Temperatures in a Test Bungalow With Some Radiant and Jacketed Space Heaters

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Temperatures in a Test Bungalow With Some Radiant and Jacketed Space Heaters

by Paul R. Achenbach

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Foreword

To provide additional data on the uniformity of temperatures obtainable in houses heated by means of a space heater, tests were undertaken in the four-room house on the grounds of the National Bureau of Standards designated as the "Test Bungalow." The tests were planned to obtain quantitative data on the temperatures in the house when heated by a radiant or a jacketed heater in each of several positions; and to ascertain the value of fans, transoms over interior connecting doorways, and underfloor plenums in improving the uniformity of the temperatures. The project was part of the research and testing program at the National Bureau of Standards conducted in cooperation with the Housing and Home Finance Agency and its technical staff.

E. U. Condon, *Director.*

Temperatures in a Test Bungalow With Some Radiant and Jacketed Space Heaters

by Paul R. Achenbach

The temperature distribution produced in a four-room Test Bungalow on the grounds of the National Bureau of Standards was observed for three space heaters with and without jackets. Tests were made to show the effect of heater location, of size and type of jacket, of open transoms over interior doorways, of an unattached fan for air circulation, and of an underfloor plenum on the temperatures in the four-room house. The temperature patterns obtained were used as a basis for conclusions concerning the severity of the climate and the size of houses of similar materials and insulation for which space heaters could provide minimum acceptable comfort. The temperature distributions for two commercial models of space heaters burning gas and oil were also included for comparison.

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I. Introduction

Space heaters are more widely used for house heating in the United States than any other single type of heating equipment. According to the housing survey of the Bureau of Census for 1940, 35 percent of all urban homes and 63 percent of all rural homes in the country were heated by space heaters of one kind or another. For technical purposes a space heater has been defined as an

> above-the-floor device for the direct heating of the space in which the device is located without the use of external pipes or ducts as integral parts of such heating device [1].[1]

[1] Numbers in brackets refer to references at the end of this paper.

Space heaters have long been known as heating stoves or parlor stoves, in this country, to distinguish them from cooking stoves.

Space heaters are manufactured for burning the common types of fuel, such as wood, coal, oil, or gas. Factors responsible for the widespread use of space heaters include: (a) Low first cost, (b) efficiency, (c) ease of installation, (d) low fuel consumption, and (e) the provision of a zone of comfort by radiation near the heater. The first cost of a space heater is much less than that of a central heating plant and for efficiency of fuel utilization, many space heaters compare favorably with

central heating plants; they also have a great advantage over open fires or fireplaces. The space heater is easy to install because it is essentially a portable piece of equipment which does not have duct work or piping built into the house structure; it burns considerably less fuel than a central heating plant and also provides a zone of comfort in its immediate vicinity by radiation, warming the room in which it is located to a higher temperature than the other rooms in the house. By American standards and from a comfort standpoint, nonuniformity of temperature is not especially desirable, but it is often accompanied by a low fuel consumption. These considerations tend to justify claims made by the manufacturers that space heaters furnish the cheapest heat in the world and are responsible, at least in part, for the predominant use of space heaters in small houses.

One of the principal disadvantages of the space heater is the inconvenience of bringing in fuel and removing ashes when the heater is located in the living room, since both operations create dust. This criticism does not apply, of course, to oil or gas fuel. Other disadvantages are that the heater occupies usable space in the living quarters and does not provide "even heat", or uniform temperatures, throughout the house. For these reasons, other home heating methods, such as steam, warm-air, or hot-water systems are sometimes preferred.

The fact that space heaters take up floor area which could be used for other purposes has not evoked much criticism in recent years although houses now being built are smaller on the average than formerly, but temperature distribution has been the subject of discussion because to some extent it is affected by climate, by the degree of insulation in the house, by the tolerance of the occupants, and by the size of the house in which the space heater is installed. In this connection, such questions arise as: How much temperature difference can be tolerated between the living room and the other rooms of the house? How much colder will such rooms be under given weather conditions in a given house construction with the use of a space heater in the living room than with other heating systems? Answers to these and related questions have heretofore been based on individual judgment or opinion. The purpose of making the tests covered in this report has been to obtain and present pertinent quantitative data and the general conclusions which these data indicate.

The British concept of house warming is different from the American in that the comfort heating of all rooms is not considered to be essential. Many homes in England are designed for the maintenance of a temperature of 50° F throughout. This is called "background heat." When one desires to read, converse, or otherwise relax, he "tops-up" a room to 65° F or a little over by means of a radiant-heat source, such as an open coal heater or an electric or gas radiant heater. In the United States, however, the ideal of heating is to have a house uniformly comfortable throughout. Some departure from uniformity of temperature is regarded as inevitable, but the arrangement which most closely approaches uniformity is considered preferable. For this reason, uniformity of temperature in the Test Bungalow has been used as the criterion for comparing the performance of the several heaters or heater arrangements considered in the tests covered in this report.

With the exception of the comfort charts prepared by the American Society of Heating and Ventilating Engineers, no standards of good heating have been officially established by any authoritative organization in the United States. However, these charts do not apply to space heaters. It is known that temperatures vary across rooms and between the different rooms of a house; temperatures also vary with many automatically controlled heating systems and devices. Some confusion would be avoided if standards or definitions were established whereby houses could be judged "adequately heated" or "well-heated." Such standards would impose certain limits on the above temperature differences within houses.

A conventional gravity hot-water heating system was installed in the basement of the Test Bungalow [2] several years ago for the purpose of comparing the performance of that type of system with other devices installed above the floor. Since the gravity hot-water system has been widely accepted by the public for many years as adequate for domestic heating, exact information on the temperature distribution produced by that method is worth while in evaluating the performance of other methods. Heated by the gravity hot-water system, the average vertical temperature difference in the Test Bungalow was about 6 deg F[2] between levels from 2 in. to 60 in. above the floor, whereas, the average of the temperature differences between rooms for the 2-, 30-, and 60-in. levels did not exceed 2 deg F. This condition prevailed when the house was heated to 70° F at the 30-in. level in the living room and when the outside temperature was 32° F. While tests have not been made under exactly comparable conditions, results obtained with the conventional gravity hot-water heating system could probably be equaled under proper conditions with both warm-air and steam systems. Therefore, for present purposes, a house with interior temperature differences no greater than the above temperature differences might be considered a well-heated house.

A different standard may be necessary for space heaters than for central heating systems, since

[2] In the text of this report deg F is used to denote differences in temperature and °F is used to denote specific values of temperature.

the heaters are not likely to produce uniformity of temperature in all rooms and since many of them emit a large proportion of their delivered heat by radiation. Rooms other than the one containing the heater receive heat by what one authority has called the "overflow" principle, which implies that air, warmed by the heater, flows by natural convection through open doors or archways into other rooms. Undoubtedly, there is also some heat transfer between rooms by transmission through partition walls.

Conspicuous among the first widely used space heaters was the simple cast-iron coal stove, which consisted essentially of a fire pot, varying from cylindrical to egg-shaped, supported on legs and fitted with a smoke collar for attachment of the flue pipe at or near the top. When sheet iron or sheet steel became plentiful, heaters were manufactured that were composed of a cylindrical fire box of rolled sheet with a cast-iron base and top. Such stoves were decorated for home use with nickel-plated parts, mica windows to expose the fire to view, and cast-iron scrolls of various patterns. The production in quantity of jacketed space heaters began some 20 years ago. In such heaters a sheet of metal called a jacket was used to enclose and form an air space around the combustion chamber. The space at the top and bottom was open, and a convection current of air flowed upward through it. To distinguish between jacketed and unjacketed heaters, the term *radiant heater* was applied to the heater without a jacket because a larger proportion of the heat was emitted by radiation for the heater without the jacket than for the jacketed heater.

The appearance of the space heater was much improved by the jacket. Also, direct physical contact with the jacket was not as hazardous as with the combustion chamber because the jacket, though perhaps quite hot, was cooler than the combustion chamber. The chief function of the jacket was to increase the proportion of convected heat produced by the device so that other rooms than the one containing the heater would receive more heat, thus decreasing the temperature difference between rooms.

