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NATIONAL BUREAU OF STANDARDS REPORT

6887

Interim Report on Task I
of
Field Studies of Year-Round Air Conditioning Systems

by

Paul R. Achenbach

Report to
Office of the Chief of Engineers
Bureau of Yards and Docks
Headquarters, U.S. Air Force

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

to

Office of the Chief of Engineers
Bureau of Yards and Docks
Headquarters, U.S. Air Force

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1. Introduction

The Arkansas Power and Light Company, the electric utility that serves the Little Rock Air Force Base, has been collecting electrical energy consumption data on 16 houses in the Air Base housing area since October 1958, using four or more demand meters on each house to record separately the energy used for the electric range, the electric water heater, the heat pump, and the total for the house on a 15-minute demand interval. Indoor air temperatures have also been recorded in each of the houses, and outdoor air temperatures were recorded at three separate stations in the housing area. The total monthly energy use indicated by these four meters in each of the 16 houses has been summarized by Arkansas Power and Light Company personnel.

These monthly summaries of energy usage and the original charts from the recording demand meters and the temperature recorders have been made available to the National Bureau of Standards for further analysis. Task I under this project indicated that the following information should be developed from these records:

(a) Information on the amount of electric power used by the occupants for cooking, lighting, ironing, etc.

(b) Information on the amount of electric power used for electric water heating.

(c) Correlation between power used by heat pump (including strip heaters) and the outdoor temperature.

(d) Estimate of the contribution of the electrical equipment (other than the heat pump) to the heating function in the winter time and to the cooling load in the summer time.

More recently the U.S. Air Force requested that the demand charts be examined to determine what elements contributed in a significant way to the monthly 15-minute peak demands in the 16 houses, since the cost of the electrical energy to the Government was closely related to the maximum demands. It was considered probable that such an analysis would indicate one or more ways in which the 15-minute demand values for the entire housing area could be reduced.

2. Description of Sample Houses

The identification of the 16 houses used for the study with respect to location, type of house, floor area, and number of bedrooms is summarized in Table 1. House types A, A_1, B, and B_1 were used to domicile airmen, and house types C, D, E, F, and G were used primarily to domicile officers. House types A_1 and B_1 were of duplex construction with carports adjoining; house types A, B, C, and D were of duplex construction with living quarters adjoining; and the remainder were of detached design. All houses were of single story construction built on concrete slabs on grade.

Table 1

Identification of Sample Houses

Street Address of House	Contractor Identification No.	House Type	Floor Area, sq ft		No. of Bedrooms
			Gross	Net	
114 Minnesota Circle	4	B_1	1070	999	3
122 Mississippi Loop	14	A_1	970	891	2
110 Missouri Circle	74	B	1070	1013	3
129 Georgia Avenue	163	B_1	1070	999	3
189 Pennsylvania Drive	172	B	1070	1013	3
102 Florida Avenue	180	A	970	891	2
115 Idaho Circle	263	A	970	891	2
126 Montana Circle	301	A_1	970	891	2
103 Arizona Drive	467	F	1680	1553	4
105 Arizona Drive	468	G	2050	1900	4
102 Alabama Drive	577	E	1190	1115	3
122 Illinois Drive	585	C	1050	999	2
130 Illinois Drive	587	D	1100	1046	3
129 Iowa Circle	656	D	1100	1046	3
123 Louisiana Drive	770	E	1190	1115	3
127 Michigan Circle	843	C	1050	999	2

There were 1535 houses in the housing area, so the sample that was used for this study represents 1.04 percent of the total. The sample includes six 2-bedroom units, eight 3-bedroom units, and two 4-bedroom units. The entire housing area was comprised of 456 2-bedroom units, 1067 3-bedroom units, and 12 4-bedroom units. It is evident from these figures that the proportion of 4-bedroom units was much greater in the sample group of houses than for the entire housing area and that the proportion of 2-bedroom houses was somewhat greater in the sample than for the entire group.

3. Analysis of Data

3.1 Monthly Electric Energy Use

The average monthly electric energy use per house for each of the major components comprising the load and for the entire house was determined for the 16 houses as a group and also for the 2-bedroom, 3-bedroom, and 4-bedroom houses as sub-groups. The average monthly energy usages for the heat pump, the water heater, the kitchen range, and miscellaneous devices were also expressed as a percentage of the total house load in each sub-group and for the entire sample. For this purpose, the energy use of the miscellaneous devices was determined by subtracting the sum of the usages of the heat pump, the water heater, and the range from the total energy use for the house. These results have been summarized in Table 2 on a monthly basis from October 1958 to March 1960, inclusive. It will be noted in Table 2 that all of the 16 houses were not occupied prior to June 1959. For this series of measurements, the energy used by the electric clothes dryer and the resistance heater in the bathroom was included in the miscellaneous devices.

The average monthly energy use in the 16 houses for the several components of the total load was plotted in Fig. 1 for the period from October 1958 to February 1960. The average monthly energy use per house for the entire housing area was also plotted as a dotted line in Fig. 1. This represents approximately 1535 houses starting with June 1959.

It will be noted in Fig. 1 that the energy use for the heat pump and for the entire house reached an annual maximum in the middle of the winter and a smaller maximum during July and August. Two minimums occurred during the year, in April and October, for the heat pump and the house as a whole when little heating or cooling was required. The winter peak usage of energy was approximately twice the summer maximum. The energy usages for the water heater, the kitchen range, and the miscellaneous devices were relatively more stable throughout the year, although the minimum use of energy for water heating and miscellaneous devices occurred in July and the maximums occurred in the colder months of the year.

Fig. 1 shows that the average monthly energy used per house for the 16 houses was very close to that for 1535 houses for the period from July 1959 to February 1960 when the base was fully occupied, despite the disproportionate number of large houses in the 16-house sample.

Considering the average values for all 16 houses, Table 2 shows that the energy used for the heat pump ranged from about 30% of the total load during the spring and fall to a value between 50 and 60% during the middle of the summer and winter; the energy used for water heating ranged from about 15% in the middle of the winter to a little over 30% in the spring and fall; the energy used for the kitchen range was 5% or less of the total throughout the year; and the energy used for miscellaneous devices ranged from 20 to 30% of the total most of the time.

Considering the 2-bedroom, 3-bedroom, and 4-bedroom houses as separate groups, Table 2 shows that for most months of the year the energy used for the heat pump and for water heating increased for the larger houses, whereas the energy used for cooking was usually the greatest in the 3-bedroom houses, and the energy used for miscellaneous devices was rather inconsistent with respect to house size.

The energy used in the sample houses for each component of the total load and the percent of the total represented by each component is summarized in Table 3 for the 12-month period from March 1959 to February 1960, inclusive. It should be noted that only 15 houses were occupied during some months of this period.

Table 3

Annual Energy Use in Sample Houses

Component of Load	Total Energy Used KWH	Percent of Total
Heat Pump	12,290	48.6
Water Heater	6,135	24.3
Range	965	3.8
Miscellaneous (by difference)	5,905	23.3
Total	25,295	100.0

Table 3 shows that the total energy used for heating and cooling by the heat pump on an annual basis was slightly less than that used for all other devices combined. The annual energy usages for water heating and miscellaneous devices were each about half as large as that for the heat pump.

3.2 Heating Accomplished by Range, Water Heater, and Miscellaneous Devices

It is known that the energy used by the electric range, the electric water heater, and the miscellaneous devices each make some contribution toward warming the house in any season of the year. This auxiliary heating reduces the load on the heating system in cold weather and increases the load on the cooling system in hot weather.

It is probable that all of the energy input to the cooking range assists in warming the house with very little time lag except for the water vapor generated by the cooking processes that escape from the house in the winter time without being condensed. During the cooling season the water vapor produced by cooking would add to the latent cooling load on the heat pump and the sensible heat emitted from the range would add to the sensible cooling load of the heat pump. For this analysis it was assumed that all of the electrical energy consumed by the cooking range was effective in warming the house.

The jacket heat losses from the water heater would warm the house winter and summer, and a variable fraction of the heat in the warm water used for bathing, dishwashing, and laundry would be transferred to the air in the house as sensible or latent heat. Observations of the electric energy required to maintain storage temperatures in the water tank in some of the sample houses during the night when no water was being drawn indicate that the jacket loss of these water heaters was 8 to 10% of the total monthly energy used for water heating. To make some allowance for the heat transferred to the air in the house from the hot water during use, it was assumed for this analysis that 15% of all the electrical energy supplied to the water heater was effective in warming the house.

It is probable that all of the electrical energy used by electric lights, resistance heaters, toasters, radio and television sets, and nearly all of the energy used by an electric iron would be converted into heat that would assist in warming a house. The situation with respect to an electric clothes dryer is less definite. Although there would be some heat transferred to the room from the jacket of the dryer, these devices are usually equipped with a small blower which uses room air to carry the water vapor and some sensible heat outside during the clothes-drying process. Such a blower, when in operation, would increase the infiltration into the house, which would probably more than offset the jacket heat loss in the winter time. In the summer time the clothes dryer would increase the cooling load somewhat. For the purpose of this analysis, it was assumed that the clothes dryer contributed nothing toward heating the houses at Little Rock Air Force Base and that all of the remainder of the energy used by miscellaneous devices was converted into heat within the house.

The electrical energy used by the electric clothes dryers at Little Rock Air Force Base was not metered separately from the other miscellaneous loads. However, the energy used for this purpose in 15 sample houses at three other air bases where it was metered separately averaged about 100 KWH per house per month. Accordingly, the energy used for miscellaneous devices in the houses at Little Rock Air Force Base was corrected by subtracting 100 KWH from the monthly totals reported in each case where the monthly total exceeded 100 KWH.

On the basis of the foregoing assumptions, the monthly contribution of the electric range, water heater, and miscellaneous devices to house heating was determined by the following expression:

$$KWH_A = KWH_R + .15\ KWH_W + (KWH_M - 100) \quad \text{where}$$

KWH_A is the computed contribution of all appliances, other than the heat pump, to house heating in KWH/month,

KWH_R is the electric energy consumption of the electric range in KWH/month,

KWH_W is the electric energy consumption of the electric water heater in KWH/month,

KWH_M is the electric energy consumed by miscellaneous devices in KWH/month.

This formula was used in deriving one of the three factors for power usage per degree day per 1,000 sq ft of floor area in the next part of this analysis for the sample houses at Little Rock Air Force Base. It is recognized that this formula could probably be improved in accuracy by a careful statistical study of the heat dissipation characteristics of the various electrical appliances, as used in a house.

3.3 Correlation of Heating Power Requirements and Heating Degree-Days

Seasonal heat requirements for residences and other types of buildings in different climates have often been compared on the basis of the number of degree-days occurring in each locality. The heat requirements for different months in the same locality have also been compared on this basis. The heat requirements of houses of similar size and construction is approximately proportional to the floor area, if the range of size is not too great. In an effort to correlate the power requirements of the 16 sample houses at Little Rock Air Force Base, three different power usage factors were determined for the months of October, November, and December of 1959 and for January 1960. These data are summarized in Tables 4-7.

These power usage factors relate the electrical energy used by the heat pump only in one case and the total energy used for heating in the other two cases to the interior floor area of the houses and to the

degree-days below an outdoor reference temperature of 65°F in two cases and to the degree-days based on the average indoor-outdoor temperature difference in the third case. The contribution made by other appliances than the heat pump to heating the houses was determined by the formula cited earlier in this report. The degree-day value based on indoor-outdoor temperature difference was determined by multiplying the monthly average indoor-outdoor temperature difference by the number of days in the month.

A review of Tables 4-7 indicates that the methods employed to obtain the power usage factors correlate the observed data for 2, 3, and 4 bedroom houses for the months from October to January reasonably well. The factors obtained, when the power consumption of the heat pump only and the degree-days related to a 65-degree base are used together, agree quite well with those obtained when the total power for heating and the degree-days based on average indoor-outdoor temperature difference are used. The variation between houses within the 2-bedroom and 3-bedroom groups is somewhat less for the latter factor, probably because it takes into account two human choices not involved in the former factor, namely, the selection of indoor temperature and the usage of power for miscellaneous appliances. It should be pointed out that the power usage factor involving the power consumption of the heat pump alone and the degree-days related to a 65-degree base is much easier to obtain than the others because less instrumentation and fewer observations are involved.

3.4 Correlation of Cooling Power Requirements and Cooling Degree-Days

A similar correlation of power usage, floor area, and cooling degree-days was tried for the month of August 1959 for the 16 sample houses, and is summarized in Table 8. In this case, however, the heat contributed by electrical appliances added to the summer cooling load rather than assisting the heat pump as it did during the winter. Also, in the summertime, the outdoor temperature frequently crosses the reference value used for degree-day totals whether the reference value is chosen at 65°F or 75°F. Solar radiation on a house is a much greater factor in the total cooling load than it is for the heating load, and it is only indirectly reflected in the indoor-outdoor temperature difference during the summer.

The degree-day values in columns 6 and 7 of Table 8 are based on the hourly values of outside temperature related to reference values of 65°F and 75°F, respectively. The degree-day values in column 8 of Table 8 are based on the mean of the maximum and minimum daily outdoor temperatures and the average indoor temperature.

It will be noted in Table 8 that the power usage factor for cooling varied over quite a range depending on the basis selected for determining the degree-days of cooling. The average value for the 16 sample

houses ranged from 2.3 KWH/degree-day (1,000 sq ft) when 65°F was used as the reference value of outdoor temperature to 8.5 in the same units when the degree-days were based on mean outdoor temperature and average indoor temperature. In the latter case the degree-day value was negative for house No. 585 because the average indoor temperature was 1°F higher than the mean daily outdoor temperature.

Basing the degree-days on the difference between mean daily outdoor temperature and average indoor temperature is probably the least suitable of the three methods for correlating power usage: first, because this temperature difference can become vanishingly small, or even negative, and yet the house can have a cooling requirement; secondly, because a house probably responds with respect to heating or cooling on a time cycle of less than 24 hours; and, thirdly, because the maximum outdoor dry bulb temperature would usually occur more or less coincidentally with the maximum solar irradiation on the house.

The data reported in the monthly summaries of power suage for the 16 sample houses at Little Rock Air Force Base are not suitable for selecting the proper outdoor reference temperature for cooling degree days because a month is too long a time increment on which to determine the lowest outdoor temperature for which cooling is required in these houses. The weekly data on outdoor temperature and hours of operation for both cooling and heating being obtained under Task IV of this study will probably reveal an approximate or average reference temperature for cooling degree-days.

3.5 Factors Affecting Peak Demands for Electric Power in the Housing Area

The unit rate for electric energy at the Little Rock Air Force Base is related by sliding scales to the following three factors: (1) the total monthly usage of electric energy, (2) the magnitude of the maximum 15-minute demand during the month, and (3) the load factor, i.e. the ratio of the average load to the peak 15-minute demand for the month. A reduction of the maximum 15-minute demand in any month would tend to lower the unit rate by virtue of its effect on the second and third factors above even if the total energy usage remained unchanged.

In order to study the contributions of the various house appliances to the peak demands for electric energy, the simultaneous demands in the sample houses at the time of the peak demand for the entire housing area were graphed for a four-hour period, bracketing the time of the maximum value for the months of August 1959 and January 1960, and the individual non-concurrent peak demands for the 16 sample houses were also graphed for periods of four hours for the same months. The data used for these graphs were taken from the strip recorder charts of the demand meters which recorded the average power demand in kilowatts in 15-minute increments for the heat pump, the water heater, the range,

and the total house load. The miscellaneous load in the house, which consisted of the lights, the toaster, the television and radio sets, the refrigerator, the clothes dryer, etc. was not metered separately, but was calculated by subtracting the sum of the range, water heater, and heat pump demands from the total house meter demand.

The concurrent demands in the sample houses at the time of the maximum demand for the entire housing area are shown in Figs. 2 - 13, inclusive, and the average of the demands of the sample houses for the same four-hour periods are shown in Fig. 14. The maximum 15-minute demand for January 1960 for the entire housing area occurred on January 18 at 11:00 a.m., and it averaged 8.1 KW for each of the 1535 houses in the project. The average demand for each of the 16 sample houses at the same time was 7.6 KW, indicating that the sample was fairly representative in this particular instance. An inspection of Figs. 2 - 7, showing the demands of the individual houses from 9:00 a.m. to 1:00 p.m. on January 18, shows that the average demands of five of the sample houses were above 8 KW, the average demands for four others were about 8 KW, and the remaining 7 houses had demands averaging below 8 KW for this four-hour period. Figs. 2 - 7 also show that, for the four hours plotted, the heat pump in eight houses had a maximum or steady high demand coincidental with the housing area maximum, the water heater in eight houses had a maximum or steady high demand coincidental with the housing area maximum, the miscellaneous loads in three houses had maximum demands coincidental with the housing area maximum, and there were no coincidental maximums for the electric range in the 16 sample houses. In each of the sample houses for which the average demand during the four hours from 9:00 a.m. to 1:00 p.m. on January 18 was greater than 8 KW, either the heat pump and water heater, or the water heater and miscellaneous appliances, or all three of these components had maximum demands at 11:00 a.m. when the maximum demand occurred for the entire housing area.

It should be noted that the graphs for miscellaneous demands show some negative values. This situation, which is a physical impossibility, is believed to be caused by a lack of perfect synchronization in the clocks and the 15-minute demand intervals of the four recorder charts used to record the demands for the heat pump, water heater, range, and total for the house.

The maximum 15-minute demand for August 1959 for the entire housing area occurred on August 24 at 11:45 a.m. when the outdoor temperature was 92°F, and the demand averaged 4.9 KW for each of the 1535 houses in the project. The average demand for each of the sample houses (15 in this case, since the total demand meter was not working at this time in house No. 587) at the same time was 5.6 KW, indicating that the demand for the sample houses was above the average for the project by about 15 percent in this instance. Figs. 8 - 13

show that the heat pump in five houses and the water heater in two houses had a maximum or a steady high demand coincidental with the housing area maximum at 11:45 a.m. on August 24, the miscellaneous appliances in five houses had a maximum demand coincidental with housing area maximum demand, and that there was no coincidental maximum demand between the electric range and the entire housing area.

The average demand for all of the sample houses for the four-hour periods bracketing the time of the maximum housing area demand in January and August are plotted in Fig. 14. It is evident in this figure that the average demand for the 16 houses is considerably steadier than for the individual houses. The total house demand averaged about 2 KW less per house in August than in January, due principally to lower heat pump and water heater demands.

