THE FLAIR HOMES ENERGY DEMO/CHBA FLAIR MARK XIV PROJECT: DESCRIPTION OF THE PROJECT HOUSES, MONITORING PROGRAM AND DATA BASE

PREPARED FOR:

Efficiency and Alternative Energy Technology Branch
Energy, Mines and Resources Canada
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RÉSUMÉ

Le Projet de démonstration de la maison à haut rendement énergétique/Mark XIV de l'ACCH, de Flair Homes, a été créé en 1985, dans le but de fournir une démonstration de divers produits, systèmes et technologies d'économie d'énergie, susceptibles d'être adoptés par l'industrie canadienne de la construction d'habitations. Vingt-quatre (24) maisons ont été construites à Winnipeg par un important constructeur de résidences et contrôlées de façon intensive par une firme d'ingénierie indépendante sur des périodes allant jusqu'à trois ans. Pendant presque toute cette période, les maisons appartenaient à des particuliers et étaient soumises à un usage normal par les occupants. Le travail sur le terrain a été complété en 1990.

Ce rapport se veut un document de référence général sur le projet et vise à compléter les autres rapports techniques issus du programme de contrôle. Ces derniers traitent d'aspects particuliers du rendement des maisons ainsi que des diverses technologies utilisées. Le présent rapport contient des renseignements généraux sur les maisons, y compris des détails sur leur enveloppe de bâtiment et leurs installations mécaniques; il donne également un bref aperçu du programme de contrôle et documente l'information dans la base de données du projet (qui contient tous les renseignements relatifs au contrôle recueillis au cours du projet). Le présent texte ne contient pas de données de contrôle ni de résultats ou de conclusions.

Le Projet Flair a reçu l'appui d'Énergie, Mines et Ressources Canada, en vertu du Programme de démonstration de la maison à haut rendement énergétique (PDMHRÉ) et du ministère de l'Énergie et des Mines du Manitoba, dans le cadre de l'Accord fédéral-Manitoba de démonstration des économies d'énergie et des énergies renouvelables (ADÉÉÉR). La gestion du projet était sous la responsabilité de Flair Homes (Manitoba) Ltd. Le contrôle et les rapports ont été effectués par la firme d'ingénieurs-conseils UNIES Ltd., de Winnipeg.

Le projet avait également pour but de fournir un soutien technique au Programme de la maison R-2000, subventionné par Énergie, Mines et Ressources Canada et administré par l'Association canadienne des constructeurs d'habitations (ACCH). La désignation «Mark XIV» a été acquise lorsqu'une part importante des priorités de recherche définies par le Comité de recherche technique de l'ACCH a été incorporée au plan de travail du projet.

SECTION 1

INTRODUCTION

1.1 THE FLAIR HOMES ENERGY DEMO/CHBA FLAIR MARK XIV PROJECT

The Flair Homes Energy Demo/CHBA Flair Mark XIV Project was created in 1985 to provide a demonstration of various energy conservation technologies, products and systems which might be suitable for the Canadian home building industry. Twenty-four houses were constructed in Winnipeg by a major tract builder and intensively monitored for periods of up to three years by an independent engineering firm. During most of this period the houses were privately owned and subjected to normal usage by their occupants. The field work was completed in 1990.

This report has been prepared as a general background document on the project and is intended to complement the other technical reports generated from the monitoring program. The latter address specific aspects of the houses' performance and the various technologies they employed. This report contains background information on the houses including details of their building envelope and mechanical systems; it also provides a short overview of the monitoring program and documents the information in the project's Data Base (which contains all the monitoring information collected during the project). No monitoring data, results or conclusions are contained herein.

Support for the Flair project was provided by Energy, Mines and Resources Canada under the Energy Demo Program and by Manitoba Energy & Mines under the Manitoba/Canada Conservation and Renewable Energy Demonstration Agreement (CREDA). Project management was the responsibility of Flair Homes (Manitoba) Ltd. Monitoring and reporting were performed by UNIES Ltd., consulting engineers, of Winnipeg.

The project was also designed to provide technical support to the R-2000 Home Program, which is funded by Energy, Mines and Resources Canada and administered by the Canadian Home Builders Association (CHBA). The CHBA's "Mark XIV" designation was acquired when a major portion of the research priorities identified by the CHBA's Technical Research Committee was incorporated into project's the work plan.

1.2 OBJECTIVES

The Flair Homes Energy Demo/CHBA Flair Mark XIV Project was established with three major objectives:

1. To demonstrate and evaluate the performance of various low energy building envelope systems.

2. To demonstrate and evaluate the performance of various space heating, hot water heating and mechanical ventilation systems.
3. To transfer the knowledge gained in the project to the Canadian home building industry.

SECTION 2

HOUSE DESCRIPTION SUMMARY

2.1 CONSTRUCTION HISTORY

Houses #1 to #20 were constructed in the northeast corner of Winnipeg in the Lakeside Meadows subdivision. Houses #1 to #10 were completed in the spring of 1985 and occupied shortly thereafter while #11 to #20 were finished in the spring of 1986 and also occupied soon afterwards. Houses #21 to #24 were built in northwest Winnipeg in the Maple Glen subdivision. House #21 was completed in the summer of 1989 and served as an unoccupied research facility until 1990. Houses #22 to #24 were completed in the spring of 1988 and occupied within six months of completion. The construction period lasted approximately five months for each structure.

2.2 SITE PLANS

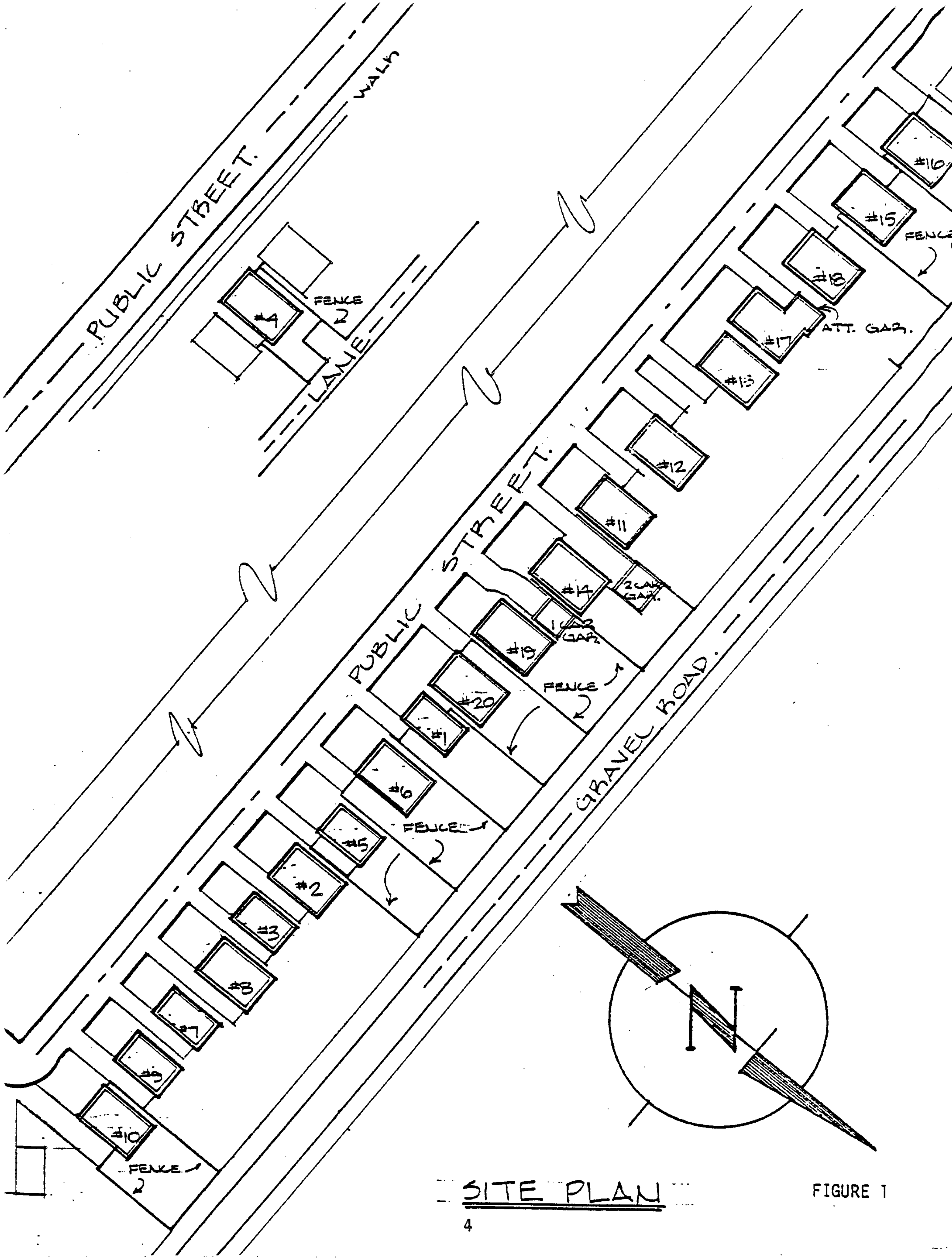
Site plans for the 24 houses are shown in Figs. 1 and 2. Houses #1 to #20 were located within approximately 1 km. of each other while #21 to #24 were located within 0.5 km. of each other. All used a south-facing orientation for their primary glazed wall.

2.3 FLOOR PLANS AND ELEVATIONS

Sample floor plans and a front elevation are shown in Figs. 3, 4 and 5. All of the houses were bungalows of similar size and layout with full basements and main floor areas (based on interior dimensions) of 60 m^2 to 85 m^2 (646 ft^2 to 915 ft^2). A variety of front elevations and roof systems were used to provide architectural variety. Most of the basements were not developed at the time of construction.

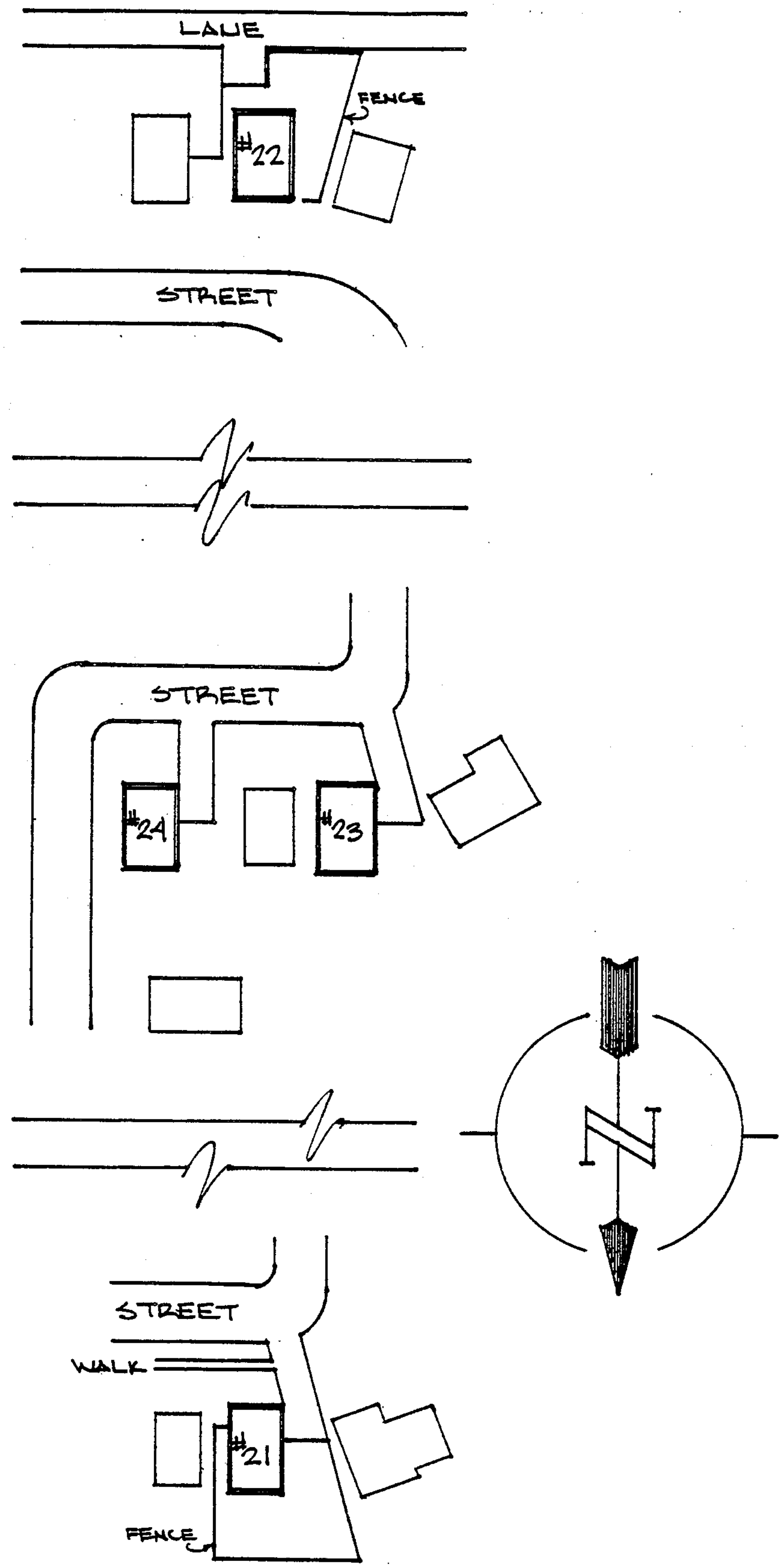
2.4 SUMMARIES

Tables 1 and 2 summarize the major building envelope and mechanical system features of the houses; detailed descriptions are given in Sections 3 and 4.



SITE PLAN

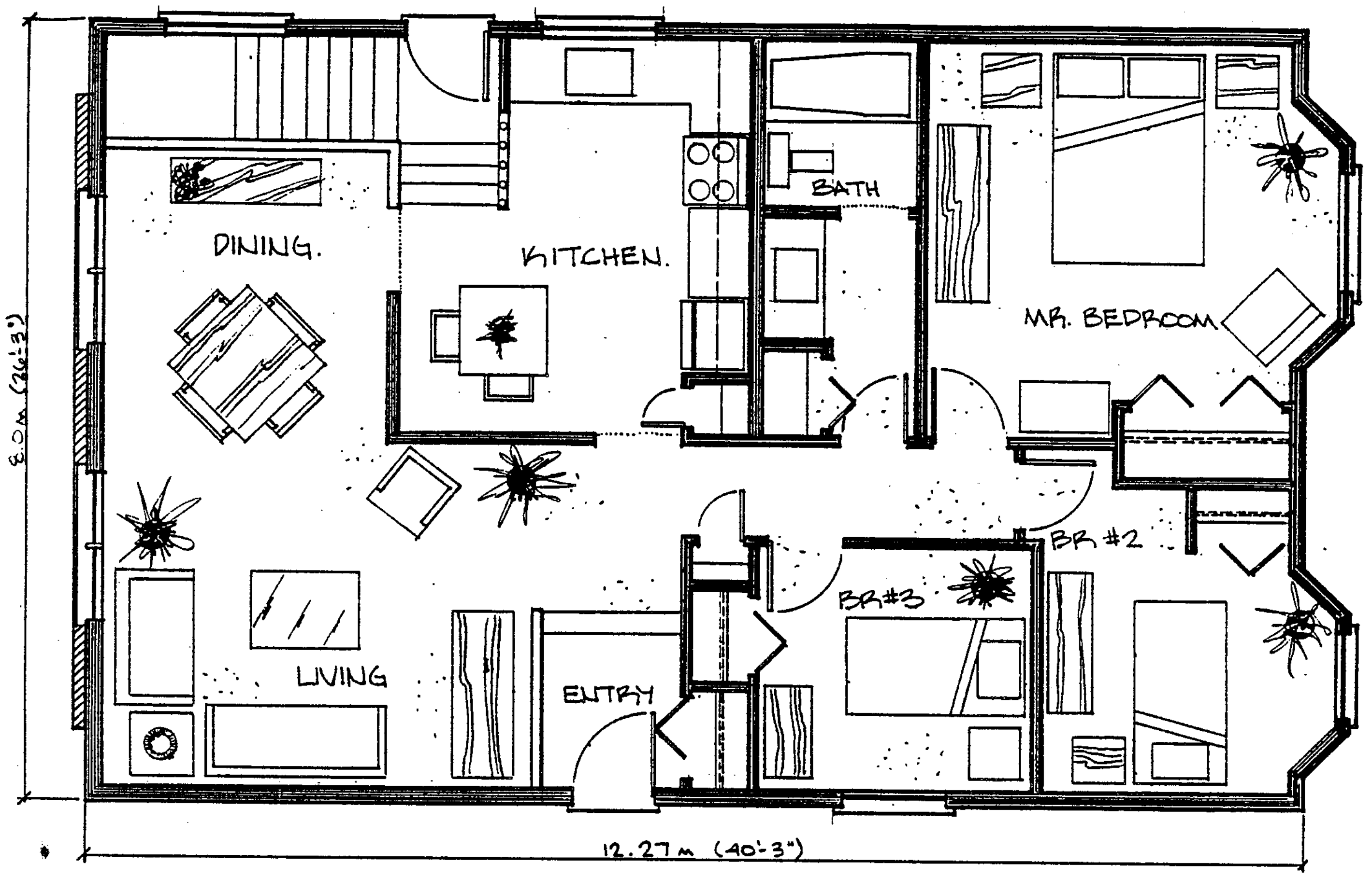
FIGURE 1

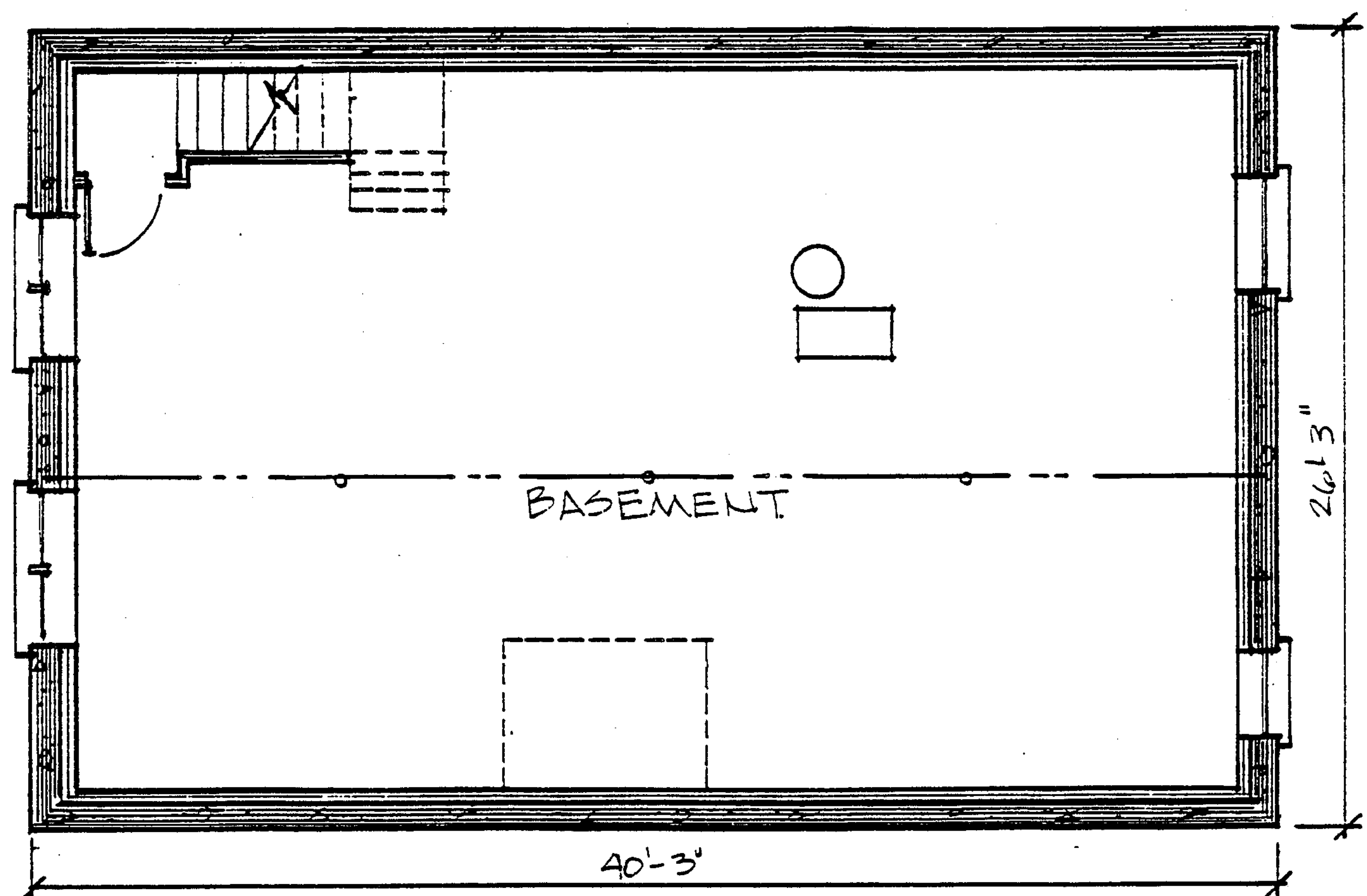


SITE PLAN N.T.S.

FIGURE 2

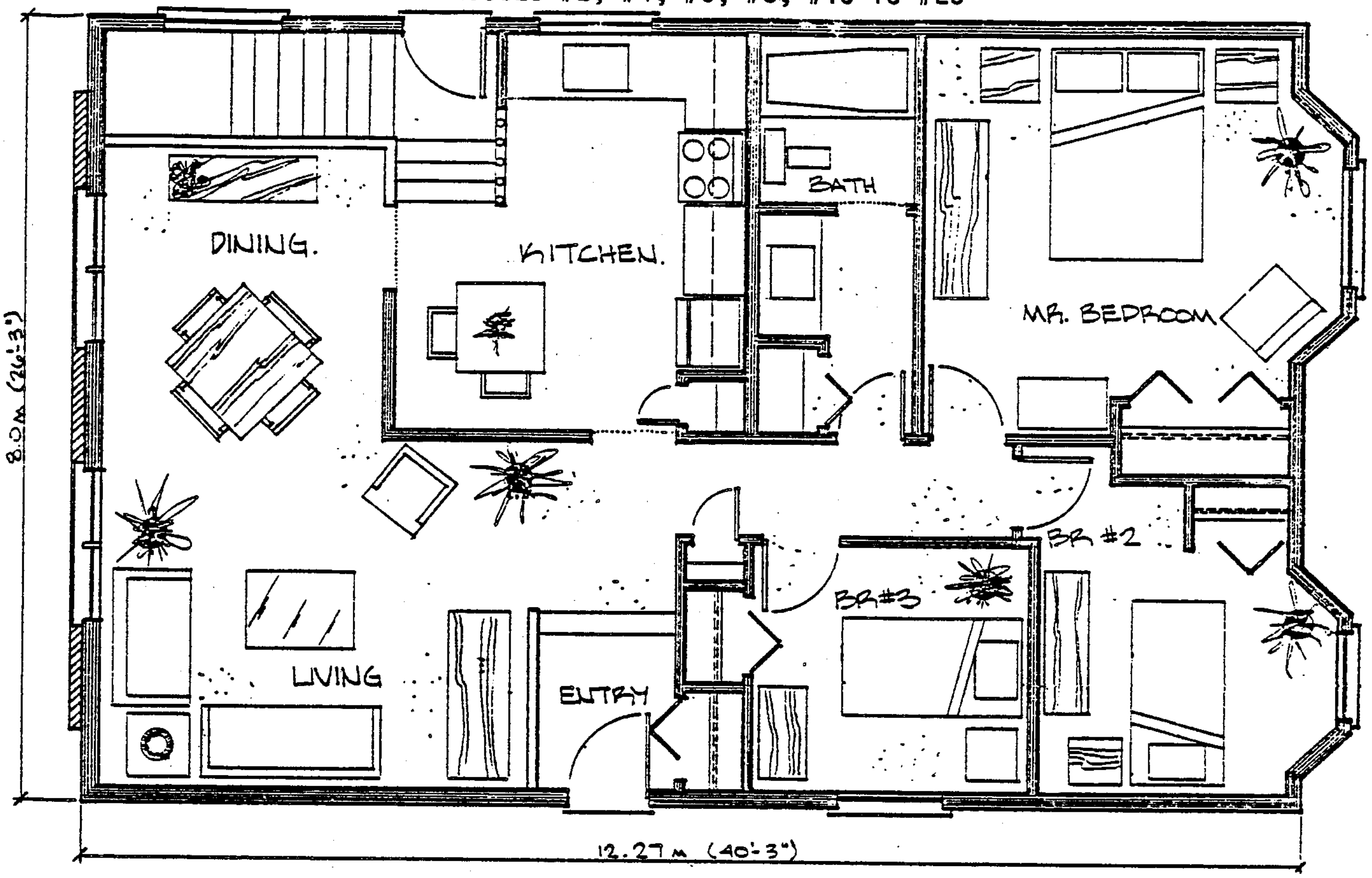
FIGURE 3





SAMPLE FLOOR PLAN
HOUSES #21, 23 and 24

SAMPLE FLOOR PLAN
HOUSES #2, #4, #6, #8, #10 TO #20



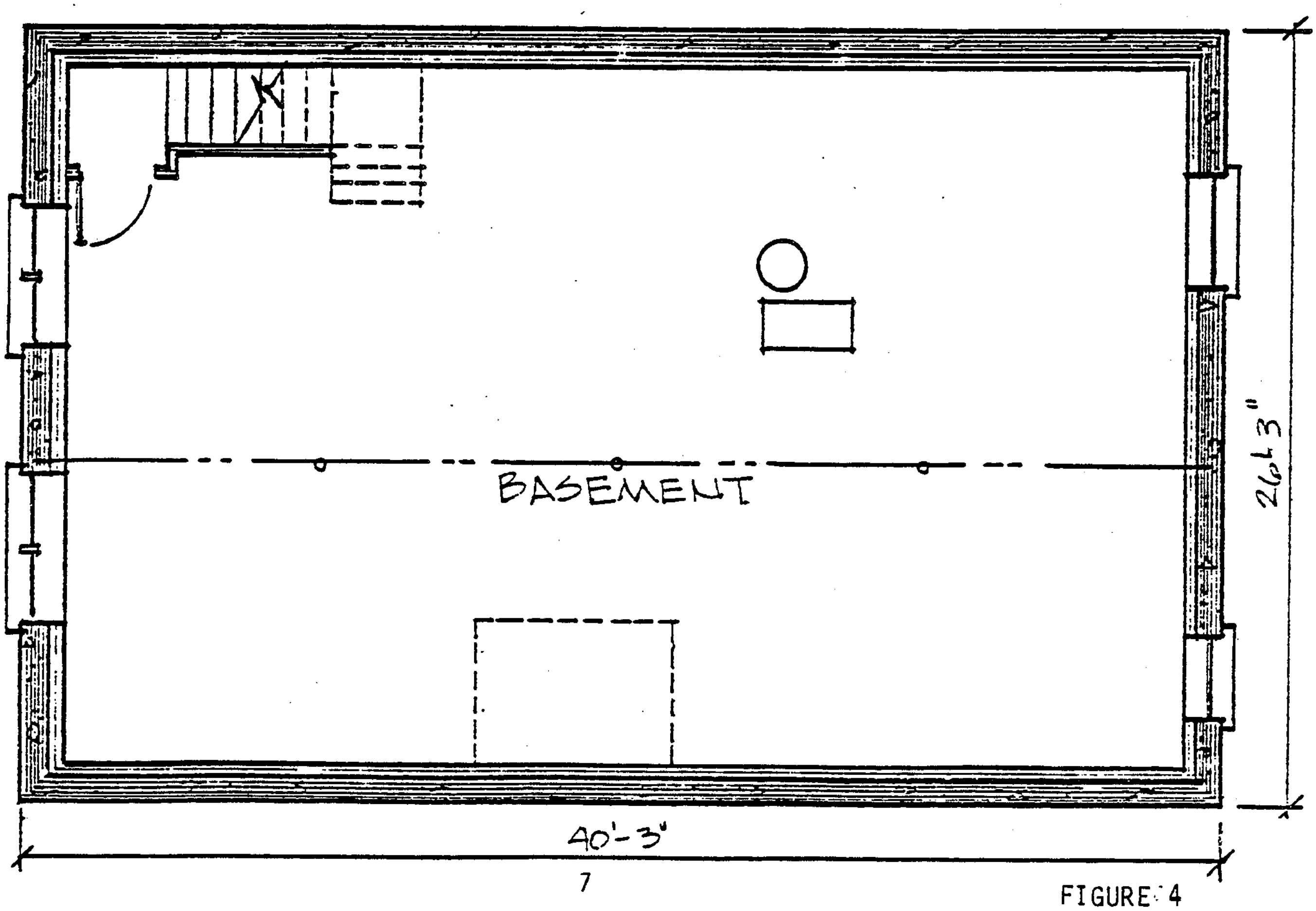


FIGURE 4

FIGURE 5

SAMPLE ELEVATION

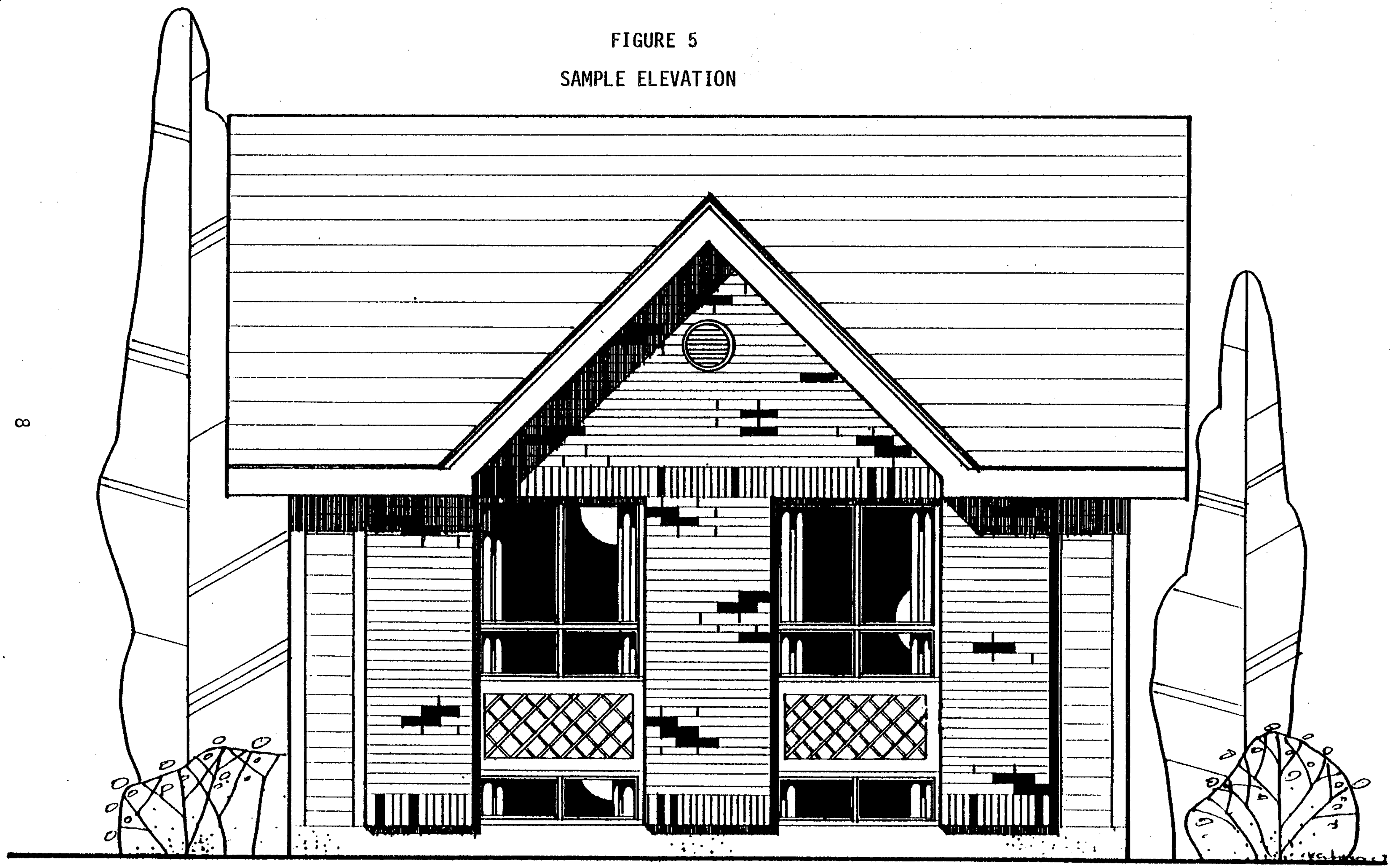


TABLE 1
DESCRIPTION OF PROJECT HOUSES

Feb/92

HOUSE	BUILDING ENVELOPE					MECHANICAL SYSTEMS		YEAR COMPLETED	ENERGY STANDARD
	WALL CONSTRUCTION	EXTERIOR WALL FINISH	BASEMENT CONSTRUCTION	CEILING/ATTIC CONSTRUCTION	WINDOWS	SPACE HEATING SYSTEM	VENTILATION SYSTEM		
1-6	38x140 (2x6), Rigid Glass Fibre Insulated Sheathing (Reversed) c/w SBPO Air Retarder	Stucco with Wood or Brick Siding	Cast Concrete	Cathedral & Truss Ceilings	Triple-Glazed; Fixed, Awning & Casement	Electric Forced Air Furnace	Heat Recovery Ventilator	1985	R-2000
7,8	38x140 (2x6)	Stucco with Wood Siding	Cast Concrete	Cathedral & Truss Ceilings	Triple-Glazed; Fixed, Awning & Casement	Electric Forced Air Furnace	Central Exhaust with Make-Up Air Duct	1985	Conventional
9,10	38x140 (2x6)	Stucco with Stone & Wood Siding	Cast Concrete	Cathedral & Truss Ceilings	Triple-Glazed; Fixed, Awning & Casement	Gas Forced Air Furnace	Bathroom Exhaust Fan	1985	Conventional
11-14	38x140 (2x6), Rigid Glass Fibre Insulated Sheathing c/w SBPO Air Retarder	Stucco with Wood, Brick or Stone Siding	Cast Concrete	Truss Ceiling	Triple-Glazed; Fixed, Awning & Casement	Electric Baseboards or Forced Air Furnace	Exhaust-only Heat Pump or Heat Recovery Ventilator	1986	R-2000
15,16	Double Wall	Stucco with Wood Siding	Cast Concrete	Truss Ceiling	Triple-Glazed; Fixed, Awning & Casement	Air-to-Air Heat Pump	Integrated with Space Heating System	1986	R-2000
17,18	Double Wall	Stucco with Brick, Wood or Stone Siding	Cast Concrete	Truss Ceiling	Triple-Glazed; Fixed, Awning & Casement	Electric Baseboards	Heat Recovery Ventilator	1986	R-2000
19,20	38x89 (2x4), Rigid Extruded Polystyrene Sheathing	Stucco with Wood & Brick Siding	Cast Concrete	Truss Ceiling	Triple-Glazed; Fixed, Awning & Casement	Electric Baseboards	Heat Recovery Ventilator	1986	R-2000
21	Predominately 38x140 (2x6) with Interior Strapping	Vinyl & Wood Siding	Cast Concrete	Cathedral & Truss Ceilings	Several Types	Several Types	Several Types	1989	R-2000
22	38x140 (2x6)	Stucco with Wood & Brick Siding	Cast Concrete	Cathedral & Truss Ceilings	Triple-Glazed; Fixed & Awning	Electric Forced Air Furnace	Central Exhaust	1988	Conventional
23	38x140 (2x6) with Interior Strapping	Stucco with Wood Siding	Cast Concrete	Cathedral & Truss Ceilings	Triple-Glazed; Fixed & Awning	Electric Forced Air Furnace	Heat Recovery Ventilator	1988	R-2000
24	38x140 (2x6) with Extruded Polystyrene Sheathing	Stucco with Wood & Brick Siding	Cast Concrete	Cathedral & Truss Ceilings	Triple-Glazed; Fixed, Awning & Casement	Electric Baseboards & Radiant Panels	Heat Recovery Ventilator	1988	R-2000

