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Selected Measured Data From Residential Housing for Use in Testing and Verification of Building Energy Analysis Programs

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Building Technology
Washington, DC 20234

January 1982

Prepared for:

Architectural and Engineering Systems Branch
Office of Conservation and Solar Energy
U.S. Department of Energy
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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, ***Secretary***
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

ABSTRACT

A set of measured residential data has been culled from three larger data sets for use in the testing and verification of building energy analysis programs. The data consist of hourly values for heating/cooling system performance and weather conditions that are sufficient in detail, it is believed, for all existent computer programs. These data have been encoded onto a magnetic tape. In addition, general information has been collected on the houses, occupants/occupant use, and heating/cooling systems.

Keywords: building energy analysis program; data tape, measured hourly data; testing and verification.

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SI Conversion

In view of the presently accepted practice of the building industry in the United States and the structure of the NBS Load Determination computer program used in this report, common U.S. units of measurement have been used throughout this report. In recognition of the position of the United States as a signatory to the General Conference of Weights and Measures, which gave official status to the metric SI system of units in 1960, appropriate conversion factors have been provided in the table below. The reader interested in making further use of the coherent system of SI units is referred to:

NBS SP330, 1972 Edition, "The International System of Units"
E380-72 ASTM Metric Practice Guide (American National Standard 2210.1).

Metric Conversion Factors

Length:	1 inch (in) = 25.4 millimeters (mm) 1 foot (ft) = 0.3048 meter (m)
Area:	1 ft2 = 0.092903 m2
Volume:	1 ft3 = 0.028317 m3
Temperature:	F = 9/5 C + 32
Temperature Interval:	1 F = 5/9 C or K
Mass:	1 pound (lb) = 0.453592 kilogram (kg)
Mass per unit volume:	1 lb/ft3 = 16.0185 kg/m3
Energy:	1 Btu = 1.05506 kilojoules (kJ)
Specific heat:	1 Btu/(lb)(F) = 4.1868 kJ/(kg)(K)
U-value:	1 Btu/(ft2)(h)(F) = 5.67826 W/(m2)(K)
R-value:	1(ft2)(h)(F)/Btu = 0.176110(m2)(K)/W

1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE

With the development and widespread use of computer programs for energy analysis of buildings has come recognition of the need for reliable measured data for use in the testing and verification of these computer programs. For the most part, in the past, computer programs have been verified by using hypothetical and measured data. The reason for the infrequent use of measured data has been a lack of data since few buildings have sufficient instrumentation to monitor the data parameters that are needed for most computer programs. This situation has changed during the last several years with data becoming available from major data collection efforts for both residential and commercial buildings [1-5]. However, some of these data prove unusable. Some typical reasons for this are:

1. Bad or missing data - due to malfunctioning sensors or data acquisition systems;

2. Part or all of data monitoring system shut down - due to repairs or normal maintenance;

3. Data anomalies - due to fluctuations in data caused by unmeasured parameters (e.g., increase in house hourly energy requirements for a period of time because of a temporary but unmonitored window opening).

While unusable data are quite understandable, it proves very annoying to the researcher who must use the data, since it usually appears randomly throughout the data set. Therefore, the researcher may spend an inordinate amount of time culling a subset of reliable data from the total available data set. The purpose of this effort is to provide a cross-section of reliable energy performance data for residential housing that can be quite readily used in the testing and verification of building energy analysis programs.

The data derived in the report and accompanying data tape came from references [1-3]. The data in reference 1 came from an Electric Power Research Institute (EPRI) study of 5 single-family detached houses located in California, New Mexico, Arkansas and New York. The data in reference 2 came from a National Bureau of Standards (NBS) study of 3 single-family detached houses in Houston, Texas. The data in reference 3 came from a Department of Energy (DoE) study of 25 townhouses in Twin Rivers, New Jersey. The data contained in the data tape consist of hourly measurement of house energy use and weather conditions. Contained in the report are thermal physical and occupant/occupant-use information about the house.

1.2 APPROACH

As is the case with any effort to select a subset of data from a larger set of data, one must establish certain guiding criteria. It was decided that since the goal of this study was to select a limited amount of measured data that would have widespread usefulness and since a sophisticated statistical analysis of the approximately 2.5 million data points was beyond the scope of this study, that the guidelines that would be followed were:

1. The selected data should all be usable, i.e., there would be no occurrences of obviously erroneous or missing data;

2. If possible, the values of the selected data would be left unchanged, i.e., data would not be replaced or modified;

3. The number of data selected would be small, consistent with the fact that the data should have widespread applicability for researchers having different needs and using different building energy analysis programs.

2. DATA SELECTION

The information gathered in this report falls into two broad categories: (1) general house, occupant, and HVAC information, and (2) specified hourly measured system performance and weather data. The former use found in appendices A-C and the latter are found on the data tape.

The general house, occupant, and HVAC information consists of:

1. house information (e.g., location, design, orientation);
2. thermal physical properties of the house envelope (e.g., areas, thermal conductivities, densities);
3. occupant/occupant-use information (e.g., number of occupants, occupancy schedule, lighting schedule);
4. HVAC information (e.g., type, maximum capacity, seasonal efficiency).

The data tape information consists of hourly measured values for:

1. ambient dry-bulb temperature;
2. relative humidity;
3. total horizontal insolation;
4. diffuse horizontal insolation;
5. wind speed;
6. wind direction;
7. space air temperature;
8. space relative humidity;
9. energy consumed by HVAC system;
10. total service energy.

In order to get the above data tape information from the large amount of data available, a decision had to be made as to how many intervals of data would be taken from each original data set and, how many days each interval would contain. It was first decided that the most important periods of time (from a residential energy analysis point of view) are the prime heating/cooling periods and the transition heating/cooling periods (periods when the house heating/ cooling requirements are small and somewhat sporadic). These periods are the most important since it is in the former that the majority of the heating/ cooling energy consumptions occur and it is in the latter that crucial potential energy savings exist. Therefore, 4 data intervals from each original group of data were selected:

1. prime heating interval (usually selected from January data);
2. transition heating interval (usually selected from April data);
3. prime cooling interval (usually selected from August data);
4. transition cooling interval (usually selected from October data).

Next, it was decided that even though the data for one day is the minimum necessary and that three day's are probably sufficient for many cases, intervals of 10 consecutive days' duration would be selected. Ten-day intervals were chosen because:

1. it was determined usable data for 10-day intervals could be found in all the original data for each of the period;
2. 10-day intervals allow the user some amount of discretion in choosing which day(s) to simulate;
3. 10-day intervals easily allow a computer program using a response factor-type calculation to use the data as they appear (computer programs using response factors generally need a lead-in period of one to three days before the effects of the initial temperature and heat flow conditions disappear).

The 10-day intervals were selected by first looking at plots of the daily HVAC heating/cooling consumptions versus time for the entire period for which data were available (see figure 1). A prime heating, a transition heating, a prime cooling, and a transition cooling period were identified. Next, the data in these identified periods were analyzed in detail to find candidate intervals (of 10 consecutive days duration) in which all of the data parameters (e.g., dry-bulb temperature, total insolation, space air temperature, etc.) were available (see figure 2). Plots of daily HVAC energy consumption versus daily average dry-bulb temperature for these intervals were then generated. If an interval showed poor correlation between these parameters an interval having better correlation was sought (see figures 3 and 4). Finally, plots of the hourly ambient dry-bulb temperature, HVAC system energy consumption and total service energy versus time were visually scanned for occurrences of abrupt changes in adjacent data points (see figure 5). If these abrupt changes could not easily be explained by corresponding changes in other data parameters, a new candidate interval was selected. In this manner, intervals consisting of well-behaved usable data were selected from each group of original data.

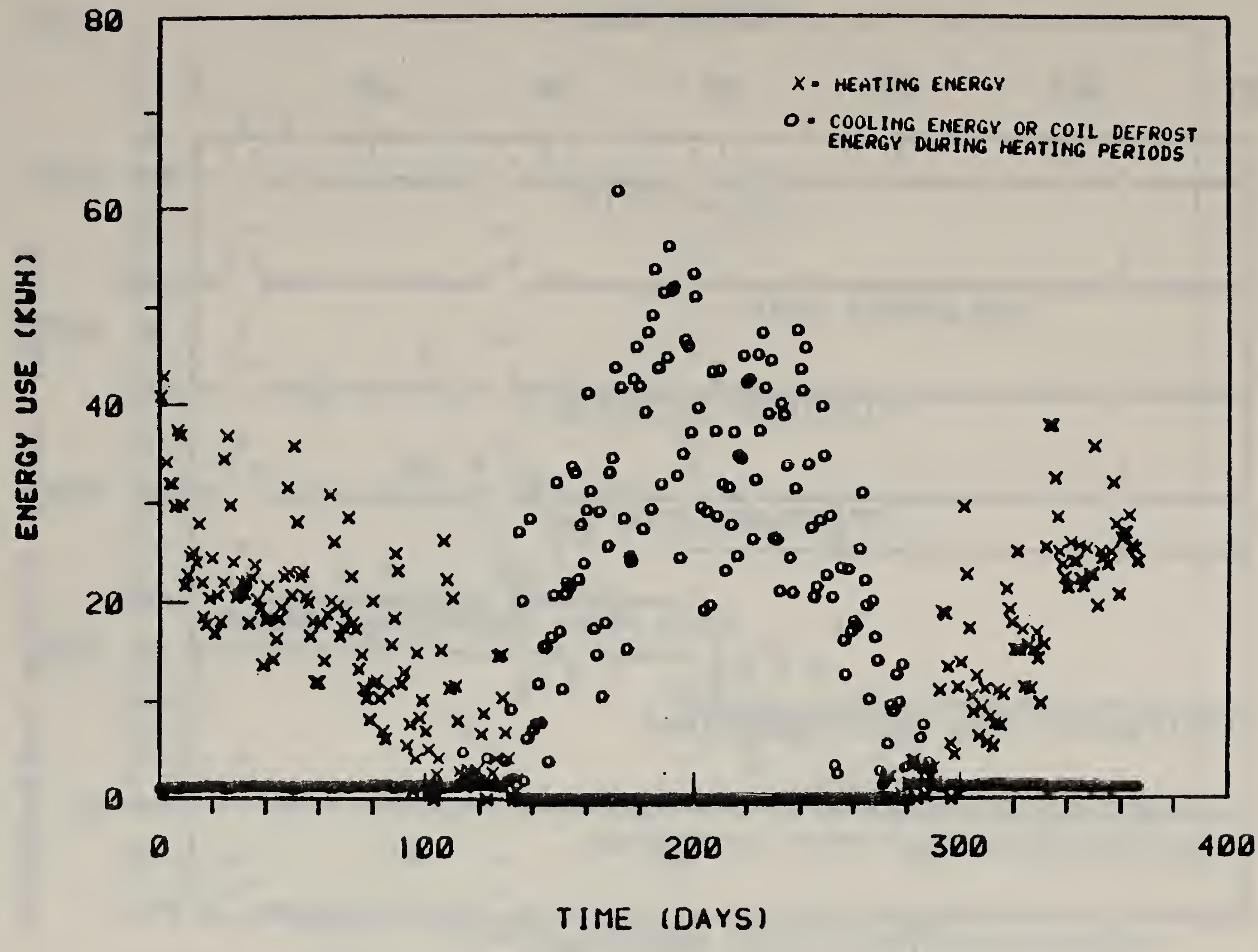

Figure 1. A typical daily energy consumption plot used to identify candidate intervals for more detailed analysis