The non-concurrent maximum demands in each of the 16 sample houses during the billing period from January 8 to February 8, 1960 were plotted in Figs. 15 - 20, inclusive. It will be noted in these figures that the individual house peaks occurred on different days and at different times of the day in most cases. The outdoor temperature at the time of the peak ranged from 21.6°F in house No. 467 to 57.6°F in house No. 263. The time of the peaks in the individual houses ranged from 7:15 a.m. to 6:15 p.m., indicating that the activities of the occupants during the day were the principal factor in creating the peak demand. The magnitude of the maximum demand in the sample houses ranged from 12.5 KW to 27 KW and averaged 17.4 KW for the 16 houses. This average value is more than twice as large as the average for the entire housing project at the time of the maximum demand for the entire project.

Figs. 15 - 20 show that the demands of the several items of electrical equipment in the sample houses had a maximum or steady high value coincidental with the maximum for the entire load in 8 houses in the case of the heat pump, in 9 houses for the water heater, in 4 houses for the electric range, and in 12 houses for the miscellaneous appliances. The demand curves for the heat pump in Figs. 15 - 20 indicate that the demand was intermittently greater than the 3 to 4 KW required by the compression system under steady operation in 13 of the 16 sample houses, indicating that the supplementary resistance heaters were energized at times even though the outdoor temperature averaged less than 32°F in only two cases at the time of the peak demand. The figures show that the water heater never contributed more than 5 KW to the peak demand and that the miscellaneous appliances contributed 8 KW or more in eight of the sample houses.

The non-current maximum demands in each of the 16 sample houses during the billing period from August 8 to September 8, 1959 were plotted in Figs. 21 - 26, inclusive. The maximum demand in the individual houses occurred on different days and at different times of the day in most cases. The time of the peaks in the individual houses

ranged from 9:30 a.m. to 8:15 p.m., with all but four occurring after noon. The outdoor temperature at the time of peak demand ranged from 78°F to 93°F. The magnitude of the peak demand ranged from 11.5 KW to 16.5 KW and averaged 13.5 KW for the 16 sample houses.

Figs. 21 - 26 show that the demands of the several items of electrical equipment in the sample houses had a maximum or steady high value coincidental with the maximum for the entire load in 10 houses in the case of the heat pump and miscellaneous appliances, in 13 houses for the water heater, and in 2 houses for the electric range.

The average of the non-concurrent demands for all of the sample houses for the four hours bracketing the time of the individual house peak demands are plotted in Fig. 27 for the months of August 1959 and January 1960. These graphs indicate a fairly high degree of coincidence among the peaks for the individual appliances in the houses in producing the maximum value for the house as a unit. This figure also shows that a short duration high demand for the miscellaneous appliances was an important contributing factor in the magnitude of the maximum total demand.

3.6 Methods of Limiting Maximum Demand in Housing Area

The electric water heaters at Little Rock Air Force Base were not wired for off-peak heating and were of such a size that the electric element was energized continuously for several hours when a considerable amount of hot water was used. The demand meter records showed that the steady power usage was 4.5 to 5.0 KW when the water heater was operating. During laundering, the electric clothes dryer, whose energy consumption was about 5 KW, would be operated intermittently, such that the 15-minute demand of the water heater and dryer could frequently total 9.5 to 10 KW.

The demand meter records and laboratory data on the heat pumps used at this air base indicate that the compressor and two blowers would use 3 to 4 KW when in operation. On a winter day with outdoor temperatures at the balance point or lower, the compressor in many of the heat pumps would be running continuously, and during a hot summer day near design conditions continuous operation of many of the heat pumps would be expected. After adding an average miscellaneous load (other than the dryer) of 1 KW, and at least 1 KW for the bathroom resistance heater in the winter time, it can be seen that peak demands on the order of 14 to 15 KW could easily recur, either winter or summer, on a day with outdoor temperatures near the design conditions when laundering operations caused the water heater and clothes dryer to be operating at the same time.

Various devices have been used to limit the power demand in houses designed for electric heating and all electric appliances. Some of the load-limiting controls that could be used for this purpose are as follows:

(1) A non-preferential total load limiting device,
(2) A total load limiting device that gave preference to certain appliances,
(3) A load selector that permitted either of two appliances, but not both, to be energized,
(4) An off-peak water heating control.

Administrative procedures could also be used to schedule a certain percentage of the houses to perform intermittent functions, such as laundering, on each day of the week. This latter method has the advantage that no equipment is required, but it might be difficult to implement and would cause some inconvenience at times.

At Little Rock Air Force Base the type of load selector that permitted either of two appliances, but not both, to be energized seems to be the most practical. Such a control could be connected to the water heater and clothes dryer circuits so only one of these devices could be energized at a time. This control should probably give preference to the clothes dryer because the water heater has at least limited storage capacity. Even this device could cause some delay in heating water and some inconvenience if prolonged laundering was carried out. Such a load selector could reduce the peak demand in a given house by 4 to 5 KW, but of course, the average reduction for all houses would be less than this value because of diversity of appliance use.

An off-peak water heating control is probably impractical at this air base considering the limited size of the water storage tanks.

A load selector might be connected to the electric range and the resistance strip heaters in the heat pump, with preference being given to the range, since the heat output of the range assists in warming the house with only a small time lag. However, such a device would not reduce the peak demands in the summertime, and the demand records show that the electric range seldom contributed significantly to the recorded maximum demands during either summer or winter.

In general, any load selector should give preference to the house heating and cooking appliances and provide for selective or delayed programming of the more irregular functions such as water heating, laundering, etc. in such a way as to cause the minimum inconvenience to the occupants of the house.

Year
Month

Total Ener
Avg for
No
Avg fo
No
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No
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No

Energy Use
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Pe
Avg fo
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Table 2

MONTHLY ELECTRIC ENERGY USAGE IN A
SELECTED GROUP OF HOUSES AT LITTLE ROCK AIR FORCE BASE

Year Month	1958 Oct.	1958 Nov.	1958 Dec.	1959 Jan.	1959 Feb.	1959 Mar.	1959 Apr.	1959 May	1959 June	1959 July	1959 Aug.	1959 Sept	1959 Oct.	1959 Nov.	1959 Dec.	1960 Jan.	1960 Feb.	1960 Mar.
Total Energy Used for Month, KWH																		
Avg for All Houses Reported	1469	2227	3683	3409	2292	1933	1379	1577	1729	1718	1901	1553	1570	2607	2575	3040	3707	2850
No. of Houses Reported	11	12	13	13	13	15	15	15	16	16	16	15	16	15	15	16	16	16
Avg for 2 Bedroom Houses	1040	1827	2800	2860	1860	1432	1008	1256	1473	1400	1467	1300	1347	2296	2352	2567	3160	2313
No. of 2 Bedroom Houses	3	3	4	4	4	5	5	5	6	6	6	6	6	5	5	6	6	6
Avg for 3 Bedroom Houses	1760	2280	3943	3246	2303	2030	1415	1593	1633	1845	1983	1483	1590	2603	2468	3025	3694	2885
No. of 3 Bedroom Houses	6	7	7	7	7	8	8	8	8	8	8	7	8	8	8	8	8	8
Avg for 4 Bedroom Houses	1240	2640	4540	5080	3120	2800	2160	2320	2880	2160	2880	2560	2080	3400	3560	4520	5400	4320
No. of 4 Bedroom Houses	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Energy Used for Heat Pump, KWH																		
Avg for All Houses Reported	582	1243	2534	2200	1155	773	432	508	881	1025	1033	671	571	1365	1247	1589	2196	1506
Percent of Total	39.6	55.8	68.8	64.5	50.4	40.0	31.3	32.2	51.0	59.7	54.3	43.2	36.4	52.3	48.4	52.3	59.2	52.8
Avg for 2 Bedroom Houses	320	1020	2020	1945	1065	716	356	424	750	860	750	520	440	1188	1184	1430	2000	1413
Percent of Total	30.8	55.8	72.1	68.0	57.3	50.0	35.3	33.8	50.9	61.4	50.8	40.0	32.7	51.7	50.3	55.7	63.3	61.1
Avg for 3 Bedroom Houses	790	1209	2560	1994	1103	775	455	478	810	1018	1050	620	645	1368	1165	1508	2089	1355
Percent of Total	44.9	53.0	64.9	61.4	47.9	38.2	32.2	30.0	49.6	55.2	53.0	41.8	40.6	52.5	47.2	49.8	56.5	47.0
Avg for 4 Bedroom Houses	350	1700	3470	3430	1520	910	530	840	1560	1550	1810	1300	670	1800	1730	2390	3220	2390
Percent of Total	28.2	64.4	76.4	67.5	48.7	32.5	24.5	36.2	54.2	71.8	62.8	50.8	32.2	52.9	48.6	52.9	59.6	55.3
Energy Used for Water Heating, KWH																		
Avg for All Houses Reported	409	495	515	611	560	609	471	549	430	349	413	452	495	573	573	605	618	626
Percent of Total	27.9	22.2	14.0	17.9	24.4	31.5	34.1	34.8	24.9	20.3	21.7	29.1	31.5	22.0	22.2	19.9	16.7	22.0
Avg for 2 Bedroom Houses	347	420	415	480	425	460	368	460	393	293	353	410	457	492	500	510	477	453
Percent of Total	33.4	23.0	14.8	16.8	22.8	32.1	36.5	36.6	26.7	20.9	24.1	31.5	33.9	21.4	21.3	19.9	15.1	19.6
Avg for 3 Bedroom Houses	403	523	569	600	540	610	450	560	393	403	433	429	470	573	580	633	663	698
Percent of Total	22.9	22.9	14.4	18.5	23.4	30.0	31.8	35.2	24.1	21.8	21.8	28.9	29.5	22.0	23.5	20.9	17.9	24.2
Avg for 4 Bedroom Houses	520	510	530	910	850	980	810	730	690	300	515	660	670	780	730	810	860	860
Percent of Total	41.9	19.3	11.7	17.9	27.2	35.0	37.5	31.5	24.0	13.9	17.8	25.8	32.2	22.9	20.5	17.9	15.9	19.9
Energy Used for Cooking Range, KWH																		
Avg for All Houses Reported	62	103	97	91	83	88	65	81	58	53	68	67	79	88	88	111	118	93
Percent of Total	4.2	4.6	2.6	2.7	3.6	4.5	4.7	5.1	3.4	3.1	3.5	4.3	5.0	3.4	3.4	3.6	3.2	3.3
Avg for 2 Bedroom Houses	53	100	80	80	75	72	36	56	40	30	53	50	47	56	48	50	60	47
Percent of Total	5.1	5.5	2.9	2.8	4.0	5.0	3.6	4.5	2.7	2.1	3.6	3.8	3.5	2.4	2.0	1.9	1.9	2.0
Avg for 3 Bedroom Houses	77	126	126	100	91	95	80	100	70	73	80	80	103	108	110	165	165	130
Percent of Total	4.4	5.5	3.2	3.1	3.9	4.7	5.7	6.3	4.3	4.0	4.0	5.4	6.5	4.1	4.5	5.4	4.5	4.5
Avg for 4 Bedroom Houses	30	30	30	80	70	100	80	70	60	40	60	70	80	88	100	80	100	80
Percent of Total	2.4	1.1	0.6	1.6	2.2	3.6	3.7	3.0	2.1	1.9	2.1	2.7	3.9	2.6	2.8	1.7	1.8	1.9
Energy Used for Misc. Devices*, KWH																		
Avg for All Houses Reported	409	385	537	523	501	468	411	439	360	291	385	364	425	583	667	735	775	625
Percent of Total	27.9	17.3	14.6	15.3	21.9	24.2	29.8	27.8	20.8	16.9	20.2	23.4	27.1	22.4	25.9	24.2	20.9	21.9
Avg for 2 Bedroom Houses	320	240	285	405	295	280	248	316	290	217	310	320	403	568	620	577	623	400
Percent of Total	30.8	13.2	10.2	14.2	15.9	19.5	24.6	25.2	19.7	15.5	21.1	24.6	29.9	24.7	26.4	22.5	19.7	17.3
Avg for 3 Bedrooms	477	443	689	551	569	500	430	455	360	353	420	354	373	555	613	728	778	702
Percent of Total	27.1	19.4	17.5	17.0	24.7	24.6	30.4	28.5	22.0	19.1	21.2	23.9	23.4	21.3	24.8	24.1	21.1	24.3
Avg for 4 Bedrooms	340	400	510	660	680	810	740	680	570	270	500	530	660	730	1000	1240	1220	990
Percent of Total	27.4	15.2	11.2	13.0	21.8	28.9	34.3	29.3	19.8	12.5	17.3	20.7	31.7	21.5	28.1	27.4	22.6	22.9

* Include electric clothes dryer and bathroom heater

Year
Month

Total Ener
Avg for
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Table 4

Relation of Power Usage and Degree-Days
Under Heating Conditions for
October 1959
Little Rock Air Force Base

Contractors House Number	Power Consumption: Heat Pump KWH	Power Consumption: Appliance Contribution KWH_A KWH	Power Consumption: Total for Heating KWH	Avg Indoor Temp °F	Avg Outdoor Temp °F	Degree-Days: Based on 65° References	Degree-Days: Based on Avg Indoor -Outdoor Temp	Inside Floor Area sq ft	Power Usage Factor, KWH/Deg-Days (1000 sq ft): Total, 65° Base	Heat Pump, 65° Base	Total, Indoor-Outdoor, ΔT
2-Bedroom Houses											
14	440	469	909	78	59	214	589	891	4.8	2.3	1.7
180	380	529	909	74	59	214	465	891	4.8	2.0	2.2
263	380	484	864	75	59	214	496	891	4.5	2.0	2.0
301	360	423	783	73	59	214	434	891	4.1	1.9	2.1
585	640	366	1006	78	59	214	589	999	4.7	3.0	1.7
843	440	240	680	70	59	214	341	999	3.2	2.1	2.0
Average	440	419	859	75	59	214	486	927	4.4	2.2	2.0
3-Bedroom Houses											
4	520	385	905	75	59	214	465	999	4.2	2.4	1.9
74	580	295	875	76	59	214	527	1013	4.0	2.7	1.6
163	1240	607	1847	76	59	214	527	999	8.6	5.8	3.5
172	680	240	920	77	59	214	558	1013	4.3	3.1	1.6
577	400	623	1023	74	59	214	465	1115	4.3	1.7	2.0
587	500	380	880	73	59	214	434	1046	3.9	2.2	1.9
656	560	486	1046	77	59	214	558	1046	4.7	2.5	1.8
770	680	618	1298	74	59	214	465	1115	5.5	2.9	2.5
Average	645	454	1099	75	59	214	500	1043	4.9	2.9	2.1
4-Bedroom Houses											
467	380	782	1162	76	59	214	527	1553	3.5	1.1	1.4
468	960	699	1659	73	59	214	434	1900	4.1	2.4	2.0
Average	670	741	1411	75	59	214	481	1727	3.8	1.8	1.7
Avg for 16 Houses	571	477	1048	75	59	214	492	1085	4.6	2.5	2.0

Year
Month

Total Ener

Avg for
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Table 5

Relation of Power Usage and Degree-Days
Under Heating Conditions for
November 1959
Little Rock Air Force Base

Contractors House Number	Power Consumption: Heat Pump KWH	Power Consumption: Appliance Contribution KWH_A KWH	Power Consumption: Total for Heating KWH	Avg Indoor Temp °F	Avg Outdoor Temp °F	Degree-Days: Based on 65° References	Degree-Days: Based on Avg Indoor -Outdoor Temp	Inside Floor Area sq ft	Power Usage Factor, KWH/Deg-Days (1000 sq ft): Total, 65° Base	Power Usage Factor: Heat Pump, 65° Base	Power Usage Factor: Total, Indoor-Outdoor, ΔT
2-Bedroom Houses											
14	1140	495	1635	76	45	640	930	891	2.9	2.0	2.0
180	920	668	1588	74	45	640	870	891	2.8	1.6	2.0
263	860	805	1665	76	45	640	930	891	2.9	1.5	2.0
301	1600	492	2092	72	45	640	810	891	3.7	2.8	2.9
585	1420	529	1949	77	45	640	960	999	3.0	2.2	2.0
843	620	3*	623	60*	45	640	450	999	1.0	1.0	1.4
Average	1093	499	1592	73	45	640	825	927	2.7	1.8	2.2
3-Bedroom Houses											
4	1220	502	1722	73	45	640	840	999	2.7	1.9	2.1
74	1180	597	1777	77	45	640	960	1013	2.8	1.8	1.8
163	2180	766	2946	71	45	640	780	999	4.6	3.4	3.8
172	1320	338	1658	76	45	640	930	1013	2.6	2.0	1.8
577	1300	781	2081	72	45	640	810	1115	2.9	1.8	2.3
587	1060	729	1789	73	45	640	840	1046	2.7	1.6	2.0
656	1160	618	1778	78	45	640	990	1046	2.7	1.7	1.7
770	1520	856	2376	72	45	640	810	1115	3.3	2.1	2.6
Average	1368	648	2016	74	45	640	830	1043	3.0	2.0	2.3
4-Bedroom Houses											
467	1840	837	2677	73	45	640	840	1553	2.7	1.8	2.0
468	1760	837	2597	73	45	640	840	1900	2.2	1.5	1.6
Average	1800	837	2637	73	45	640	840	1727	2.5	1.7	1.8
Avg for 16 Houses	1319	616	1934	73	45	640	831	1085	2.8	1.9	2.2

* House 843 apparently not occupied. This data not included in the average.

