NORTHERN VENTILATION PROJECT

**DATA COLLECTION AND REPORT
PREPARED FOR
CANADA MORTGAGE AND HOUSING
CORPORATION**

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INTRODUCTION

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BACKGROUND AND ISSUES

The trend towards energy efficient housing has resulted in a drastic reduction in energy losses associated with air infiltration (air leakage). This trend (spearheaded by the R2000 program) has filtered down into all facets of the building industry. The net effect is that houses are being built to tighter and tighter standards despite builders efforts to intentionally do so. Given this current trend it becomes apparent that more and more houses (both new and renovated) will have to incorporate some form of intentional ventilation to ensure adequate air quality.

Mechanical ventilation, in the form of an HRV, is the most familiar form of controlled ventilation in tight houses in southern Canada. The use of HRV's in the north is a relatively new phenomena, and reliable performance data is limited. Recently designers have been looking at Passive Ventilation Systems as an alternative to mechanical ventilation systems for northern and remote areas where electrical costs, maintenance costs and serviceability make mechanical ventilation systems either prohibitively expensive or inappropriate for the market. Reliable data on the performance of this approach to ventilation is also limited.

The Yellowknife HRV project was designed as a real time, real life application of HRV's in Arctic construction. The project also afforded an opportunity to monitor a passive ventilation systems, designed by the Northwest Territories Housing Corporation (NWTHC), and compare its performance to that of the HRV's. From the initial tender documents through construction to operation the project was handled in a normal fashion with no special emphasis on the HRV aspect in relation to other considerations. In the context, the HRV installation is what we would expect to occur in a mass installation strategy for the north.

While it is difficult to act in a non-intrusive mode, every attempt was made to allow the events to unfold as they would in normal project construction. During start-up, no special attention was given to the maintainers other than that which they would normally receive at project completion. In terms of turning the units over to occupants, the same rule was applied in that the tenants moved in through the normal procedures available to the N.W.T. Housing Corporation. Operations and complaints from that point were per the normal course of events. The team was interested in understanding whether or not the units would perform as laboratory and limited test applications have predicted.

The issues surrounding HRV's in the Arctic environment relate to the depth and length of the cold season without much variance from the mean. In many locations, the low temperatures coupled with wind driven snow provide special problems to mechanical systems. At the community level, there is a limited availability of spare parts and expertise required to repair the equipment. For this reason, a passive system was also tested for comparison to the HRV's.

Through all of this, it should be recognized that solutions which may have minor cost implications in southern Canada can have major life cycle cost influences where the logistical considerations of construction and the very high cost of construction trades in the communities play an important part.

OBJECTIVES

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The objectives of the field monitoring are to establish the practical performance co-efficients of the various components in a field environment.

Maintenance level, costs, owner acceptance, repairs and living environment are also part of the evaluation.

With the above in mind, the objectives are stated as follows:

1. To evaluate how HRV's will be incorporated into the normal construction stream in the north.

2. To carry out non-intrusive evaluation of field performance of various air-to-air heat exchangers in typical housing units in the Arctic.

3. To compare the general performance of passive air-to-air ventilation with mechanical air-to-air ventilation alternatives in the Arctic environment.

DESIGN AND INSTALLATION

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SYSTEM DESCRIPTION

The Yellowknife project incorporates four different methods of ventilating the typical northern residents. Because these systems may be installed by construction crews not totally familiar with the details of each unit, it was felt that the project should be tendered in the normal tendering stream, along with all other aspects of the housing project. In order to incorporate such realism, the Housing Corporation of the N.W.T. agreed to allow a section of the specifications to be added to their normal construction tender to include these HRV's and passive ventilation.

Two duplexes were built in Yellowknife on Latham Island and were labeled A and B for one duplex, and C and D for the second.

In Unit A, a Swedish Kantherm HRV was installed in the mechanical room. The Kantherm was chosen because it offered a uniquely different way of providing ventilation and heat recovery. Figure I shows how the unit works. Compared to that found in traditional HRV's the unit was considered attractive for several reasons. These include:

- ORF lab testing had shown net sensible effectiveness in the order of 90% at 0 Degrees Celsius (net sensible effectiveness includes fan energy contribution to the airstream).

- Power consumption for the unit is 70W.

- The defrost test at -20C for 24 hours indicated no apparent problems.

Defrost for the unit is achieved by shutting off the supply side for 10 seconds every 25 seconds. The defrost is initiated by sensing an external temperature. The Kantherm HRV was provided to the Contractor in much the same way that it would be supplied by a typical H and V supplier. Instructions were included with the unit and the typical level of drawings that would be used for such projects were included. No extra attention was given beyond that which would normally produce an acceptable product at final inspection. Sketch SKM-12 and Drawing V1 outline the installation detail, coupled with the Specifications of Appendix D.

Unit B was specified to include the installation of a Lifebreath Model 200 HRV manufactured by NuTech. The Lifebreath was installed in a crawlspace beneath the bathroom. The crawlspace was adjacent to the mechanical room, separated by an uninsulated partition wall. The unit uses an aluminum counter flow heat exchanger core and the unit is driven by two 50 Watt fans. The defrost cycle is initiated when the cold supply temperature drops below -4.5C. The unit goes into a timed defrost cycle, it ventilates for approximately 30 minutes, then defrosts for approximately 2 1/2 minutes. When in defrost, a damper moves, blocking the cold supply air inlet. At the same time, it opens to let warm house air to defrost the core. Both exhaust and supply air streams remain on at all times.

The same level on instructions and specifications were included for the Contractor to install the equipment, as per Unit A. Sketches SKM-16 and Drawing V1 outline the installation detail along with Specifications of Appendix D.

For Unit C, a similar specification was included for a passive ventilation system as suggested by the N.W.T. Housing Corporation. While there are a number of versions of this system, we chose two current versions that could be incorporated. One is a modified below radiation makeup and high peak roof level exhausts, and the second is a standard wall mount pipe grille. Again, no special instructions were given beyond the normal inspection services provided during construction. Sketches SKM-1, 2, 8, 9 and 10 describe the setup while drawing V2 outlines the location of equipment, Appendix D provides Specifications.

For Unit D, an Air Changer DRA150 series unit manufactured by Clawsey-Short was installed in a similar fashion to the Lifebreath unit. The unit uses a polypropylene copolymer plastic heat exchanger core and the unit is driven by a 60 Watt fan. The defrost cycle is achieved by shutting down the supply air in response to a temperature sensor in the warm air supply side. Defrost duration is controlled by a 30 minute time delay and the temperature differential of the defrost control. Similar specifications and drawings were included for the Contractor, and the same level of supervision per the other units was provided. See Appendix D for Specifications and Sketches SKM-15 along with Drawing V2.

Table 1 is a summary of the manufacturers performance data for the Kantherm, Lifebreath and Air Changer respectively.

DESIGN SPECIFICATIONS

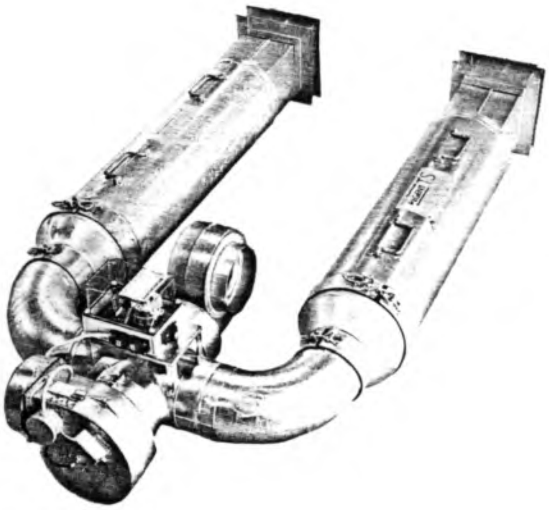
The specification that was incorporated in the tender documents is included as Appendix D. Sketches outlining the installatin of the air-to-air exchangers are incorporated as Appendix A. Drawing V1 and V2 relate the systems and sensors and are included as Appendix B. Full drawing sets of the project are available from the Northwest Territories Housing Corporation in Yellowknife.

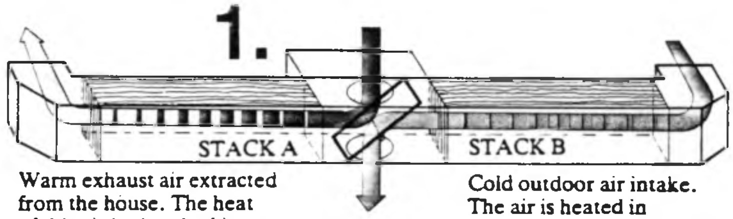
TABLE 1: Latham Island Ventilation Project

HRV Performance Data

UNIT	MANUFACTURER	MODEL	SUPPLY TEMPERATURE (C)	NET AIRFLOW (L/s)	AVERAGE POWER (WATTS)	SENSIBLE RECOVERY EFFICIENCY	APPARENT SENSIBLE EFFECTIVENESS
A	Regent	Kantherm TS200	0	55	70	78	N/A
			-25	N/A	N/A	N/A	N/A
B	Lifebreath	NuTech 200 Max	0	56	100	60	67
			-25	55	100	59	69
D	Air Changer	DRA150	0	55	85*	76	84*
			-25	57	72	57	79

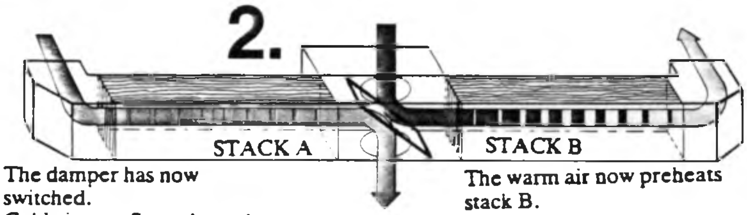
* Value interpolated from Energy Performance Data to allow comparison.





Warm exhaust air extracted from the house. The heat of this air is absorbed in stack A.

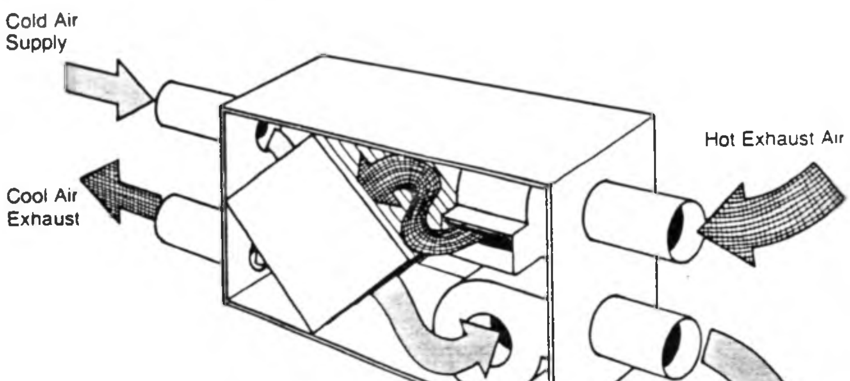
Cold outdoor air intake. The air is heated in preheated stack B which is thus cooled.

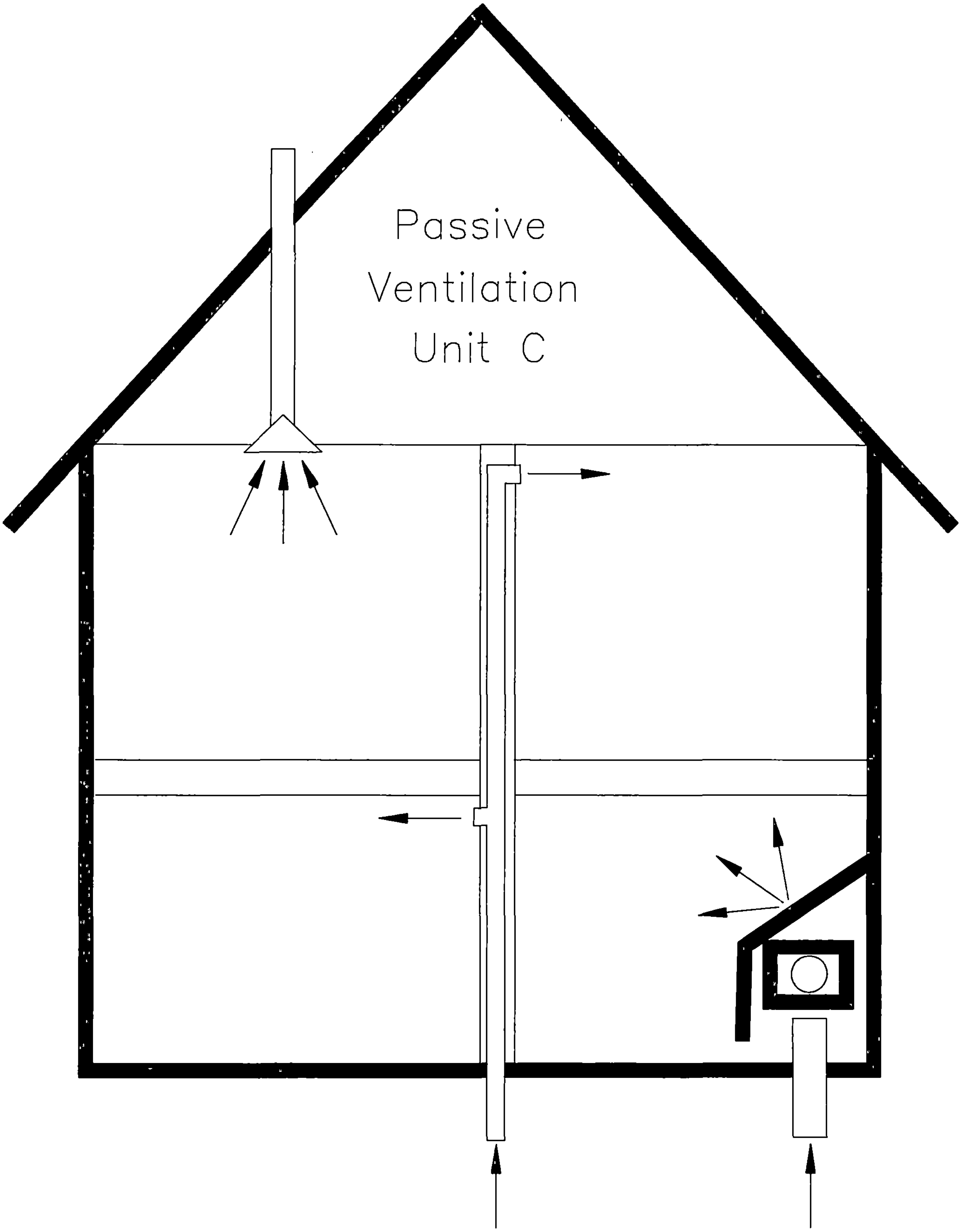


The damper has now switched.
Cold air now flows through stack A and is heated.

The warm air now preheats stack B.

Damper positions 1 and 2 are repeated at intervals of approx. 1 min.





See Appendix A — Sketches SKM1, 2, 8, 9, and 10

MONITORING PACKAGE AND INSTRUMENTATION

MONITORING PACKAGE AND INSTRUMENTATION

YELLOWKNIFE SYSTEM

The monitoring package includes an Electronic Measuring Systems (EMS), to convert various transducer outputs to a digital form on an RS232 Bus, suitable for manipulation by a computer.

For the Yellowknife project, output from the electronic measuring system is delivered to a modem module with buffer capability. The output is transmitted directly by telephone wires to a centrally located computer in Yellowknife. The central computer interrogates two EMS units directly so that PC computers are not required on site at the project. In this way, continuous monitoring takes place without disturbing the tenants and verification of the data stream can be made at any time from the project centre. Data collected is stored on hard disk and archived for the entire test period. Total records collected exceed 30 megabytes.

Software was developed to remotely control the Electronic Measuring System which is capable of measuring all types of transducer outputs. Multipliers and constants were incorporated into the program output for direct recording to disks.

To compliment the data storage, a data analysis program was developed, which allows manipulation of the output data in any form desired, including standard deviations, statistical averages, instantaneous measurements, graphical output by minute, hour, day, average for the month, year, tabulated data for spreadsheet or database.

Flexibility in analysis of the output is a key element for this style of research as trends over specific periods are best viewed in graphical form initially, with subsequent statistical analysis through spreadsheets or other digital methods once the patterns are established.

The Yellowknife ventilation project is a subset of a more comprehensive heating, ventilation and building environment demonstration project conducted in the two duplexes. The performance of various heating options are presented under a separate report.

A list of the relevant equipment and sensors is included in Appendix C.

Table 2 is a list of measurements relevant to the ventilation project.

TABLE 2: List of Sensors for Yellowknife Ventilation Project

Unit A: Kantherm TS200

CH	DESCRIPTION	SENSOR ID	UNITS	TYPE OF SENSOR
2	Bedroom 1 Temperature	TE2	Celsius	AD590
3	Bedroom 3 Temperature	TE3	Celsius	AD590
5	Bedroom 2 Temperature	TE5	Celsius	AD590
28	Katherm Exchanger Supply/Exhaust Temperature	T6	Celsius	AD590
29	Kantherm Fresh/Stale Air Temperature	T5	Celsius	AD590
48	Bathroom Temperature	T4H4	Celsius	Alpha
49	Bathroom RH	T4H4	%	Alpha
61	Mechanical Room Temperature	T3	Celsius	AD590
62	Mechanical Room Temperature	T4	Celsius	AD590

Unit B: Lifebreath 200 Max

CH	DESCRIPTION	SENSOR ID	UNITS	TYPE OF SENSOR
1	Bedroom 1 Temperature	TE1	Celsius	AD590
4	Bedroom 3 Temperature	TE4	Celsius	AD590
6	Bedroom 2 Temperature	TE6	Celsius	AD590
32	Bathroom Temperature	T3H3	Celsius	Alpha
33	Bathroom RH	T3H3	%	Alpha
36	Velocity of Stale Air From House	F2	Ft/Min	EDRA5
37	Velocity of Fresh Air Flow To House	F3	Ft/Min	EDRA5
50	Stale Air Temp. To Outside	T8	Celsius	AD590
51	Fresh Air Temp. To House	T9	Celsius	AD590
52	Stale Air Temp. From House	T10	Celsius	AD590
53	Fresh Air Temp. From Outside	T11	Celsius	AD590
61	Mechanical Room Temperature	T3	Celsius	AD590
62	Mechanical Room Temperature	T4	Celsius	AD590

Unit C: Passive Ventilation

CH	DESCRIPTION	SENSOR ID	UNITS	TYPE OF SENSOR
66	Bedroom 1 Temperature	TE1	Celsius	AD590
67	Bedroom 3 Temperature	TE3	Celsius	AD590
69	Bedroom 2 Temperature	TE5	Celsius	AD590
71	Passive Vent Exhaust Flow Rate	F5	Ft 3/Min	
78	Bathroom RH	T4H4	%	Alpha
79	Bathroom Temperature	T4H4	Celsius	Alpha
94	Top Hall RH	T6H6	%	Alpha
95	Top Hall Temperature	T6H6	Celsius	Alpha

Unit D: Air Changer DRA150

CH	DESCRIPTION	SENSOR ID	UNITS	TYPE OF SENSOR
65	Bedroom 1 Temperature	TE1	Celsius	AD590
68	Bedroom 3 Temperature	TE4	Celsius	AD590
70	Bedroom 2 Temperature	TE6	Celsius	AD590
80	Fresh Air Temp. From Outside	T8	Celsius	AD590
81	Stale Air Temp. To Outside	T9	Celsius	AD590
82	Fresh Air Temp. To House	T10	Celsius	AD590
83	Stale Air Temp. From House	T11	Celsius	AD590
93	Velocity Of Fresh Air Flow To House	F3	Ft/Min	EDRA5
96	Velocity of Stale Air From House	F2	Ft/Min	EDRA5
110	Top Hall RH	T6H6	%	Alpha
111	Top Hall Temperature	T6H6	Celsius	Alpha
112	Hybrid Ventilation Supply	F1	Ft/Min	EDRA5
115	Duct Temperature	T6	Celsius	AD590
116	Heat Exchange Duct	T2	Celsius	AD590
126	Bathroom RH	T3H3	%	Alpha
127	Bathroom Temperature	T3H3	Celsius	Alpha

SUMMARY OF DATA COLLECTION

SUMMARY OF DATA COLLECTION

Data was collected from October through April and exceeds thirty megabytes of information. With such a large number of records, a great level of detail was obtained and is digitally available for review. For the purposes of analysis, the data was essentially continuous. It should be recognized that there are several levels of data reduction to arrive at the numbers presented here. Since the entire data base is digitized and accessible on a single computer, it is possible to consolidate, verify standard deviations, graph, plot and correlate the information in many contexts.

Tables 1 and 2 outline the compiled summary of the variables used by Unit and by Channel respectively. These may be cross referenced to Drawings V1 and V2. Table 3 is a monthly summary of the data collected from October to April.

Where possible, the data base was used in an iterative process to convert sensor inputs to metric (where applicable), to calculate functions and instantaneous values for the variables to accumulate the desired output. This was done using a 386 based computer with math co-processor to make the task practical.

Custom programs were written to carry out the analysis and findings section, with the output discussed in the data analysis subsection, engineering performance.

TABLE 3: Summary of Raw Data

Unit A: Kantherm

Building Environment

	NOVEMBER	JANUARY
Bedroom 1 Temperature	28.9	30.6
Bedroom 2 Temperature	27.4	29.4
Bedroom 3 Temperature	26.9	28.2
Bathroom Temperature	25.4	26.0
Bathroom RH	54%	47%

UNIT B: NuTech

Ventilation System

Exhaust Air Flow Rate (fpm)	407	457	Flow Area=6"
Supply Air flow Rate (fpm)	515	546	Flow Area=6"
Exhaust Air Temperature Before Heat Exchanger	32.3	34.1	
Exhaust Air Temperature After Heat Exchanger	13.2	6.4	
Supply Air Temperature Before Heat Exchanger	4.1	-5.2	
Supply Aire Temperature After Heat Exchanger	21.7		
Outdoor Temperature	-7.0	-19.9	
Mechanical Room Temperatures	40.0	40.4	

Building Environment

Bedroom 1 Temperature	31.2	32.2
Bedroom 2 Temperature	32.6	32.5
Bedroom 3 Temperature	31.2	32.0
Bathroom Temperature	27.1	27.5
Bathroom RH	25%	14%

Unit C: Passive Ventilation

Ventilation System

	NOVEMBER	JANUARY
Exhaust Air Flow Rate (cfm)	25.5	55.9
Outdoor Temperature	-7.0	-19.9

Building Environment

Bedroom 1 Temperature	27.9	28.6
Bedroom 2 Temperature	28.3	28.8
Bedroom 3 Temperature	28.6	29.2
Bathroom Temperature	26.5	26.0
Bathroom RH	52%	36%
Top Hall Temperature	27.0	25.8
Top Hall RH	48%	35%

Unit D: Air Changer

Ventilation System

Exhaust Air Flow Rate (fpm)	441.9	587	Flow Area=6"
Supply Air Flow Rate (fpm)	667.6	483.8	Flow Area=6"
Exhaust Air Temperature Before Heat Exchanger	26.8	27.7	
Exhaust Air Temperature After Heat Exchanger	9.2	17.2	
Supply Air Temperature Before Heat Exchanger	-8.3	-20.1	
Supply Air Temperature After Heat Exchanger	18.8	21	
Outdoor Temperature	-7.0	-19.9	

Building Environment

	NOVEMBER	JANUARY
Bedroom 1 Temperature	26.1	28.4
Bedroom 2 Temperature	27.6	30.3
Bedroom 3 Temperature	28.7	32.4
Bathroom Temperature	24.3	24.2
Bathroom RH	28%	14%
Top Hall Temperature	24.2	24.9
Top Hall RH	25%	13%

DATA ANALYSIS AND FINDINGS

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METHODOLOGY

The HRV's and passive system were located as shown in Appendix A and Appendix B. Engineering evaluation consisted of monitoring the units under varying conditions from October 1987 to May 1988. Table 4 lists variables monitored by unit and their minimum, maximum and average values over the monitoring period. It also shows the number of records and the table is cross referenced to Sketches 1 and 2. For the purposes of cross reference, Table 5 lists some information for sensors listed by channel. Worksheets 1 and 2 in the Table section compile the data for the test period.

The field evaluation of the ventilation options are presented on two levels. The first level is a month by month summary of the energy requirments, efficiencies and building environment performance for each system. The second level is amore in-depth analysis of the dynamic performance of the ventilation options in moderate and severe Yellowknife conditions. For this purpose the months of November, 1987 and January, 1988 were used.

ENERGY REQUIREMENTS

The total sensible energy rate requirments for the ventilation systems were calculated for each sampling as follows:

W(total)=K*Q(max)*(T(3)-T(1))

where:

W(total) =Watts (sensible) input required
Q(max) =Greater outflow/inflow from/to dwelling, CMS(Cu. Meters/Sec)
T(3) =Average dwelling temperature, Celsius
T(1) =Outside air temperature, Celsius
K=A dimensioned constant to account for the use of mixed units as recorded and calibrated by the transducers in the ducts.

For the above equation K=1207 Watts/CMS - Degrees Celsius for standard air.

The net sensible dwelling energy input for the four systems were caluclated as the difference between recovered (sensible) heat and subsequent makeup by the dwelling to the average space temperature for each sampling as follows:

W(inc)=K*[Q(max)*(T(3)-T(1))-Q(s)*(T(2)-T(1))] where:

W(inc)= Incremental watts (sensible) input required by dwelling.
Q(max)= Greater of outflow/inflow to/from dwelling, CMS
Q(s)= Supply flow to unit, CMS
T(1)= Outside air temperature, Celsius
T(2)= Fresh air supply to dwelling, Celsius
T(3)= Average dwelling temperature, Celsius
K= A dimensioned constant to account for the use of the mixed units as recorded and calibrated by the transducers in the ducts.

For the above equation, K=1207 Watts/CMS - Degrees Celsius

Heat Recovery Performance

The performance of the HRV's were evaluated in two ways using equations similar to those derived for laboratory evaluation. These are:

-Senisble Heat-Recovery Efficiency
-Apparent Effectiveness

Sensible Heat-Recovery Efficiency

In laboratory tests, sensible heat recovery is generally used to determine and compare HRV recovery performance. Sensible Heat Recovery Efficiency takes into account the total energy that must be added to the dwelling, including that associated with leakage through the envelope for which there is no heat recovery. Factors such as casing heat gains and cross leakage contamination which can be isolated in the lab, could not or were not measured in the field, and as such, interpretation of field results must take these factors into account. Second, laboratory tests are conducted under controlled constant supply and stale exhaust air temperatures and relative humidities. The temperatures and relative humidities in the field, however, are not constant and application of the standard performance equations then take into account this dynamic behaviour in the environment. Thus, caution must be taken when comparing field performance values to that measured in the lab.

The Sensible Heat-Recovery Efficiency is defined as follows:

$$E = \frac{M(s) * (T(3) - T(2))}{M(max) * (T(3) - T(1))}$$

where:

E is the Sensible Heat-Recovery Efficency integrated over time.
M(s) is the supply air mass flow rate
T(3) is the average room temperature
T(2) is the supply air temperature after heat recovery
T(1) is the outside air temperature

M(max) is the greater of inflow or outflow mass flow rates.