TABLE 2
AIR AND VAPOUR BARRIER DETAILS

Feb/92

HOUSE	AIR BARRIER							VAPOUR BARRIER		
	TYPE	SEALING METHOD					CREW			
		HEADERS	CANTILEVERS	PARTITION WALLS AT CEILING	WINDOW & DOOR ROUGH OPENINGS	ELECTRICAL OUTLETS		WALLS	CEILING	BASEMENT
1-6	ADA	Closed Cell Polyethylene Gaskets	Closed Cell Polyethylene Gaskets	Gaskets	Gaskets	Poly-Pan Boxes & Gaskets	A	Paint	Paint	Paint
7,8	ADA	Closed Cell Polyethylene Gaskets	Closed Cell Polyethylene Gaskets	Gaskets	Gaskets	Poly-Pan Boxes & Gaskets	A	Paint	Paint	Paint
9,10	4 mil Polyethylene	None	None	Unsealed Polyethylene	Unsealed Polyethylene	Unsealed Polyethylene	A	Polyethylene	Polyethylene	Polyethylene
11-14	Simplified ADA	None	None	None	Ethafoam Rod Gaskets	Poly-Pan Boxes & Gaskets	B	Paint	Paint	Paint
15,16	6 mil Polyethylene	Caulking	Caulking	Sealed Polyethylene	Sealed Polyethylene	Sealed Polyethylene	B	Polyethylene	Polyethylene	Polyethylene
17,18	6 mil Polyethylene	Caulking	Caulking	Sealed Polyethylene	Sealed Polyethylene	Sealed Polyethylene	B	Polyethylene	Polyethylene	Polyethylene
19,20	ADA	Closed Cell Polyethylene & Neoprene Gaskets	Closed Cell Polyethylene & Neoprene Gaskets	Neoprene Gaskets	Ethafoam Rod Gaskets	Poly-Pan Boxes & Gaskets	B	Paint	Paint	Paint
21	Primarily 6 mil Polyethylene	Sealed Polyethylene	Sealed Polyethylene & SBPO Air Retarder	Sealed Polyethylene	Various	Sealed Polyethylene	C	Polyethylene	Polyethylene	Polyethylene
22	Primarily 6 mil Polyethylene	Sealed Polyethylene & SBPO Air Retarder	Sealed Polyethylene & SBPO Air Retarder	Saturated Urethane Open Cell Gaskets	Various	Polyethylene	D	Polyethylene	Polyethylene	Polyethylene
23	6 mil Polyethylene	Sealed Polyethylene & SBPO Air Retarder	Sealed Polyethylene & SBPO Air Retarder	Sealed Polyethylene	Various	Sealed Polyethylene	D	Polyethylene	Polyethylene	Polyethylene
24	6 mil Polyethylene	Sealed Polyethylene & SBPO Air Retarder	Sealed Polyethylene & SBPO Air Retarder	Saturated Urethane Open Cell Gaskets	Various	Polyethylene	D	Polyethylene	Polyethylene	Polyethylene

SECTION 3

BUILDING ENVELOPE SYSTEMS

3.1 HOUSES #1 to #6

Houses #1 to #6 were built using the Airtight Drywall Approach (ADA) in which the drywall serves as a structural air barrier with gaskets placed at strategic locations between major structural elements to control air leakage; vapour barrier protection is provided by the paint. The main walls used 38x140 (2x6) frame construction with 38 mm (1½") exterior insulated sheathing ("Glasclad"), reversed so that the attached spun-bonded air retarder ("Tyvek") faced inwards thereby eliminating the need to tape the joints since they were located over framing members. Stucco was used on three of the four walls. Continuous drywall was installed on the ceiling prior to installation of the partition walls and penetrations were kept to a minimum. Concrete basements with 200 mm (8") walls and cast-in-place headers were used throughout with thermal protection provided using interior batt insulation and framing. A conventional polyethylene vapour barrier was used in the basement. All of the houses were designed and built to meet the R-2000 Standard. Further details are shown in Figs. 6 and 7.

<u>GASKET SCHEDULE</u>

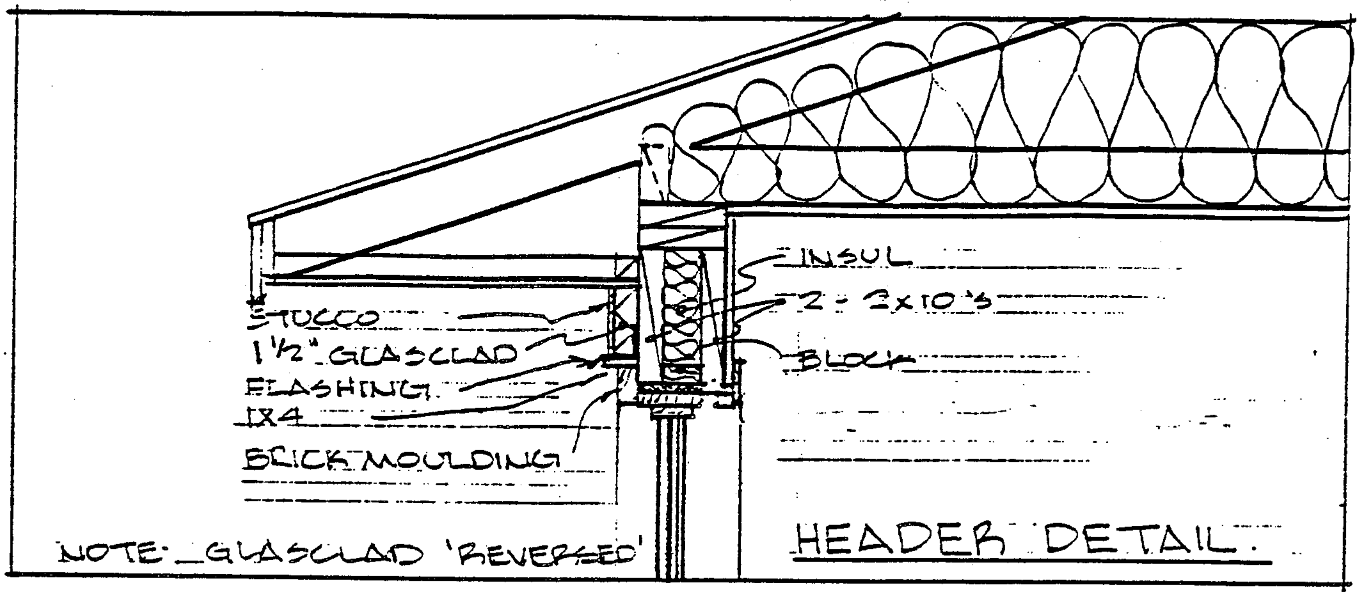
Type 1 - Polyethylene sill plate gasket
Electrical Outlets - Poly pan boxes and foam cover gaskets

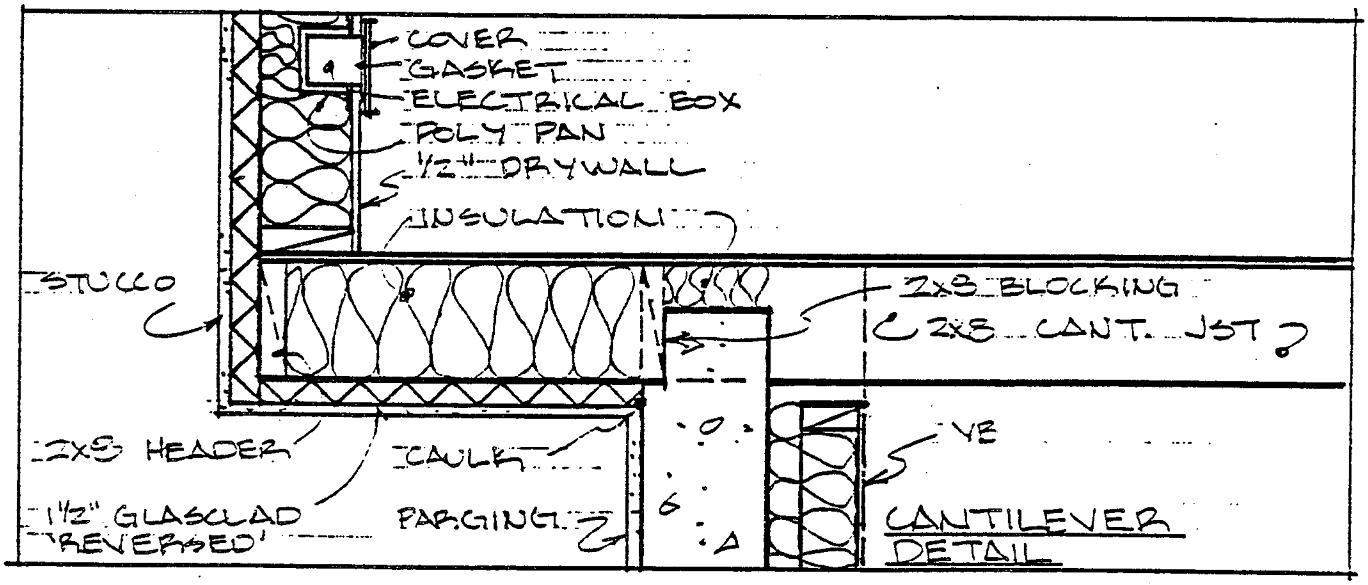
<u>PAINT SCHEDULE</u>

<u>Walls</u>
- o Latex primer
- o Latex finish coat

<u>Ceiling</u>
- o Latex primer
- o Texture finish coat

FIGURE 6
CONSTRUCTION DETAILS HOUSES #1 TO #6





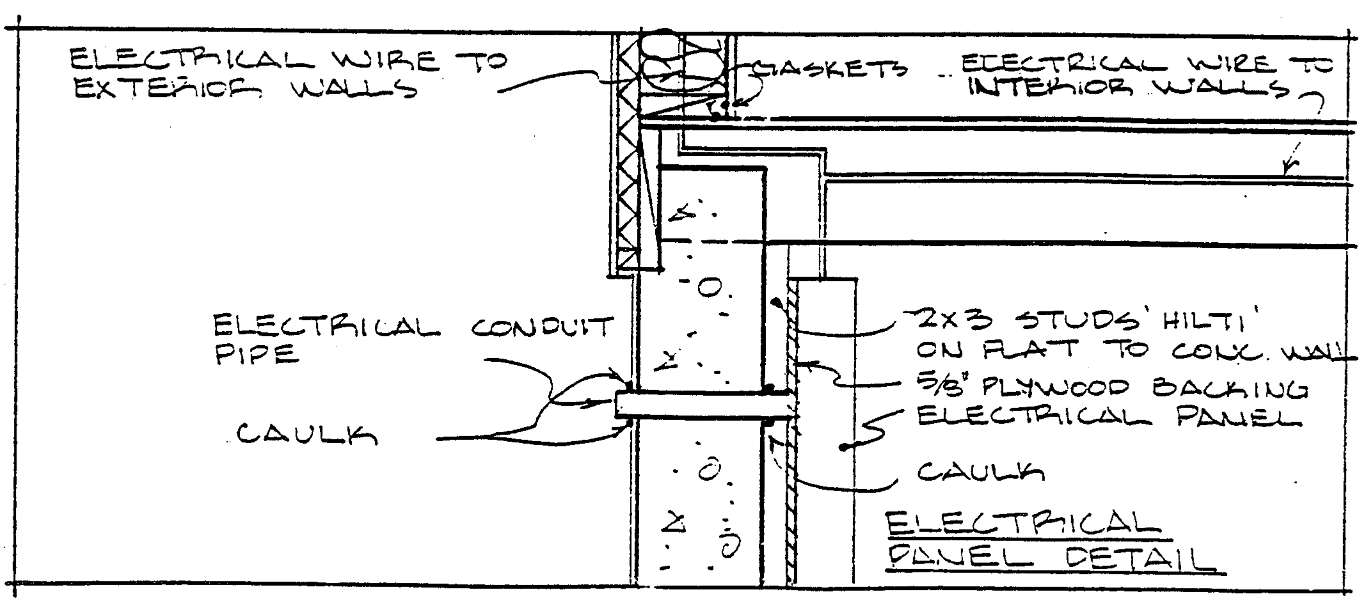
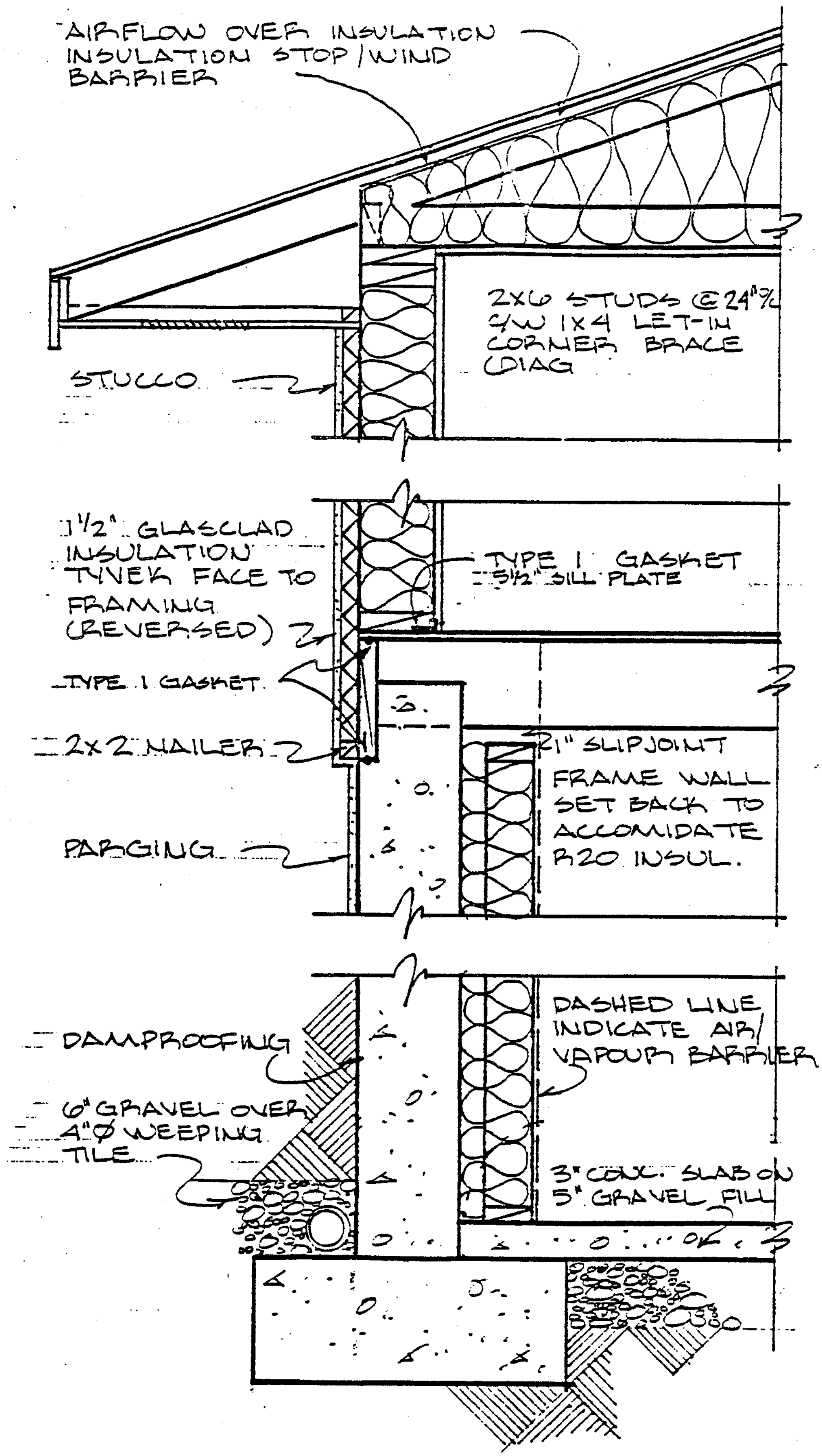


FIGURE 7



CROSS SECTION HOUSES #1 TO #6

3.2 HOUSES #7 and #8

The building envelopes were similar to those used in Houses #1 to #6 except conventional fibreboard sheathing was used in place of the exterior insulated sheathing. ADA was used for the main walls and ceilings with the basements employing conventional polyethylene vapour barriers. Stucco was used on three of the four walls. With the exception of the ADA details, these two houses were similar, in terms of construction practices, to most conventional homes in the Winnipeg area. Additional details are given in Figs. 8 and 9.

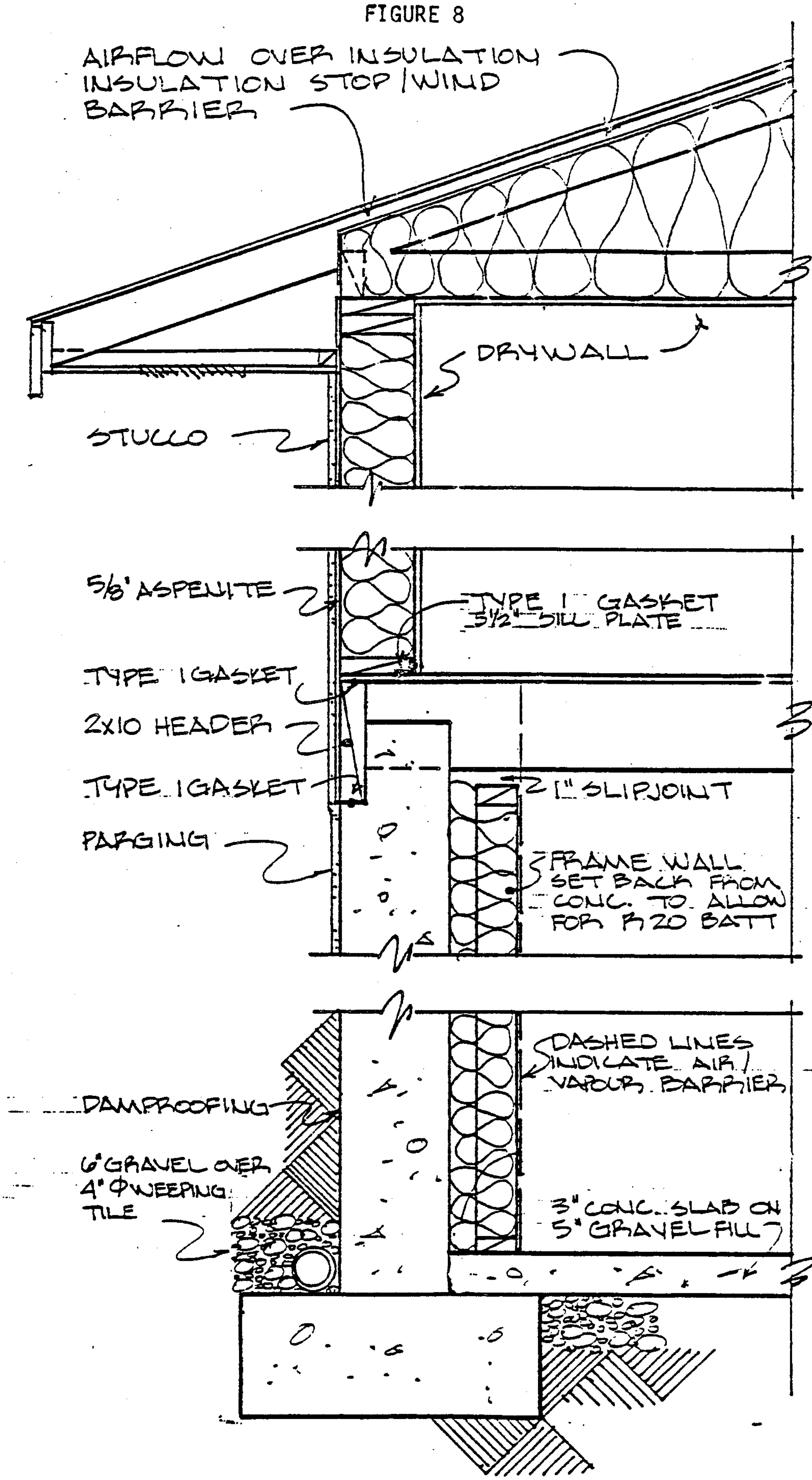
GASKET SCHEDULE

Type 1 - Polyethylene sill plate gasket
Electrical outlets - Poly pan boxes and foam cover gaskets

PAINT SCHEDULE

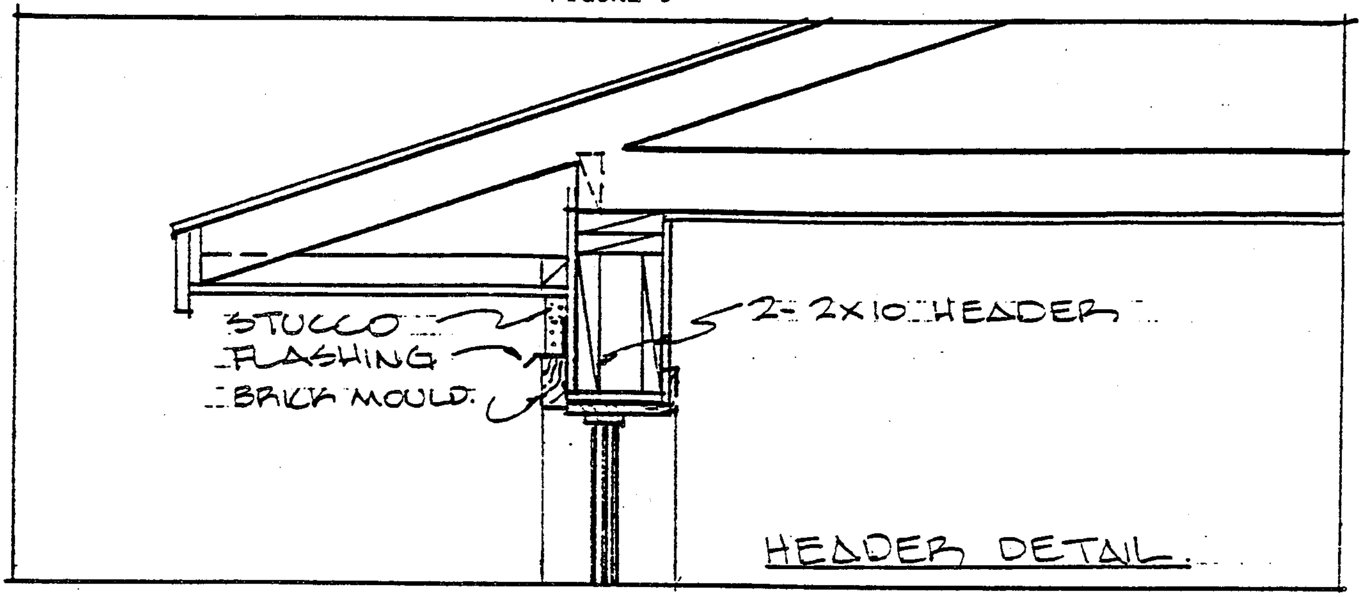
Walls
o Latex primer
o Latex finish coat
Ceiling
o Latex primer
o Texture finish coat