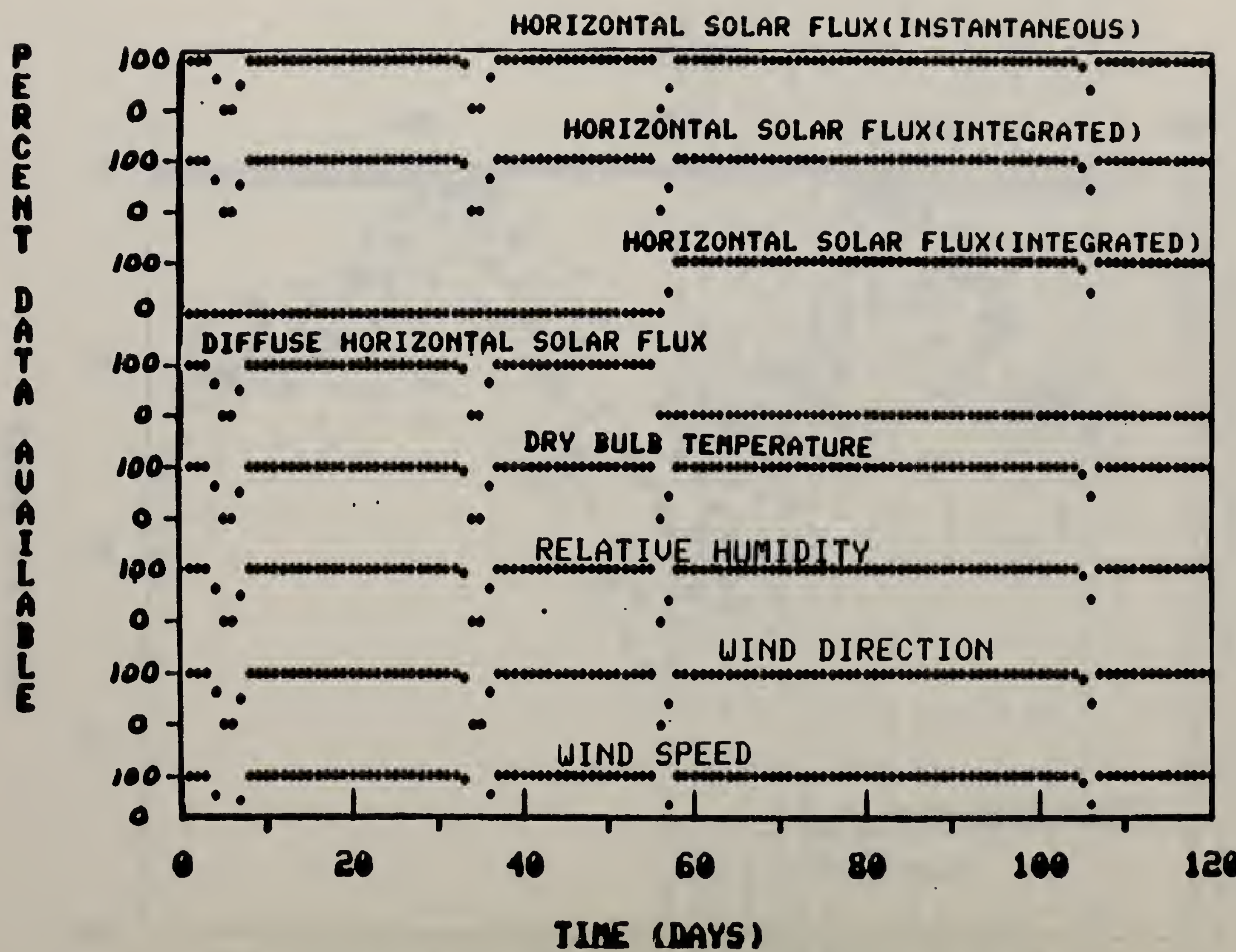

Figure 2. A typical plot used to determine coincindenc of data parameters

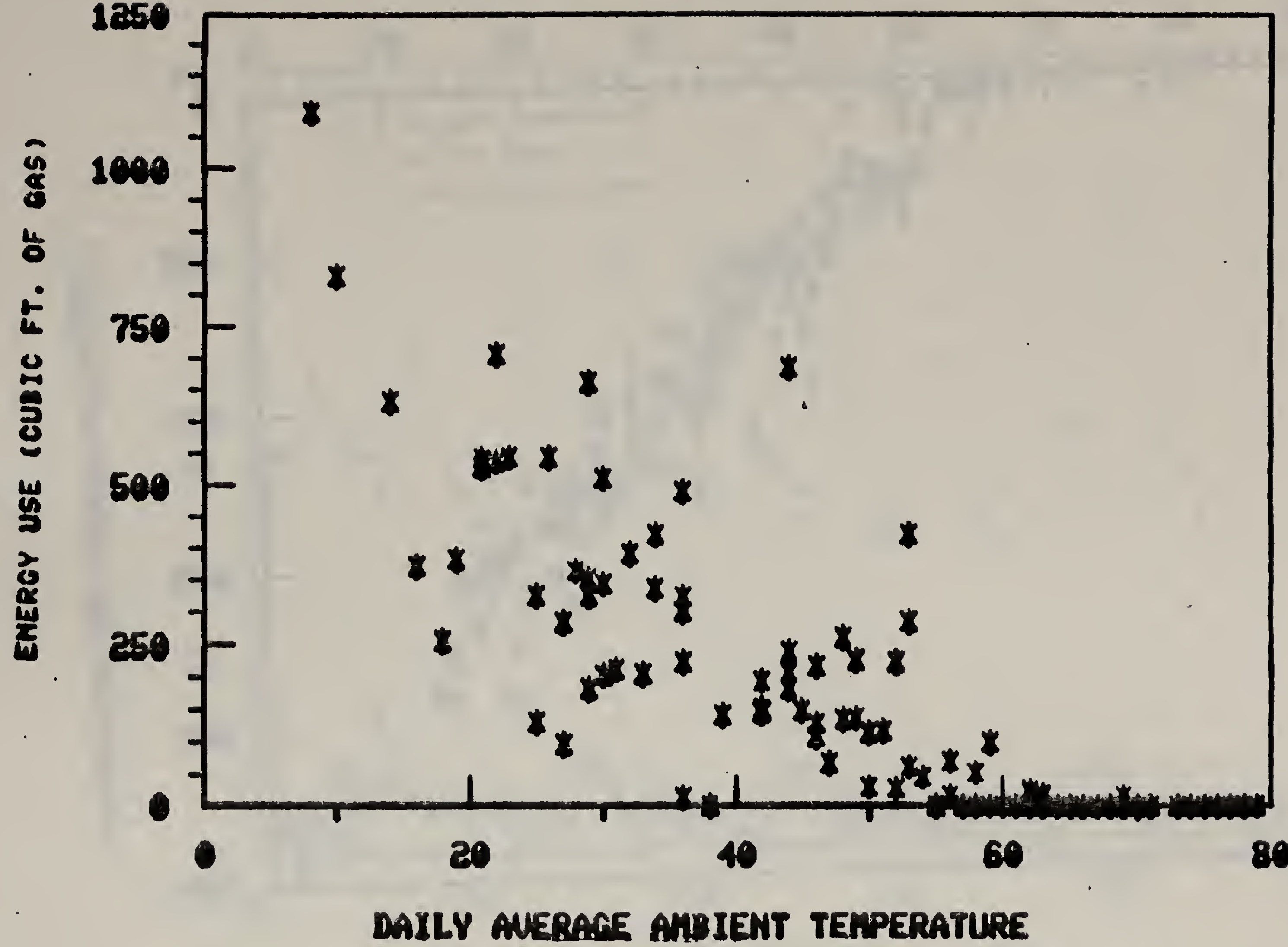

Figure 3. Plot showing poor correlation between daily heating energy consumption and average daily dry-bulb temperature

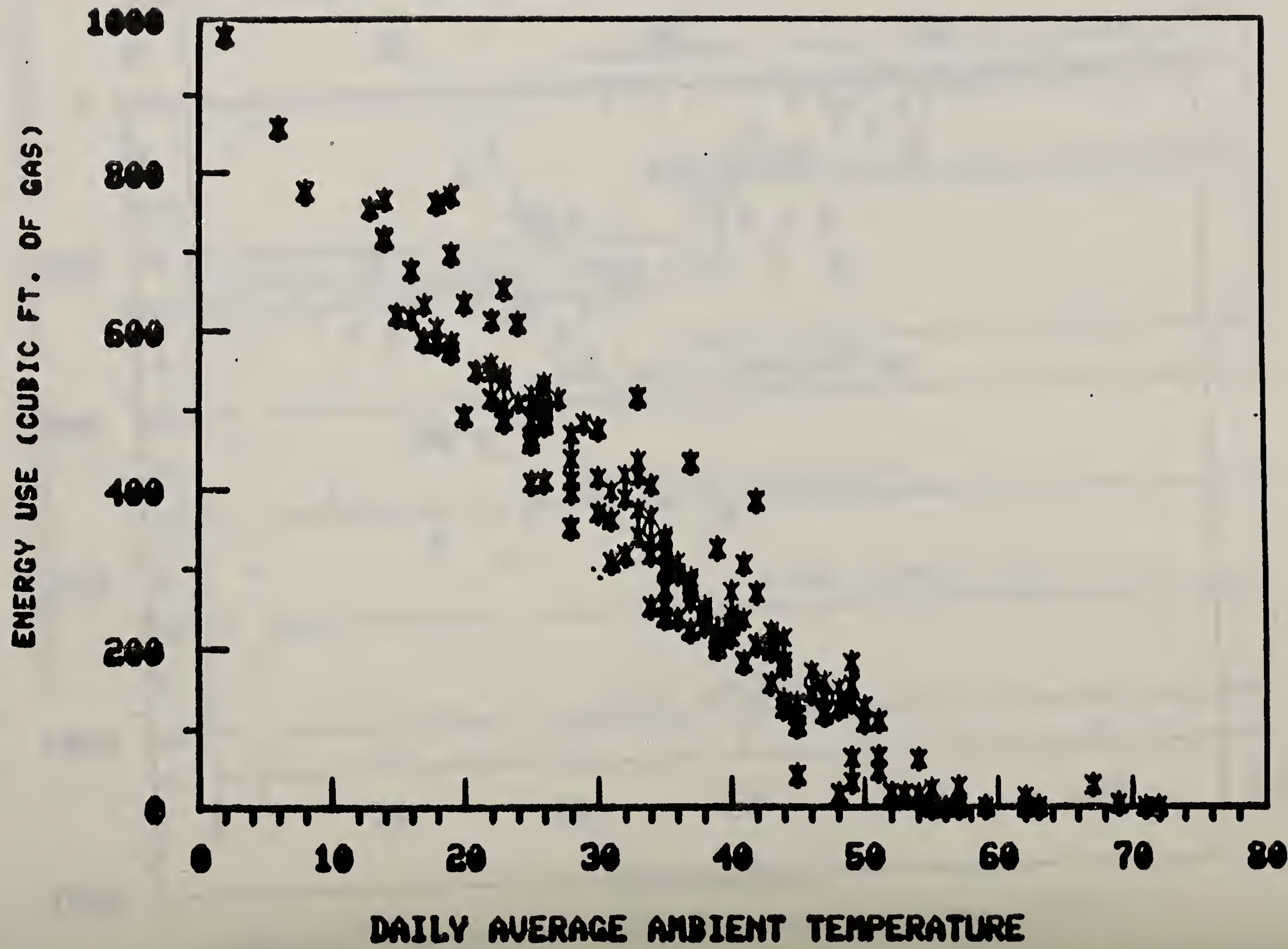

Figure 4. Plot showing good correlation between daily heating energy consumption and average daily dry-bulb temperature

