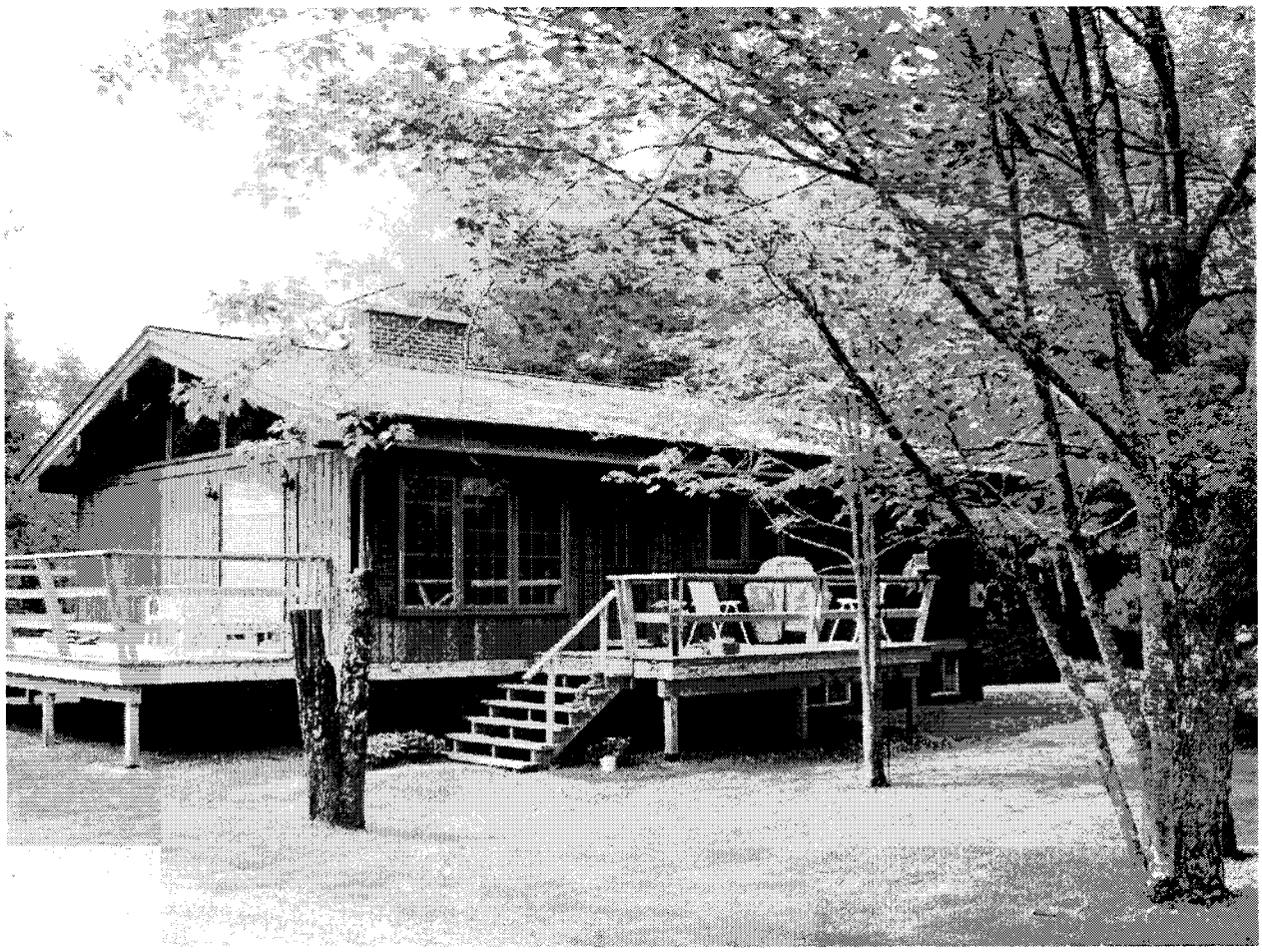
Appendix C
House Three
Photographs of System 9 of 11
H3,009



Appendix C
House Three
Photographs of System 10 of 11
H3,010



Appendix C
House Three
Photographs of System 11 of 11
H3,011



Appendix D
Houses One, Two, and Three
Data Collection Equipment

Phillips Comparison Test Report

Comparison Test of Airflow Results
Pan with Flow Collar – Versus – Saddle Style Flow Collar

Bert Phillips, P.Eng., MBA

Objective

To answer the question, Why were the indicated airflows measured with a flow collar in a pan significantly different than the airflows measured with a saddle type flow measuring device?