Space heaters with jackets of various designs are being manufactured. Usually a decorative grill is fitted over the top of the device. Heretofore, there has not been adequate correlation of design and performance, it being thought that much air circulation through the jacket would reduce temperature differences throughout the house. It has now been demonstrated, however, that a house can be heated by means of radiant panels in the ceiling, whereby the floor and other parts of the room are warmed by radiant heat emitted from the ceiling surfaces. This suggests that a space heater might be used to produce a relatively thin layer, or blanket, of hot air against the ceiling, all over the house if possible, thus heating the ceiling and allowing radiant heat to be emitted to the floor and walls below. The extent to which architects and designers of heaters are able to adapt this principle to space heaters has not been fully established. Further experimentation is still necessary in warm-air heating by radiant panels in the ceiling, although some useful information on this subject is provided by the test results reported in this paper.

Space heaters that burned coal, wood, gas, and oil were extensively used during the war to heat new dwellings containing from two to five rooms. One reason for their widespread use during that period was the necessity for conserving materials and labor directly connected with the war effort since in heating capacity per pound of metal the space heater excelled all other heating systems.

Because the space heater is portable and not considered to be part of real estate, the construction of the house and the arrangement of rooms are frequently not planned to provide the most satisfactory conditions for good temperature distribution with the space heater method. Although the floor plan may not have been designed for heating the house with a space heater, the arrangement of the rooms and doorways should be considered before the heater location is selected. There is usually one particular place in any structure where the space heater furnishes the best distribution of heat. In a new house intended for space heater use, the heating method should be coordinated with the architectural design to obtain the most satisfactory results.

In most installations, rooms other than the one containing the space heater are warmed to some extent by convection and radiation. Warmed air passes from one room to another through open doorways or connecting archways. However, in many homes a space heater is used to warm one or two rooms only, while the doors to other rooms are kept closed, especially in severe weather. In larger residences, more than one heater is often used. This report deals entirely with the performance of a single space heater in a multiroom house and presents only data on the temperature distribution attained under specified conditions.

In former times, the cooking stove was relied upon to warm the kitchen. Currently, however, insulated cooking devices have been developed which make it essential for the main heating device to also heat the kitchen. The increased use of "open" construction, consisting in the use of arches instead of doors between some rooms, facilitates the use of space heaters.

Space heaters with full-length jackets and grilled openings at the top are popular. However, many radiant heaters and partially jacketed heaters are manufactured, and each type undoubtedly has its logical field of utility. Space heaters that burn gas or oil are frequently equipped with fans to circulate air through the jacket and throughout

the living space. Four or five properly arranged rooms can be heated with such devices, and in some cases ducts on the heater or special passages between rooms are provided to improve the air circulation. An ordinary space heater, whether jacketed or unjacketed, will not heat adjoining rooms as well as the room in which the heater is located, but there is little, if any, published quantitative information on the difference in temperature between the several rooms of the houses heated by space heaters.

Because of the wide use of space heaters in Federal housing projects and the dearth of data on the heat distribution and other characteristics of this type of heating device, an investigation of the performance of some radiant and jacketed heaters was undertaken at the National Bureau of Standards in a four-room house designated as the Test Bungalow. The purpose of the work was to compare the temperatures produced by placing radiant and jacketed heaters in different positions, to compare the effects of different jackets, to formulate recommendations regarding the limitations of space heater use, and to determine whether or not unattached fans, transoms over interior connecting doorways, and underfloor plenums would improve conditions in a home heated by a space heater.

II. The Test Bungalow

The Test Bungalow at the National Bureau of Standards is similar to House B, described in Technical Bulletin No. 4, "Principles of Planning Small Houses," issued by the Federal Housing Administration.[3] It has four rooms and a bath on one floor with a small hallway, near the middle of the structure, which connects the rooms. Two arrangements of the interior partitions and doors were used during the present tests. They are shown on the floor plans in figures 1 and 2, All rooms except the bathroom, including the hallway, are provided with movable ceilings that can be adjusted to any height between 7 ft and 9 ft by means of permanently installed overhead screw jacks. During the tests of space heaters described in this report, the ceiling height was 8 ft. The Bungalow has a full basement but, for tests during which conditions in basementless houses were simulated, the basement was not heated. Figure 3 is a photograph of the house taken before the refrigerated enclosure was erected.

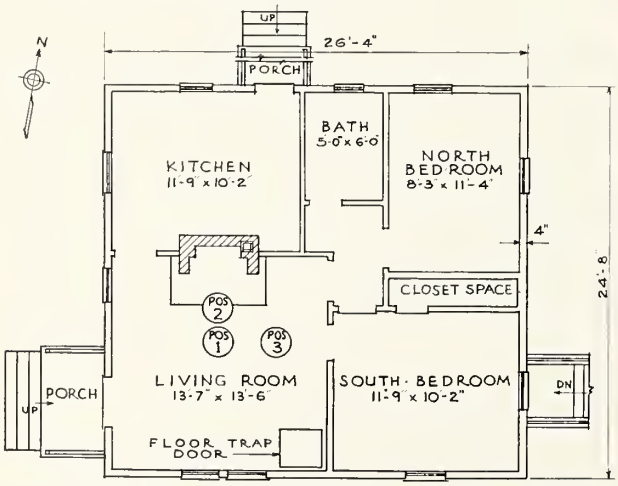

FIGURE 1. *Floor plan of the Test Bungalow showing heater positions 1, 2, and 3 and alternate door to south bedroom open.*

[3] Out of print but may be consulted in depository libraries.

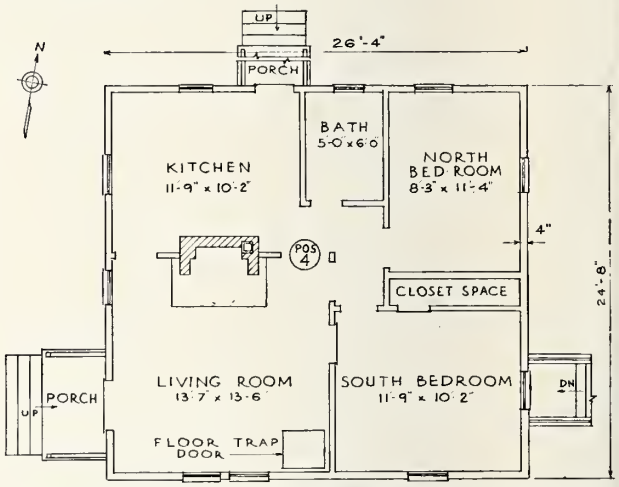

FIGURE 2. *Floor plan of the Test Bungalow showing heater position 4 in temporary opening in living room partition wall and the normal interior door arrangement.*

FIGURE 3. *Exterior view of the Test Bungalow before enclosure was built.*

The outside walls of the Test Bungalow are conventional in construction and consist of 2- by 4-in. studding with sheathing and lap siding on the outside, separated by a layer of building paper,

and ½-in. gypsum board on the inside. The walls are not insulated. The bungalow has a double floor, and both subfloor and finish floor are of 1-in. pine. Building paper is laid between the subfloor and the finish floor in the conventional manner. The ceiling consists of ¼-in. plywood supported by a framework of 2- by 4-in. timbers. The entire ceiling is insulated with rock-wool batts, 3⅝ in. thick, laid between the joists. The windows are double hung except the one in the bathroom and one of those in the kitchen. The window frames and sash are of wood. There is no weatherstripping around the windows or doors.

The heat-transfer coefficients for the floor, side walls, and ceiling were measured by means of heat-flow meters of the Nicholls type fastened to the surfaces. Expressed in terms of Btu/hr (ft^2) (°F), the coefficients were: For side walls from inside to outside, 0.276; for floor from upper surface to basement air when the plenum was not in place beneath the floor, 0.363; and for ceiling from under surface of ceiling to attic air, 0.087. The areas of the windows in the Test Bungalow were as follows: Kitchen, 16.7 sq ft; living room, 35.1 sq ft; bath, 5.0 sq ft; and each of the bedrooms, 23.4 sq ft. The exterior door in the living room measured 3 ft by 6 ft 8 in., whereas, that in the kitchen measured 2 ft 6 in. by 6 ft 8 in. The floor and wall areas of the several rooms may be computed from the dimensions given in figure 1.

The Test Bungalow is enclosed for experimental purposes in an insulated structure which provides a space of 5 ft or more on all sides and over the roof between the bungalow and the enclosure. A refrigerating unit, installed in the space between the bungalow and the enclosure, makes it possible to maintain the air around the bungalow at selected temperatures in the range from 0° to 70° F. During tests, the blowers in the refrigerating unit circulated air at a rate of about 9,000 cfm and maintained the air at the four corners of the bungalow at the same temperature within about ± 1 deg F. The maximum air velocity around the bungalow was approximately two miles per hour. The bungalow enclosure and the refrigerating unit are shown in figures 4 and 5, respectively.