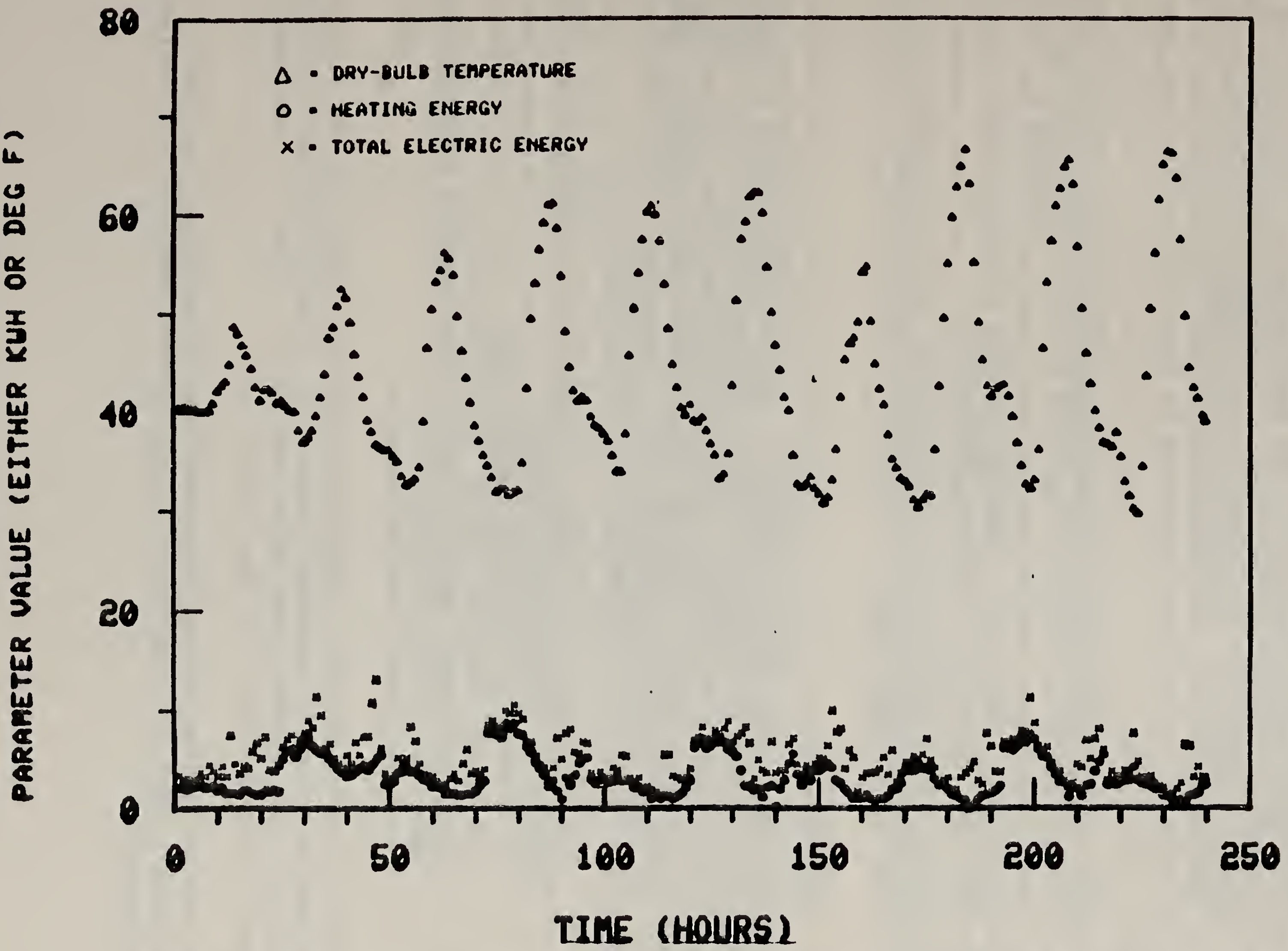

Figure 5. A typical plot of hourly heating energy consumption total electric energy consumption, and dry-bulb temperature for a 10 day interval that were used to identify abrupt or discontinuous behavior of the data

3. DATA

3.1 HEAT PUMP DATA

These data were taken from reference 1. The five test dwellings are all detached single-family homes. They are located in Oakdale, California; Lancaster, California; Albuquerque, New Mexico; Warren, Arkansas, and White Plains, New York. Three of the houses are one-story slab-on-grade construction, one house is a one-story over crawlspac construction, and one house is a two-story over basement and crawlspace construction. The walls range in value from R-11 to R-23 and the ceilings from R-16 to R-36. All of the data were taken in 1976.

These data are of particular interest because they are for homes having heat pumps (which are having widespread use due to their efficiency) and because of the climatic variation (heating degree days from 1245 to 4848 and cooling degree days from 1068 to 1525, base 65°F). The heat pump energy and the resistant heat energy were measured separately.

The data for the houses with heat pumps are found in appendix A and the first five files on the data tape.

3.2 HOUSTON DATA

These data were taken from reference 2. The test dwelling is a wood-frame rambler with brick veneer outer covering and constructed over slab-on-grade. The walls are insulated with 3.5 inch rock wool batts and the ceiling with 4.0 inches of loose rock wool. The test house is located in Houston, Texas, and the data taken during the summer of 1977. These test data differ from the other two sets of data examined in five major respects:

1. the house was not occupied (occupant heat generation was simulated by heat from electric light bulbs);
2. only summer (cooling) data were taken;
3. the hourly sensible cooling load was measured;
4. the hourly space relative humidity was measured (humidity variations were due to air infiltration);
5. the daily latent load was measured.

Because of point one above, these data were not subject to the perturbations that can be caused by occupancy action. It is worth mentioning that part of these data have already been run on the DoE [6], BLAST [7], and NBSLD [8] computer programs with very good results [9].

The data pertaining to this house are found in appendix B and file six on the data tape. Note that this file is only 20 days long since it consists of only cooling data.

3.3 TWIN RIVERS DATA

These data were taken from reference 3, and represent only a very small portion of the total data available from this source. At one time or another, 27 townhouses were instrumented in Twin Rivers, New Jersey, during the years 1973 to 1977. These data are and probably will be the most comprehensive building energy data for a townhouse community. The data have undergone extensive studies and the interested reader is again referred to the above reference.

The heating data for this study were chosen from the very large original data set by selecting data for the townhouse whose daily winter heating energy had the best correlation to daily average outdoor dry-bulb temperature. Since the cooling data for this townhouse appeared to be representative of the other houses it too was selected.

The data in this section differ from the data in 3.1 and 3.2 in that they represent measured data for a residential multi-family dwelling rather than a detached single-family dwelling. The data are for a townhouse of conventional construction, with frame walls and R-7 insulation. The townhouse consists of two floors (each of about 720 ft^2) over a full, unfinished basement.

It should be pointed out that the original data set had neither dew point temperatures nor relative humidities. In keeping with our stated philosophy of having the data directly usable, relative humidity values were generated and put on the data tape. These generated relative humidity values were taken from National Weather Service daily relative humidity profiles for an average January, April, August, and October day [10]. These generated values should have little effect on heating analysis since there was no humidifier in the dwelling. For cooling analysis, however, these generated relative humidity values will have a significant effect because of the latent contribution to the cooling requirement. The user is cautioned to keep this point in mind as a possible source of error when comparing calculated cooling energy consumption to measured energy consumption (which has a latent energy portion in it).

The general house data for this section are found in appendix C and File 7 on the data tape.

4. DATA TAPE FORMAT

The data are contained in seven files on a single reel of unlabeled nine track magnetic tape. The data are recorded in ASCII notation at a density of 1600 characters per inch. Each file is followed by one end-of-file (EOF) mark with the exception of the last file (File 7) which had two EOF's following it. Table 1 lists some important information regarding the tape files.

Each physical tape record contains all the data for a given hour. Thus, 24 records constitute one day's (24 hours) data. For ease of access, all the records have the same format. Table 2 gives a description of the record format. A listing of the first 24 records from File 1 is found in table 3.

Within each file the selected ten-day periods are run sequentially together. For example, in file one, a ten-day period (240 records) of prime heating is followed immediately by a ten-day period of moderate heating, which is followed by a ten-day period of prime cooling, which is then followed by a ten-day period of prime cooling, which is then followed by a ten-day period of moderate cooling. This arrangement allows a user to run through all the selected data for a given house by simply reading the proper file. A prospective user should keep in mind the following two points:

1. For those simulation programs that need to stabilize to ambient weather conditions. the predicted results for the first two or three days of each 10-day heating/cooling period will probably have a certain degree of error in them.

2. The selected 10-day periods usually do not end on the last day of a month, therefore, those computer programs that depends on the last day of a month to key their output will not be activated properly.

TABLE 1. Tape File Information

File 1 -- Heat pump data for single story frame house in Oakdale, California, built over unheated crawlspace. There were no space relative humidity data taken at this site. For the heating periods the coil defrost energy is found in the cooling energy entry. See Appendix A for additional information.

File 2 -- Heat pump data for slab-on-grade, single story frame house in Lancaster, California. There were no space relative humidity data taken at this site. For the heating periods the coil defrost energy is found in the cooling energy entry. See Appendix A for additinal information.

File 3 -- Heat pump data for slab-on-grade, single story frame house in Albuquerque, New Mexico. There were no space relative humidity data taken at this site. For the heating periods the coil defrost energy is found in the cooling energy entry. See Appendix A for additional information.

File 4 -- Heat pump data for slab-on-grade, single story frame house in Warren, Arkansas. There were no space relative humidity data taken at this site. For the heating periods the coil defrost energy is found in the cooling energy entry. See Appendix A for additional information.

File 5 -- Heat pump data for single story frame house in White Plains, New York, built over conditioned basement and unheated crawlspace. There were no space relative humidity data taken at this site. The solar radiation data is missing for the cooling periods. For the heating periods the coil defrost energy is found in the cooling energy entry. See appendix A for additional information.

File 6 -- Data for slab-on-grade, single story brick veneer house in Houston, Texas. For this file only, the sensible energy is separate from the total cooling energy. The sensible cooling energy is found in the auxillary electric energy entry. The daily total latent load is found in the fan energy entry each hour. Diffuse solar radiation data were not taken at this site. Since this file contains only cooling data it is only 20 days long. See Appendix B for additional information

File 7 -- Data for a two-story townhouse over unheated basement in Twin Rivers, New Jersey. Space relative humidity data were not taken at this site. Ambient relative humidity data were also missing and were replaced with values taken from Reference 6. Diffuse solar radiation data is missing. The heating energy is in cubic feet of gas/hour rather than kwh. See Appendix C for additional information.

TABLE 2. Tape Record Information

Variable Position	Variable Description	Field Length	Units
1	Hour of the Day	7	Hour
2	Day of the Month	7	Day
3	Month of the Year	7	Month
4	Year	7	Year
5	Dry-Bulb Temperature	7	Degree F
6	Relative Humidity	7	Percent %
7	Total Horizontal Insolation	7	Btu/Sq. Ft. Hour
8	Diffuse Horizontal Insolation	7	Btu/Sq. Ft. Hour
9	Wind Speed	7	mph
10	Wind Direction	7	Compass Degree(e.g.,E=90
11	Space Temperature	7	Degree F
12	Space Relative Humidity	7	Percent %
13	Heating Energy	7	kwh
14	Cooling Energy	7	kwh
15	Fan Energy	7	kwh
16	Total Electric Service Energy	7	kwh
17	Auxillary Electric Energy	7	kwh
18	File Number	7	Dimentionless

Note -- all numbers are real and can be read with a free field format or the following fixed field format:

FORMAT(18f7.1)

TABLE 3. LISTING OF THE FIRST 24 RECORDS IN FILE 1

1.0	12.0	1.0	76.0	40.5	93.0	.0	.0	.0	.0	72.9	-99.9	2.3	.0	.2	3.4	.0	1.0
2.0	12.0	1.0	76.0	40.5	93.0	.0	.0	4.0	11.0	73.0	-99.9	2.3	.0	.2	2.8	.0	1.0
3.0	12.0	1.0	76.0	40.6	93.0	.0	.0	6.0	6.0	72.9	-99.9	2.1	.0	.2	3.2	.0	1.0
4.0	12.0	1.0	76.0	40.5	93.0	.0	.0	3.0	8.0	72.7	-99.9	2.3	.0	.2	3.0	.0	1.0
5.0	12.0	1.0	76.0	40.4	93.0	.0	.0	6.0	12.0	72.5	-99.9	2.4	.0	.2	3.0	.0	1.0
6.0	12.0	1.0	76.0	40.1	93.0	.0	.0	5.0	12.0	72.5	-99.9	2.5	.0	.3	3.7	.0	1.0
7.0	12.0	1.0	76.0	40.1	93.0	.0	.0	5.0	14.0	72.6	-99.9	2.3	.0	.2	3.3	.0	1.0
8.0	12.0	1.0	76.0	40.2	96.0	3.1	1.9	6.0	10.0	73.4	-99.9	2.2	.0	.2	4.5	.0	1.0
9.0	12.0	1.0	76.0	40.9	96.0	12.1	11.5	8.0	10.0	73.5	-99.9	2.4	.0	.2	3.8	.0	1.0
10.0	12.0	1.0	76.0	42.1	93.0	22.2	22.2	5.0	5.0	74.4	-99.9	1.9	.0	.2	3.3	.0	1.0
11.0	12.0	1.0	76.0	42.7	93.0	20,6	20.5	4.0	13.0	74.4	-99.9	2.3	.0	.2	4.3	.0	1.0
12.0	12.0	1.0	76.0	43.2	89.0	26.4	26.8	7.0	14.0	75.6	-99.9	1.7	.0	.2	3.3	.0	1.0
13.0	12.0	1.0	76.0	44.9	86.0	95.2	75.0	4.0	19.0	76.1	-99.9	1.7	.0	.2	7.5	.0	1.0
14.0	12.0	1.0	76.0	48.6	80.0	96.3	63.8	3.0	25.0	76.7	-99.9	1.7	.0	.2	4.6	.0	1.0
15.0	12.0	1.0	76.0	47.9	77.0	39.3	39.3	6.0	31.0	77.0	-99.9	1.5	.0	.2	3.5	.0	1.0
16.0	12.0	1.0	76.0	46.7	74.0	18.5	18.3	7.0	32.0	75.9	-99.9	2.0	.0	.2	4.5	.0	1.0
17.0	12.0	1.0	76.0	45.7	66.0	4.9	4.1	8.0	36.0	75.5	-99.9	1.9	.0	.2	4.1	.0	1.0
18.0	12.0	1.0	76.0	44.4	74.0	1.3	.2	7.0	1.0	76.1	-99.9	1.7	.0	.2	5.9	.0	1.0
19.0	12.0	1.0	76.0	42.5	76.0	.0	.0	5.0	36.0	75.9	-99.9	1.6	.0	.2	6.7	.0	1.0
20.0	12.0	1.0	76.0	41.2	79.0	.0	.0	3.0	33.0	75.2	-99.9	1.6	.0	.2	5.2	.0	1.0
21.0	12.0	1.0	76.0	42.2	86.0	.0	.0	5.0	34.0	75.0	-99.9	2.0	.0	.2	7.4	.0	1.0
22.0	12.0	1.0	76.0	42.4	89.0	.0	.0	5.0	34.0	74.9	-99.9	1.8	.0	.2	4.0	.0	1.0
23.0	12.0	1.0	76.0	42.0	86.0	.0	.0	.0	.0	74.9	-99.9	2.0	.0	.2	3.9	.0	1.0
24.0	12.0	1.0	76.0	41.0	92.0	.0	.0	5.0	23.0	74.5	-99.9	1.8	.0	.2	4.5	.0	1.0

5. CONCLUSIONS

The measured data discussed in this report (and encoded onto the accompanying data tape) provide a tool for the testing and verification of building energy analysis programs. The data are representative of that found in excessive experimental efforts to quantify residential energy use. The data are of sufficient detail in measurement of building energy use parameters and of variety in building type, location, and HVAC system as to have widespread application for building researchers.