Approach

Airflows and static pressures were measured using both methods separately and together in two ducts on a forced air heating system. The impact of the flow collar and pan apparatus on airflow was determined by comparing airflows indicated by the saddle type flow measuring device with the flow collar and pans apparatus placed over the grille to those without it over the grille. In a similar fashion, the impact of the saddle type device was determined by comparing airflows indicated by the flow collar and pan apparatus, with and without the saddle device inserted in the duct. The relative accuracy of the devices was assessed by simultaneously measuring indicated airflows for both devices and comparing these values.

Test Description and Observations

The measurements were done in a house with exposed forced air ductwork in the basement. Duct #1 was a straight, six inch diameter duct running about 2 meters laterally from the supply trunk to the supply grille boot. Static pressure was measured at the wall of the duct just upstream of the boot to the supply grille. The insertion point for the saddle device was about the mid way between the take off and the boot.

The data (presented in Table 1-D) indicates that placing a pan with flow collar over a supply air grille measurably increases static pressure (or airflow resistance) and reduces airflow. The four inch flow collar and pan affected airflow at a significant level, while the six inch flow collar and pan had a modest impact on airflows. The saddle type flow measuring device appeared not to affect static pressures or air flows at a significant level. For this duct configuration, there was good agreement between airflow measuring methods (i.e., for a given test condition, the pan with flow collar apparatus indicated similar airflows to the saddle device). The position of the pan over the grille was found to have a modest impact on indicated airflow (the range was less than 10% of measured flow).

Duct #2 had an elbow shortly after the take off from the supply trunk, ran straight for about 3 meters then went through two close coupled elbows and into the supply grille boot. Two flow measuring ports for the saddle type device were installed 15 cm downstream of the elbow near the supply trunk, one in the same plane as the duct run and one perpendicular to the plane of the duct run (i.e., one horizontal and one vertical insertion port). A third port was located at the mid point of the long straight duct and a fourth was located about 10 cm upstream of the two close coupled elbows leading to the supply grille boot. Static pressure was measured at the wall of the duct at these same locations.

The configuration for Duct #2 allowed an assessment of the impact of an elbow on the saddle device. The data for Duct #2 indicated that placing a pan with flow collar over a supply air grille increased static pressure or resistance, reducing airflow through the grille, but that the saddle device did not appear to impact airflow very much. The wide range of indicated airflows for the saddle device (i.e., 18 to 38 L/s) shows the impact of location and orientation on the saddle device and confirms the importance of locating airflow measuring devices well away from the influence elbows, balance dampers, fans, etc. The saddle device indicated the same airflows at the third and fourth measurement ports, and this flow was in close agreement with indicated airflow for the pan with the six inch flow collar, but agreement was not so good for the pan with the four inch flow collar. There was not a measurable difference in static pressures between the third and fourth measurement ports.

During the investigation into compliance with Part 9 ventilation requirements in the 1995 NBC, room by room airflows were measured using a six inch flow collar in a box, similar to the one used in the Clarke study. At that time, tests were run to compared indicated flow through a six inch flow collar against that through a calibrated nozzle. Those measurements indicated good agreement. Those tests did not go the step further to evaluate the impact of the hood on airflows.

Two Air Instrument Resources MP6KD micromanometers resolving to 0.001 in.W.G. were used for pressure measurements during these tests. As part of the quality assurance for the tests, the micromanometers were teed to a pressure source and their relative calibration was checked. The micromanometers were in full agreement within the range of pressures measured during the tests.

Conclusions

In the Clarke study, the saddle type airflow measuring device usually indicated higher airflows than the pan with flow collars attached. This is consistent with the findings that the pan with flow collar device restricts airflow to a measurable degree while the saddle device does not appear to appreciably impact airflow.

In some cases, extreme differences in indicated airflows between the two methods may be the result of placing the saddle device too close to an elbow or other device that causes turbulence or non-symmetrical airflow in the duct.

Table 1 - D

	SP in. WG			Indicated Airflow L/s			
	Downstream of elbow		Near Boot	Hood	Saddle at Elbow		Saddle In
	//	L			//	L	Straight
Duct #1							
Initial Condition			0.070	...			...
Saddle Inserted			0.070	...			37.8
Pan with 4" collar			0.092	25.1			...
Pan with 4" collar and saddle			0.092	25.1			28.4
Pan with 6" collar			0.073	37.2			...
Pan with 6" collar and saddle			0.073	37.2			36.5
Duct #2							
Initial Condition	0.066	0.075	0.079	...	...	...	...
Saddle Inserted			0.079	...	18.2	37.8	31.6
Pan with 4" collar			0.090	20.7	...	...	...
Pan with 4" collar and saddle			0.090	20.7	11.9	30.8	25.8
Pan with 6" collar			0.080	29.4	...	...	...
Pan with 6" collar and saddle			0.080	29.4	16.9	37.1	30.0