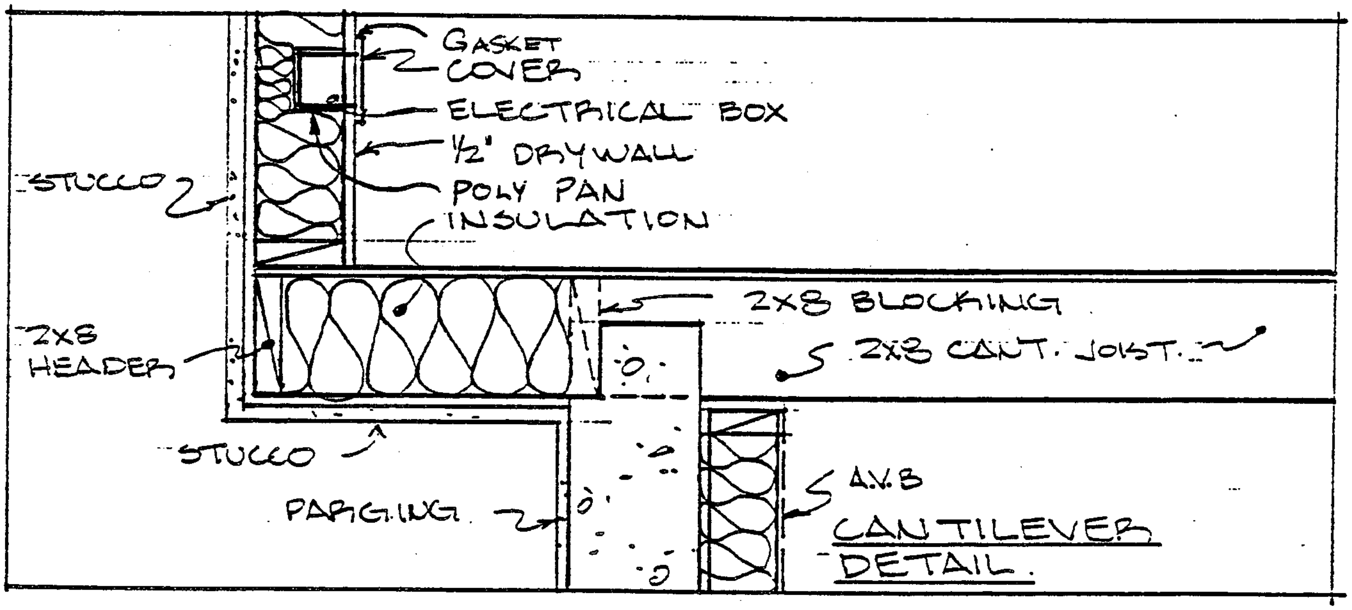
FIGURE 8

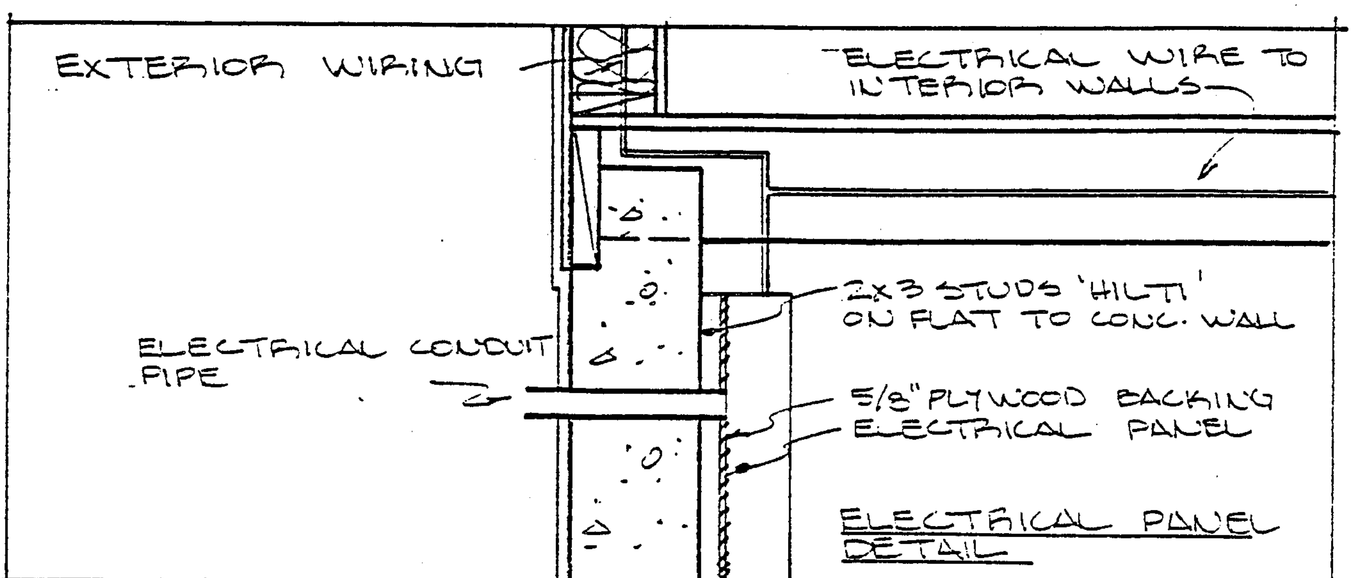


CROSS SECTION HOUSES #7 & #8

FIGURE 9





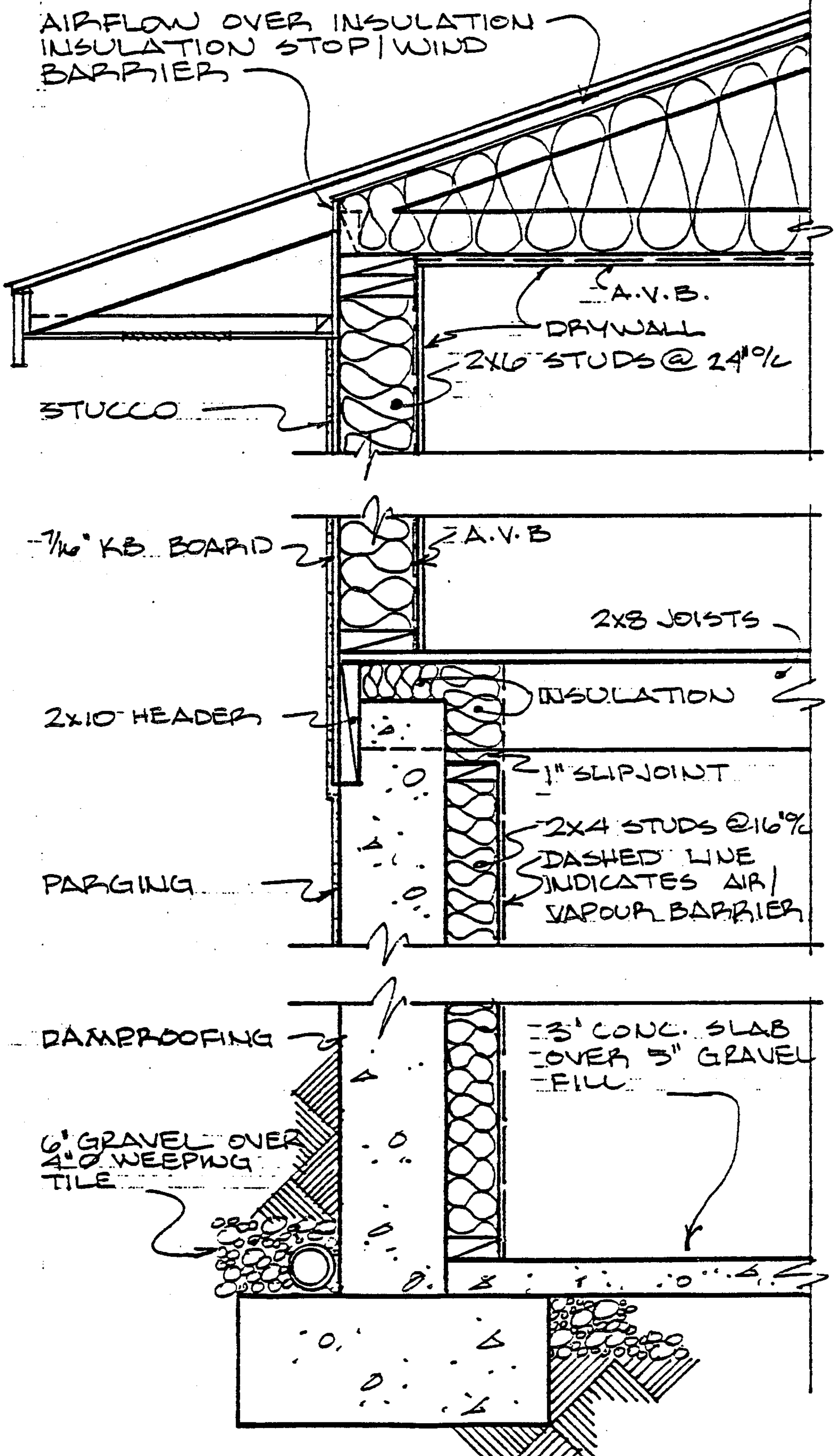


CONSTRUCTION DETAILS HOUSES #7 & #8

3.3 HOUSES #9 and #10

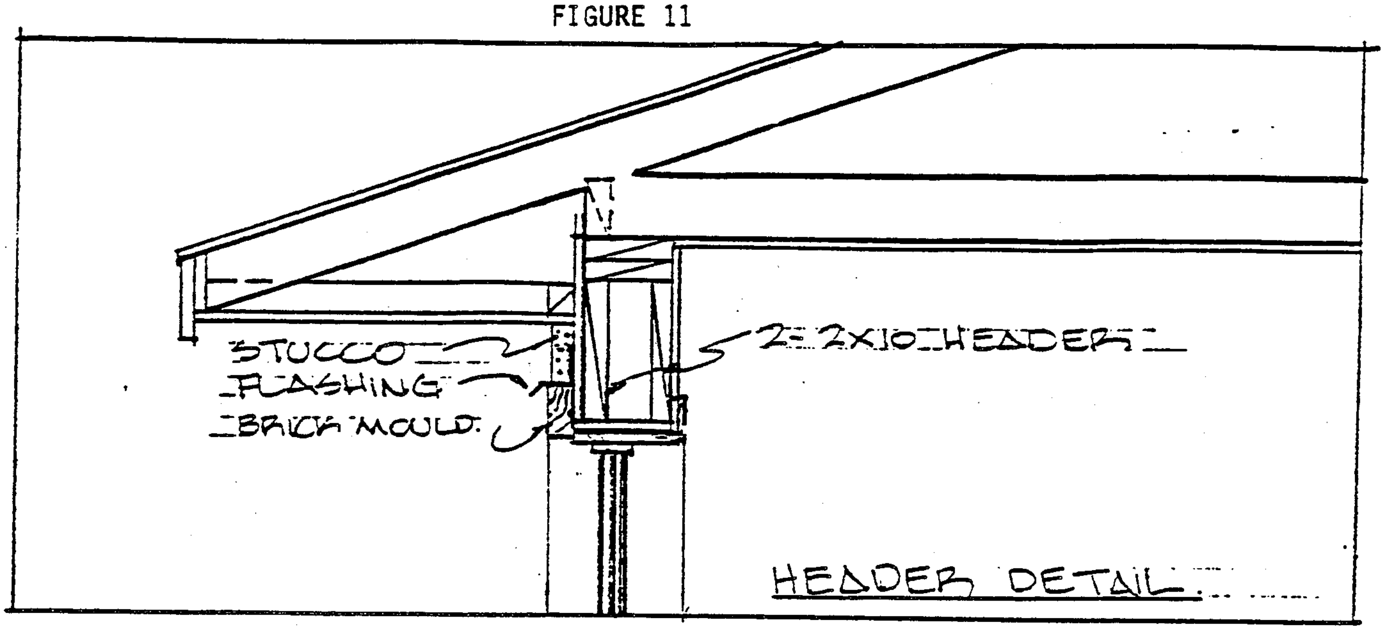
These two houses were the most typical of current, conventional construction practices in the Winnipeg market. The main walls used 38x140 (2x6) framing insulated to RSI 3.52 (R-20) with fibreboard sheathing on the exterior. The vapour barrier consisted of 4 mil polyethylene stapled-in-place with no effort to seal joints in adjacent sheets or penetrations. No special measures were taken to reduce air leakage around the floor system although stucco was used on three of the four walls (past experience has shown stucco can significantly reduce air leakage, particularly at this location). Penetrations for electrical outlets on exterior walls were "bagged" with polyethylene but not tightly sealed. No gaskets or other measures were used in the two houses. Additional details are given in Figs. 10 and 11.

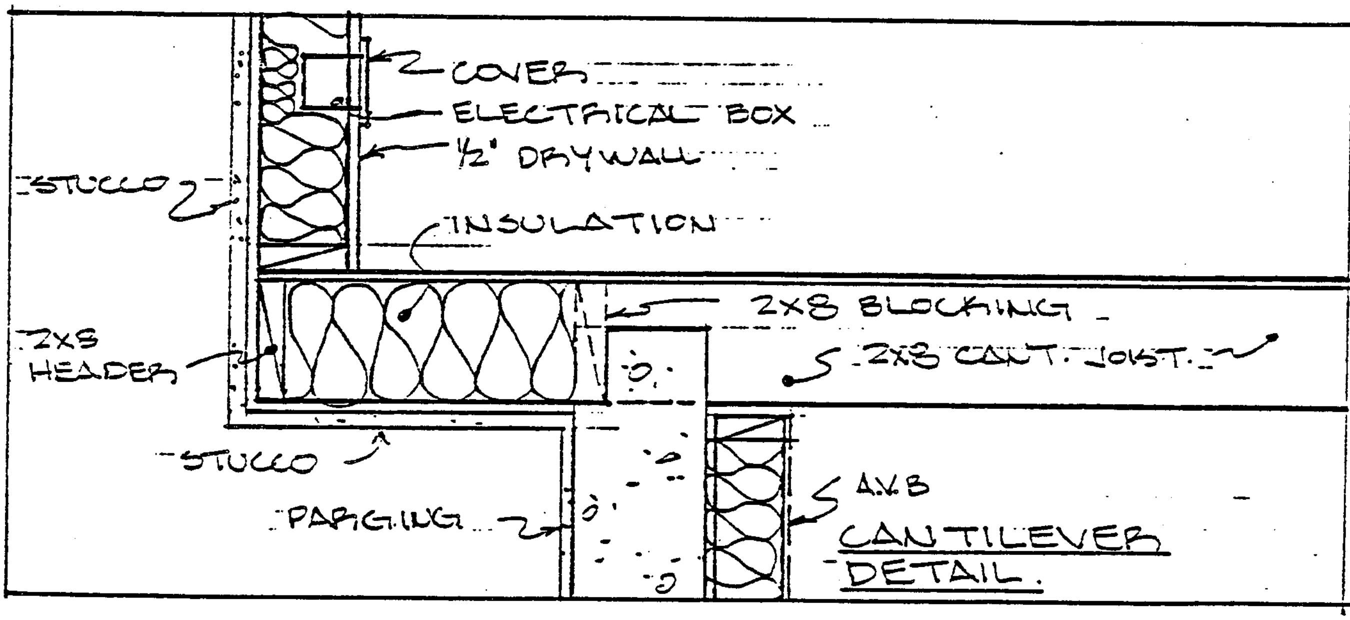
FIGURE 10

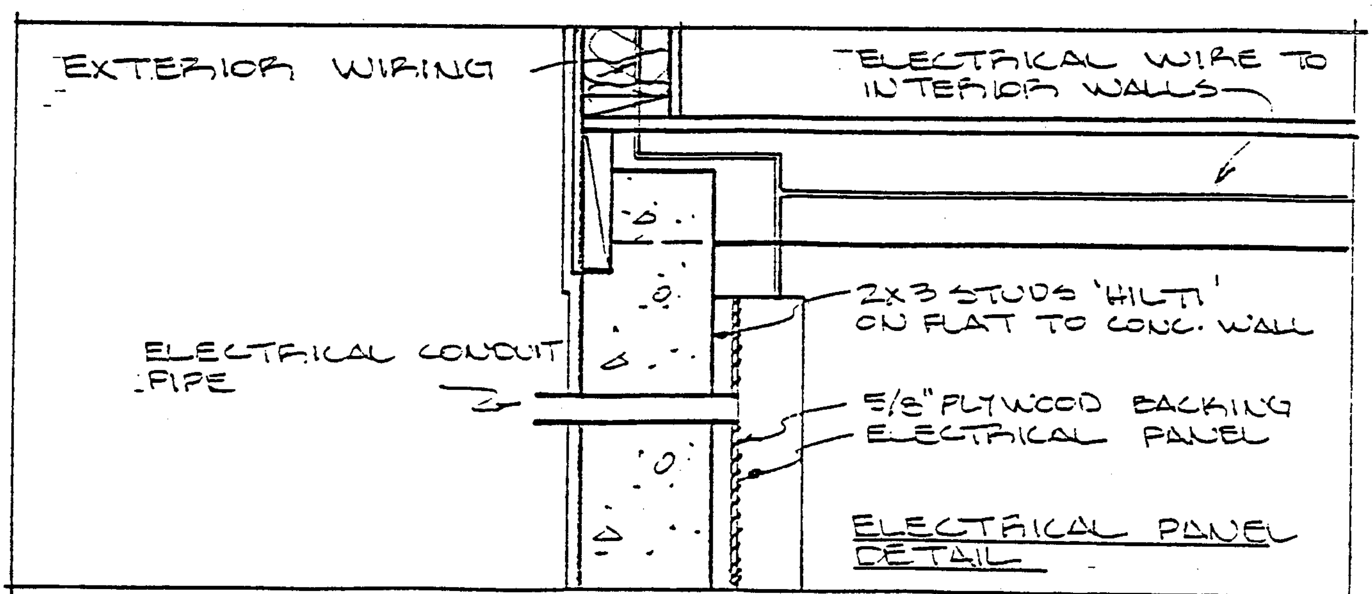


CROSS SECTION HOUSES #9 & #10

FIGURE 11







CONSTRUCTION DETAILS HOUSES #9 & #10

3.4 HOUSES #11 and #12

These two houses were designed using the Fiberglas Canada Inc. Low Energy House System (FCI LEHS). This is basically a simplified version of the ADA system except that the use of gaskets is restricted to a few key locations: electrical outlets on exterior walls and the rough-openings around doors and windows. No polyethylene was used in either house. The FCI LEHS intentionally produces a slightly leakier envelope than standard ADA construction and the house is intended to be operated under a slight negative pressure differential by an exhaust-only heat pump which provides ventilation through envelope leakage.

The main wall construction consisted of 38x140 (2x6) framing with 51 mm (2") exterior insulated sheathing and a taped Tyvek air retarder. Stucco was used on three of the four walls. Basement insulation consisted of 76 mm (3") of exterior rigid glass fibre ("Baseclad"); no interior framing or finishing was applied. The concrete floor slab was cast on top of 38 mm (1 ½") of Glasclad (with the Tyvek removed to accelerate curing of the concrete). Both houses were built to the R-2000 Standard. Construction details are given in Figs. 12 and 13.

GASKET SCHEDULE

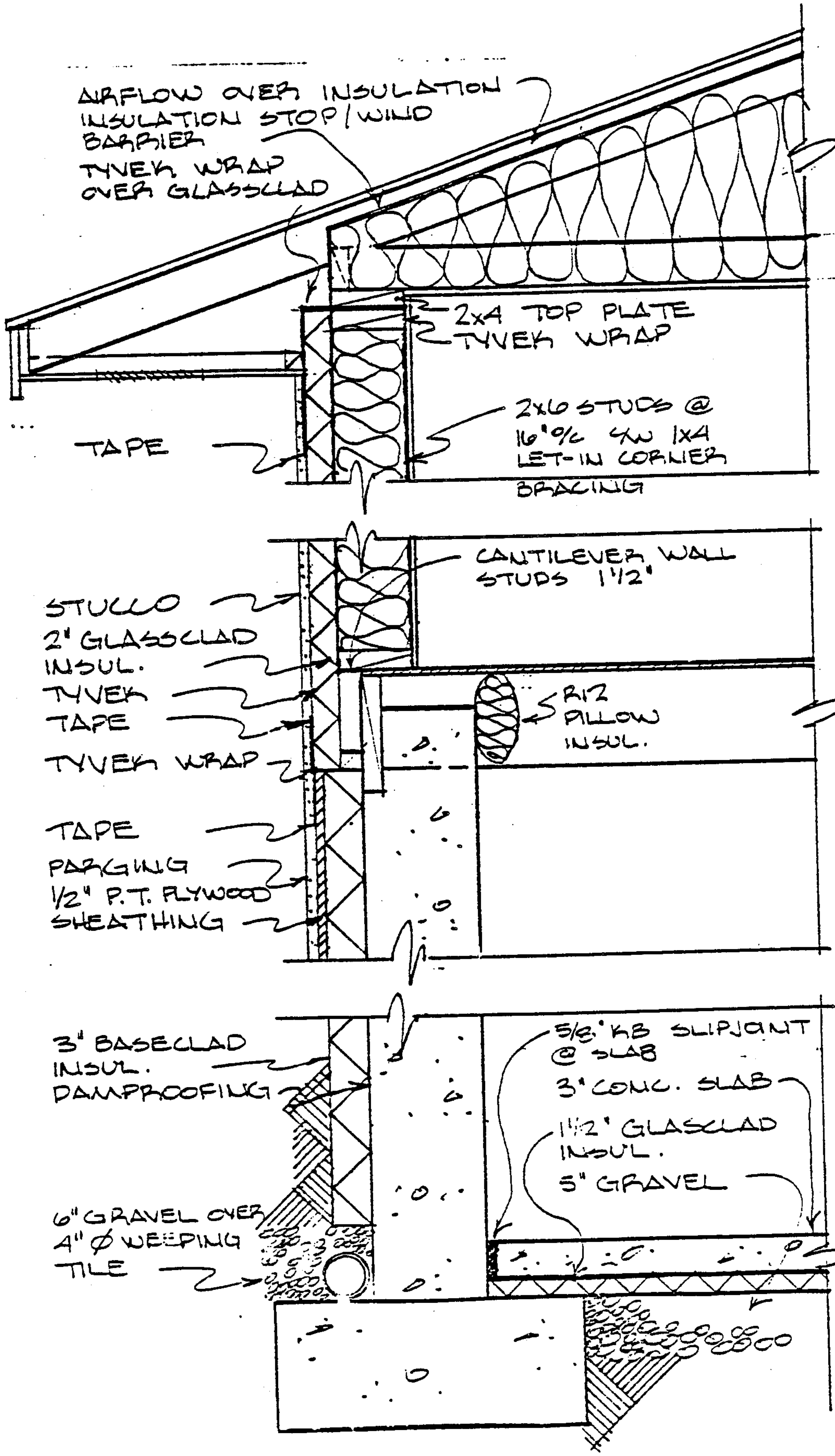
Type 2 - Ethafoam rods of appropriate diameter
Electrical outlets - Poly pan boxes and foam cover gaskets

PAINT SCHEDULE

Walls
- o Latex primer
- o Oil base primer
- o Latex finish coat

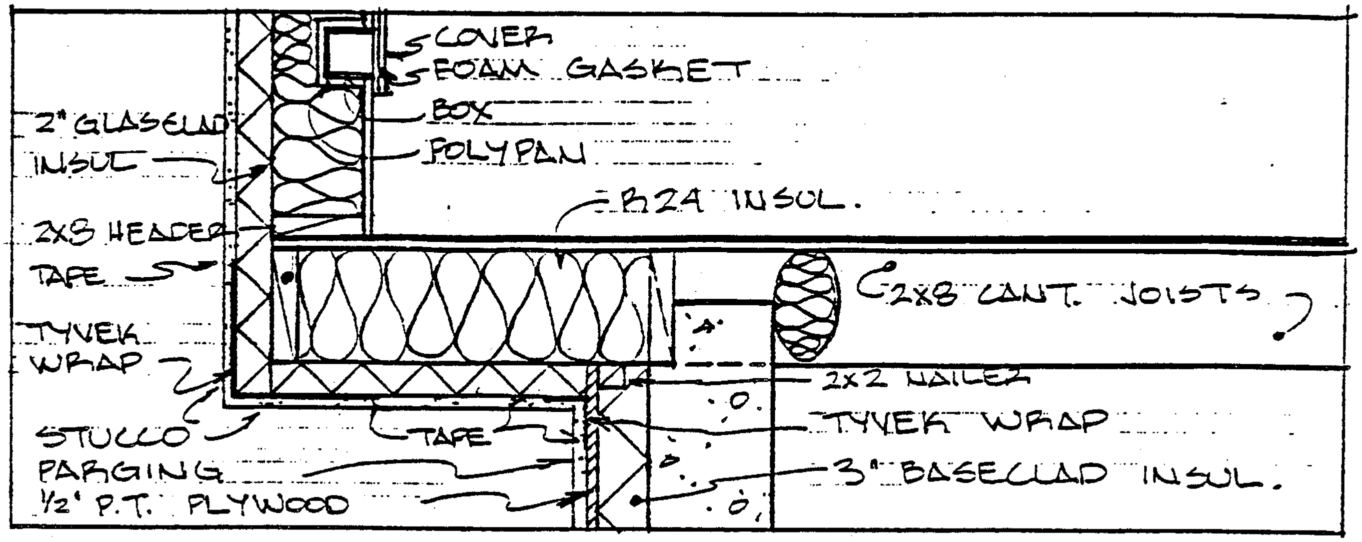
Ceiling
- o Latex primer
- o Oil base primer
- o Texture finish

FIGURE 12

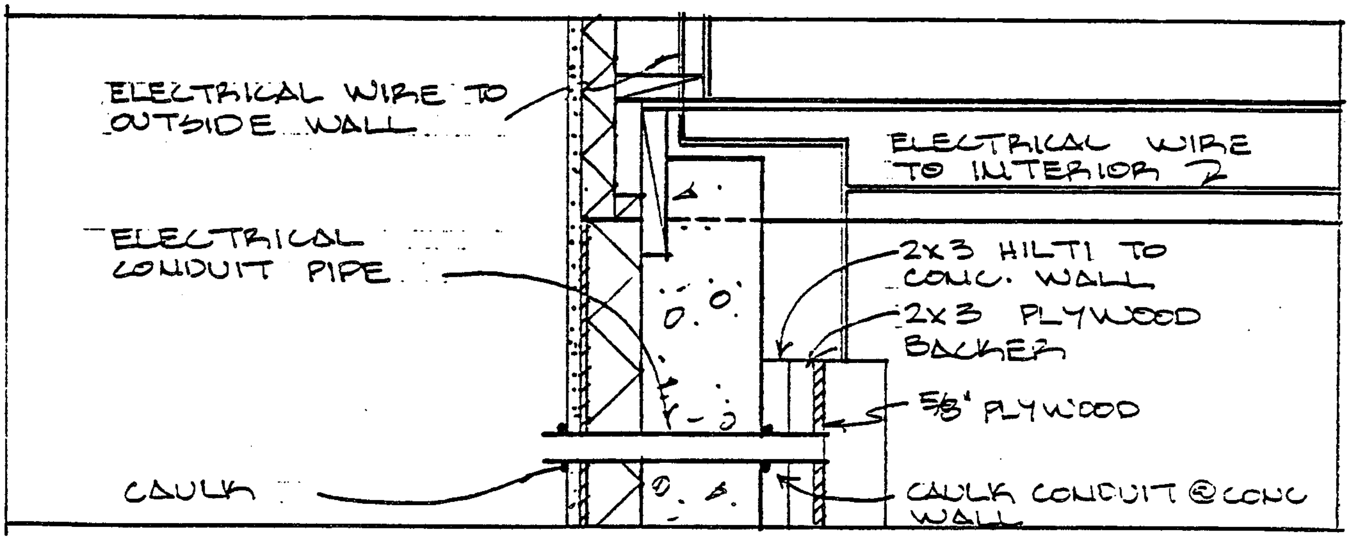


CROSS SECTION HOUSES #11 & #12

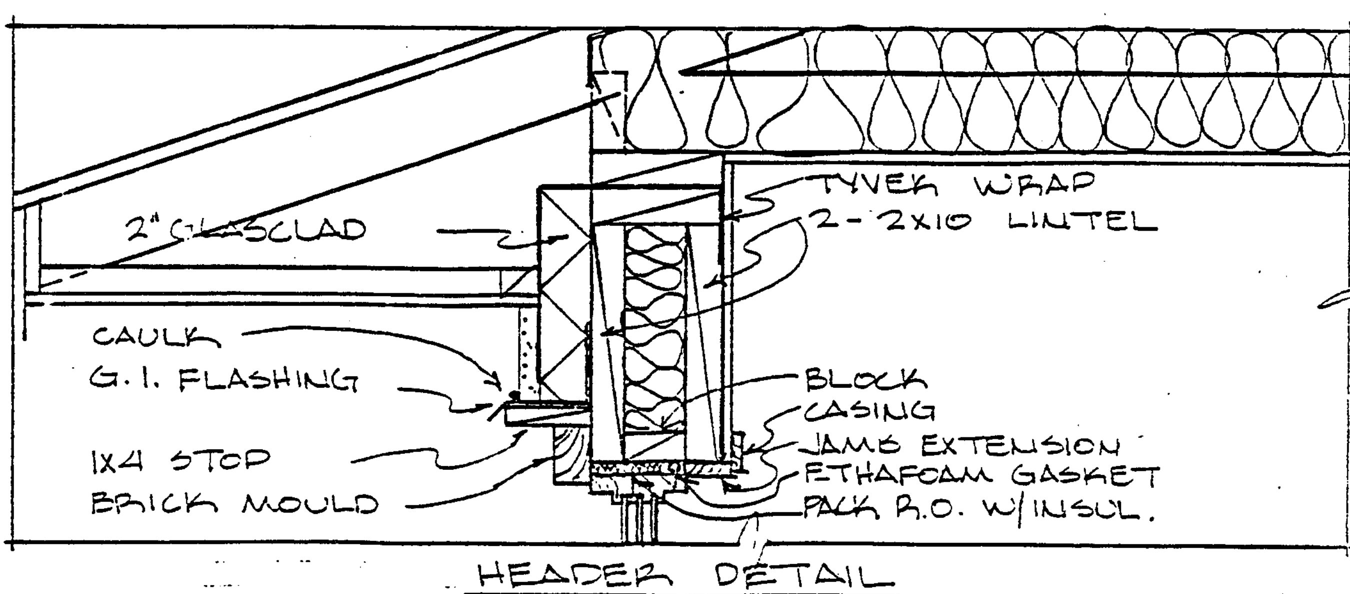
FIGURE 13



CANTILEVER DETAIL



ELECTRICAL PANEL DETAIL



HEADER DETAIL

CONSTRUCTION DETAILS HOUSES #11 & #12

3.5 HOUSES #13 and #14

These were similar to Houses #11 and #12 since they also used the FCI LEH System. The main walls were built using 38x140 (2x6) framing with 51 mm (2") of taped Glasclad insulated sheathing. Gaskets were only used around door and window penetrations and at electrical outlets on exterior walls. Stucco was used on three of the four walls. The basement insulation system more closely resembled conventional practice with interior batt insulation and framing and a polyethylene vapour barrier. No sub-slab insulation was used. Both houses were built to the R-2000 Standard. See Figs. 14 and 15.

<u>GASKET SCHEDULE</u>

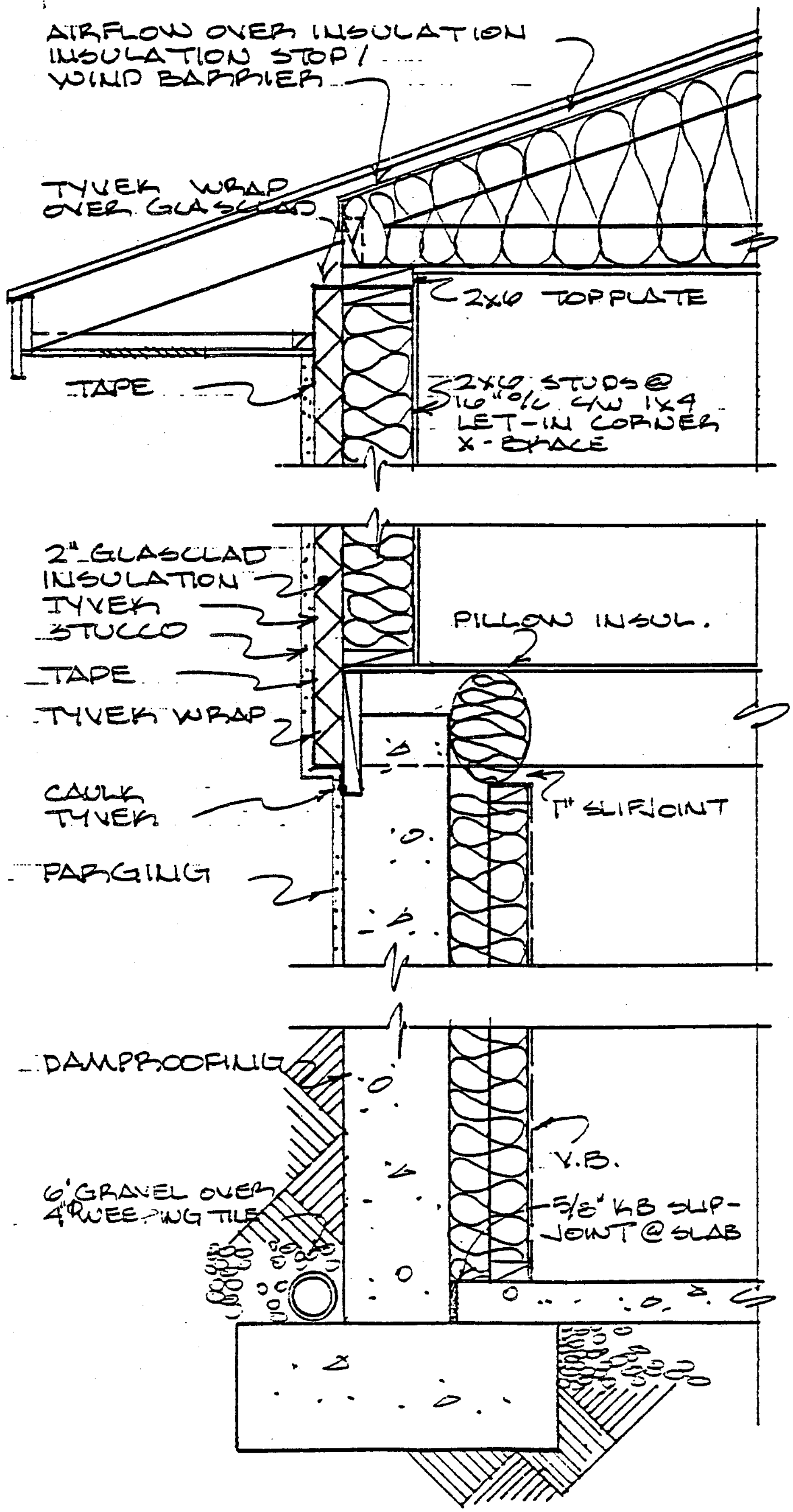
Type 2 - Ethafoam rods of appropriate diameter
Electrical outlets - Poly pan boxes and foam cover gaskets

<u>PAINT SCHEDULE</u>

<u>Walls</u>
o Latex primer
o Oil base primer
o Latex finish coat

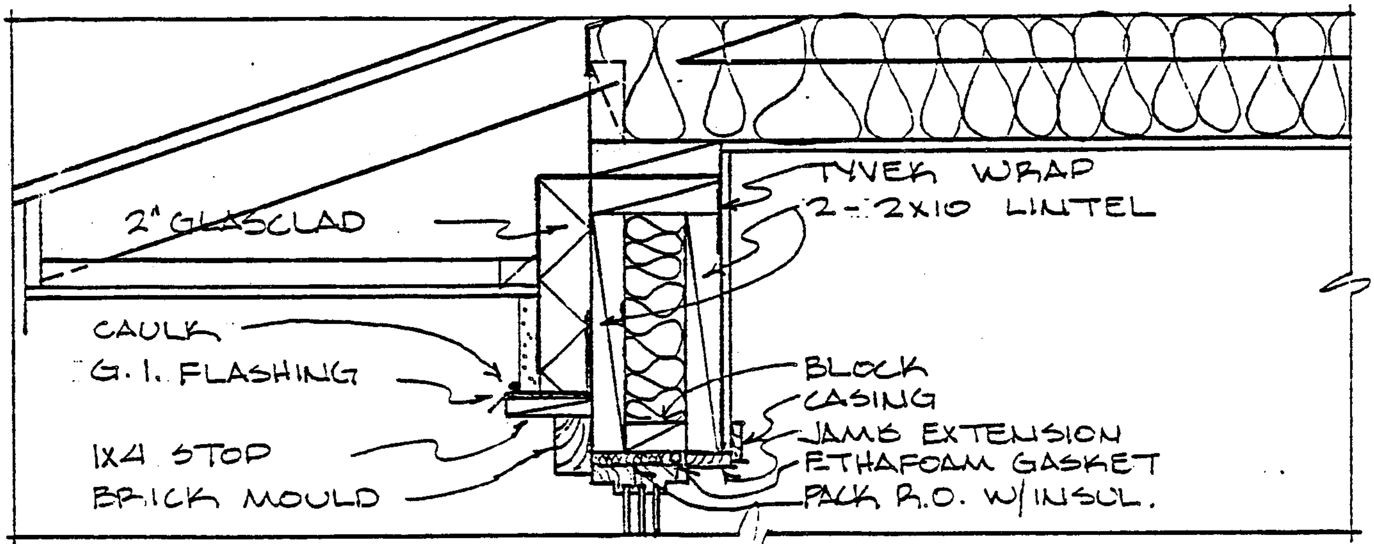
<u>Ceiling</u>
o Latex primer
o Oil base primer
o Texture finish