A prospective user of any of these data should not expect to track the data identically, but should expect to predict major trends in energy use. The accuracy of the analytical predictions depend on the type of energy analysis program chosen. One would hope that a rather sophisticated program could predict the energy use results for a several day period within 10 to 15 percent. Of the three groups of data, the Houston cooling data are probably the best use in determining how closely a given program predicts the measured results. This is because the Houston data resulted from an intensive data gathering effort over a relatively short time span for unoccupied houses; thus, data problems were discovered quickly and the data did not have inherently random influences caused by human actions. However, the heat pump data and the townhouse data are interesting because they do reflect these influence occupants had on the house energy use and in the final analysis a building energy analysis program must also produce reasonable results for this real world case.

A data tape containing information for commercial buildings could also be produced from existing data sources. However, this is a more difficult task than the one accomplished here and it is suggested the endeavor should not be undertaken until the usefulness of this tape has been shown.

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OAKDALE TEST BUILDING

Location:	Oakdale, California
Latitude:	37° 46'
Longitude:	120° 51'
Altitude:	140 feet
Conditioned Floor Area:	1380 ft^2
Orientation:	253°

The Oakdale Test Building is a single story frame construction, single family dwelling, built over an unheated crawlspace. It has an attached unheated garage, and there is a full size attic below the pitched roof. During the heating season, the heat pump system is bypassed on Tuesdays, Thursdays, and Saturdays, and all heating energy is supplied by resistance heat.

The walls have an R-value of 23; the ceiling has R-36. Oakdale normally has 2806 heating degree days, and 1259 cooling degree days.

Design Loads

a) Heating - not available
Design Conditions

b) Cooling - not available
Design Conditions

Thermostat Set Points

Heating - 68°F

Cooling - 78°F

Occupancy

Total - 2 Adults, 2 Children

Schedule - See page 6

Lighting and Appliance Load

Total - 4252 watts

Schedule - See page 6

HVAC System

a)

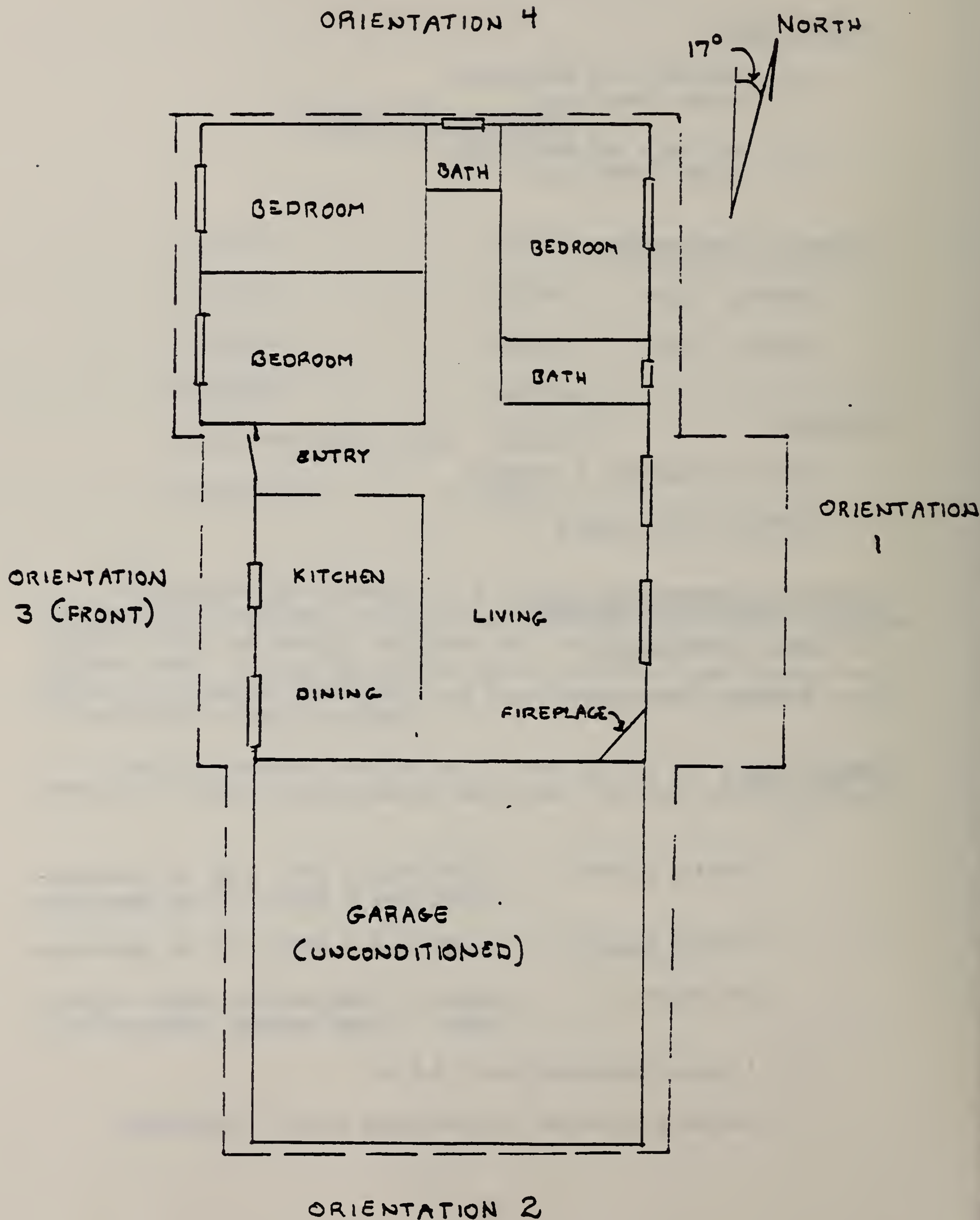
Heating Capacity:	37,000 Btuh @ 45°F, 3.65 kW compressor 22,000 Btuh @ 20°F, 3.10 kW compressor
Cooling Capacity:	36,000 Btuh @ 95°F, 4.61 kW compressor
Fan Power:	Outdoor - 350w heating, 440w cooling Indoor - 550w heating, 550w cooling

b) 1 stage resistance heat, 9.6 kW

c) Ductwork installed in crawlspace with 1" insulation

Building Floor Plan

Scale: 1 inch = 10.8 feet



MATERIALS OF CONSTRUCTION

	Thickness (inches)	Conductivity (Btu-in/°f-hr)	Density (lb/ft³)	Specific Heat (Btu/lb-°f)
a) Outside Walls (R=23)				
stucco	1.0	5.0	116.0	0.28
sheating	0.5	0.25	5.0	0.32
insulation	3.5	0.17	11.0	0.16
wallboard	0.5	1.15	50.0	0.26
b) Ceiling (R=36)				
insulation	6.0	0.17	11.0	0.16
wallboard	0.5	1.15	50.0	0.26
c) Roof (R=1.0)				
slate	0.50	10.0	120.0	0.30
asphalt roll	0.25	1.62	70.0	0.36
plywood	0.50	0.80	34.0	0.29
d) Floor (R=2.7)				
carpet	0.50	0.45	10.0	0.40
plywood	1.25	0.80	34.0	1.65
e) Doors (R=1.3)				
Wood	1.0	0.80	32.0	0.65

BUILDING ENVELOPE COMPONENT DATA

Orientation	1	2	3	4
Azimuth, degrees	73	163	253	343
Roof, ft^2	670	0	670	0
Walls, ft^2	450	300	450	300
Glass, ft^2	84(1)	0	66(2)	6(3)
Doors, $ft^2$2	0	0	22	0

NOTES

All windows are single pane 1/8 sheet

(1) 4 ft^2 have shading coefficient = 1.0

80 ft^2 have shading coefficient = 0.6 (uninsulated drapes)

(2) 6 ft^2 have shading coefficient = 0.74 (curtains)

60 ft^2 have shading coefficient = 0.6

(3) shading coefficient = 0.74

OCCUPANCY, LIGHTING AND APPLIANCE SCHEDULES

Time of Day	Number Of Occupants Weekdays	Weekends	Percent Of Connected Load Connected Load = 4252 watts
0000	4	4	24
0100	4	4	17
0200	4	4	12
0300	4	4	11
0400	4	4	16
0500	4	4	19
0600	4	4	22
0700	2	3	39
0800	0	3	55
0900	0	3	78
1000	0	3	85
1100	0	3	82
1200	0	3	78
1300	0	3	65
1400	0	3	52
1500	0	3	66
1600	2	3	82
1700	4	3	85
1800	4	3	99
1900	4	4	100
2000	4	4	94
2100	4	4	80
2200	4	4	43
2300	4	4	23

PALMDALE TEST BUILDING

Location:	Lancaster, California
Latitude:	34° 38'
Longitude:	118° 8'
Altitude:	2460 ft
Conditioned Floor Area:	1423 ft^2
Orientation:	52°

The Palmdale Test Building is a single story frame construction, single family dwelling with a slab on grade foundation. It has a naturally vented attic below the pitched roof.

The walls have an R-value of 11, the ceiling has R-16. Palmdale normally has 1245 heating degree days, and 1185 cooling degree days.