Year
Month

Total Ener
Avg for
No
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No
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No

Energy Use
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Table 6

Relation of Power Usage and Degree-Days
Under Heating Conditions for
December 1959
Little Rock Air Force Base

Contractors House Number	Power Consumption: Heat Pump KWH	Power Consumption: Appliance Contribution KWH_A KWH	Power Consumption: Total for Heating KWH	Avg Indoor Temp °F	Avg Outdoor Temp °F	Degree-Days: Based on 65° References	Degree-Days: Based on Avg Indoor-Outdoor Temp	Inside Floor Area sq ft	Power Usage Factor, KWH/Deg-Days (1000 sq ft): Total, 65° Base	Power Usage Factor, KWH/Deg-Days (1000 sq ft): Heat Pump, 65° Base	Power Usage Factor, KWH/Deg-Days (1000 sq ft): Total, Indoor-Outdoor, ΔT
2-Bedroom Houses											
14	1140	535	1675	77	43	643	1054	891	2.9	2.0	1.8
180	760	732	1492	73	43	643	930	891	2.6	1.3	1.8
263	1080	859	1939	77	43	643	1054	891	3.4	1.9	2.1
301	1742	529	2271	73	43	643	930	891	4.0	3.0	2.7
585	1200	560	1760	77	43	643	1054	999	2.7	1.9	1.7
843	1000	306	1306	69	43	643	806	999	2.0	1.6	1.6
Average	1154	587	1741	74	43	643	971	927	2.9	2.0	2.0
3-Bedroom Houses											
4	1320	390	1710	74	43	643	961	999	2.7	2.1	1.8
74	980	677	1657	75	43	643	992	1013	2.6	1.5	1.6
163	1700	720	2420	74	43	643	961	999	3.8	2.6	2.5
172	980	278	1258	71	43	643	868	1013	1.9	1.5	1.4
577	1140	1016	2156	71	43	643	868	1115	3.0	1.6	2.2
587	720	824	1544	72	43	643	899	1046	2.3	1.1	1.6
656	1140	735	1875	78	43	643	1085	1046	2.8	1.7	1.7
770	1340	1036	2376	72	43	643	899	1115	3.3	1.9	2.4
Average	1165	710	1875	73	43	643	942	1043	2.8	1.8	1.9
4-Bedroom Houses											
467	1540	926	2466	72	43	643	899	1553	2.5	1.5	1.8
468	1920	1293	3213	74	43	643	961	1900	2.7	1.6	1.8
Average	1730	1110	2840	73	43	643	930	1727	2.6	1.6	1.8
Avg for 16 Houses	1231	714	1945	74	43	643	951	1085	2.8	1.8	1.9

Year
Month

Total Ener
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Table 7

Relation of Power Usage and Degree-Days
Under Heating Conditions for
January 1960
Little Rock Air Force Base

Contractors House Number	Power Consumption: Heat Pump KWH	Power Consumption: Appliance Contribution KWHA KWH	Power Consumption: Total for Heating KWH	Avg Indoor Temp °F	Avg Outdoor Temp °F	Degree-Days: Based on 65° References	Degree-Days: Based on Avg Indoor-Outdoor Temp	Inside Floor Area sq ft	Power Usage Factor, KWH/Deg-Days (1000 sq ft): Total 65° Base	Power Usage Factor: Heat Pump, 65° Base	Power Usage Factor: Total, Indoor-Outdoor, ΔT
2-Bedroom Houses											
14	1440	458	1898	76	42	694	1020	891	3.1	2.3	2.1
180	1160	601	1761	73	42	694	930	891	2.8	1.9	2.1
263	1160	694	1854	75	42	694	990	891	3.0	1.9	2.1
301	2040	658	2698	74	42	694	960	891	4.4	3.3	3.2
585	1400	595	1995	76	42	694	1020	999	2.9	2.0	2.0
843	1380	613	1993	73	42	694	930	999	2.9	2.0	2.1
Average	1430	603	2033	75	42	694	975	927	3.2	2.2	2.3
3-Bedroom Houses											
4	1400	825	2225	74	42	694	960	999	3.2	2.0	2.3
74	1020	934	1954	73	42	694	930	1013	2.8	1.5	2.1
163	2580	858	3438	74	42	694	960	999	5.0	3.7	3.6
172	1800	609	2409	74	42	694	960	1013	3.4	2.6	2.5
577	1400	1076	2476	71	42	694	870	1115	3.2	1.8	2.6
587	840	1040	1880	73	42	694	930	1046	2.6	1.2	1.9
656	1340	729	2069	77	42	694	1050	1046	2.9	1.9	1.9
770	1680	1019	2699	73	42	694	930	1115	3.5	2.2	2.6
Average	1508	886	2394	74	42	694	949	1043	3.3	2.1	2.4
4-Bedroom Houses											
467	2180	1418	3598	74	42	694	960	1553	3.3	2.0	2.4
468	2600	1265	3865	73	42	694	930	1900	3.0	2.0	2.2
Average	2390	1342	3732	74	42	694	945	1727	3.2	2.0	2.2
Avg for 16 Houses	1589	837	2426	74	42	694	958	1085	3.3	2.1	2.4

Year
Month

Total Ener
Avg for
No
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Table 8

Relation of Power Usage and Degree-Days
Under Cooling Conditions for
August 1959
Little Rock Air Force Base

Contractors House Number	Power Consumption: Heat Pump KWH	Power Consumption: Appliance Contribution KWH_A KWH	Avg Indoor Temp °F	Avg Outdoor Temp °F	Degree-Days: Hourly Values, 65°F Base	Degree-Days: Hourly Values, 75°F Base	Degree-Days: Daily Mean Above Indoor Avg	Inside Floor Area sq ft	Power Usage Factor KWH/Deg-Days (1000 sq ft): Hourly Values, 65°F Base	Power Usage Factor KWH/Deg-Days (1000 sq ft): Hourly Values, 75°F Base	Power Usage Factor KWH/Deg-Days (1000 sq ft): Daily Mean Above Indoor Avg
2-Bedroom Houses											
14	840	400	76	79	447	170	93.0	891	2.1	5.5	10.1
180	900	380	70	79	447	170	279.0	891	2.3	6.0	3.6
263	680	68	76	79	447	170	93.0	891	1.7	4.5	8.2
301	1040	572	75	79	447	170	124.0	891	2.6	6.9	9.4
585	380	316	80	79	447	170	- 31.0	999	0.9	2.2	-12.3*
843	660	162	76	79	447	170	93.0	999	1.5	3.9	7.1
Average	750	316	76	79	447	170	-	927	1.9	4.8	-
3-Bedroom Houses											
4	1240	276	74	79	447	170	155.0	999	2.8	7.3	8.0
74	1280	583	73	79	447	170	186.0	1013	2.8	7.5	6.8
163	1080	852	72	79	447	170	217.0	999	2.4	6.4	5.0
172	680	188	75	79	447	170	124.0	1013	1.5	4.0	5.4
577	880	543	77	79	447	170	62.0	1115	1.8	4.7	12.8
587	1360	274	73	79	447	170	186.0	1046	2.9	7.8	7.0
656	800	549	77	79	447	170	62.0	1046	1.7	4.5	12.4
770	1080	454	72	79	447	170	217.0	1115	2.2	5.7	4.5
Average	1050	465	74	79	447	170	151	1043	2.3	6.0	7.7
4-Bedroom Houses											
467	1740	438	74	79	447	170	155.0	1553	2.5	6.6	7.2
468	1880	635	77	79	447	170	62.0	1900	2.2	5.9	16.1
Average	1810	439	76	79	447	170	109	1727	2.4	6.3	11.7
Avg for 16 Houses	1032	434	75	79	447	170	-	1085	2.1	5.6	-

* Interior temp. 1°F above exterior temp.

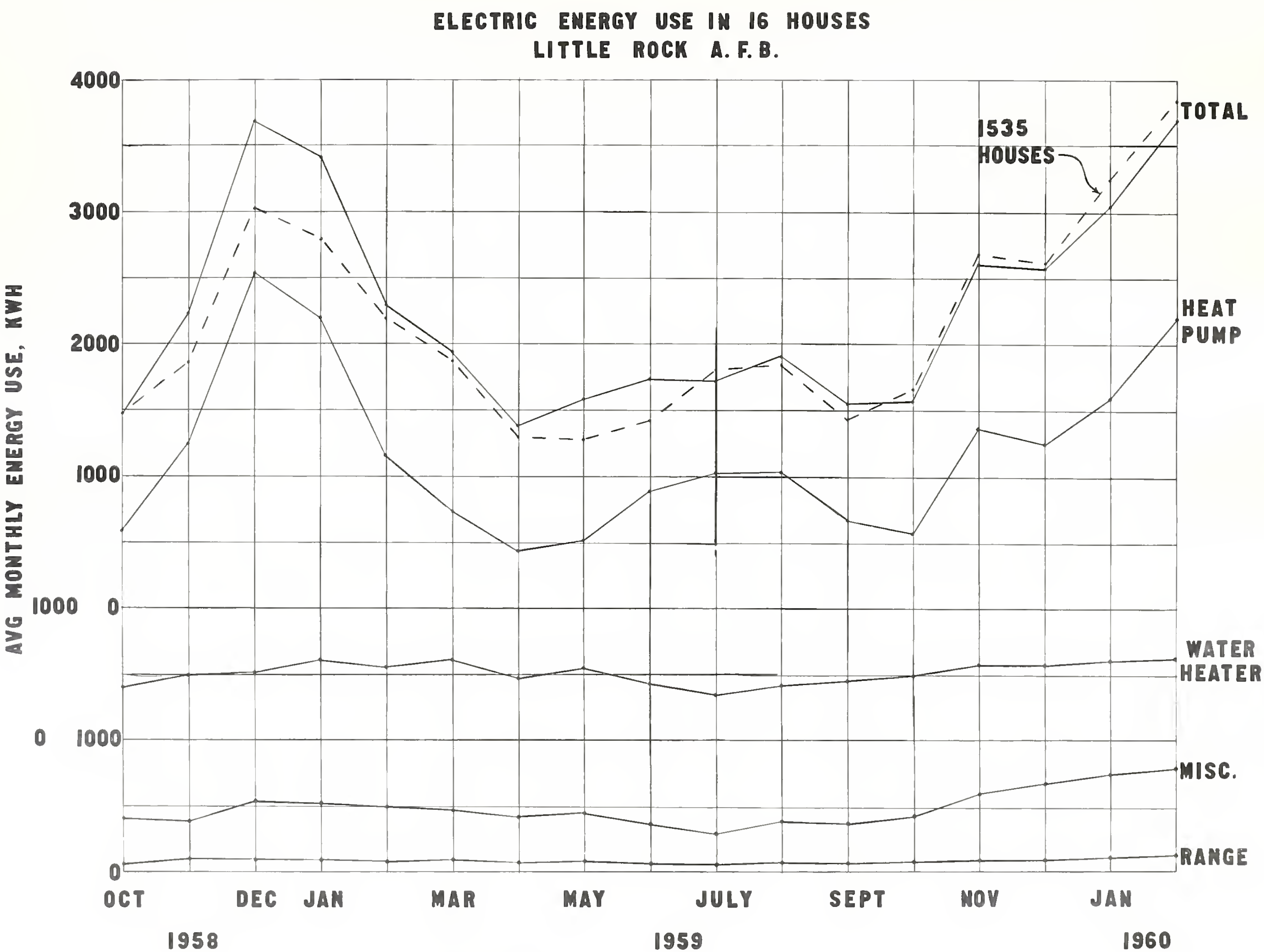
ELECTRIC ENERGY USE IN 16 HOUSES
LITTLE ROCK A.F.B.
AVG MONTHLY ENERGY USE, KWH
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Figure 1

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.

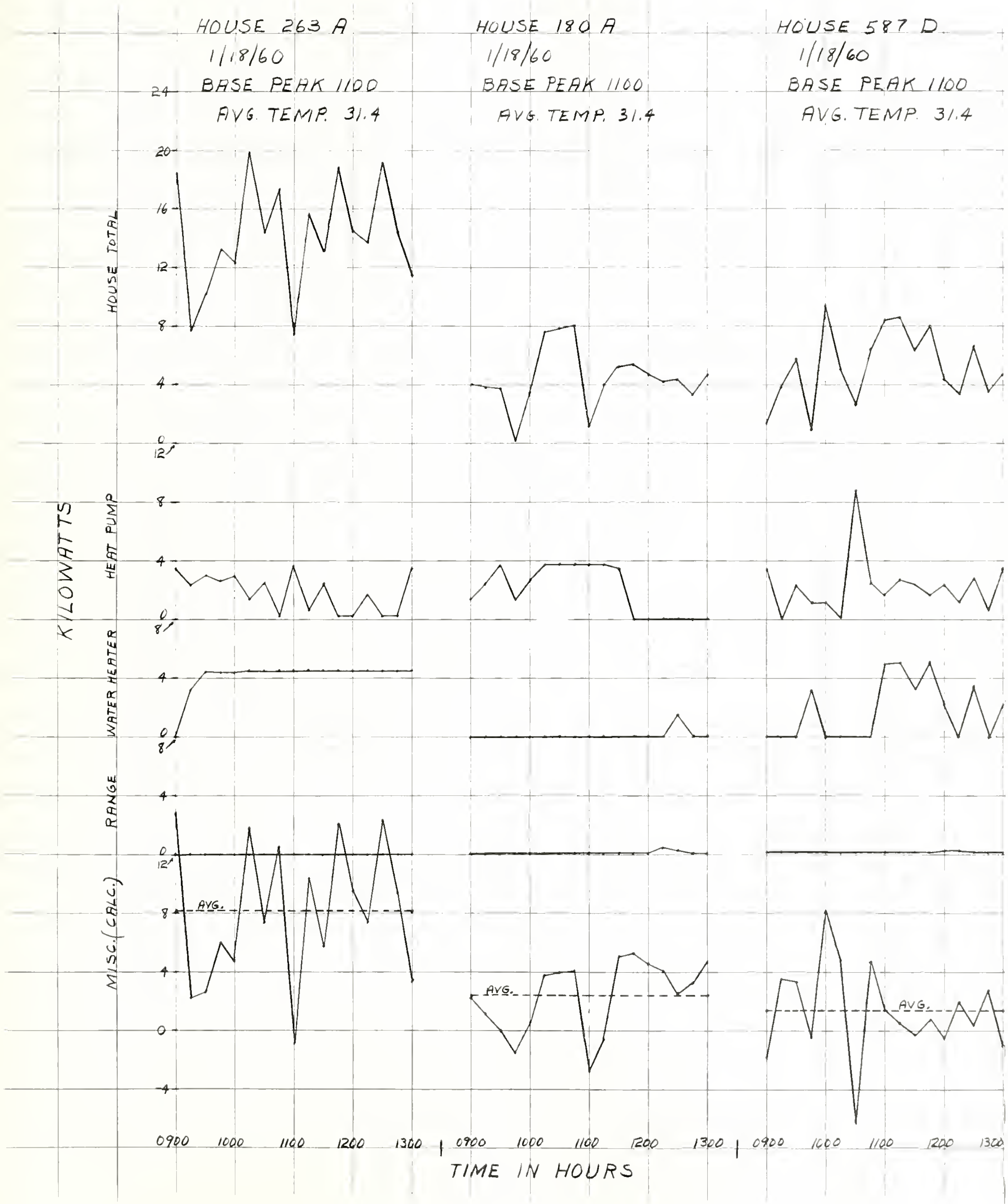


Figure 2

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.