FIGURE 14

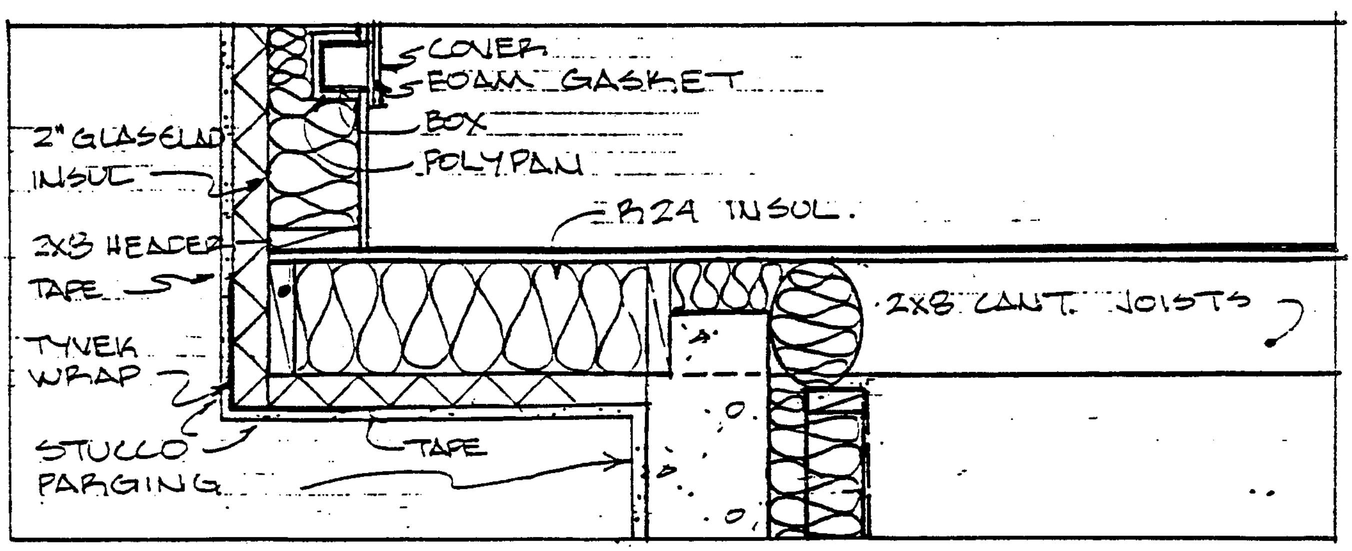


CROSS SECTION HOUSES #13 & #14

FIGURE 15



HEADER DETAIL



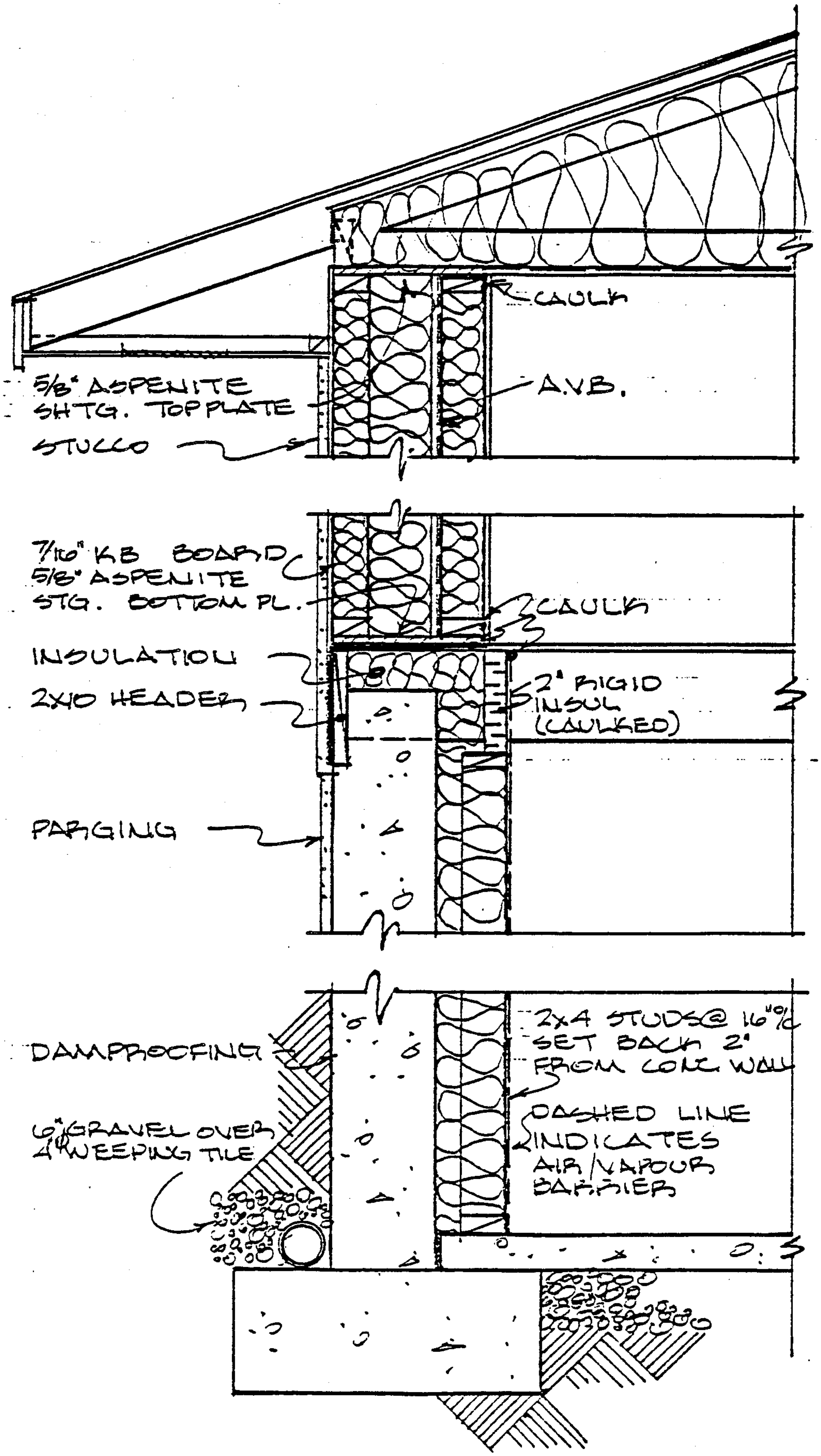
CANTILEVER DETAIL

CONSTRUCTION DETAILS HOUSES #13 & #14

3.6 HOUSES #15 to #18

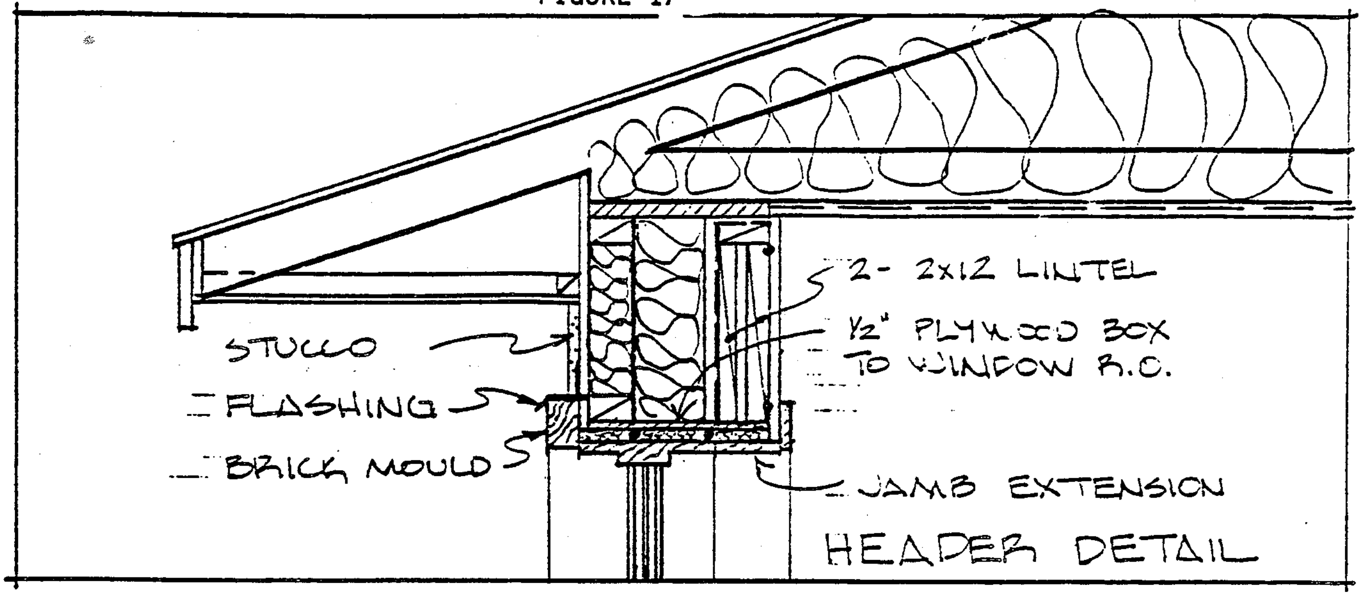
These four houses were built with the double wall system to achieve very high levels of thermal resistance and envelope airtightness. The air/vapour barrier consisted of 6 mil polyethylene located on the exterior of the inner frame wall (to protect it against damage during construction). All joints and penetrations in the polyethylene were caulked with acoustical sealant and stapled in place. Rough-openings around doors and windows were sealed using the "poly-wrap" approach to provide a near-airtight seal. A carefully sealed polyethylene air/vapour barrier was used on the ceiling with the drywall installed prior to the partition walls. Stucco was used on three of the four walls. The basement used interior batt insulation and framing with pieces of extruded polystyrene sealed into the header spaces to maintain the continuity of the air/vapour barrier. A standard 6 mil polyethylene vapour barrier was used for the basement walls. All four houses were designed and built to the R-2000 Standard. Additional details are shown in Figs. 16 and 17.

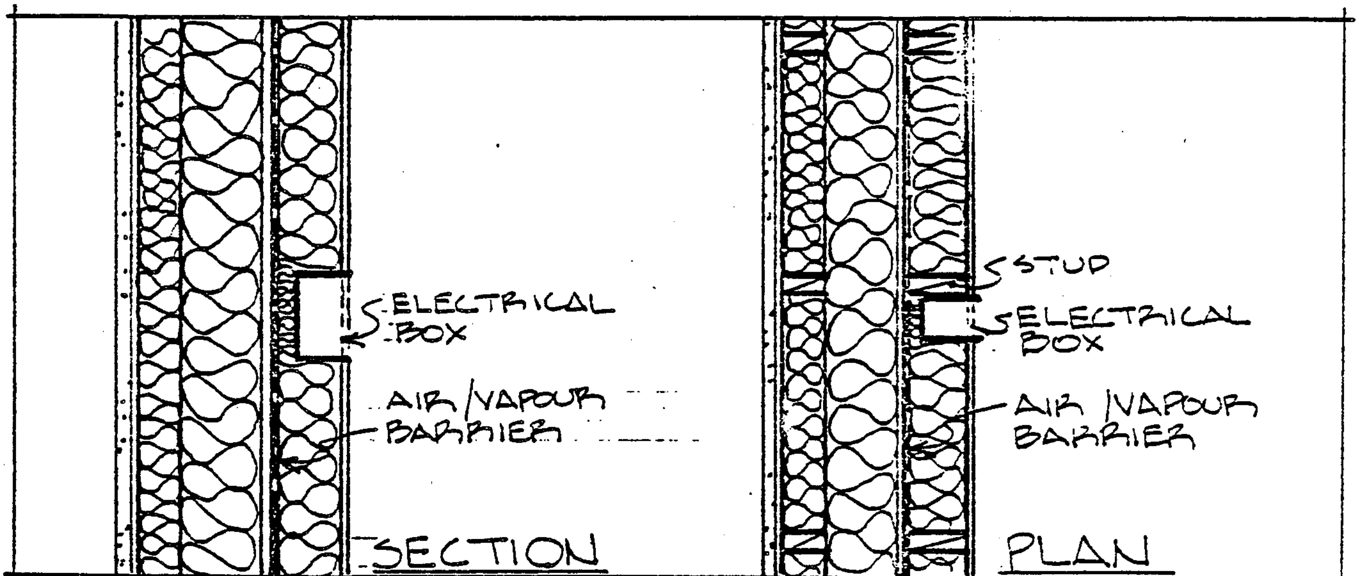
FIGURE 16



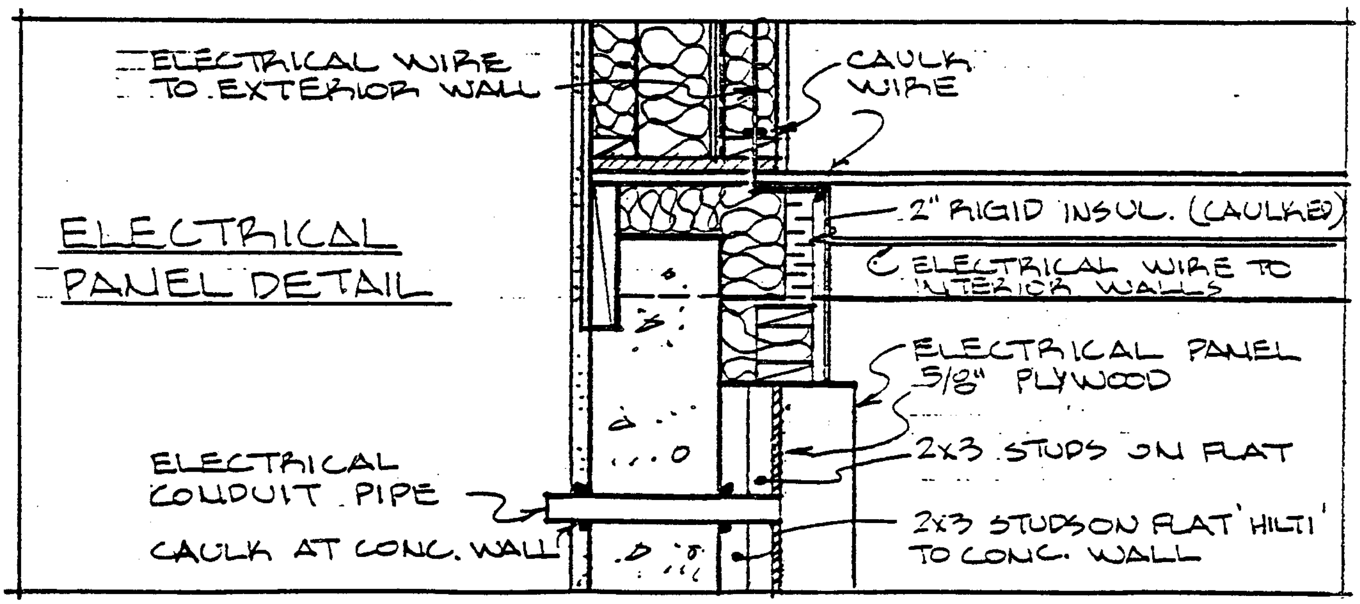
CROSS SECTION HOUSES #15 TO #18

FIGURE 17





ELECTRICAL WALL FIXTURE DETAIL



3.7 HOUSES #19 and #20

Houses #19 and #20 were also built using the ADA system but with different gasket types than used in the other homes. The main wall construction used 38x89 (2x4) framing with 51 mm (2") of extruded polystyrene ("SM") insulated sheathing. Stucco was used on three of the four walls. The basement construction employed both interior and exterior insulation systems. On the exterior, 51 mm (2") of SM was used to form a continuous line with the main wall sheathing while RSI 2.11 (R-12) batt insulation and framing were used on the interior with a conventional polyethylene vapour barrier. Both houses were built to the R-2000 Standard. Further construction details are shown in Figs. 18 and 19.

<u>GASKET SCHEDULE</u>

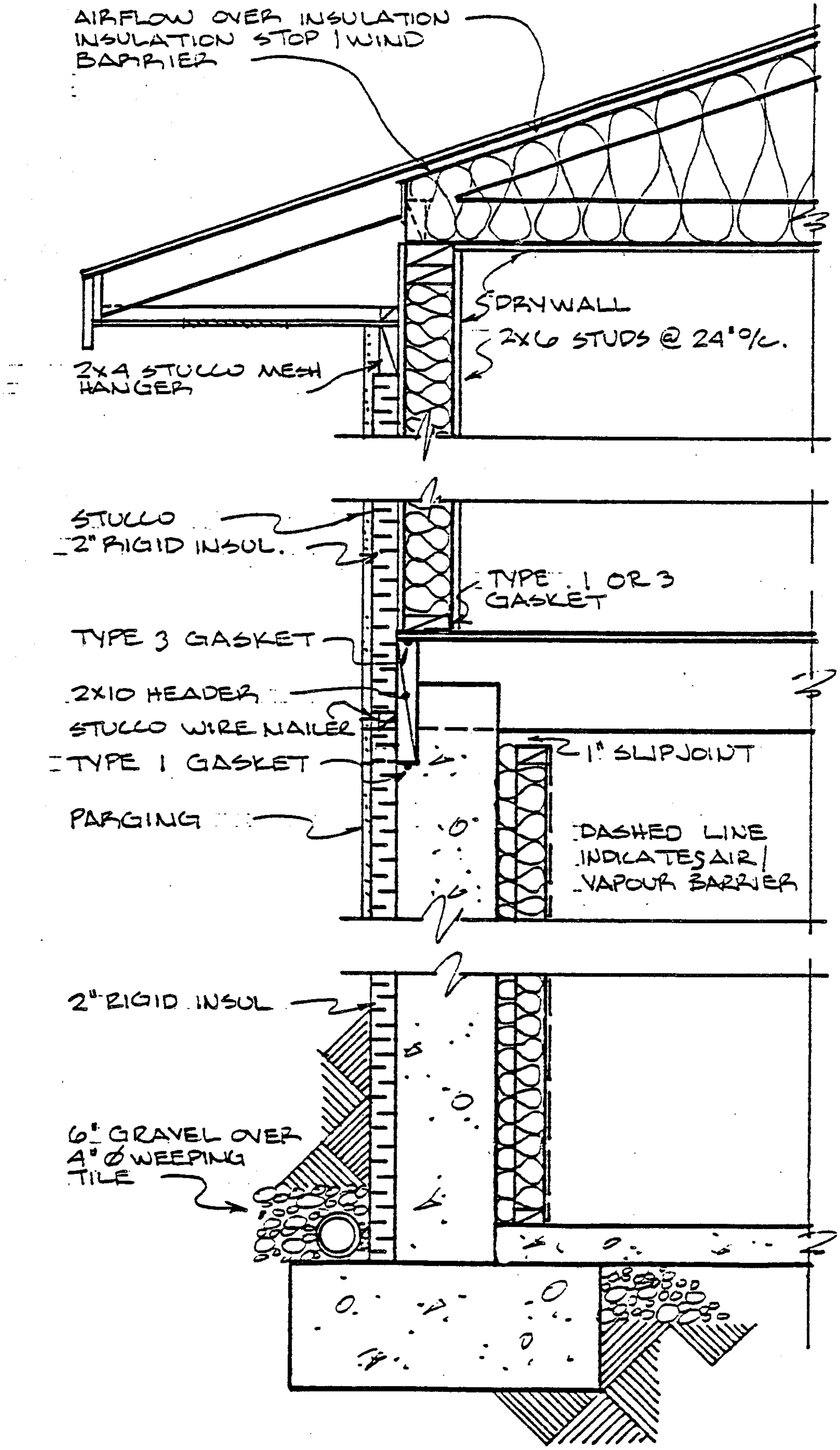
Type 1 - Polyethylene sill plate gaskets
Type 2 - Ethafoam rod of appropriate diameter
Type 3 - Neoprene gaskets with adhesive backing
Electrical outlets - Poly pan boxes and foam cover gaskets

<u>PAINT SCHEDULE</u>

<u>Walls</u>
- o Latex primer
- o Oil base primer
- o Latex finish coat

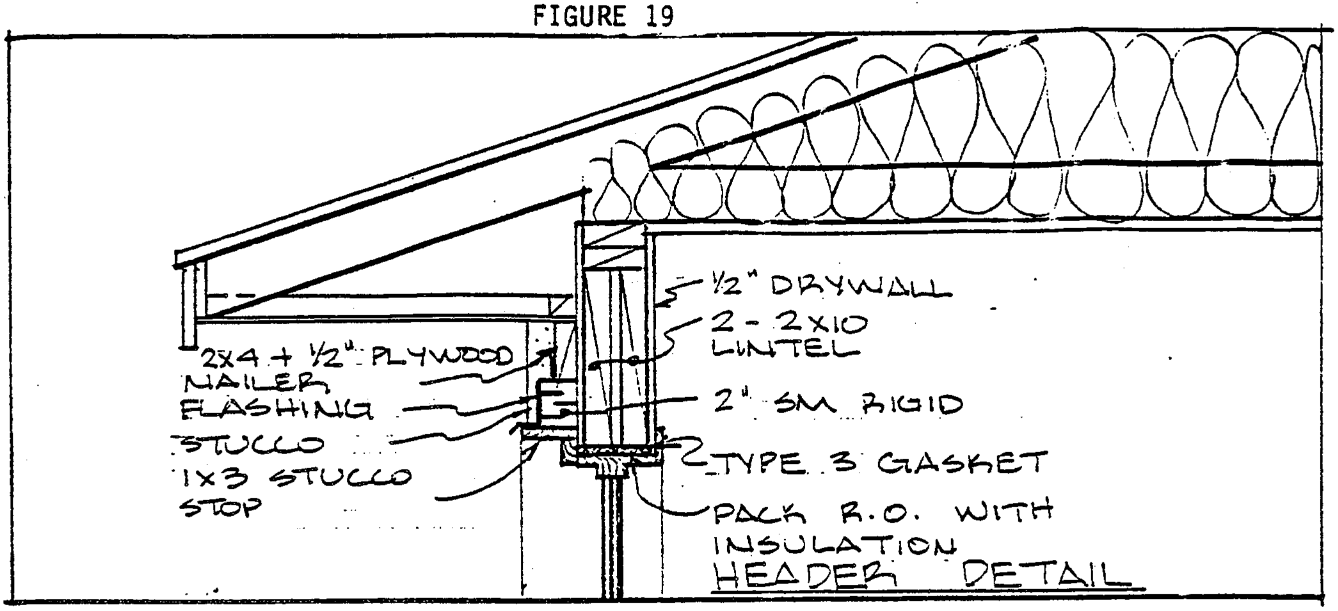
<u>Ceiling</u>
- o Latex primer
- o Oil base primer
- o Texture finish coat

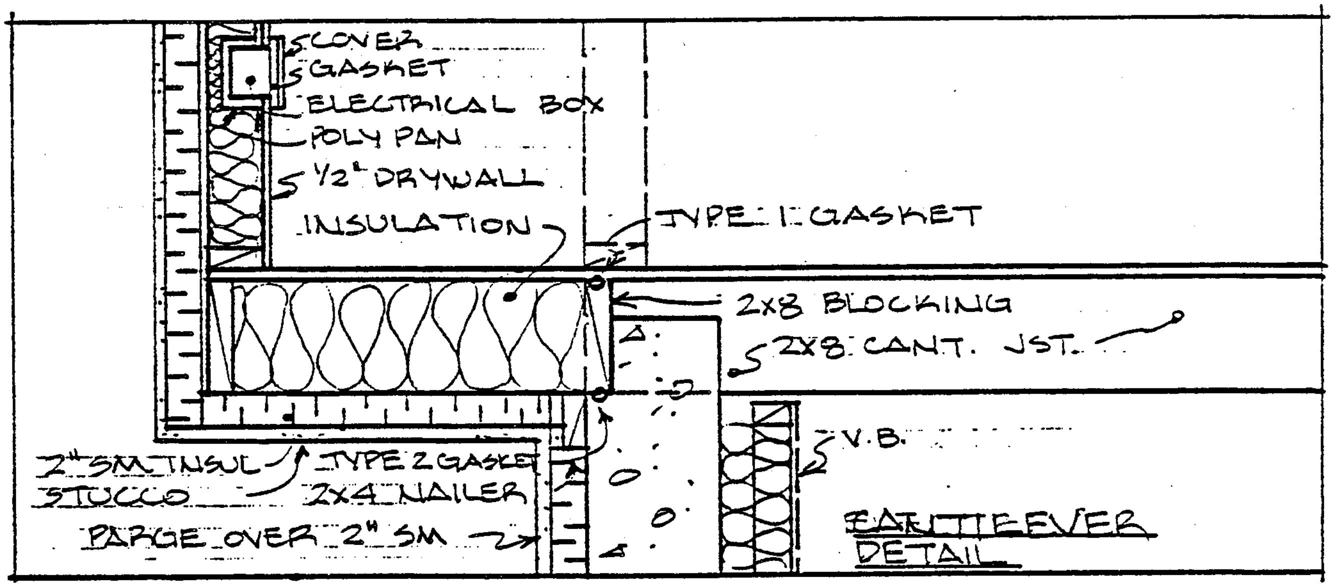
FIGURE 18

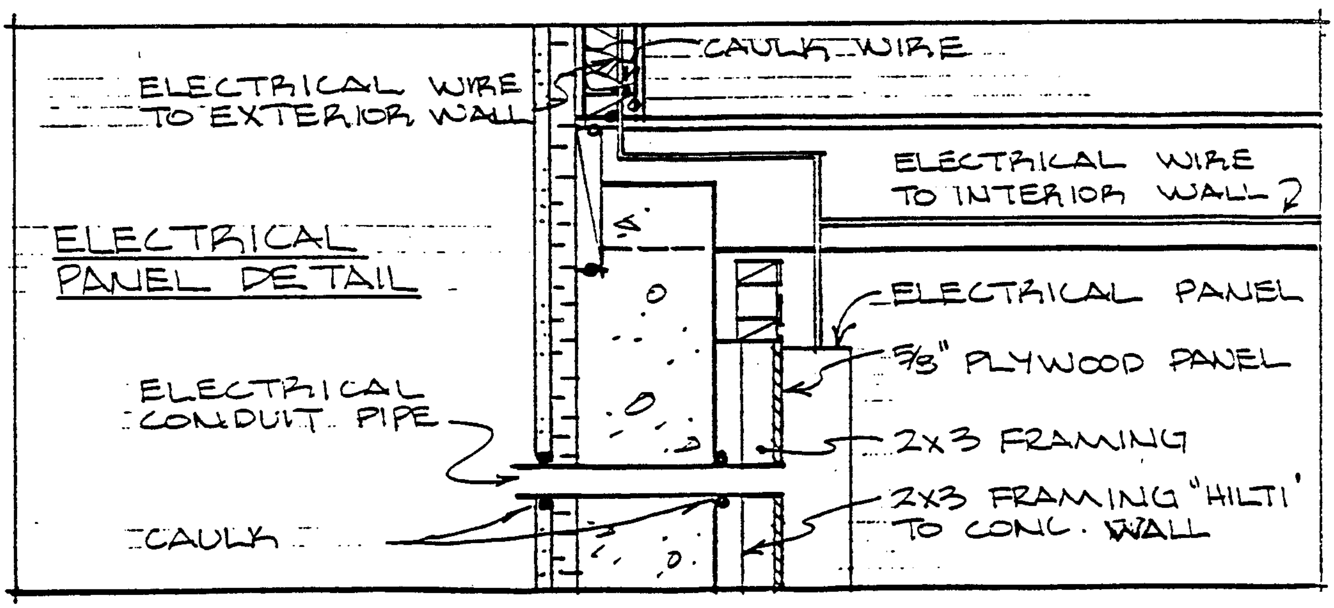


CROSS SECTION HOUSES #19 TO #20

FIGURE 19







CONSTRUCTION DETAILS HOUSES #15 TO #18

3.8 HOUSE #21

House #21 was unique among the project house in that it was designed to serve as an unoccupied research structure. As such, it was built using a variety of air/vapour barrier systems, exterior wall constructions, thermal insulation techniques and window types. The house was not designed to the R-2000 standard. Two air/vapour barrier systems were used: conventional 6 mil polyethylene with carefully sealed joints and penetrations (used on the ceiling and approximately 80% of the exterior wall area) and ADA for the remaining 20% of the wall area. The main walls used 2x6 (38x140) framing with 2x2 (38x38) horizontal interior strapping and 1x4 (19x89) horizontal strapping on the exterior, with the exception of the south walls which used standard 2x6 (38x140) framing. A Tyvek air retarder was used in place of conventional building paper. Vertical vinyl siding was used on three walls and horizontal wood siding on the south side.

A standard truss ceiling was used over the bedrooms, bathroom and the central hallway with the drywall applied prior to installation of the partition walls. A cathedral ceiling was used in the living and dining rooms and the kitchen with the drywall applied after erection of the partition walls.

A 200 mm (8") thick cast-in-place concrete basement was used with interior framing and insulation on the east, south and west walls and exterior Baseclad insulation on the north side. The basement floor was constructed with a polyethylene air barrier underneath the concrete slab to control radon and soil gas entry. A variety of insulation and air/vapour barrier systems were used in the floor header area. Gasket and paint schedules for the ADA portions of the envelope are given below. Further details on the air/vapour barrier system are contained in Figs. 20 to 23.

The window types ranged from conventional triple-glazed, sealed units to state-of-the-art superwindows. In addition, several different methods were used to seal the gaps between the window frames and rough-openings. The window schedule and the sealing techniques used for the window and door rough-openings are shown in Table 3 and Fig. 24.

<u>GASKET SCHEDULE</u>

o Open celled urethane gaskets ("Ultra Seal")