Design Loads

a) Heating - 45,476 Btuh
Design Conditions: 14°F Winter dry bulb temperature

b) Cooling - 28,294 Btuh
Design Conditions: 102°F dry bulb, 69°F wet bulb

Thermostat Set Points

Heating - 74°

Cooling - 72°

Occupancy

Total - 2 Adults, 2 Children

Schedule - See Page 6

Lighting and Appliance Load

Total - 5101 watts

Schedule - See Page 6

HVAC System

a)

Heating Capacity: (45°F) 52,000 Btuh, COP = 2.7

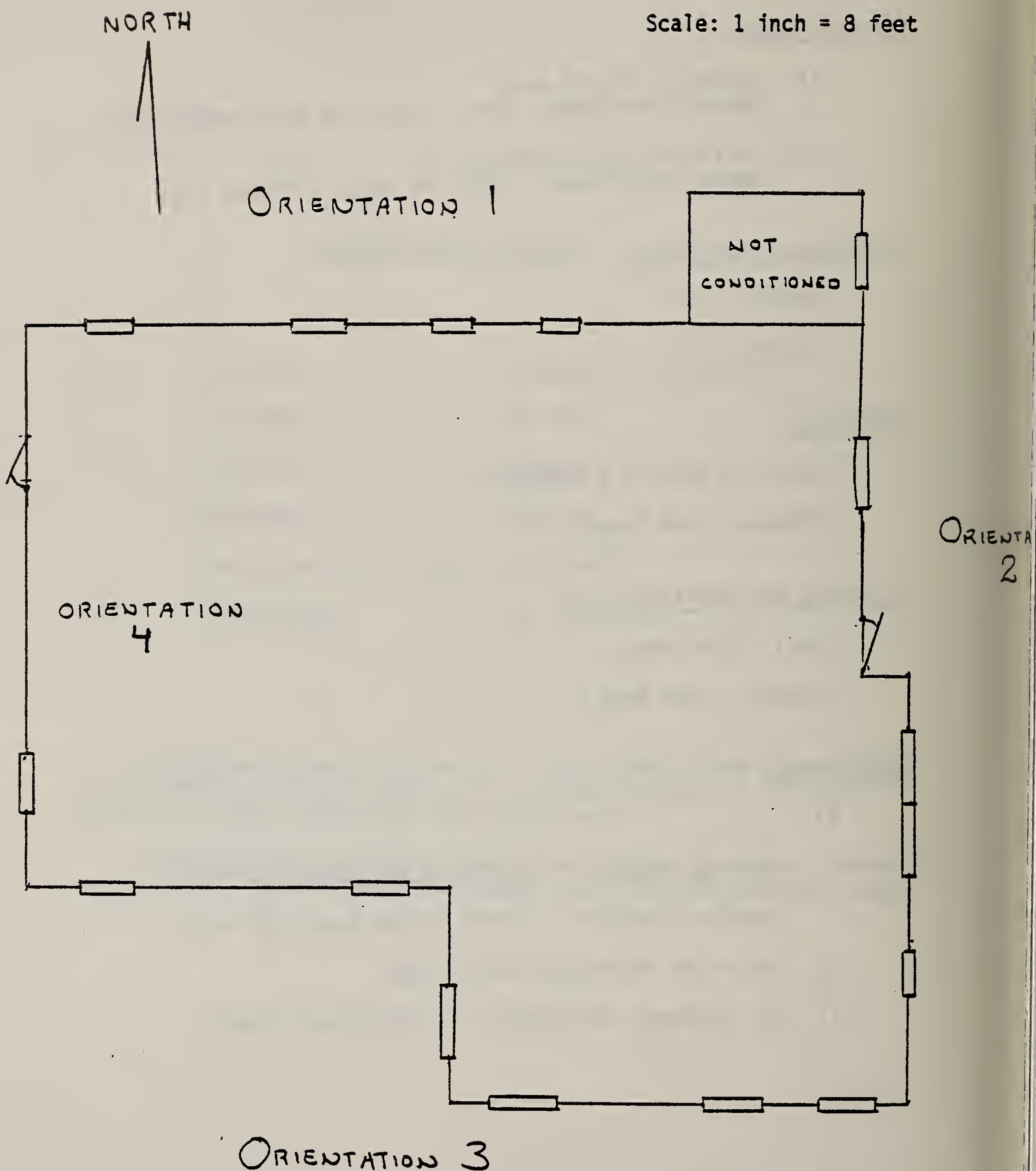
Cooling Capacity: (95°F) 49,000 Btuh, COP = 2.2

b) One stage resistance heat, 9.6kW

c) All ductwork insulated (1"), installed in attic

Building Floor Plan

Scale: 1 inch = 8 feet



MATERIALS OF CONSTRUCTION

	Thickness (inches)	Conductivity (Btu-in/°F-hr)	Density (lb/ft³)	Specific Heat (Btu/lb-°F)
a) Front Wall (R=10.17)				
wood siding	0.75	1.10	45.0	0.67
felt	0.03	1.33	70.0	0.40
insulation	3.00	0.32	3.0	0.16
plaster	0.50	5.80	116.0	0.24
b) Other 3 walls (R=9.63)				
stucco	0.75	5.00	116.0	0.28
felt	0.03	1.33	70.0	0.40
insulation	3.00	0.32	3.0	0.16
plaster	0.50	5.80	16.0	0.24
c) Ceiling (R=15.71)				
insulation	5.00	0.32	3.0	0.16
plaster	0.50	5.80	16.0	0.24
d) Roof				
asbestos shingle	0.25	0.57	70.0	0.30
building paper	0.03	1.33	70.0	0.40
sheating	0.25	0.38	18.0	0.31
plywood & studs	0.50	0.80	34.0	0.29
e) Doors				
Wood	1.00	0.50	32.0	0.65
f) Slab Floor				
carpet & pad	0.50	0.24	5.00	0.33
concrete slab	4.00	12.00	140.00	0.28

BUILDING ENVELOPE COMPONENT DATA

Orientation		1	2	3	4
Azimuth, degrees		52	142	232	322
Roof,	ft^2	560	240	560	240
Walls,	ft^2	307	280	402	171
Glass,	ft^2	35.65[1]	78.50[2]	56.0[3]	37.2[4]
Doors,	$ft^2$2	0	22	0	22

NOTES:

All Windows are 1/4" plate glass

(1) 24 ft^2 have shading coefficient = 0.75 (curtains)

11.65 ft^2 have shading coefficient = 0.35 (venetion blinds)

(2) 16 ft^2 have shading coefficient = 0.75

56.5 ft^2 have shading coefficient = 0.60 (uninsulated drapes)

(3) 26 ft^2 have shading coefficient = 0.42 (insulated drapes)

30 ft^2 have shading coefficient = 0.75

(4) 20 ft^2 have shading coefficient = 0.60

17.2 ft^2 have shading coefficient = 0.75

OCCUPANCY, LIGHTING AND APPLIANCE SCHEDULE

Time Of Day	Number of Occupants Weekdays	Weekends	Percentage of Connected Load Connected Load = 5101 watts
0000	4	4	33
0100	4	4	39
0200	4	4	40
0300	4	4	37
0400	4	4	38
0500	4	4	43
0600	4	4	55
0700	3	3	43
0800	1	3	39
0900	1	3	53
1000	1	3	67
1100	1	3	63
1200	1	3	63
1300	1	0	56
1400	1	0	61
1500	3	1	67
1600	3	1	82
1700	4	4	88
1800	4	4	100
1900	4	4	80
2000	4	4	58
2100	4	4	47
2200	4	4	45
2300	4	4	47

ALBUQUERQUE TEST BUILDING

Location:	Albuquerque, New Mexico
Latitude:	35° 07'
Longitude:	106° 27'
Altitude:	5400 ft
Conditioned Floor Area:	1806 ft^2
Orientation:	0°

The Albuquerque Test Building is a single story frame construction, single family dwelling with a slab on grade foundation. It has an attached unheated garage, and a full size vented attic below the pitched roof.

The walls have an R-value of 14, the ceiling has R-25. Albuquerque normally has 4337 heating degree days and 1394 cooling degree days.

Design Loads

a) Heating - 45,102 Btuh
Design Conditions - 0°F winter dry bulb temperature

b) Cooling - 35,618 Btuh
Design Conditions - 100°F dry bulb, 70°F wet bulb

Thermostat Set Points

Heating - 70°F

Cooling - 75°F

Occupancy

Total - 2 Adults

Schedule - See Page 6

Lighting and Appliance Load

Total - 4388 watts

Schedule - See Page 6

HVAC System

a)

Heating Capacity: (17°F) 27,000 Btuh, COP = 1.8
(49°F) 49,000 Btuh, COP = 2.6

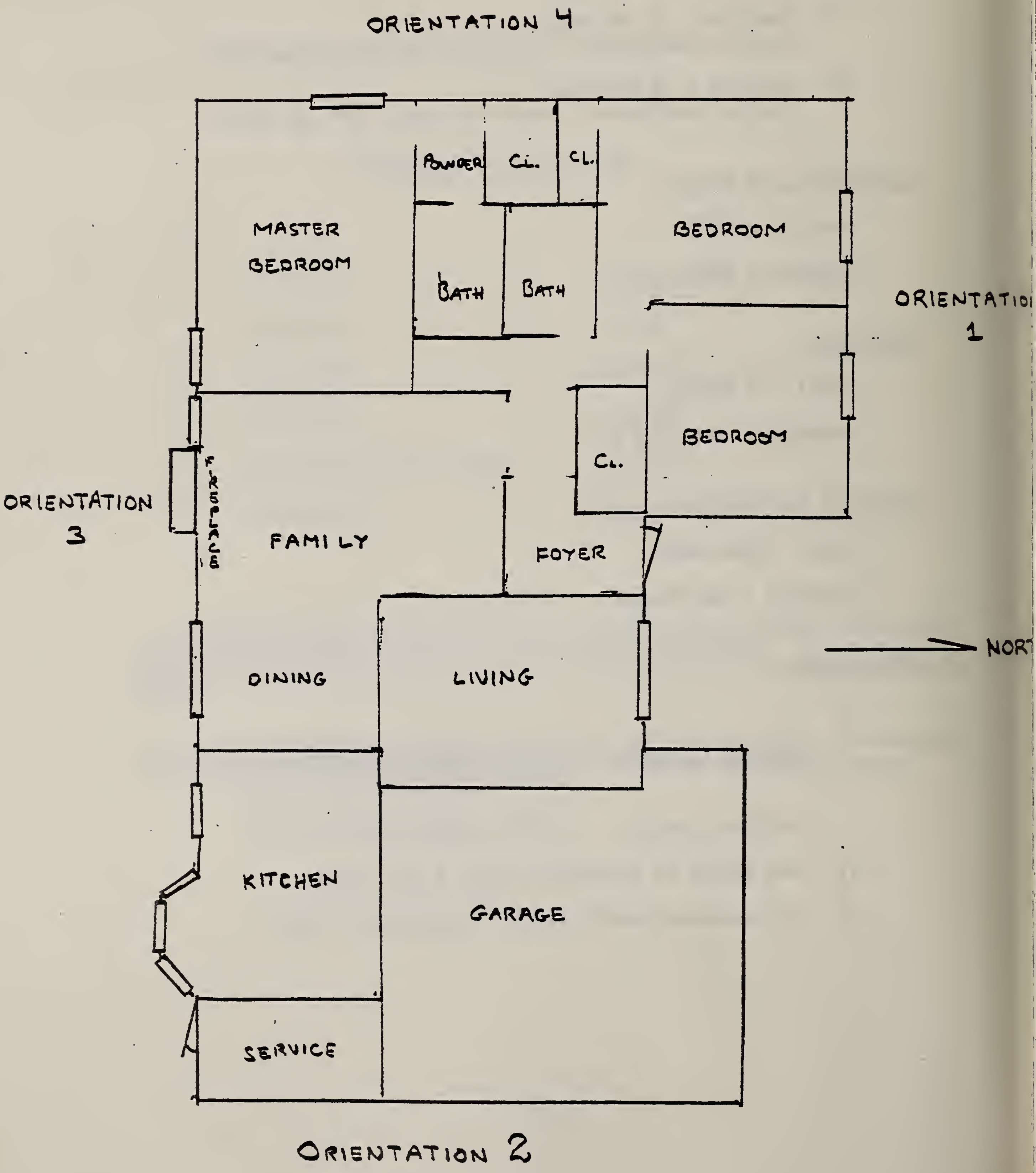
Cooling Capacity: (95°F) 46,000 Btuh, EER = 7.1

b) Two stages of resistance heat, 9.2 kW each

c) All ductwork insulated (2"), installed in attic

Building Floor Plan

Scale: 1 inch = 12.2 feet



MATERIALS OF CONSTRUCTION

	Thickness (inches)	Conductivity (Btu-in/°F-hr)	Density (lb/ft^3)	Specific Heat (Btu/lb-°F)
a) Outside Walls (R=14.2)				
brick	4.0	5.0	120.0	0.22
celotex sheathing	0.5	0.25	5.0	.32
insultation (batt)	3.6	0.32	3.0	.16
gypsum board	0.5	3.3	45.0	.20
b) Ceiling (R=25.2)				
insulation (blown)	8.0	.32	3.0	.16
gypsum board	0.5	3.3	45.0	.20
c) Doors				
wood	1.0	0.8	32.0	.65
d) Slab Floor				
carpet & pad	0.5	.24	5.0	.33
concrete slab	4.0	12.0	140.0	.28
e) Garage Walls				
same as outside walls, but without brick facing				
f) Partition House/Garage				
sheetrock	.625	3.3	45.0	.20
g) Roof				
shingles	0.25	0.57	70.0	0.30
sheating	0.13	1.33	70.0	0.40
plywood	0.50	0.80	34.0	0.29

BUILDING ENVELOPE COMPONENT DATA

Orientation	1	2	3	4
Azimuth, degrees	270	0	90	180
Roof, ft^2	195	806	195	806
Vertical Walls, ft^2	296	346	60	350
Windows(1), ft^2	20	70	0	107
Doors, ft^2	0	22	0	22

NOTES:

(1) All windows 1/8" single sheet (shading coefficient = 0.6)

OCCUPANCY, LIGHTING AND APPLIANCE SCHEDULES

Time of Day	Number of Occupants Weekdays	Number of Occupants Weekends	Percentage of Connected Load Connected Load = 4388 watts
0000	2	2	20
0100	2	2	17
0200	2	2	16
0300	2	2	14
0400	2	2	16
0500	2	2	17
0600	1	2	36
0700	1	2	57
0800	1	2	53
0900	1	2	53
1000	1	2	33
1100	1	0	32
1200	1	0	28
1300	1	0	33
1400	1	2	29
1500	1	2	27
1600	1	2	23
1700	1	2	37
1800	2	2	73
1900	2	2	100
2000	2	2	91
2100	2	2	57
2200	2	2	35
2300	2	2	24

ARKANSAS TEST BUILDING

Location:	Warren, Arkansas
Latitude:	32° 40'
Longitude:	92° 10'
Conditioned Floor Area:	1688 ft^2
Orientation:	178°

The Arkansas Test Building is a single story frame construction, single family dwelling. It has a slab on grade foundation. There is an unconditioned attached garage and a full size attic below a pitched roof.