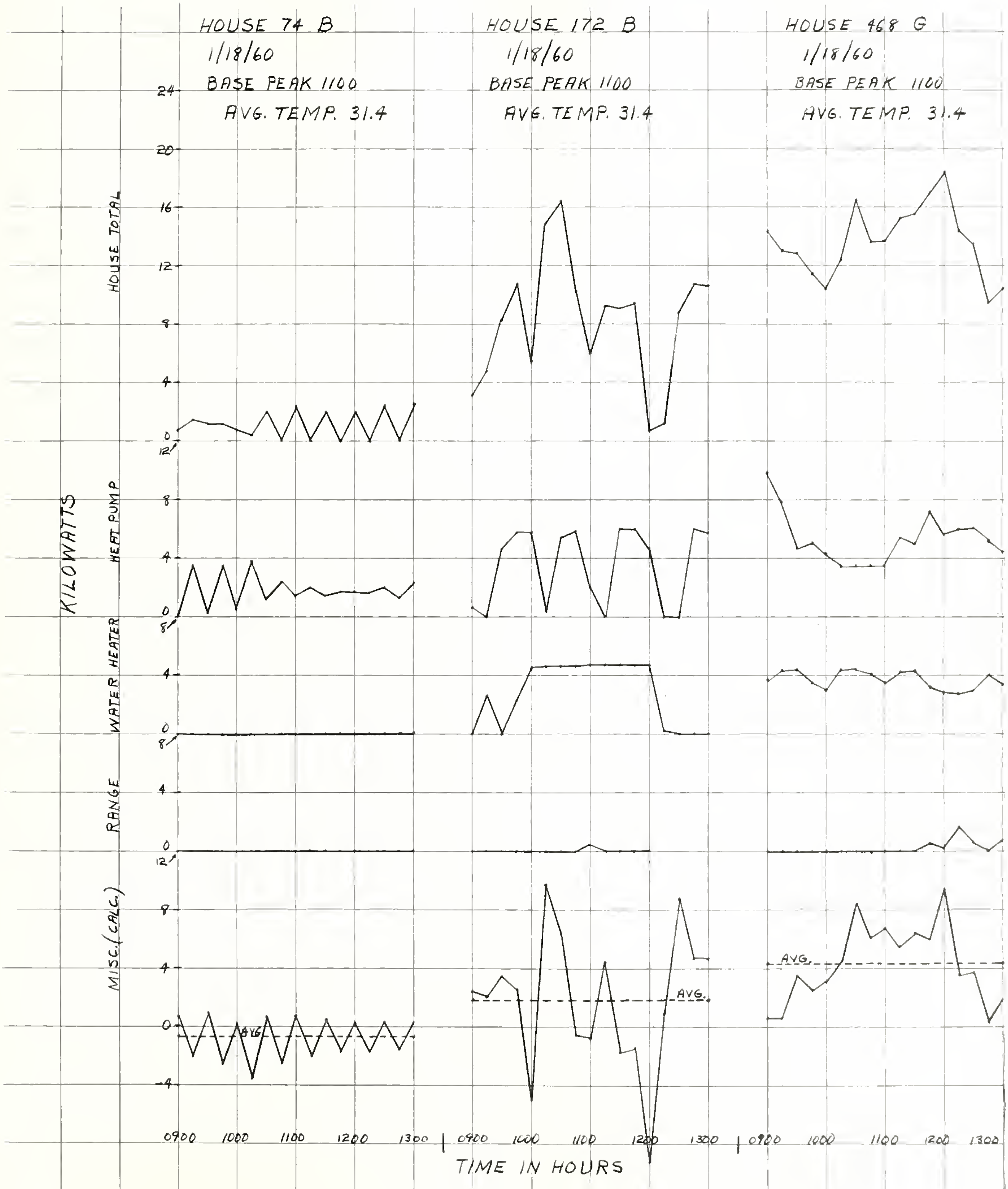


Figure 3

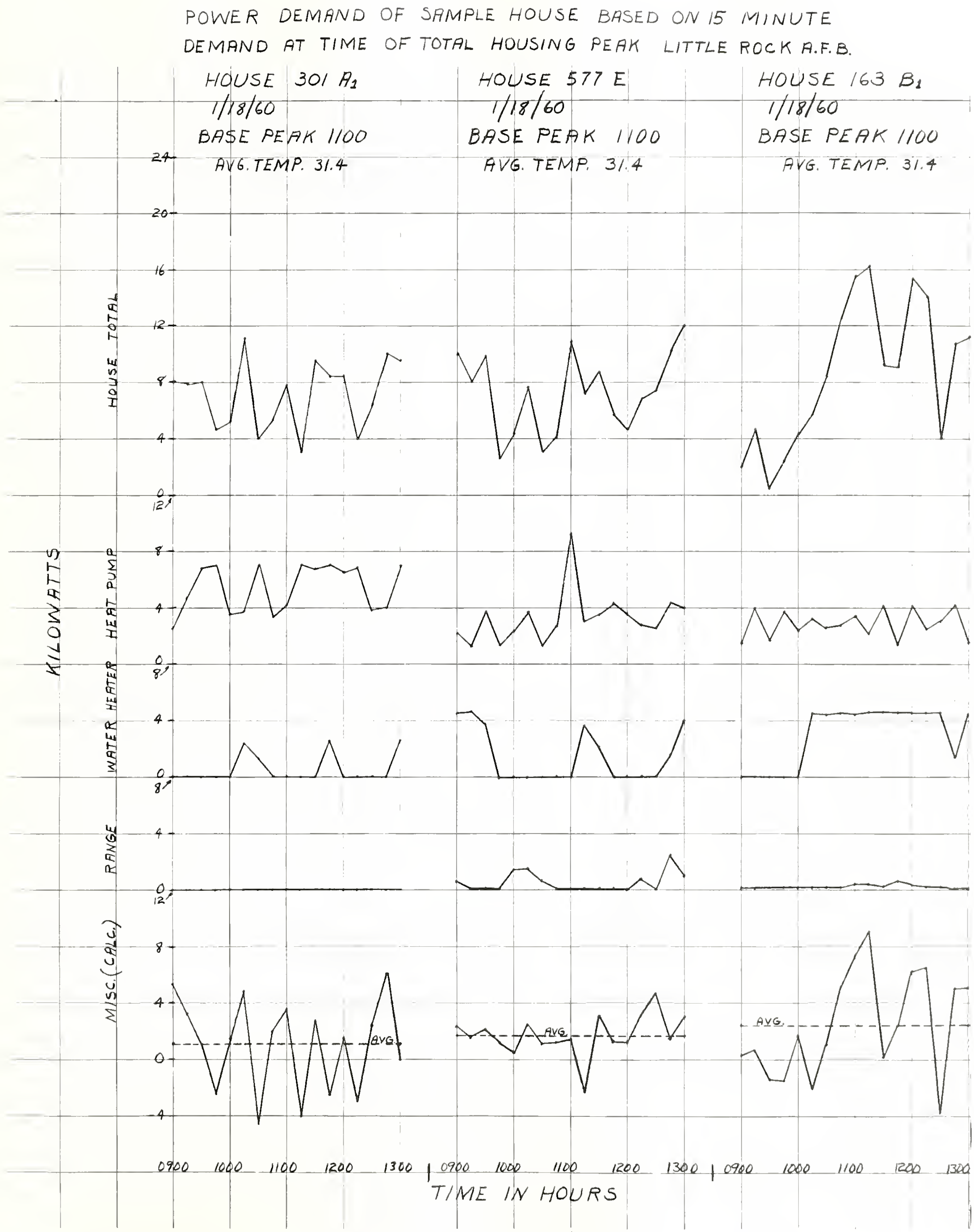

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.
HOUSE 301 A1
1/18/60
BASE PEAK 1100
AVG. TEMP. 31.4
HOUSE 577 E
1/18/60
BASE PEAK 1100
AVG. TEMP. 31.4
HOUSE 163 B1
1/18/60
BASE PEAK 1100
AVG. TEMP. 31.4
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
0900
1000
1100
1200
1300
TIME IN HOURS

Figure 4

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.

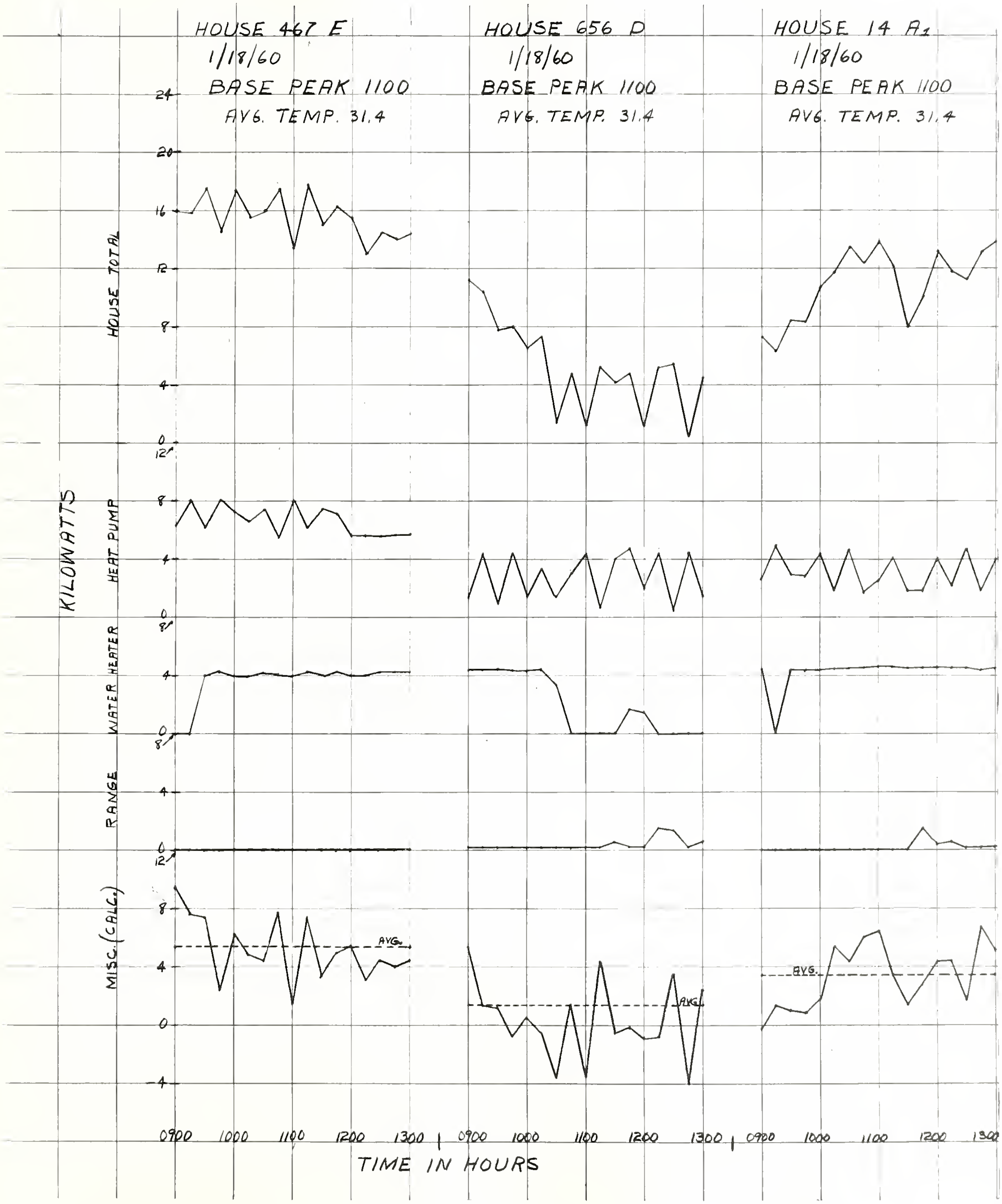


Figure 5

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.

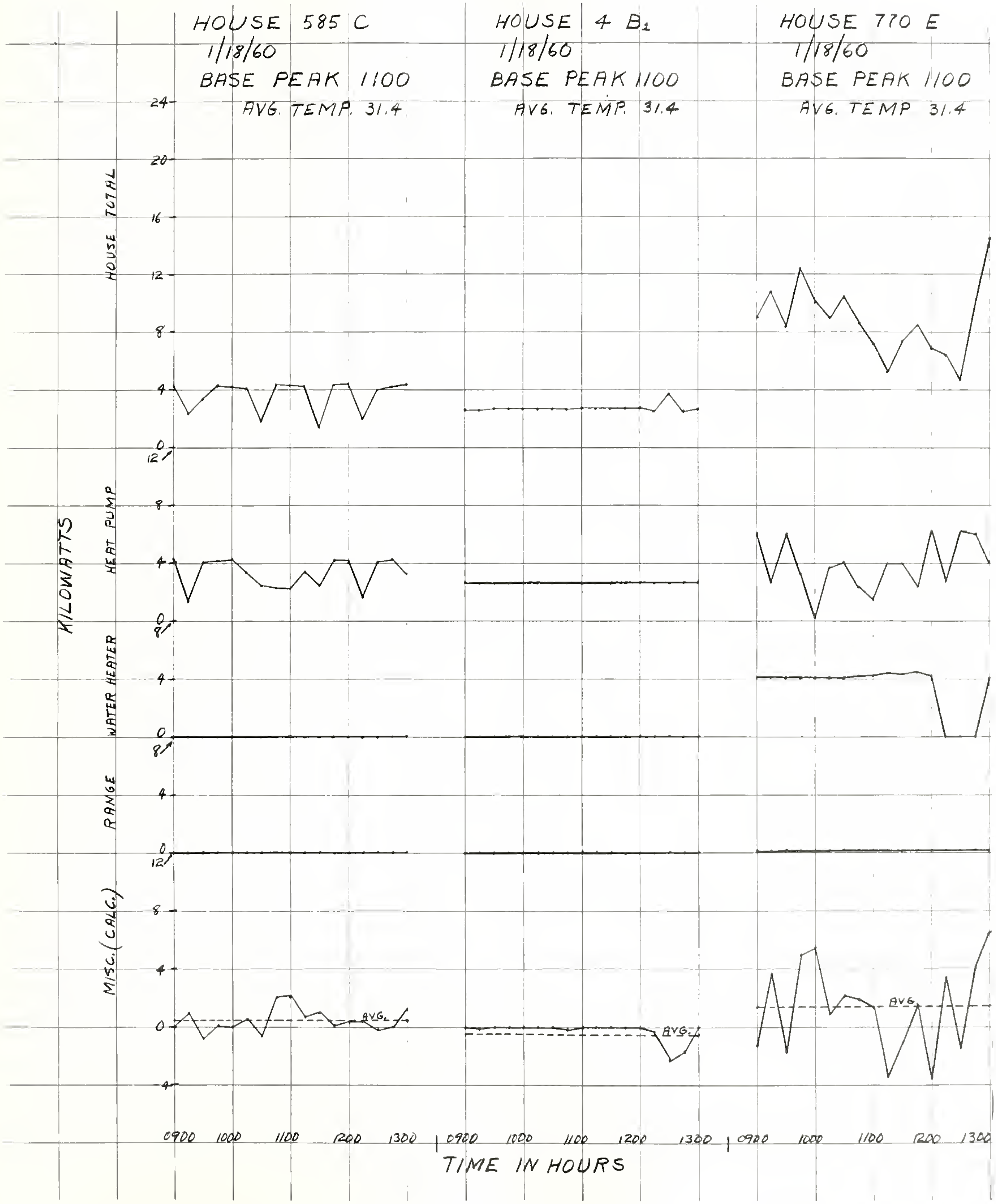


Figure 6

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.

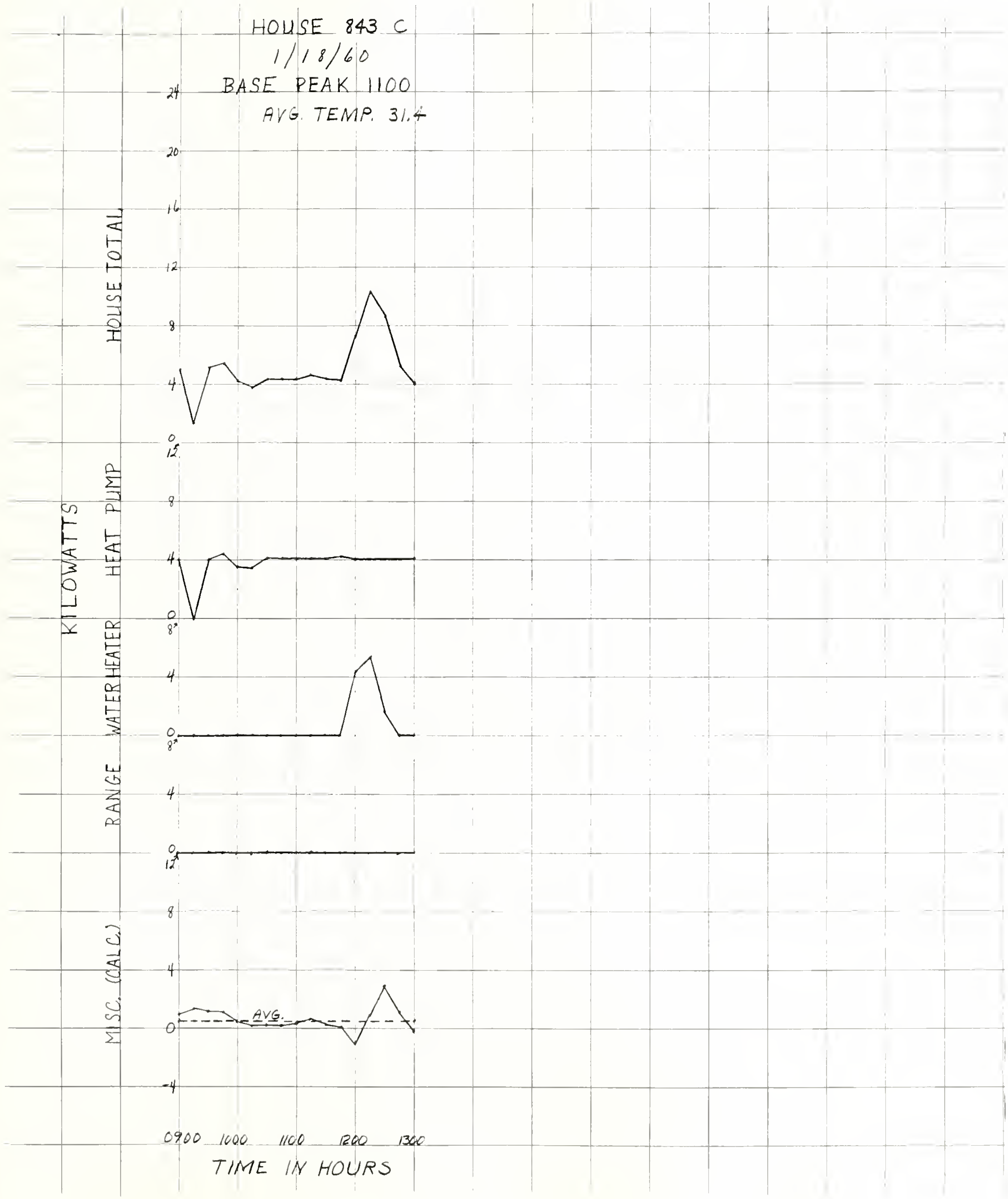


Figure 7

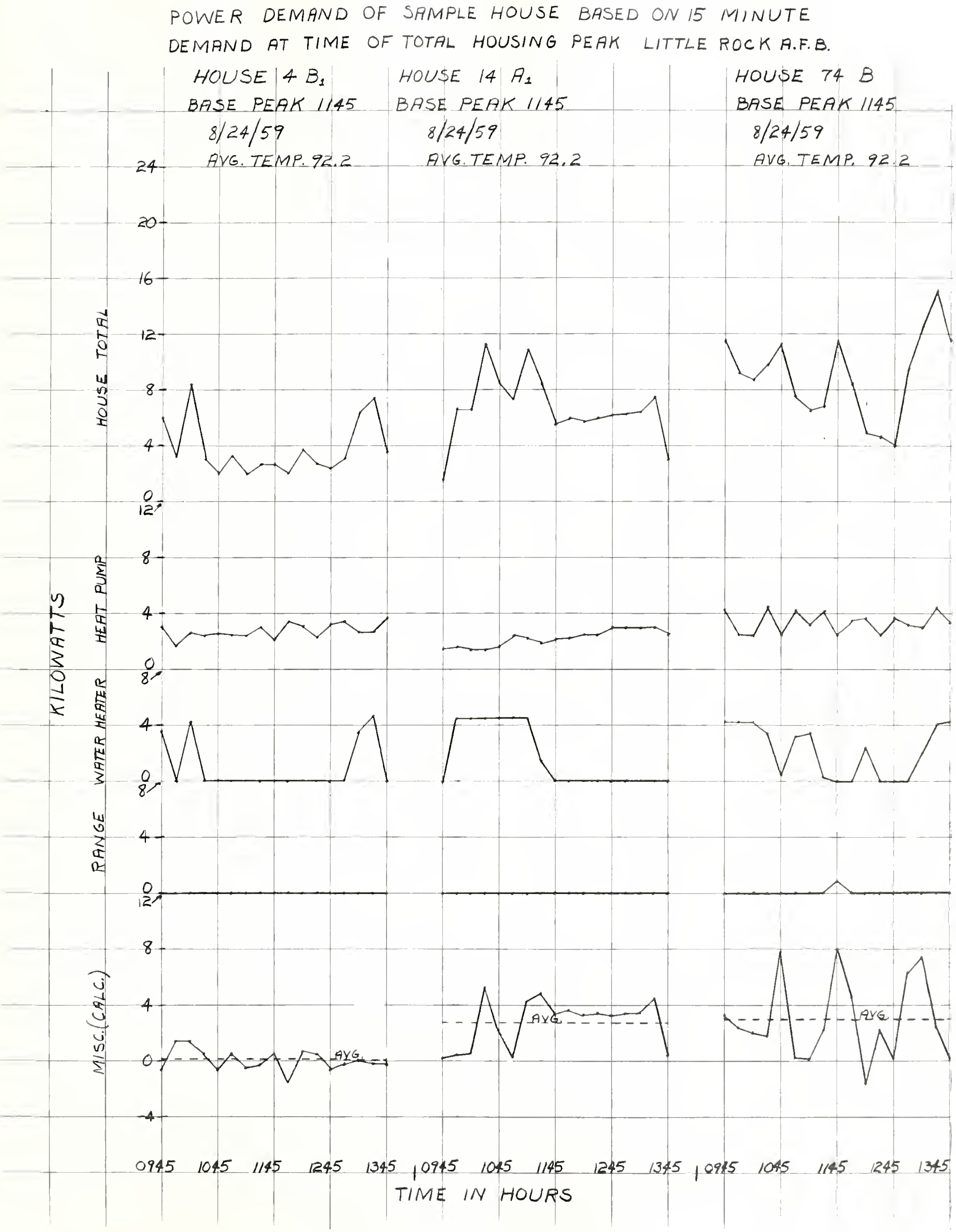

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE
DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.
HOUSE 4 B1
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 14 A1
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 74 B
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
0945 1045 1145 1245 1345
TIME IN HOURS