FIGURE 4. *Insulated enclosure for the Test Bungalow.*

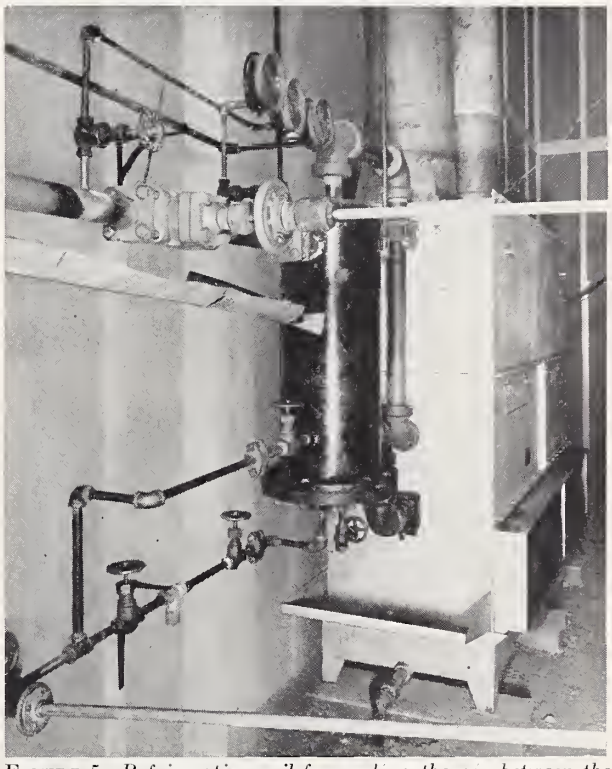

FIGURE 5. *Refrigerating coil for cooling the air between the Test Bungalow and the insulated enclosure.*

III. Test Specimens

Two coal-fired radiant space heaters of the magazine type were chosen for test. Each heater was designed to have a firebrick lining extending from the grate to the lower edge of the dome section. The smaller heater, designated as heater A, had a nominal fuel capacity of 100 lb of coal, and the larger heater, designated as heater B, had a nominal fuel capacity of 200 lb of coal. The dimensions and coal capacity of the two heaters were:

		Heater A	Heater B
Nominal coal capacity	*lb*	100	200
Grate area	*sq in*	177	227
Body diameter	*in*	19	21
Over-all height	*in*	42	50

Heater A and heater B are shown in figures 6 and 7, respectively.

The third specimen, heater C (fig. 8), consisted of a cast-iron combustion chamber and an enameled cast-iron jacket. It was a coal heater of the

FIGURE 6. *Heater A in position 2 with unattached fan mounted near the ceiling above the mantel.*

surface-fired type, with a rectangular firepot measuring 11½ in. by 22 in. at the level of the door sill.

For experiment, heater A was fitted successively with four sheet-metal jackets spaced at different distances from the heating surface. Each jacket was cylindrical in shape, conforming to the body of the heater, and extended from the level of the ashpit to that of the lower edge of the dome section. The jackets were spaced at a distance from the heating surface as follows:

Jacket ---------- *No.*	1	2	3	4
Distance from heating surface -- *in.*	2½	4	6	4

Jacket 4 had an inner liner spaced 1 in. from the jacket; the other jackets (1, 2, and 3) were of the same shape as jacket 4, except that none had a liner. Space heater A, with jacket 4, is shown in figure 9.

Firebrick linings were removed from heaters A and B and heat was supplied to each of them for test purposes by means of a cylindrical, electric-heating element fitted into the combustion chamber. The use of electric energy permitted better control of the heater and more accurate measurement of the energy supplied. The electric-heating element consisted of nichrome wire coils wound in horizontal turns around a 16-in. cylinder. When installed in a combustion chamber, the heating element was separated from the firebox wall by an air space about 1 in. wide. Figure 10 shows the electric heating element, and figure 11 shows it installed in heater A. The heat output of the element was measured with calibrated watt-hour

FIGURE 7. *Heater B without jacket.*

meters graduated in divisions of 10 whr. There was no smoke pipe attached to heaters A and B during the tests. The output of the space heater was equal to the electric-energy input.

The jacketed cast-iron heater C, was fired with anthracite and this device was placed on a platform scale so that fuel consumption could be determined as closely as possible by the decrease in weight during test. Flue-gas losses were determined from flue-gas temperature and analysis. The output of space heater C was equal to the heat input minus the flue-gas losses.

All comparisons between different heaters in this report are made for conditions of approximately equal heat output.

Figure 12 shows the gas-fired heater and figure 13 the oil-fired heater for which data are given in this report. The gas-fired heater was jacketed and equipped with an 18-in.-diameter disk fan mounted on the back. When in operation, the fan forced air through openings in a cast-iron heat transfer element and through a 21½-in.-diameter circular grille equipped with deflecting vanes. This heater

FIGURE 8. *Heater C with cast-iron jacket.*

FIGURE 9. *Heater A with jacket 4 in position 4 in temporary opening in partition wall.*

FIGURE 10. *Electric heating element used for tests with heaters A and B.*

FIGURE 11. *Heater A with dome removed showing position of electric heating element in the heater.*

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was located in the living room in front of the fireplace at position 2.

The oil-fired heater was jacketed and equipped with a small blower attached to one of the side panels. The blower forced warmed air toward the hallway from the heater position, which was between position 2 and the hall. This heater burned oil in a vaporizing pot-type burner.

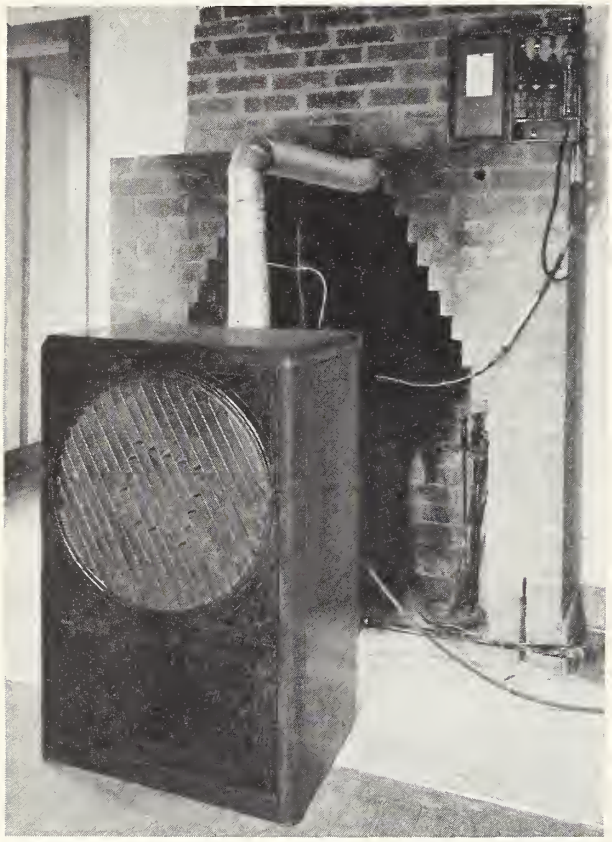

FIGURE 12. *Gas-fired space heater with attached circulating fan in position 2 in the living room.*