<u>PAINT SCHEDULE</u>

<u>Walls & Ceilings</u>

o Latex primer

FIGURE 20

SECTION HOUSE #21

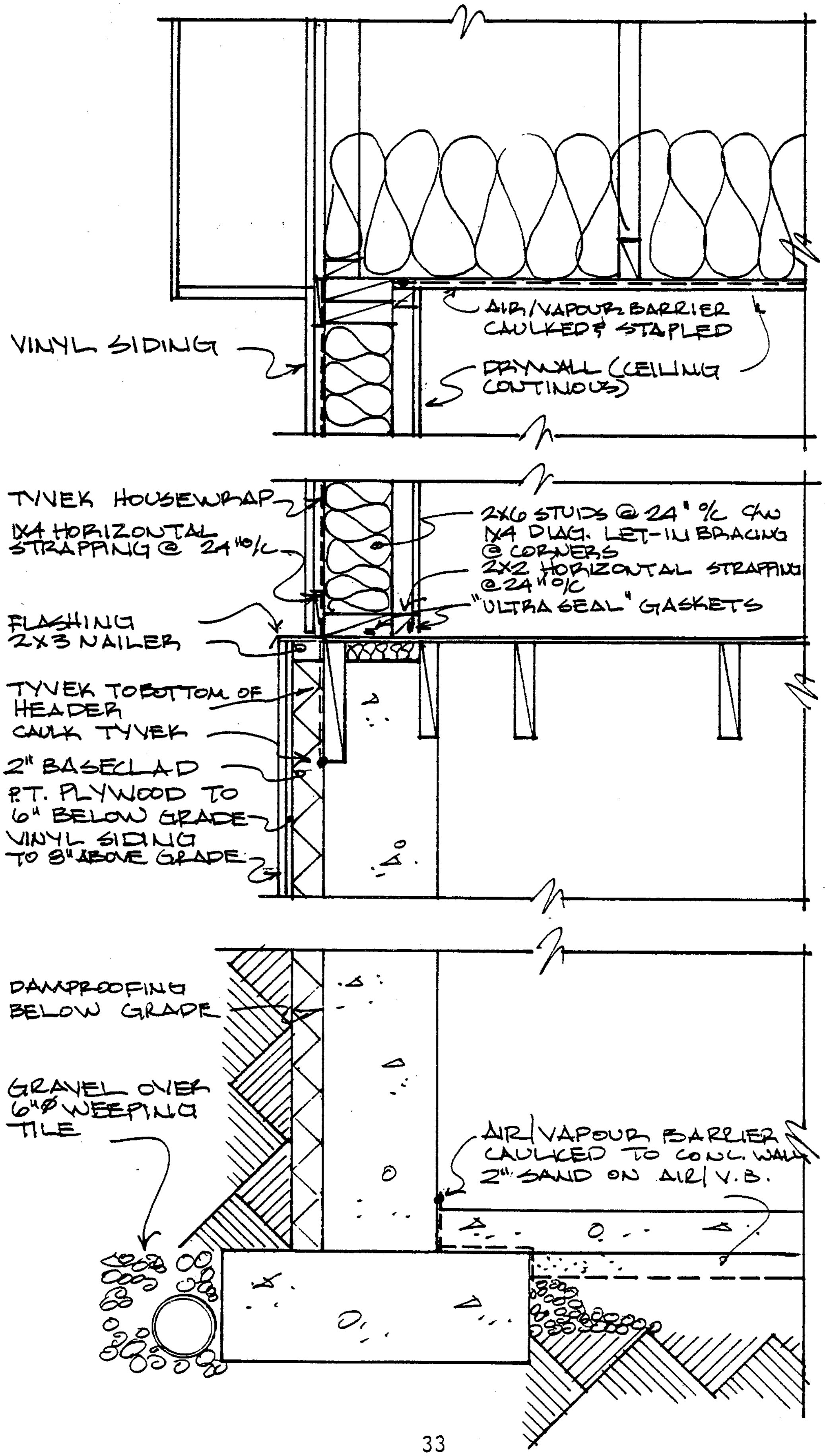


FIGURE 21

SECTION HOUSE #21

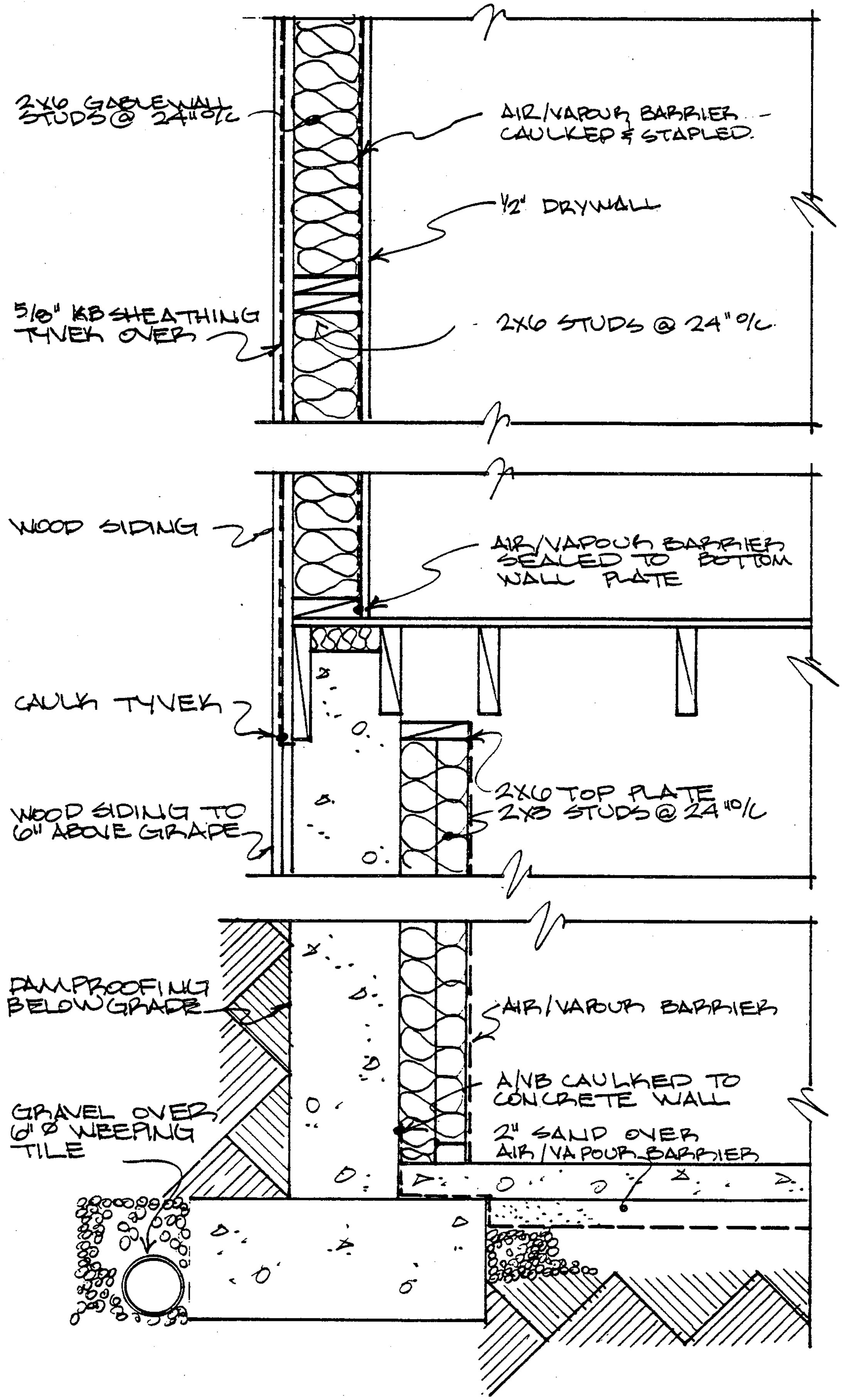


FIGURE 22

SECTION HOUSE #21

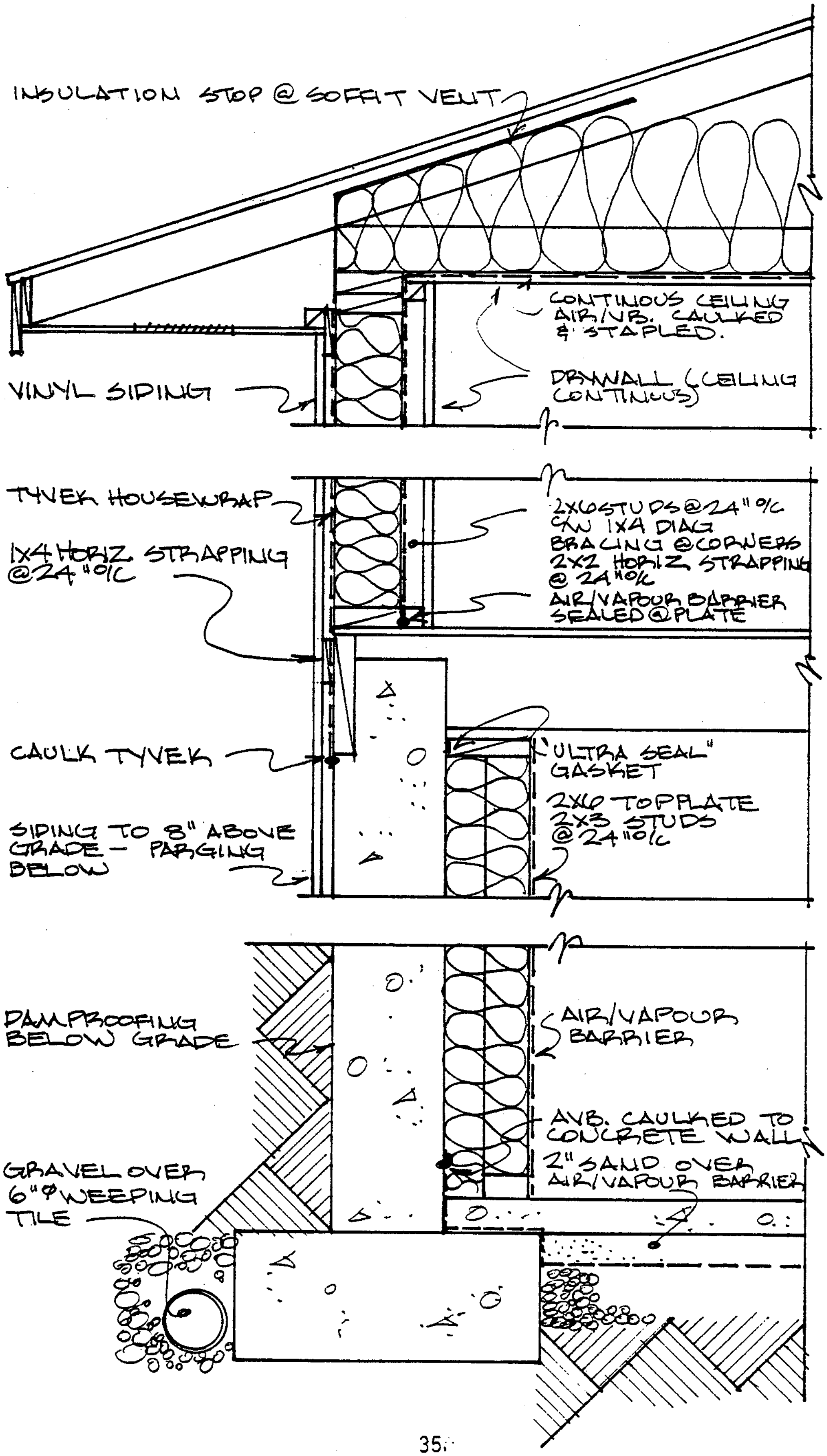
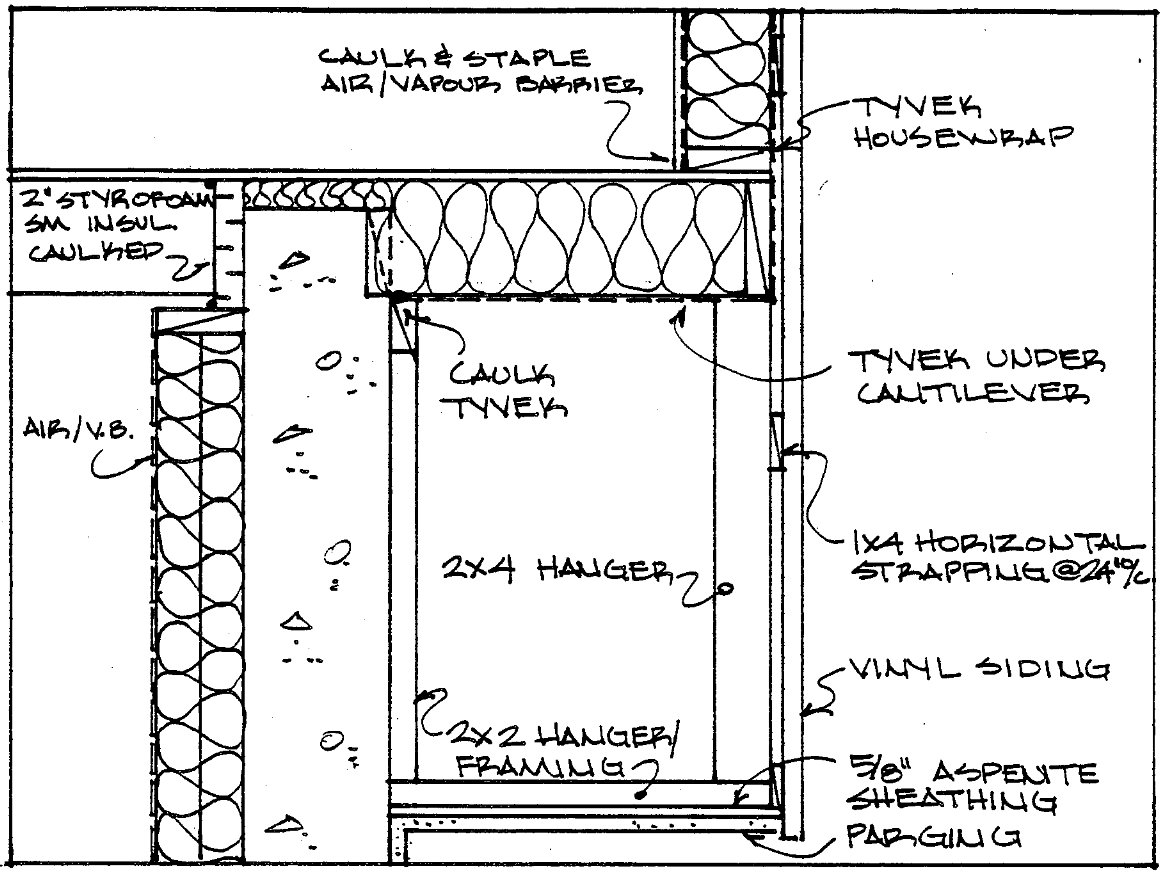
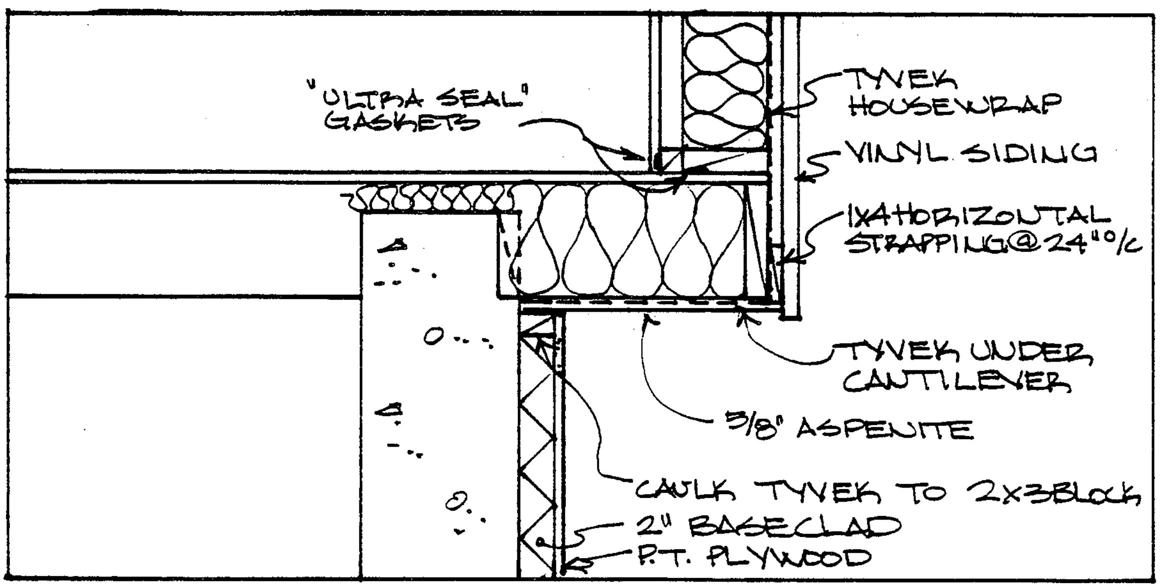
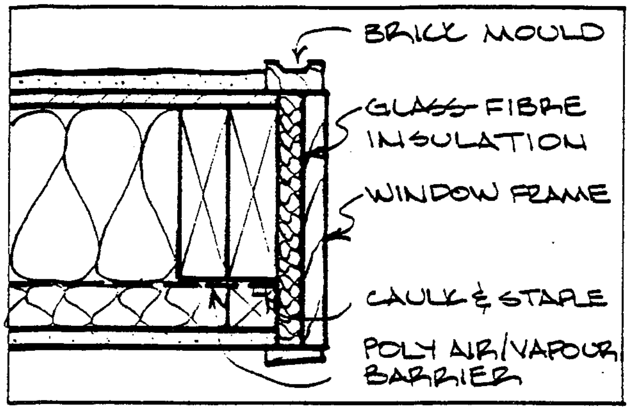


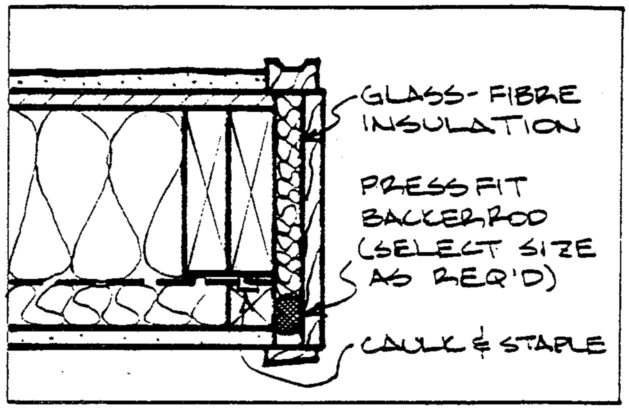
FIGURE 23
CANTILEVER HOUSE #21



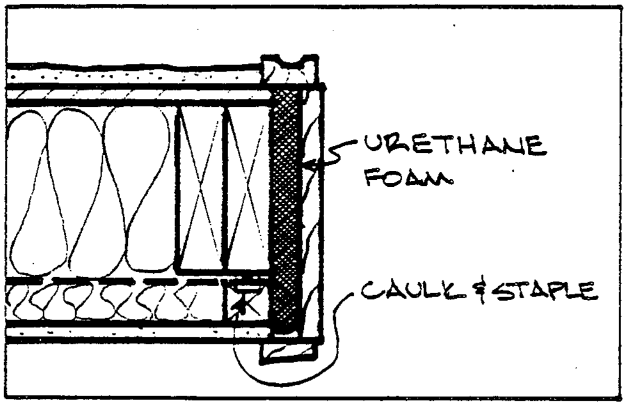




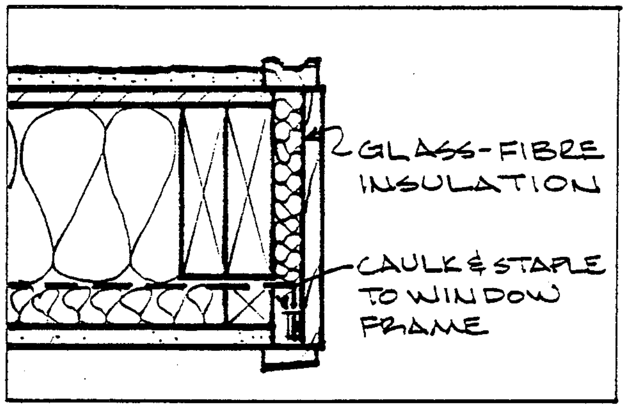
M1- CONVENTIONAL



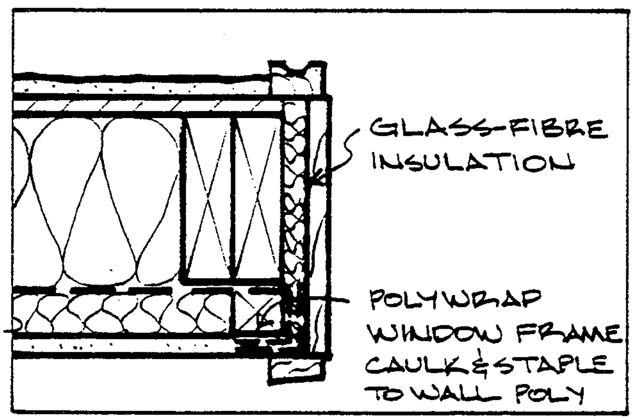
M2 - BACKER ROD



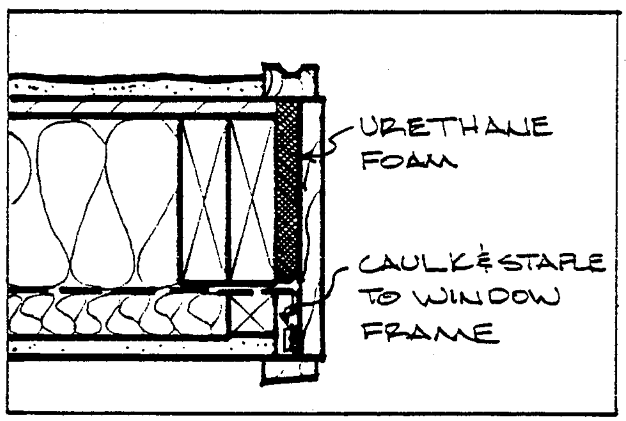
M3-URETHANE FOAM



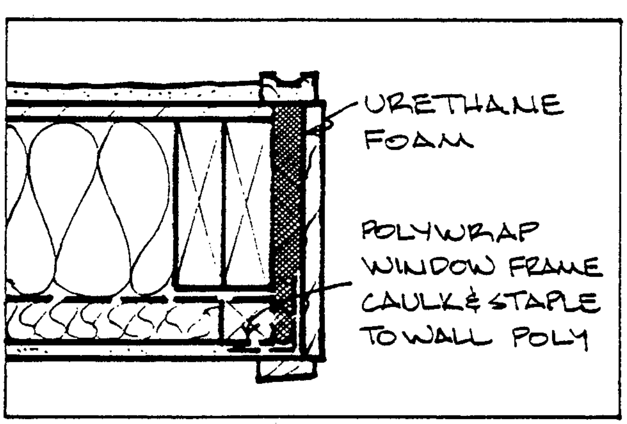
M4- POLY RETURN



M5 - POLY WRAP



M6- POLY RETURN / URETHANE



M7- POLY WRAP / URETHANE

ROUGH-OPENING AIR SEALING METHODS

FIGURE 24

TABLE 3
WINDOW SCHEDULE

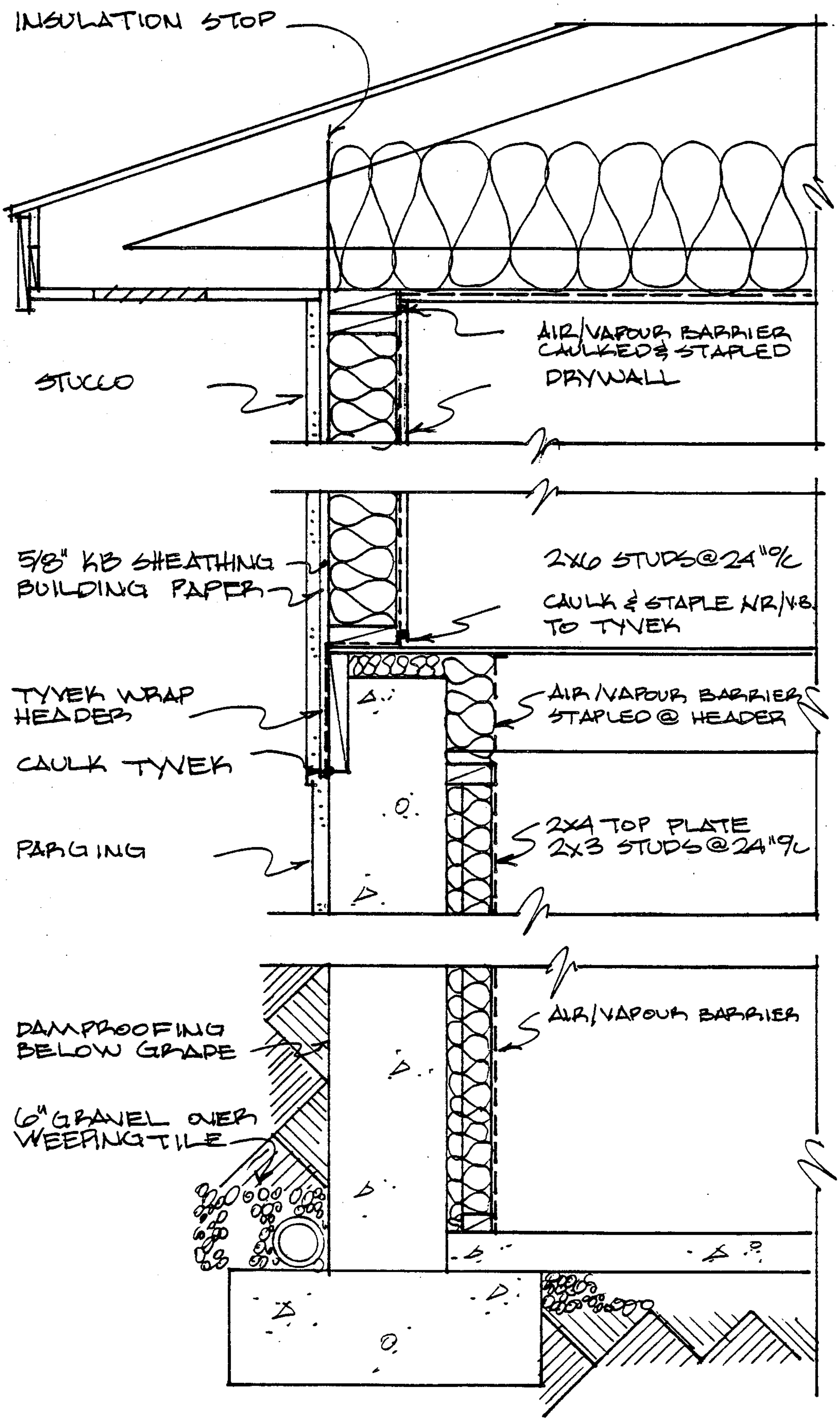
HOUSE NO.	MANUFACTURER	NO. OF GLAZINGS	GLAZING SYSTEM OUTSIDE-TO-INSIDE	SPACER	GAS FILL	FRAME	ROUGH-OPENING SEALING METHOD	NOTES
21	WILLMAR	3	GLASS GLASS GLASS	SWIGGLE	AIR	WOOD	M3	VENTILATOR WINDOW, SUPERWINDOW
	WILLMAR	4	GLASS HEAT MIRROR 88 HEAT MIRROR 88 GLASS	METAL	AIR	WOOD	M5	SUPERWINDOW
	WILLMAR	4	GLASS HEAT MIRROR 66 HEAT MIRROR 66 GLASS	METAL	AIR	WOOD	M1	SUPERWINDOW
	LOEWEN	3	GLASS GLASS/LOW E GLASS/LOW E	SWIGGLE	ARGON	WOOD	M5, NO SEALING	SUPERWINDOW
	LOEWEN	3	GLASS GLASS GLASS	METAL	AIR	WOOD	M1	CONVENTIONAL TRIPLE GLAZING
	TEMPA	3	GLASS GLASS GLASS/LOW E	METAL	AIR	WOOD	M4	ELECTRIC WINDOW, SUPERWINDOW
	PARAMOUNT	3	GLASS GLASS/LOW E GLASS/LOW E	METAL	ARGON	VINYL	M1, M2	SUPERWINDOW
22	WILLMAR	4	GLASS HEAT MIRROR 66 HEAT MIRROR 66 GLASS	METAL	AIR	WOOD	M1, M5	SUPERWINDOW
	LOEWEN	3	GLASS GLASS GLASS	METAL	AIR	WOOD	M5	CONVENTIONAL TRIPLE GLAZING
23	LOEWEN	3	GLASS GLASS/LOW E GLASS/LOW E	METAL	ARGON	WOOD	M1, M2, M3, M4, M5	SUPERWINDOW
	LOEWEN	3	GLASS GLASS GLASS	METAL	AIR	WOOD	M1, M2, M7	CONVENTIONAL TRIPLE GLAZING
24	PARAMOUNT	3	GLASS GLASS/LOW E GLASS/LOW E	METAL	ARGON	VINYL	M1, M3, M5	SUPERWINDOW
	WILLMAR	4	GLASS HEAT MIRROR 66 HEAT MIRROR 66 GLASS	METAL	ARGON	WOOD	M2, M4, M5	SUPERWINDOW

3.9 HOUSE #22

House #22 used a conventional 2x6 (38x140) frame wall and a 6 mil polyethylene air/vapour barrier, carefully sealed at all joints and penetrations. Two significant departures from standard practice included the use of a Tyvek header wrap to control floor system leakage and the use of gaskets at the top of the partition walls to minimize leakage into the attic. Stucco was the main exterior surface system. Ceiling construction was conventional. The basement consisted of a 200 mm (8") cast-in-place concrete wall with a 100 mm (4") floor slab with batt insulation and interior framing. The house was not designed to the R-2000 Standard. Additional construction details are given in Fig.25. Several types of windows, doors and rough-opening sealing techniques were used, as summarized in Table 3 and Fig. 24.

FIGURE 25

SECTION HOUSE #22

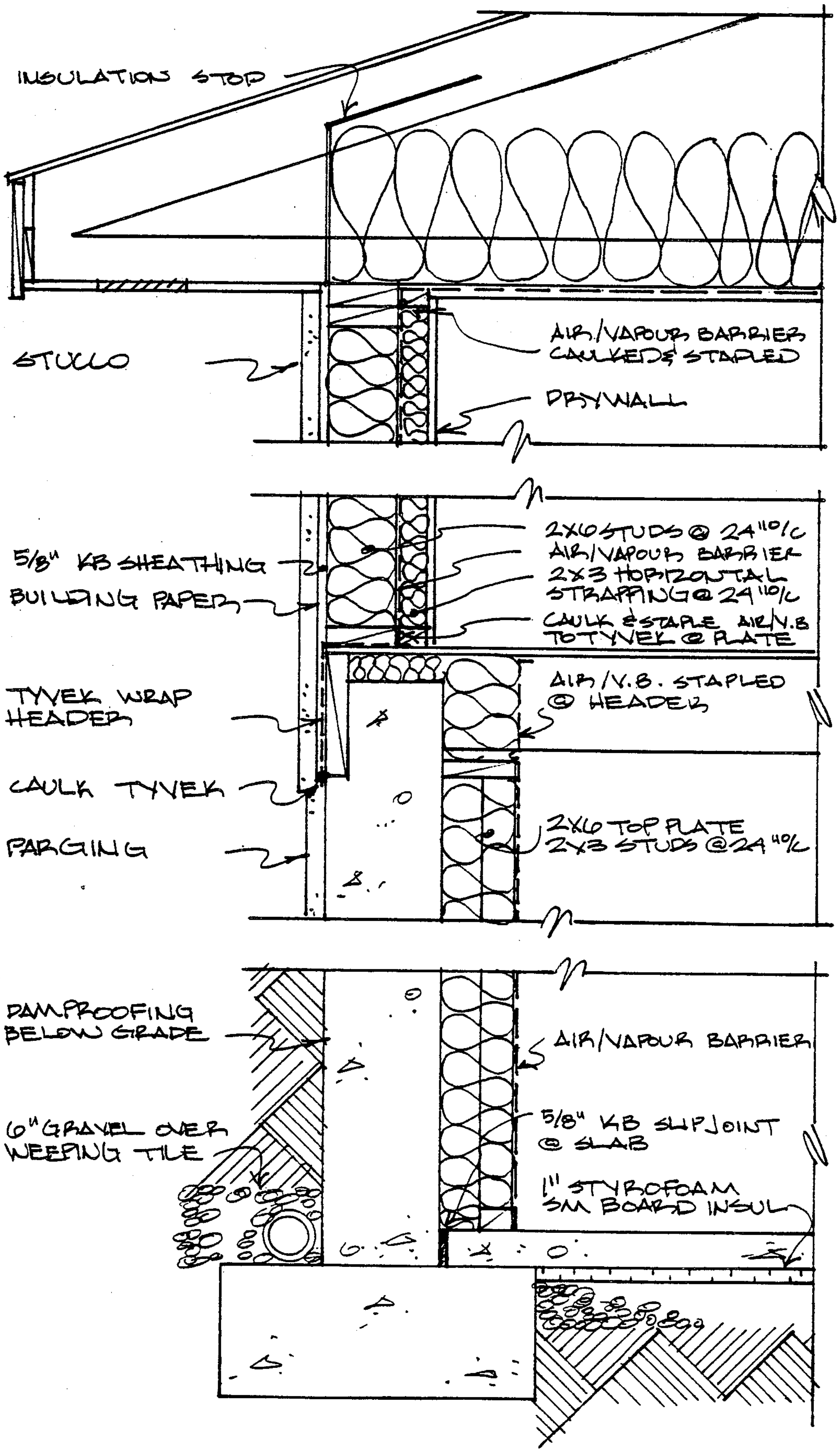


3.10 HOUSE #23

House #23 used a standard 2x6 (38x140) frame wall with 2x2 (38x38) interior horizontal strapping. A carefully sealed 6 mil polyethylene air/vapour barrier was used throughout and a Tyvek header wrap was installed around the floor system and underneath the cantilevers. Stucco was used on three of the main walls with wood siding on the south side. Basement construction was relatively conventional, a 200 mm (8") cast-in-place concrete wall and 100 mm (4") floor slab with interior insulation and framing on the walls; one exception was that 25 mm (1") of SM rigid insulation was used beneath the floor slab. Another departure from conventional practice was the use of crack initiators and control joints cast into the floor slab and basement walls. The house was designed to the R-2000 Standard. Additional construction details are given in Fig. 26. Two types of windows were used with six methods of sealing the rough-openings as summarized in Table 3 and Fig. 24.

FIGURE 26

SECTION HOUSE #23



3.11 HOUSE #24

House #24 used a 2x6 (38x140) frame wall with 38 mm (1½") of Glasclad exterior insulated sheathing. Stucco was used on three walls with brick and wood siding on the south side. The air/vapour barrier was similar to that used in House #23, consisting of 6 mil polyethylene for most areas with a Tyvek header wrap around the floor system and cantilevers; however gaskets were used at the top of the partition walls to control air leakage. Basement construction was also similar to House #23: a 200 mm (8") cast-in-place concrete wall and 100 mm (4") floor slab. However, a layer of 38 mm (1½") Glasclad was used below the floor slab with the Tyvek removed to aid concrete curing. The house was built to the R-2000 Standard. Further construction details are provided in Figs. 27 and 28. Two types of windows were used with five methods of sealing the rough-openings as shown in Table 3 and Fig. 24.