The value can also be derived directly from the energy requirement analysis as follows:

$$E = \left(1 - \frac{(Winc)}{(Wtotal)}\right) * dt$$

where Winc and Wtotal are defined above.

Apparent Effectiveness

The apparent effectiveness is defined as follows:

> The ratio of actual heat transfer to the thermodynamically limited maximum heat transfer possible in a counter flow unit of infinite transfer area.

This value is generally used to evalute the heat transfer medium (core) and predict final delivered temperatures.

As for Sensible Heat-Recovery Efficiency, the value measure in the lab is under controlled constant interior and exterior conditions. The results presented in this analysis reflect dynamic conditions, and thus should be interpreted in this context.

The apparent effectiveness is caluclated as each measurement of temperature and flow are sampled by the system and converted to a watts rate recovery.

The formula used to calculate the effectiveness is as follows:

$$E = \frac{M(s)*(T1-T2)}{M(min)*(T1-T3)}$$

where E = apparent heat effectiveness,

and:

T1= Fresh air temperature from outside entering HRV
T2= Fresh air temepratture to dwelling leaving HRV
T3= Stale air temperature from dwelling to HRV
M(s)= Air mass flow rate of supply
M(min)= The lesser of supply or exhaust mass flow rate.

Cross Leakage

Cross Leakage introduces a practical unknown that exceeds the error introduced by sensible versus total effectiveness. The Kantherm (Regent) in dwelling A has an inherent cross leakage at each damper swing, as well as the potential for damper leakage due to the mechanical nature of the damper operation. The tendency of leakage/bypass flows on this HRV is to recirculate that stale unit air (under positive pressure relative to the dwelling at the damper) back to the inlet of fresh air fan (under relative negative presssure) in a closed loop. Application of the above formula may give an apparent high effectiveness for the unit under such circumstances. This caution is included as flow measurements were based on the fans supply (and/or exhaust) flows to/from the dwelling side (due to unreliability of the hall effect flow transducers at low temperatures), and not absolute supply and exhaust quantities to the outside.

Duct Gains

Duct gains is the energy absorbed by the air flowing in the duct from the surrounding air. The greater the temperature difference between the innner and outer air the greater the rate of energy absorbtion by the colder air. This effect was more prominent in the NuTech HRV than in the Air Changer and has an impact on this comparative performance. The impact would be that the NuTech efficiency would appear lower than in actuality, if no duct gains were occurring.

Flow Volume Corrections

The flow volumes were adjusted for calculation purposes to account for mass/volume (density) variances at the wide temperature ranges of our recorded data. To trend the density effect reasonably for the overall experiment so that standard K (constant density) could be used, the volume flow was corrected to T(3), the warmer temperature. For example, if measured at the temperature T(2), the equation would be:

$$Q(T3) = Q(T2) \times T(3)/T(2)$$

where:

Q(T3)= Volume flow corrected to T(3) (near standard)
Q(T2)= Volume flow recorded at T(2), outside temperature
T(3)= Near standard temperature (house side of system)
T(2)= Temperature at which flow volume Q(T2) is measured.

Because the above equation is ration based, any unit group may be used, as long as they are consistent on both sides of the equation.

Passive System Efficiency

Passive System Efficiency for the passive system is, of course, zero, because of this, the elemental comparison for the four systems was based on net energy requirements, ie, subsequent make up by dwelling to the average space temperature. This was done for the dwellings as actually operated and observed.

For fundamental screening, relative humidities were used as the guide to acceptable performance, without regard for the variances in the air change volumes observed amonginstallations.

Comparative Performance

For a final comparative analysis, extrapolation of the calculations and computer derived output was adjusted to a fixed air change in order to assess long term operating costs of the alternatives.

For purposes of comparison, the relationship:

W-Hr net/ac/d = (W*Vol/Mah + E)/(Tda - Toa)

where:

W-Hr net/ac/d = net Watt-hours/air change added by dwelling based on temperature difference between Toa an Tda
W= Watt average net input by dwelling system for the air change
Vol= Mass of dwelling air volume
Tda= Average dwelling temperature for the air change
Toa= Average outside temperature for the air change
Mah= Average mass of air/hr brought into dwelling for the air change
E= Electrical energy consumed by HRV for the air change

All of the formula calculations were handled by the computer as part of a global iteration process on the databases. The nth iterative delta-time was calculated as an average lapse of all the sensors measured (for that equation) since the n-1 iteration. This approach worked well for the warmer outside tempertures (above -10C), but is less accurate for the lower temperatures as the HRV's cycled at a defrost frequency that was of a lower order than the sampling time for the system to collect all the variables. Graphs 3, 4, 7, and 8 of HRV activity point out the problem. Therefore, the efficiencies as iterated for the lower temperatures may be less reliable than those calculated for the warmer outside air temperatures (above -10C).

ENGINEERING PERFORMANCE

The discussion carried out under this section refers to such data and is based on the detailed collection done over the life of the project.

The Kantherm HRV was erratic in its performance. It is recognized that the unit was abused at the time of installation, and feel the data obtained is not sufficiently representative to either approve or reject this unit. Graph 1 outlines the operating problems of this unit during the month of January. It is noted that the unit did not appear to be operating properly during the test period.

The engineering performance discussed in this section follows the approach outlined in the Data Analysis and Findings section.

Energy Requirements

As outlined in the previous Data Analysis and Findings section, to assess the HRV's and the passive ventilation on a common basis, the NET dwelling system input was chosen. Relative humidity was used as a comparative guide to effectiveness on an "as used" basis without controlled input by the project monitors. Finally, the systems were evaluated on a common basis related to air change as developed previously, and summarized in worksheets 1 and 2.

Graphs 8 through 13 show the net energy requirements for the systems (excluding electrical), while Graphs 14 and 15 relate the common relative humidities in the bathrooms for the same periods. For both November and January, the RH measurements for the Air Changer and the NuTech track very closely and rise and fall in phase with the outside temperature. The passive system operated in the 50% range during November, and in the 30% RH range during January. The tracking of the passive system with the outdoor temperature is direct, but not as sharply defined as the mechanical systems and slightly lagging in phase.

Operation of the Kantherm unit was not consistent, nor was it's operation continuous. Coupled with the fact that there were two young children and a mother at home all day made this unit operate at the highest humidity levels of the Project. The lowest average RH levels were recorded for the Air Changer and NuTech HRV's, giving levels less than 20% for winter conditions. These units had a single mother with two school aged children and a couple with two school aged children respectively.

The optimum RH performer was the passive system, averaging 30 - 35% during January. This unit has a couple of two school aged children, one baby and two grandparents at home. It was however, the most extensive to operate per Worksheet 1.

Of life cycle costing importance is the net energy requirements for the various system. Worksheet 1 reduces the computer data to a common basis of Watts/Air Change/Deg.. Since each dwelling has identical volumes, this comparison is consistent for common evaluation of both HRV's and Passive systems. This worksheet combines the electrical energy and heating energy required for each alternative, based on current Yellowknife costs. Note that costs increase as temperature falls, even though the apparent efficiency reads higher.

Excluding life-style considerations, the heating flux per duplex was computed as 6083 Wh/Deg. day (excluding solar). Actual heating consumption for the Kantherm and NuTech duplex was 5506 Wh/Deg. day for January, which essentially excludes solar due to sun angle at the time. For the duplex containing the Passive and Air Changer, the January flux was 5684 Wh/Deg. day. Graph 16 summarizes the duplex energy consumption. The calculated value assumes no heat recovery and 0.5 air change/hour.

Note that these comparisons should be viewed in a relative context, as the HRV's spent considerable time in defrost cycle during January, as a frequency that was as fast or faster than our sample rate.

Apparent Effectiveness

The data selected to show the apparent effectiveness covers the mild winter conditions and the firm winter conditions (November and January).

A look at Graph 2 shows that for temperatures in the +8 to -20 degrees Celsius range, the air changer's apparent effectiveness is slightly better than the NuTech unit. Toward the end of November in a warm spell, the NuTech does manage to marginally outperform the Air Changer. Both units perform in the 70-80% range for the month, with the Air Changer reaching peaks in excess of 85%. The rise and fall of the Air Changer curve reflects a variance in the exhaust side flows related to interaction of the system to Hybrid heating arrangement and window opening during the warmer days.

For the Kantherm unit, the data was indeterminate. The problems with the spot measurements causes the apparent efficiency to calculate erratically, and is not a realistic assessment of the thermodynamics taking place. Because of the nature of the Kantherm, a dedicated fast sampler should be used capable of continuous integration of the exponential fall and rise of the exhaust and incoming air in order to provide reasonable iterations. As stated previously, the computer calculations for the Kantherm are not shown in order to avoid misrepresenting the unit's apparent efficiency. Manual observation of the unit indicated that the apparent efficiency (when operating) was similar to that of the Air Changer.

To show the detailed operation of the HRV's in November, 24 hour computer Graphs 3 and 4 of the raw data for a November day for the NuTech and Air Changer are included. Noted that the units operate more or less in a balanced steady-state, and the performance is as one would expect from the literature.

Graph 5, showing January's apparent effectiveness for the HRV's, has outside temperatures ranging from -10 to -40 degrees Celsius. With the exception of two test bumps of the Hybrid system's fresh air on the 06th and 20th of January, the Air Changer is superior, averaging 80%. The Air Changer's apparent efficiency increases as the temperature falls, as expressed by November versus January's data. The NuTech unit shows very little change from November to January. The apparent efficiency data overstates the energy impact of both units, as worksheets and two of the tables show.

The apparent efficiency should be approached with some caution, as the 24 hour raw data Graphs 6 and 7 indicate. Graphs 6 and 7 show the frantic cycling that occurs at Arctic design temperatures, compared to the same Graphs 3 and 4 for November. These frequent defrosting cycles distort the true effectiveness because of the crossover effect, as well as this the high mechanical space temperatures (averaging in the mid 40's Celsius) contributed to the heat gain through duct gains. Micro calculations indicate that apparent efficiency under these conditions can be in error. To accurately assess such errors requires more sophisticated equipment that that used for this project.

CONSTRUCTABILITY

In our construction architectural/engineering experience, none of the mechanical HRV's appeared difficult or technically complicated to install. However, (in the north at least) the housing industry may not always attract the same level of mechanical expertise as other infrastructure and public building projects.

It was therefore surprising to see the apparent difficulty that the mechanical subtrade had on this project. The Kantherm HRV in Unit A appeared to create problems, and in fact, the unit was damaged in the process of installation. Before final construction, due to circumstances beyond the General Contractor's control, the Mechanical SubContractor went into receivership. The Kantherm unit appeared to be a problem to this particular contract.

The NuTech HRV posed less of a problem to the same Contractor in that it is essentially contained in one box. However, he did manage to reverse the outlets and appeared somewhat at odds with the meaning of stale air from the house and stale air to outside versus fresh air from outside and fresh air to the house. Again, the issues seem straightforward to us, but we are pointing this out as there will, no doubt, be air-to-air heat exchangers that will never operate properly because of such action.

The passive ventilation system did not appear to present problems in construction to the Contractor.

In Unit D, by the time the SubContractor had installed the NuTech unit, the Air Changer unit installed smoothly.

From a constructability, perspectiver, therefore, the passive ventilation system was the easiest to install and without a doubt, the most foolproof during the installation. It had no moving parts.

COST ANALYSIS

The price comparisons given here relate to the costs incurred at the time of tender in 1986.

The costs for Unit A, the Kantherm Unit, are estimated at $1,900.00. The value is estimated because the unit was supplied by Ontario Research. The fact that the unit is connected in three pieces contributes incrementally to the labour component of the installation.

For Unit B, the NuTech Exchanger, the installation and capital costs were $1,490.00. This Unit could be considered a middle-of-the-line solution.

The Air Changer Unit was slightly more expensive but similarly in terms of labour and cost $1,580.00 to install.

For the Passive System of Unit C, the incremental costs for the installation was $350.00.

From an operating point of view, Worksheets 1 and 2 outline the relative operating relationships. In Worksheet 1, the costs were taken at a typical Yellowknife price. The cost per air change is $0.21 for the Passive System, while the NuTech was $0.068 and the Air Changer was $0.059 at design conditions (-40C). Thus, the Passive System was approximately twice as expensive to operate as the HRV approach, even when electrical costs were considered at the rates shown.

Worksheet 2, the compiled data summary for a remote community where the electrical costs are much higher ($0.55 for the example), shows that the costs remain in approximately the same ratio as long as the fuel costs increase in proportion to the electrical. The HRV's performed less air changes at colder temperatures and thereby use more electricity per air change, thus increasing their total cost per air change. The more remote communities have a slightly smaller margin between the Passive System and the HRV systems due to the influence of the electrical cost component.

RELIABILITY

All of the mechanical HRV's worked well above the freezing point. None of the mechanical HRV's operated well (in their defrost modes) below -20 degrees Celsius. Upon inspection, each unit in the colder periods had frosted cores and rim ice. This year, we experienced higher than average snowfall and wind, and it was noted that the heat recovery units were unable to clear driven snow from the coils. Blockages that occurred on the fresh air side of the system in general, would not clear without manual thawing procedures.

The systems installed in the Yellowknife units were to be controlled by the occupants or maintainers. Although the tenants were advised that the speeds could be varied no observable attempt was made to control either humidity levels or air flow volumes by manipulating the HRV speed or seasonal adjustments.

The Kantherm HRV had to be shut down during the cold part of January as the air being delivered to the unit was far too cold and was deemed uncomfortable by the tenants. The flow divider did not operate properly.

The Passive System of Unit C operated without interference. However, at design conditions, there was some ice buildup on the exhaust vents at the roof similar to that found on plumbing stacks. This tended to "flat rate" the air changes of the Passive System at lower temperatures.

MARKET ANALYSIS

In reviewing the systems, the Passive ventilation system warrants further investigation, especially if the acceptable air change rate can be kept below 0.5 air changes per hour. Given that such can be accomplished, the reliability of operation is good, with the exception of frosting of the vent at very cold conditions. Further investigation needs to be carried out in this area.

The Kantherm unit was not properly tested due to operational problems, and reflects the nature of all HRV's in that they are mechanically complex in terms of controls and operation. Given that the increased defrost cycling at lower temperatures does not appear to adversely affect the space environment, it is practical to assume that HRV's can work in the extreme Arctic environment. The problem with the mechanical units relate to maintenance and the overhead price that is hidden from this analysis in terms of man-hours and man-years of maintenance staff required to carry out a program to look after such units on a large scale in public housing. Considering that the cost of operating the Passive System at approximately 1/2 air change per hour for the winter season is less than $300.00, the Passive System appears to be attractive in the current cost environment.

OTHER RELEVANT FINDINGS

We noticed that as the temperature dropped, the apparent efficiency of the HRV's increased but the cost of operation also increased. In reviewing the computer iteration process to calculate costs, it is revealed that although the instantaneous efficiency increases with the larger delta temperature, the increase in defrost cycle time drives up the electrical costs for the same quantity of outside air, and imbalances in flow become most pronounced.

In publicly occupied units, there is generally little interest display in the mechanics of the dwelling. Because of this, it is apparent that a large scale introduction of HRV's would require an increase in staff at the community level to account for proper operation of these units.

All of the mechanical units appeared to have a certain amount of the air that would bypass the exhaust to fresh air side directly. In addition, the intake runs for the units would pick up some heat from the mechanical spaces which, under certain circumstances, could lead to a false reading of efficiency for the closed system. It is very difficult to achieve a continuous balance between the supply and exhaust flows of the HRV's at all operating points because of the build up of rime ice on the exhaust and ingestion of snow on the intake. The Kantherm unit has a possible leakage problem on the bypass damper which behaves similarly to the crossover problems of the conventional HRV's, but the outside filters auto-clean due to the reversing action of the flows.

For the conventional HRV's, the intake filters and screens suffered from the ice fog hoar frost build up, typical of all fresh air intakes. This continuous build up at the outside wall is a problem of equal magnitude to the passive vent icing on the out flow.

RECOMMENDATIONS AND CONCLUSIONS

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RECOMMENDATIONS

1. It is recommended that further investigation be carried out on the Passive Ventilation System for the high Arctic. Given the potential of stack effect at design conditions for a typical Arctic community, this approach has merit.

2. It is recommended that the designers of HRV's look at the operation of the units at the minus 30 degree Celsius range, with a view to maintaining balanced flows and effective defrost designs. Because of the high cost of electricity in the Arctic, it is recommended that defrost be achieved by other than electrical means.

3. It is recommended that the Kantherm unit be retested using a dedicated fast sampler monitoring system at the extreme design conditions of the Arctic. As the unit was part of a larger sampling, the sample rate was not sufficiently fast to accurately assess this dynamic system.

CONCLUSIONS

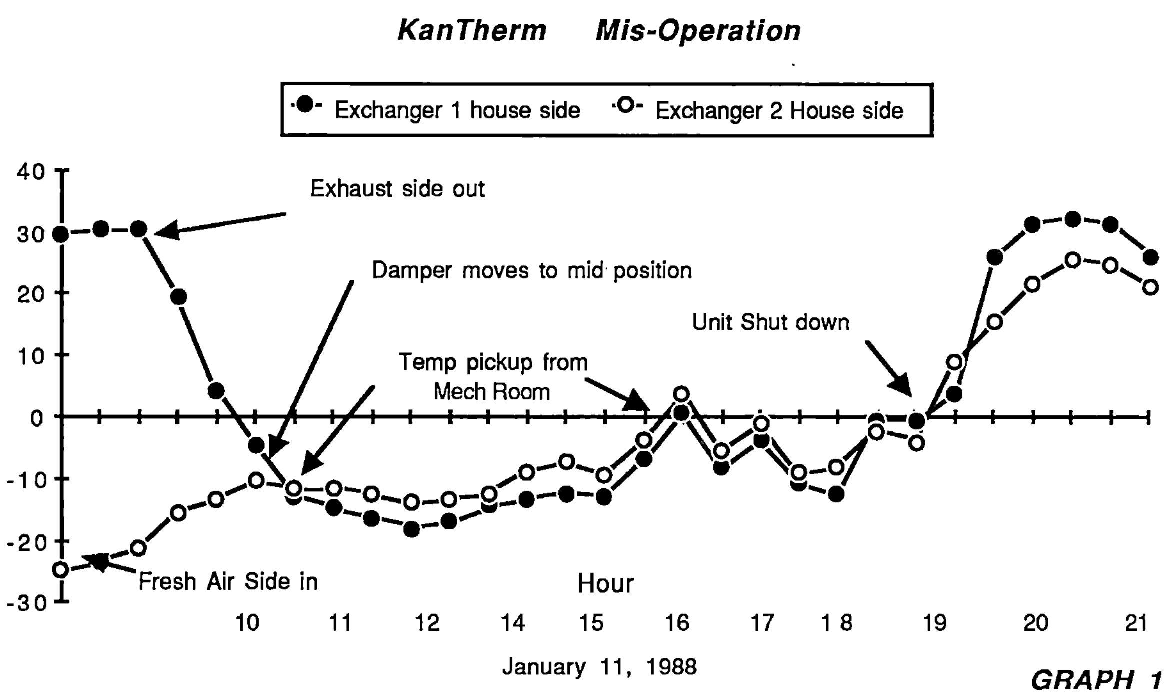
It is concluded that effective relative humidities can be maintained in a dwelling space with air changes of 1/4 per hour as delivered by the Passive system. Given that such a rate of change is sufficient, the incremental costs in unit operation is sufficiently low to warrant its' application at this time.

Considering that the relative humidities of Unit A were slightly high with the Kantherm off, it is concluded that some form of air change is required in the units to maintain humidity control. Given that the Passive system kept the humidity levels reasonable, considering the number of inhabitants in the dwelling full time, it is apparent that the volumes required for humidity control are quite low.

HRV's operate more effectively than a Passive system even in a high defrost/operation ratio, and high electrical costs. The consideration to use HRV's must also account for increased labour for an effective maintenance program.

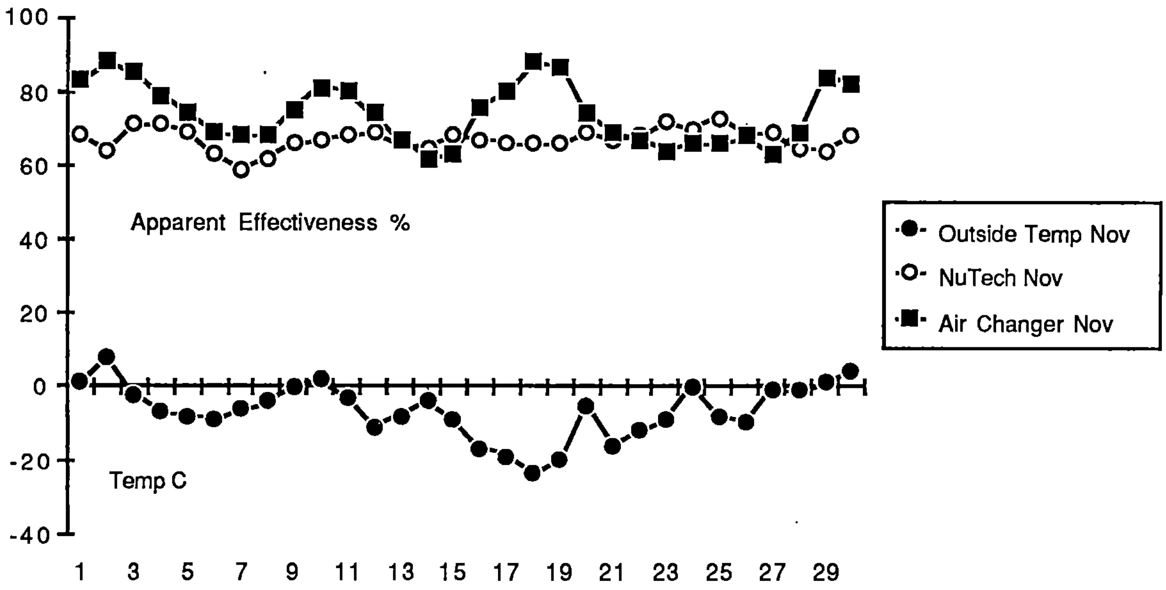
ATTACHMENTS

GRAPHS


KanTherm Mis-Operation
Exchanger 1 house side
Exchanger 2 House side
40
30
20
10
0
-10
-20
-30
Exhaust side out
Damper moves to mid position
Unit Shut down
Temp pickup from
Mech Room
Fresh Air Side in
Hour
10
11
12
14
15
16
17
1 8
19
20
21
January 11, 1988