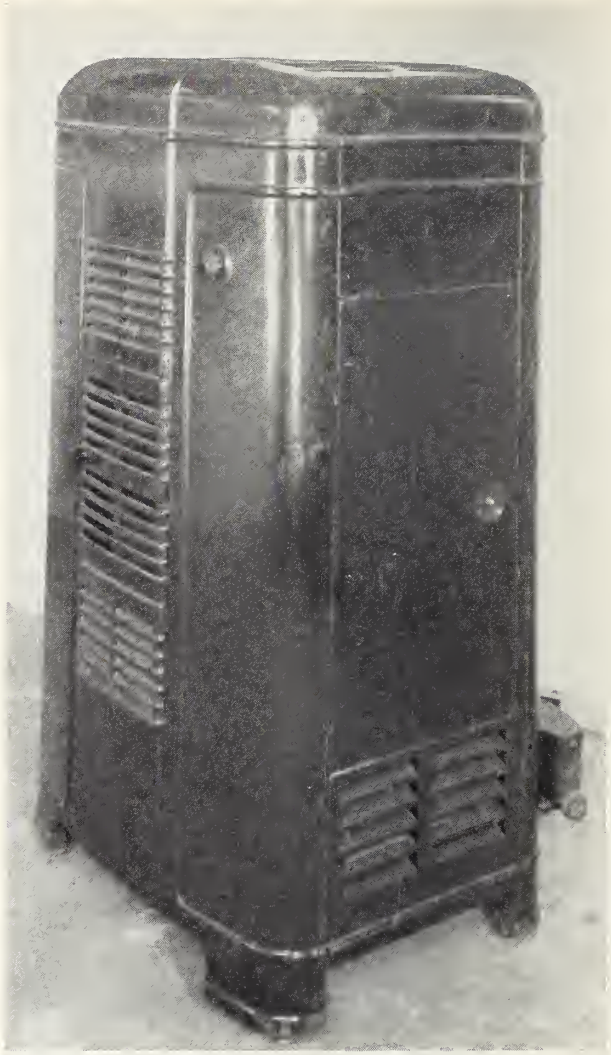

FIGURE 13. *Oil-fired space heater with attached circulating fan.*

IV. Temperature Measurements

Temperatures in the bungalow were measured by means of thermocouples covered with cork insulation and supported by strings suspended from the ceiling. Five strings were used in each of the four large rooms, one at the center of the room and one midway between the center and each corner of the room, except that in the living room the center string was moved toward the double window in the south wall and was located 36 in. from the wall to avoid having it too close to the heater under test. Three strings were used in the bathroom, one at the center of the room and one midway between the center and each of the walls along the longer axis of the room. Five thermocouples were attached to each string, at 2, 30, 60, 78, and 94 in. above the floor. In addition, an unheated globe thermometer was used to measure the radiation-convection temperature at one station in the living room 30 in. above the floor. This station was the same as that to which the center string of thermocouples in the living room was moved, as described above. The globe thermometer, an enclosed mercury element for a temperature recorder, and some of the cork-covered thermocouples are shown in figure 14.

The temperatures of the upper and lower surfaces of the floor, the inside of the exterior walls,

FIGURE 14. *View showing globe thermometer, shielded thermocouples, cork-covered thermocouples, and an enclosed mercury element for a temperature recorder.*

the outside of the exterior walls, the basement air, and the attic air were also determined by means of thermocouples. Thermocouples were placed at each of the four outside corners of the bungalow at the floor and ceiling levels to obtain the average temperature of the air surrounding the structure.

It was observed that the globe thermometer and a cork-covered thermocouple adjacent to it indicated substantially the same temperature when both were located in the living room and exposed to radiation from a space heater located in the same room. The temperature indicated by the thermocouple decreased about 3 deg F under the same radiant influences when the cork was removed. It was considered impractical to measure the temperature at the 115 stations of observation in the bungalow with eupatheoscopes, globe thermometers, or other instruments for evaluating the mean radiant temperature so the cork-covered thermocouples were used in place of these more cumbersome instruments.

V. Test Procedure

The temperatures on the inside and on the outside of the bungalow, as well as in the basement and attic, were permitted to attain a steady state by the maintenance of a constant heat supply inside the bungalow and a constant low temperature outside for several hours prior to each test. After steady conditions were attained, a test period of 24 hr or more commenced, during which observations of the inside temperatures for approximately 150 stations were recorded at 4-hr intervals and the outside temperature and electric-energy consumption each hour.

Heater A, the smaller cylindrical stove, was operated without a jacket in each of three positions in the living room and in one position near the center of the house, and the temperature distribution in the bungalow was observed for one or more outside temperatures for each position. The four positions are described below and shown on the bungalow floor plan in figures 1 and 2:

Position 1. At the intersection of the center lines of the fireplace and the doorway between the living room and south bedroom. (See fig. 1.)

Position 2. On the center line of the fireplace and with the stove 30 in. from the north wall of the living room. (See fig. 1.)

Position 3. On the center line of the doorway between the living room and south bedroom and with the stove 28 in. from the east wall of the living room. (See fig. 1.)

Position 4. Central location provided by cutting a temporary opening in the living-room partition on the north side adjacent to the hallway. (See fig. 2.) For the tests in position 4, the partition between the kitchen and hall was removed and the alternate door into the south bedroom was used as shown in figure 2.

Heater A with each of the four jackets, heater B, and heater C were tested in one or more of the four positions described above. Heater A was tested as a radiant heater in position 1 with outside temperatures of 50°, 32°, 20°, and 8° F, with the heat output adjusted to provide an average temperature of about 82° F at the 60-in. level in the living room at each outside temperature. The heat outputs corresponding to these outside temperatures were about 14,000, 22,000, 26,500, and 31,500 Btu/hr, respectively. Thereafter, all other tests were made with the heat output fixed for the corresponding outside temperature, as indicated above, except that, in a few cases, tests were made with one or more other rates of heat output for an outside temperature of 32° F to

observe the effect on comfort and temperature distribution.

Duplicate tests were made of heater B with the principal source of heat in the combustion chamber first at 24 in. and then at 39 in. above the floor, using a selected group of electric heating coils, to determine the effect of the height of the heat source on the temperature distribution produced in the house. Other tests were made of radiant heater A, radiant heater B, and heater A with jacket 1 to find the effect of opening the transom over the door between the living room and hall and that over the door between the hall and the north bedroom. The transoms were rectangular openings 12 by 30 in. with centers 6 in. below the ceiling.

All the heaters used for this investigation were tested with natural circulation of the air over the heating surface and in the living space and some tests were made of all heaters, except heater B, using a fan in the vicinity of the heater to force some of the warmed air toward adjoining rooms.

FIGURE 15. *Heater A with lined jacket in position 2 showing location of desk fan on mantel.*

FIGURE 16. *Heater A in position 4 over floor grill used in conjunction with underfloor plenum.*

A conventional 12-in., four-bladed fan of the desk type was used for this purpose. After experimenting with the fan in different positions, it was found that best results were obtained by placing the fan on the fireplace mantel where it blew warm air toward the hall. The fan in the selected position on the mantel is shown in figure 15.

A radiant and a jacketed heater were tested in position 4 with a plenum under the entire floor extending to a distance of $3\frac{5}{8}$ in. below the 10-in. floor joists. A large register under the heater, as shown in figure 16, and a small register adjacent to the outside wall in each of the four larger rooms permitted air movement between the living space and the plenum. Observations of the air movement through the registers were made with each heater. Additional tests were made with all five registers closed to provide a "dead" air space beneath the floor joists.

The results obtained under 68 different test conditions are shown in the Appendix, which contains tables 21 to 88, inclusive. For the purpose of analyzing the results, different groups of these tables have been selected to make specific comparisons, and the significant data from each group are summarized in tables 1 to 20.

VI. Effect of Heater Location on Temperature Distribution

The test results show that nearly uniform temperatures were obtained when the heater, whether radiant or jacketed, was located at position 4 near the center of the house with approximately equal opportunity for the air to circulate through doorways to each of the surrounding rooms. Table 1 shows the average of the maximum temperature differences between the warmest and coldest rooms for the 2-, 30-, and 60-in. levels for each heater position at an outside temperature of 32° F. The zone from 2 to 60 in. above the floor will be called "the living zone" throughout this report. Table 1 shows that the maximum horizontal temperature difference between rooms was about half as large for a heater in position 4 (see fig 2) as for the same heater located in position 1, 2, or 3 (see fig. 1), for both radiant and jacketed heaters. The maximum horizontal temperature difference between rooms in the living zone ranged from 8.6 deg F to 17.1 deg F for positions 1, 2, and 3, and from 4.3 deg F to 7.2 deg F for position 4, with an outside temperature of 32° F. When the heater was located in the living room in position 3, the temperature differences between rooms were slightly lower than for either position 1 or position 2, with either a jacketed or a radiant heater.

The maximum vertical temperature difference in any room between 2 in. and 60 in. above the floor, using the average of the temperatures at the five stations, for an outside temperature of 32° F, is shown in table 2 for each heater position. These data show that the heater position had no significant effect on the maximum vertical temperature difference in the living zone.

Another advantage of locating a heater in a hall, in addition to greater uniformity of temperature, is that excessive heat due to radiation adjacent to the heater does not lessen the useful living space in any of the rooms, as is the case when a heater is located in one of the rooms.