Figure 8

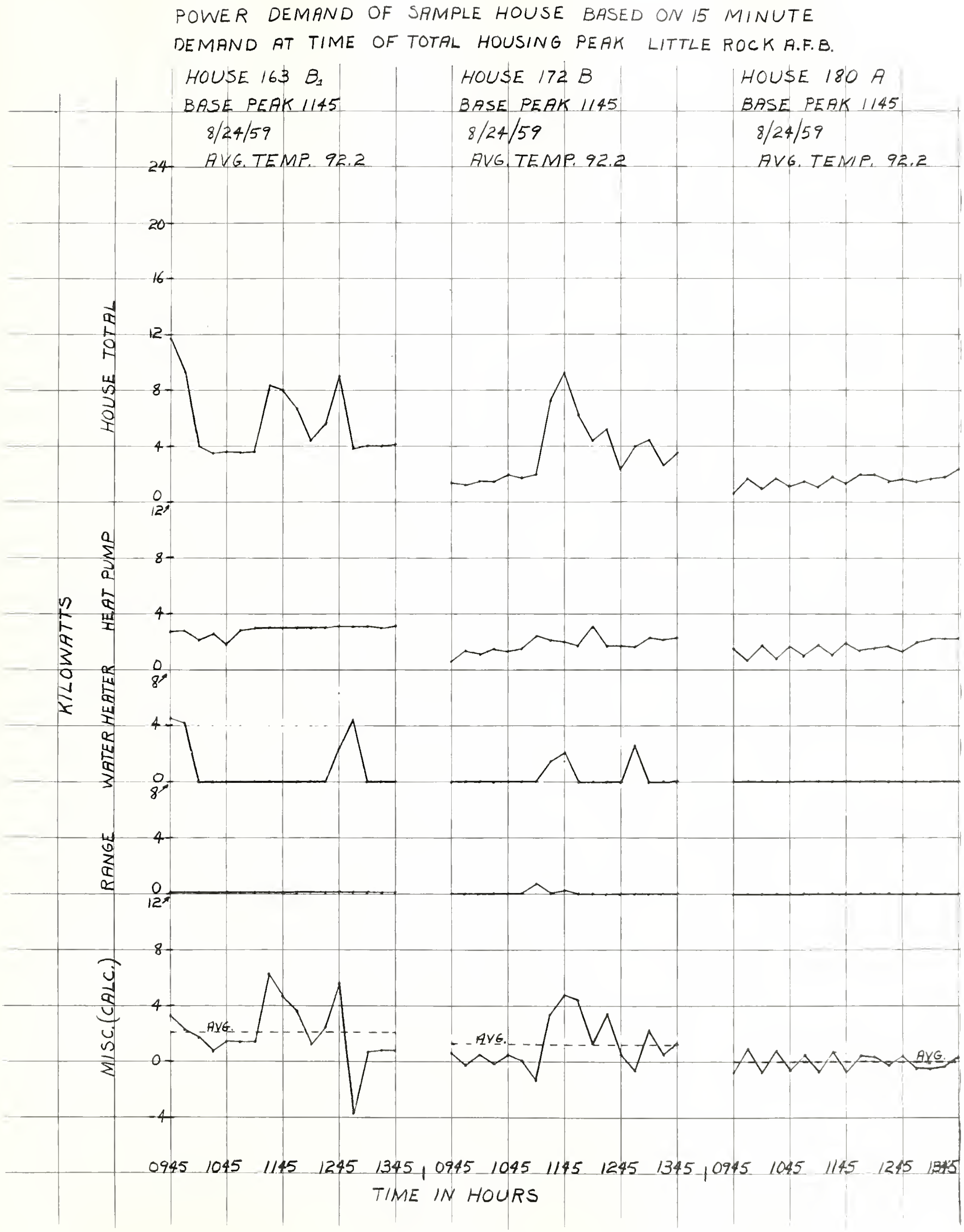

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE
DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.
HOUSE 163 B1
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 172 B
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 180 A
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
24
20
16
12
8
4
0
-4
0945 1045 1145 1245 1345
TIME IN HOURS

Figure 9

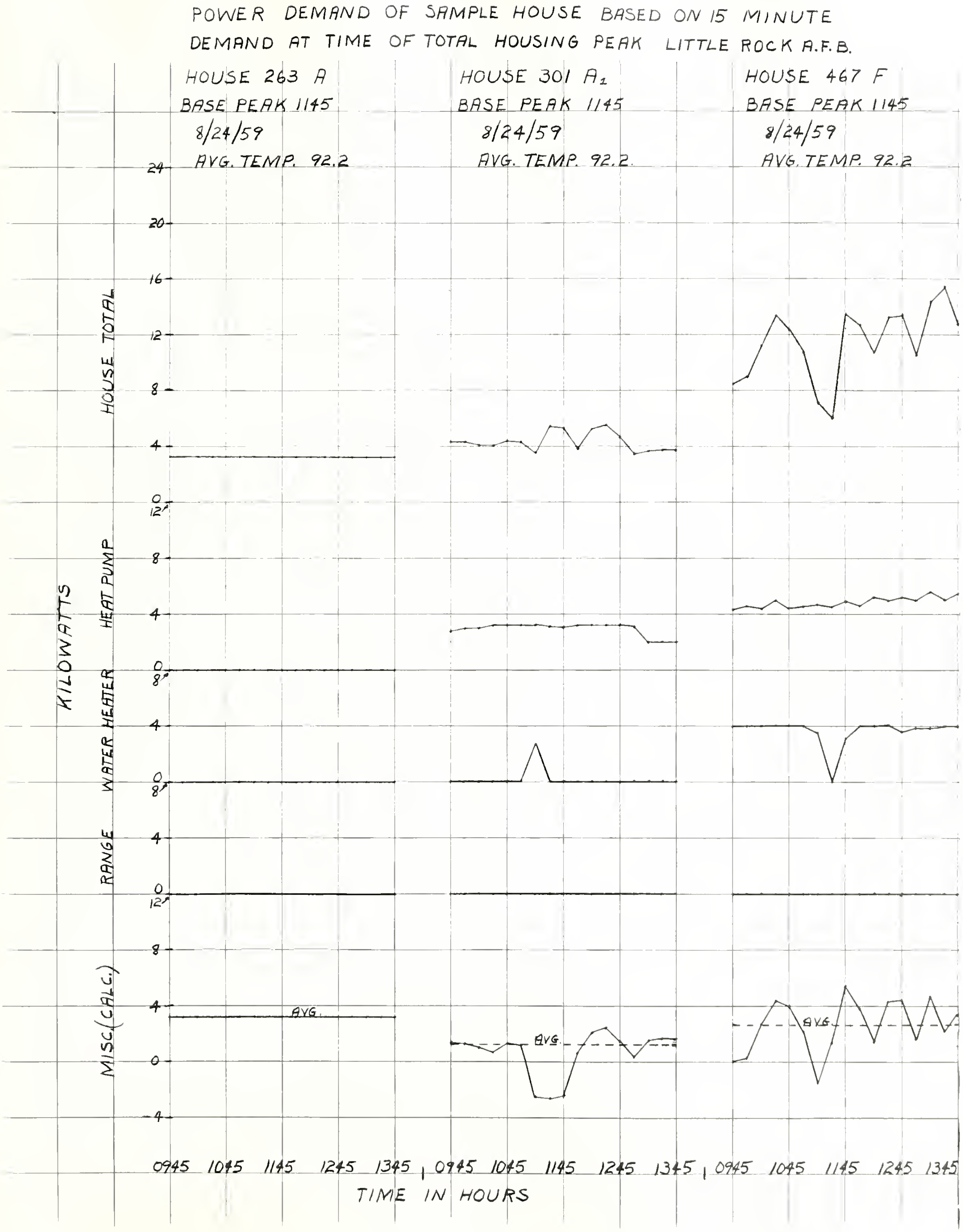

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE
DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.
HOUSE 263 A
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 301 A2
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 467 F
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC.(CALC.)
AVG.
0945 1045 1145 1245 1345
TIME IN HOURS

Figure 10

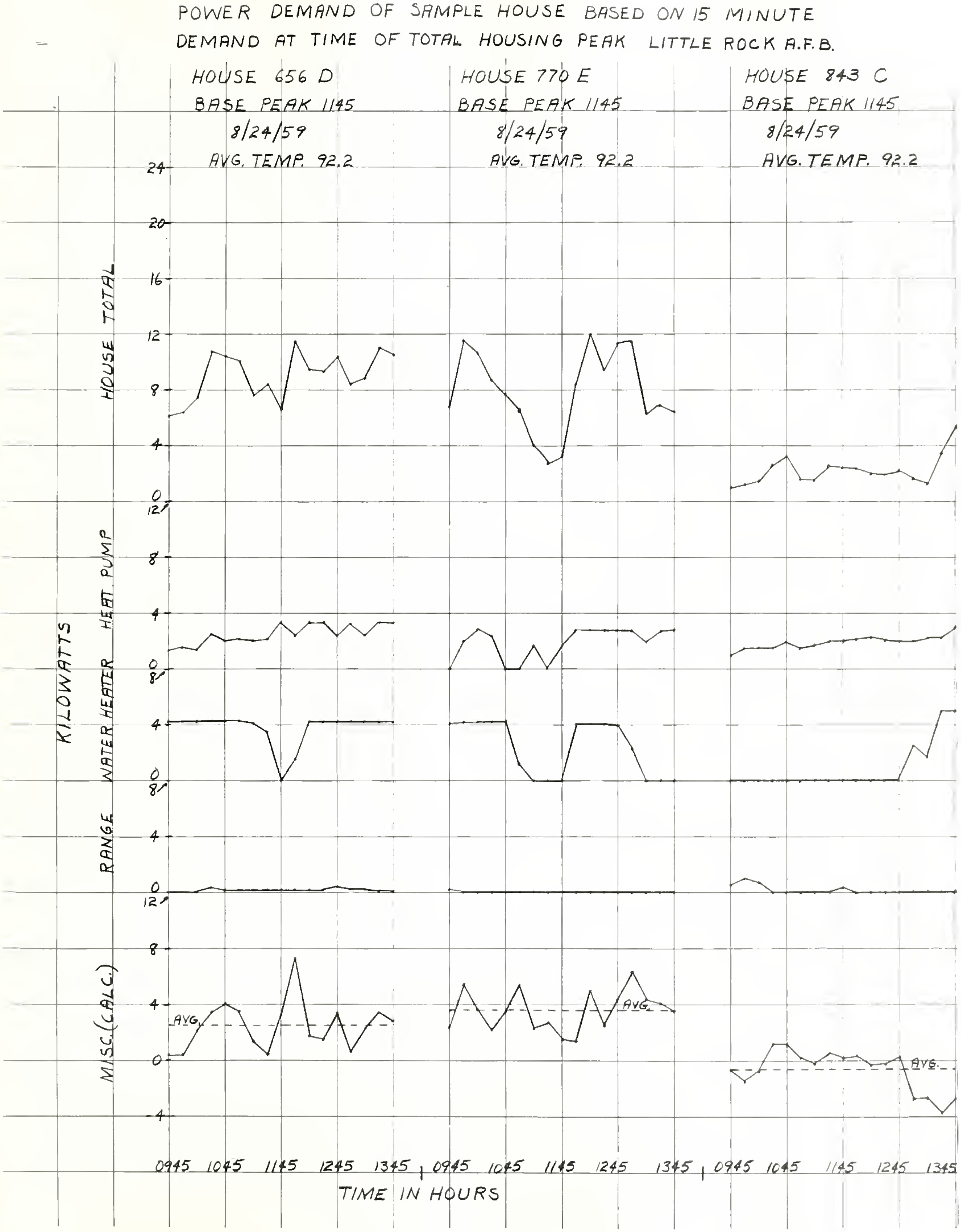

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.
HOUSE 656 D
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 770 E
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 843 C
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
0945 1045 1145 1245 1345
TIME IN HOURS

Figure 11

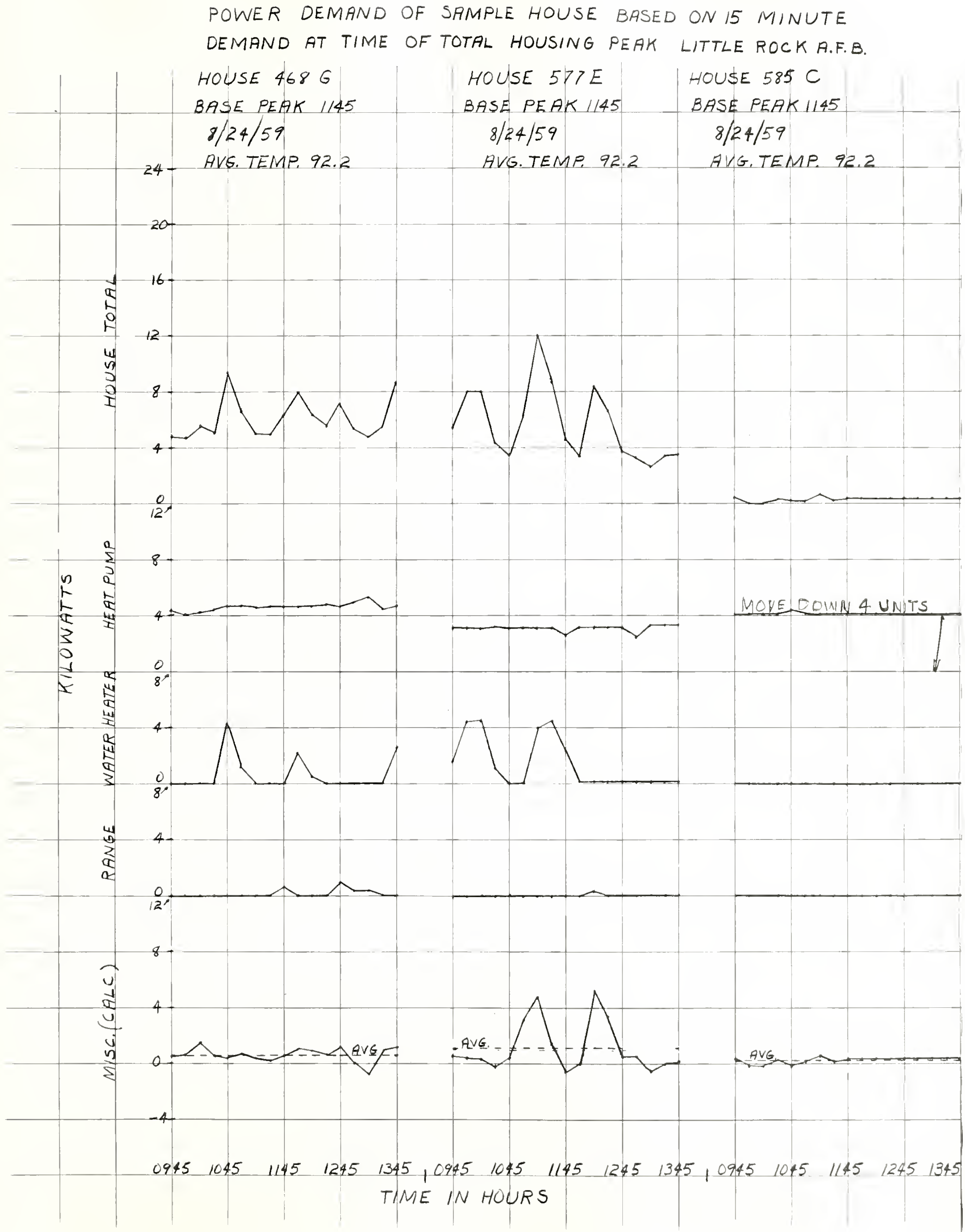

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE
DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.
HOUSE 468 G
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 577 E
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
HOUSE 585 C
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
MOVE DOWN 4 UNITS
AVG.
24
20
16
12
8
4
0
-4
0945 1045 1145 1245 1345
TIME IN HOURS

Figure 12

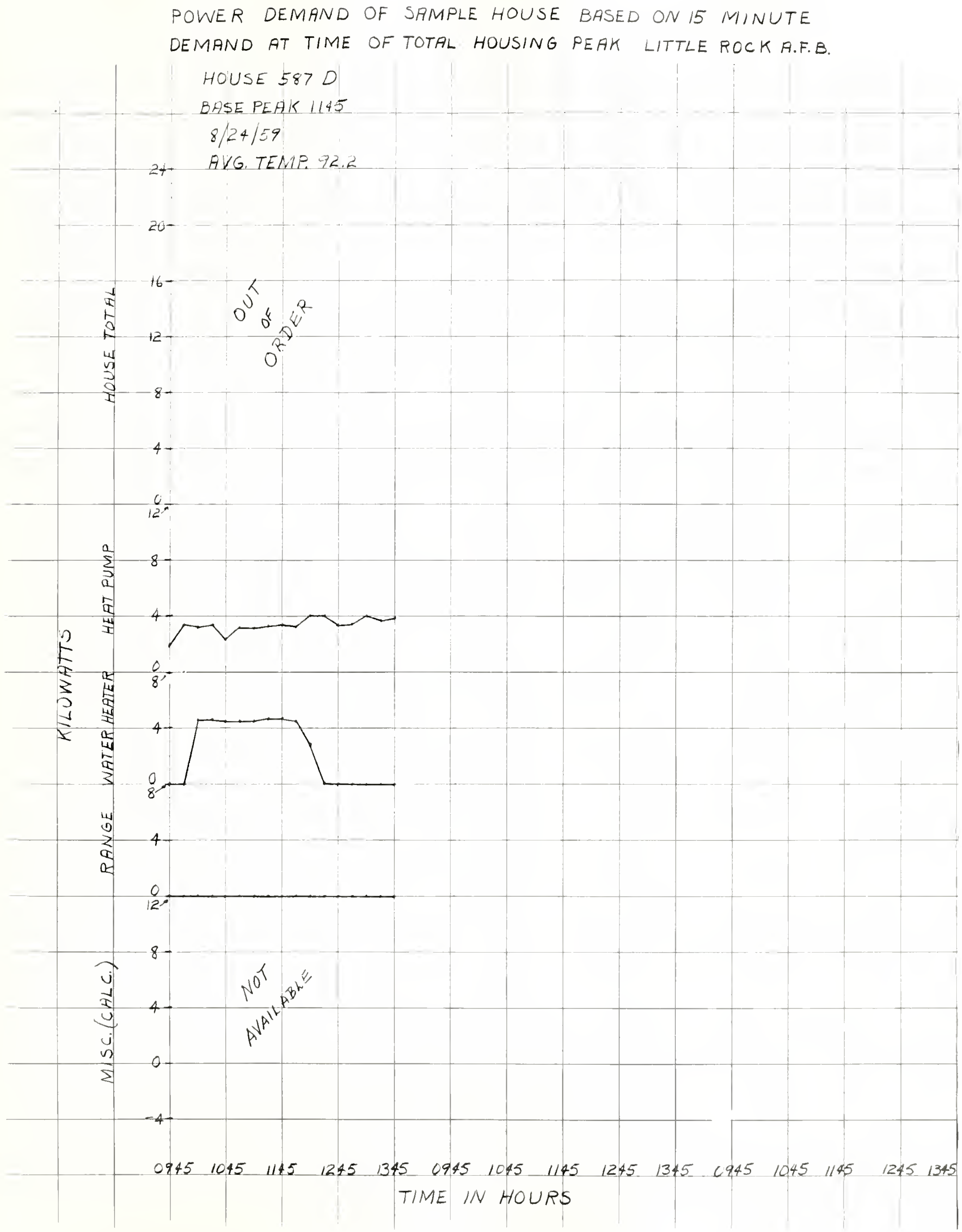

POWER DEMAND OF SAMPLE HOUSE BASED ON 15 MINUTE
DEMAND AT TIME OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.
HOUSE 587 D
BASE PEAK 1145
8/24/59
AVG. TEMP. 92.2
KILOWATTS
HOUSE TOTAL
OUT OF ORDER
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
NOT AVAILABLE
0945 1045 1145 1245 1345 0945 1045 1145 1245 1345 0945 1045 1145 1245 1345
TIME IN HOURS