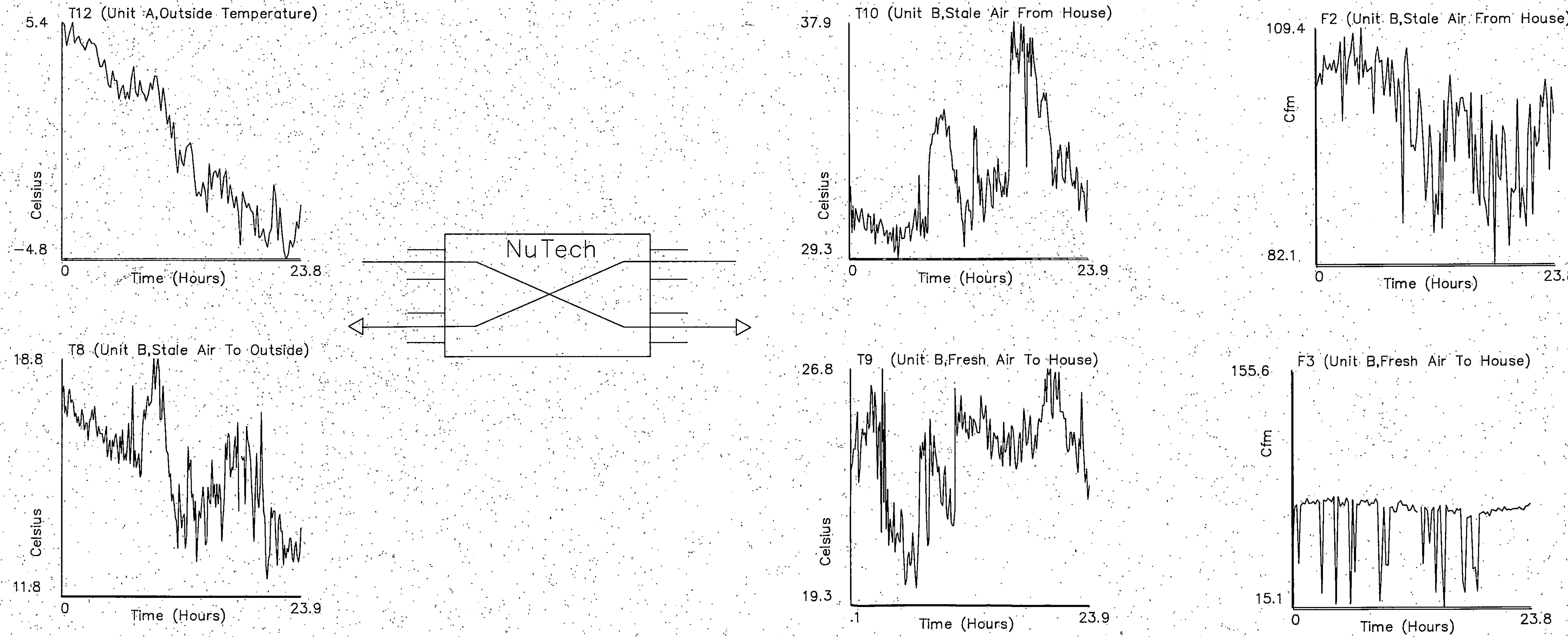
GRAPH 1

Apparent Effectiveness November '87



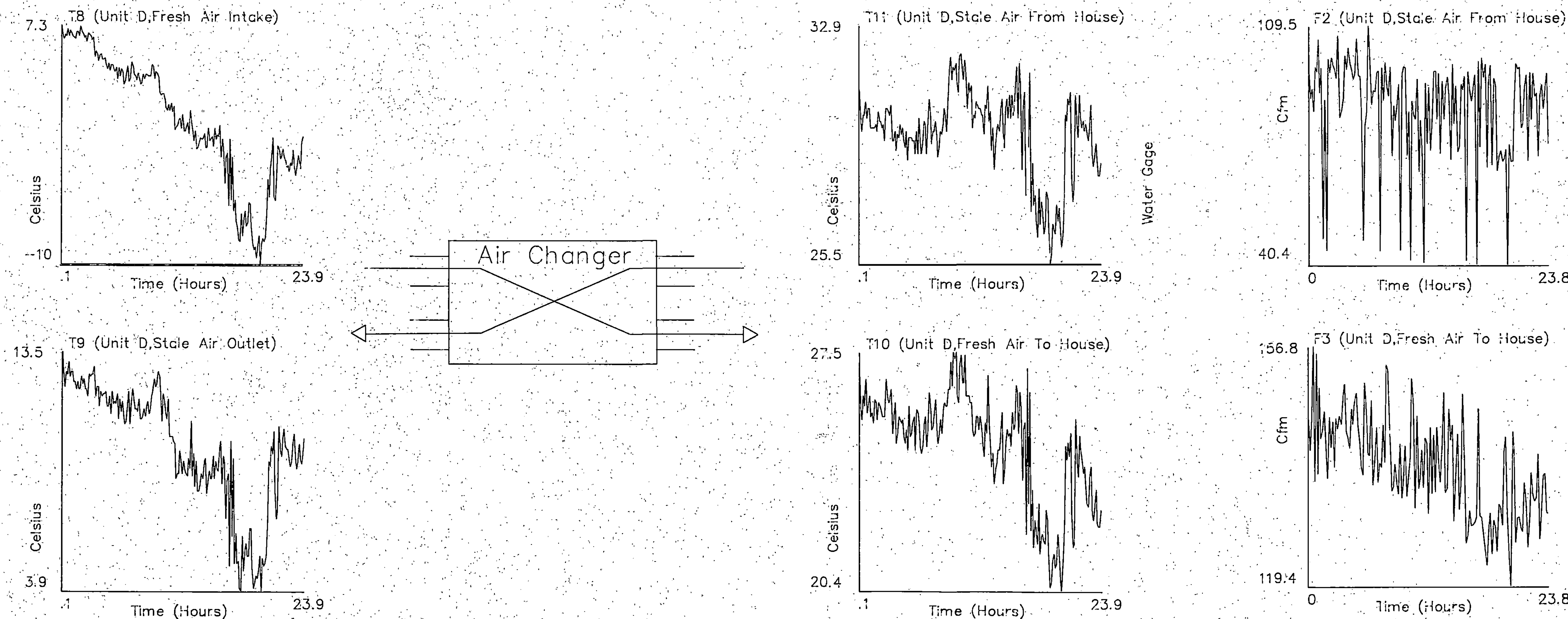
Graph 2

November 1987



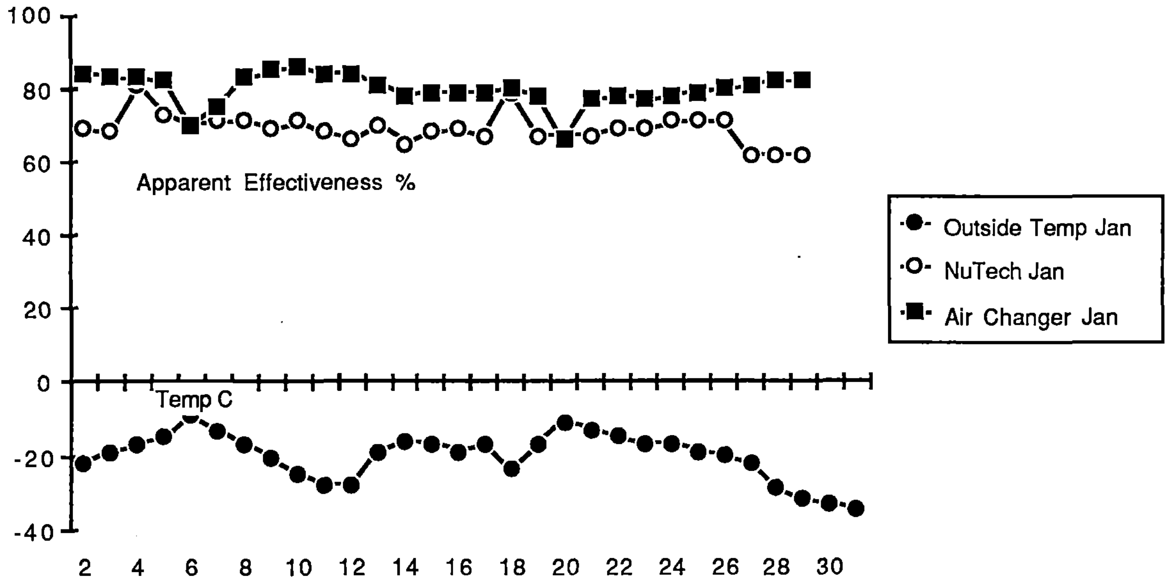
Graph 3

November 1987



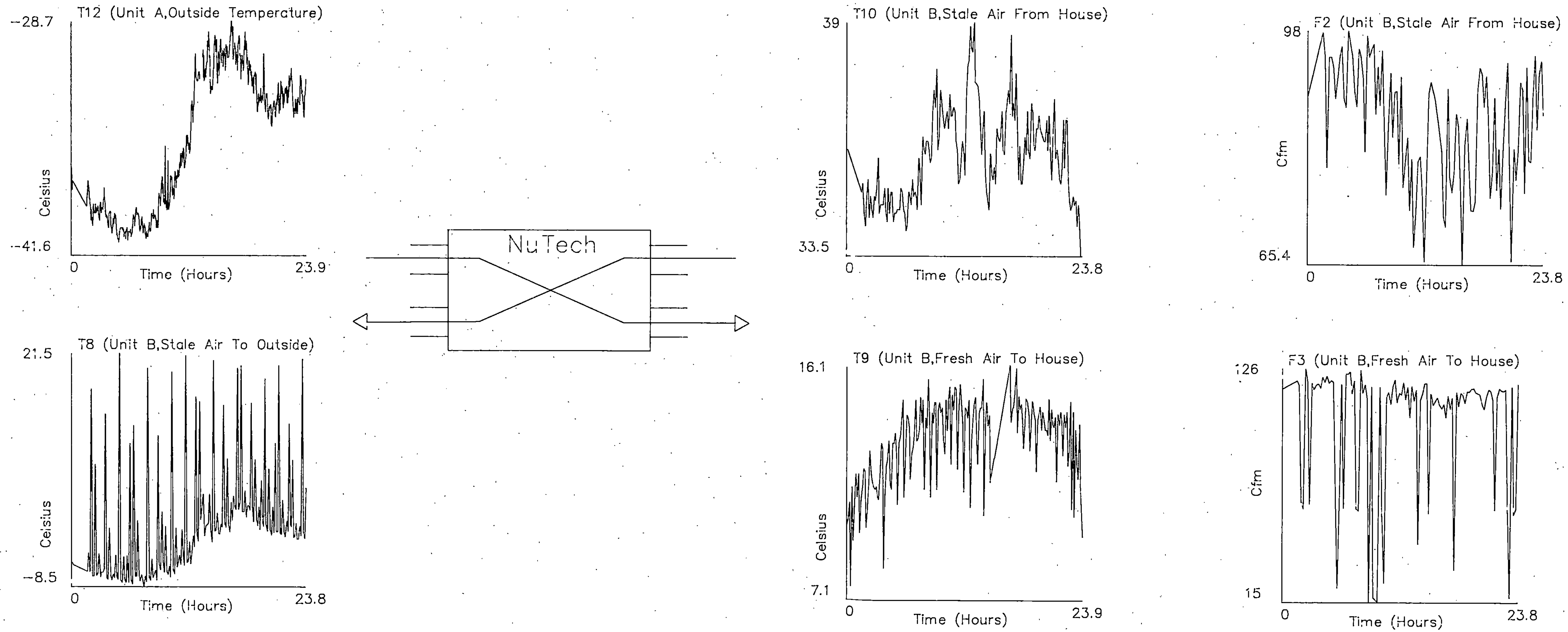
Graph 4

Apparent Effectiveness January '88



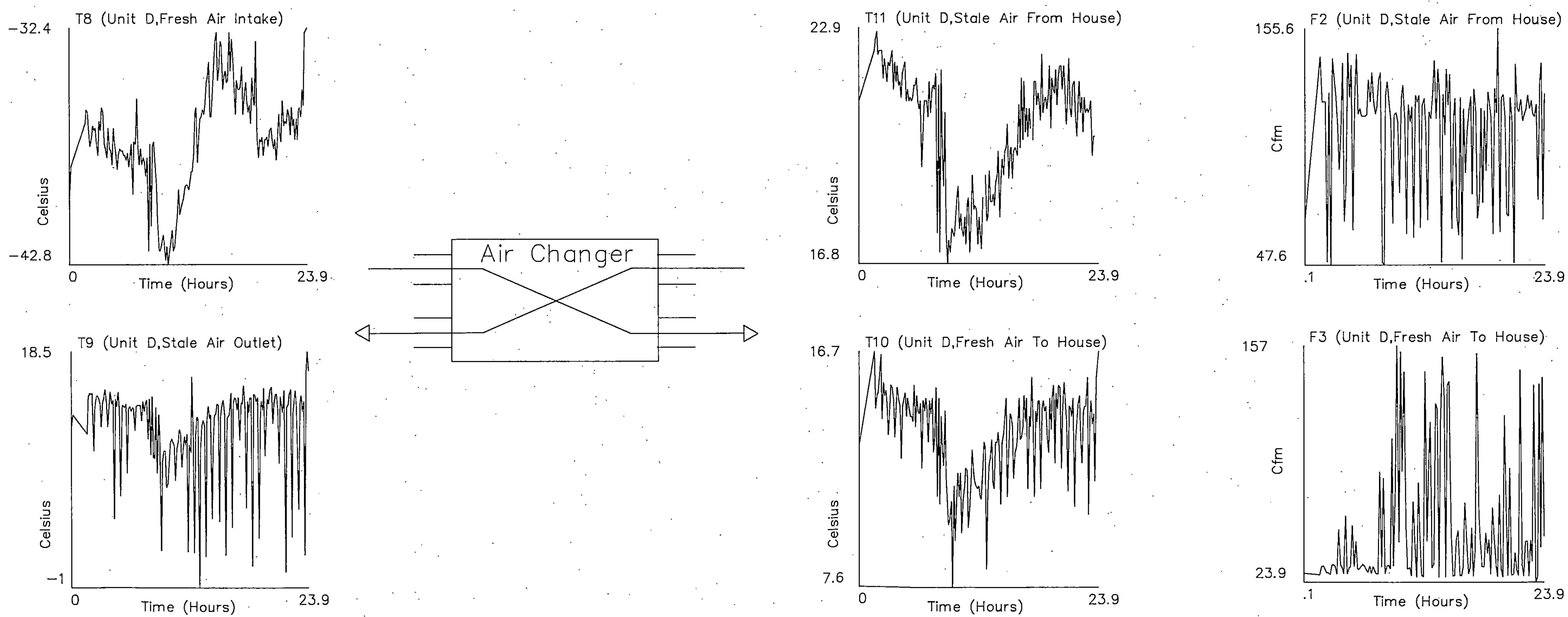
Graph 5

January 1988



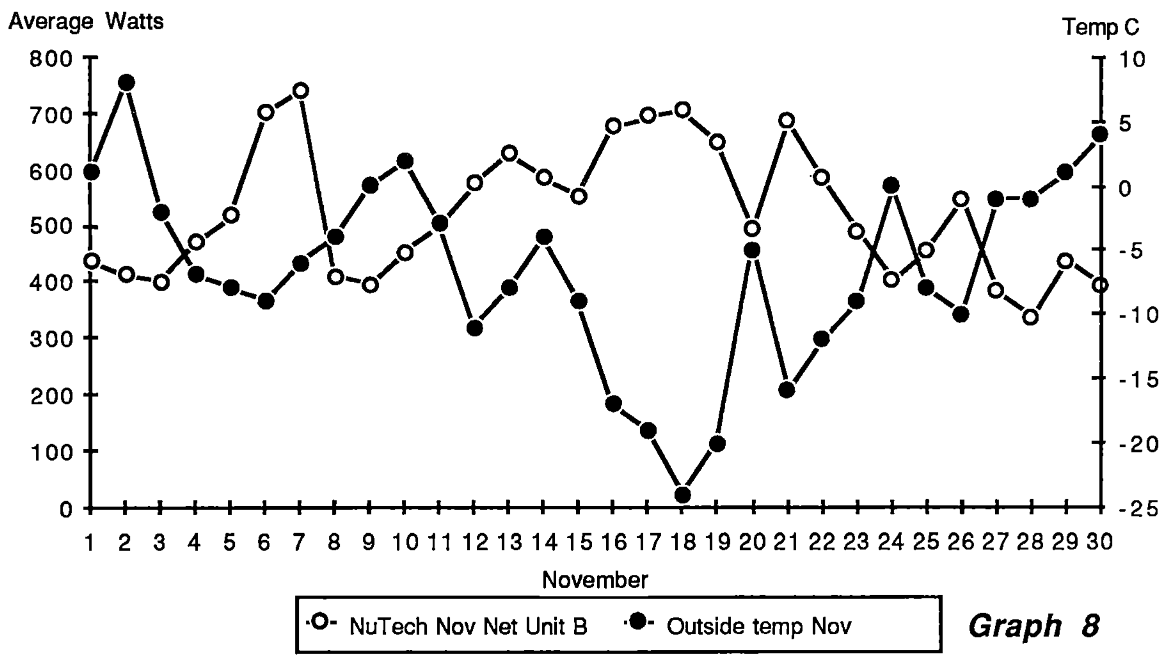
Graph 6

January 1988

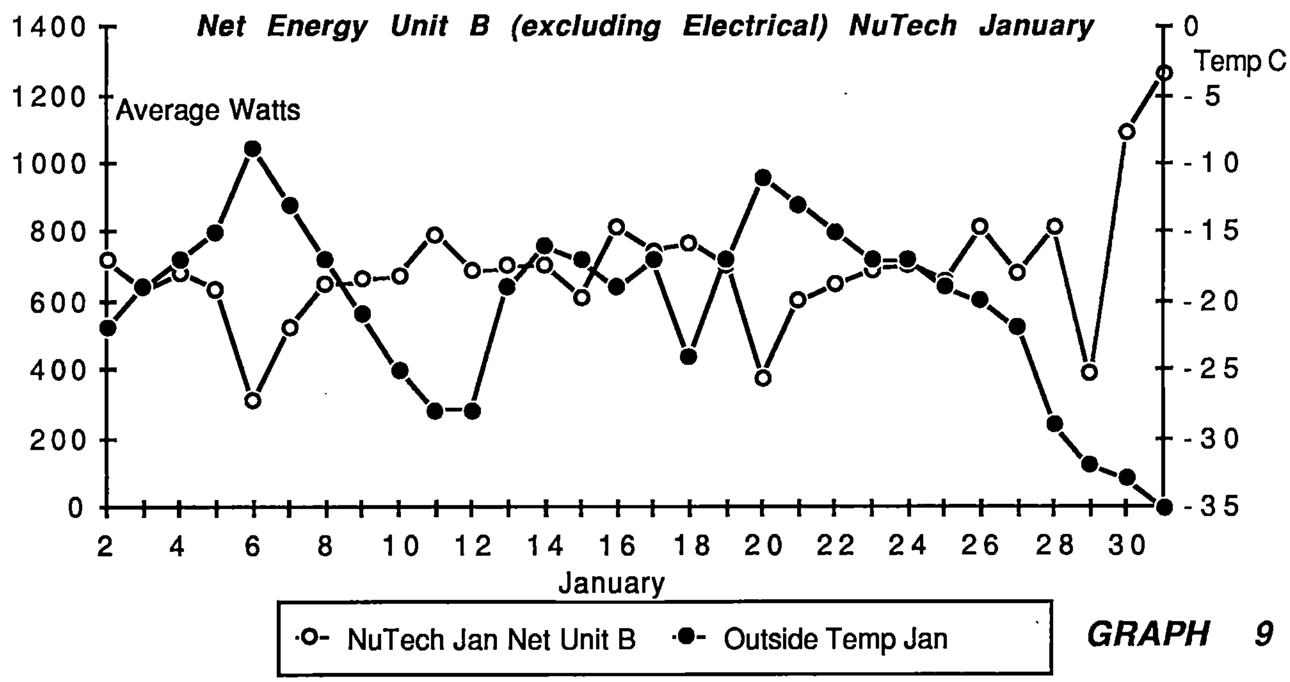


Graph 7

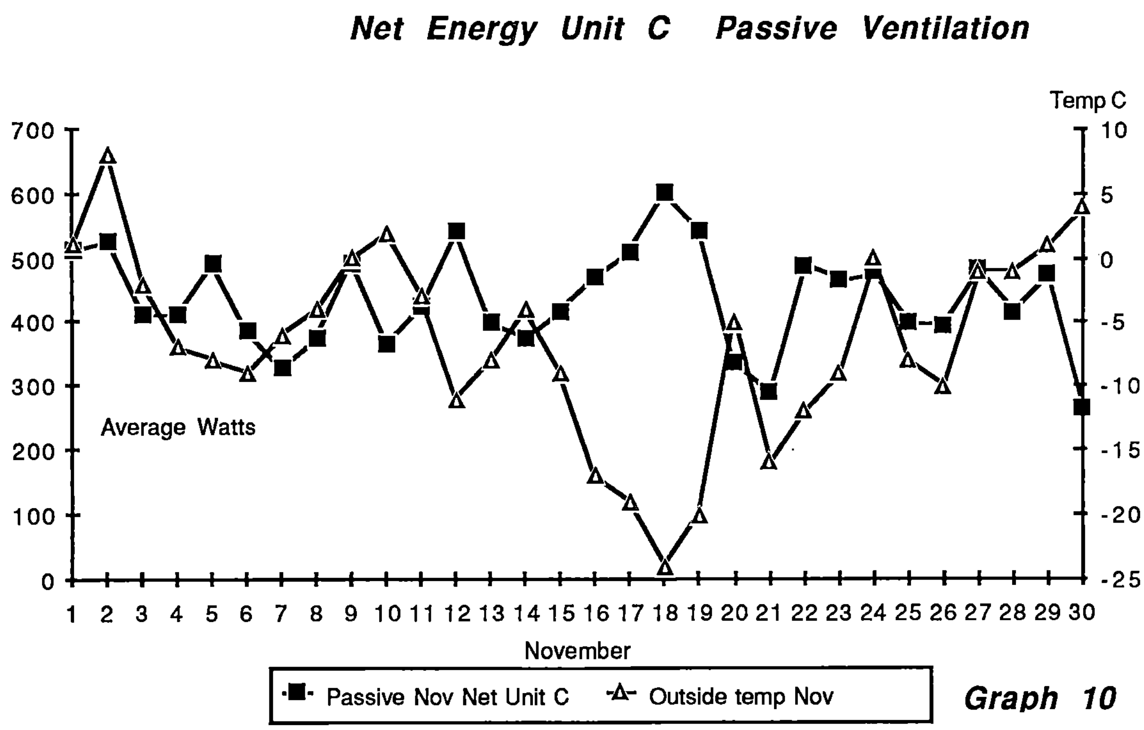
Net Energy Unit B (excluding Electrical) NuTech Unit



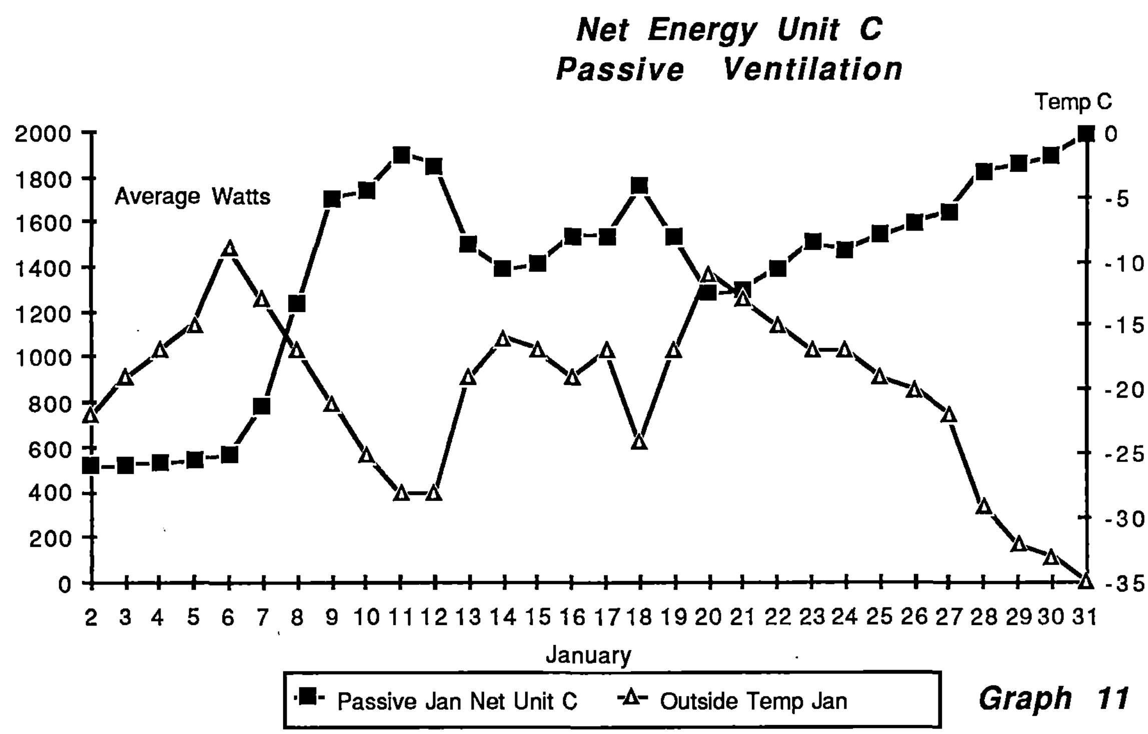
Graph 8


Net Energy Unit B (excluding Electrical) NuTech January
Average Watts
Temp C
1400
1200
1000
800
600
400
200
0
0
- 5
- 1 0
- 1 5
- 2 0
- 2 5
- 3 0
- 3 5
2
4
6
8
1 0
1 2
1 4
1 6
1 8
2 0
2 2
2 4
2 6
2 8
3 0
January
NuTech Jan Net Unit B
Outside Temp Jan

GRAPH 9

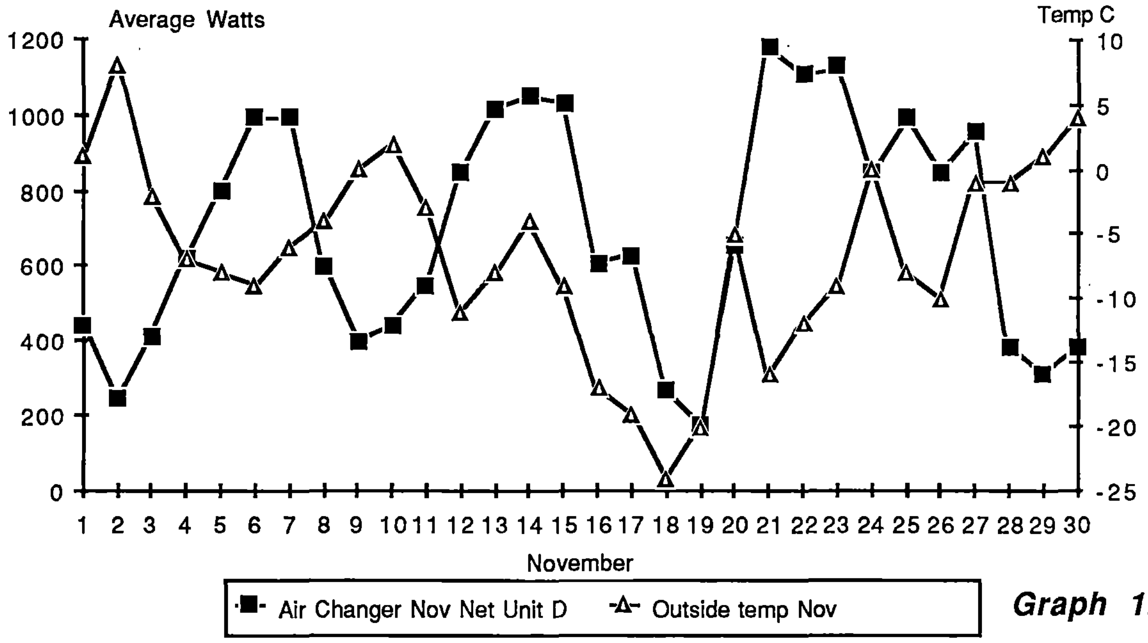

Net Energy Unit C Passive Ventilation
Temp C
700
600
500
400
300
200
100
0
10
5
0
-5
-10
-15
-20
-25
Average Watts
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
November
Passive Nov Net Unit C
Outside temp Nov

Graph 10


Net Energy Unit C
Passive Ventilation
Temp C
Average Watts
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
-5
-10
-15
-20
-25
-30
-35
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
January
Passive Jan Net Unit C
Outside Temp Jan

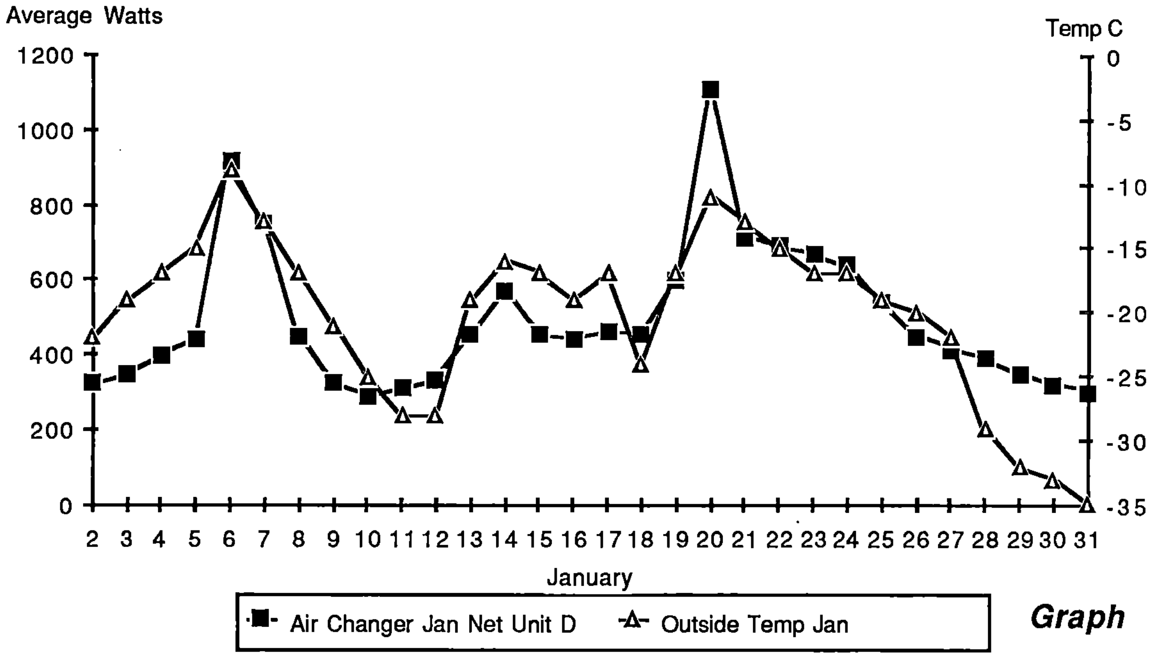
Graph 11

Net Energy Unit D Air Changer (excluding Electrical)