The walls have an R-value of 14, the ceiling has R-20. Warren, Arkansas, normally has 3241 heating degree days and 1925 cooling degree days.

Design Loads

a) Heating - 47,365 Btuh
Design Conditions - not available

b) Cooling - 30,699 Btuh
Design Conditions - not available

Thermostat Set Points

Heating - 74°F
Cooling - 78°F

Occupancy

Total - 2 Adults

Schedule - See Page 6

Lighting and Appliance Load

Total - 4209 watts

Schedule - See Page 6

HVAC System

a)

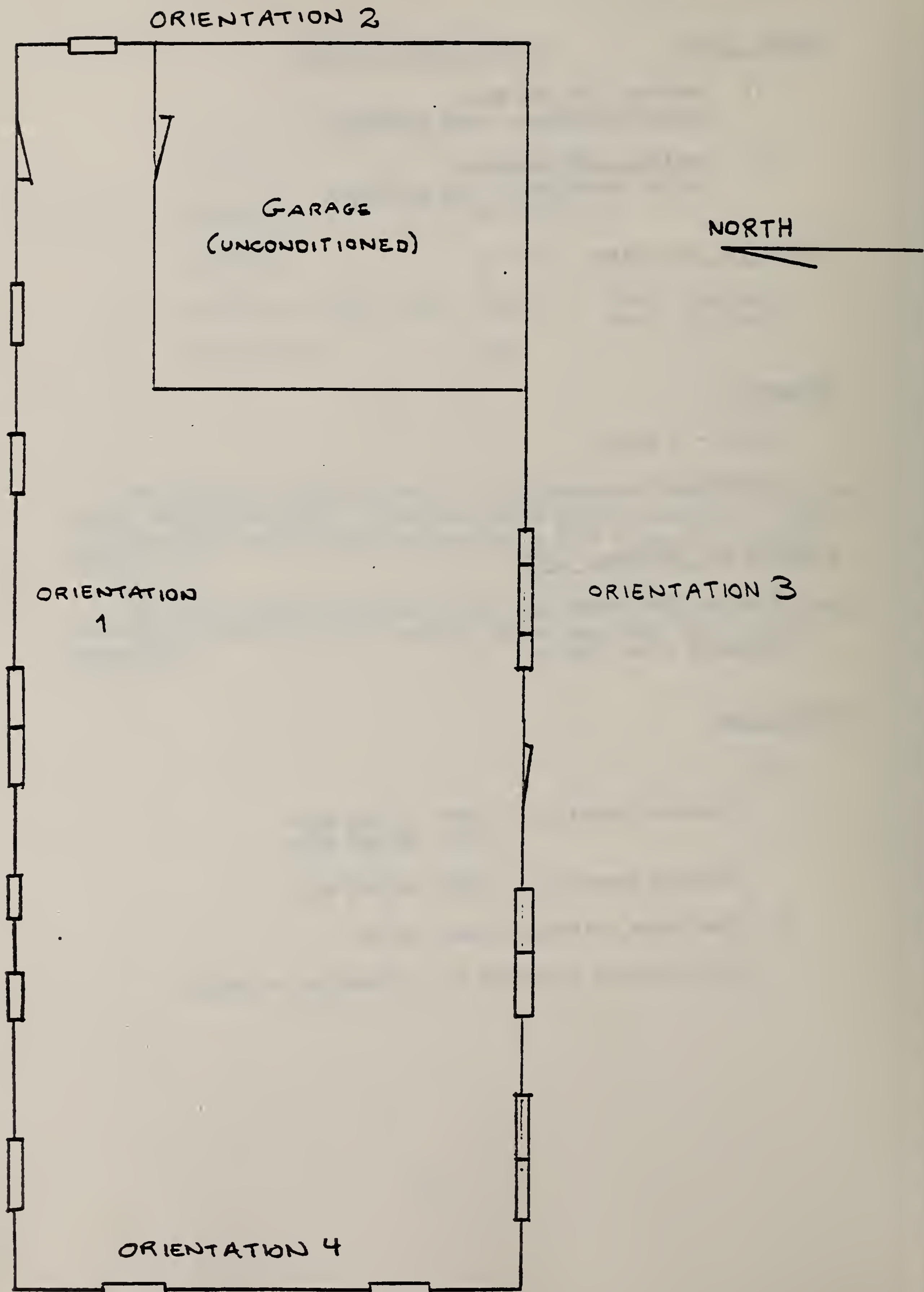
Heating Capacity:	(49°F)	37,000 Btuh
	(17°F)	22,000 Btuh
Cooling Capacity:	(95°F)	34,000 Btuh

b) One stage resistance heat, 15 kW.

c) All ductwork insulated (2"), installed in attic

Building Floor Plan

Scale: 1 inch = 8 feet



MATERIALS OF CONSTRUCTION

	Thickness (inches)	Conductivity (Btu-in/°F-hr)	Density (lb/ft^3)	Specific Heat (Btu/Lb-°F)
a) Outside Walls (R=13.8)				
brick	3.50	5.00	120.0	0.22
celotex	0.50	0.25	5.0	0.32
insulation	3.50	0.32	3.0	0.16
sheet rock	0.50	3.30	45.0	0.22
b) Ceiling (R=20.3)				
insultation	6.00	0.32	3.0	0.16
sheet rock	0.50	3.30	45.0	0.22
c) Roof				
asbestos shingles	0.25	0.57	70.0	0.30
felt paper	0.13	1.33	70.0	0.40
plywood	0.50	0.80	34.0	0.29
d) Doors				
wood	1.0	0.8	32.0	0.65
e) Floors				
carpet & pad	1.0	0.41	10.0	0.34
concrete slab	4.0	12.00	140.0	0.28

BUILDING ENVELOPE COMPONENT DATA

Orientation	1	2	3	4
Azimuth, °	358	88	178	268
Roof, ft^2	720	180	720	180
Walls, ft^2	471	382	279	210
Windows, ft^2	86(1)	109(2)	117	22
Doors	22	0	22	0

NOTES

a) All windows single pane 1/8" sheet glass

b) Shading coefficient = 0.74 (uninsulated drapes) unless otherwise noted

(1) 29 ft^2 have shading coefficient = 0.42 (curtains)

(2) Shading coefficient = 0.42

OCCUPANCE, LIGHTING AND APPLIANCE USE SCHEDULES

Time of Day	Number Of Occupants Weekdays	Weekends	Percentage Of Connected Loads Connected Load = 4209 watts
0000	2	2	4
0100	2	2	6
0200	2	2	5
0300	2	2	6
0400	2	2	14
0500	2	2	34
0600	2	2	87
0700	1	1	100
0800	1	1	98
0900	1	1	82
1000	1	0	83
1100	1	1	79
1200	1	1	66
1300	1	1	46
1400	1	0	41
1500	1	0	48
1600	1	1	52
1700	2	2	62
1800	2	2	59
1900	2	2	41
2000	2	2	45
2100	2	2	52
2200	2	2	32
2300	2	2	8

NEW YORK TEST BUILDING

Location:	White Plains, New York
Latitude:	41° 4'
Longitude:	73° 42'
Altitude:	150 feet
Conditioned Floor Area:	1860 ft^2
Orientation:	270°

The New York Test Building is a two story frame construction, single family dwelling. There is a conditioned basement and unconditioned crawlspace, and an attached unconditioned garage. There is a full size attic below the pitched roof.

The walls have an R-value of 12, the ceiling has R-19. White Plains normally has 4848 heating degree days, and 1068 cooling degree days.

Design Loads

a) Heating - 57,020 Btuh
   Design Conditions: 0°F. Winter dry bulb temperature

b) Cooling - 30,230 Btuh
   Design Conditions: 95°F dry bulb, 75°F wet bulb

Thermostat Set Points

Heating - 65°F

Cooling - 73°F

Occupancy

Total - 2 Adults, 3 Children

Schedule - See Page 6

Lighting and Appliance Load

Total - 3289 Watts

Schedule - See Page 6

HVAC System

a)

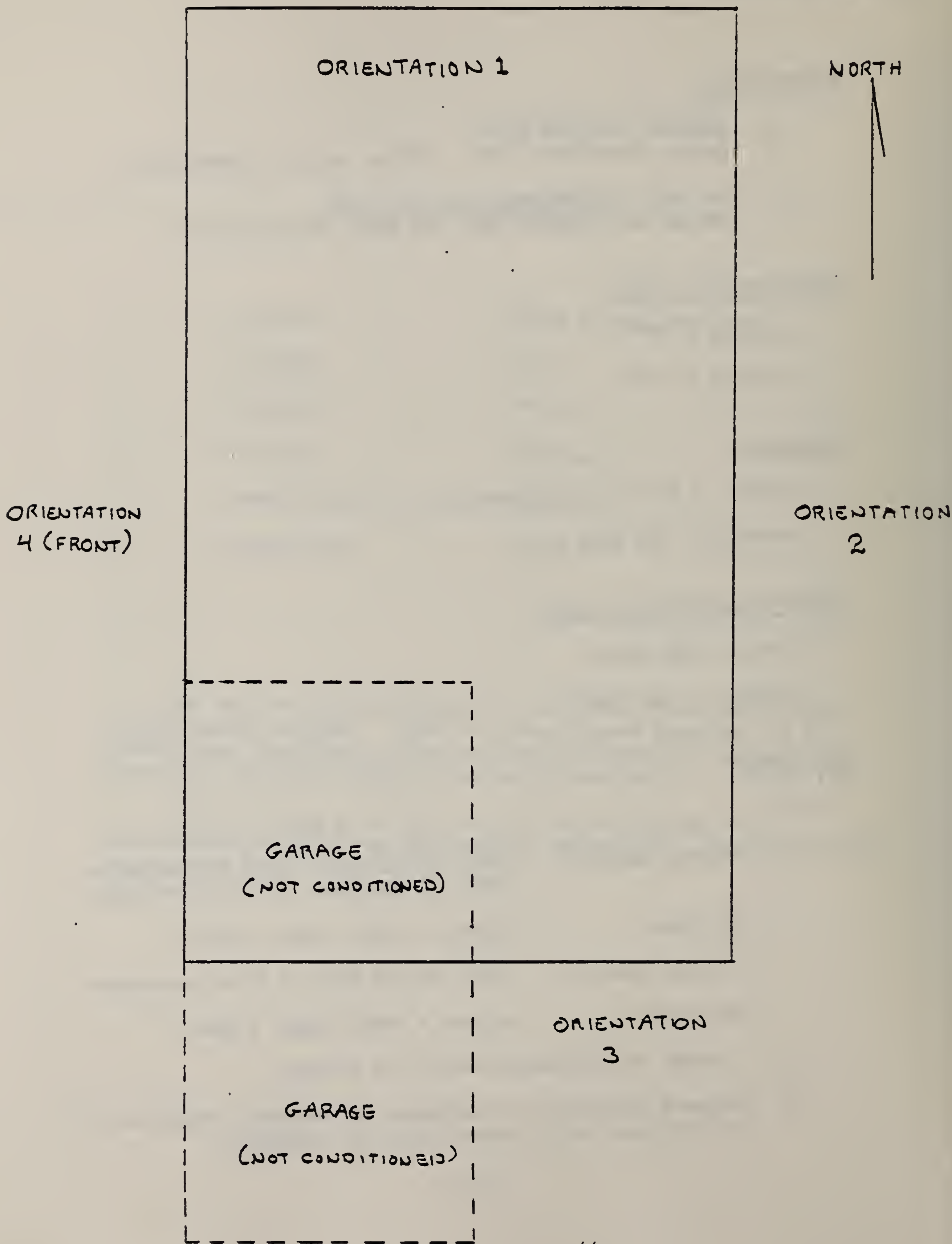
Heating Capacity:	(45°F) 37,000 Btuh, 3.65 kW compressor (20°F) 22,000 Btuh, 3.10 kW compressor
Fan Power:	Outdoor = 350w, Indoor = 500w
Cooling Capacity:	(95°F) 36,000 Btuh, 4.61 kW compressor
Fan Power:	Outdoor = 440w, Indoor = 500w

b) 4 stages of resistance heat, 19.2 kW total

c) Ductwork installed in crawlspace and basement; insulated (1") in crawlspace only, return ducts not insulated