Hood refers to the pan and flow collar device

"//" refers to horizontal insertion port for saddle probe

"L" refers to vertical insertion port for saddle probe

Airflow for flow measuring devices was calculated using the equation:

$Q = C \times dP^{0.5}$ where: Q is in L/s

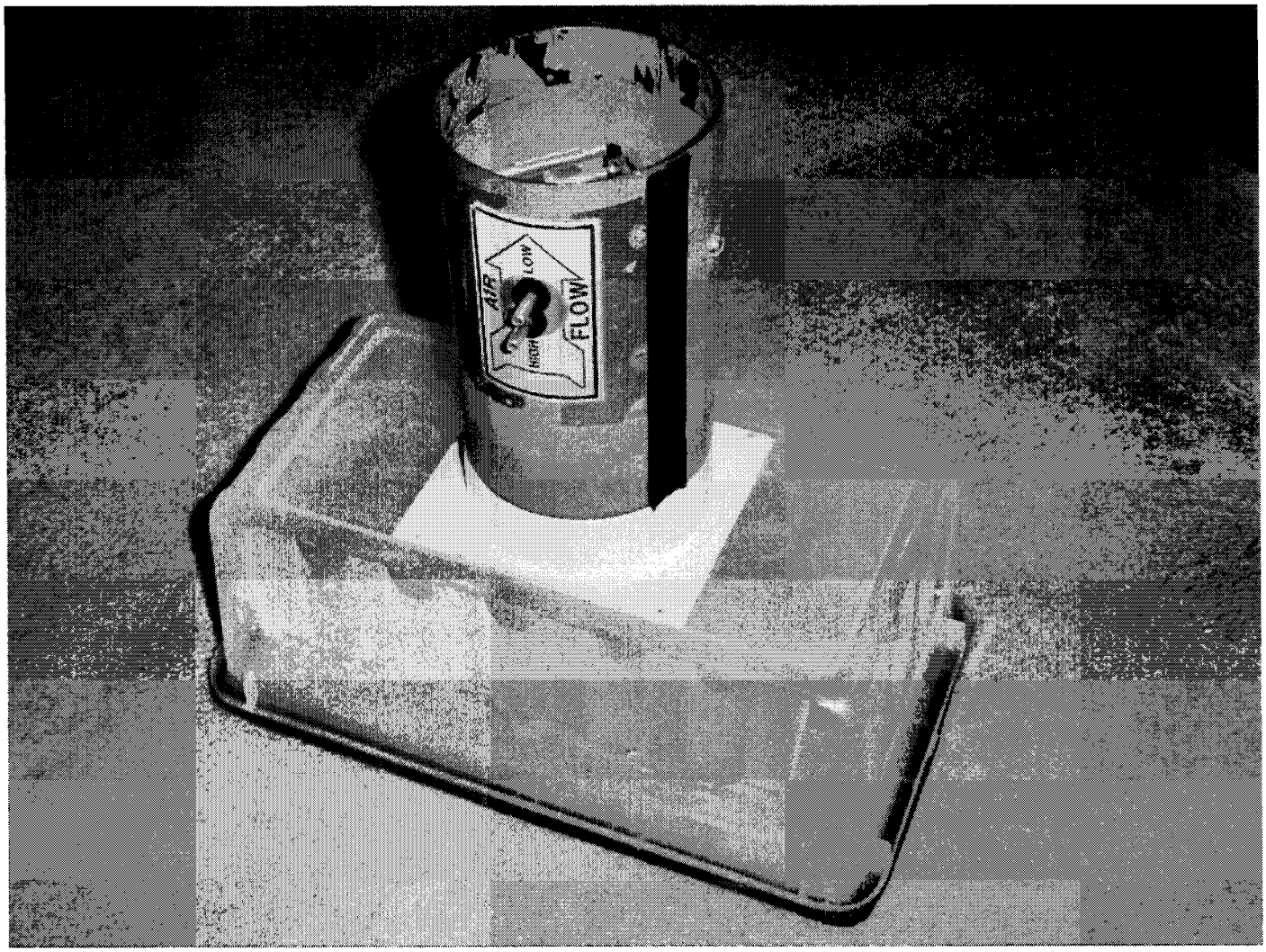
dP is in inches W.G.