Figure 13

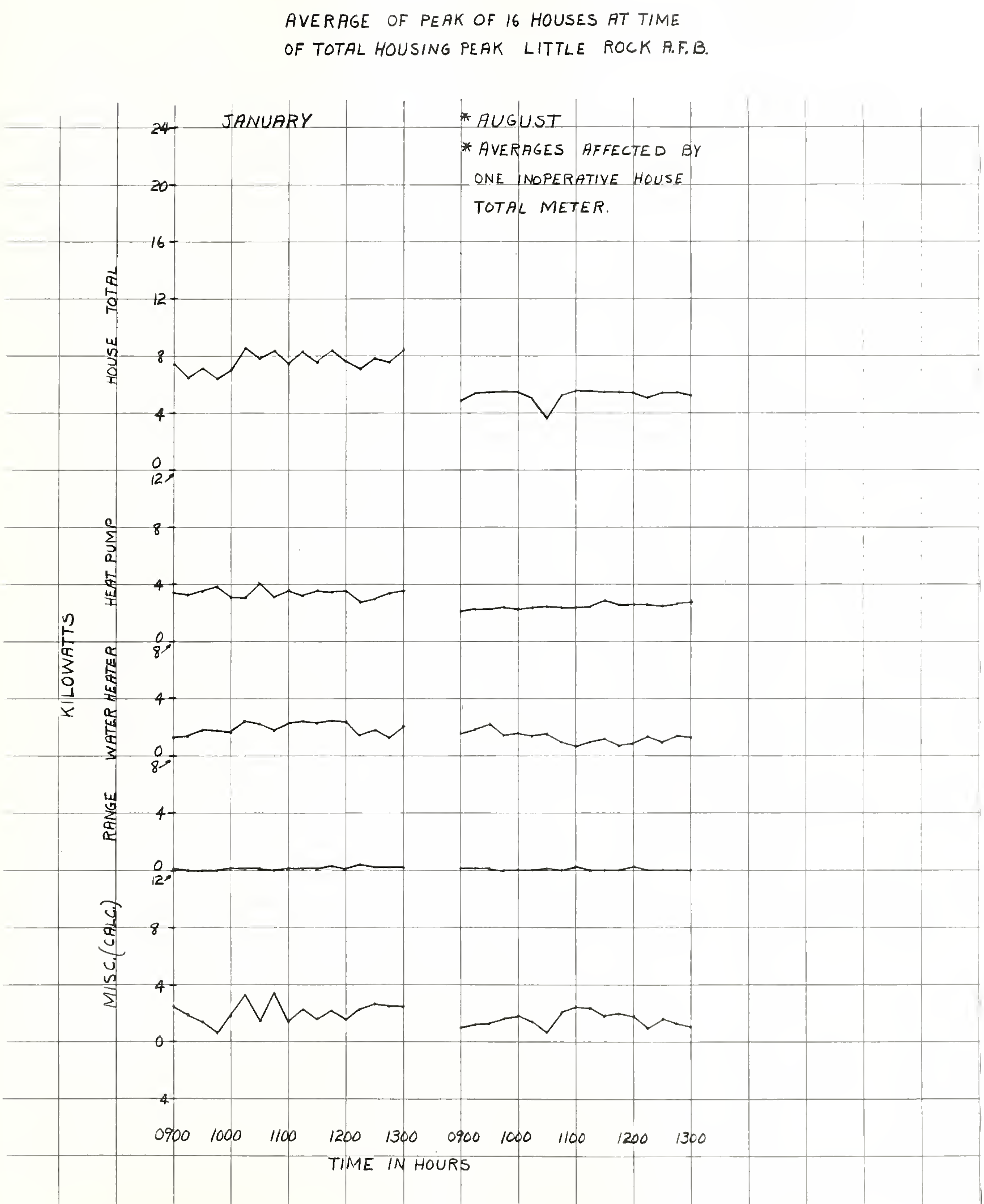

AVERAGE OF PEAK OF 16 HOUSES AT TIME
OF TOTAL HOUSING PEAK LITTLE ROCK A.F.B.
JANUARY
* AUGUST
* AVERAGES AFFECTED BY
ONE INOPERATIVE HOUSE
TOTAL METER.
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
KILOWATTS
24
20
16
12
8
4
0
12
8
4
0
8
4
0
8
4
0
12
8
4
0
4
0900
1000
1100
1200
1300
0900
1000
1100
1200
1300
TIME IN HOURS

Figure 14

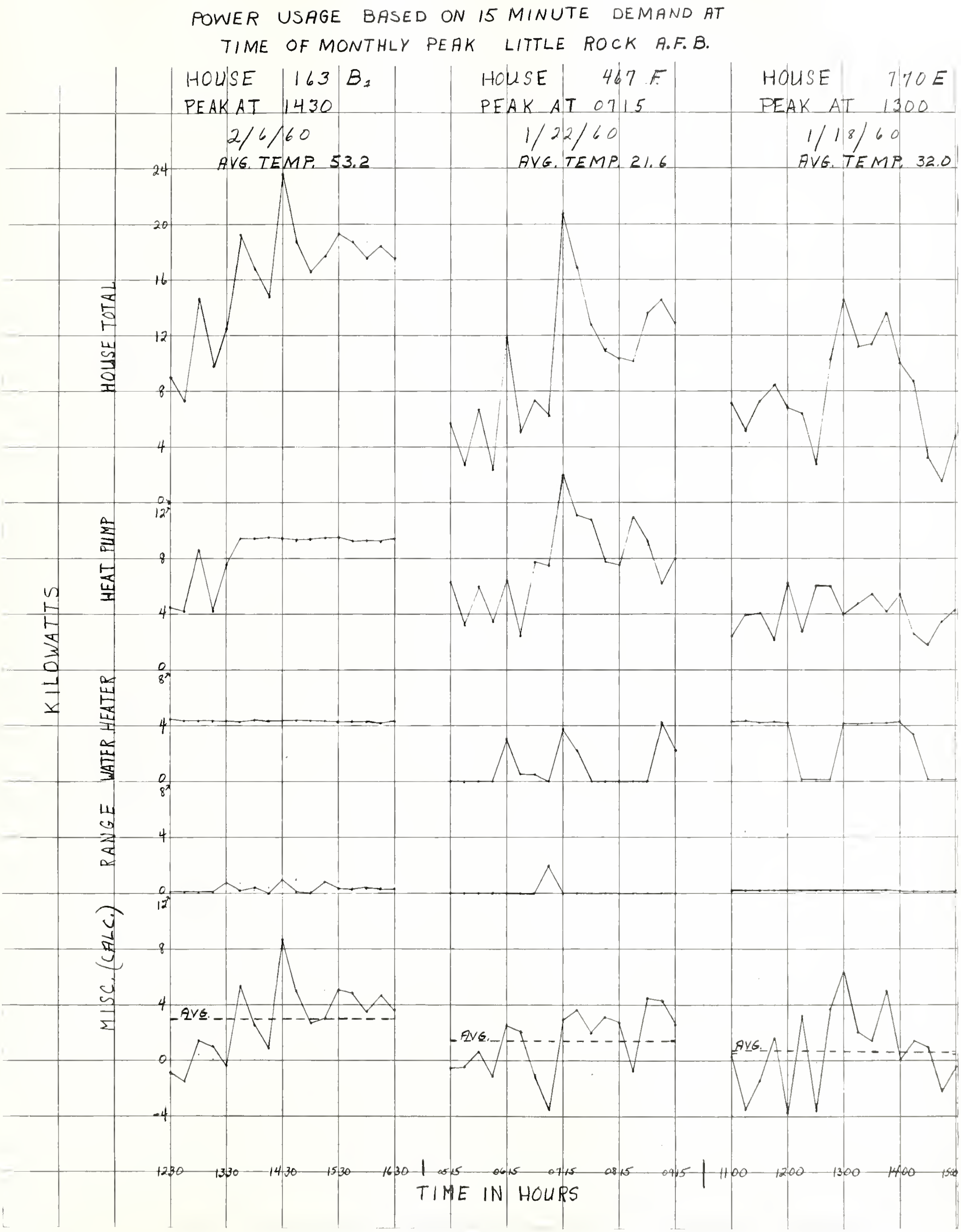

POWER USAGE BASED ON 15 MINUTE DEMAND AT
TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.
HOUSE 163 B
PEAK AT 1430
2/6/60
AVG. TEMP. 53.2
HOUSE 467 F
PEAK AT 0715
1/22/60
AVG. TEMP. 21.6
HOUSE 770 E
PEAK AT 1300
1/18/60
AVG. TEMP. 32.0
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
TIME IN HOURS

Figure 15

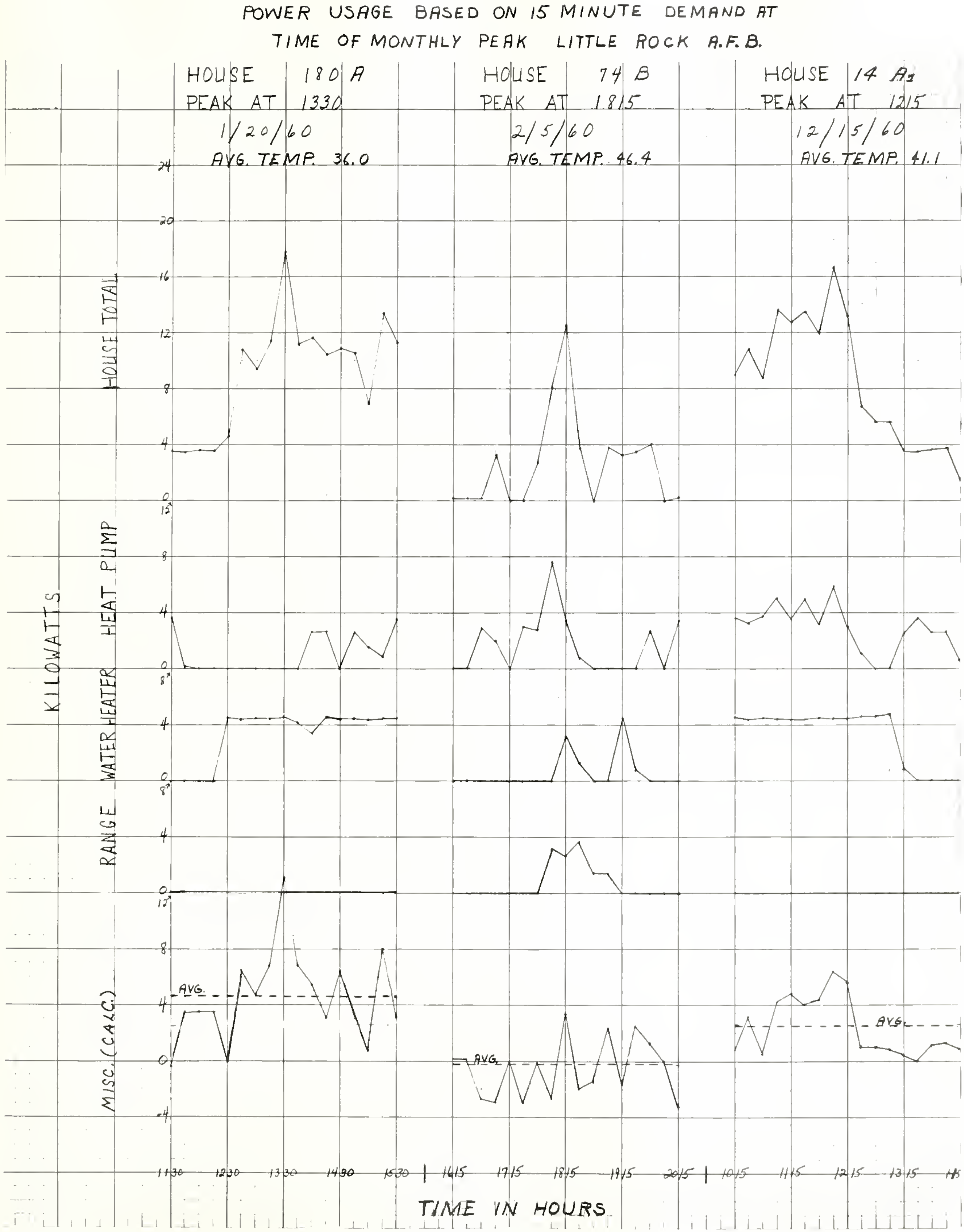

POWER USAGE BASED ON 15 MINUTE DEMAND AT TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.
HOUSE 180 A
PEAK AT 1330
1/20/60
AVG. TEMP. 36.0
HOUSE 74 B
PEAK AT 1815
2/5/60
AVG. TEMP. 46.4
HOUSE 14 A
PEAK AT 1215
12/15/60
AVG. TEMP. 41.1
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
TIME IN HOURS

Figure 16

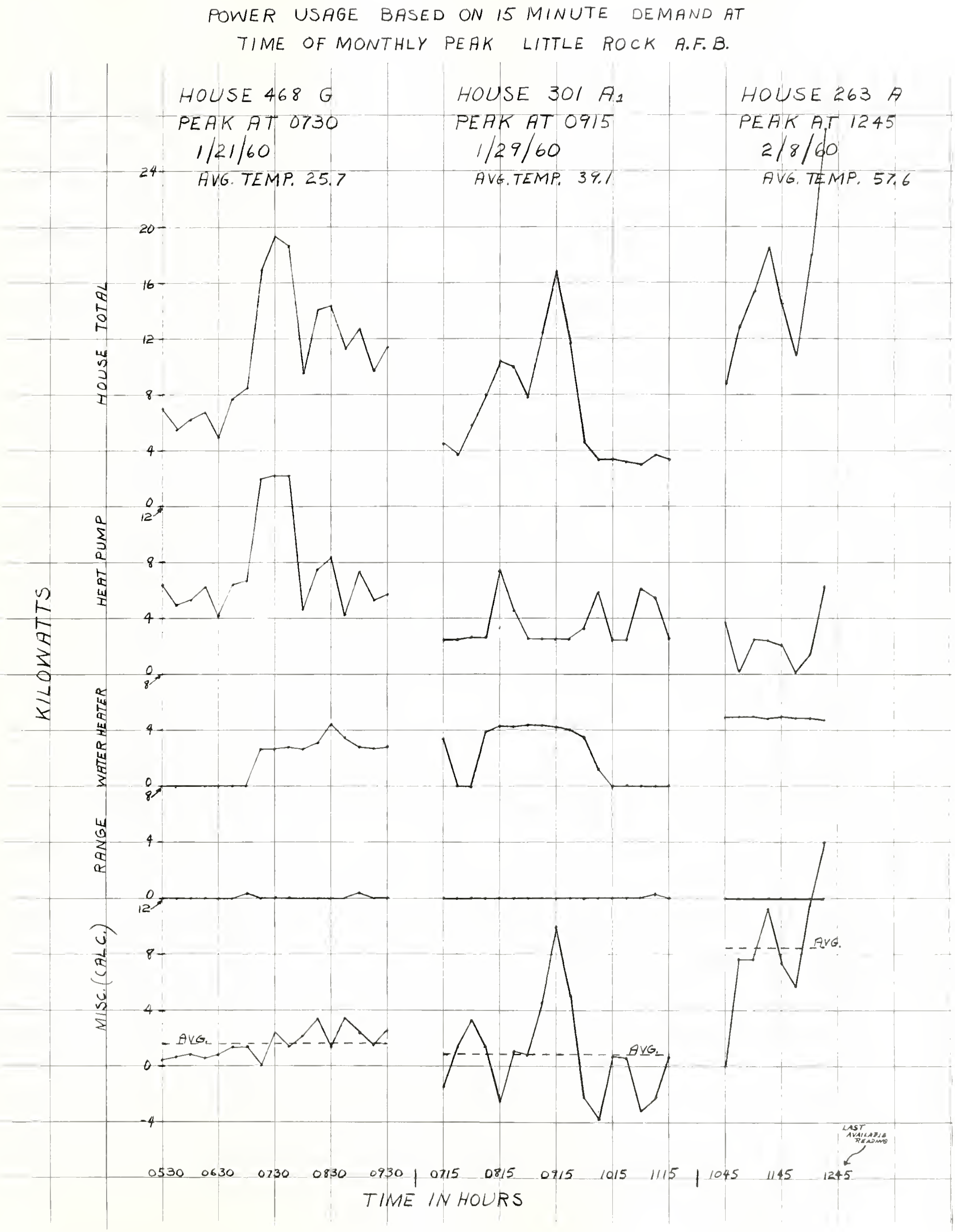

POWER USAGE BASED ON 15 MINUTE DEMAND AT
TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.
HOUSE 468 G
PEAK AT 0730
1/21/60
AVG. TEMP. 25.7
HOUSE 301 A1
PEAK AT 0915
1/29/60
AVG. TEMP. 39.1
HOUSE 263 A
PEAK AT 1245
2/8/60
AVG. TEMP. 57.6
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
LAST AVAILABLE READING
0530 0630 0730 0830 0930 0715 0815 0915 1015 1115 1045 1145 1245
TIME IN HOURS