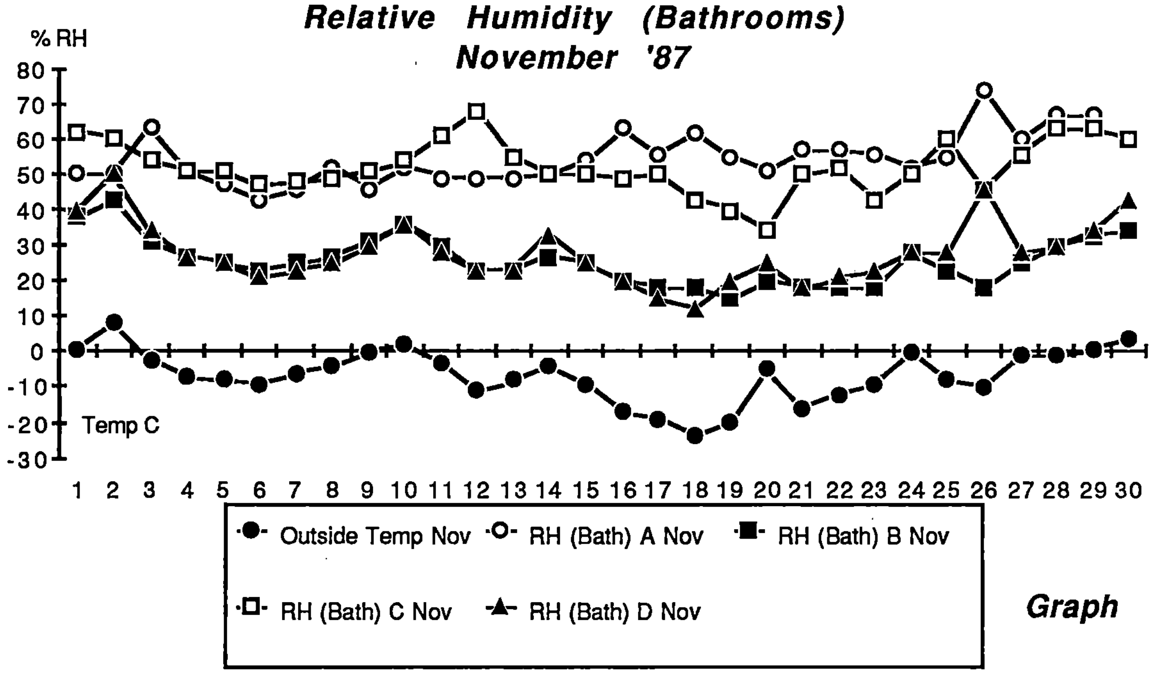
Graph 12

Net Energy Unit D Air Changer (excluding Electrical)

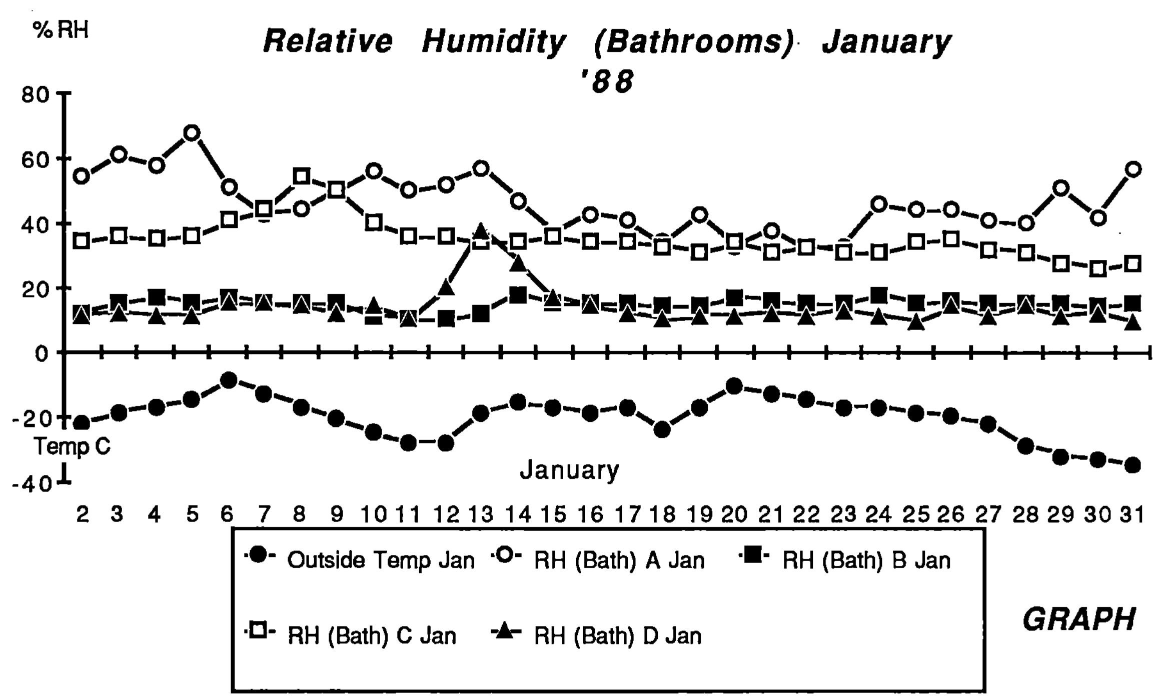


Graph 13

Relative Humidity (Bathrooms)
November '87

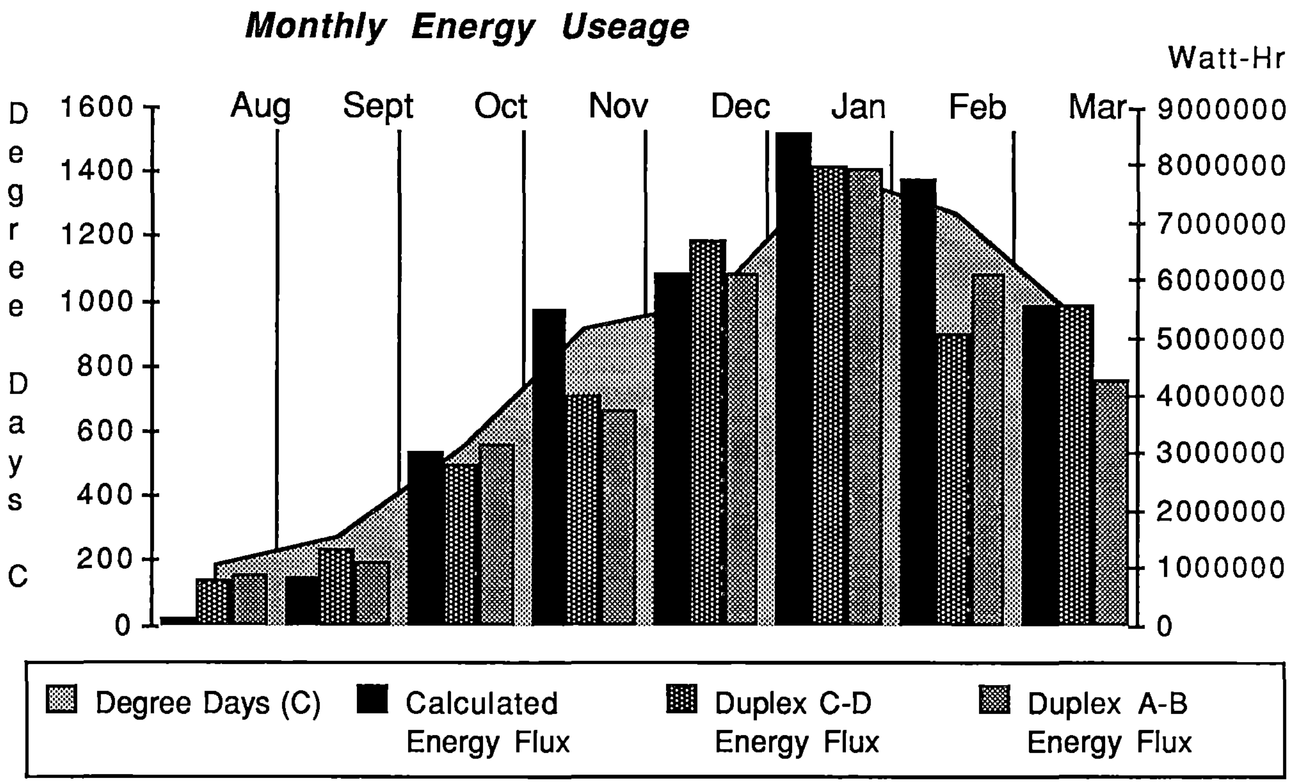


Graph 14



% RH
Relative Humidity (Bathrooms) January '88
80
60
40
20
0
-20
Temp C
-40
January
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Outside Temp Jan
RH (Bath) A Jan
RH (Bath) B Jan
RH (Bath) C Jan
RH (Bath) D Jan

GRAPH 15



Monthly Energy Useage
Watt-Hr
Degree Days C
1600
1400
1200
1000
800
600
400
200
0
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
Degree Days (C)
Calculated Energy Flux
Duplex C-D Energy Flux
Duplex A-B Energy Flux

GRAPH 16

TABLES & WORKSHEETS

TABLE 4

Unit	Month	Ch.	Description	Sensor	Minimum	Maximum	Average	# Records
C	Jan 1988	94	Top hall RH	T6H6	0.2	0.8	0.35	2,385
		78	Bathroom RH	T4H4	0.21	0.91	0.36	2,386
		73	Sub floor centre bottom temp	T12B	6.84	45.84	20.47	11,922
		71	Passive vent air cfm	F5	3.28	178.05	55.87	2,949
		67	Bedroom 3 temp	TE3	19.45	47.54	29.21	11,916
		69	Bedroom 2 temp	TE5	19.45	49.13	28.79	11,918
	Nov 1987	73	Sub floor centre bottom temp	T12B	6.05	30.54	21.37	12,464
		74	Sub floor kitcgen temp	T17	9.35	34.75	24.93	12,468
		78	Bathroom RH	T4H4	0.33	0.99	0.52	2,487
		94	Top hall RH	T6H6	0.27	0.94	0.48	2,495
		95	Top hall temp	T6H6	16.79	32	26.95	2,495
		79	Bathroom temp	T4H4	13.93	30.04	26.51	2,495
		72	Sub floor centre top temp	T12A	7.25	31.12	21.99	12,462
		69	Bedroom 2 temp	TE5	17.25	34.45	28.33	12,463
		71	Passive Vent Stack cfm	F5	0	120.67	25.46	3,114
		66	Bedroom 1 temp	TE2	10.35	34.13	27.94	12,470
		67	Bedroom 3 temp	TE3	14.25	35.84	28.62	12,466
CD	Jan 1988	123	Shared porch temp	T18	3.64	44.54	19.55	11,913
	Nov 1987	123	Shared porch temp	T18	0.43	33.04	23.86	12,453
D	Jan 1988	65	Bedroom 1 temp	Te1	18.45	46.34	28.37	11,897
		76	Sub floor living room temp	T19	6.75	41.25	22.87	11,919
		80	Air Changer fresh air from outside	T8	-45.55	5.94	-20.06	3,954
		82	Air Changer Fresh air to house	T10	-3.86	44.34	20.95	3,979
		93	Air Changer Fresh air fpm	F3	54	2,637	483.8	2,982
		110	Top hall RH	T5H5	0.05	0.52	0.13	2,314
		112	Hybrid Ventilation supply air fpm	F1	296	640	592	2,384
		116	Heat exchanger duct	T2	-26.15	32.84	-0.8	11,909
		127	Bathroom temp	T3H3	14.8	27.95	24.17	2,385
		84	Pressure differential	P1	-1.18	0.05	-0.61	11,915
		126	Bathroom RH	T3H3	0.05	0.75	0.14	2,317
		115	Heat exchanger duct temp	T6	-15.07	35.34	8.05	11,916
		111	Top hall temp	T5H5	16.75	28.75	24.87	2,386
		96	Air Changer stale air house fpm	F2	172	3,592	587	2,938
		83	Air Changer Stale air from house	T11	-9.86	47.95	27.71	3,979
		81	Air Changer stale air to outside temp	T9	-25.05	38.75	17.23	3,978
		77	Sub floor centre temp	T20	3.45	49.63	25.1	11,921
		75	Sub floor kitchen temp	T21	2.45	37.84	19.02	11,921
		68	Bedroom 3 temp	TE4	21.85	48.63	32.35	11,915
		70	Bedroom 2 temp	TE6	20.12	48.95	30.25	11,917
	Nov 1987	81	Air changer stale air outside temp	T9	-7.06	24.62	9.24	4,151
		83	Air changer stale air from house	T11	2.25	32.95	26.82	4,155
		84	pressure differential	P1	-1.5	3.03	-0.61	12,455
		93	Air Changer Fresh air fpm	F3	46.3	1,974	667.6	3,119
		110	Top hall RH	T5H5	0.05	0.57	0.25	2,494
		111	Top hall temp	T5H5	5	28.85	24.17	2,488
		112	Hybrid ventilation fresh air fpm	F1	150	1,843	571	2,462
		115	Hybrid exhaust duct temp	T6	-26.87	31.62	14.34	12,448
		126	Bathroom RH	T3H3	0.07	0.94	0.28	2,491
		127	Bathroom temp	T3H3	10.1	29.85	24.29	2,450
		116	Hybrid exhaust duct temp	T2	-30.96	29.75	3.51	12,441
		96	Air Changer stale air house fpm	F2	151.4	1,876	441.9	3,119
		82	Air Changer fresh air to house	T10	1.85	35.95	18.74	4,154
		75	Sub floor kitchen temp	T21	-2.25	33.84	22.39	12,468
		77	Sub floor centre temp	T20	1.85	34.95	27.96	12,455
		80	Air Changer Fresh air outside temp	T8	-30.46	9.43	-8.27	4,141
		76	Sub floor living room temp	T19	1.03	30.54	23.33	12,457
		65	Bedroom 1 temp	TE1	4.25	31.35	26.13	12,471
		68	Bedroom 3 temp	TE4	6.94	33.75	28.73	12,461
		70	Bedroom 2 temp	TE6	6.44	48.63	27.57	12,479
							Total:	683,620

Unit	Month	Ch.	Description	Sensor	Minimum	Maximum	Average	# Records
	Nov 1987	19	Outside Air temp	T12	-28.46	17.45	-6.96	2,490
	Jan 1988	19	Outside Air Temp	T12	-48.75	-4.87	-19.87	4,101
A	Jan 1988	2	Bedroom 1 temp	TE2	20.75	37.25	30.55	2,386
		8	Sub Floor centre bottom temp	T12B	12.75	27.62	22.03	1,327
		11	Sub Floor living room temp	T19	5.05	33.84	25.07	3,973
		48	Bathroom temp	T4H4	20.29	30.2	26.02	2,384
		28	Kantherm Exchanger supply/exhaust temp	T6	-30.66	46.25	2.84	2,380
		49	Bathroom RH	T4H4	0.05	0.99	0.47	3,679
		29	Kantherm fresh/stale air temp	T5	-19.37	44.54	19.93	2,383
		9	Sub Floor kitchen temp	T17	9.75	31.45	21.26	2,383
		7	Sub Floor centre top temp	T12A	10.43	28.95	23.36	2,385
		3	Bedroom 3 temp	TE3	19.25	35.04	28.24	5,959
		5	Bedroom 2 temp	TE5	18.45	37.63	29.36	2,386
	Nov 1987	9	Sub floor kitchen temp	T17	20.12	32.34	25.17	2,495
		11	Sub floor living room temp	T19	21.12	33.04	26.2	4,154
		28	Kantherm supply/exhaust temp	T6	-22.46	41.45	1.95	2,495
		48	Bathroom temp	T4H4	20.6	29.45	25.37	2,496
		49	Bathroom RH	T4H4	0.05	1	0.54	3,863
		29	Kantherm fresh/stale temp	T5	-8.75	39.13	31.02	2,495
		8	Sub floor centre bottom temp	T12B	17.75	28.45	22.45	1,388
		5	Bedroom 2 temp	TE5	21.95	32.75	27.36	2,496
		7	Sub Floor Centre top temp	T12A	20.04	31.75	24.45	2,496
		2	Bedroom 1 temp	TE2	23.62	34.34	28.88	2,496
		3	Bedroom 3 temp	TE3	21.25	32.45	26.89	6,230
AB	Jan 1988	35	Pressure differential	P1	-1.81	0.5	-0.83	3,973
		61	Mechanical Room temp	T3	33.13	49.75	41.32	2,385
		10	Shared Porch Temp	T18	22.12	43.13	33.62	2,385
	Nov 1987	10	Shared porch temp	T18	22.25	41.13	32.78	2,496
		35	Pressure differential	P1	-4.87	0.02	-0.86	4,153
		61	Mechanical room temp	T3	32.13	48.13	40.78	2,496
B	Jan 1988	1	Bedroom 1 temp	TE1	26.75	36.34	32.17	2,981
		32	Bathroom temp	T3H3	23.13	30.45	27.52	2,382
		36	NuTech Stale air from house fpm	F2	265.4	599.5	456.6	2,381
		50	NuTech stale air to outside temp	T8	-15.45	31.45	6.41	3,973
		53	NuTech fresh air from outside temp	T11	-32.16	7.63	-5.2	3,972
		12	Sub floor centre temp	T21	23.85	41.34	35.14	1,491
		62	Mechanical Room temp	T4	31.35	47.84	39.47	2,386
		13	Sub floor kitchen temp	T22	12.05	35.63	28.99	5,958
		52	NuTech stale air from house temp	T10	27.54	41.63	34.08	3,973
		37	NuTech fresh air to house fpm	F3	58.8	1,417.2	545.6	2,389
		33	Bathroom RH	T3H3	0.05	0.98	0.14	3,970
		14	Sub floor living room temp	T23	16.04	40.45	32.42	2,386
		4	Bedroom 3 Temp	TE4	22.85	36.75	31.96	2,386
		6	Bedroom 2 temp	TE6	14.93	45.34	32.48	11,917
	Nov 1987	32	Bathroom temp	T3H3	23.38	29.7	27.07	2,496
		33	Bathroom RH	T3H3	0.11	0.97	0.25	4,147
		36	NuTech stale air from house fpm	F2	304.4	620.9	406.6	2,496
		50	NuTech Stale air to outside temp	T8	-1.25	32.63	13.2	4,153
		51	NuTech fresh air to house	T9	-4.83	33.7	21.72	2,486
		52	NuTech stale air from house	T10	27.04	39.95	32.29	4,153
		62	Mechanical room temp	T4	31.85	45.25	39.17	2,496
		53	NuTech fresh air from outside	T11	-19.87	22.04	4.12	4,153
		37	NuTech fresh air to house fpm	F3	66.3	1,379.7	515.4	2,496
		14	Sub floor living room temp	T23	19.85	38.04	29.16	2,496
		12	Sub floor centre temp	T21	24.85	39.54	32.47	1,561
		13	Sub floor kitchen temp	T22	24.04	33.63	28.71	6,229
		1	Bedroom 1 temp	TE1	19.62	35.75	31.15	3,119
		4	Bedroom 3 temp	TE4	27.12	36.63	31.21	2,496
		6	Bedroom 2 temp	TE6	8.85	37.84	32.61	12,454
C	Jan 1988	66	Bedroom 1 temp	TE2	17.62	46.25	28.62	11,920
		72	Sub floor centre top temp	T12A	8.93	44.75	21.45	11,921
		74	Sub floor kitchen temp	T17	11.75	46.04	23.97	11,920
		79	Bathroom temp	T4H4	13.75	29.13	25.96	2,385
		95	Top hall temp	T6H6	19.2	29.25	25.84	2,384

TABLE 5

Ch.	Unit	Month	Description	Sensor	Minimum	Maximum	Average	# Records
1	B	Jan 1988	Bedroom 1 temp	TE1	26.75	36.34	32.17	2,981
		Nov 1987	Bedroom 1 temp	TE1	19.62	35.75	31.15	3,119
2	A	Jan 1988	Bedroom 1 temp	TE2	20.75	37.25	30.55	2,386
		Nov 1987	Bedroom 1 temp	TE2	23.62	34.34	28.88	2,496
3	A	Jan 1988	Bedroom 3 temp	TE3	19.25	35.04	28.24	5,959
		Nov 1987	Bedroom 3 temp	TE3	21.25	32.45	26.89	6,230
4	B	Jan 1988	Bedroom 3 Temp	TE4	22.85	36.75	31.96	2,386
		Nov 1987	Bedroom 3 temp	TE4	27.12	36.63	31.21	2,496
5	A	Jan 1988	Bedroom 2 temp	TE5	18.45	37.63	29.36	2,386
		Nov 1987	Bedroom 2 temp	TE5	21.95	32.75	27.36	2,496
6	B	Jan 1988	Bedroom 2 temp	TE6	14.93	45.34	32.48	11,917
		Nov 1987	Bedroom 2 temp	TE6	8.85	37.84	32.61	12,454
7	A	Jan 1988	Sub Floor centre top temp	T12A	10.43	28.95	23.36	2,385
		Nov 1987	Sub Floor Centre top temp	T12A	20.04	31.75	24.45	2,496
8	A	Jan 1988	Sub Floor centre bottom temp	T12B	12.75	27.62	22.03	1,327
		Nov 1987	Sub floor centre bottom temp	T12B	17.75	28.45	22.45	1,388
9	A	Jan 1988	Sub Floor kitchen temp	T17	9.75	31.45	21.26	2,383
		Nov 1987	Sub floor kitchen temp	T17	20.12	32.34	25.17	2,495
10	AB	Jan 1988	Shared Porch Temp	T18	22.12	43.13	33.62	2,385
		Nov 1987	Shared porch temp	T18	22.25	41.13	32.78	2,496
11	A	Jan 1988	Sub Floor living room temp	T19	5.05	33.84	25.07	3,973
		Nov 1987	Sub floor living room temp	T19	21.12	33.04	26.2	4,154
12	B	Jan 1988	Sub floor centre temp	T21	23.85	41.34	35.14	1,491
		Nov 1987	Sub floor centre temp	T21	24.85	39.54	32.47	1,561
13	B	Jan 1988	Sub floor kitchen temp	T22	12.05	35.63	28.99	5,958
		Nov 1987	Sub floor kitchen temp	T22	24.04	33.63	28.71	6,229
14	B	Jan 1988	Sub floor living room temp	T23	16.04	40.45	32.42	2,386
		Nov 1987	Sub floor living room temp	T23	19.85	38.04	29.16	2,496
19		Nov 1987	Outside Air temp	T12	-28.46	17.45	-6.96	2,490
		Jan 1988	Outside Air Temp	T12	-48.75	-4.87	-19.87	4,101
28	A	Jan 1988	Kantherm Exchanger supply/exhaust temp	T6	-30.66	46.25	2.84	2,380
		Nov 1987	Kantherm supply/exhaust temp	T6	-22.46	41.45	1.95	2,495
29	A	Jan 1988	Kantherm fresh/stale air temp	T5	-19.37	44.54	19.93	2,383
		Nov 1987	Kantherm fresh/stale temp	T5	-8.75	39.13	31.02	2,495
32	B	Jan 1988	Bathroom temp	T3H3	23.13	30.45	27.52	2,382
		Nov 1987	Bathroom temp	T3H3	23.38	29.7	27.07	2,496
33	B	Jan 1988	Bathroom RH	T3H3	0.05	0.98	0.14	3,970
		Nov 1987	Bathroom RH	T3H3	0.11	0.97	0.25	4,147
35	AB	Jan 1988	Pressure differential	P1	-1.81	0.5	-0.83	3,973
		Nov 1987	Pressure differential	P1	-4.87	0.02	-0.86	4,153
36	B	Jan 1988	NuTech Stale air from house fpm	F2	265.4	599.5	456.6	2,381
		Nov 1987	NuTech stale air from house fpm	F2	304.4	620.9	406.6	2,496
37	B	Jan 1988	NuTech fresh air to house fpm	F3	58.8	1,417.2	545.6	2,389
		Nov 1987	NuTech fresh air to house fpm	F3	66.3	1,379.7	515.4	2,496
48	A	Jan 1988	Bathroom temp	T4H4	20.29	30.2	26.02	2,384
		Nov 1987	Bathroom temp	T4H4	20.6	29.45	25.37	2,496
49	A	Jan 1988	Bathroom RH	T4H4	0.05	0.99	0.47	3,679
		Nov 1987	Bathroom RH	T4H4	0.05	1	0.54	3,863
50	B	Jan 1988	NuTech stale air to outside temp	T8	-15.45	31.45	6.41	3,973
		Nov 1987	NuTech Stale air to outside temp	T8	-1.25	32.63	13.2	4,153
51	B	Nov 1987	NuTech fresh air to house	T9	-4.83	33.7	21.72	2,486
52	B	Jan 1988	NuTech stale air from house temp	T10	27.54	41.63	34.08	3,973
		Nov 1987	NuTech stale air from house	T10	27.04	39.95	32.29	4,153
53	B	Jan 1988	NuTech fresh air from outside temp	T11	-32.16	7.63	-5.2	3,972
		Nov 1987	NuTech fresh air from outside	T11	-19.87	22.04	4.12	4,153
61	AB	Jan 1988	Mechanical Room temp	T3	33.13	49.75	41.32	2,385
		Nov 1987	Mechanical room temp	T3	32.13	48.13	40.78	2,496
62	B	Jan 1988	Mechanical Room temp	T4	31.35	47.84	39.47	2,386
		Nov 1987	Mechanical room temp	T4	31.85	45.25	39.17	2,496
65	D	Jan 1988	Bedroom 1 temp	Te1	18.45	46.34	28.37	11,897
		Nov 1987	Bedroom 1 temp	TE1	4.25	31.35	26.13	12,471
66	C	Jan 1988	Bedroom 1 temp	TE2	17.62	46.25	28.62	11,920
		Nov 1987	Bedroom 1 temp	TE2	10.35	34.13	27.94	12,470
67	C	Jan 1988	Bedroom 3 temp	TE3	19.45	47.54	29.21	11,916