FIGURE 27

SECTION HOUSE #24

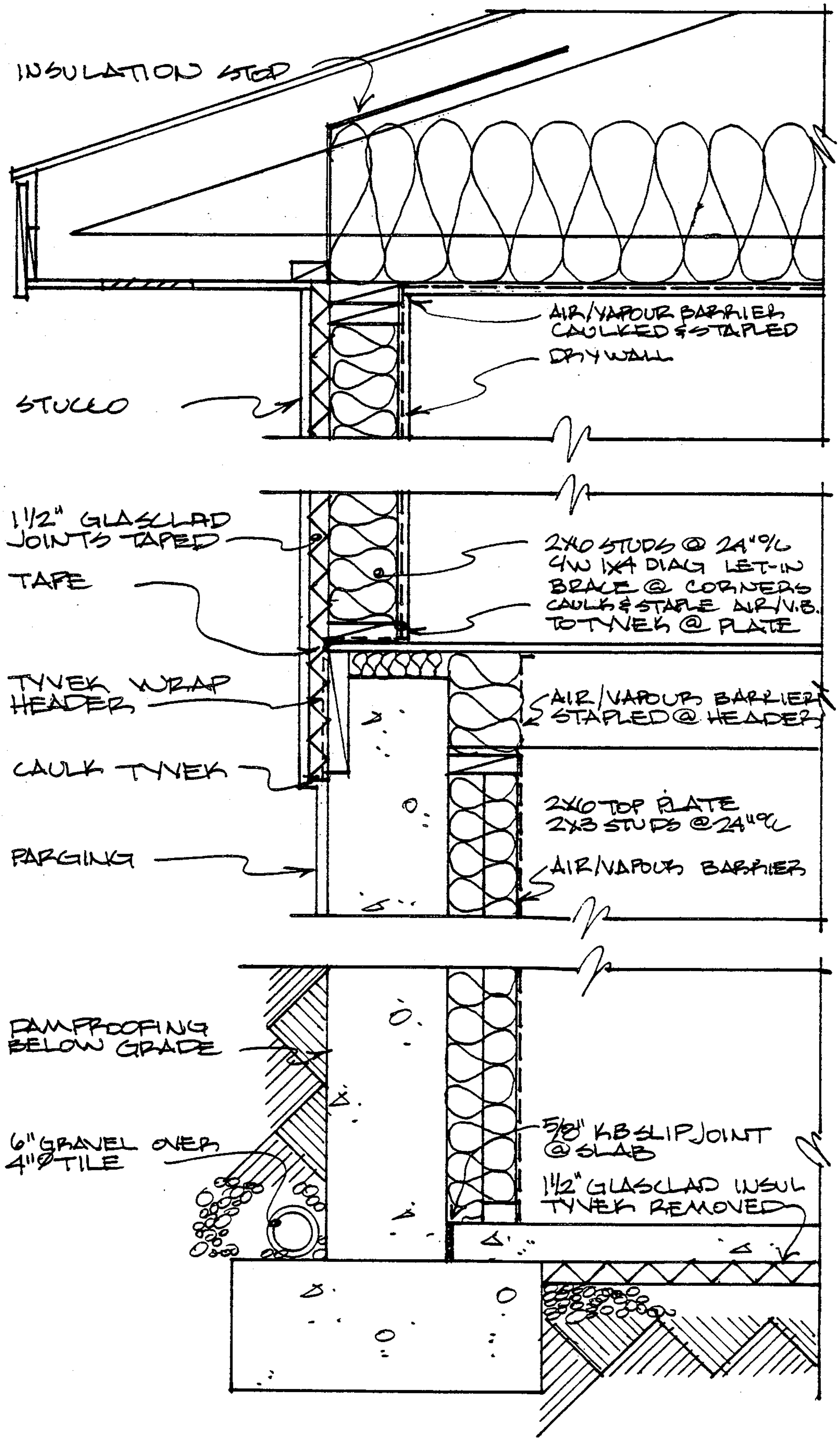
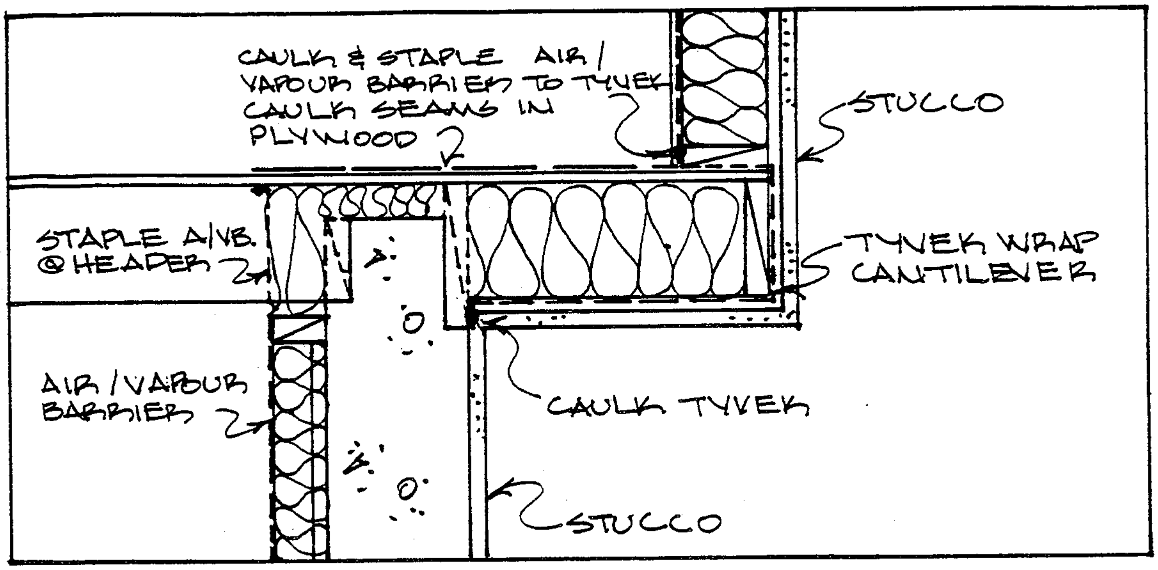
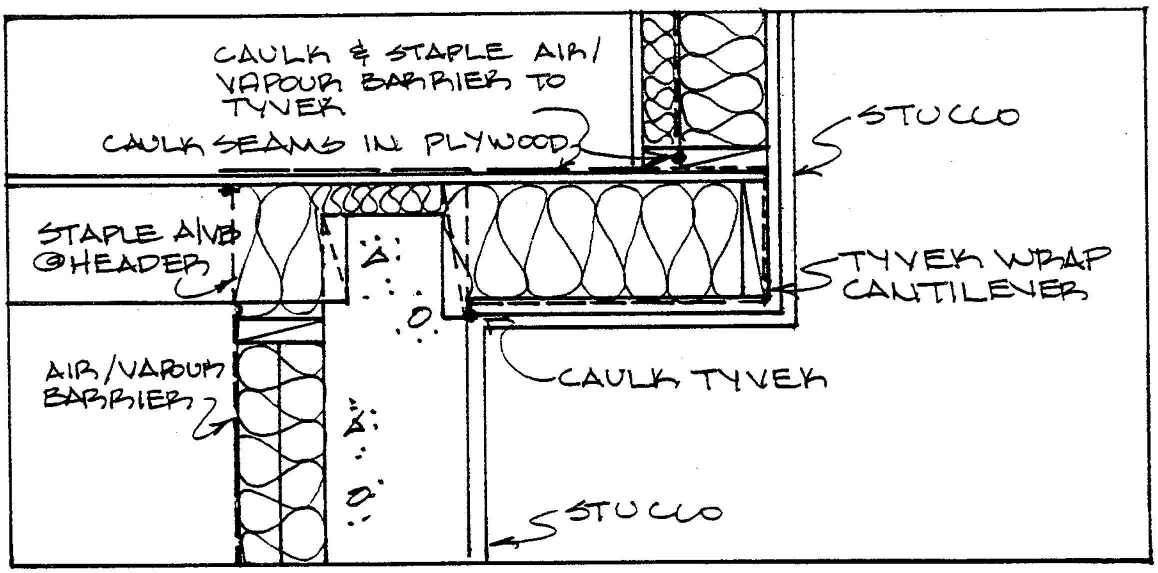


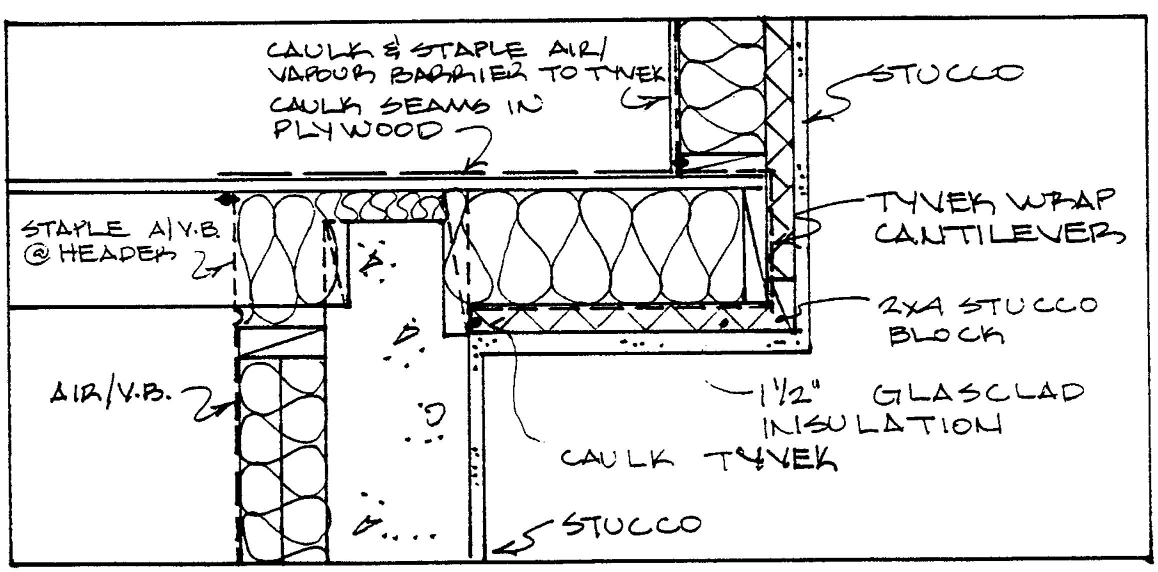
FIGURE 28



HOUSE #22



HOUSE #23



HOUSE #24

CANTILEVER DETAILS

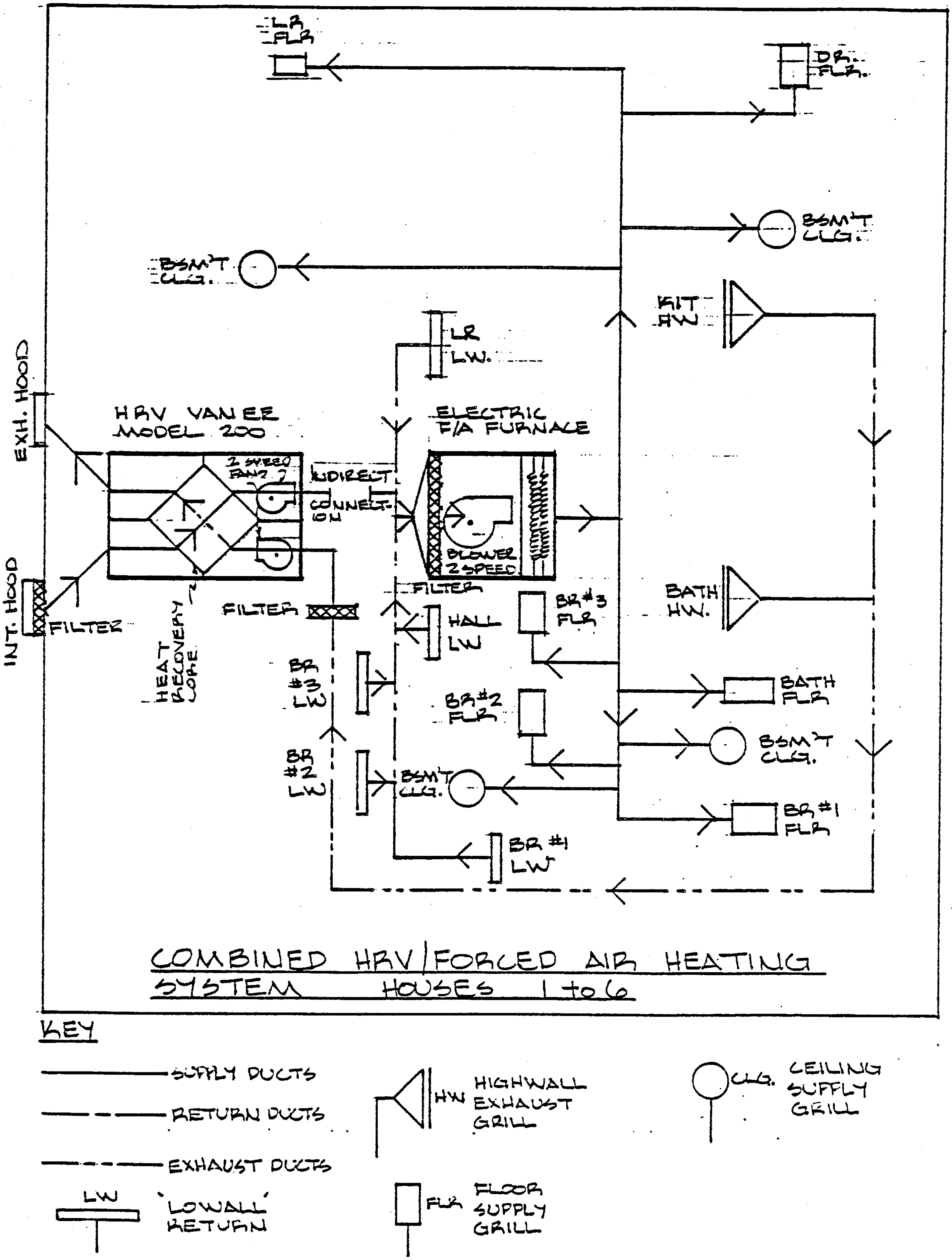
SECTION 4

MECHANICAL SYSTEMS

4.1 HOUSES #1 to #6

The heating system in these six houses consisted of a standard 10 kW forced air electric furnace with floor-mounted supply and return air registers in each room. A two-speed furnace blower distributed the ventilation air and provided a more uniform temperature distribution. The hot water heating system used a standard 182 l (40 I.G.) electric DHW tank. The ventilation system used a CES Inc. Van EE 200 Heat Recovery Ventilator (HRV) with exhaust grilles located in the bathroom, kitchen and laundry areas. Supply air was delivered to the furnace return air plenum through an indirect connection. The HRV provided both low and high speed operation for continuous and peak ventilation capacities respectively. The ventilation system was normally operated in a balanced state with control provided by a dehumidistat located in the hallway with manual override switches in the bathrooms and kitchens. The HRV was a first-generation unit. A mechanical system schematic is shown in Fig. 29.

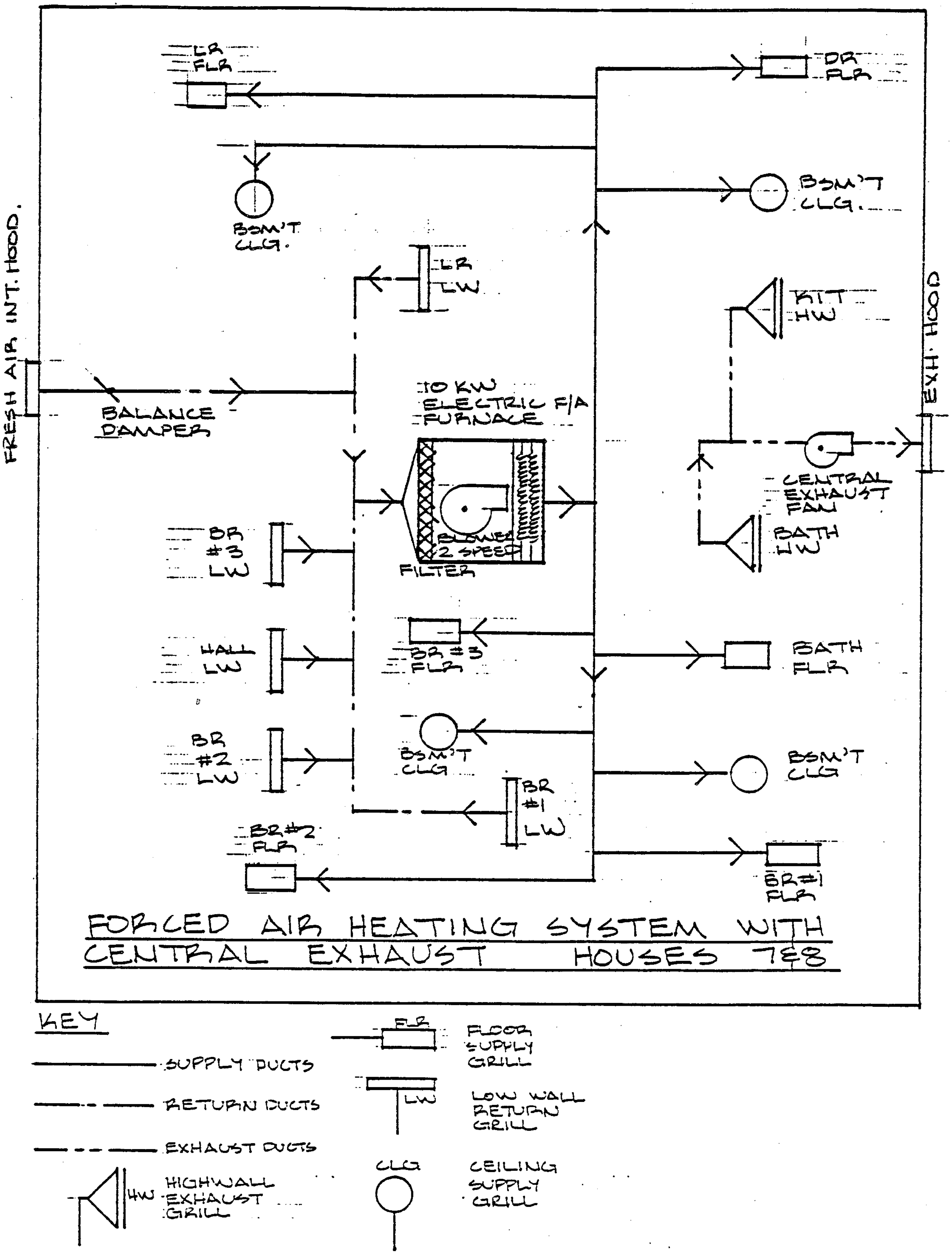
FIGURE 29


LR FLR
DR. FLR.
BSM'T CLG.
BSM'T CLG.
KIT HW
LR LW.
EXH. HOOD
HRV VAN EE MODEL 200
ELECTRIC F/A FURNACE
2 SPEED FAN
INDIRECT CONNECTION
BLOWER 2 SPEED
FILTER
INT. HOOD
FILTER
HEAT RECOVERY CORE
FILTER
HALL LW
BR #3 FLR
BATH HW.
BR #3 LW
BATH FLR
BR #2 FLR
BR #2 LW
BSM'T CLG.
BSM'T CLG.
BR #1 FLR
BR #1 LW
COMBINED HRV/FORCED AIR HEATING SYSTEM HOUSES 1 to 6
KEY
SUPPLY DUCTS
RETURN DUCTS
EXHAUST DUCTS
LW 'LOWALL' RETURN
HW HIGHWALL EXHAUST GRILL
FLR FLOOR SUPPLY GRILL
CLG. CEILING SUPPLY GRILL

4.2 HOUSES #7 and #8

The heating system in these two houses also used a 10 kW electric furnace with floor-mounted supply and return air registers located in each room and a two-speed blower to provide air circulation. Hot water heating was supplied by a conventional 182 l (40 I.G.) electric DHW tank. The ventilation system consisted of a central exhaust blower, controlled by a centrally located dehumidistat and manually activated switches, drawing air from the bathroom and kitchen thereby depressurizing the house whenever they were in operation. A 100 mm (4") make-up air duct was installed from the outdoors to the furnace return air plenum through a hard (i.e. direct) connection. See Fig. 30.

FIGURE 30

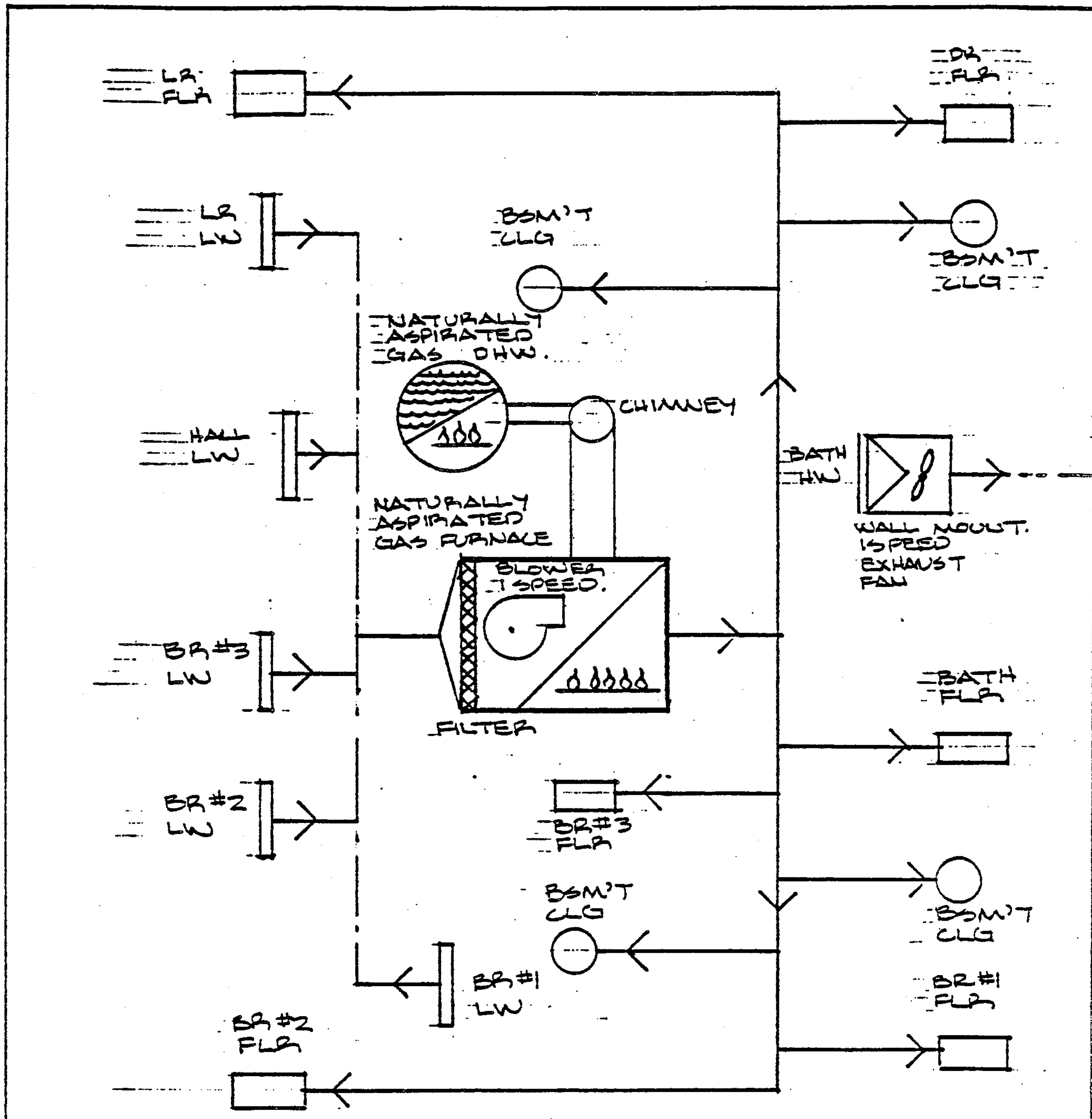


LR FLR
BSM'T CLG.
LR LW
FRESH AIR INT. HOOD
BALANCE DAMPER
10 KW ELECTRIC F/A FURNACE
BLOWER 2 SPEED
FILTER
BR #3 LW
HALL LW
BR #2 LW
BR#2 FLR
BR #3 FLR
BSM'T CLG
BR #1 LW
DR FLR
BSM'T CLG.
KIT HW
EXH. HOOD
CENTRAL EXHAUST FAN
BATH HW
BATH FLR
BSM'T CLG
BR#1 FLR
FORCED AIR HEATING SYSTEM WITH CENTRAL EXHAUST HOUSES 7&8
KEY
SUPPLY DUCTS
RETURN DUCTS
EXHAUST DUCTS
HIGHWALL EXHAUST GRILL
HW
FLR
FLOOR SUPPLY GRILL
LW
LOW WALL RETURN GRILL
CLG
CEILING SUPPLY GRILL

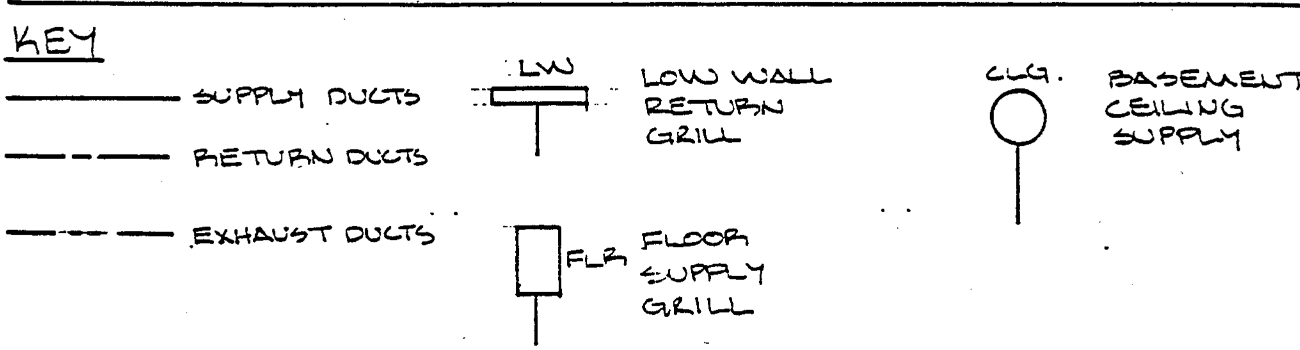
4.3 HOUSES #9 and #10

The heating system consisted of a conventional, naturally aspirated forced air gas furnace with floor-mounted supply and return air registers located in each room. The seasonal efficiency of the furnace was estimated at 60%. Hot water heating was provided by a conventional 114 l (25 I.G.) gas DHW tank. The ventilation system used a bathroom exhaust fan venting directly outdoors; neither make-up nor combustion air intakes were installed. See Fig. 31.

FIGURE 31



CONVENTIONAL NATURALLY ASPIRATED SPACE + DHW HEATING SYSTEM WITH UNITARY EXHAUST SYSTEM HOUSES 9&10.



4.4 HOUSES #11 and #12

Houses #11 and #12 used the "Habitair" system manufactured by Fiberglas Canada Inc. as part of the FCI Low Energy House System. As shown in Figs. 32 and 33, the Habitair consisted of an integrated HRV which provided unbalanced, exhaust-only ventilation plus supplementary space heating, DHW heating and a degree of air-conditioning. Ventilation was supplied by air leakage through the envelope. The primary space heating requirements were provided by conventional electric baseboards sized to meet the full design load.

4.4.1 System Description

The Habitair consisted of a Heat Recovery Module (HRM) which contained a heat pump, DHW tank and exhaust fan, plus an Air Distribution Module (ADM) containing a hot water coil, recirculation fan, and a ductwork crossover mechanism. Operation of the exhaust fan, which extracted air from the bathroom and kitchen, was controlled by a manually adjusted four speed switch. Supplemental exhaust capacity was provided by a manually controlled booster fan in the bathroom.

4.4.2 Winter Operation

Stale air from the bathroom and kitchen was extracted by the exhaust fan through the heat pump evaporator coil before being exhausted outdoors. The recovered energy was transferred to the integral DHW tank via the heat pump condenser.

Supplemental space heating was provided by the Habitair by recirculating air from the living room and bedrooms over a hot water coil in the ADM and returning the heated air to the front of the house. When a demand for space heating was sensed by the first stage of the two-stage living room thermostat, and the DHW was above a pre-set temperature, water was circulated from the DHW tank to the hot water coil. If this was unable to satisfy the load, the zone temperature fell below the second stage set point and the living room baseboard heaters were activated. The Habitair also operated in heating mode (during winter operation) if there was a demand for cooling.

4.4.3 Summer Operation

The system was converted to summer operation using a manual changeover lever on the ADM. Exhaust air was routed over the hot water coil in the ADM and recirculation air passed through the HRM. The direction of recirculation air in the ductwork was reversed with conditioned air supplied to each room and return air extracted through the grille located in the front door well. Operation of the heat pump was initiated by a demand for DHW or space cooling (as sensed by the cooling stage of the living room thermostat). If there was a demand for cooling, and the temperature of the DHW rose above a high limit, the DHW circulation pump was activated and excess heat in the DHW tank was dumped to the exhaust air stream through the fan coil. A demand for DHW always resulted in house air being cooled, even with no demand for cooling. This could potentially cause the baseboard heaters to be activated during the summer.

4.4.4 Domestic Hot Water

DHW heating was supplied by the heat pump condenser coil located in the bottom of the DHW tank in the HRM. During the heating season, the heat pump operated whenever there was a demand for DHW. If the demand for DHW heating exceeded that available from the heat pump, and the tank temperature fell below the set point of a second thermostat, two 750 W electric heaters in the tank were energized. In the summer, the heat pump was activated by either a demand for DHW heating or space cooling. Excess heat in the tank was dumped via the hot water coil in the ADM to the exhaust air. Auxiliary DHW heating was provided, as required, by the in-tank electric heaters. A conventional 114 l (25 I.G.) electric DHW tank was also used in Houses #11 and #12 for monitoring purposes.

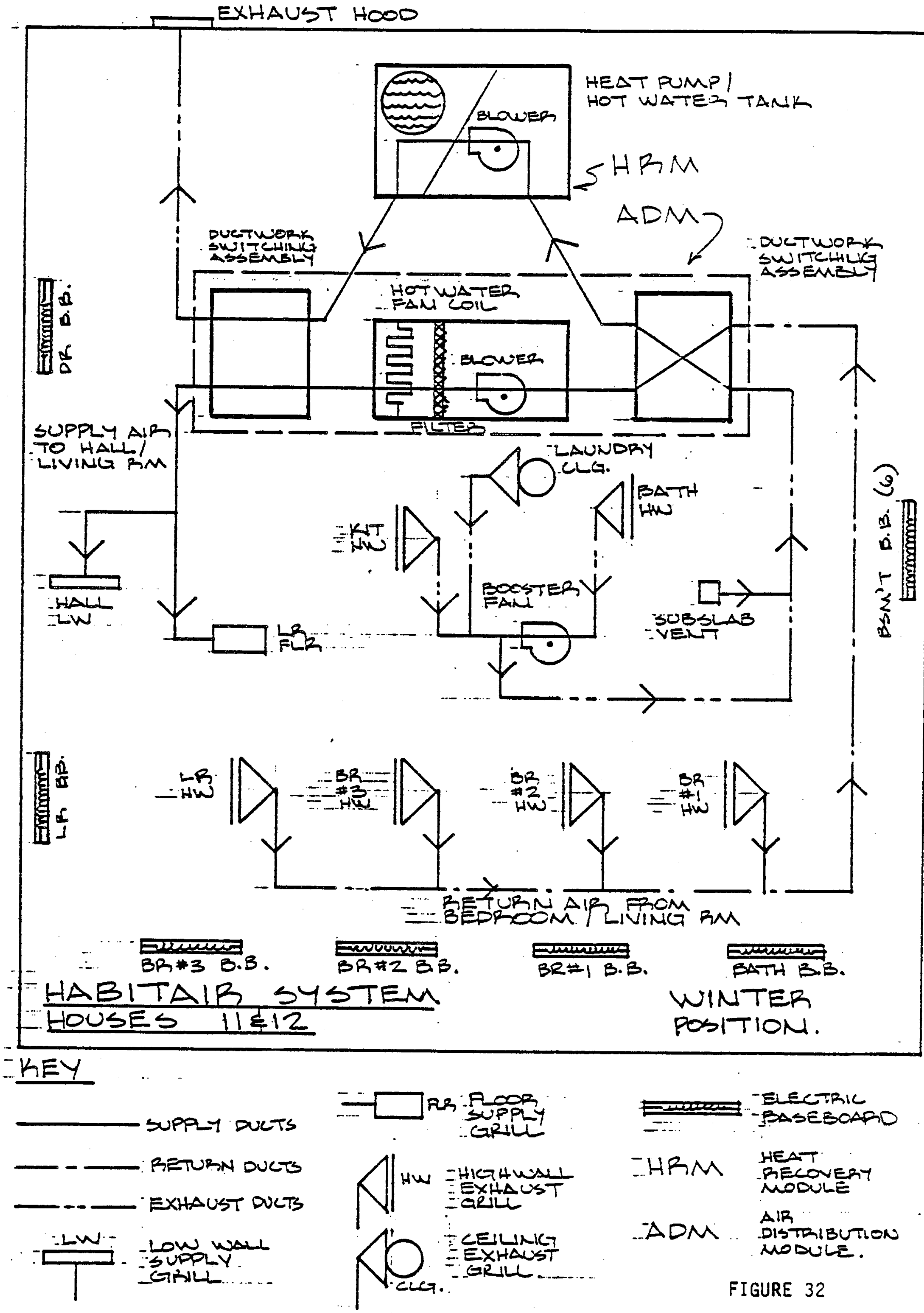

EXHAUST HOOD
HEAT PUMP / HOT WATER TANK
BLOWER
SHRM
ADM
DUCTWORK SWITCHING ASSEMBLY
DUCTWORK SWITCHING ASSEMBLY
HOT WATER FAN COIL
BLOWER
FILTER
DR. B.B.
SUPPLY AIR TO HALL / LIVING RM
LAUNDRY CLG.
BATH HW
KIT HW
BOOSTER FAN
SUBSLAB VENT
HALL LW
LR FLR
BSM'T B.B. (6)
LR B.B.
LR HW
BR #3 HW
BR #2 HW
BR #1 HW
RETURN AIR FROM BEDROOM / LIVING RM
BR#3 B.B.
BR#2 B.B.
BR#1 B.B.
BATH B.B.
HABITAIR SYSTEM
HOUSES 11&12
WINTER POSITION.
KEY
SUPPLY DUCTS
RETURN DUCTS
EXHAUST DUCTS
LW
LOW WALL SUPPLY GRILL
FR FLOOR SUPPLY GRILL
HW HIGHWALL EXHAUST GRILL
CLG. CEILING EXHAUST GRILL
ELECTRIC BASEBOARD
HRM HEAT RECOVERY MODULE
ADM AIR DISTRIBUTION MODULE.