Figure 17

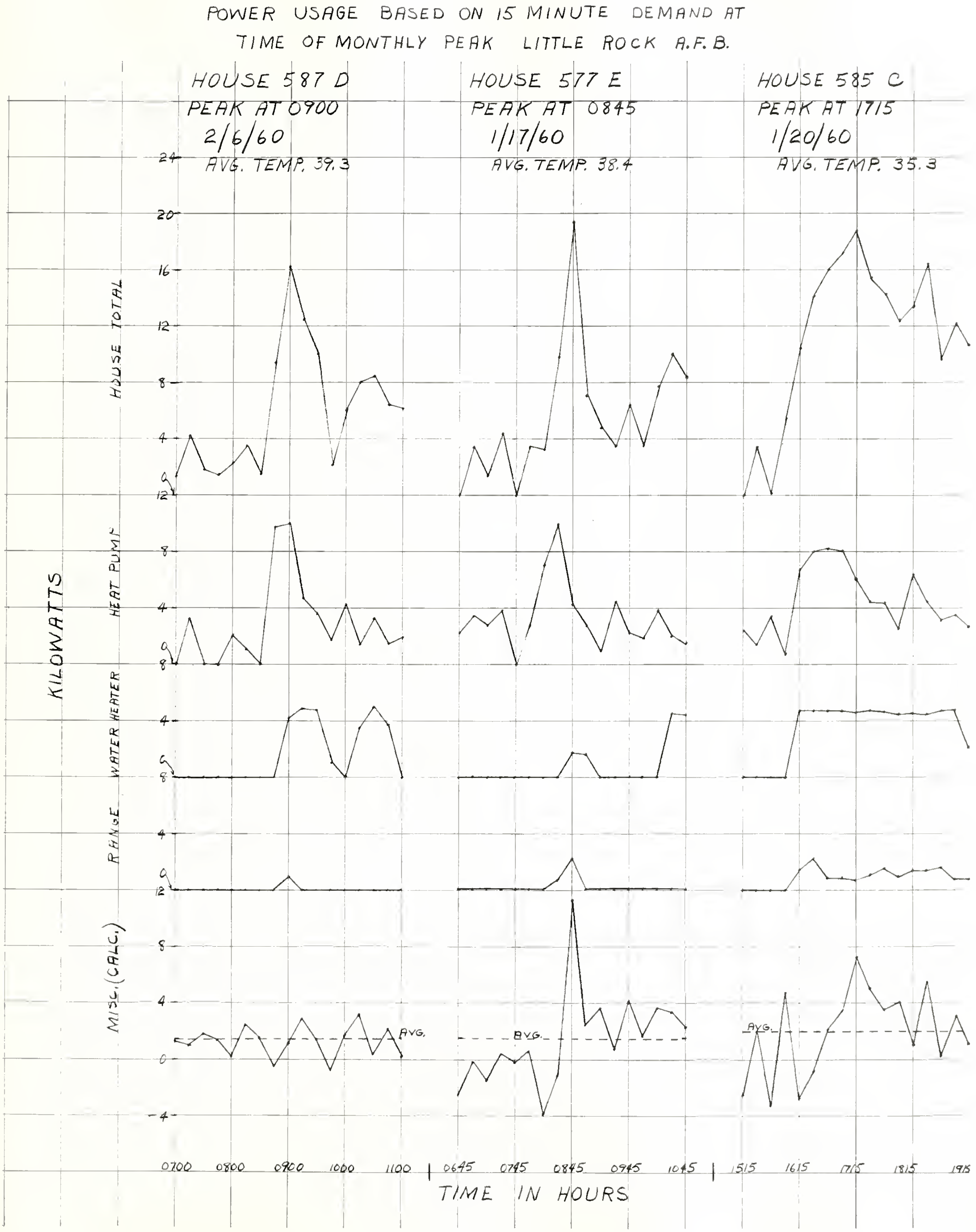
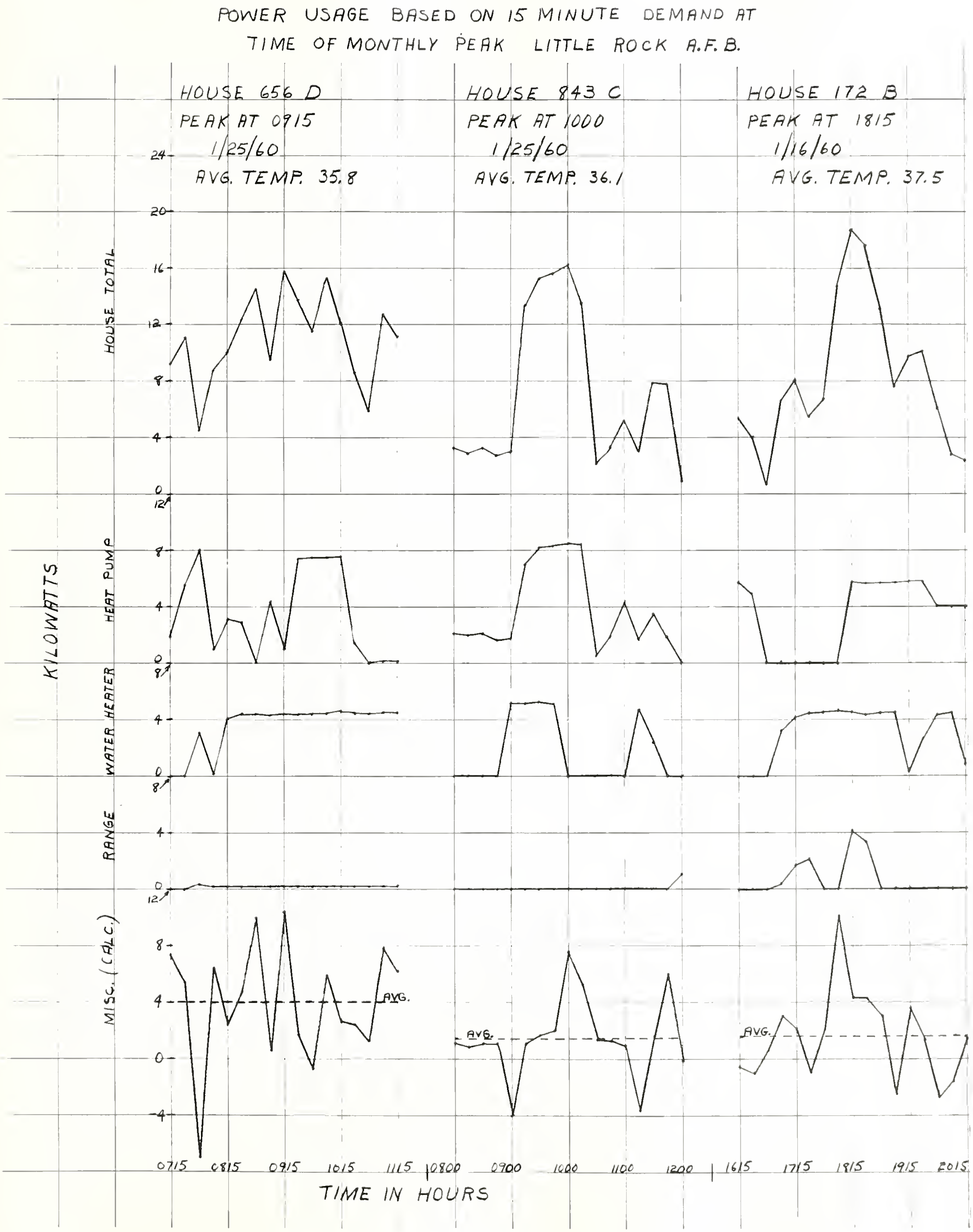

POWER USAGE BASED ON 15 MINUTE DEMAND AT TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.
HOUSE 587 D
PEAK AT 0900
2/6/60
AVG. TEMP. 39.3
HOUSE 577 E
PEAK AT 0845
1/17/60
AVG. TEMP. 38.4
HOUSE 585 C
PEAK AT 1715
1/20/60
AVG. TEMP. 35.3
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
0700 0800 0900 1000 1100
0645 0745 0845 0945 1045
1515 1615 1715 1815 1915
TIME IN HOURS

Figure 18



POWER USAGE BASED ON 15 MINUTE DEMAND AT
TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.
HOUSE 656 D
PEAK AT 0915
1/25/60
AVG. TEMP. 35.8
HOUSE 843 C
PEAK AT 1000
1/25/60
AVG. TEMP. 36.1
HOUSE 172 B
PEAK AT 1815
1/16/60
AVG. TEMP. 37.5
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
0715 0815 0915 1015 1115 0800 0900 1000 1100 1200 1615 1715 1815 1915 2015
TIME IN HOURS

Figure 19

POWER USAGE BASED ON 15 MINUTE DEMAND AT
TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.

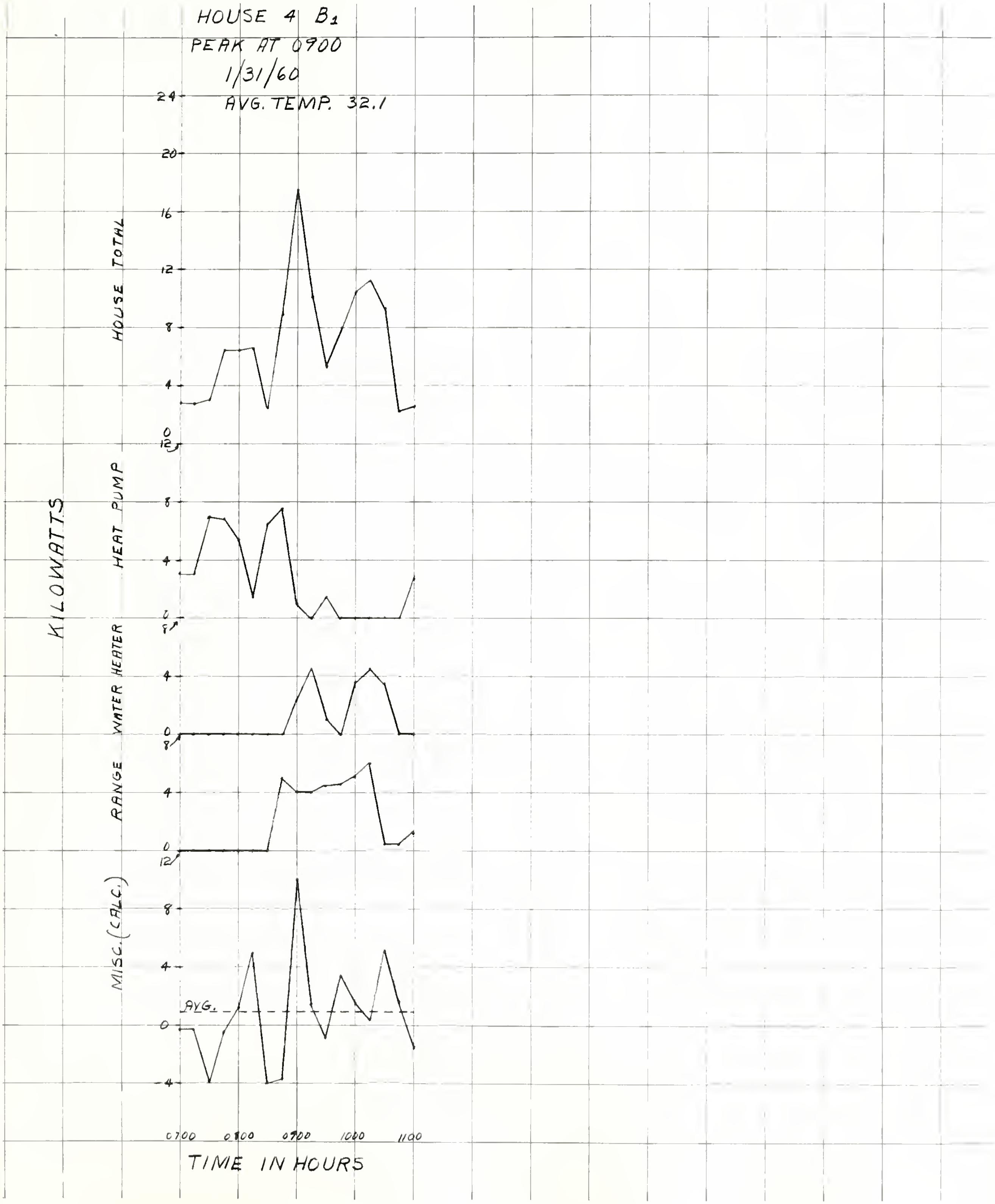


Figure 20

POWER USAGE BASED ON 15 MINUTE DEMAND AT TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.

Figure 21

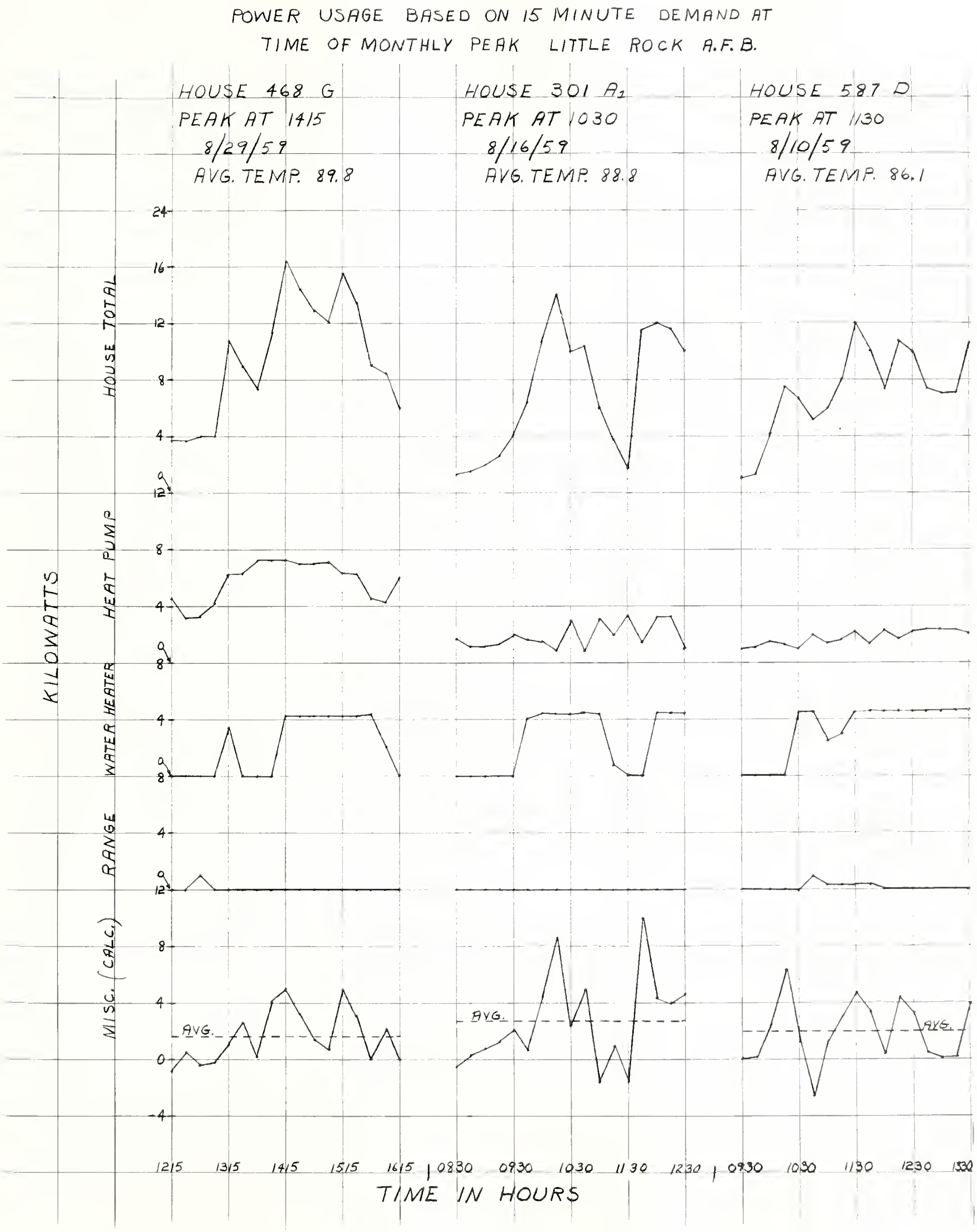

POWER USAGE BASED ON 15 MINUTE DEMAND AT
TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.
HOUSE 468 G
PEAK AT 1415
8/29/59
AVG. TEMP. 89.8
HOUSE 301 A1
PEAK AT 1030
8/16/59
AVG. TEMP. 88.8
HOUSE 587 D
PEAK AT 1130
8/10/59
AVG. TEMP. 86.1
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
TIME IN HOURS

Figure 22

POWER USAGE BASED ON 15 MINUTE DEMAND AT TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.