Ch.	Unit	Month	Description	Sensor	Minimum	Maximum	Average	# Records
67	C	Nov 1987	Bedroom 3 temp	TE3	14.25	35.84	28.62	12,466
68	D	Jan 1988	Bedroom 3 temp	TE4	21.85	48.63	32.35	11,915
		Nov 1987	Bedroom 3 temp	TE4	6.94	33.75	28.73	12,461
69	C	Jan 1988	Bedroom 2 temp	TE5	19.45	49.13	28.79	11,918
		Nov 1987	Bedroom 2 temp	TE5	17.25	34.45	28.33	12,463
70	D	Jan 1988	Bedroom 2 temp	TE6	20.12	48.95	30.25	11,917
		Nov 1987	Bedroom 2 temp	TE6	6.44	48.63	27.57	12,479
71	C	Jan 1988	Passive vent air cfm	F5	3.28	178.05	55.87	2,949
		Nov 1987	Passive Vent Stack cfm	F5	0	120.67	25.46	3,114
72	C	Jan 1988	Sub floor centre top temp	T12A	8.93	44.75	21.45	11,921
		Nov 1987	Sub floor centre top temp	T12A	7.25	31.12	21.99	12,462
73	C	Jan 1988	Sub floor centre bottom temp	T12B	6.84	45.84	20.47	11,922
		Nov 1987	Sub floor centre bottom temp	T12B	6.05	30.54	21.37	12,464
74	C	Jan 1988	Sub floor kitchen temp	T17	11.75	46.04	23.97	11,920
		Nov 1987	Sub floor kitcgen temp	T17	9.35	34.75	24.93	12,468
75	D	Jan 1988	Sub floor kitchen temp	T21	2.45	37.84	19.02	11,921
		Nov 1987	Sub floor kitchen temp	T21	-2.25	33.84	22.39	12,468
76	D	Jan 1988	Sub floor living room temp	T19	6.75	41.25	22.87	11,919
		Nov 1987	Sub floor living room temp	T19	1.03	30.54	23.33	12,457
77	D	Jan 1988	Sub floor centre temp	T20	3.45	49.63	25.1	11,921
		Nov 1987	Sub floor centre temp	T20	1.85	34.95	27.96	12,455
78	C	Jan 1988	Bathroom RH	T4H4	0.21	0.91	0.36	2,386
		Nov 1987	Bathroom RH	T4H4	0.33	0.99	0.52	2,487
79	C	Jan 1988	Bathroom temp	T4H4	13.75	29.13	25.96	2,385
		Nov 1987	Bathroom temp	T4H4	13.93	30.04	26.51	2,495
80	D	Jan 1988	Air Changer fresh air from outside	T8	-45.55	5.94	-20.06	3,954
		Nov 1987	Air Changer Fresh air outside temp	T8	-30.46	9.43	-8.27	4,141
81	D	Jan 1988	Air Changer stale air to outside temp	T9	-25.05	38.75	17.23	3,978
		Nov 1987	Air changer stale air outside temp	T9	-7.06	24.62	9.24	4,151
82	D	Jan 1988	Air Changer Fresh air to house	T10	-3.86	44.34	20.95	3,979
		Nov 1987	Air Changer fresh air to house	T10	1.85	35.95	18.74	4,154
83	D	Jan 1988	Air Changer Stale air from house	T11	-9.86	47.95	27.71	3,979
		Nov 1987	Air changer stale air from house	T11	2.25	32.95	26.82	4,155
84	D	Jan 1988	Pressure differential	P1	-1.18	0.05	-0.61	11,915
		Nov 1987	pressure differential	P1	-1.5	3.03	-0.61	12,455
93	D	Jan 1988	Air Changer Fresh air fpm	F3	54	2,637	483.8	2,982
		Nov 1987	Air Changer Fresh air fpm	F3	46.3	1,974	667.6	3,119
94	C	Jan 1988	Top hall RH	T6H6	0.2	0.8	0.35	2,385
		Nov 1987	Top hall RH	T6H6	0.27	0.94	0.48	2,495
95	C	Jan 1988	Top hall temp	T6H6	19.2	29.25	25.84	2,384
		Nov 1987	Top hall temp	T6H6	16.79	32	26.95	2,495
96	D	Jan 1988	Air Changer stale air house fpm	F2	172	3,592	587	2,938
		Nov 1987	Air Changer stale air house fpm	F2	151.4	1,876	441.9	3,119
110	D	Jan 1988	Top hall RH	T5H5	0.05	0.52	0.13	2,314
		Nov 1987	Top hall RH	T5H5	0.05	0.57	0.25	2,494
111	D	Jan 1988	Top hall temp	T5H5	16.75	28.75	24.87	2,386
		Nov 1987	Top hall temp	T5H5	5	28.85	24.17	2,488
112	D	Jan 1988	Hybrid Ventilation supply air fpm	F1	296	640	592	2,384
		Nov 1987	Hybrid ventilation fresh air fpm	F1	150	1,843	571	2,462
115	D	Jan 1988	Heat exchanger duct temp	T6	-15.07	35.34	8.05	11,916
		Nov 1987	Hybrid exhaust duct temp	T6	-26.87	31.62	14.34	12,448
116	D	Jan 1988	Heat exchanger duct	T2	-26.15	32.84	-0.8	11,909
		Nov 1987	Hybrid exhaust duct temp	T2	-30.96	29.75	3.51	12,441
123	CD	Jan 1988	Shared porch temp	T18	3.64	44.54	19.55	11,913
		Nov 1987	Shared porch temp	T18	0.43	33.04	23.86	12,453
126	D	Jan 1988	Bathroom RH	T3H3	0.05	0.75	0.14	2,317
		Nov 1987	Bathroom RH	T3H3	0.07	0.94	0.28	2,491
127	D	Jan 1988	Bathroom temp	T3H3	14.8	27.95	24.17	2,385
		Nov 1987	Bathroom temp	T3H3	10.1	29.85	24.29	2,450
							Total:	683,620

WORKSHEET 1

Compiled Data Summary..Yellowknife Ventilation-> WORKSHEET 1

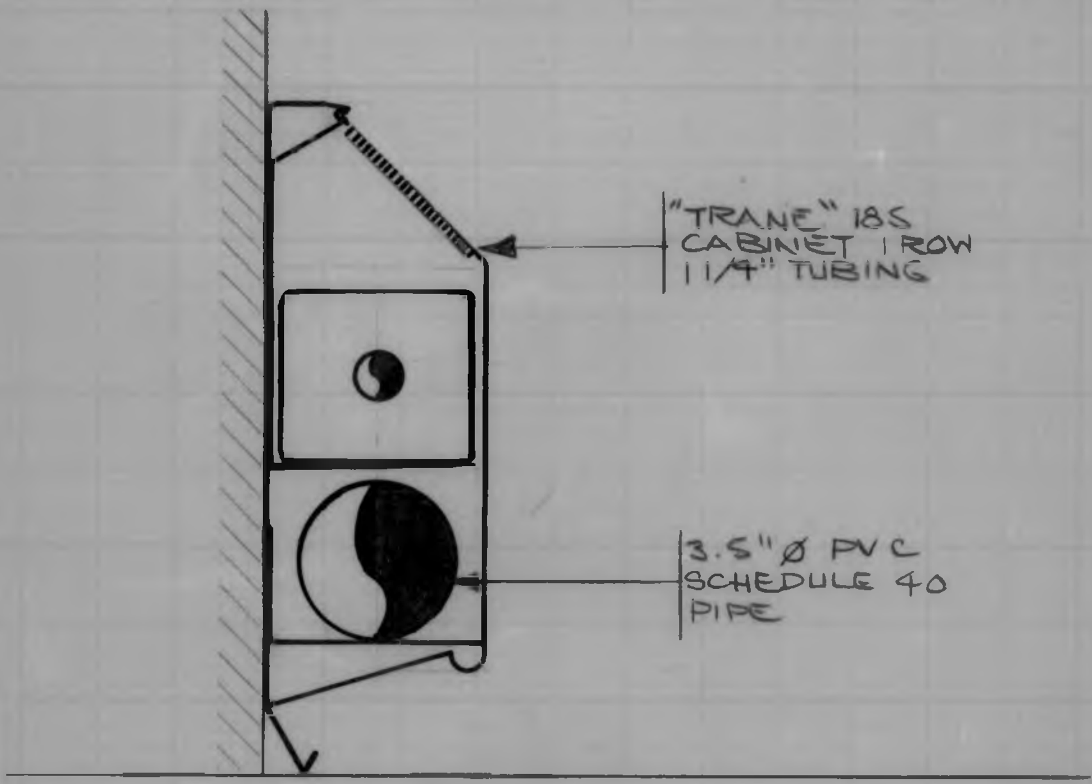
Unit Costs -for-->	Electrical $/Kw -->	$0.10		Fuel $/litre-->	$0.28		
Heat exchanger	Temperature (Outside) C	Dwelling Wh added as Heat /Deg/AC	Base Watts HRV	Mean # AC per Hour	Electrical Cost /AC	Fuel Cost /AC	Total Cost /AC
NuTech 200 (Unit B)	0	30	120	0.6	0.02	0.01957	0.03957
	-2	29.6	120	0.59351	0.02022	0.02124	0.04146
	-4	29.2	120	0.58702	0.02044	0.02286	0.0433
	-6	28.8	120	0.58053	0.02067	0.02443	0.0451
	-8	28.4	120	0.57404	0.0209	0.02594	0.04684
	-10	28	120	0.56755	0.02114	0.0274	0.04855
	-12	27.6	120	0.56106	0.02139	0.02881	0.0502
	-14	27.2	120	0.55457	0.02164	0.03017	0.05181
	-16	26.8	120	0.54808	0.02189	0.03147	0.05337
	-18	26.4	120	0.54159	0.02216	0.03273	0.05488
	-20	26	120	0.5351	0.02243	0.03393	0.05635
	-22	25.6	120	0.52861	0.0227	0.03507	0.05778
	-24	25.2	120	0.52212	0.02298	0.03617	0.05915
	-26	24.8	120	0.51563	0.02327	0.03721	0.06049
	-28	24.4	120	0.50914	0.02357	0.03821	0.06177
	-30	24	120	0.50265	0.02387	0.03915	0.06302
	-32	23.6	120	0.49616	0.02419	0.04003	0.06422
	-34	23.2	120	0.48967	0.02451	0.04087	0.06537
	-36	22.8	120	0.48318	0.02484	0.04165	0.06649
	-38	22.4	120	0.47669	0.02517	0.04238	0.06755
	-40	22	120	0.4702	0.02552	0.04306	0.06858
Passive System (Unit C)	0	109	0	0.092	0	0.07111	0.07111
	-2	109	0	0.0977	0	0.07823	0.07823
	-4	109	0	0.1034	0	0.08534	0.08534
	-6	109	0	0.1091	0	0.09245	0.09245
	-8	109	0	0.1148	0	0.09956	0.09956
	-10	109	0	0.1205	0	0.10667	0.10667
	-12	109	0	0.13468	0	0.11378	0.11378
	-14	109	0	0.14886	0	0.12089	0.12089
	-16	109	0	0.16304	0	0.12801	0.12801
	-18	109	0	0.17722	0	0.13512	0.13512
	-20	109	0	0.1914	0	0.14223	0.14223
	-22	109	0	0.20558	0	0.14934	0.14934
	-24	109	0	0.21976	0	0.15645	0.15645
	-26	109	0	0.23394	0	0.16356	0.16356
	-28	109	0	0.24812	0	0.17067	0.17067
	-30	109	0	0.2623	0	0.17778	0.17778
	-32	109	0	0.27008	0	0.1849	0.1849
	-34	109	0	0.27786	0	0.19201	0.19201
	-36	109	0	0.28564	0	0.19912	0.19912
	-38	109	0	0.29342	0	0.20623	0.20623
	-40	109	0	0.3012	0	0.21334	0.21334
Air Changer (Unit D)	0	31	60	0.6	0.01	0.02023	0.03023
	-2	30.4	60	0.5836	0.01028	0.02182	0.0321
	-4	29.8	60	0.5672	0.01058	0.02333	0.03391
	-6	29.2	60	0.5508	0.01089	0.02477	0.03566
	-8	28.6	60	0.5344	0.01123	0.02612	0.03735
	-10	28	60	0.518	0.01158	0.0274	0.03898
	-12	27.4	60	0.5016	0.01196	0.0286	0.04056
	-14	26.8	60	0.4852	0.01237	0.02972	0.04209
	-16	26.2	60	0.4688	0.0128	0.03077	0.04357
	-18	25.6	60	0.4524	0.01326	0.03173	0.045
	-20	25	60	0.436	0.01376	0.03262	0.04638
	-22	24.4	60	0.4196	0.0143	0.03343	0.04773
	-24	23.8	60	0.4032	0.01488	0.03416	0.04904
	-26	23.2	60	0.3868	0.01551	0.03481	0.05033
	-28	22.6	60	0.3704	0.0162	0.03539	0.05159
	-30	22	60	0.354	0.01695	0.03588	0.05283
	-32	21.4	60	0.3376	0.01777	0.0363	0.05407
	-34	20.8	60	0.3212	0.01868	0.03664	0.05532
	-36	20.2	60	0.3048	0.01969	0.0369	0.05659
	-38	19.6	60	0.2884	0.0208	0.03708	0.05789
	-40	19	60	0.272	0.02206	0.03719	0.05925

WORKSHEET 2

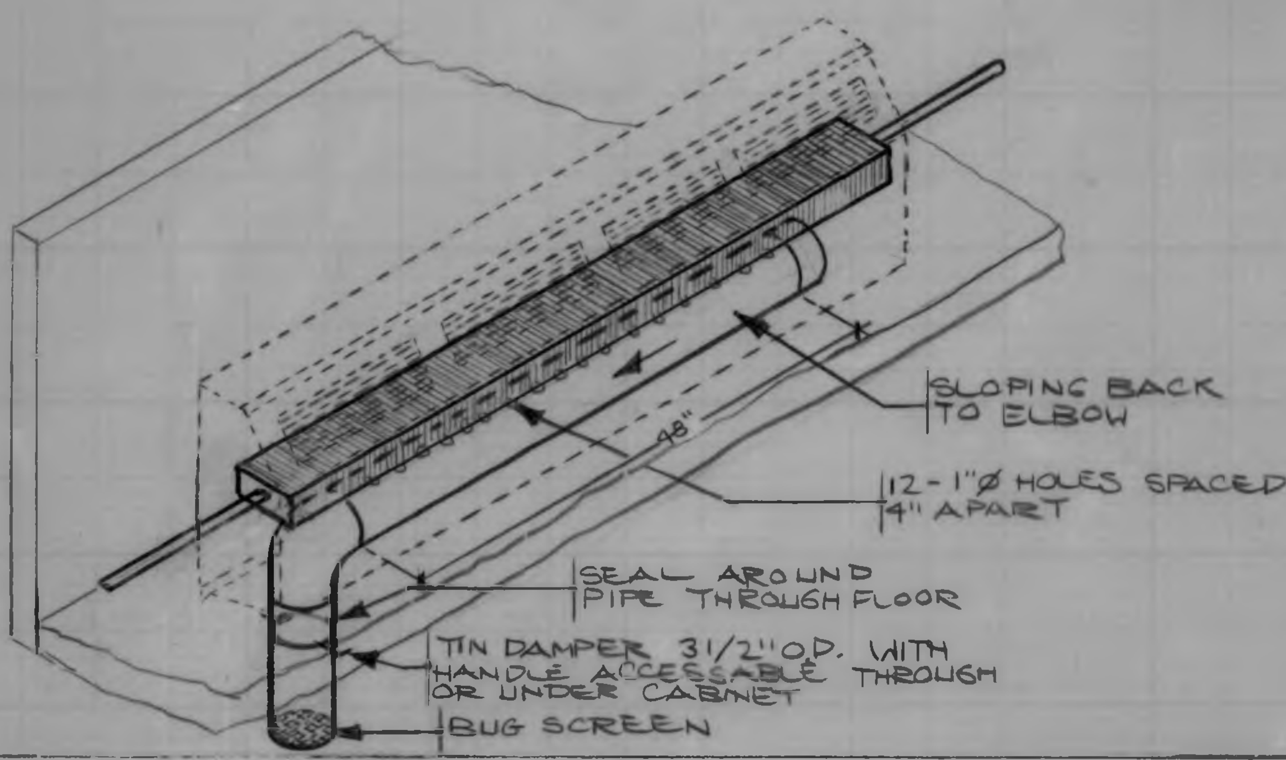
Compiled Data Summary..Remote Community-> WORKSHEET 2

Unit Costs -for-->	Electrical $/Kwh -->	$0.55		Fuel $/litre-->	$0.92		
Heat exchanger	**Temperature (Outside) C**	**Dwelling Wh added as Heat /Deg/AC**	**Base Watts HRV**	**Mean # AC per Hour**	**Electrical Cost /AC**	**Fuel Cost /AC**	**Total Cost /AC**
NuTech 200 (Unit B)	0	30	120	0.6	0.11	0.06431	0.17431
	-2	29.6	120	0.59351	0.1112	0.0698	0.181
	-4	29.2	120	0.58702	0.11243	0.07511	0.18755
	-6	28.8	120	0.58053	0.11369	0.08026	0.19395
	-8	28.4	120	0.57404	0.11497	0.08523	0.20021
	-10	28	120	0.56755	0.11629	0.09003	0.20632
	-12	27.6	120	0.56106	0.11763	0.09466	0.2123
	-14	27.2	120	0.55457	0.11901	0.09912	0.21813
	-16	26.8	120	0.54808	0.12042	0.10341	0.22383
	-18	26.4	120	0.54159	0.12186	0.10753	0.22939
	-20	26	120	0.5351	0.12334	0.11147	0.23481
	-22	25.6	120	0.52861	0.12486	0.11524	0.2401
	-24	25.2	120	0.52212	0.12641	0.11885	0.24525
	-26	24.8	120	0.51563	0.128	0.12228	0.25027
	-28	24.4	120	0.50914	0.12963	0.12553	0.25516
	-30	24	120	0.50265	0.1313	0.12862	0.25992
	-32	23.6	120	0.49616	0.13302	0.13154	0.26456
	-34	23.2	120	0.48967	0.13478	0.13428	0.26906
	-36	22.8	120	0.48318	0.1366	0.13685	0.27345
	-38	22.4	120	0.47669	0.13845	0.13925	0.27771
	-40	22	120	0.4702	0.14037	0.14148	0.28185
Passive System (Unit C)	0	109	0	0.092	0	0.23366	0.23366
	-2	109	0	0.0977	0	0.25703	0.25703
	-4	109	0	0.1034	0	0.28039	0.28039
	-6	109	0	0.1091	0	0.30376	0.30376
	-8	109	0	0.1148	0	0.32712	0.32712
	-10	109	0	0.1205	0	0.35049	0.35049
	-12	109	0	0.13468	0	0.37386	0.37386
	-14	109	0	0.14886	0	0.39722	0.39722
	-16	109	0	0.16304	0	0.42059	0.42059
	-18	109	0	0.17722	0	0.44395	0.44395
	-20	109	0	0.1914	0	0.46732	0.46732
	-22	109	0	0.20558	0	0.49069	0.49069
	-24	109	0	0.21976	0	0.51405	0.51405
	-26	109	0	0.23394	0	0.53742	0.53742
	-28	109	0	0.24812	0	0.56078	0.56078
	-30	109	0	0.2623	0	0.58415	0.58415
	-32	109	0	0.27008	0	0.60752	0.60752
	-34	109	0	0.27786	0	0.63088	0.63088
	-36	109	0	0.28564	0	0.65425	0.65425
	-38	109	0	0.29342	0	0.67761	0.67761
	-40	109	0	0.3012	0	0.70098	0.70098
Air Changer (Unit D)	0	31	60	0.6	0.055	0.06645	0.12145
	-2	30.4	60	0.5836	0.05655	0.07168	0.12823
	-4	29.8	60	0.5672	0.05818	0.07666	0.13484
	-6	29.2	60	0.5508	0.05991	0.08137	0.14129
	-8	28.6	60	0.5344	0.06175	0.08583	0.14758
	-10	28	60	0.518	0.06371	0.09003	0.15374
	-12	27.4	60	0.5016	0.06579	0.09398	0.15977
	-14	26.8	60	0.4852	0.06801	0.09767	0.16568
	-16	26.2	60	0.4688	0.07039	0.1011	0.17149
	-18	25.6	60	0.4524	0.07294	0.10427	0.17721
	-20	25	60	0.436	0.07569	0.10718	0.18287
	-22	24.4	60	0.4196	0.07865	0.10984	0.18849
	-24	23.8	60	0.4032	0.08185	0.11224	0.19409
	-26	23.2	60	0.3868	0.08532	0.11439	0.1997
	-28	22.6	60	0.3704	0.08909	0.11627	0.20537
	-30	22	60	0.354	0.09322	0.1179	0.21112
	-32	21.4	60	0.3376	0.09775	0.11927	0.21702
	-34	20.8	60	0.3212	0.10274	0.12039	0.22313
	-36	20.2	60	0.3048	0.10827	0.12125	0.22951
	-38	19.6	60	0.2884	0.11442	0.12185	0.23627
	-40	19	60	0.272	0.12132	0.12219	0.24351

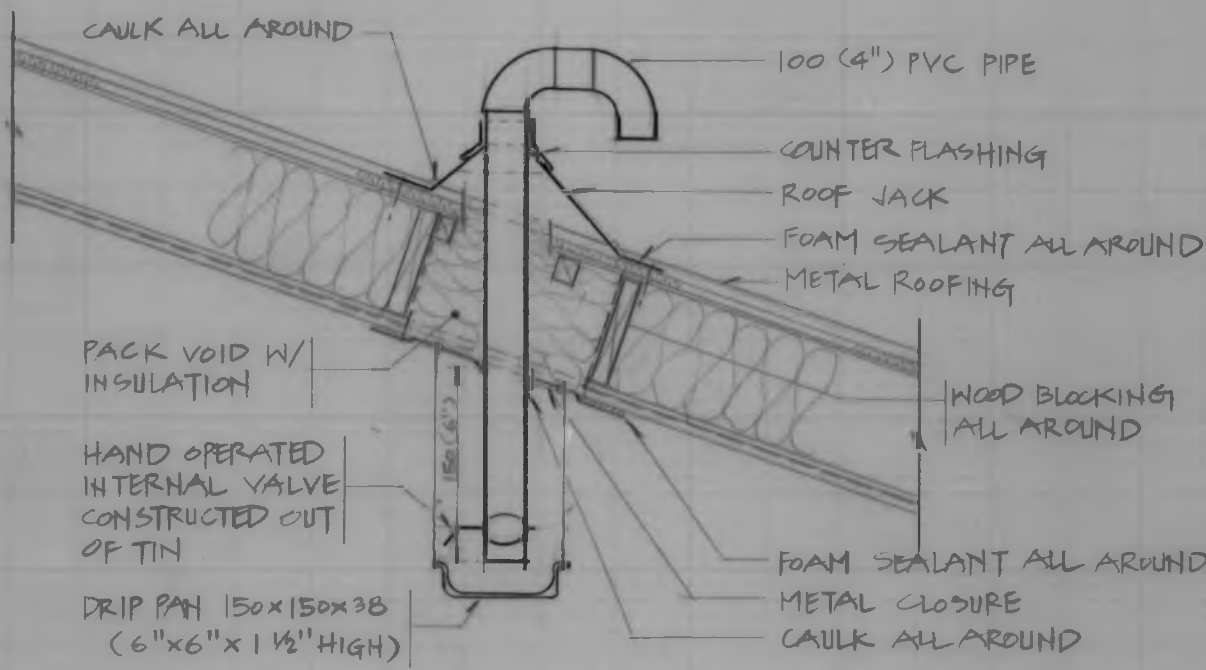
APPENDIX A - SKETCHES



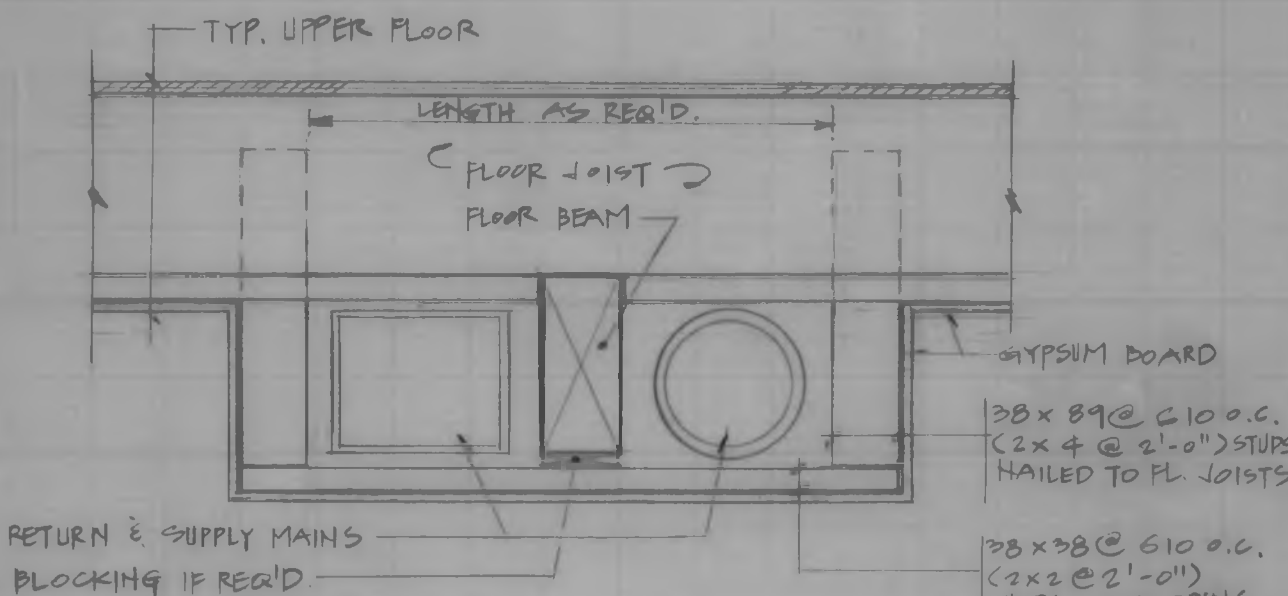
NOTE; DO NOT GLUE FITTINGS



DRAWING TITLE PASSIVE VENTING DETAIL - MAIN FLOOR UNIT "C"		
JOB TITLE NORTHERN VENTILATION		JOB NUMBER 86-006
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY D. C.	SCALE N.T.S.
	DRAWN BY R. H.	DATE MAY 23/86
	CHECKED BY	DRAWING NO SKM-1