FIGURE 32

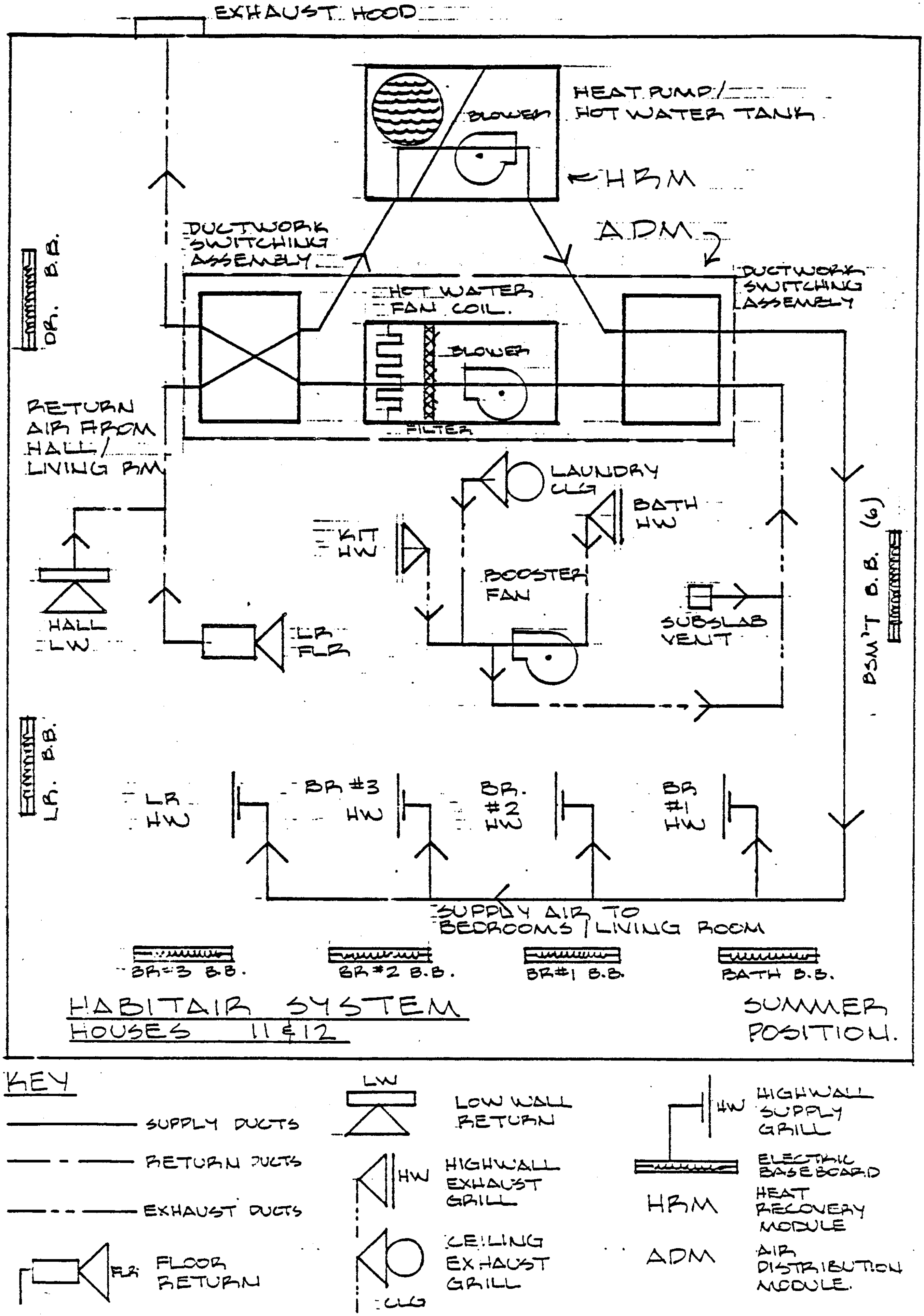

EXHAUST HOOD
HEAT PUMP/ HOT WATER TANK
BLOWER
HRM
ADM
DUCTWORK SWITCHING ASSEMBLY
DUCTWORK SWITCHING ASSEMBLY
HOT WATER FAN COIL.
BLOWER
FILTER
DR. B.B.
RETURN AIR FROM HALL/ LIVING RM
LAUNDRY CLG
BATH HW
KIT HW
BOOSTER FAN
SUBSLAB VENT
BSM'T B.B. (6)
HALL LW
LR FLR
LR. B.B.
LR HW
BR #3 HW
BR. #2 HW
BR #1 HW
SUPPLY AIR TO BEDROOMS/LIVING ROOM
BR#3 B.B.
BR#2 B.B.
BR#1 B.B.
BATH B.B.
HABITAIR SYSTEM
HOUSES 11 & 12
SUMMER POSITION.
KEY
SUPPLY DUCTS
RETURN DUCTS
EXHAUST DUCTS
FLR FLOOR RETURN
LW LOW WALL RETURN
HW HIGHWALL EXHAUST GRILL
CLG CEILING EXHAUST GRILL
HW HIGHWALL SUPPLY GRILL
ELECTRIC BASEBOARD
HRM HEAT RECOVERY MODULE
ADM AIR DISTRIBUTION MODULE.

FIGURE 33

4.5 HOUSES #13 AND #14

Space heating in Houses #13 and #14 was provided by a conventional 10 kW forced air electric furnace. The ventilation system used a CES Inc. Van EE 2000 HRV exhausting from the bathrooms, kitchens and laundry areas while supplying air to the furnace return air plenum through an indirect connection. Hot water heating was provided by a conventional 182 l (40 I.G.) electric DHW tank. The ventilation system was normally operated in a balanced configuration with low and high speeds to provide continuous and peak ventilation respectively. Distribution of the ventilation air was provided through continuous operation of the furnace blower. Supply and return air registers were located in each zone of the house. With the exception of a single floor-mounted register in the living room, only high-sidewall supply air registers were used. Control of the ventilation system was provided by a dehumidistat and manual override switches. The HRV was a second-generation unit. See Fig. 34.

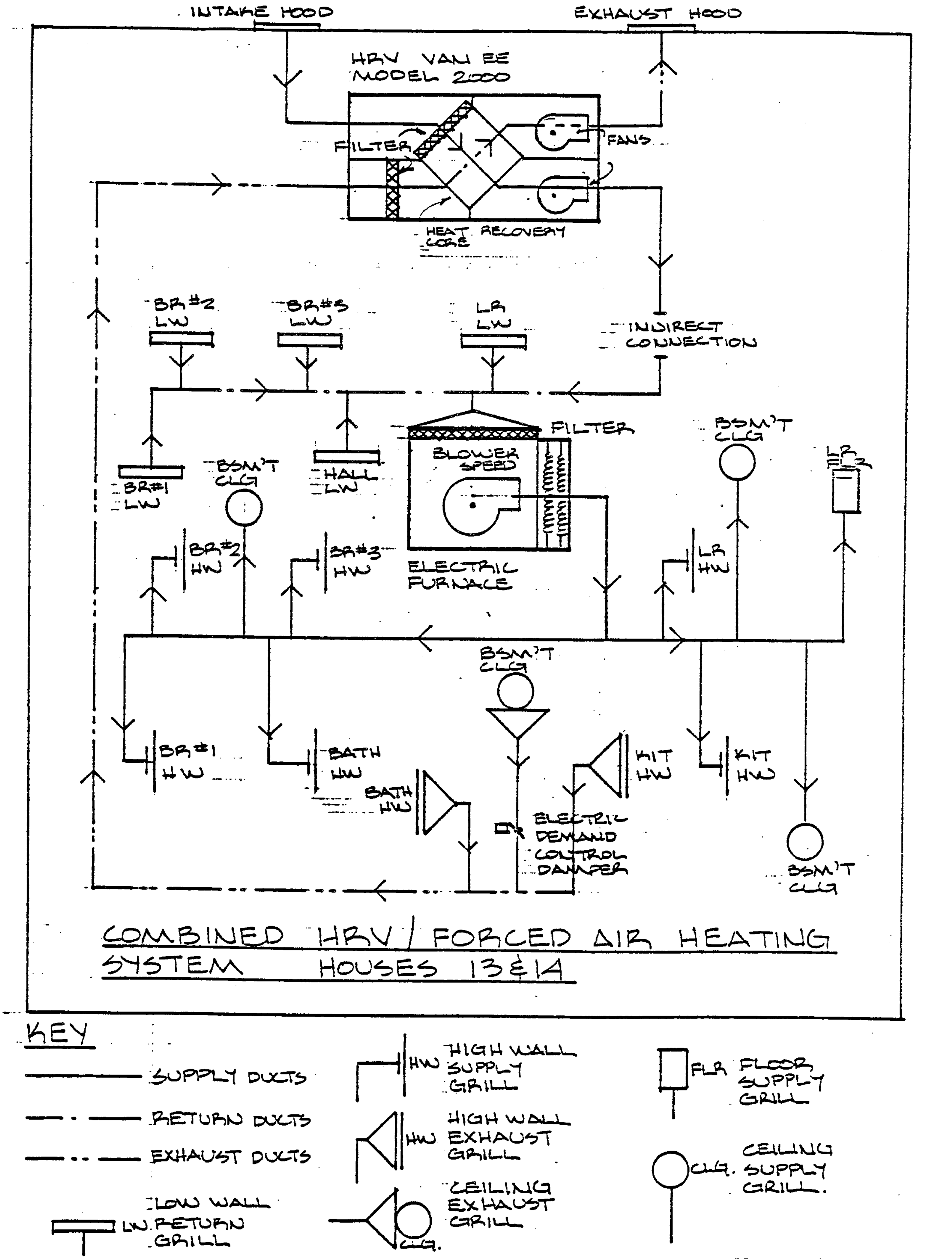

INTAKE HOOD
EXHAUST HOOD
HRV VAN EE
MODEL 2000
FILTER
FANS
HEAT RECOVERY CORE
BR#2 LW
BR#3 LW
LR LW
INDIRECT CONNECTION
FILTER
BSM'T CLG
BLOWER SPEED
BSM'T CLG
HALL LW
BR#1 LW
LR FLR
BR#2 HW
BR#3 HW
ELECTRIC FURNACE
LR HW
BSM'T CLG
BR#1 HW
BATH HW
BATH HW
KIT HW
KIT HW
ELECTRIC DEMAND CONTROL DAMPER
BSM'T CLG
COMBINED HRV / FORCED AIR HEATING SYSTEM HOUSES 13 & 14
KEY
SUPPLY DUCTS
RETURN DUCTS
EXHAUST DUCTS
LOW WALL
LW RETURN GRILL
HW HIGH WALL SUPPLY GRILL
HW HIGH WALL EXHAUST GRILL
CEILING EXHAUST GRILL
CLG.
FLR FLOOR SUPPLY GRILL
CLG. CEILING SUPPLY GRILL.

FIGURE 34

4.6 HOUSES #15 and #16

These two houses used the Peach multi-source heat pump HRV which combined the space heating and cooling, DHW, ventilation and heat recovery systems into a single integrated package.

4.6.1 Peach PPHC12/45 Description

As shown schematically in Fig. 35, the Peach utilized an outdoor air loop, an indoor recirculation air loop and a DHW circulation loop. In addition to the 1 ton heat pump, the Peach used an integral 16 kW electric forced air furnace to provide space heating when the heat pump was unable to meet the load (although only 8 kW were installed for the project houses). Ventilation air was supplied from the outdoor air loop through an internal damper into the recirculation loop. A second internal damper exhausted some of the recirculation air into the outdoor loop. The manufacturer stated that by opening the inlet and outlet dampers equally, the air flows would be balanced. For every 25 mm (1") of damper opening, the flow rate was reported to increase by 10% of the maximum rate. Damper adjustment was performed manually at the time of commissioning. Recirculation air was supplied to each zone through high-sidewall grilles and returned from each room through baseboard return air grilles.

4.6.2 Exhaust System

To meet the design capacity for exhaust air, a separate exhaust system was installed using two fans to vent air from the bathroom and laundry room. A separate kitchen range hood fan was also installed, controlled by a hood switch.

4.6.3 Winter Operation

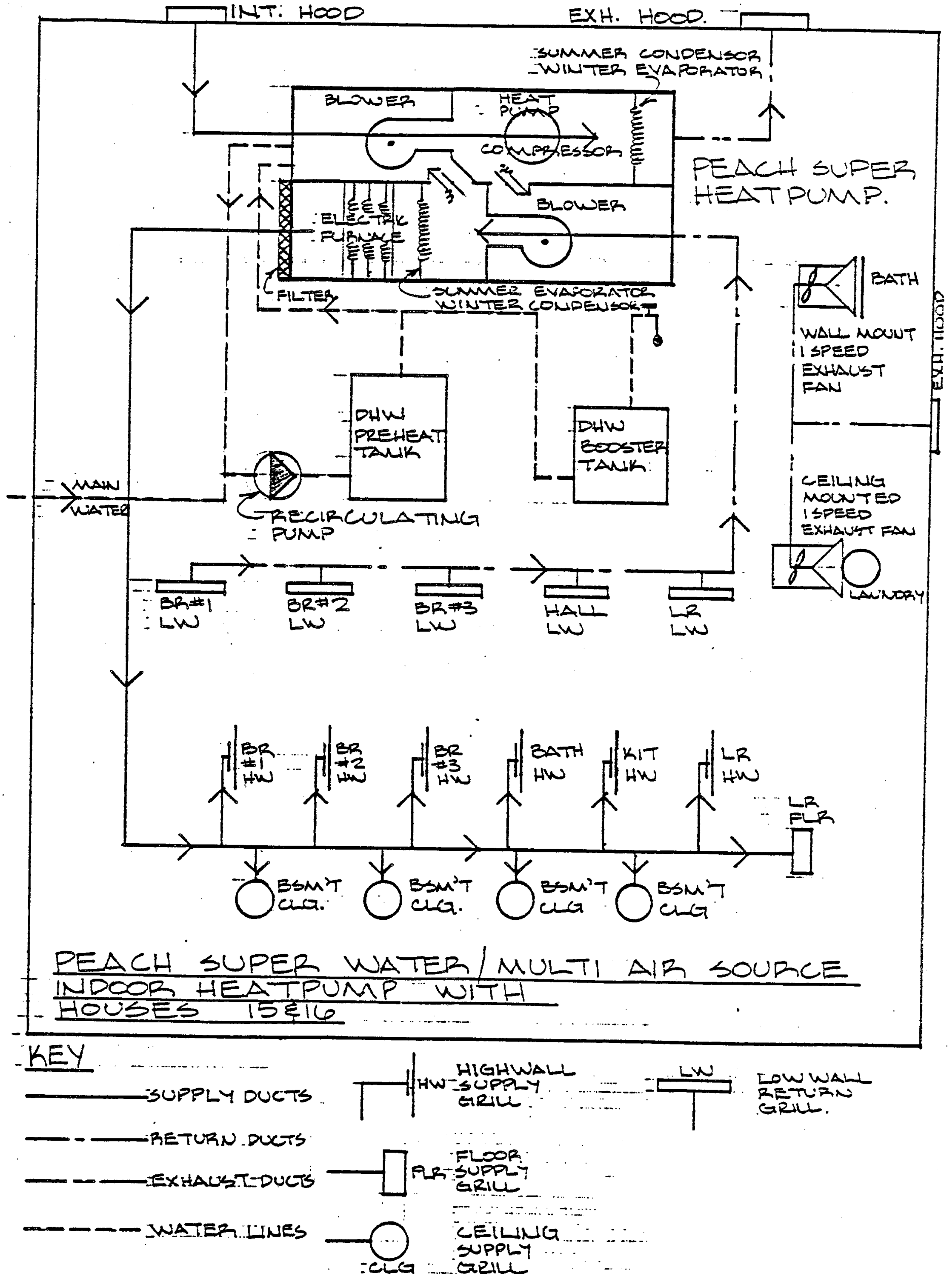
The heat pump transferred heat from the outdoor air stream to the indoor recirculation loop with the electric furnace supplying additional heat, as necessary, to meet the space heating load. A Honeywell T6031 controller, which sensed outdoor air temperature, interrupted the compressor power supply at outdoor air temperatures below -12 °C (10 °F). The deadband on this control was 5 °C (9 °F). When the first stage of the thermostat called for heat, the two blowers in the Peach switched to high speed until the demand was satisfied. Then the recirculation blower reverted to low speed and the heat pump compressor and outdoor air loop blower shut down. The heat pump also operated to meet a demand for DHW heating. At low outdoor temperatures, the heat pump power supply was interrupted although the outdoor air loop blower was still run on a demand for heat. If the heat pump was unable to meet the heating requirements, and the room temperature fell 1 °C (2 °F) below the first stage set point, the second stage of the thermostat activated the electric furnace until room temperature returned to the second stage set point.

4.6.4 Summer Operation

The heat pump was automatically reversed when cooling was demanded. The unit extracted heat from the recirculation loop and transferred it to the DHW and the outdoor air loop airstream. Cooling was supplied on a demand from the thermostat located on the main floor. When there was a call for cooling, the two blowers were switched to high speed and the compressor started in the cooling mode. When the demand was satisfied, the recirculation blower was returned to low speed and the compressor and outdoor air blower turned off. Control of the cooling system was provided by the thermostat located in the hall which reversed operation of the heat pump and started it as an air-conditioning unit.

4.6.5 DHW Heating

A two-tank DHW system consisting of a 182 l (40 I.G.) preheat tank and a 114 l (25 I.G.) booster tank was used in conjunction with the Peach. Water from the top of the preheat tank was circulated to the Peach, where it was heated by the condenser and then returned to the bottom of the preheat tank. A thermostatic control in the bottom of the preheat tank, set at 50 °C (122 °F), started the circulation pump when the preheat tank temperature fell below the set point. This switch also activated the heat pump, if it was not already operating. A second thermostatic control, located at the top of the DHW tank and set at 35 °C (95 °F), activated the electric heating elements when the tank temperature fell below this temperature. When there was a demand for DHW, preheated water was drawn from the top of the preheat tank and supplied to the booster tank. Make-up water from the mains entered the bottom of the preheat tank.



INT. HOOD
EXH. HOOD
SUMMER CONDENSOR
WINTER EVAPORATOR
BLOWER
HEAT PUMP
COMPRESSOR
PEACH SUPER HEATPUMP.
BLOWER
ELECTRIC FURNACE
FILTER
SUMMER EVAPORATOR
WINTER CONDENSOR
BATH
WALL MOUNT 1 SPEED EXHAUST FAN
EXH. HOOD
DHW PREHEAT TANK
DHW BOOSTER TANK
MAIN WATER
RECIRCULATING PUMP
CEILING MOUNTED 1 SPEED EXHAUST FAN
LAUNDRY
BR#1 LW
BR#2 LW
BR#3 LW
HALL LW
LR LW
BR #1 HW
BR #2 HW
BR #3 HW
BATH HW
KIT HW
LR HW
LR FLR
BSM'T CLG.
BSM'T CLG.
BSM'T CLG
BSM'T CLG
PEACH SUPER WATER/MULTI AIR SOURCE INDOOR HEATPUMP WITH HOUSES 15&16
KEY
SUPPLY DUCTS
RETURN DUCTS
EXHAUST DUCTS
WATER LINES
HW HIGHWALL SUPPLY GRILL
LW LOW WALL RETURN GRILL
FLR FLOOR SUPPLY GRILL
CLG CEILING SUPPLY GRILL

FIGURE 35

4.7 HOUSES #17 and #18

Houses #17 and #18 used a conventional electric baseboard heating system with individual room thermostats. The ventilation system used a Nilan heat pump HRV with a dedicated ductwork system to provide distribution of the ventilation air to each zone with exhaust air being taken from the kitchen and bathroom. Ventilation air was provided to the living areas through high-sidewall grilles. A recirculating range hood was also provided. See Fig. 36.

The Nilan functioned in a fashion similar to that of a conventional air-to-air HRV except a heat pump, instead of a heat exchanger, was used to transfer energy, permitting (for example) the supply air temperature to be raised above that of the exhaust air. The unit's two blowers normally ran on low speed but on demand for increased ventilation (by switch or dehumidistat), both fans were switched to high speed. The Nilan operated in heating mode only. The model used in the project houses was designed for European power but was able to function satisfactorily on 240 VAC 60 cycle single phase power.

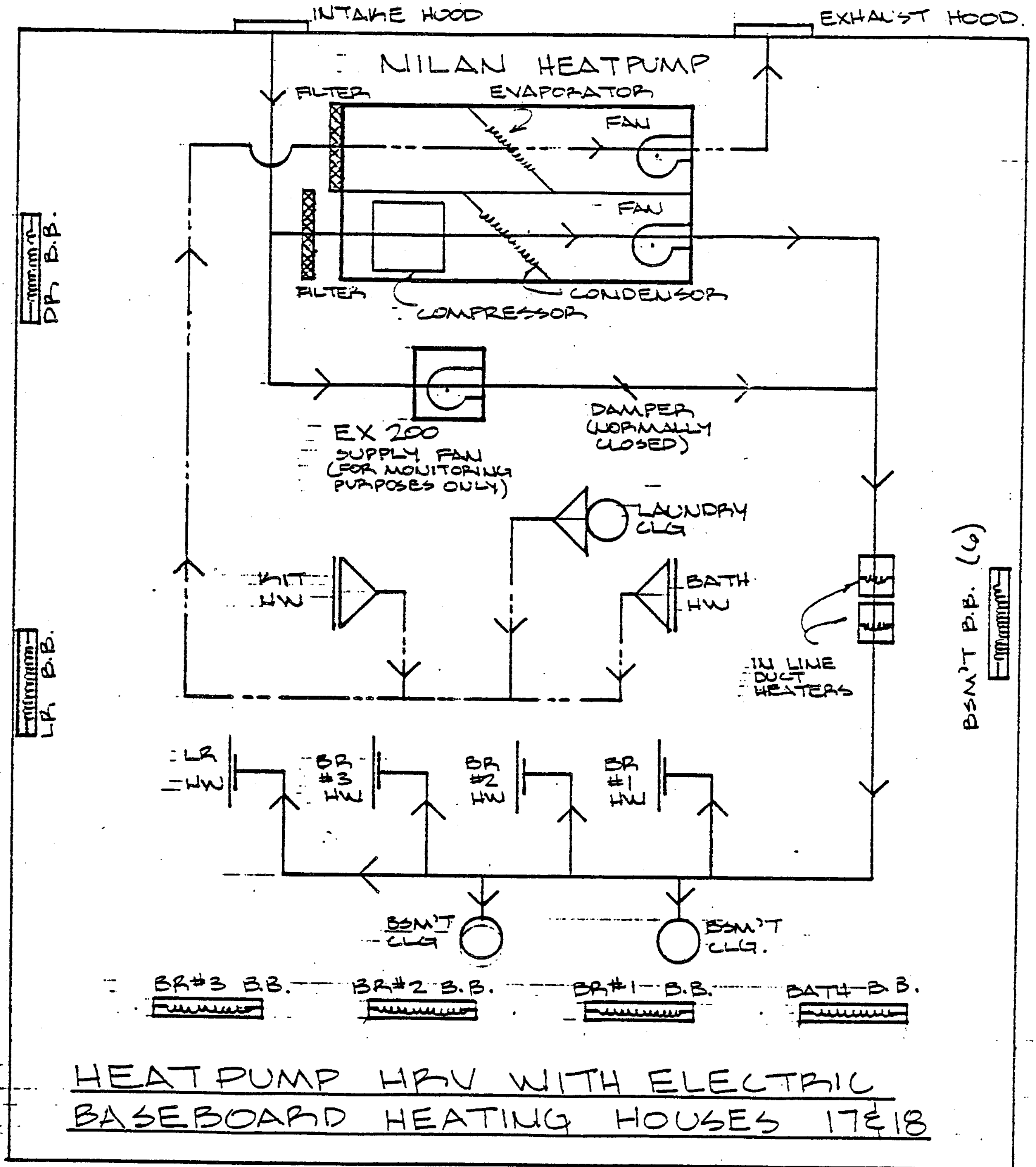
4.7.1 Winter Operation

The compressor was controlled by the first stage of a two stage heating thermostat with the two blowers controlled by the dehumidistat. On demand for heating, a relay operated by the first stage of the thermostat started the heat pump. If the heat pump was unable to satisfy the heating demand, and the room temperature fell below the second stage set point on the thermostat, the second stage relay supplied power to the baseboard heaters. Electric duct heaters downstream of the Nilan provided additional heating if the air temperature in the ductwork dropped below 5 °C (41 °C).

During defrost, both the supply and exhaust fans were shut down and defrost was carried out using hot refrigerant gas. Time to defrost was reported to be 1 to 3 minutes.

4.7.2 Summer Operation

In the cooling mode, the thermostat was set back to prevent the compressor from operating since high temperatures would create an overpressure condition in the heat pump resulting in excessive cycling. The blowers operated as normal supply and exhaust fans, switched to high on demand by the dehumidistat or switches.



KEY

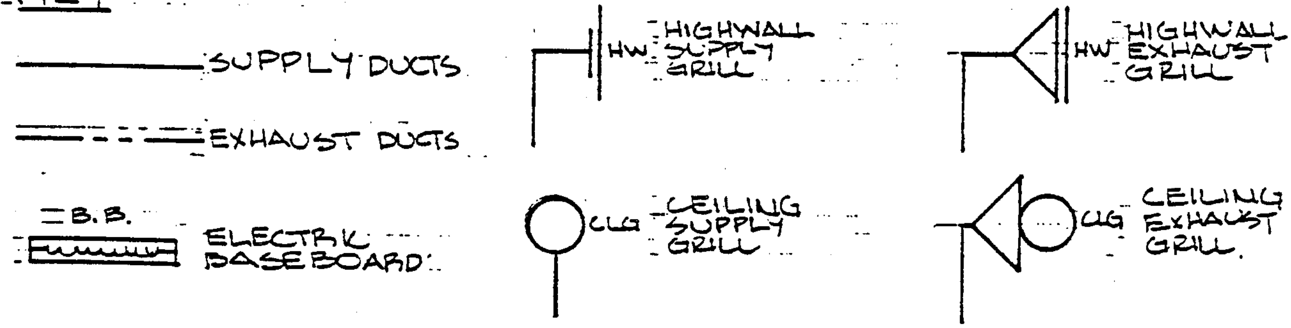


FIGURE 36

4.8 HOUSES #19 and #20

These two houses used a conventional electric baseboard heating system with individual room thermostats. The ventilation system used a CES Inc. Van EE 2000 HRV with a dedicated ductwork system to provide distribution of the ventilation air to each zone with the exhaust air being extracted from the bathroom, kitchen and laundry area. The ventilation system was operated in a balanced mode with low and high speeds to provide continuous and peak ventilation respectively. The HRV was a second-generation unit. The supply air ductwork was sized to meet the ventilation load. High-sidewall grilles were used for the ventilation air. System control was provided by a dehumidistat and manual switches. Hot water heating was supplied by a conventional 182 l (40 I.G.) electric DHW tank. See Fig. 37.

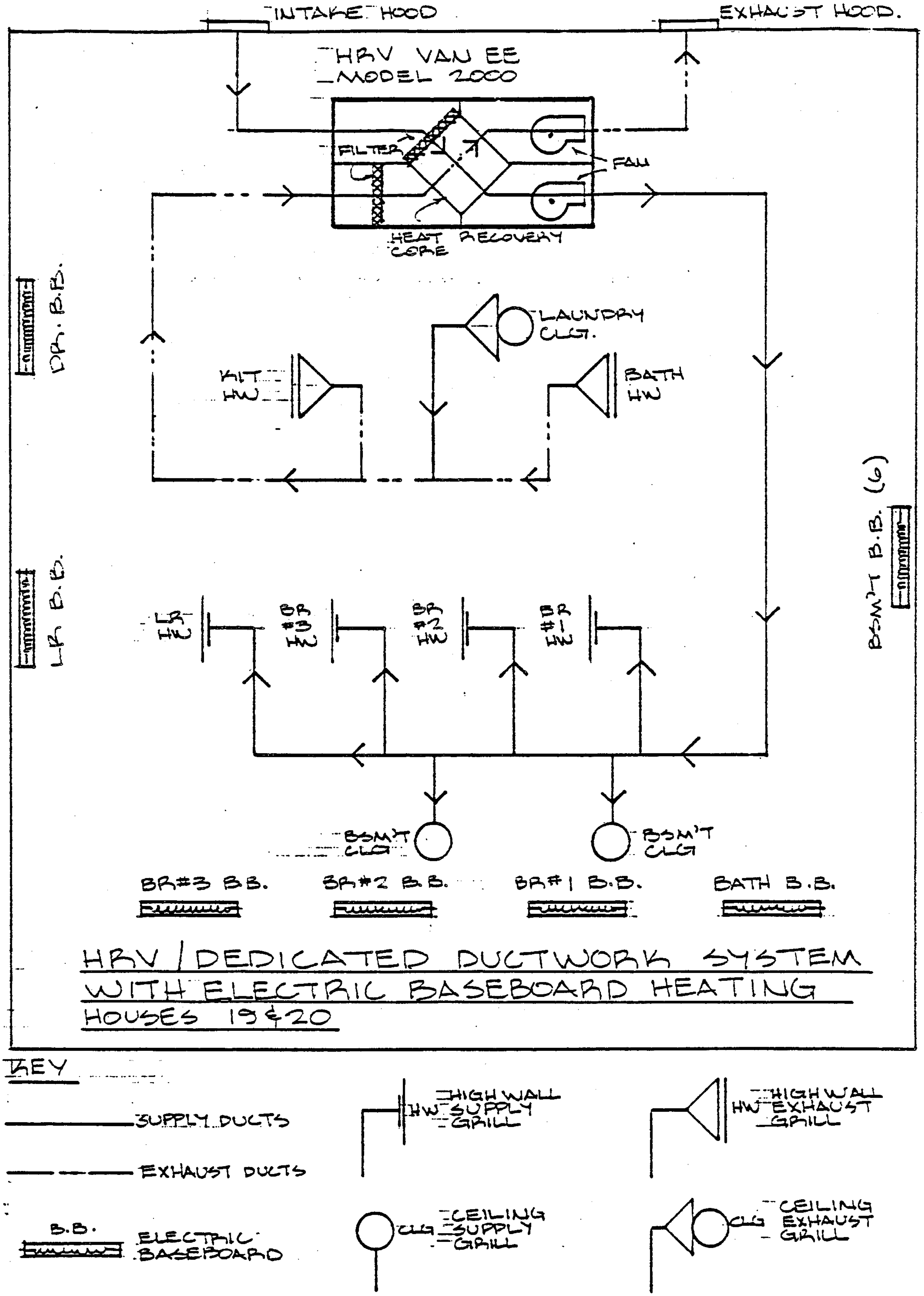

INTAKE HOOD
EXHAUST HOOD.
HRV VAN EE
MODEL 2000
FILTER
FAN
HEAT RECOVERY CORE
LAUNDRY CLG.
KIT HW
BATH HW
DR. B.B.
LR B.B.
BSM'T B.B. (6)
LR HW
BR #3 HW
BR #2 HW
BR #1 HW
BSM'T CLG
BSM'T CLG
BR#3 B.B.
BR#2 B.B.
BR#1 B.B.
BATH B.B.
HRV / DEDICATED DUCTWORK SYSTEM
WITH ELECTRIC BASEBOARD HEATING
HOUSES 19 & 20
KEY
SUPPLY DUCTS
EXHAUST DUCTS
B.B. ELECTRIC BASEBOARD
HW HIGH WALL SUPPLY GRILL
HW HIGH WALL EXHAUST GRILL
CLG CEILING SUPPLY GRILL
CLG CEILING EXHAUST GRILL

FIGURE 37

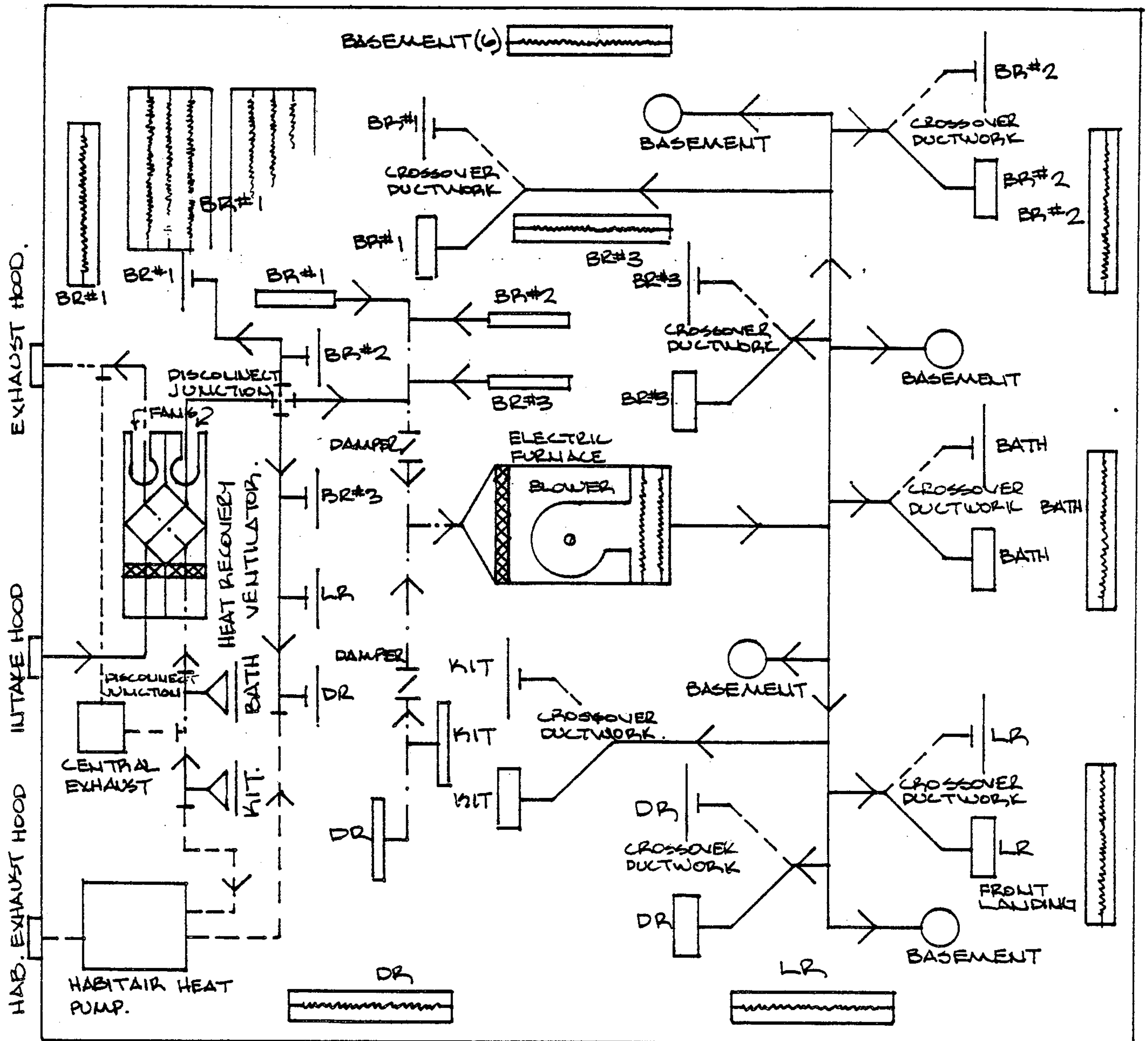
4.9 HOUSE #21

Multiple space heating, domestic hot water heating and ventilation systems were used in House #21 with each designed to be individually controlled or disconnected, as desired. The space heating systems consisted of: a 15 kW two-speed electric forced air furnace, electric baseboard heaters with zone controls in each room, electric radiant ceiling panels in the master bedroom and an integrated space/DHW/air-conditioning/ventilation system ("Habitair 2800"). In addition, natural gas service was provided to the house to permit future installation of gas-fired appliances. The DHW heating system consisted of a conventional 182 l (40 I.G.) electric tank, as well as the Habitair.