C = 101 for the 4 inch flow collar

C = 240 for the 6 inch flow collar

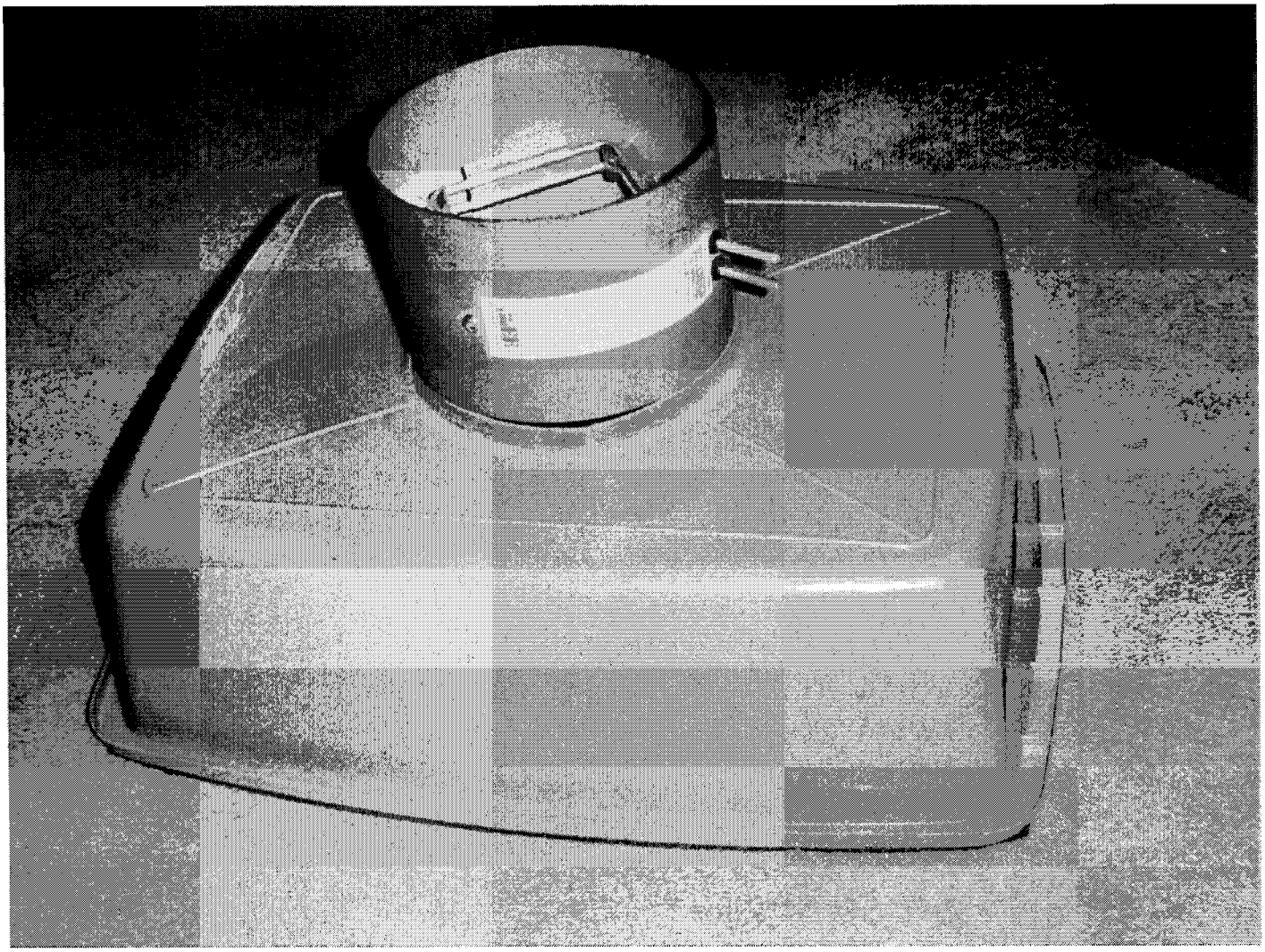
C = 218 for the saddle type flow measuring device

Appendix D
Houses One, Two, and Three
Photographs of Data Collection Equipment 1 of 3
H123,007