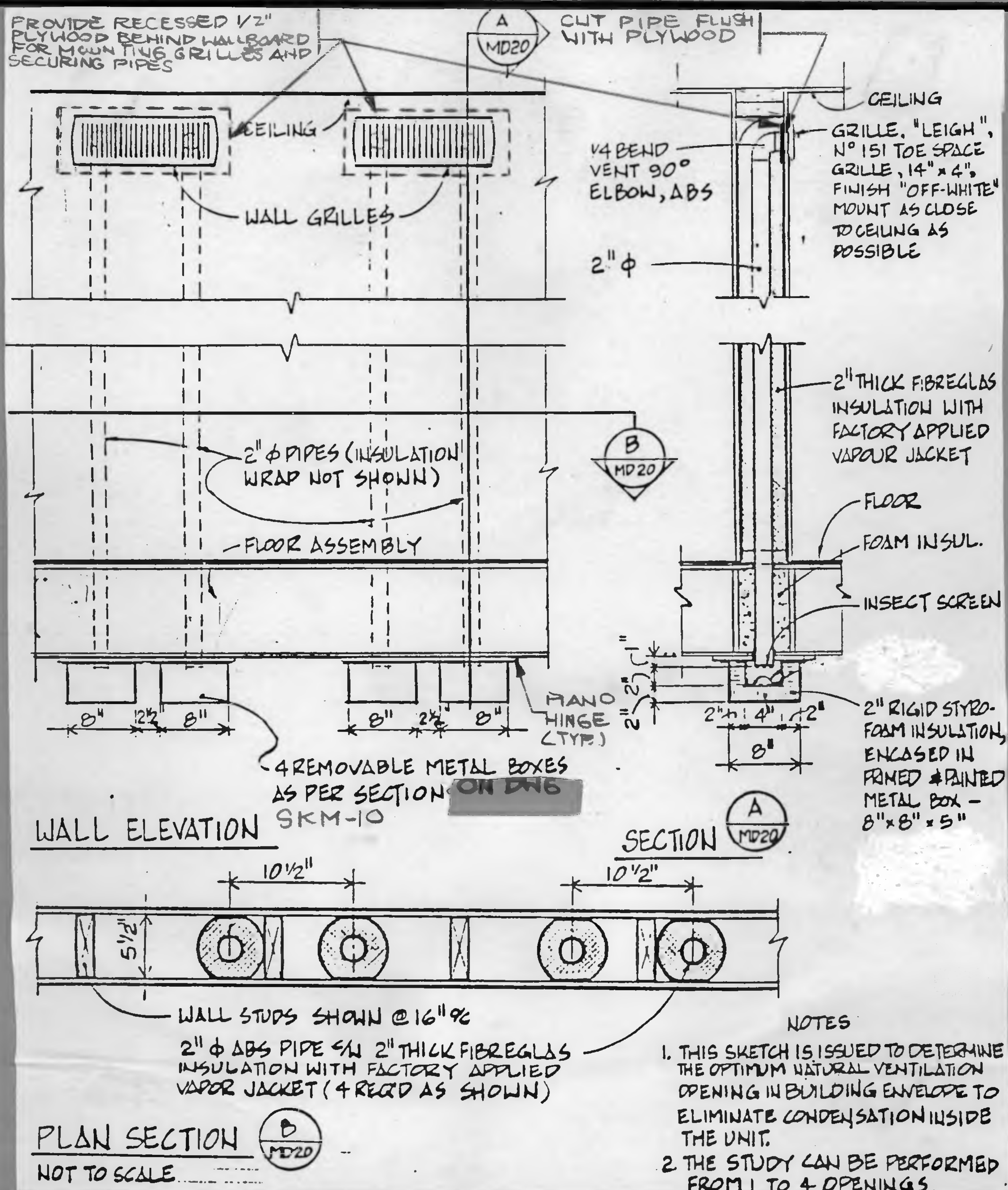


UNIT 'C'
PASSIVE VENTING APPARATUS - TOP FLOOR 1:20

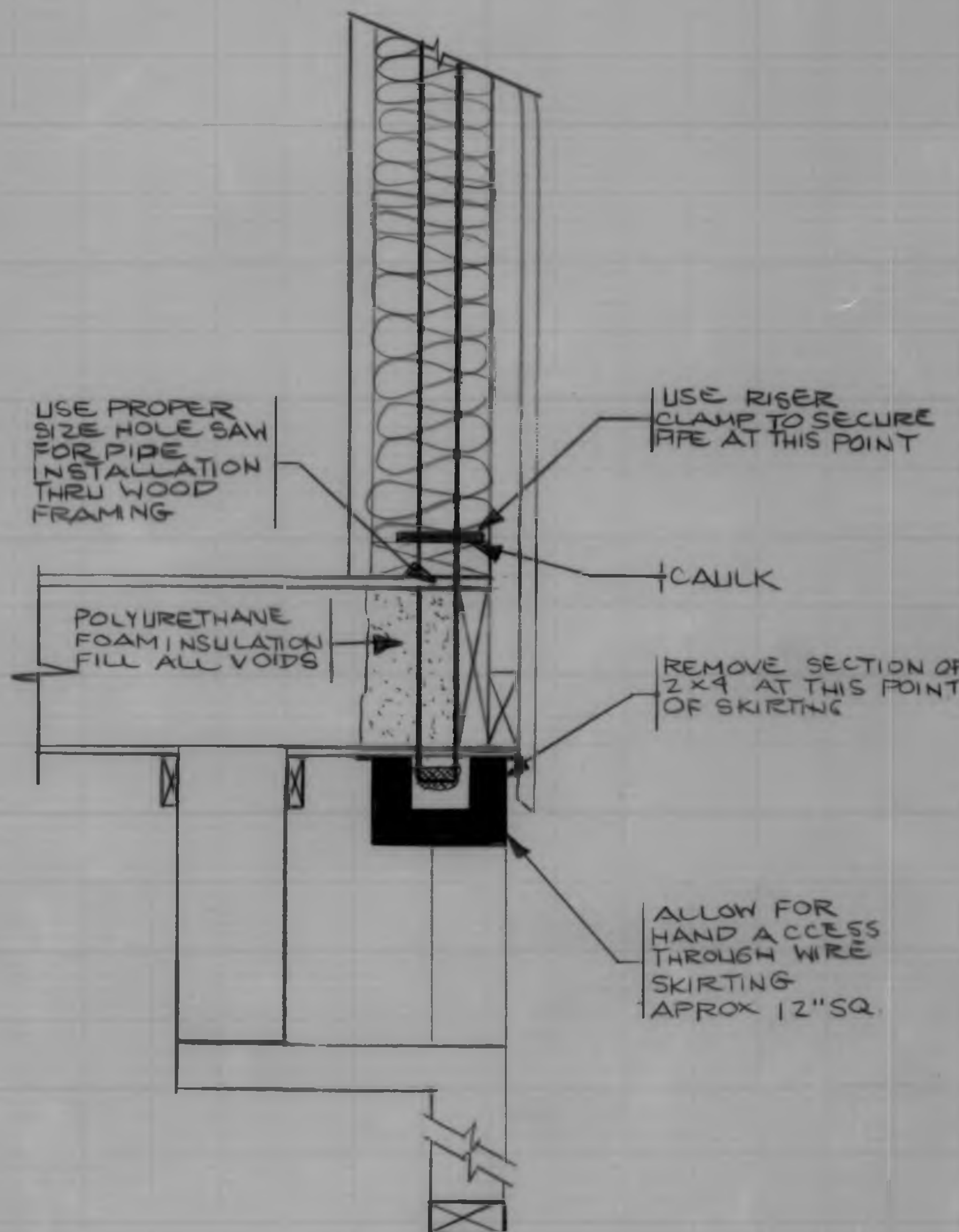


FRAMING DETAIL FOR SUPPLY & RETURN MAINS 1:10

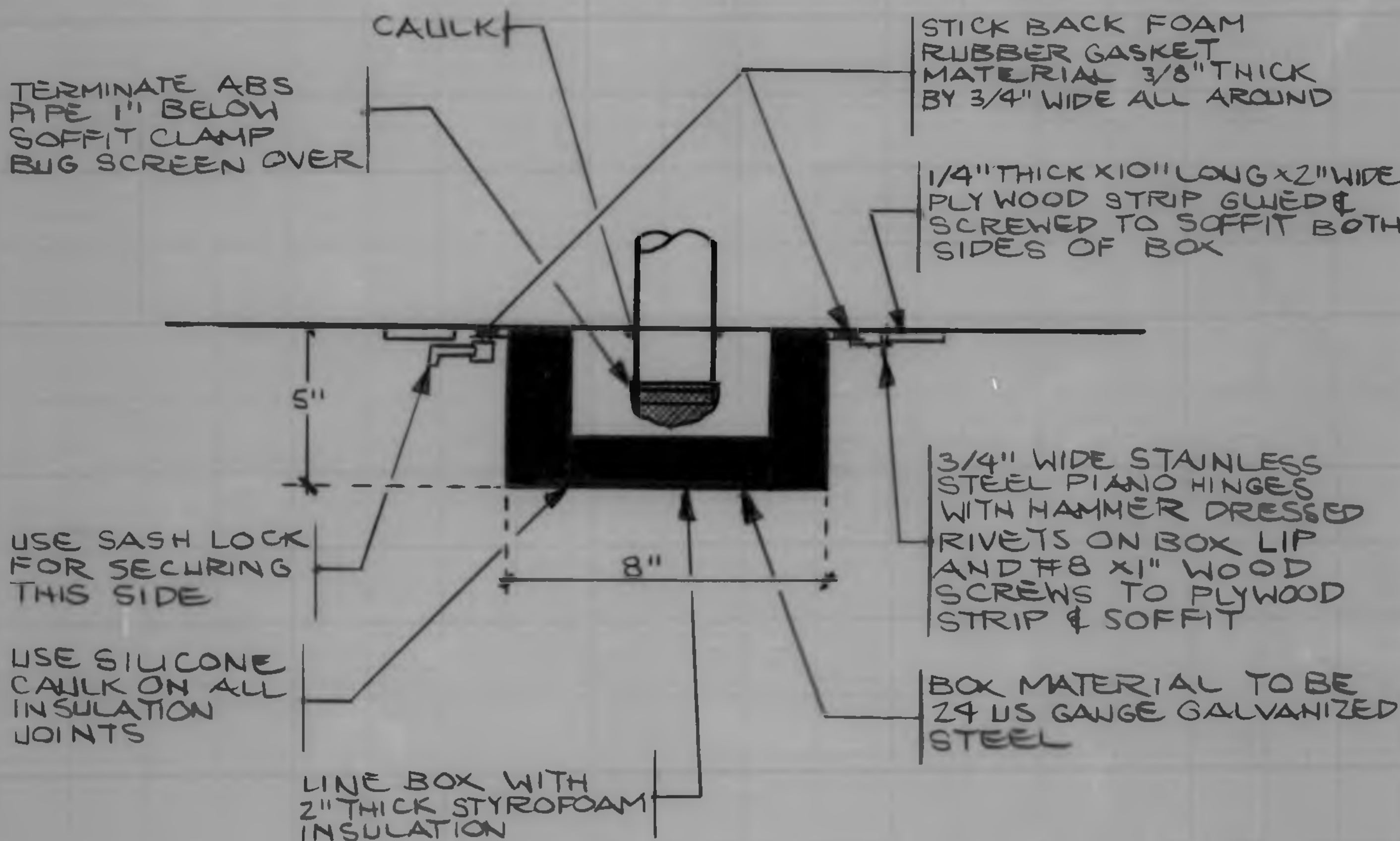
DRAWING TITLE	ARCHITECTURAL DETAILS		
JOB TITLE	NORTHERN VENTILATION - CMHC	JOB NUMBER	86-005
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS	DESIGNED BY D.C., B.C.	SCALE	AS SHOWN
	DRAWN BY B.C.	DATE	MAY 23/86
P.O. BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	CHECKED BY D.C.	DRAWING NO	SKM-2



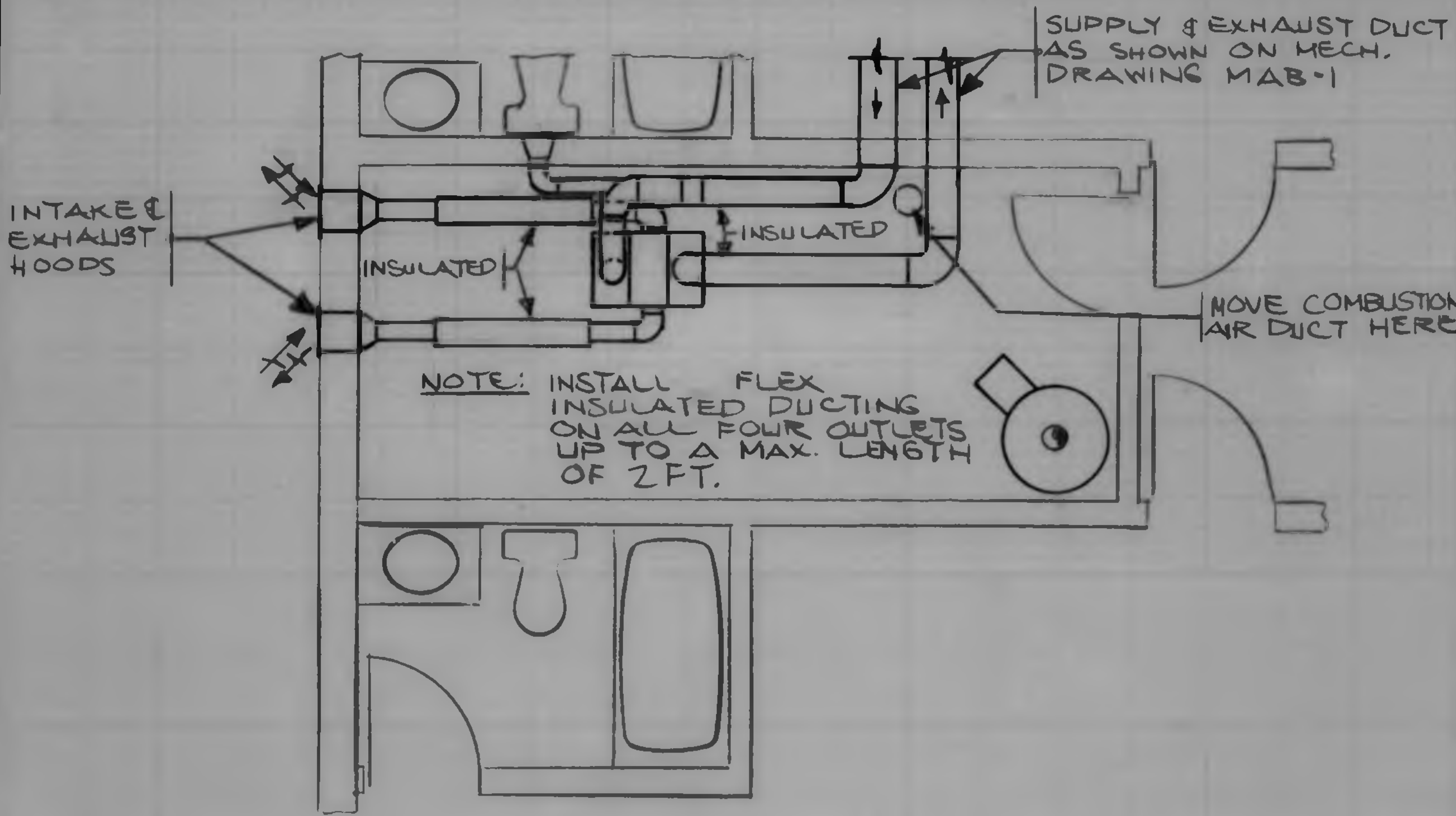
DRAWING TITLE: PASSIVE VENTILATION PIPING		
JOB TITLE: NORTHERN VENTILATION LATHAN ISLAND		JOB NUMBER: 86-131
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY: W.T.	SCALE: N.T.S.
	DRAWN BY: G.L. & R.H.	DATE: OCT/86
	CHECKED BY: B.F.	DRAWING NO: SKM-8



DRAWING TITLE PASSIVE VENT PIPE & BOX INSTALLATION LAYOUT		
JOB TITLE NORTHERN VENTILATION LATHAN ISLAND		JOB NUMBER 86-131
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY W.T	SCALE N.T.S.
	DRAWN BY R.H.	DATE OCT./86
	CHECKED BY B.F.	DRAWING NO SKM-9

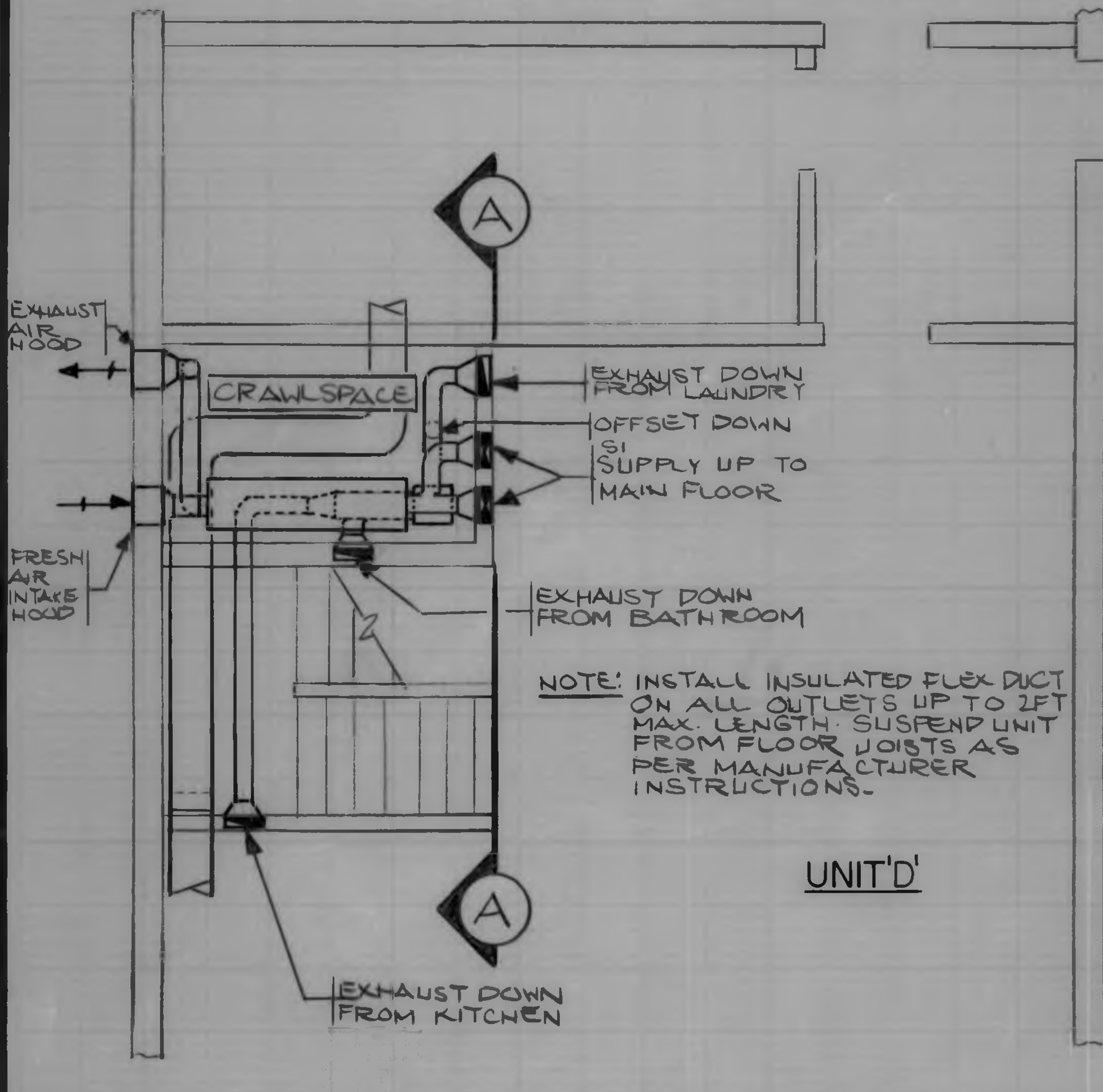


DRAWING TITLE BOX COVER MOUNTING DETAIL		
JOB TITLE NORTHERN VENTILATION LATHAN ISLAND		JOB NUMBER 86-131
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY B.F.	SCALE N.T.S.
	DRAWN BY R.H.	DATE OCT./86
	CHECKED BY B.F.	DRAWING NO SKM-10



PARTIAL FLOOR PLAN UNIT 'A'

DRAWING TITLE REVISED KANTHERM DUCT LAYOUT		
JOB TITLE NORTHERN VENTILATION LATHAN ISLAND		JOB NUMBER 86-131
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY B.F	SCALE N.T.S.
	DRAWN BY R.H	DATE OCT./86
	CHECKED BY B.F.	DRAWING NO SKM-12

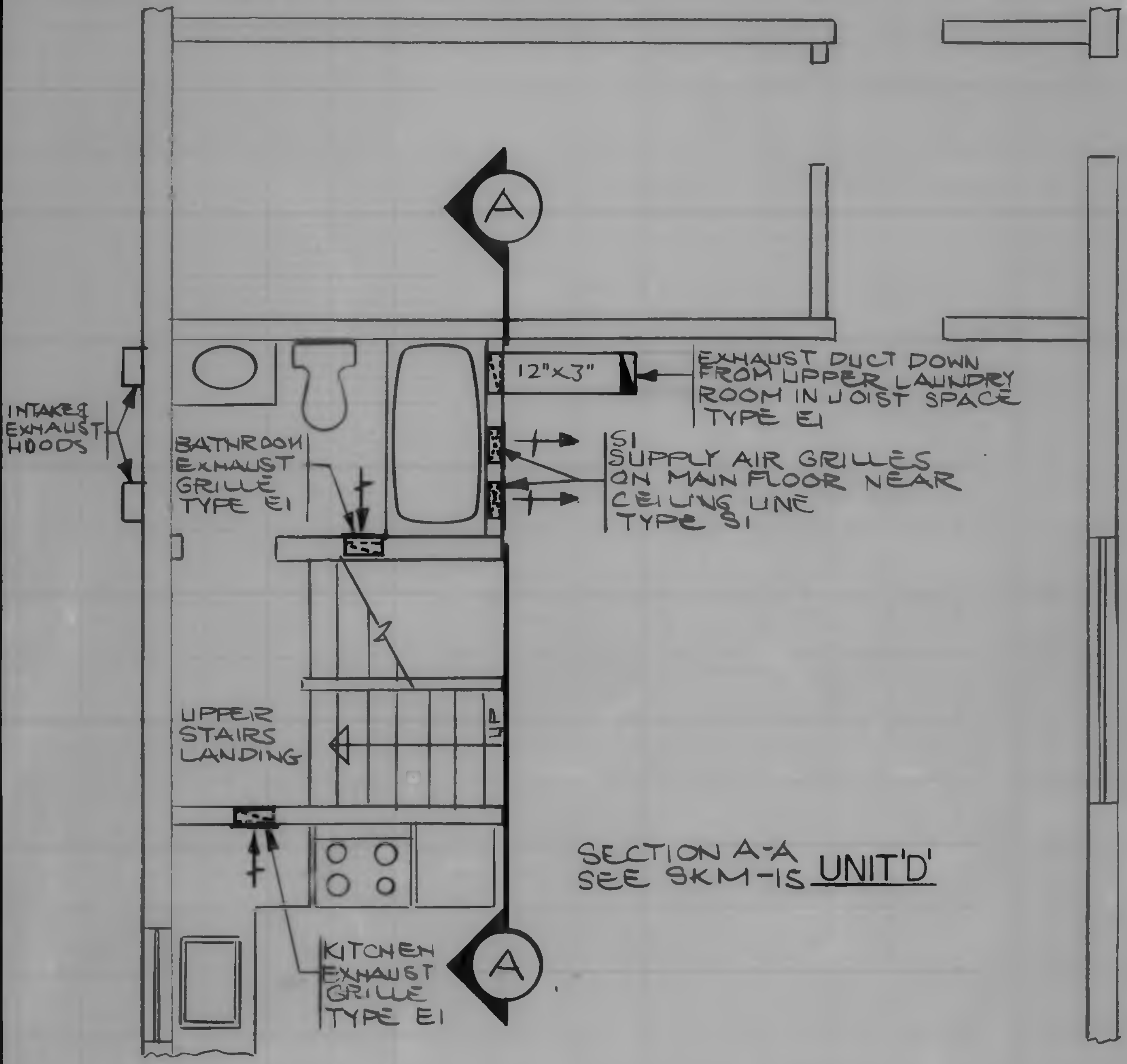


NOTE: INSTALL INSULATED FLEX DUCT ON ALL OUTLETS UP TO 2FT MAX. LENGTH. SUSPEND UNIT FROM FLOOR JOISTS AS PER MANUFACTURER INSTRUCTIONS.

UNIT 'D'

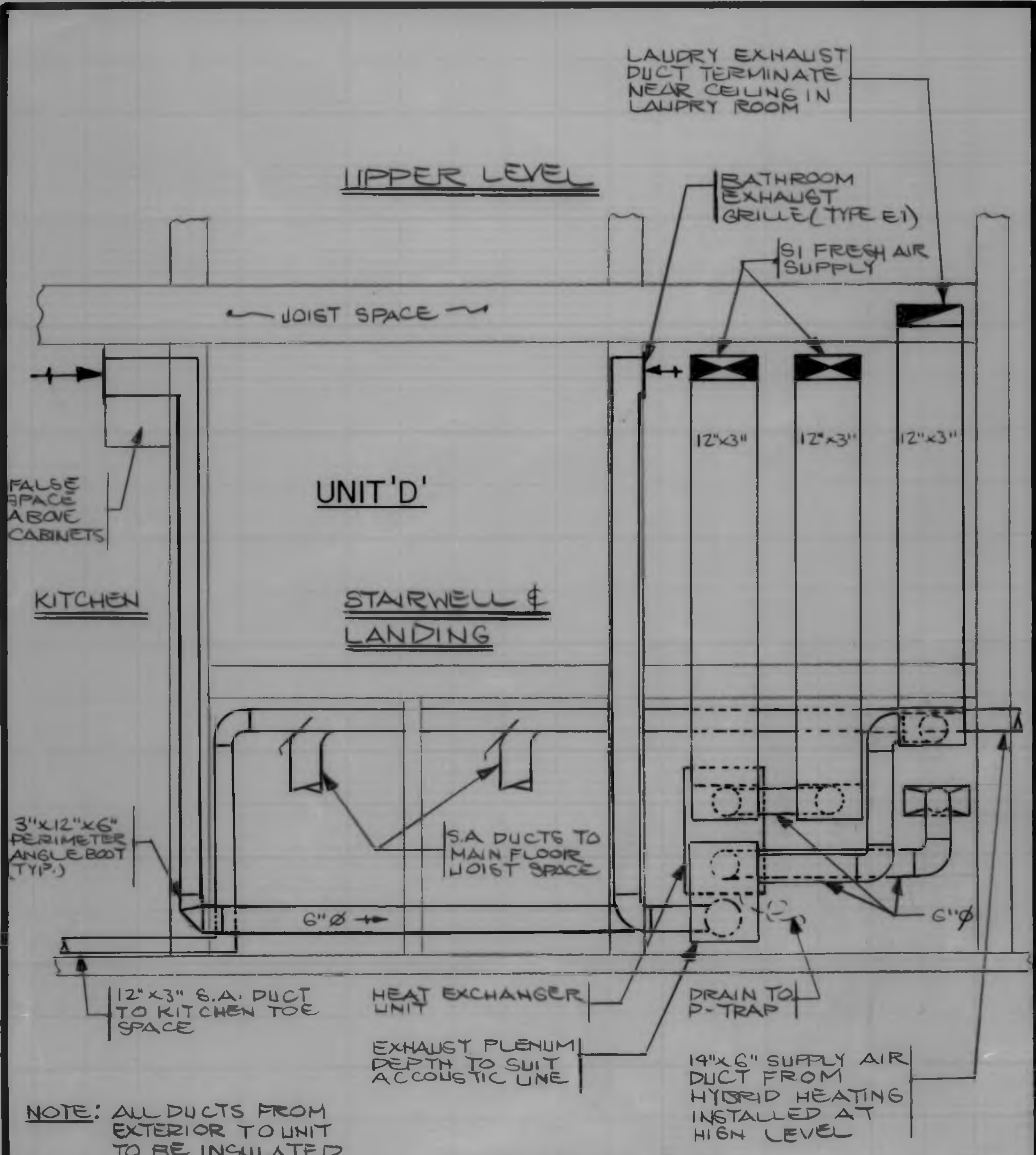
PARTIAL MAIN FLOOR PLAN

DRAWING TITLE: CRAWLSPACE HEAT x DUCT LAYOUT "AIR CHANGER"	
JOB TITLE: NORTHERN VENTILATION LATHAN ISLAND	JOB NUMBER: 86-131
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY: B.F. / SCALE: N.T.S.
	DRAWN BY: R.H / DATE: OCT./86
	CHECKED BY: B.F. / DRAWING NO: SKM-13



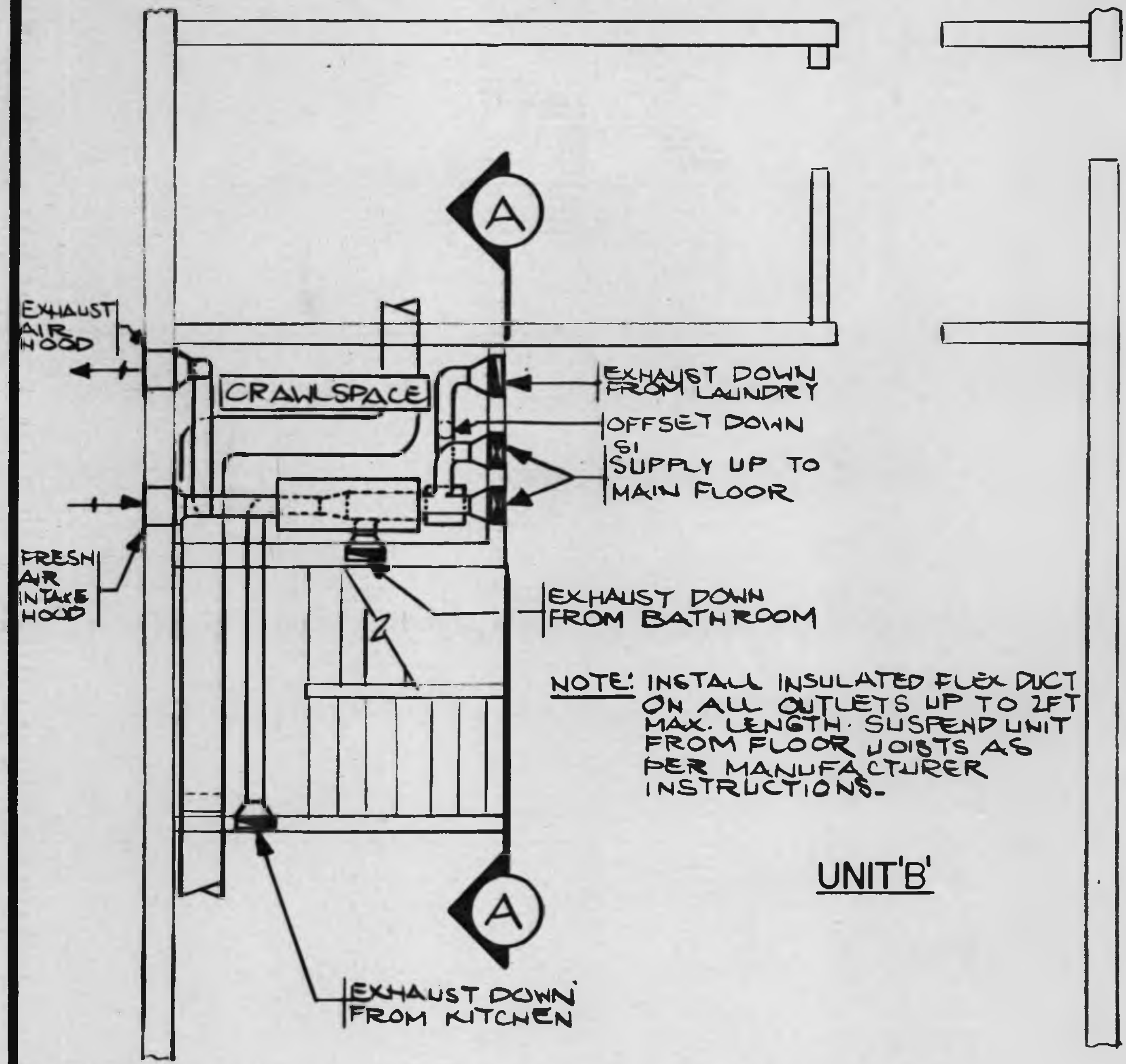
PARTIAL MAIN AND RAISED FLOOR PLAN

DRAWING TITLE MAIN FLOOR HEAT X DUCT LAYOUT "AIR CHANGER"		
JOB TITLE NORTHERN VENTILATION LATHAN ISLAND		JOB NUMBER 86-131
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY B.F. DRAWN BY R.H. CHECKED BY B.F.	SCALE N.T.S. DATE OCT./86 DRAWING NO SKM-14



SECTION A-A

DRAWING TITLE VERTICAL SECTION OF DUCT LAYOUT "AIR CHANGER"	
JOB TITLE NORTHERN VENTILATION LATHAN ISLAND	JOB NUMBER 86-131
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY B.F.
	DRAWN BY R.H.
	CHECKED BY B.F.
SCALE 1/2" = 1'0"	DATE OCT./86
DRAWING NO SKM-15	



NOTE: INSTALL INSULATED FLEX DUCT ON ALL OUTLETS UP TO 2FT MAX. LENGTH. SUSPEND UNIT FROM FLOOR JOISTS AS PER MANUFACTURER INSTRUCTIONS.