TABLE 1. *Inside horizontal temperature differences for type A heater in four locations at an outside temperature of 32° F* [a]

Location of heater A	Average of the maximum temperature differences between rooms for the 2-, 30-, and 60-in. levels above the floor		
	Without jacket	With jacket 1	With jacket 4
	°F	°F	°F
Position 1:			
Living room, close to center	17.1	11.6	----------
Position 2:			
Living room, close to fireplace	16.0	10.6	8.6
Position 3:			
Living room, close to bedroom wall	14.1	9.7	----------
Position 4:			
Central location in temporary opening	7.2	----------	4.3

[a] Data from tables 22, 26, 28, 29, 35, 37, 41, 53, 56.

TABLE 2. *Inside vertical temperature differences for type A heater in four locations at an outside temperature of 32° F* [a]

Location of heater A	Maximum vertical temperature differences in living zone from 2 to 60 in. above the floor		
	Without jacket	With jacket 1	With jacket 4
	°F	°F	°F
Position 1:			
Living room, close to center	10.6	12.1	----------
Position 2:			
Living room, close to fireplace	11.2	12.2	12.5
Position 3:			
Living room, close to bedroom wall	11.3	12.3	----------
Position 4:			
Central location in temporary opening	11.0	----------	13.0

[a] Data from tables 22, 26, 28, 29, 35, 37, 41, 53, 56.

VII. Comparison of Radiant and Jacketed Heaters

Data in table 3 show that the maximum horizontal temperature differences between rooms in the living zone averaged about 5 deg F less for the jacketed heaters in position 2 than for the radiant heaters in the same location. The average of these maximum temperature differences in the living zone was 10.1 deg F for all the jacketed heaters and 15.6 deg F for the radiant heaters. For position 4, the air-insulated jacket, No. 4, provided a temperature difference between rooms in the living zones 3 deg F lower than that observed for a radiant heater. On the other hand, the maximum vertical temperature difference in the living zone averaged 1.8 deg F less for the radiant heaters than for the jacketed heaters. These results were observed for an outside temperature of 32° F.

For low outside temperatures ranging from 0° to 10° F, the radiant type of heater still produced lower vertical temperature differences than the jacketed-type heater, and the jacketed-type heater produced lower temperature differences between rooms than the radiant heater. In each case, the disparity of performance between the two types of heaters was greater for low outside temperatures than has just been shown for an outside temperature of 32° F.

The data in table 4, with the same heat output and outside temperature, show that the radiant heater in position 4 warmed the air 2 in. above the floor in the rooms other than the living room to a temperature from 4 to 6 deg F higher than the jacketed heaters in the same position. Also, under this condition, higher temperatures were

TABLE 3. *Inside temperature differences at specific heights above the floor for three types of heater, with and without jackets, in two different locations for an outside temperature of 32° F* [a]

Test	1	2	3	4	5	6	7	8	9
Heater	A	A	B	A	A	A	A	A	C
Jacket	None	None	None	1	2	3	4	4	(b)
Position	2	4	2	2	2	2	2	4	2
Height above floor, in.	Maximum temperature difference between rooms, °F								
2	18.0	8.1	16.0	11.5	11.4	11.5	8.8	5.8	12.1
30	16.2	7.4	15.4	11.0	9.5	9.5	7.1	3.5	10.1
60	13.8	6.0	13.9	9.3	9.7	10.4	9.8	3.7	10.3
78	16.9	8.3	17.3	17.0	16.2	14.7	18.6	8.4	18.4
94	16.4	9.5	19.0	17.7	16.7	14.7	20.3	11.1	20.8
	Maximum vertical temperature difference, °F								
2 to 60	11.2	11.0	10.6	12.2	12.3	12.7	12.5	13.0	13.8
2 to 94	19.1	18.0	19.3	24.6	24.3	22.3	30.6	26.3	28.8

[a] Data from tables 26, 29, 34, 37, 48, 51, 53, 56, 59.
[b] Cast iron.

TABLE 4. *Inside temperatures in the living zone for three types of heater, with and without jackets, in two different locations for an outside temperature of 32° F* [a]

Test	1	2	3	4	5	6	7	8	9
Heater	A	A	B	A	A	A	A	A	C
Jacket	None	None	None	1	2	3	4	4	(b)
Position	2	4	2	2	2	2	2	4	2
Height above floor, in.	Temperatures in living room, °F								
2	77	71	76	71	71	72	69	65	71
30	82	77	81	76	76	77	73	68	76
60	84	80	84	80	81	83	81	75	83
	Average of temperatures in other four rooms, °F								
2	62	66	62	61	61	62	61	60	61
30	68	72	68	67	67	68	67	65	67
60	72	76	72	72	72	74	72	72	73

[a] Data from tables 26, 29, 34, 37, 48, 51, 53, 56, 59.
[b] Cast iron.

observed at all levels in the living zone in all rooms except the living room with radiant heater A in position 4 than for any of the other space heaters tested in any position. The conditions in the living room were also considered satisfactory for radiant heater A in position 4. That is, for the same heat output, a radiant heater centrally located with free access for radiation and convection to the surrounding rooms provided higher room temperatures in the living zone than any other heater tested in any location.

The results shown in table 4 for an outside temperature of 32° F indicate that between 15 and 20 percent more heat output would be required from a jacketed heater than from a radiant heater in position 4 to attain equal temperatures in the living zone of the several rooms. Possibly the greater fuel consumption of the jacketed heater is justified by the advantage gained in temperature difference between the rooms and in the safety of operation. That is, the data obtained with the radiant and jacketed space heaters show that each type had certain advantages. To summarize:

(a) The jacketed heaters, regardless of the position chosen for the heater, produced lower temperature differences between rooms than did the radiant heaters.

(b) The radiant heaters, regardless of position, produced lower temperature differences between the 2- and 60-in. levels than did the jacketed heaters.

(c) For a given heat output, the radiant heater in position 4 produced considerably higher temperatures in the living zone in all rooms than did the jacketed heater in the same position. Consequently, the radiant heater in position 4 produced a given degree of warmth in the living zone of all rooms with less fuel than did the jacketed heaters.

VIII. Comparison of Jackets

Jacket 4, with the liner, was superior in performance to any of the other four jackets tested. The average of the maximum temperature differences between rooms in the living zone was 2 deg F less with jacket 4 than the averages for the other four jackets for an outside temperature of 32° F. This reduction in the temperature difference between rooms was accomplished principally by reducing the temperatures 2 in. and 30 in. above the floor in the living room. The lined jacket had a negligible effect on the temperature 60 in. above the floor in the living room.

The results in tables 3 and 4 show that the performances of heater A, equipped for successive runs with jackets 1, 2, and 3, spaced 2½ in., 4 in., and 6 in. from the heating surface, respectively, and of heater C with a cast-iron jacket were practically identical. There was a variation of only 0.6 deg F in the average of the maximum temperature differences in the living zone between rooms for these four jackets. The temperature difference between rooms averaged 10.5 deg F for these four jacketed heaters for an outside temperature of 32° F.

There was a variation of 1.6 deg F between the maximum vertical temperature differences in the living zone for the five different jackets tested when the outside temperature was 32° F. Jackets 1 and 2 produced almost identical vertical temperature differences and these were lower than the rest, while the cast-iron jacket on heater C produced the highest vertical temperature difference.

The surface temperatures of the several heater jackets for a heat output of 21,000 Btu/hr and

the temperature of the heating surface of radiant heater A for the same heat output are shown in table 5. The air-insulated jacket was much cooler than any of the other jackets, reaching only 100° F near the upper rim. The total heat emission by radiation for heater A without a jacket and with each of four jackets was computed from the observed surface temperatures for an estimated emissivity of 0.9. It will be noted that a little over one-half of the total heat was emitted by radiation from the unjacketed heater, while about one-fourth of the total heat was emitted by radiation from the same heater enclosed by jackets 1, 2, and 3. The air-insulated jacket, No. 4, was effective in reducing the radiant heat emission from the body of the heater. It reduced the radiated heat from the jacket to about one percent of the total heat output of the heater. The percentage of radiant heat for jacket 4, shown in table 5, was emitted almost entirely from the dome of the heater. The proportion of heat emitted by radiation from a given heater would, no doubt, increase with increased heat output or firing rate since radiation from a surface is proportional to the fourth power of the absolute temperature.