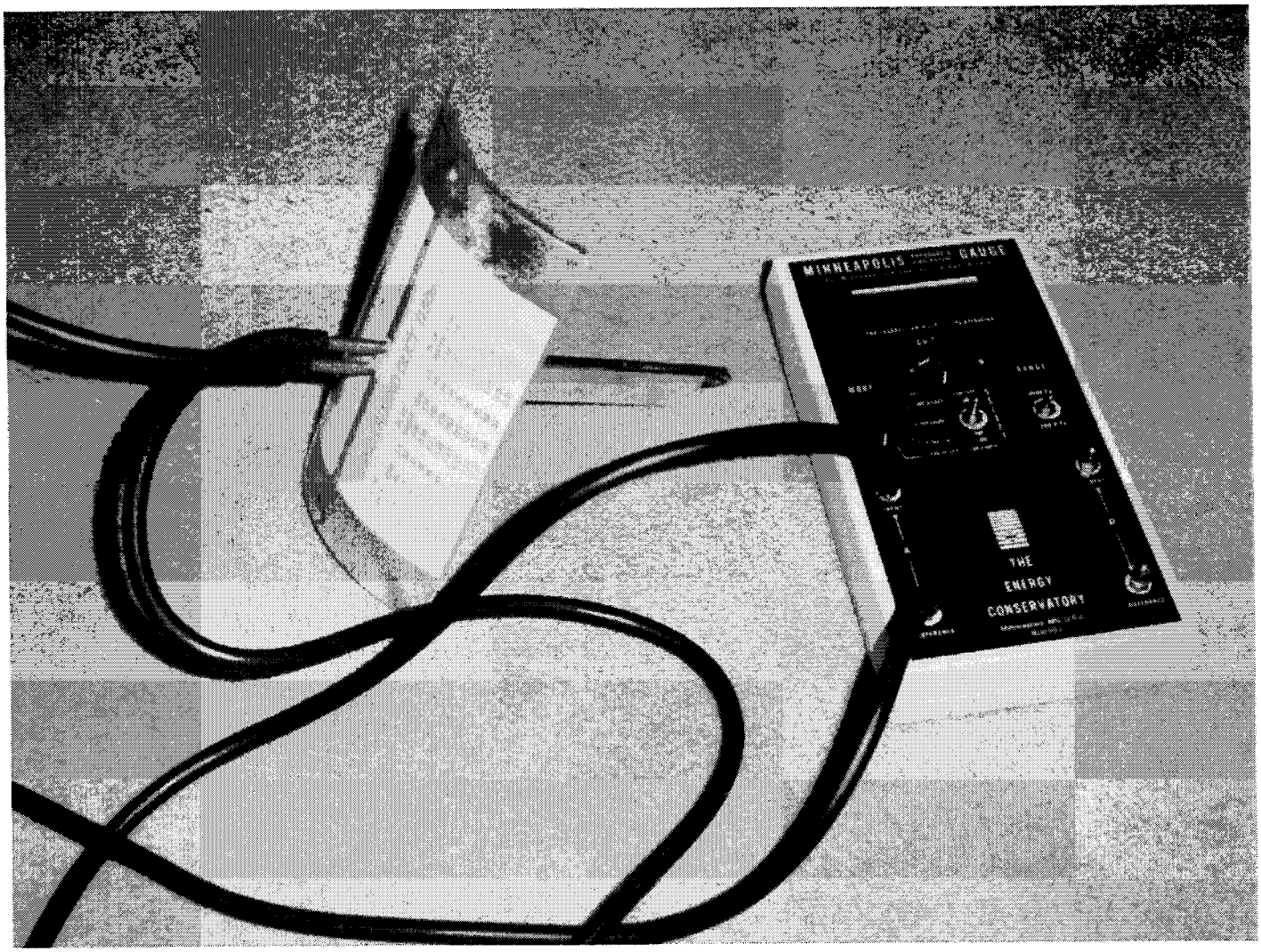
The above picture displays a plastic food storage container which has been fitted with weatherstripping around its main rim, and a 4 inch diameter opening in the bottom along with a collar to which a 4" diameter floor collar may be taped. The capture hood measures 12" (L) x 5.5" (W) x 5" (D) and was used to measure air flow from 4" x 10" warm-air supply diffusers.

Appendix D
Houses One, Two, and Three
Photographs of Data Collection Equipment 2 of 3
H123,011



The above picture displays a plastic kitty litter tray which has been fitted with weatherstripping around its main rim, and a 6" diameter opening in the bottom along with a collar to which a 6" diameter floor collar may be taped. The capture hood measures 16" (L) x 13" (W) x 5.5" (D) and was used to measure air flow to return-air grilles.

Appendix D
Houses One, Two, and Three
Photographs of Data Collection Equipment 3 of 3
H123,012



The above picture displays the digital manometer used to collect air-flow data, and a 6" diameter "saddle" style flow collar used to take pressure readings by inserting the probe into a duct of the same diameter. The metal saddle is equipped with a foam backing which enable the flow collar to maintain a sealed contact with the duct surface as measurements are taken.