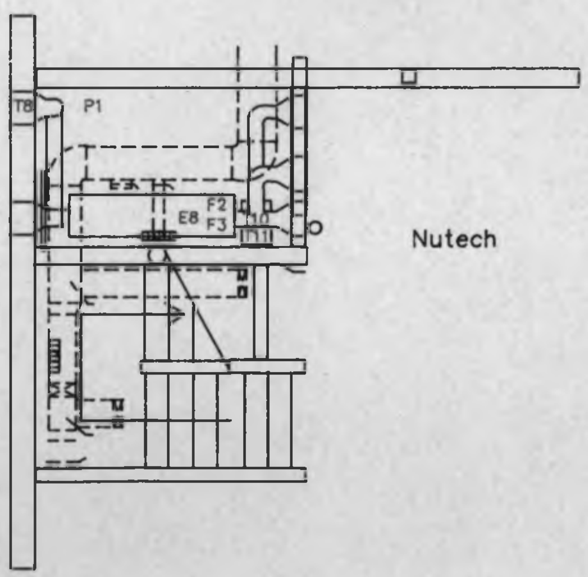
UNIT 'B'

PARTIAL MAIN FLOOR PLAN

NOTE: ALL DUCTS ROUTING IS IDENTICAL TO "AIR CHANGER" DUCTS IN UNIT 'D'

DRAWING TITLE: CRAWLSPACE HEAT x DUCT LAYOUT "NUTECH"		
JOB TITLE: NORTHERN VENTILATION LATHAN ISLAND		JOB NUMBER: 86-131
FERGUSON, SIMEK, CLARK CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T., CANADA. X1A 2P4	DESIGNED BY: B.F.	SCALE: N.T.S.
	DRAWN BY: R.H	DATE: OCT./86
	CHECKED BY: B.F.	DRAWING NO: SKM-16

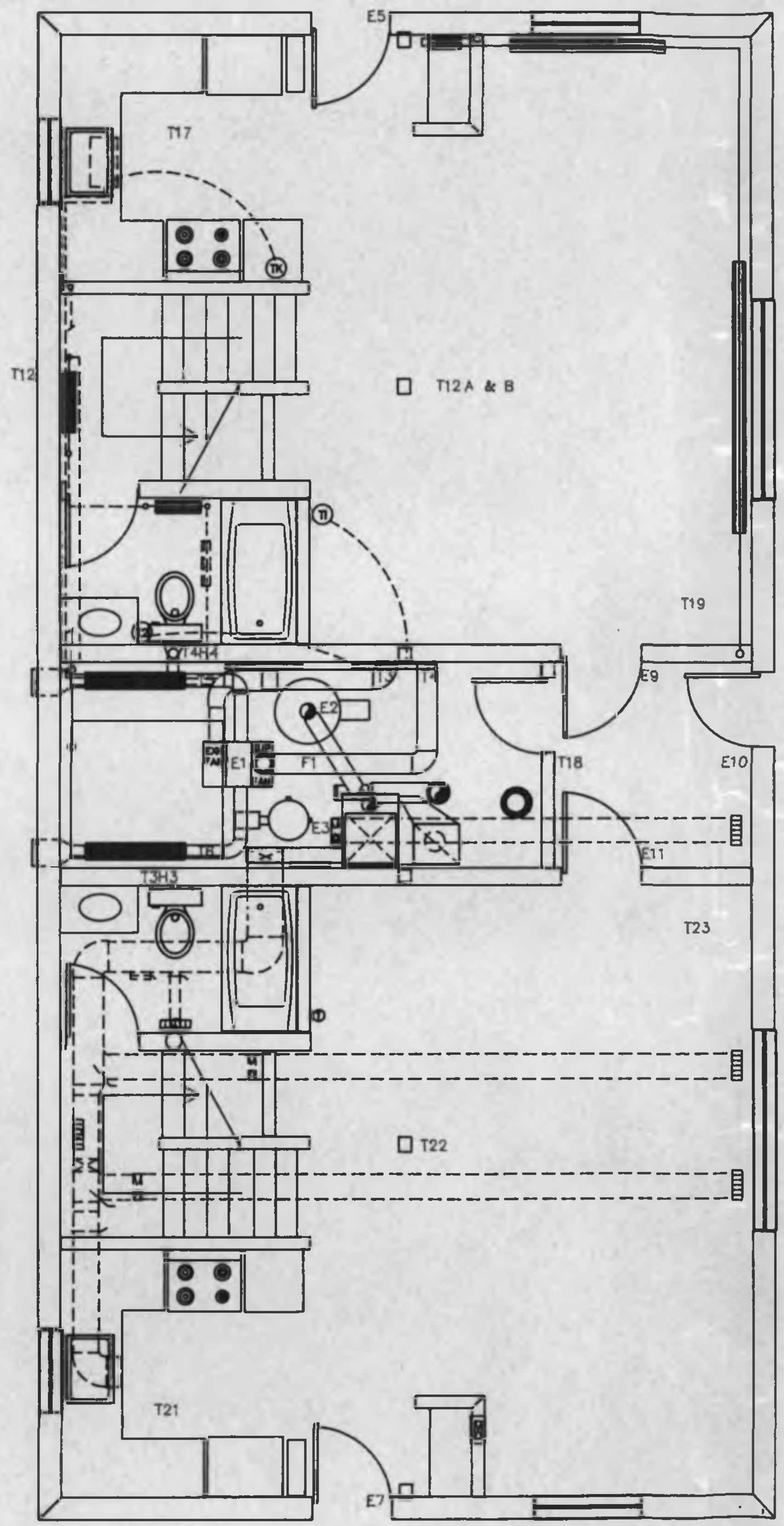
APPENDIX B - DRAWINGS



CRAWLSPACE

Kantherm

Nutech



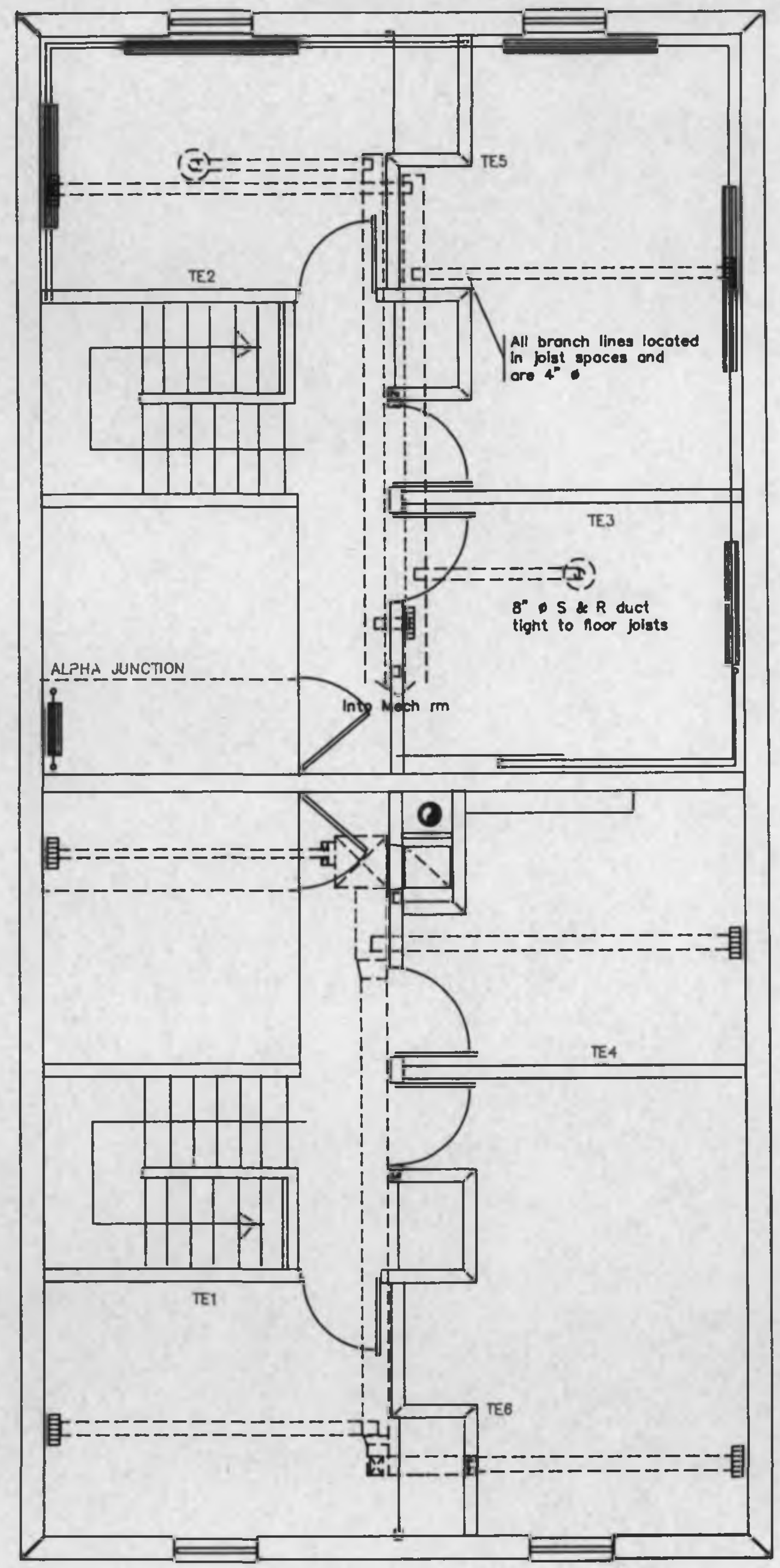
MAIN FLOOR UNITS A & B

UNIT A

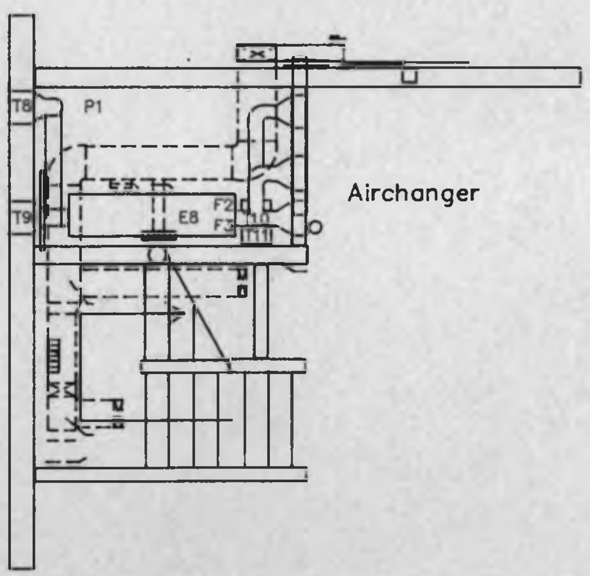
Domestic Hot Water Heating

UNIT B

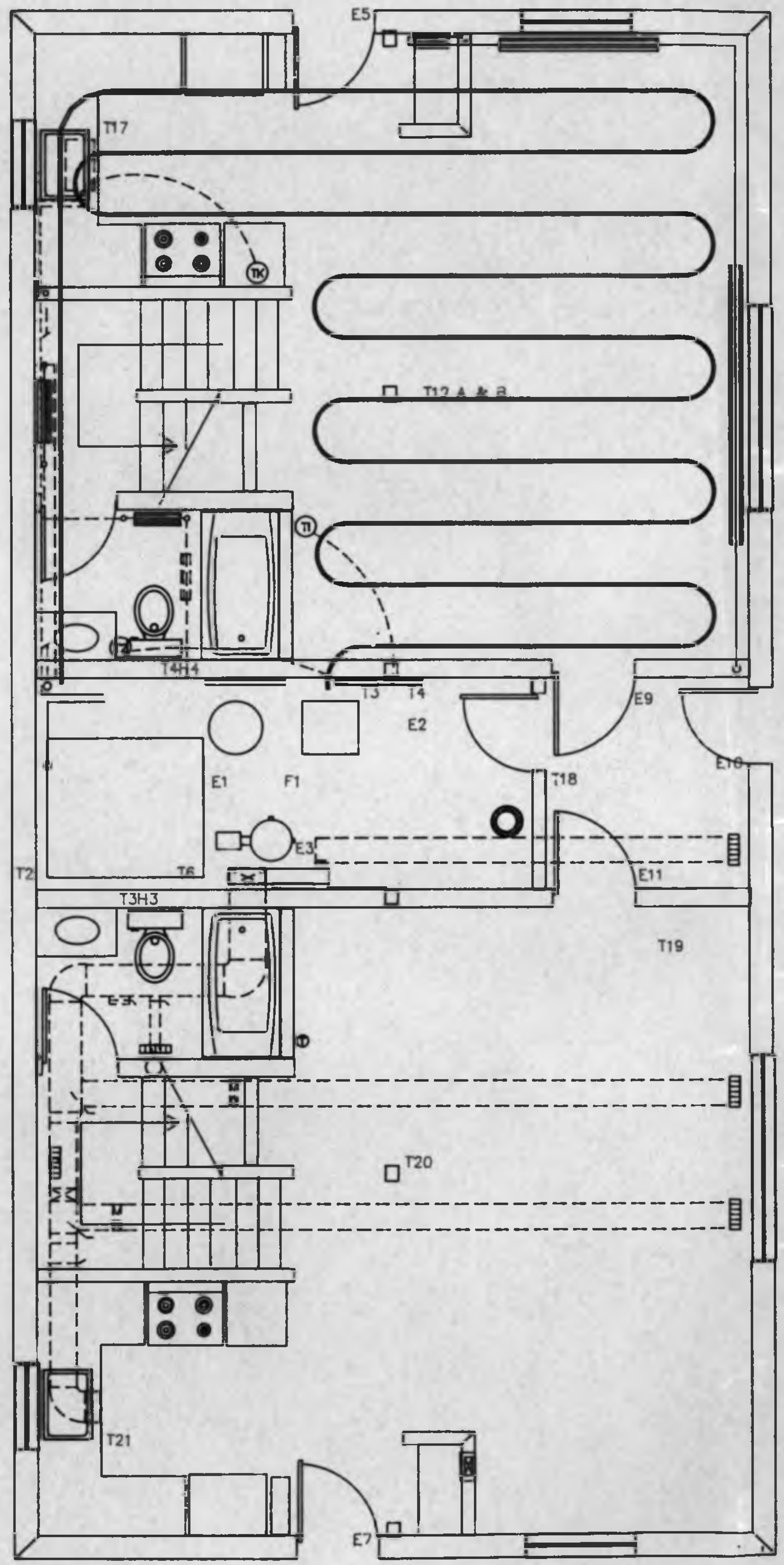
Forced Air Furnace



SECOND FLOOR UNITS A & B



CRAWLSPACE



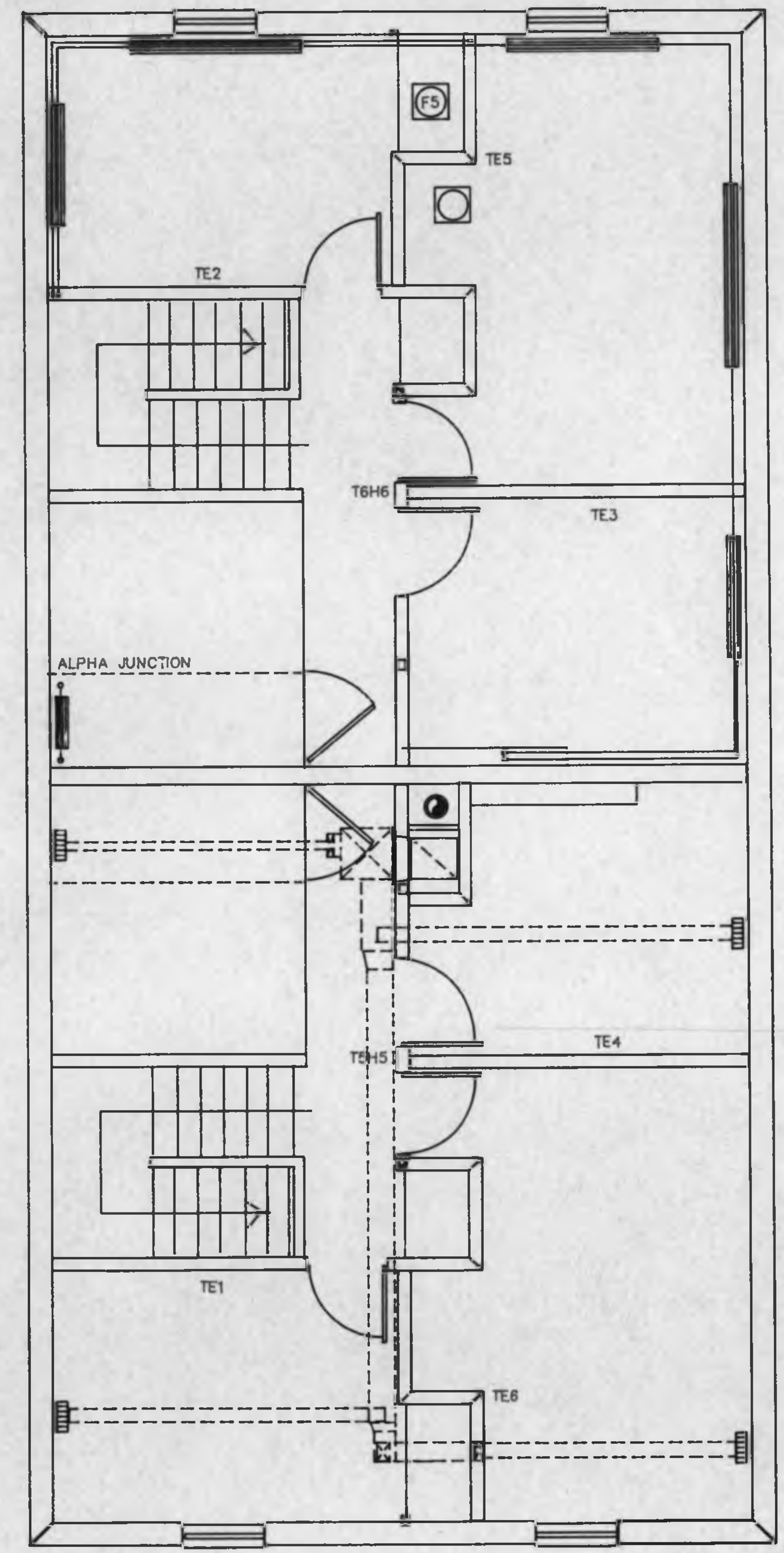
MAIN FLOOR UNITS C & D

UNIT C

Hydronic Heating
Passive Venting

UNIT D

Hybrid System



SECOND FLOOR UNITS C & D

V2

APPENDIX C - MONITORING EQUIPMENT

MODEL 641 ELECTRONIC MEASUREMENT SYSTEM

ANALOG INPUTS

Number of channels	: 64 multifunction*/differential [Note 1]
A/D converter	: 12 bit-plus-sign, dual slope, integrating
Conversion rate	: Typically: 10 channels per second Worst case: 7.5
Measurable signal types	: Volts — DC; Resistance — Ω; Current — mA; Frequency — Hz

***any channel, any order, any range, totally software selectable**

DC VOLTAGE

Channel types : All channels fully differential. Single-ended measurements made by connecting channel Low input to analog common.

Input impedance : single-ended: 5 MΩ, differential: 10 MΩ

Ranges (built-in) :

Gain	Full-Scale	Resolution
1	± 4.096 V	1.0 mV
10	±0.4096 V	0.1 mV
100	±40.96 mV	10 μV
500	±8.192 mV	2.0 μV

Accuracy : 0.1% + 2 digits

RESISTANCE

Measurement mode : 3-wire for single channel measurements
4-wire using 2 channels

Ranges :

Full-Scale	Resolution
200 Ω	0.048 Ω
20000 Ω	4.8 Ω
200000 Ω	48 Ω

Accuracy : 0.3% + 2 digits

DC CURRENT

Ranges [Note 2] :

Full-Scale	Resolution
0.409 mA	0.1 μA
4.096 mA	1.0 μA

Accuracy : 0.5% + 2 digits

FREQUENCY

Waveform Types	: any shape, internal amplication and squaring
Measurement method	: pulse-period measured with binary counters and computer clock signal
Trigger-point	: Zero-crossing detector
Ranges	: DC to 10000 Hz, 255 ranges, 16-bit counter
Resolution	: 4 μS per bit on 0.26 sec maximum period range [Note 3]

DIGITAL INPUTS

Number of inputs	: 16, TTL compatible
Conditioning	: Internal pull-up resistors
Logic "0" voltage	: -0.5 to 0.8 V
Logic "1" voltage	: 2.0 to 5.0 V

DIRECTLY COMPATIBLE SENSORS

- Thermocouples, types E, T, J, K, R, S
- IC temperature sensors (AD590, MTS102, LM3911, LM135)
- Displacement transducers
- Pyranometers
- Anemometers
- Hall effect transducers
- Thermistors
- Pressure sensors
- Humidity sensors
- Liquid flow meters
- KWH meters
- Liquid level sensors

COMPUTER INTERFACE

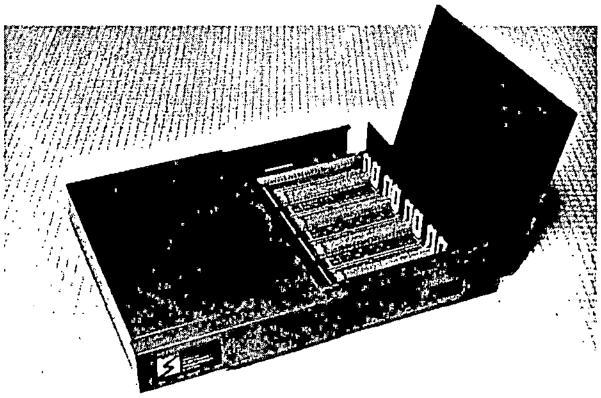
Base unit	: memory-mapped/dedicated bus interface with switch-selectable address.
Interface Cards	: Optional computer interface cards available for IBM PC, APPLE II+/IIe, and Commodore PET/C64/C128. Card installs in any slot and connects to unit via interface cable. Multiple EMS units may be connected to a single interface card.
Serial Interface	: Optional RS-232C interface card can be installed internal to EMS unit for operation with most common computers.
CPU Card	: Optional CPU card available with on-board program EPROM, CMOS RAM, battery-backed real-time clock, serial interface port and built-in operating system software for stand-alone applications.

SOFTWARE

Optional software packages are available for the IBM PC (MS-DOS), APPLE II+/IIe, Commodore 64/128/PET, and other computers.
Sophistication ranges from Level 1 software, a complete library of Model 641 subroutines to fully automated, menu-driven data acquisition packages.

GENERAL SPECIFICATIONS

Power requirements	: 12-14 VDC input power @ 0.5A maximum			
Connection method	: Screw terminals included with base unit			
Operating temperature range	: 5°C to 40°C			
Relative humidity	: 8 to 80%			
Storage temperature	: -30°C to 60°C			
Size	:	**Height**	**Width**	**Depth**
		60 mm	450 mm	365 mm
		2.4 inches	17.7 inches	14.4 inches
Base unit weight	: 3.5 kg			



Notes

1. When thermocouples are measured, one of the 32 analog channels is used by the system for software auto-zeroing and cold junction compensation.
2. Higher currents (e.g, 4..20 mA) are measured using precision shunts and the DCV function.
3. Specifications based on 1 MHz clock frequency.