The upward velocity of the air between the heating surface and each jacket, measured by timing the travel of visible smoke through the air space, is shown in table 6. The quantity of air circulated was computed on the assumption that the observed velocity was the average for the space between the heater and jacket. Additional convection occurred near the outer surface of the jackets, and there was induced circulation of air above the heater.

TABLE 5. *Surface temperatures for type A and C heaters and computed radiant heat emission for type A heater, with and without jackets, for a heat output of 21,000 Btu/hr*

Heater	Jacket	Range and averages of jacket temperatures		Computed radiant heat emission	
		°F	°F	Btu/hr	Percent
A	Without	[a]300 to 500	[a]407	10,900	52
A	1	125 to 300	214	5,100	24
A	2	125 to 250	208	5,100	24
A	3	125 to 250	200	5,300	25
A	4	70 to 100	82	2,160	10
C	Cast iron	125 to 250			

[a] Heating-surface temperature.

TABLE 6. *Air circulation through space-heater jackets*

Jacket	Observed air velocity through jacket	Computed air circulation
	ft/min	cfm
1	116	136
2	140	281
3	93	322
4	99	199
Cast iron	[a]	

[a] Not measured.

Data on partially jacketed heaters were not obtained. It is probable that such heaters would have a performance intermediate between that of a full-jacketed and a radiant heater. A partial radiant feature would not contribute to temperature uniformity in a house. It might, however, be desirable for providing additional warmth in the form of radiant heat in selected areas or directions.

IX. Effect of Heater Size

The temperatures observed in the Test Bungalow with heaters A and B, both without jackets, are shown in table 7 and comparison indicates that moderate differences in heater dimensions do not cause great differences in house temperature distribution for the same heat output. Heater B was 2 in. larger in diameter and 8 in. taller than heater A with a nominal fuel capacity twice that of heater A and a grate area of 227 sq in., compared to 177 sq in. for heater A. Although these differences in size and capacity apparently caused little difference in temperature distribution, greater disparity in these physical characteristics might increase the difference in performance.

The vertical temperature difference for the living room was 2.4 deg F greater in the living zone and 5.0 deg F greater from floor to ceiling for the larger heater than for the smaller. The air temperatures 2 in. and 30 in. above the floor in the living room were a little higher with heater A than with heater B, while the air temperatures at the higher levels were somewhat lower with heater A. In the other four rooms, the temperatures at all levels were almost identical for the two heaters.

TABLE 7. *Effect of heater size on inside temperature distribution and differences for type A and type B radiant space heaters in position 1, with a heat output of 21,500 Btu/hr at an outside temperature of 32° F* [a]

Height above floor, in.	Heater A, height 42 in. Combustion chamber, 19-in. diam		Heater B, height 50 in. Combustion chamber, 21-in. diam	
	Living room	Other rooms	Living room	Other rooms
	Room temperatures, °F			
2	77.5	60.8	75.9	61.6
30	82.8	66.9	81.8	67.1
60	83.7	70.6	84.5	71.0
78	90.3	73.3	91.7	74.1
94	92.3	77.0	95.7	78.2
	Temperature difference, °F			
2 to 60	6.2	9.8	8.6	9.4
2 to 94	14.8	16.2	19.8	16.6

[a] Data from tables 23 and 31.

X. Height of Heat Source

Increasing the height of the principal heat source in radiant heater B from 24 to 39 in. above the floor increased the temperatures from the 60-in. level to the ceiling in the living room, but had no significant effect on the air temperatures 2 in. and 30 in. above the floor in the living room or at any height in the other rooms. The increase in temperature for the higher heat source was 2.0 deg F at a height of 60 in. from the floor and 4.7 deg F at a height of 94 in. above the floor in the living room. A comparison of the temperatures in the Test Bungalow for the two heights of the heat source is shown in table 8 for otherwise identical test conditions.

TABLE 8. *Effect of height of heat source on inside temperature distribution and differences for radiant heater B in position 1 at an outside temperature of 32° F* [a]

Height above floor, in.	Heat source at 39 in. above floor		Heat source at 24 in. above floor	
	Living room	Other rooms	Living room	Other rooms
	Room temperatures, ° F			
2	75.1	60.3	75.3	60.4
30	80.9	65.3	81.1	65.4
60	85.6	69.0	83.6	69.2
78	94.8	72.1	91.2	72.5
94	100.1	75.9	95.4	76.1
	Temperature difference, ° F			
2 to 60	10.5	8.7	8.3	8.8
2 to 94	25.0	15.6	20.1	15.7

[a] Data from tables 32 and 33.

XI. Open Transoms Over Interior Doorways

The use of open transoms of 2½-ft² area over the doorways between the living room and the hall and between the hall and the north bedroom raised the temperatures at all levels in the north bedroom with both radiant and jacketed heaters. The rise in temperature resulting from the opening of transoms for two radiant heaters and one jacketed heater is summarized in table 9. The increase in temperature in the north bedroom ranged from 1.2 to 1.9 deg F, 2 in. above the floor and from 2.6 to 3.8 deg F, 60 in. above the floor. The increase in temperature was even greater near the ceiling.

The change in the temperature of the bathroom produced by the opening of transoms between living room and hall and between hall and north bedroom was less than 1 deg F in most cases. With the jacketed heater, most of the temperatures in the bathroom were lowered by opening the transoms. There was no transom over the door between the bathroom and hall.

The temperatures near the ceiling in the living room, kitchen, and south bedroom were lowered at most of the stations of observation when the transoms were opened, indicating that the open transom over the north bedroom door permitted a greater proportion of the hot air in the hall to enter the north bedroom than when the transom was closed.

TABLE 9. *Inside temperature rise produced at specific heights above the floor by the opening of transoms over interior doorways for two types of radiant space heaters, with and without jackets, for a heat output of 22,000 Btu/hr at an outside temperature of 32° F* [a]

Height above floor, in.	Heater A, without jacket, position 2		Heater B, without jacket, position 1		Heater A, with jacket, position 2	
	Bedroom	Bath	Bedroom	Bath	Bedroom	Bath
	Temperature rise, ° F					
2	1.2	0.6	1.9	0.9	1.6	0.1
30	1.1	.4	2.3	1.5	1.2	[b]−1.1
60	2.6	.6	3.6	1.7	3.8	0.0
78	3.6	.2	5.0	0.6	5.4	[b]−1.7
94	4.7	.1	7.9	.7	4.7	[b]−1.8

[a] Data from tables 26, 27, 31, 32, 37, and 42.
[b] Negative sign indicates a decrease in temperature.

XII. Effect of Outside Temperature on the Temperature Distribution

The average temperatures observed in the Test Bungalow for radiant heater A and for each of the jacketed heaters are summarized in table 10 for a range of outside temperatures. For each outside temperature, the temperatures at five levels in the living room and the averages of the temperatures at five levels in the other four rooms are tabulated. This table gives a comparison of the performance of all the heaters, all the jackets, and all the positions for an outside temperature of 32° F, with a heat output of about 22,000 Btu/hr, and also for an outside temperature in the range from 0° to 17° F, with heat output between 29,000 and 34,000 Btu/hr.

TABLE 10. *Average room temperatures in Test Bungalow at specific heights above the floor, for two types of heater, with and without jacket, with natural circulation of air for different heat outputs, at outside temperatures ranging from 51° to 0° F* [a]

Height above floor, inches	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms
Heater A, without jacket, position 1												
Outside temp, ° F	50				32		22				8	
Heat output, Btu/hr	13,900				21,400		26,500				31,500	
	° F	° F	° F	° F	° F	° F	° F	° F	° F	° F	° F	° F
2	78	67			77	60	75	56			73	52
30	82	72			82	66	83	63			82	59
60	83	75			83	70	84	68			83	64
78	88	76			89	72	92	71			92	68
94	89	79			91	76	94	76			94	73
Heater A, without jacket, position 4												
Outside temp, ° F					32						0	
Heat output, Btu/hr					22,200						33,800	
2					71	66					62	56
30					77	72					71	64
60					80	76					75	69
78					83	78					80	73
94					86	82					83	78
Heater A, jacket 1, position 2												
Outside temp, ° F	51		32		32		22		17			
Heat output, Btu/hr	13,600		22,600		28,200		26,400		29,300			
2	74	67	71	61	75	63	69	57	70	58		
30	78	72	76	67	81	70	75	64	76	65		
60	81	75	80	72	86	76	81	70	82	71		
78	89	78	91	76	99	81	93	76	97	77		
94	92	81	95	80	104	87	100	81	102	82		
Heater A, jacket 2, position 1												
Outside temp, ° F	50		32		33		22		17			
Heat output, Btu/hr	14,200		23,000		26,700		28,200		31,100			
2	74	66	72	61	76	64	71	58	73	60		
30	78	71	78	67	82	71	78	66	80	68		
60	81	75	83	73	88	77	84	72	88	75		
78	89	77	93	77	101	82	97	77	101	80		
94	98	80	99	82	107	86	102	83	107	85		
Heater A, jacket 2, position 2												
Outside temp, ° F					32				12		10	
Heat output, Btu/hr					22,000				31,900		33,500	
2					71	61			69	57	68	55
30					76	67			77	65	75	63
60					81	72			84	72	83	71
78					91	76			96	78	95	76
94					95	81			101	83	99	82
Heater A, jacket 3, position 2												
Outside temp, ° F			33								10	
Heat output, Btu/hr			22,300								31,700	
2			72	62							66	55
30			77	68							75	64
60			83	74							84	71
78			91	77							93	76
94			94	81							97	80

[a] Data from tables 21 to 60.