Building Floor Plan

Scale: 1 inch = 7 feet



MATERIALS OF CONSTRUCTION

	Thickness (inches)	Conductivity (Btu-in/°F-hr)	Density (lb/ft^3)	Specific Heat (Btu/lb-°F)
a) Outside Walls (R=11.54)				
absestos shingle	0.50	4.00	120.0	0.25
sheating	0.50	0.25	5.0	0.32
insultation	3.50	0.32	3.0	0.16
air space	0.50	1.10	0.0	0.00
wallboard	0.50	3.30	45.0	0.20
b) Ceiling (R=18.9)				
insulation	6.0	0.32	3.0	0.16
wallboard	0.50	3.30	45.0	0.20
c) Roof (R=2.7)				
asphalt shingle	0.25	4.0	120.0	0.25
sheating	0.50	0.25	5.0	0.32
plywood	0.50	0.80	34.0	0.29
d) Basement Walls (R=2.0)				
concrete block	8.00	4.00	49.0	0.20
e) Floor Over Basement, Crawlspace (R=11.0)				
wood flooring	2.00	0.80	45.0	0.67
insultation	3.50	0.32	3.0	0.16
air space	48.0	1.10	0.00	0.00
f) Basement, Crawlspace Floor (R=19)				
asphalt tile	2.50	0.13	120.0	0.35
concrete slab	4.00	12.00	140.0	0.28
g) Doors (R=1.25)				
wood	1.00	0.80	32.0	0.65

BUILDING ENVELOPE COMPONENT DATA

Orientation	1	2	3	4
Azimuth, degrees	0	90	180	270
Roof, ft^2	0	832	0	832
Walls, ft^2	264	624	448	560
Glass, ft^2	0	83(1)	18	85(2)
Doors, ft^2	0	0	0	22

Floor area over basement = 243 ft^2

Floor area over crawlspace = 180 ft^2

NOTES

All windows are double pane 1/4" plate unless noted

With shading coefficient = 0.33 (shades & uninsulated drapes)

(1) 39 ft^2 have shading coefficient = 1.0 (glass doors)

(2) 2.25 ft^2 have shading coefficient = 1.0 and is single pane 1/4" plate

OCCUPANCY, LIGHTING AND APPLIANCE SCHEDULES

Time of Day	Number of Occupants Weekdays	Weekends	Percentage of Connected Load Connected Load = 3289 watts
0000	5	5	60
0100	5	5	55
0200	5	5	43
0300	5	5	40
0400	5	5	34
0500	5	5	33
0600	5	5	49
0700	4	4	85
0800	1	4	94
0900	1	4	88
1000	1	4	78
1100	1	4	63
1200	1	4	53
1300	1	0	49
1400	1	0	54
1500	4	1	63
1600	4	4	66
1700	5	1	79
1800	5	1	82
1900	5	1	98
2000	5	1	100
2100	5	1	91
2200	5	1	80
2300	5	1	68

APPENDIX B. DATA FOR SINGLE-FAMILY DETACHED HOUSE IN HOUSTON, TEXAS

HOUSTON TEST BUILDING

LOCATION:	HOUSTON, TEXAS
LATITUDE:	29 DEG 4 MIN
LONGITUDE:	95 DEG 24 MIN
ALTITUDE:	63 FEET
CONDITIONED FLOOR AREA:	1020 SQ. FT.

THERMOSTAT SET POINTS

HEATING - NOT APPLICABLE

COOLING - 76 DEG F

OCCUPANCY

TOTAL - SIMULATED

LIGHTING AND APPLIANCE LOAD

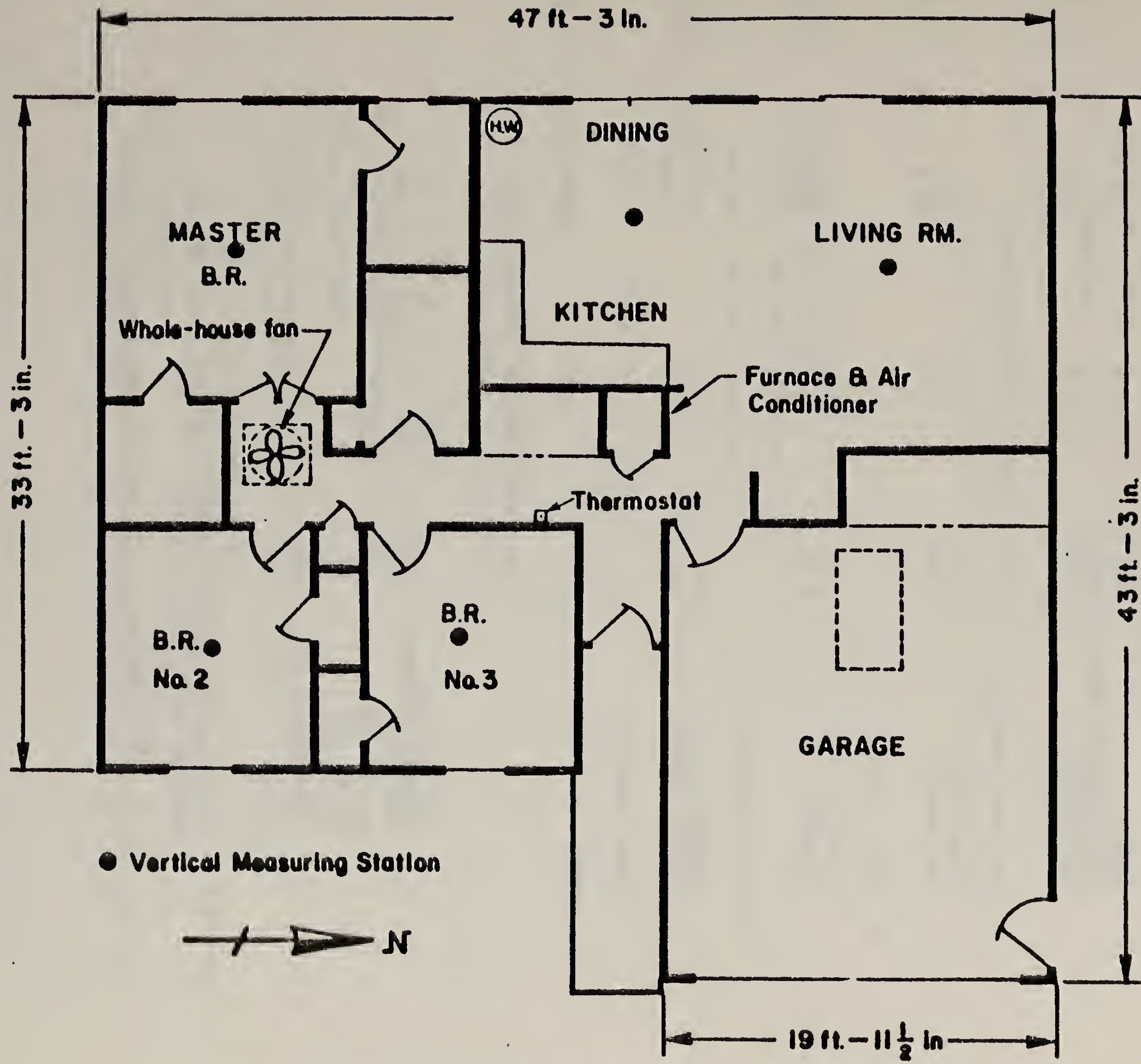
TOTAL - 1285 WATTS/HR

HVAC SYSTEM

A) SPLIT VAPOR-COMPRESSION REFRIGERATION SYSTEM
COOLING CAPACITY: 30,000 BTUH
A/C COP: HOURLY VALUE CAN BE CALCULATED FROM DATA TAPE

AIR INFILTRATION

A TYPICAL VALUE IS 0.63 AIR CHANGES PER HOUR



Floor Plan Of Houston Test House

MATERIALS OF CONSTRUCTION

	THICKNESS (INCHES)	CONDUCTIVITY (BTU/ IN-F-HR)	DENSITY (LB/FT3)	SPECIFIC HEAT (BTU/LB-F)
A) OUTSIDE WALLS (R=14)				
BRICK	4.0	5.0	120.0	0.2
AIR SPACE (R=.91)	1.0	---	---	---
INSULATION	3.5	0.3	2.0	0.2
WALLBOARD	0.38	1.44	55.0	0.26
B) CEILING (R=10.3)				
INSULATION	3.0	0.3	5.7	0.2
WALLBOARD	0.38	1.44	55.0	0.26
C) ROOF (R=0.64)				
SHINGLE	0.25	1.0	73.0	0.2
PLYWOOD	0.38	0.96	34.0	0.38
D) FLOOR (R=3.9)				
CONCRETE	4.0	12.0	140.0	0.2
CARPET (R=0.9)	---	---	---	---
DOORS (R=1.3)				
WOOD	1.0	0.80	32.0	0.65

BUILDING ENVELOPE COMPONENT DATA

ORIENTATION	1	2	3	4
AZIMUTH, DEGREES	90	180	270	360
ROOF, FT2	510	0	510	0
WALLS, FT2	158	249	261	249 (1)
GLASS, FT2	27	0	93	0
DOOR, FT2	20	0	0	0
GARAGE DOOR, FT2	150	0	0	0

NOTES

ALL GLASS IS 1/8 INCH SINGLE PANE WITH A U=1.06 AND SHADING COEFFICIENT OF 0.55

(1) APPROXIMATELY 67 FT2 ENCLOSE THE ATTACHED GARAGE

APPENDIX C. DATA FOR TOWNHOUSE IN TWIN RIVERS, NEW JERSEY

TWIN RIVERS TOWNHOUSE

LOCATION:	TWIN RIVERS, NEW JERSEY
LATITUDE:	40 DEG 21 MIN
LONGITUDE:	74 DEG 39 MIN
ALTITUDE:	100 FEET
CONDITIONED FLOOR AREA:	1500 SQ. FT.

THERMOSTAT SET POINTS

HEATING - 68 DEG F (NOMINAL)

COOLING - 76 DEG F (NOMINAL)

OCCUPANCY

TOTAL - 2 ADULTS, 2 CHILDREN

HVAC SYSTEM

A) ELECTRIC AIR CONDITIONER

COOLING CAPACITY: 24,000 BTUH

B) FORCED AIR GAS FURNANCE

HEATING CAPACITY: 80,000 BTUH
FURNANCE EFFICIENCY: 0.75

AIR INFILTRATION

The approximate air changes per hour can be found from the following equation [3] :

$$AC = 0.186+(0.0148 \mp 0.0018)DT$$

where DT = Indoor-Outdoor temperature differece in degrees C

OTHER INFORMATION

The attic insulation in this townhouse has been increased from R-11 to R-30. The townhouse is an interior unit not an end unit.