The primary ventilation system used a CES Inc. Van EE 2000 HRV exhausting from the bathroom and kitchen and supplying air to the furnace ductwork or to each zone of the house using a low volume dedicated ductwork system. A central exhaust system was installed which could be connected in lieu of the HRV. The Habitair could also provide exhaust-only ventilation. Ventilation control was provided by a dehumidistat on the main floor with manual switches in the wet areas of the house.

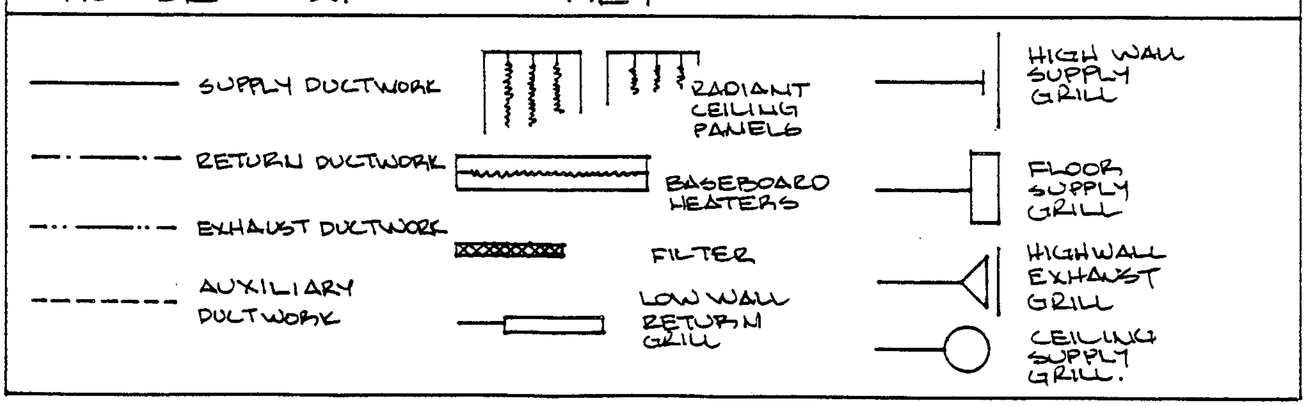
A flexible air distribution system, using special crossover ductwork, was designed which permitted space and ventilation air to be supplied to each room using either conventional floor-mounted registers or high-sidewall supply grilles. In addition, individual room return air grilles were installed as well as a central, large capacity return air grille in the main hall - either could be connected. The system schematic is shown in Fig. 38.

FIGURE 38



F/A ELECTRIC FURNACE WITH HIWALL OR FLOOR SUPPLIES, HRV WITH DEDICATED OR FURNACE SUPPLY DUCTWORK, RADIANT CEILING PANELS, BASEBOARD HEAT, HEAT PUMP, CENTRAL EXHAUST

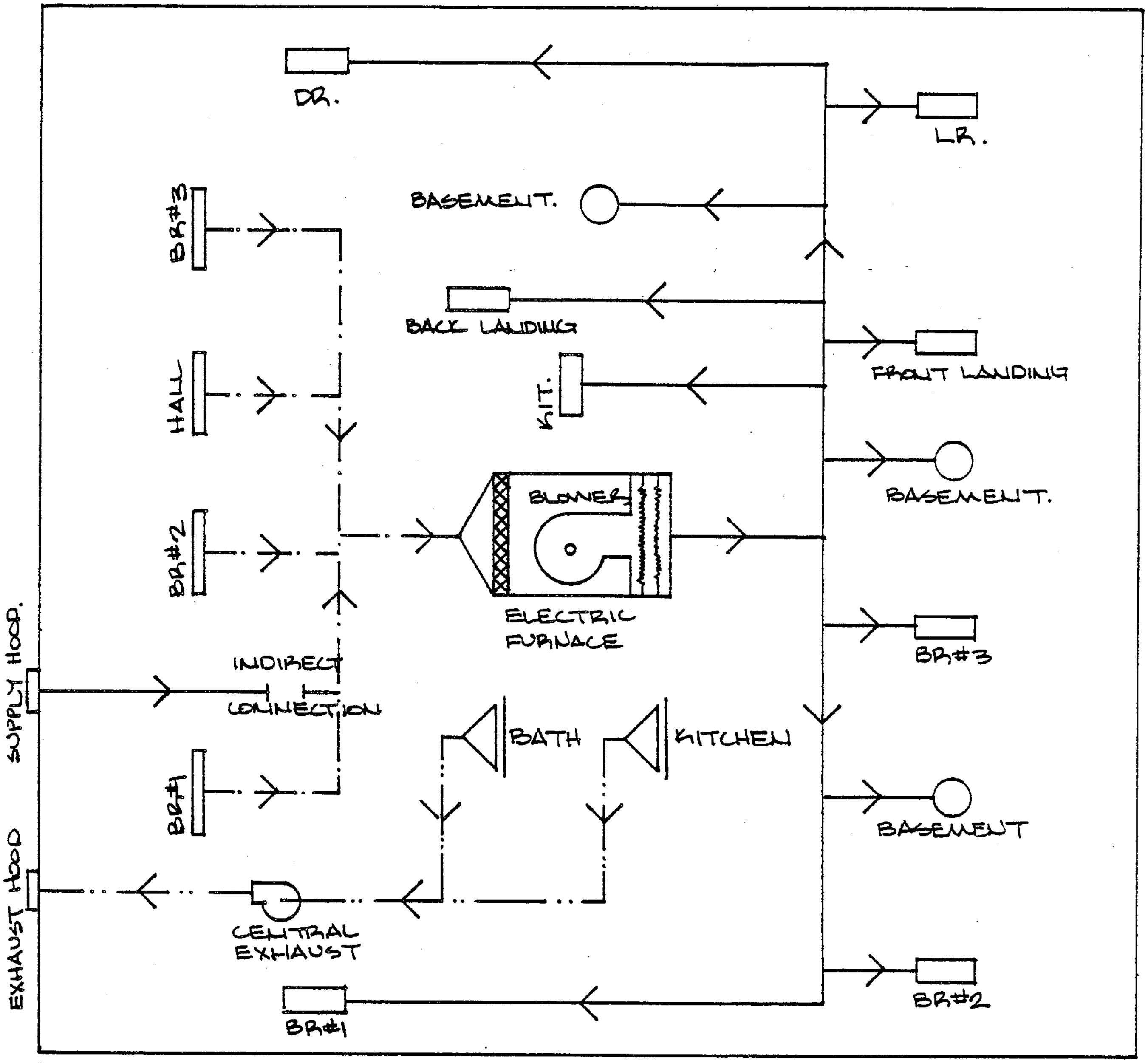
HOUSE #21 KEY



4.10 HOUSE #22

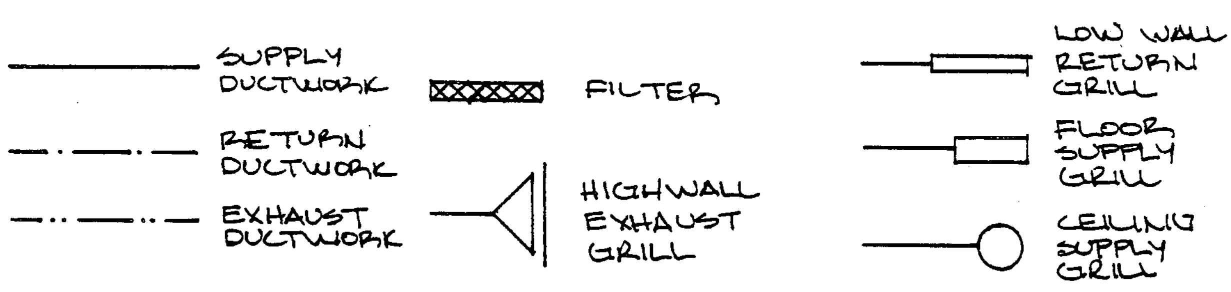
The mechanical systems in House #22 were fairly conventional, consisting of a 15 kW electric forced air furnace, 182 l (40 I.G.) DHW tank and a central exhaust ventilation system. The furnace used a two-speed blower to aid in ventilation air distribution along with supply and return air registers in each room. The ventilation system was controlled by switches in the bathroom and kitchen, the two rooms from which it exhausted air. A make-up air intake to the furnace return air plenum was also provided. The mechanical system schematic is shown in Fig. 39.

FIGURE 39



FORCED AIR HEATING SYSTEM WITH CENTRAL EXHAUST

HOUSE #22 KEY

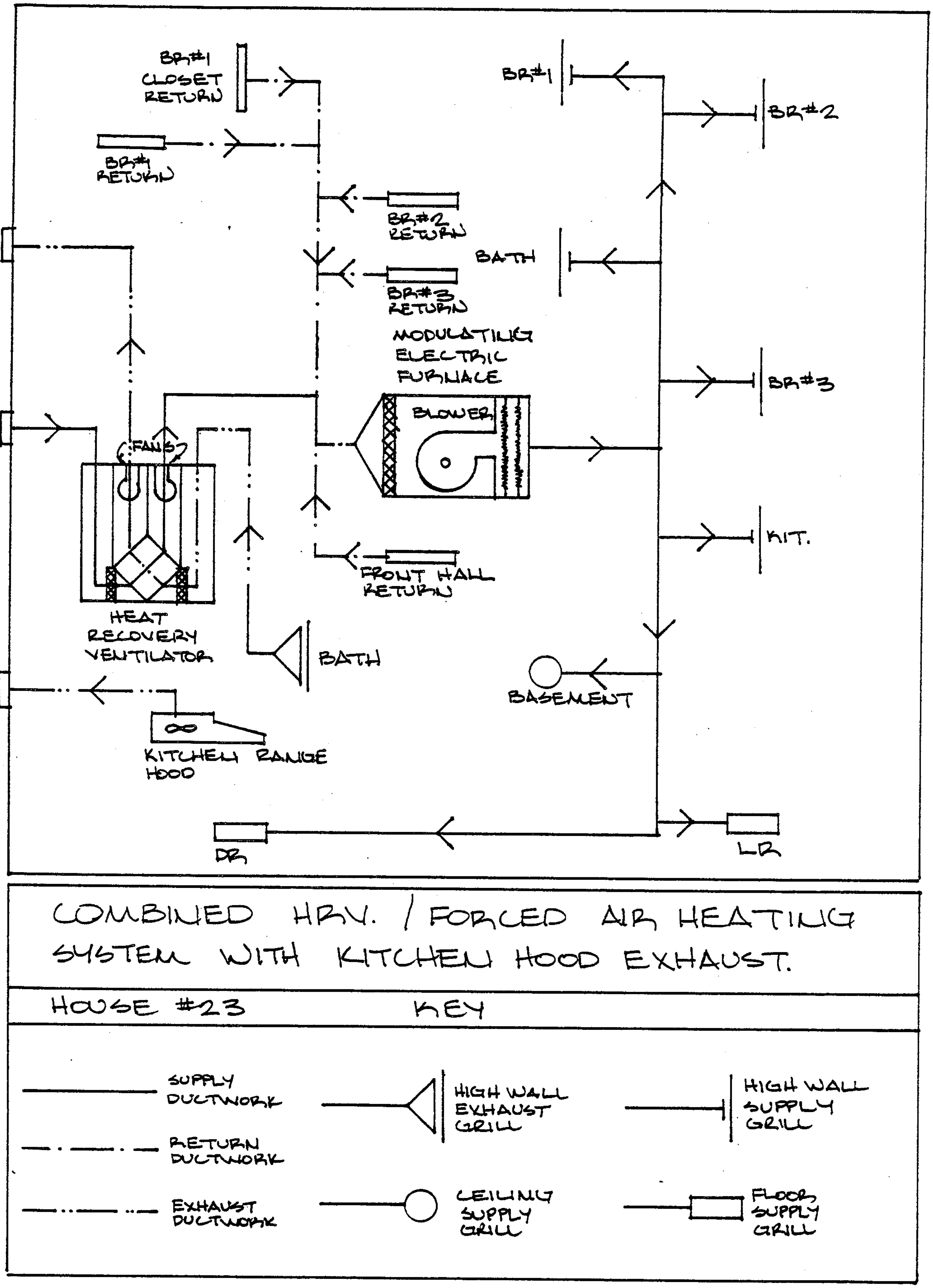


4.11 HOUSE #23

The space heating system consisted of a modulating 10 kW electric forced air furnace which adjusted its heat output to aid in preheating the ventilation air and thereby reduce potential problems from cool drafts at the registers. The furnace used a two-stage thermostat which activated the heat output in 5 kW increments. The domestic hot water heating system consisted of an interior air source electric heat pump which extracted heat from the basement air for preheating the DHW. A conventional 182 l (40 I.G.) electric DHW tank was also included, plumbed in series with the heat pump.

The ventilation system consisted of a low capacity HRV ("Lifebreath 100 DEF") which exhausted air from the bathroom and was supplemented with a kitchen range hood venting directly outdoors. Supply air provided by the HRV was ducted into the furnace return air plenum. Ventilation system control was provided by a dehumidistat located on the HRV with a manual override switch in the bathroom. Figure 40 shows the mechanical system schematic.

FIGURE 40



COMBINED HRV. / FORCED AIR HEATING SYSTEM WITH KITCHEN HOOD EXHAUST.

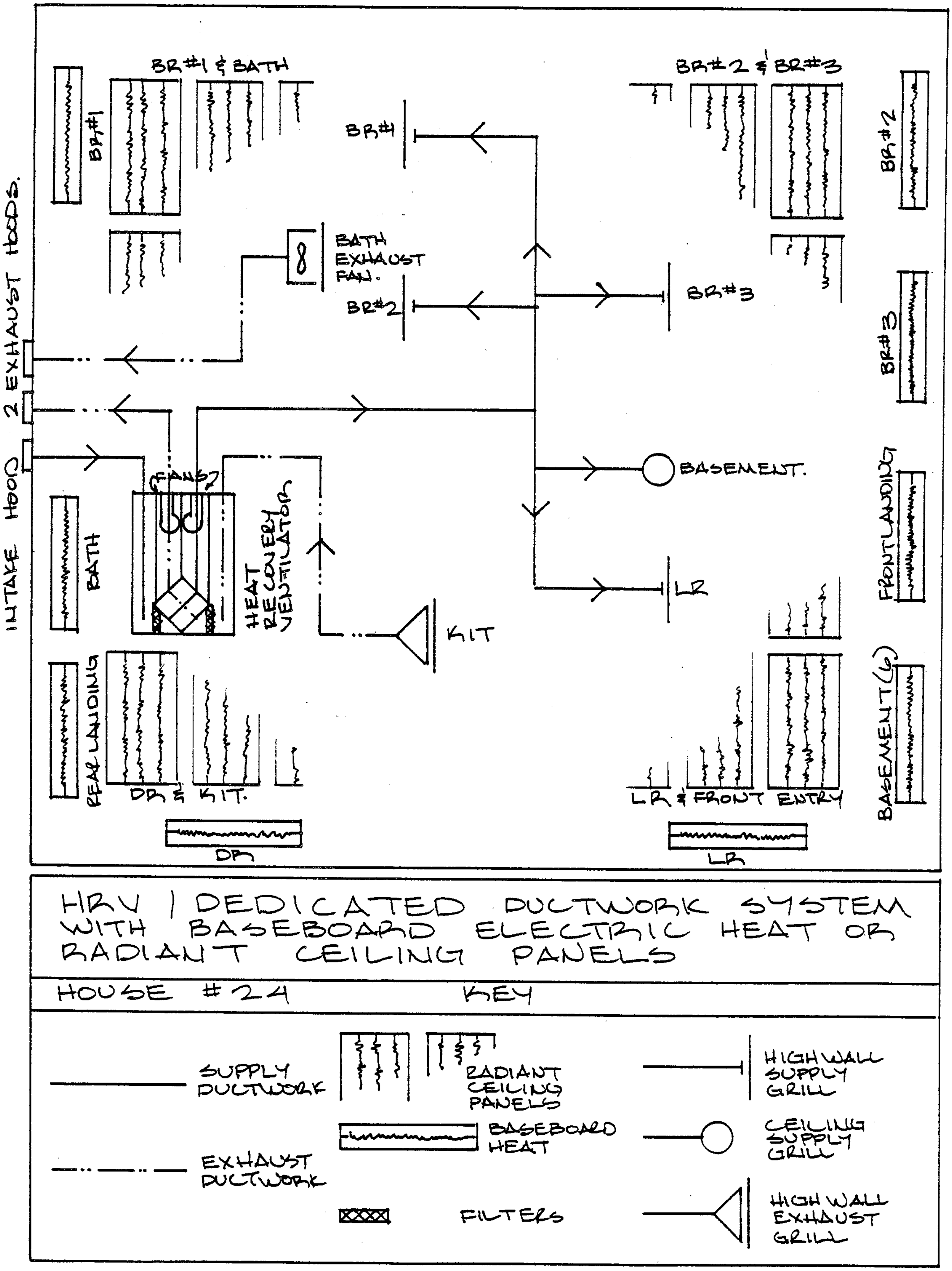
HOUSE #23

4.12 HOUSE #24

House #24 had two complete heating systems serving the main floor: conventional electric baseboards with individual room controls and a ceiling-mounted electric radiant heating system also under individual room control. Either system could be activated at any time. Basement heating was provided by electric baseboards. The DHW system consisted of a 182 l (40 I.G.) electric tank.

The ventilation system used a low capacity HRV ("Van EE 1000 VLD") with a dedicated ductwork system to supply ventilation air to each zone using high-sidewall supply grilles. In addition, a bathroom exhaust fan was installed which vented directly outside. Figure 41 shows the mechanical system schematic.

FIGURE 41


BR#1 & BATH
BR#2 & BR#3
BR#1
BR#4
BR#2
BATH EXHAUST FAN.
BR#2
BR#3
BR#3
2 EXHAUST HOODS.
INTAKE HOOD
FANS
HEAT RECOVERY VENTILATOR
BASEMENT.
BATH
FRONT LANDING
LR
KIT
REAR LANDING
DR & KIT.
LR & FRONT ENTRY
BASEMENT (6)
DR
LR
HRV / DEDICATED DUCTWORK SYSTEM WITH BASEBOARD ELECTRIC HEAT OR RADIANT CEILING PANELS
HOUSE #24
KEY
SUPPLY DUCTWORK
RADIANT CEILING PANELS
HIGH WALL SUPPLY GRILL
BASEBOARD HEAT
CEILING SUPPLY GRILL
EXHAUST DUCTWORK
FILTERS
HIGH WALL EXHAUST GRILL

SECTION 5

DESCRIPTION OF THE MONITORING PROGRAM

5.1 OVERVIEW OF THE MONITORING PROGRAM

The monitoring program developed for the Flair Homes Energy Demo/CHBA Flair Mark XIV Project had, as its objective, the collection of all relevant data, information and observations required to permit informed commentary upon the performance of the houses in three broad categories: energy performance, the indoor environment and building envelope performance. Although several dozen distinct variables were measured at various times, the monitoring program can basically be summarized as shown in Table 4.

TABLE 4

MONITORING PROGRAM

ENERGY PERFORMANCE	INDOOR ENVIRONMENT	BUILDING ENVELOPE
o Space Heating o DHW Heating o Appliance Energy o Operating Conditions o Air Change Rate	o Air Quality o Pollutant Levels o Ventilation System Operation o Occupancy Characteristics	o Airtightness o Thermographic Performance o Wood Moisture Content

SECTION 6

PROJECT DATA BASE

6.1 DATA BASE

This section summarizes the information contained in the Flair project Data Base. Information collected from the monitoring of the 24 houses was edited, organized and stored for future reference. The data base was produced, and is maintained by, UNIES Ltd. Additional information, beyond that described in this report, was also collected for specific purposes, typically to provide supplementary data to that normally acquired.

6.2 DATA STORAGE FORMAT

Monitoring data was collected during monthly site visits and on various other occasions, depending on the monitoring being performed. Most of the information was stored in hard-copy (i.e. paper) format, however much of the energy consumption and building envelope performance data was also entered into a custom-built electronic data base to facilitate processing, plotting and analysis. This consisted of a fixed length random access file in which each record in the file corresponded to one site visit to a single house. Data records could be added to the file in any order. A directory was automatically maintained so that data for any particular house and date could be located. Another directory, identified as the house definition directory, defined each house for which data was available.

6.3 DESIGN DATA

The following information dealing with the design and construction of the 24 project houses has been produced and stored:

a) HOT-2000 Input Data
- o Houses #1 to #24
- o Storage format: hard copy and electronic

b) Design Drawings
- o Houses #1 to #10: major details only
- o Houses #11 to #24: complete working drawings
- o Storage format: hard copy

c) Mechanical System Operating Descriptions
- o Descriptions of the method of operation of the heating, ventilation and DHW systems
- o Houses #1 to #24
- o Storage format: hard copy

d) Incremental Costs
- o Construction costs for over 100 building envelope and mechanical system options
- o Storage format: hard copy

6.4 BUILDING ENVELOPE PERFORMANCE

The building envelope performance data is organized into three categories: airtightness tests results, wood moisture content data and results of the thermographic surveys.

a) Airtightness Data
- o Monitoring schedule: Table 5 contains the schedule of airtightness tests performed between March 1986 and April 1990
- o Contents: test results and summaries of air leakage locations
- o Storage format: hard copy

b) Wood Moisture Content
- o Monitoring schedule: the wood moisture content of framing members used in various parts of the building envelope was measured during the monthly site visits, as summarized in Table 6
- o Storage format: hard copy and electronic

c) Thermographic Surveys
- o Monitoring schedule: see Table 7, each survey consisted of an examination of the building envelope with any thermal anomalies identified were recorded
- o Storage format: hard copy and electronic (processing software required to read)

TABLE 5
AIRTIGHTNESS TEST SCHEDULE

HOUSE	MAR/86	JUL/86	NOV/86	FEB/87	JUL/87	NOV/87	FEB/88	MAY/88	JUN/88	JUL/88	AUG/88	NOV/88	MAR/89	JUN/89	AUG/89	DEC/89	JAN/90	MAR/90	APR/90
1	X		X	X			X					X	X						
2		X	X	X	X	X	X			X		X	X						
3	X		X	X	X		X						X						
4	X		X	X	X		X			X			X						
5	X		X	X	X		X						X						
6	X		X	X	X		X			X			X						
7	X		X	X						X			X						
8	X		X	X	X		X			X			X						
9	X	X	X	X	X	X	X			X		X	X						
10	X	X	X	X	X	X	X			X		X	X						
11	X	X	X	X	X		X						X						
12	X	X	X	X	X		X			X			X						
13	X	X	X	X	X		X			X			X						
14	X	X		X	X		X			X			X						
15	X	X	X	X			X			X			X						
16	X	X	X	X			X						X						
17	X	X	X	X	X	X	X			X		X	X						
18	X	X	X	X	X	X	X			X		X	X						
19	X	X	X	X	X		X			X			X						
20	X	X	X	X	X		X			X			X						
21																	X		
22								X		X						X			X
23								X	X					X		X			X
24											X				X	X		X	

TABLE 6
WOOD MOISTURE CONTENT SCHEDULE
(READINGS TAKEN MONTHLY)

HOUSE	WALLS	ATTIC	CATHEDRAL CEILING	FLOOR JOISTS
1	APR/86-MAR/89	APR/86-MAR/89		
2	APR/86-MAR/89	APR/86-MAR/89		
3	MAY/86-MAR/89	MAY/86-MAR/89		
4	MAY/86-FEB/89	MAY/86-FEB/89		
5	MAY/86-FEB/89	MAY/86-FEB/89		
6	MAY/86-FEB/89	MAY/86-FEB/89		
7	APR/86-MAR/89	APR/86-MAR/89		
8	APR/86-MAR/89	APR/86-MAR/89		
9	APR/86-MAR/89	APR/86-MAR/89		
10	APR/86-MAR/89	APR/86-MAR/89		
11	AUG/86-MAR/89	AUG/86-MAR/89		
12	JUL/86-MAR/89	JUL/86-MAR/89		
13				
14				
15	OCT/86-FEB/89	OCT/86-FEB/89		
16	MAY/86-FEB/89	MAY/86-FEB/89		
17				
18				AUG/86-MAR/89
19	MAY/86-MAR/89	MAY/86-MAR/89		
20	AUG/86-MAR/89	AUG/86-MAR/89		AUG/86-MAR/89
21	NOV/89-NOV/90		NOV/89-NOV/90	NOV/89-NOV/90
22				
23	NOV/88-APR/90			
24				

TABLE 7
THERMOGRAPHIC SURVEYS SCHEDULE

HOUSE	MAR/86	FEB/87	APR/88	MAR/89
1	X	X		X
2	X	X		X
3	X	X		X
4	X	X		X
5	X	X		X
6	X	X		X
7	X	X		X
8	X	X		X
9	X	X		X
10	X	X		X
11	X	X		X
12	X	X		X
13	X	X		X
14	X	X		X
15	X	X		X
16	X	X		X
17	X	X		X
18	X	X		X
19	X	X		X
20	X	X		X
21				X
22			X	X
23			X	X
24			X	X

6.5 ENERGY PERFORMANCE DATA

Energy and water consumption data and related information were obtained from meter readings and other measurements made during the monthly site visits. In addition, see the sub-sections dealing with Indoor Air Quality and Mechanical Systems.

- o Monitoring schedule: Table 8 contains the monitoring schedule for each house along with the monitoring period and the parameters measured
- o Storage format: hard-copy and electronic

TABLE 8
ENERGY DATA SCHEDULE
(READINGS TAKEN MONTHLY)

HOUSE	ENERGY CONSUMPTION						WATER CONSUMPTION		SPACE CONDITIONS	SOIL THERMAL CONDUCTIVITY
	TOTAL ELECTRICAL	SPACE HEATING	DHW HEATING	APPLIANCES	CAR PLUG	INTEGRATED MECHANICAL SYSTEM	TOTAL	DHW		
1	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
2	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
3	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
4	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
5	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
6	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
7	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
8	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
9	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
10	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89	NOV/85-MAR/89			NOV/85-MAR/89		NOV/85-MAR/89	
11	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89		AUG/86-MAR/89	
12	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89		JUL/86-MAR/89	
13	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89			JUL/86-MAR/89		JUL/86-MAR/89	APR/86-MAR/89
14	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89	JUL/86-MAR/89			JUL/86-MAR/89		JUL/86-MAR/89	
15	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89		AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	APR/86-MAR/89
16	MAY/86-MAR/89	MAY/86-MAR/89	MAY/86-MAR/89	MAY/86-MAR/89		MAY/86-MAR/89	MAY/86-MAR/89	MAY/86-MAR/89	MAY/86-MAR/89	
17	MAR/86-MAR/89	MAR/86-MAR/89	MAR/86-MAR/89	MAR/86-MAR/89	MAR/86-MAR/89		MAR/86-MAR/89		MAR/86-MAR/89	
18	MAR/86-MAR/89	MAR/86-MAR/89	MAR/86-MAR/89	MAR/86-MAR/89	MAR/86-MAR/89		MAR/86-MAR/89		MAR/86-MAR/89	
19	MAY/86-MAR/89	MAY/86-MAR/89	MAY/86-MAR/89	MAY/86-MAR/89	MAY/86-MAR/89		MAY/86-MAR/89		MAY/86-MAR/89	
20	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89	AUG/86-MAR/89		AUG/86-MAR/89		AUG/86-MAR/89	
21	NOV/89-NOV/90	NOV/89-NOV/90	NOV/89-NOV/90	NOV/89-NOV/90		NOV/89-NOV/90	NOV/89-NOV/90	NOV/89-NOV/90	NOV/89-NOV/90	
22	MAY/89-APR/90	MAY/89-APR/90	MAY/89-APR/90	MAY/89-APR/90			MAY/89-APR/90		MAY/89-APR/90	
23	SEP/89-APR/90	SEP/89-APR/90	SEP/89-APR/90	SEP/89-APR/90			SEP/89-APR/90	SEP/89-APR/90	SEP/89-APR/90	
24	MAY/89-MAR/90	MAY/89-MAR/90	MAY/89-MAR/90	MAY/89-MAR/90			MAY/89-MAR/90	MAY/89-MAR/90	MAY/89-MAR/90	

6.6 INDOOR AIR QUALITY

Indoor air quality was monitored by performing periodic measurements of pollutant concentrations and other related variables. Most of the measurements were conducted on roughly a seasonal basis although some pollutants, such as carbon dioxide, were measured during the monthly site visits. Also, see the sub-section dealing with Mechanical Systems.

- o Monitoring schedule: see Tables 9 and 10
- o Storage format: hard-copy

TABLE 9
AIR QUALITY MONITORING SCHEDULE
(EXCEPT CARBON DIOXIDE)

DATE	FORMALDEHYDE	RADON DAUGHTERS	PARTICULATES	NITROGEN DIOXIDE	RELATIVE HUMIDITY	TEMPERATURE	TOTAL AIR CHANGE RATE
MARCH/86	1-10	1-10	1-5, 7-10	2,3,9,10	1-10	1-10	1-10
AUGUST/86	1-20	1-14, 16,17,19,20	1-14, 16,17,19,20				
OCTOBER/86	1-7, 9-20	1-20	1-5, 7-20	2,3,9,10	2-11, 12-20	2-11, 12-20	1-20
FEBRUARY/87	1-20	1-5, 7-12, 14-20	1-5, 7-12, 14-20	2,3,9,10	2-11, 12-17, 19,20	2-11, 12-17, 19,20	1-17, 19-20
AUGUST/87	9,10 13,14 19,20				2,3 5-20	2,3 5-20	9,10 13,14 19,20
OCTOBER/87	1-20	1-3, 5-19	1-3, 5-19		2-20	2-20	1-20
JANUARY/88	1-20	1-13, 15-20	1-3, 5-19		2-15, 17-20	2-15, 17-20	1-20
SEPTEMBER/88	9,10 13,14 19,20						9,10 13,14 19,20
FEBRUARY/89	1-20	1-20	1-20		2-4,6,8, 9,11,12,14-20	2-4,6,8, 9,11,12,14-20	1-20

TABLE 10
CARBON DIOXIDE MONITORING SCHEDULE
(READINGS TAKEN MONTHLY)

HOUSE	CARBON DIOXIDE
1	APR/86-MAR/89
2	APR/86-MAR/89
3	APR/86-MAR/89
4	APR/86-MAR/89
5	APR/86-MAR/89
6	APR/86-MAR/89
7	APR/86-MAR/89
8	APR/86-MAR/89
9	APR/86-MAR/89
10	APR/86-MAR/89
11	AUG/86-MAR/89
12	JUL/86-MAR/89
13	JUL/86-MAR/89
14	JUL/86-MAR/89
15	AUG/86-MAR/89
16	MAY/86-MAR/89
17	MAR/86-MAR/89
18	MAR/86-MAR/89
19	MAY/86-MAR/89
20	AUG/86-MAR/89
21	
22	
23	
24	

6.7 MECHANICAL SYSTEMS

Mechanical system performance was monitored by recording the utilization (i.e. hours of operation) of various systems, coupled with measurements of the air flow rates through the ventilation systems during the monthly site visits. See also the sub-section dealing with Indoor Air Quality.

- o Monitoring schedule: see Table 11
- o Storage format: hard-copy

TABLE 11
MECHANICAL SYSTEMS MONITORING SCHEDULE
(READINGS TAKEN MONTHLY)

HOUSE	HRV UTILIZATION	CENTRAL EXHAUST SYSTEM UTILIZATION	INTEGRATED MECHANICAL SYSTEM UTILIZATION	VENTILATION SYSTEM AIR FLOW RATES
1	MAR/86-MAR/89			MAR/86-MAR/89
2	MAR/86-MAR/89			MAR/86-MAR/89
3	MAR/86-MAR/89			MAR/86-MAR/89
4	MAR/86-MAR/89			MAR/86-MAR/89
5	MAR/86-MAR/89			MAR/86-MAR/89
6	MAR/86-MAR/89			MAR/86-MAR/89
7		MAR/86-MAR/89		MAR/86-MAR/89
8		MAR/86-MAR/89		MAR/86-MAR/89
9				
10				
11			AUG/86-MAR/89	AUG/86-MAR/89
12				AUG/86-MAR/89
13	JUL/86-MAR/89			JUL/86-MAR/89
14	JUL/86-MAR/89			JUL/86-MAR/89
15				
16				
17				MAR/86-MAR/89
18				MAR/86-MAR/89
19	MAY/86-MAR/89			MAY/86-MAR/89
20	AUG/86-MAR/89			AUG/86-MAY/89
21				
22		MAY/89-APR/90		MAY/89-APR/90
23	SEP/89-APR/90			SEP/89-APR/90
24	MAY/89-MAR/90			MAY/89-MAR/90