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TABLE 10. *Average room temperatures in Test Bungalow at specific heights above the floor, for two types of heater, with and without jacket, with natural circulation of air for different heat outputs, at outside temperatures ranging from 51° to 0° F*[a]—Con.

Height above floor, inches	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms
Heater A, jacket 4, position 2												
Outside temp, ° F			32		33				12			
Heat output, Btu/hr			22,200		26,000				32,100			
2			69	61	73	64			66	56		
30			73	67	79	71			72	63		
60			81	72	88	77			84	71		
78			94	77	103	83			101	78		
94			99	81	109	89			107	85		
Heater A, jacket 4, position 4												
Outside temp, ° F			32		32						11	
Heat output, Btu/hr			21,700		24,100						31,700	
2			65	60	68	63					62	56
30			68	65	72	69					67	64
60			75	72	79	77					77	73
78			82	78	88	82					86	81
94			87	83	93	89					92	89
Heater C, cast-iron jacket, position 2												
Outside temp, ° F			33						14			
Heat output, Btu/hr			21,600									
2			71	61					69	55		
30			76	67					76	63		
60			83	73					86	72		
78			94	77					99	78		
94			100	82					107	84		

[a] Data from tables 21 to 60.

The data in table 10 show that both the vertical temperature difference in each room and the temperature difference between the room containing the heater and the other rooms increased as the outside temperature decreased. When the heater was located in position 4, only the vertical temperature difference increased with lowering temperature. Since one room may be too warm for comfort at some level in the living zone, while another room is too cold for comfort at some level, the total temperature difference in the living zone is defined for these tests as the difference between the average temperature at the 60-in. level in the living room and the minimum average temperature at the 2-in. level in any room. This follows because the living room was always the warmest room. The total temperature difference reflects the ability of a heater to produce uniformity of temperature both vertically and horizontally in the entire house.

When a space heater warms adjacent rooms by natural convection, heat is transferred by air currents due to differences in temperature. It follows, therefore, that the heat delivery to an adjacent room can be increased only by increasing the temperature difference between the rooms. This is demonstrated by the results summarized in table 10. For four of the heaters, the temperature distribution was observed for two rates of heat output for an outside temperature of 32° F. In these instances, the temperature differences occurring in the living zone increased as the heat output increased, even though the outside temperature remained the same.

In figure 17, the maximum total temperature differences in the living zone between any two rooms in the Test Bungalow with natural circulation were plotted as ordinates, and the heat out-

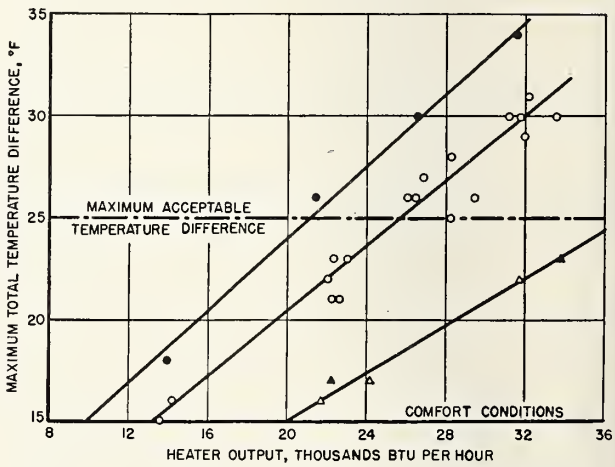

FIGURE 17. *Maximum total temperature difference in the living zone of the entire Test Bungalow for space heaters with natural circulation for a range of heat output from 10,000 to 36,000 Btu/hr.*

●Radiant heater in living room; ○jacketed heaters in living room; ▲radiant heater in position 4; △jacketed heater in position 4.

puts of the space heater were plotted as abscissas. These data were taken directly from the tables in the Appendix, since table 10 shows only the average of the temperatures in four of the rooms in the bungalow. It will be noted that the total temperature differences for the radiant heater when located in the living room were considerably greater than for any other heater, while those for both the radiant and jacketed heaters in position 4 were much lower than for the other positions in the bungalow. The points for all five of the jacketed heaters located in the living room were scattered somewhat, but the relation between heat output and total temperature difference can reasonably be represented by a single straight line, as shown in figure 17.

The heat outputs that may be obtained from the several heaters in different positions for given total temperature differences are shown in table 11 as taken from figure 17.

TABLE 11. *Total temperature difference [a] in relation to heat output for space heaters, with and without jackets, with natural circulation of air*

Maximum total temperature differenee in living zone, ° F	Heater output		
	Heater without jacket in living room	Heater with jacket in living room	Heaters with and without jaekets in eentral loeation
	Btu/hr	*Btu/hr*	*Btu/hr*
15	10,000	13,000	20,000
20	15,500	19,500	28,500
25	21,000	25,500	37,000
30	26,500	32,000	
35	32,000		

[a] The "total temperature difference" is the maximum differenee of temperature between any two rooms in the living zone from 2 to 60 in. above the floor.

XIII. Effect of Circulating Fan

The results obtained when a fan of the conventional desk type was used in conjunction with a space heater to circulate the air in the Test Bungalow are summarized in tables 12, 13, and 14. The fan, which was 12 in. in diameter, was tried in three locations with radiant heater A, (1) at the transom over the door between the living room and hall, blowing toward the hall, (2) at the ceiling over the fireplace mantel, blowing toward the hall, as shown in figure 6, and (3) on the left end of the fireplace mantel, blowing toward the hall, as shown in figure 15. The results summarized in table 14 for the radiant heater in position 2 show that somewhat higher temperatures were observed in all rooms but the one containing the heater when the fan was located on the fireplace mantel than when the fan was located in the other two positions. This suggests that the fan should be as near as practicable to the place where the warm air rises from the heater. The remaining tests were made with the fan on the fireplace mantel, as shown in figure 15.

A comparison of tables 3 and 12 shows that the fan reduced the maximum temperature differences between rooms from 1 to 3.5 deg F in the living zone for an outside temperature of 32° F when used with heaters located in the living room. The fan had a negligible effect for radiant heater A in position 4 and an adverse effect on the maximum temperature difference between rooms with a jacketed heater in position 4. The fan had no significant effect on the average vertical temperature difference in the living zone of the bungalow but materially reduced the floor-to-ceiling temperature difference.

A comparison of tables 4 and 13 shows that the fan raised the temperatures of the living zone in the rooms other than the living room from 1 to 7 deg F and at the same time increased the living-

TABLE 12. *Inside temperature differences at specific heights for two types of space heater, with and without jackets, at two different locations, with unattached fan, at an outside temperature of 32° F [a]*

Test	1	2	3	4	5	6	7	8
Heater	A	A	A	A	A	A	A	C
Jaeket	None	None	1	2	3	4	4	[b]
Position	2	4	2	2	2	2	4	2
Height above floor, in.	Maximum temperature differenees between rooms, °F							
2	14.5	6.8	8.5	8.3	8.5	6.8	6.7	10.2
30	14.9	7.5	8.5	7.7	7.0	5.6	6.7	9.0
60	11.1	5.6	8.5	9.4	9.1	9.2	6.8	9.5
78	10.2	4.0	9.4	9.6	11.4	10.4	6.0	11.4
94	8.6	2.2	12.4	10.6	14.2	14.6	4.2	16.9
	Maximum vertieal temperature differences, °F							
2 to 60	9.9	10.8	11.4	12.4	12.1	12.5	13.1	13.1
2 to 94	13.3	13.5	17.4	14.9	20.4	21.8	16.1	22.3

[a] Data from tables 63, 65, 67, 69, 72, 74, 76, and 79.
[b] Cast iron.