Specifications subject to change without notice

MANUFACTURED BY
SCIEMETRIC INSTRUMENTS INC
P.O BOX 1048 MANOTICK, ONTARIO, CANADA, K0A 2N0
(613) 692-3506

HARDWARE PRODUCTS FOR DATA ACQUISITION AND CONTROL

SCIEMETRIC INSTRUMENTS

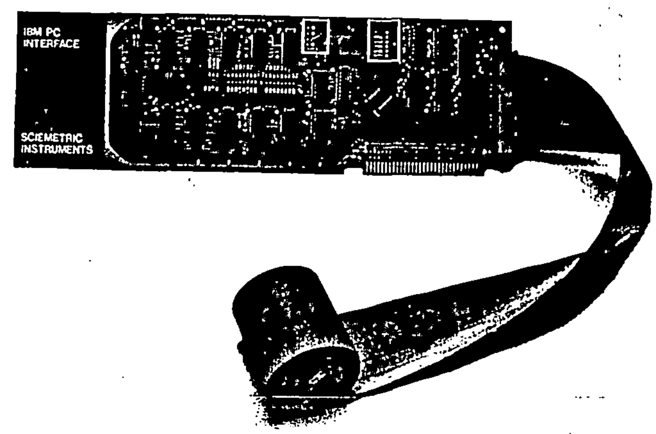
INTERFACES

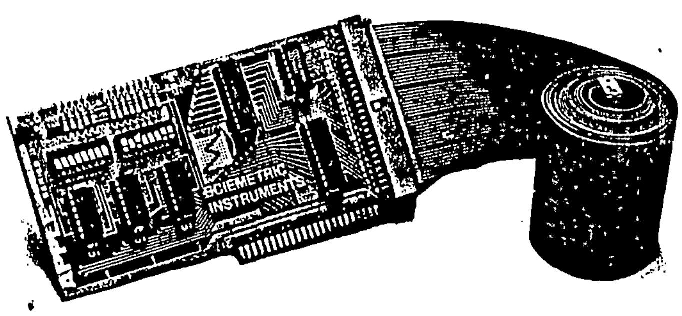
IBM PC* INTERFACE: SERIES 801

Interface card for connecting up to four (4) model 8Ø82A's or up to sixteen (16) PDC 848's (or combinations) to the IBM PC or compatible computers. Multiple units connected to the interface card via daisy-chained cable.

* Uses any full length PC slot
* Switches select memory vs. port address and location
* Single slot supports multiple units
* Complete documentation included
* 2 m connecting cable included

* Trademark of IBM Ltd.





APPLE** INTERFACE: SERIES 701B

Interface card for connecting up to eight (8) model 8Ø82A's or up to thirty-two (32) PDC 848's (or combinations) to APPLE compatible computers. Multiple units connected to the interface card via daisy-chained cable.

* APPLE II, II+, IIe, compatibles
* Uses any APPLE slot
* Switch selectable card address
* Single slot supports multiple units
* Complete documentation included
* 2 m connecting cable included

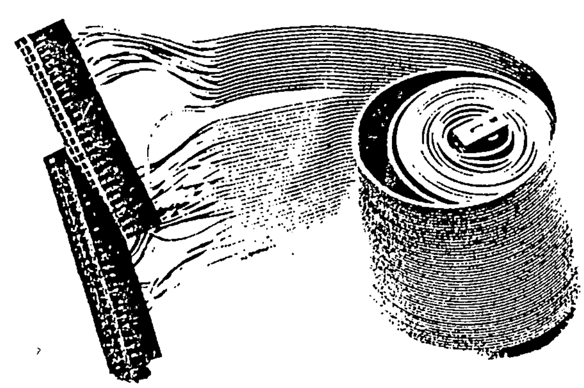
** Trademark of Apple Computers, Inc.

COMMODORE PET*** INTERFACE: SERIES 601

Interface for connecting multiple 8Ø82A's and PDC 848's to Commodore PET series computers. Cable attaches between PET memory expansion port and 8Ø82A/PDC. Multiple units connected via daisy-chained cable.

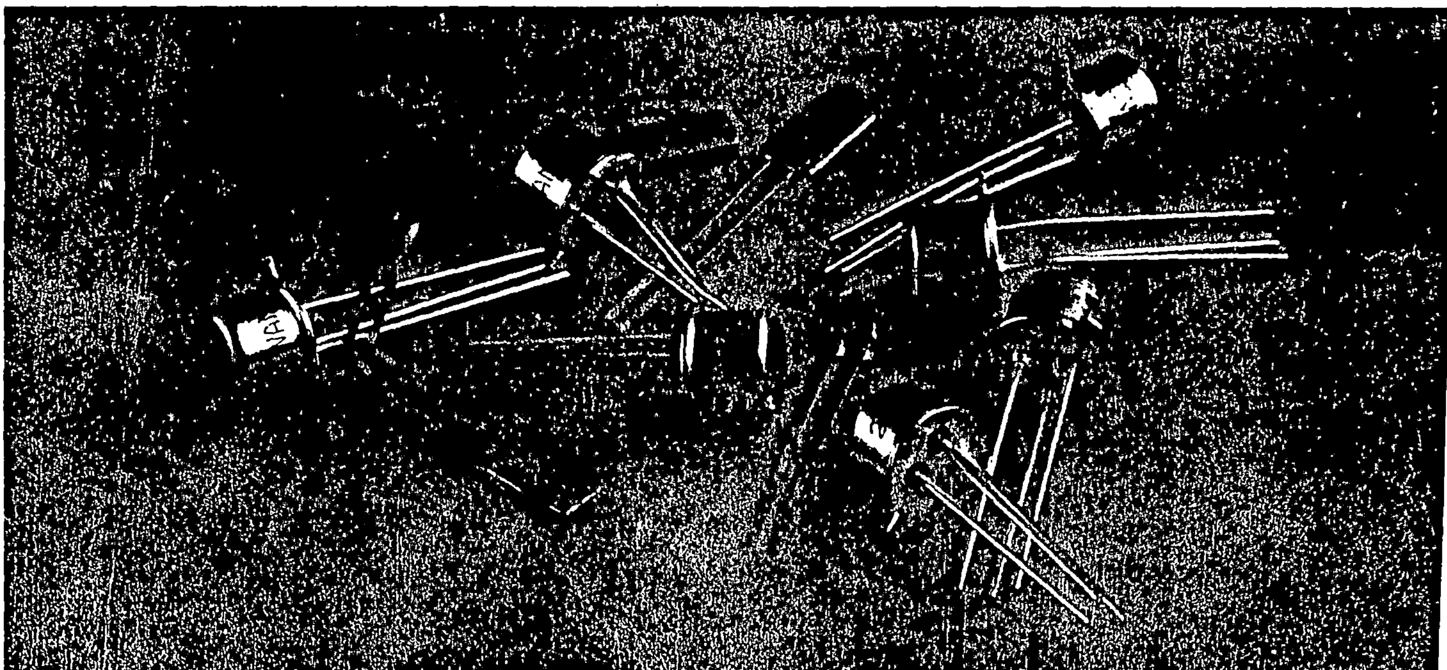
* PET series 2ØØ1, 4Ø16, 4Ø32, 8Ø32, etc.
* Switch selectable address via 8Ø82A internal switches
* Number of units limited only by free PET memory
* Complete documentation included

*** Trademark of Commodore Business Machines Ltd



SCIEMETRIC INSTRUMENTS P.O. BOX 1048, MANOTICK, ONTARIO, CANADA K0A 2N0 (613) 692-3507

Solid State Temperature Sensor
AD590 Series
Linear 1 Microamp per Kelvin Output (-273)



AD590 Applications

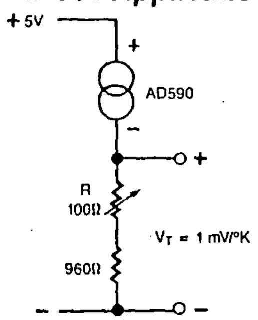


Fig. 1 Basic Operation Circuit

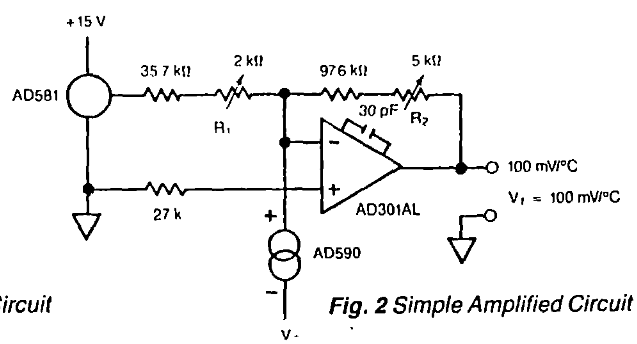


Fig. 2 Simple Amplified Circuit

- **Linear Current Output**
- **Broad Range −55 to 150°C**
- **No Linearization Circuitry Required**
- **Versatile and Economical**
- **Fast Response**

The AD590 is a small temperature transducer that converts a temperature input into a proportional current output.

The advanced technology in the AD590 is especially suited for special temperature measurement and control applications between −55 and 150°C when solid state reliability, linearity and accuracy are required. The AD590 can be used to determine minimum, average, and differential temperatures, in addition to being used for thermocouple cold junction compensation and temperature control applications. The size and responsiveness of the AD590 make it perfect for uses where size is a consideration, such as on PC boards or heat sinks.

Just power up—and measure the absolute temperature (Kelvin). No linearization, amplification or cold junction compensation is required (fig. 1). To convert reading to °C, subtract 273.15.

AD590 Applications

- ***Ideal for Fast Response Surface Measurements***
- ***Sensors for Controllers and Meters***
- ***Use in Custom Made Probes***
- ***Use on PC Boards for Accurate Measurements***

PRICED AS LOW AS

$4.50 EACH

Honeywell

Comfort Control Systems

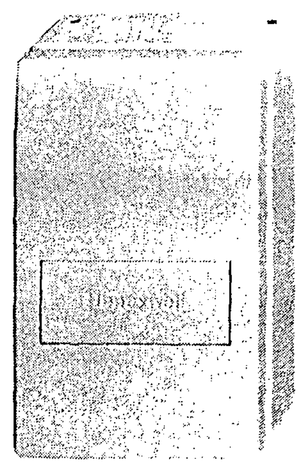
H7506A/H7508A

Humidity Sensor
Humidity-Temperature Sensor

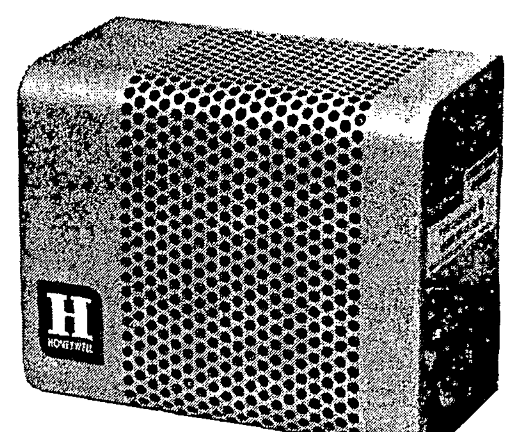
Specifications

APPLICATION

The H7506A is a capacitance type relative humidity space sensor for control and indication of relative humidity in commercial or industrial installations.
The H7506A humidity sensor mounted in a duct sampling chamber 14002362-001 can be used for duct humidity sensing, i.e. as high limit control.
The H7508A Humidity-Temperature sensor combines a capacitance type relative humidity sensor and a Balco 500 Ohm temperature sensor for outside air sensing, both mounted in one case. The sensors are shielded by a perforated, wrap-around cover for maximum air circulation and protection from physical damage.
These sensors must be used in conjunction with suitable electronic controllers (i.e. MicroniK 100 or Excel), and automation systems. The temperature compensation feature, built into the humidity sensors, maintains the sensor accuracy through the ambient temperature range.



H7506A



H7508A

SPECIFICATIONS

Power supply	: 24 Volts $^{+10\%}_{-15\%}$ 50/60 Hz
Power consumption	: 400 mW
Sensing element	: Capacitance element
Sensing range	: 10...90% RH
Output signal	: 0...1 V/0...100% RH
Sensitivity	: 10 mV/% RH
Accuracy	: ± 1% RH
Temperature coefficient	: < 0.2%/K
Response time	: < 3 min.
Ambient temperature	: 0...50°C
Storage temperature	: —20... + 80°C
Relative humidity	: 5...95% RH

Sensors are calibrated at 21°C

WIRING

From sensor to ...	Type of wire	Length max. up to 100 m	Length max. up to 150 m
Controller	Local standard	18 AWG	14 AWG

ORDERING INFORMATION

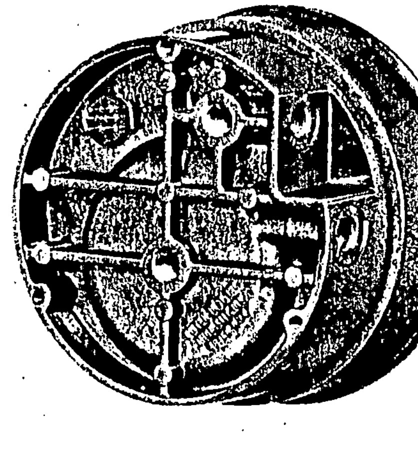
1) Space humidity sensor	H7506A
2) Duct humidity sensor	H7506A + 14002362-001
3) Outside air humidity-temperature sensor	H7508A

NOTE

The relative humidity sensors should not be used in an atmosphere containing ketones.

12/82
R.F.T.
MLF II.G.2.
Honeywell, 740 Ellesmere Road, Scarborough, Ontario M1P 2V9. Offices across Canada.
Printed in Canada
Form Number 95C-10274
Comm. Div.

SERIES 600 DIFFERENTIAL PRESSURE TRANSMITTER (continued)



SERIES 600 TRANSMITTER MODELS & RANGES

MODEL NUMBER	RANGES IN INCHES OF WATER		
	AS STOCKED	MIN. RANGE	MAX. RANGE
602-0	0- 0.25	0- 0.20	0- 0.70
602-1	0- 0.50	0- 0.40	0- 1.8
602-2	0- 2.0	0- 1.1	0- 5.0
602-3	0- 5.0	0- 5.0	0-22.0
602-4	0-15.0	0-13.0	0-59
	RANGE IN PSI		
602-5	0-20	0-2.0	0-23

Span can be adjusted to any range between minimums and maximums listed above.

How to Order: See price list, Bulletin S-26.

SPECIFICATIONS – 4-20 mA Strain Gage Transmitter

GENERAL

Maximum Pressure: 35 PSIG
Media Compatibility: Air & noncombustible, noncorrosive gases

ELECTRICAL

Power Supply: 20 to 30 VDC, or 18 to 26 VAC, or 15 VDC regulated
Output Signal: 4 to 20 mA DC, 3 or 4 wire (limited at 30 mA)
Loop Resistance: 0 to 500 ohms at 15 VDC (4 wire)
250 to 1200 ohms at 30 VDC (3 wire)
150 to 1400 ohms at 10-35 VDC (4 wire current sourcing)
Warm-up Time: 5-10 minutes
Current Consumption: 100 mA (min.)
200 mA (max.)

MECHANICAL

Weight: 1 lb. 10 oz.
Span & Zero Adjustments: Protected potentiometers, externally accessible
Pressure Connections: 1 8-27 NPT, female

PERFORMANCE AT ROOM TEMPERATURE

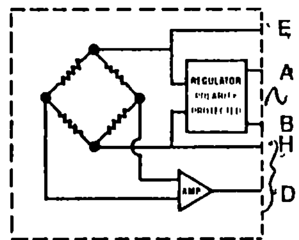
Zero Output: 4 mA
Full Scale Span: 16 mA
Static Accuracy: • 2% Span
Span & Zero: Adjustable to 0 05%
Repeatability: 0 5% Span
Resolution: Infinitesimal

ENVIRONMENTAL

Operating Temperature: 20 to 120 F (dry air)
Compensated Temperature: 30 to 120 F
Thermal Errors: [illegible] 1% 50 F

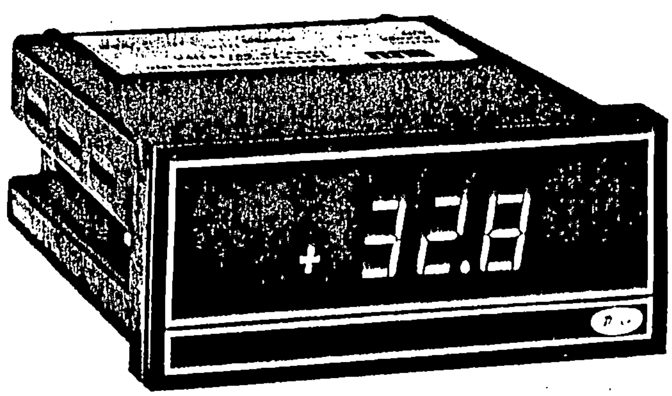
STANDARD ACCESSORIES

- 5 ft. cable assembly
- Span and zero adjustment tool
- Mounting hardware kit including screws and washers plus two each tubing adapters and pipe plugs.



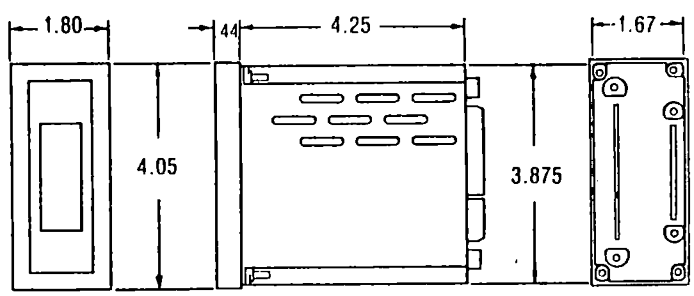
E INTERNAL VOLTAGE SUPPLY +15 VDC
A, B POWER INPUT 20 to 30 VDC OR 18 to 26 VAC
H CURRENT SOURCING CONTROL TERMINAL
D CURRENT SINKING CONTROL TERMINAL 4-20 mA LIMITED AT 30 mA

A-701 Digital Readout



Light emitting diode display reads out in any required engineering units to 1999 for 4-20 ma current loop input. Provides operating power to the Series 600 Transmitter.

The A-701 Digital Readout provides local or remote readout of pressures monitored by the Series 600 Transmitter. The standard unit is supplied to read 0-100.0 to indicate percentage of transmitter pressure range. However, the A-701 can also be field adjusted to read out in the range and engineering units specified for your application with any one of four decimal point locations (1.999, 19.99, 199.9 or 1999). Since a 22 VAC, 180 ma output is provided for operation of the Series 600 Transmitter, this device and the transmitter make up a complete digital pressure indicating system. Other features include automatic polarity and over range indication, .6 high LED digits, ±0.5% accuracy, and panel mounting with all necessary hardware supplied. Operates from 115/230 VAC (±15%) line voltage with all electrical connections made by means of a 30 pin edge connector supplied with the A-701. Draws only 3.5 watt and weighs 15 oz.



EDRA 5 Electronic Direct Reading Anemometer

Description

The EDRA 5 is an electronic instrument which provides direct readout of air velocity. Models are available in either analogue form, equipped with a high quality taut-band moving coil meter, or with digital readout (metric only) featuring a low power consumption liquid crystal display.

The 100 mm (4 in) diameter rotating vane measuring head is supplied with a handle and extension rods for use where access is limited. The instrument is powered by rechargeable batteries but can also be operated from the mains supply.

The electronic output socket gives 0-1 mA forced current on each velocity range. This facility may be used for a variety of purposes such as recorder-driving, remote display via a duplicate readout, alarm triggering or to initiate control functions.

EDRA 5 is built into a substantial aluminium case with welded seams which provides storage space for the accessories supplied with the instrument. A soft carrying case is also available.

Applications

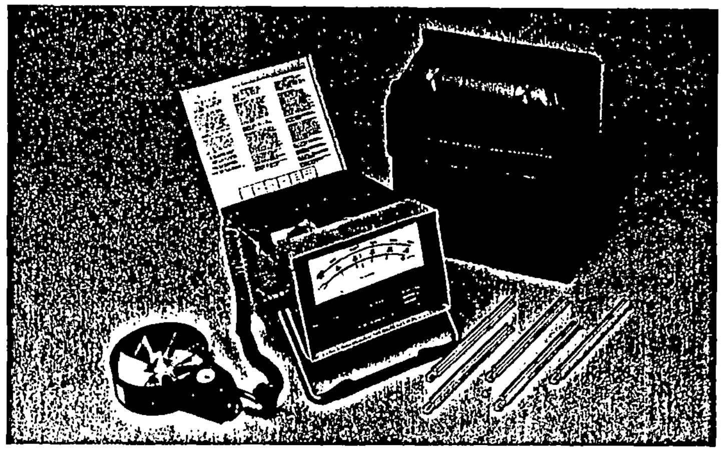
The EDRA 5 is primarily designed for measurement of velocity at supply and extract grilles in air conditioning systems and is used throughout the H & V industry for proportional system balancing. It is also suitable for permanent monitoring and in this application the rechargeable battery will automatically function as a standby power supply in the event of mains power failure. The low velocity model is particularly suitable for use in fume cupboards and laminar flow cabinets.

Operation

Full operating instructions are provided with each instrument.

Accuracy and Calibration

Normal accuracy is shown in the table. Where higher accuracy is required, Airflow offer a certified calibration service for individual instruments. It is good practice to return the instrument to Airflow for a calibration check at least once a year and also if it has been accidentally mishandled. Airflow operate an instrument hire service for the convenience of U.K. customers having equipment repaired or recalibrated.



Specification

Parameter	Edra Five & Edra Five LV	Edra Five Digital
Measuring Range	Edra 5: 0.25–5 m/s (50-1000 ft/min) 3.5-25 m/s (700-5000 ft/min) Edra 5LV: 0.25-1 m/s (50-200 ft/min) 0.7-5 m/s (150-1000 ft/min)	0.25-30 m/s (Exceeding this velocity may cause damage to the measuring head)
Accuracy at 20°C and 1013 mbar	Calibrated to better than ± 1% FSD	Calibrated to better than ± 1.5% FSD
Operating Environment (Indicator Unit)	Barometric pressure 500 mbar to 2 bar Temperature −10°C to +50°C	500 mbar to 2 bar −5° to +50°C
Operating Environment (Measuring Head)	Barometric pressure 500 mbar to 2 bar Temperature −10°C to +70°C (short periods to −30°C)	As Edra Five
Power Supply	Mains: Nominal 110-240V/1 phase/ 50-60 Hz Power consumption approx. 3 watts. Fuse rating: 3A Battery: Rechargeable nickel-cadmium type. 15 hrs. operation per charge	As Edra Five
Readout	Taut-band moving coil meter 1 mA FSD. Scale length: 125mm	Liquid crystal display Digit height 17.7 mm update period approx. 1.5 s
Recorder output	0-1 mA on each range Load 5k ohm maximum	0-1 mA. Load 5k ohm maximum
Standard Accessories	1. Mains cable. 2. Screw-in handle for head. 3. Set of 5 extension rods for measuring head 5 x 169 mm long. 4. Plug for recorder output socket.	As Edra Five
Optional Accessories	1. Adjustable shoulder/neck strap. 2. Head/Indicator extension cables Max. length 100 metres. 3. All-angle swivel bracket for head/ extension rod joint. 4. Carrying case.	As Edra Five
Overall Dimensions	220 mm x 130 mm x 210mm	As Edra Five
Total Weight with standard accessories	2.5 kg	As Edra Five

AIRFLOW

AIRFLOW DEVELOPMENTS LIMITED
Lancaster Road, High Wycombe
Buckinghamshire HP12 3QP England
Telephone High Wycombe (0494) 25252/443821
Telex 83288

APPENDIX D - CONSTRUCTION SPECIFICATIONS

FERGUSON
SIMEK
CLARK

ENGINEERS & ARCHITECTS
4910-53rd STREET. YELLOWKNIFE, N.W.T (403) 920-2882
P.O. BOX 1777 X1A-2P4 TELEX 034-45619

Our File: 86-131

October 31, 1986

NWT Housing Corporation
Yellowknife District Office
P.O. Box 2732
Yellowknife, N.W.T.
X1A 2R1

Att: Ralph Meikle

Dear Ralph:

Re: Northern Ventilation Study Duplex Housing Latham Island, Units A,B,C & D

Please process a Contemplated Change Order for the following changes to the original contract.

Quotes are to be submitted with a material labour and freight breakdown including number of man hours, room and board if applicable, and subtrades original specification guidlines shall govern.

ITEM #1

Extra passive ventilation piping installation Unit C.

A. Provide and install all necessary piping, grilles, insulation and sheet metal for a complete system as per sketches SKM # 8,9,10 & 11.

ITEM #2

Install extra (Air changer) heat recovery unit as a complete functioning system. The air changer unit only is supplied by Ferguson, Simek, Clark Ltd. This shall be installed in Housing Unit D.

A. Contractor to pick unit up at trucking depot upon arrival and assume responsibility for handling and storage.

B. Provide and install all related ducting, grilles, controls and wiring required for complete system operation.

C. Cut and or frame holes as required to allow for duct routing and securing.

D. Insulate all ducting from exterior to unit and 6' down stream wherever practical with 2" vapour seal insulation making good all joints.

E. Provide and install wiring to 120V duplex receptical using an individual 15 amp circuit from main power panel and clearly mark panel in type written letters. Also supply from separate circuit 24 volt remote control for timers and switches. To control high speed.

. . ./2

FERGUSON
SIMEK
CLARK
ENGINEERS & ARCHITECTS

ITEM #3

Install using the same perameters as item #2 a Nutech and Kantherm heat recovery unit also supplied by Ferguson, Simek, Clark.

Items No. 2.A,.B,.C,.D, and .E shall also imply for installing these units in housing unit A and D. Kantherm installed in Unit A. Nutech installed in Unit B.

Following is a specification guidline for all equipment and/or components required for Items 2 and 3:

1.1	Flex Duct	.1	6" dia insulated for cold end and warm end ducting. Catalogue # 1FD625.
1.2	Outside Vent Hoods	.1	6" dia c/w fresh air filters. Catalogue # OVH6. Provide four extra filters for each system.
1.3	24V Wire	.1	Catalogue # V133. Class II 24V doorbell wire.
1.4	Exhaust Grilles	.1	Swing up exhaust grille face c/w GFM4 filters 45 - 75 CFM air flow. Provide six extra filters for each system.
1.5	Supply Grilles	.1	Provide 12 x 8 vertical bar double deflection grilles equal to Titus.
1.6	Insulation	.1	1" thick flex wrap complete RFK medium foil wrap vapour barrier. Use contact cement or equal on all joints and tape overlapping min of 2".
1.7	Crank Timers	.1	Provide three remote 30 min switch timers in each unit location to be determined on site. One for kitchen, bathroom and laundry. Catalogue # CT30. Allow for 10 total switches.
1.8	Note	.1	Catalogue numbers were taken from the Air Changer catalogue. All components specified are available locally through Bartle & Gibson. Other components may be used if of equal or better quality. Six copies of shop drawings of all components must be provided.
1.9	Drawings	.1	Shop drawing of heat recovery units are included in this CCO for information only.

Yours truly,

FERGUSON, SIMEK, CLARK

B. Feodoroff

Bernie Feodoroff

ATTACHMENTS

GRAPHS

TABLES AND WORKSHEETS

TABLE 4

TABLE 5

WORKSHEET 1

WORKSHEET 2

APPENDIX A - SKETCHES

APPENDIX B - DRAWINGS

APPENDIX C - MONITORING EQUIPMENT

APPENDIX D - CONSTRUCTION SPECIFICATIONS