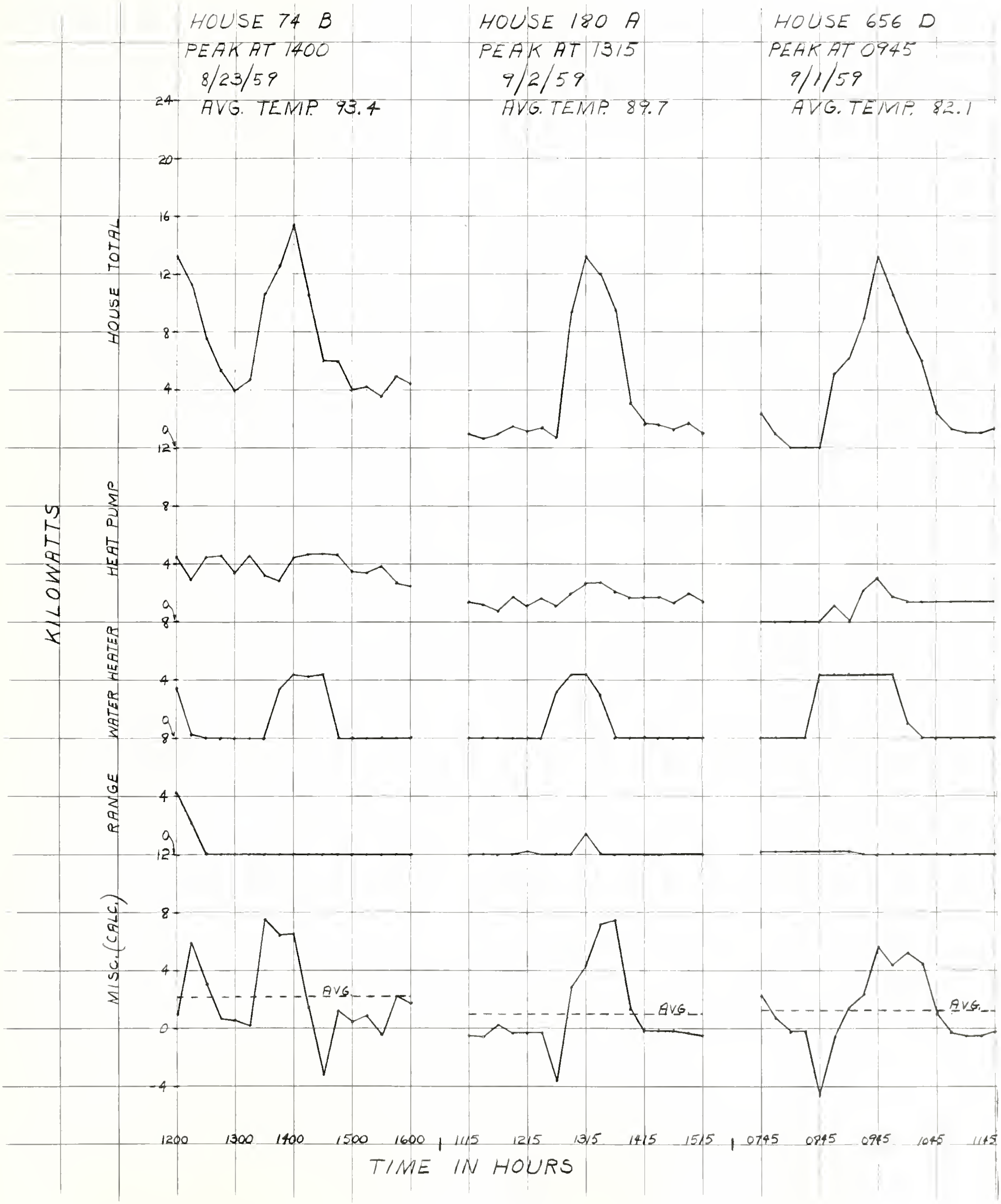


Figure 23

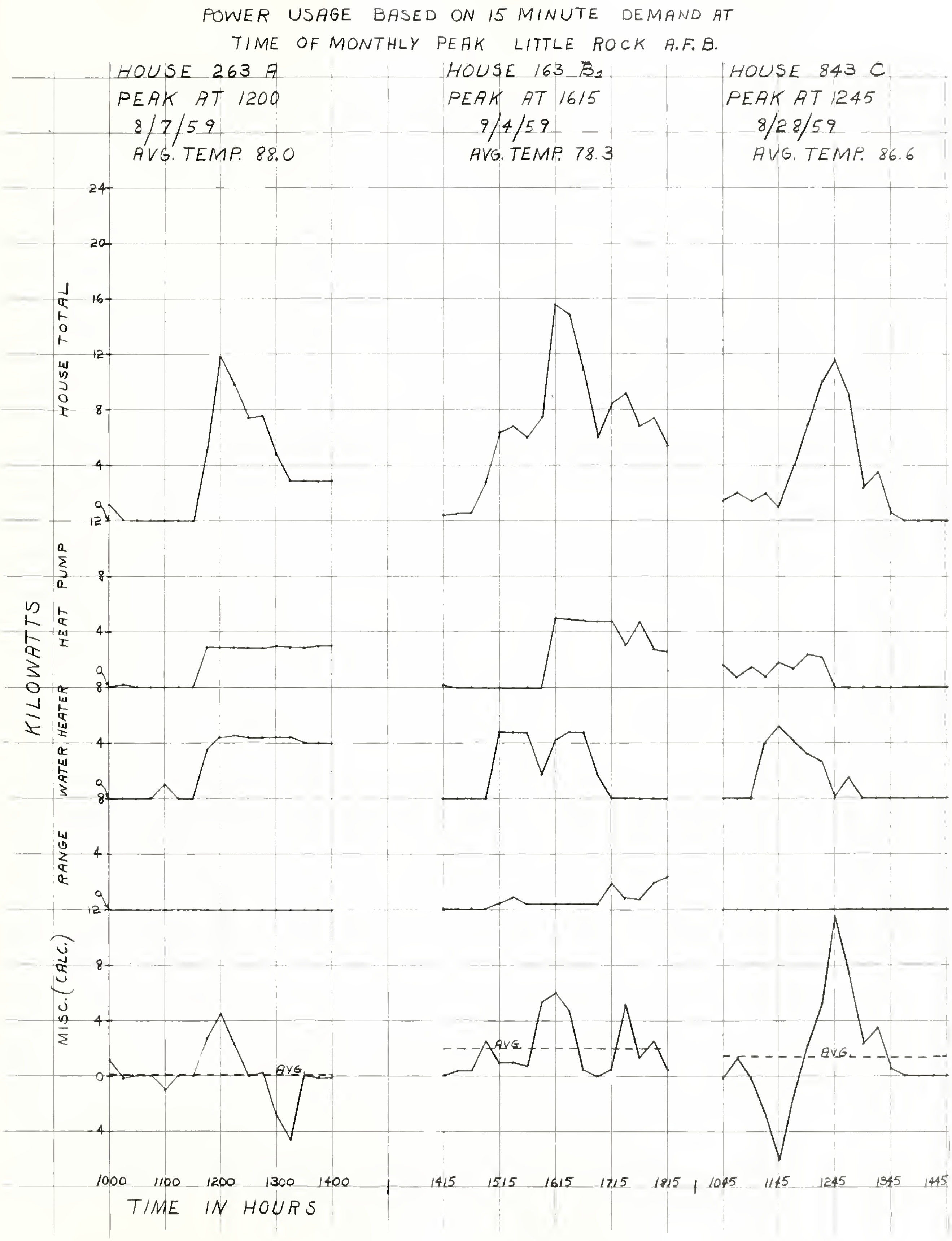

POWER USAGE BASED ON 15 MINUTE DEMAND AT
TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.
HOUSE 263 A
PEAK AT 1200
8/7/59
AVG. TEMP. 88.0
HOUSE 163 B1
PEAK AT 1615
9/4/59
AVG. TEMP. 78.3
HOUSE 843 C
PEAK AT 1245
8/28/59
AVG. TEMP. 86.6
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
1000 1100 1200 1300 1400
1415 1515 1615 1715 1815
1045 1145 1245 1345 1445
TIME IN HOURS

Figure 24

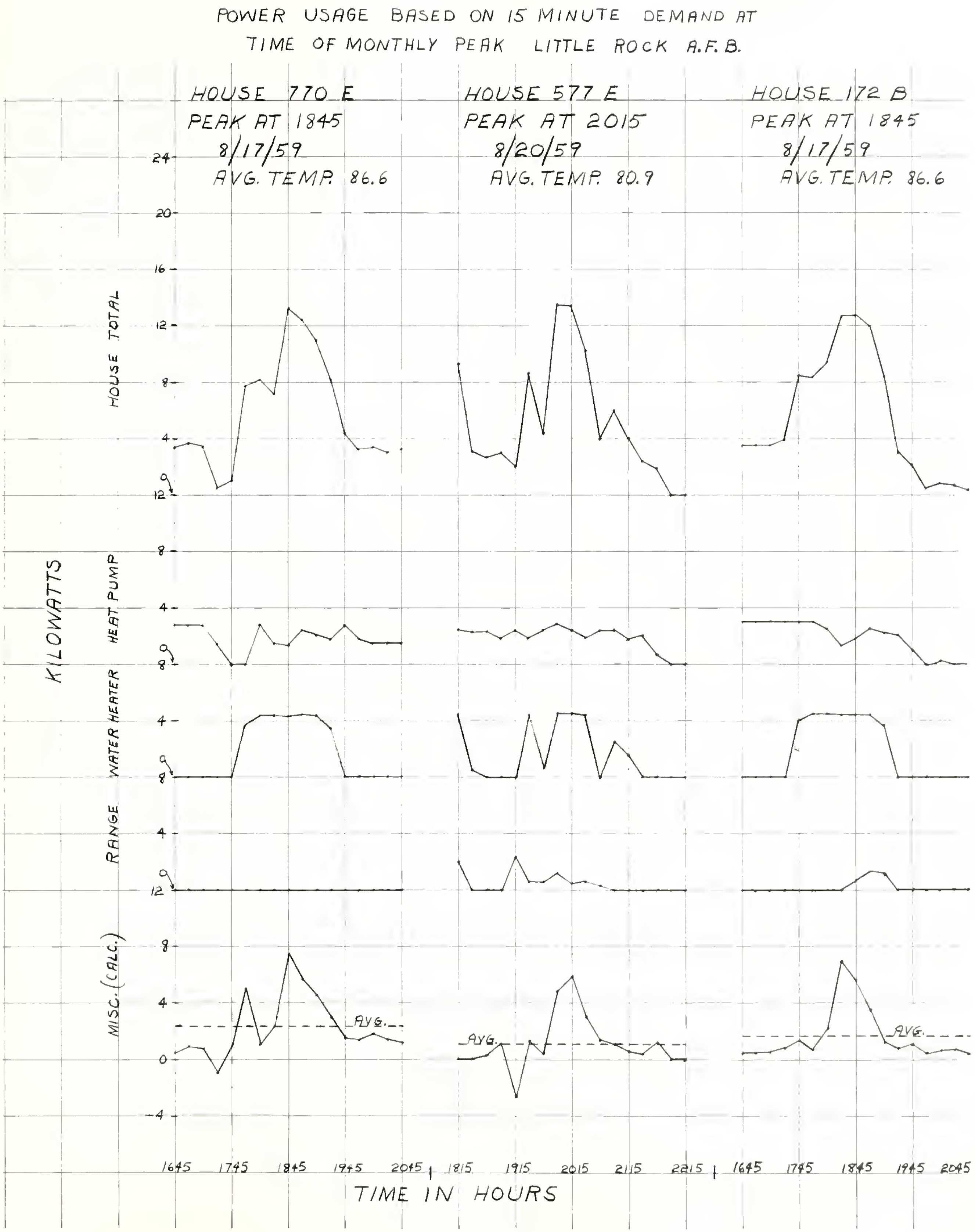

POWER USAGE BASED ON 15 MINUTE DEMAND AT
TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.
HOUSE 770 E
PEAK AT 1845
8/17/59
AVG. TEMP. 86.6
HOUSE 577 E
PEAK AT 2015
8/20/59
AVG. TEMP. 80.9
HOUSE 172 B
PEAK AT 1845
8/17/59
AVG. TEMP. 86.6
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
AVG.
24
20
16
12
8
4
0
-4
1645 1745 1845 1945 2045
1815 1915 2015 2115 2215
1645 1745 1845 1945 2045
TIME IN HOURS

Figure 25

POWER USAGE BASED ON 15 MINUTE DEMAND AT TIME OF MONTHLY PEAK LITTLE ROCK A.F.B.

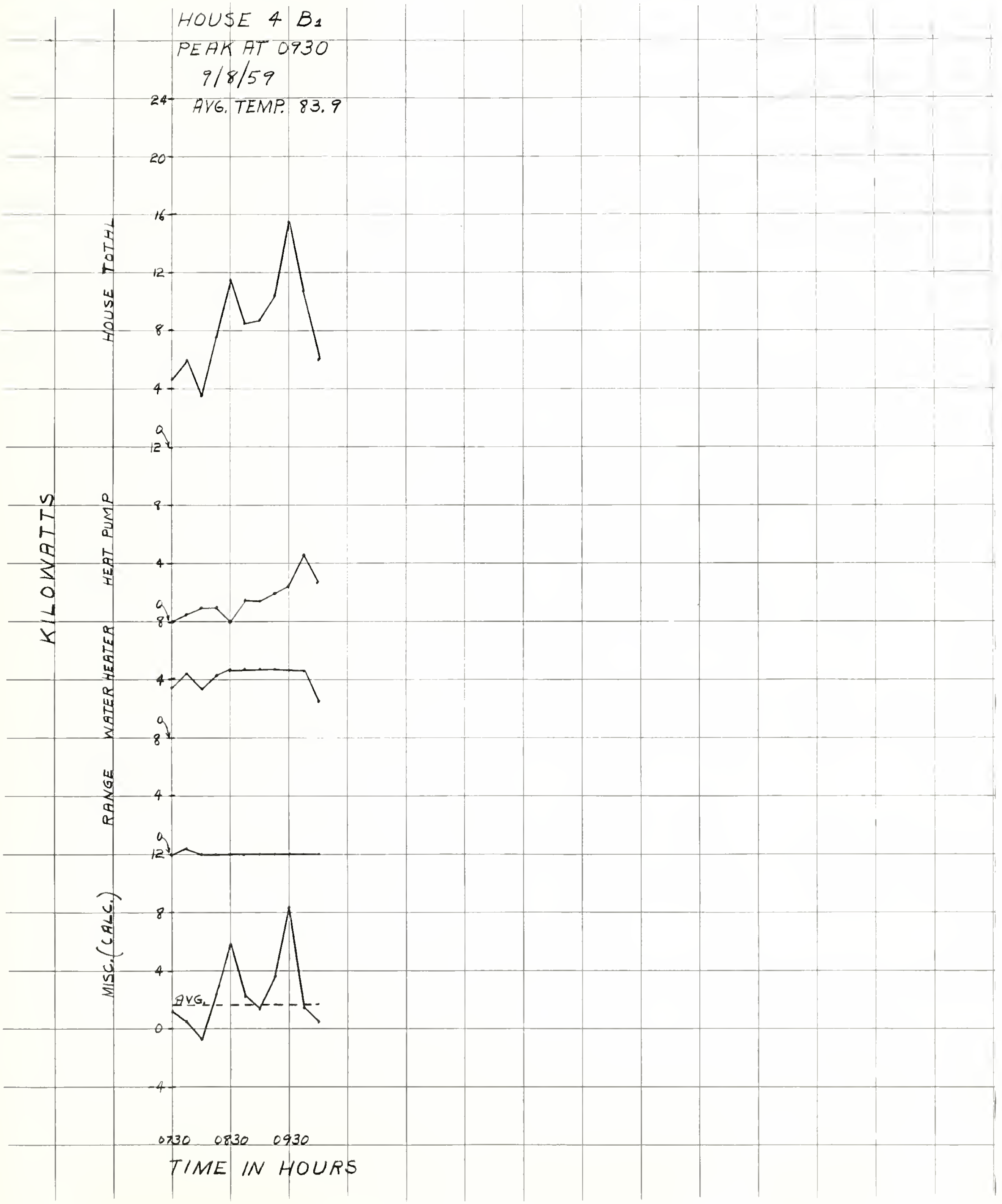


Figure 26

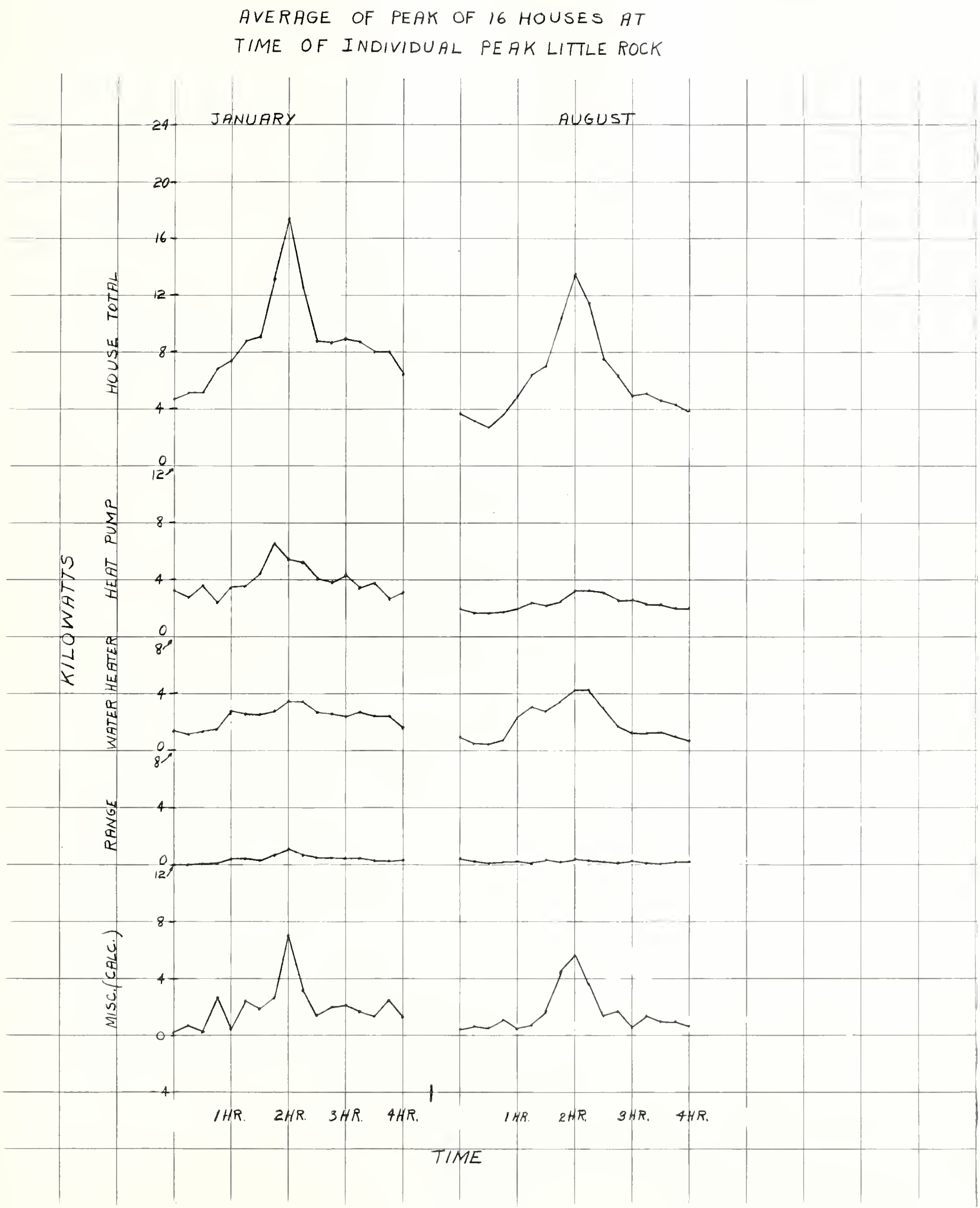

AVERAGE OF PEAK OF 16 HOUSES AT
TIME OF INDIVIDUAL PEAK LITTLE ROCK
JANUARY
AUGUST
KILOWATTS
HOUSE TOTAL
HEAT PUMP
WATER HEATER
RANGE
MISC. (CALC.)
24
20
16
12
8
4
0
12
8
4
0
8
4
0
8
4
0
12
8
4
0
-4
1HR. 2HR. 3HR. 4HR.
1HR. 2HR. 3HR. 4HR.
TIME

Figure 27

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

- Office of Basic Instrumentation.
- Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.

NBS