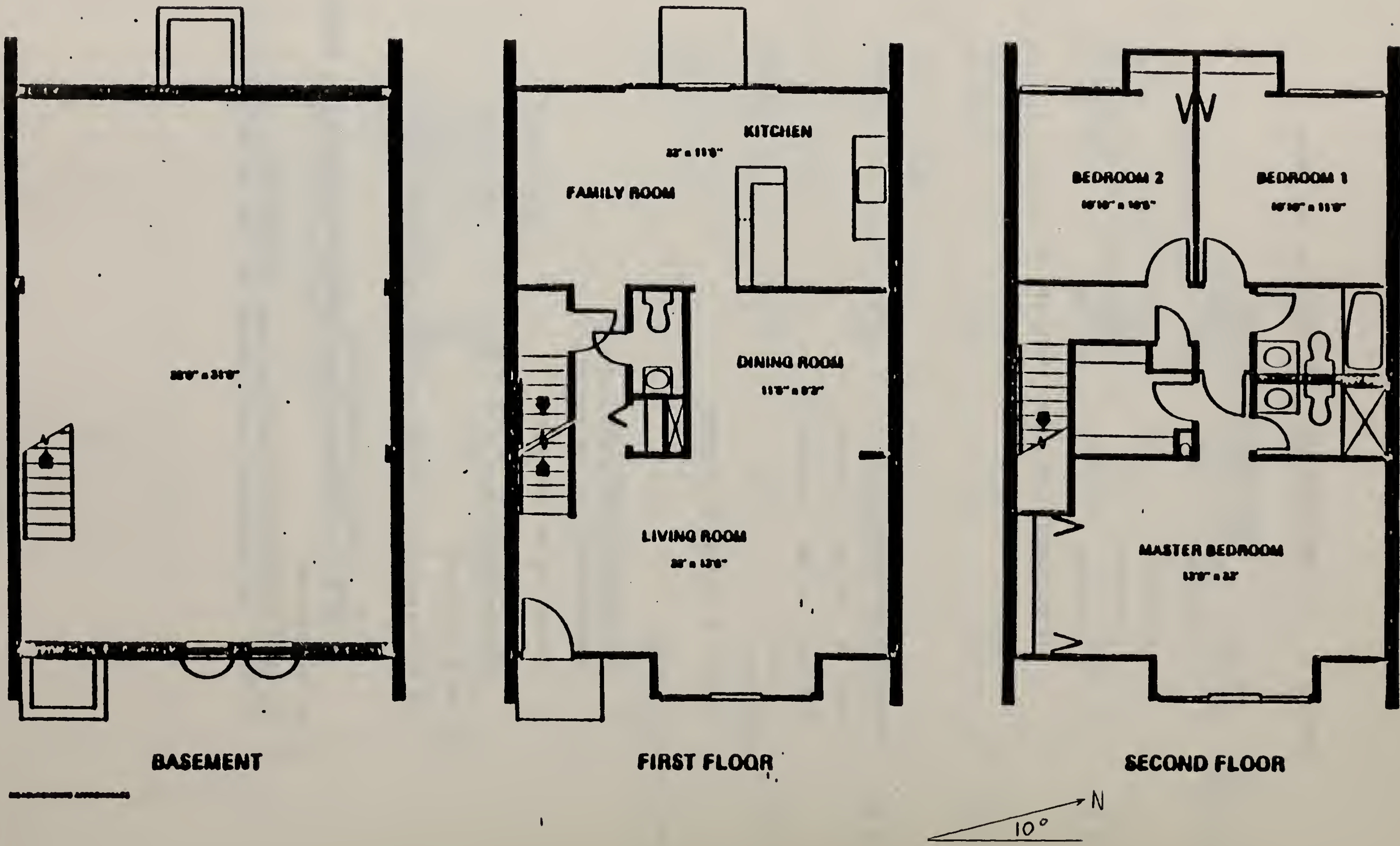


FIGURE C-1. TWIN RIVERS TOWNHOUSE

Table C.1

Physical Properties of Building Materials

Item	$\rho[\frac{lbm}{cu ft}]$	$C_p[\frac{Btu}{lbm\ °F}]$	$k[\frac{Btu}{hr\ ft\ °F}]$	d[in]	$U[\frac{Btu}{hr\ ft^2\ °F}]$	$C_s[\frac{Btu}{ft^2\ °F}]$
Plywood	34.	0.29	.0665	½	1.60	0.41
Wood Siding, lapped	32.	0.31	.0511	½	1.23	0.41
Studs and Joists*	32.	0.33	.068	3⅝	0.225	3.19
" " "	"	"	"	5⅝	0.145	4.95
" " "	"	"	"	7⅝	0.107	6.71
Gypsum Board	50.	0.26	.0936	½	2.25	0.54
Building Paper	—	—	—	—	16.70	—
Asphalt Shingles	70.	0.22**	.09***	½***	2.27	0.64***
Cinder Blocks	55.6	0.16	.387	8	0.581	5.93
Brick	120.	0.2	.417	8	0.63	16.0
Concrete	144.	0.16	.54	4	1.62	7.68
Stone Fill	95.	0.2	1.04	4	3.12	6.33
Linoleum Tile	50.***	0.30	.83***	½***	20.	0.63***
Rug (with fibrous pad)	50.***	0.48	.02	½	0.48	1.0***
Window Glass	161.	0.18	.59	⅛	56.6	0.30
Insulation, Batt R-7	0.9	0.18	.027	2¼	0.143	0.03
" " R-11	"	"	"	3½	0.091	0.05
" " R-19	"	"	"	6⅛	0.053	0.08
Earth (dry, stony)	120.	0.2	.5	—	—	—
Earth (wet)	120.	0.2	.3	—	—	—
Indoor film coeff.	0.075	0.24	—	—	1.46	(Vertical)
" " "	—	—	—	—	1.63	(Horizont.)
Attic film coeff.	—	—	—	—	2.20	—
Outdoor film coeff.****	—	—	—	—	6.0	(15 mph wind)
Air spaces	—	—	—	1-4	1.12	(Vertical)
" "	—	—	—	1	1.09	(Horizont.)
" "	—	—	—	4	0.91	(Horizont.)
" "	—	—	—	8	0.90	(Horizont.)

*One-dimensional heat transfer only

**Asphalt, pure

***Estimates

ρ = Density

C_p = Specific Heat Cap.

k = Conductivity

d = Thickness

****Approximate dependence on wind: $h[Btu/hr\text{-}ft^2\text{-}°F] = 1.8 + 0.28*V[mph]$

Conductance $U = \frac{k}{(d/12)}$ Capacitance (Capacity per unit area) $C_s = \rho * C_p * d/12$

Table C.2 (continued)

	$U[\frac{Btu}{hr\ ft^2\ °F}]$	R=1/U	$C_s[\frac{Btu}{ft^2\ °F}]$
4. **Basement Walls:**			
below grade only:			
Indoor film coefficient	1.46	0.68	0.
8" Cinder Blocks	0.58	1.72	5.93
		2.40	5.93
above grade, additionally:			
Outside film coefficient:	(6.00)	(0.17)	(0.)
		2.57	5.93
Composite U-value above grade:	0.39		
Composite U-value below grade*:	0.42		
5. **Basement Floor:**			
Indoor film coefficient	1.63	0.61	0.
4" Concrete floor	1.62	0.62	7.68
4" Stone fill	3.12	0.32	6.33
		1.55	14.01
Composite U-value*:	0.65		
6. **Party Walls:**			
Indoor film coefficient	1.46	0.68	0.
½" Gypsumboard	2.25	0.44	0.54
4" Air space/2x4 Studs**	1.03	0.97	0.33
		2.09	0.87
Composite U-value (wood frame alone):	0.48		
8" Cinder Block	0.58	1.72	5.93
Neighbor wood frame	0.48	2.09	0.87
		5.90	7.67
Composite U-value (wood+masonry):	0.17		
7. **Downstairs Floor (carpet or tiles):**			
Indoor film coefficient	1.63	0.61	0.
½" Plywood/2x8 Joists***	1.46	0.69	1.1
Carpet (fibrous pad)	0.48	2.08	1.0
alternate: Linoleum floor tiles	(20.00)	(0.05)	(0.63)
Indoor film coefficient	1.63	0.61	0.
		3.99	2.11
Composite U-value (carpet)	0.25		
Composite U-value (tiles)	0.51		

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*Below grade Basement losses are evaluated without using this value.
**Composite values for 4" Air sp. in parallel with 1⅝x3⅝ studs 16" o.c.
***Composite values for ½" Plywood in parallel with 1⅝x5⅝ joists 16" o.c.

Table C.2 (continued)

8. Upstairs Floor (carpet or tiles):	$U[\frac{Btu}{hr\,ft^2\,°F}]$	R=1/U	$C_s[\frac{Btu}{ft^2\,°F}]$
Indoor film coefficient	1.63	0.61	0.
½" Gypsumboard	2.25	0.44	0.54
8" Air Space/2x8 trusses*	0.82	1.22	0.68
½" Plywood	1.60	0.62	0.41
Carpet (fibrous pad)	0.48	2.08	1.0
alternate: Linoleum floor tiles	(20.00)	(0.05)	(0.63)
Indoor film coefficient	1.63	0.61	0.
		5.58	2.63
Composite U-value (carpet):	0.18		
Composite U-value (tiles):	0.28		

9. Partition Walls:			
Indoor film coefficient	1.46	0.68	0.
½" Gypsumboard	2.25	0.44	0.54
4" Air space/2x4 Studs**	1.03	0.97	0.33
½" Gypsumboard	2.25	0.44	0.54
Indoor film coefficient	1.46	0.68	0.
		3.21	1.41
Composite U-value:	0.31		

10. Front Door:

Composite U-value: 0.54

11. Windows (80% glass area):

U-values, including film coefficients

Wind speed [mph]	0	5	10	15	
Single Pane	0.76	0.96	1.07	1.13	$[\frac{Btu}{hr\,ft^2\,°F}]$
Double Pane	0.58	0.70	0.75	0.78	

Capacitance 0.30 Btu/ft²°F

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*Composite values of 8" Air space in parallel with 1⅝x7⅝ joists, 16" on center. See text and Sketch (a).

**Composite values of 4" Air space in parallel with 1⅝x3⅝ studs, 16" on center. See text and Sketch (a).

Table C.3

Heat Transfer Constants H and Heat Capacities C

for a Twin Rivers 3-Bedroom Townhouse

	Table A.2#	Area[ft²]	H[Btu/hr °F]	C[Btu/°F]
1) Outside Walls:				
Front Walls	1	363	35.6	621
Back Walls	1	318	31.1	544
Front Door	10	20	10.8	34
Total Conduction and Capacity			77.5	1199
Extra End Unit Wall	1	545	52.9	9205
2) Windows:				
Front (single pane/double pane)	11	80	90.4 / 52.0	24
Back (single pane/double pane)	11	106	119.8 / 68.9	32
Total Conduction and Capacity			210.2/120.9	56
Extra End Unit Window	11	16	20.8 / 12.5	5
3) Basement:				
Windows (single pane)	11	8	9.0	2
Walls (above grade)	4	65	14.8	385
Walls (bel. gr.; Standard*/Sinden**)	4	246	18.5/23.7	1459
Floor (Standard*/Sinden**)	4	726	27.2/11.8	10171
Total Conduction and Capacity			60.5/50.3	12017
Extra End Unit Wall (above grade)	4	55	21.5	326
Extra End Unit Wall (below grade)	4	184	13.8/17.7	1091
Total Extra End Unit Wall			95.8/89.5	1417
4) Attic:				
Roof conduction	3	906	507.4	1259
Attic ventilation (0.5 cfm/sqft)	-	—	412.0	—
Total Roof Heat Loss Constant			919.4	
Ceiling	2	763	65.6	702
Extra End Unit Attic Wall	4	113	50.9	1808

*Recommended by ASHRAE, Handbook of Fundamentals, 1972; adapted for $\Delta T = 40$ °F.
**Frank Sinden, CES Note#4; two-dimensional exact solution.

Table C.3 (continued)

5) Air Infiltration:	Volume	$H[\frac{Btu}{hr\,°F}]$ AI[hr^{-1}]	H[..] AI[..]
First and Second Floor only	11600	104 (0.5)	157 (0.75)
Above Grade Space	13500	122 (0.5)	182 (0.75)
First & Second Floor & Basement	17400	157 (0.5)	235 (0.75)
Both Floors, Basement and Attic	20000	180 (0.5)	270 (0.75)
Basement alone	5800	104 (1.0)	157 (1.50)

6) Party Walls (both):	Table A.2#	Area[ft^2]	$H[\frac{Btu}{hr\,°F}]$	$C[\frac{Btu}{°F}]$
Wood frame alone	6	1122	539	976
Wood frame & Masonry & Wood frame	6	1122	191	8606
7) Downstairs Floor:				
Floor with Carpet	7	451	113	952
Floor with Tiles	7	275	140	479
Total Conduction and Capacity			253	1431
8) Upstairs Floor:				
Floor with Carpet	8	588	106	1546
Floor with Tiles	8	138	39	312
Total Conduction and Capacity			145	1858
9) Partition Walls:				
Downstairs	9	549	—	774
Upstairs	9	736	—	1038
Total Capacity				1812

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

A set of measured residential data has been culled from three larger data sets for use in the testing and verification of building energy analysis programs. The data consist of hourly values for heating/cooling system performance and weather conditions that are sufficient in detail, it is believed, for all existent computer programs. These dats have been encoded onto a magnetic tape. In addition, general information has been collected on the houses, occupants/occupant use, and heating/cooling systems.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

building energy analysis program; data tape, measured hourly data; testing and verification

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