TABLE 13. *Room temperature in the living zone for two types of space heater, with and without jackets, in two locations, with an unattached fan, at an outside temperature of 32° F [a]*

Test	1	2	3	4	5	6	7	8
Heater	A	A	A	A	A	A	A	C
Jacket	None	None	1	2	3	4	4	[b]
Position	2	4	2	2	2	2	4	2
Height above floor, in.	Temperature in living room, °F							
2	77	70	71	73	71	70	69	71
30	84	77	79	79	77	76	77	78
60	83	79	82	84	83	83	80	83
	Average of temperatures in other rooms, °F							
2	64	66	63	65	64	64	65	63
30	70	73	71	73	72	72	72	71
60	73	76	74	76	75	75	76	74

[a] Data from tables 63, 65, 67, 69, 72, 74, 76, and 79.
[b] Cast iron.

TABLE 14. *Average room temperatures in Test Bungalow at specific heights above the floor for two types of heater, with and without jacket, with unattached fan, for different heat outputs at outside temperatures ranging from 32° to 1° F*[a]

Height above floor, in.	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms
Heater A, without jacket, position 2										
Outside temp, °F	32		32		32		11			
Heat output, Btu/hr	22,000		22,200		22,000		31,600			
Fan position	At transom		At ceiling over mantel		On mantel		On mantel			
	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
2	78	63	76	63	77	64	77	59		
30	84	68	82	69	84	70	86	67		
60	84	70	84	72	83	73	84	71		
78	86	72	85	73	84	74	84	72		
94	89	73	86	75	84	76	86	74		
Heater A, without jacket, position 4, fan on mantel										
Outside temp, °F			32						1	
Heat output, Btu/hr			21,800						34,300	
2			70	66					62	58
30			77	73					74	69
60			79	76					77	72
78			79	77					77	73
94			79	78					77	75
Heater A, jacket 1, position 2, fan on mantel										
Outside temp, °F			32				11			
Heat output, Btu/hr			22,600				31,300			
2			71	63			68	57		
30			79	71			76	64		
60			82	74			82	70		
78			84	75			85	76		
94			89	77			94	81		
Heater A, jacket 2, position 2, fan on mantel										
Outside temp, °F			32				12		9	
Heat output, Btu/hr			22,600				31,900		33,400	
2			73	65			68	59	69	58
30			79	73			77	69	79	69
60			84	76			83	73	85	73
78			85	77			87	75	88	75
94			88	79			93	77	95	78
Heater A, jacket 3, position 2, fan on mantel										
Outside temp, °F			32				12			
Heat output, Btu/hr			22,100				30,900			
2			71	64			67	59		
30			77	72			78	69		
60			83	75			83	73		
78			87	76			85	74		
94			92	78			90	76		
Heater A, jacket 4, position 2, fan on mantel										
Outside temp, °F			32				13			
Heat output, Btu/hr			22,700				31,300			
2			70	64			66	59		
30			76	72			74	70		
60			83	75			84	75		
78			85	76			88	77		
94			91	78			96	79		
Heater A, jacket 4, position 4, fan on mantel										
Outside temp, °F			32		32				5	
Heat output, Btu/hr			22,100		24,700				33,900	
2			69	65	72	66			60	56
30			77	72	79	74			71	67
60			80	76	82	78			79	73
78			81	77	83	79			84	75
94			81	78	84	81			86	78

[a] Data from tables 61 to 80.

TABLE 14. *Average room temperatures in Test Bungalow at specific heights above the floor for two types of heater, with and without jacket, with unattached fan, for different heat outputs at outside temperatures ranging from 32° to 1° F*[a]—Continued

Height above floor, in.	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms
Heater C, cast-iron jacket, position 2, fan on mantel										
Outside temp, °F			32				14			
Heat output, Btu/hr			20,300							
2			71	63			68	58		
30			78	71			76	68		
60			83	74			83	73		
78			86	76			89	75		
94			94	77			98	77		

[a] Data from tables 61 to 80.

room temperatures at the 30- and 60-in. heights. However, for the radiant heater in position 4, the effect of the fan was negligible. The rise in temperature produced by the use of the fan was most marked in the case of a jacketed heater in position 4, for which an increase in temperature ranging from 4 to 9 deg F was observed in all rooms of the house. A greater increase in temperature occurred in the living room than in the other rooms for this heater position, thus causing a greater temperature difference between rooms with the fan in use. Better results probably would have been attained with the fan nearer the heater directing the air toward the colder areas of the house.

For outside temperatures in the range from 0° F to 10° F, the use of a desk fan on the mantel raised the living zone temperatures in all rooms from 1 to 7 deg F but the effect in the living room was less than in the other rooms. At the same time the air temperatures at the ceiling were reduced from 5 to 10 deg F in all rooms. Table 14 shows the average temperatures observed with the several heaters for outside temperatures ranging from 0° F to 32° F when the desk fan was used.

The maximum total temperature differences in the living zone between any two rooms in the Test Bungalow when using the desk fan on the fireplace mantel are plotted in figure 18 as ordinates and the heat outputs of the space heaters are plotted as abscissae in the same manner as was done for natural circulation. The radiant heater in the living room occasioned the greatest total temperature differences, while the same heater in position 4 caused the lowest temperature differences of all the heaters tested. Again, the results for all of the jacketed heaters in the living room can be represented by a single straight line, as was true for the same heaters with natural circulation. The total temperature differences associated with the jacketed heater in position 4 were about 2 deg F greater than those for the radiant heater in the same position for a given heat output.

A comparison of figure 17 and figure 18 shows that lower total temperature differences occurred when using the desk fan with all heaters except

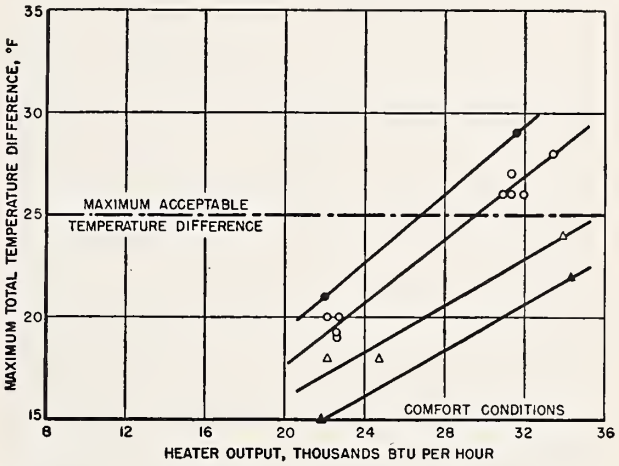

FIGURE 18. *Maximum total temperature difference in the living zone of the entire Test Bungalow for space heaters with unattached fans for a range of heat output from 20,000 to 36,000 Btu/hr.*

● Radiant heater in living room; ○ jacketed heaters in living room; ▲ radiant heater in position 4; △ jacketed heater in position 4.

the jacketed heater in position 4. The heat output that may be obtained from the several heaters in different positions in conjunction with the desk fan for given total temperature differences are shown in table 15. These data are taken from figure 18. A few of the values have been obtained by extrapolation of the straight line functions.

TABLE 15. *Total temperature difference*[a] *in relation to heat output for space heaters, with and without jacket, with unattached fan*

Maximum total temperature difference in living zone, °F	Heater output			
	Heater without jacket in living room	Heater with jacket in living room	Heater with jacket in central location	Heater without jacket in central location
	Btu/hr	*Btu/hr*	*Btu/hr*	*Btu/hr*
15	14,800	16,700	18,300	21,900
20	20,000	23,100	27,000	31,000
25	26,800	29,600	35,800	39,500
30	32,800	36,000		

[a] The "total temperature difference" is the maximum difference of temperature between any two rooms in the living zone from 2 to 60 in. above the floor.

XIV. Performance of Space Heaters With Integral Fans

Two space heaters with integral fans for circulating warm air were tested several years ago with substantially the same equipment as that used for the tests covered in this report, except that the Test Bungalow was not then enclosed for outside temperature control. A comparison of the performance of those two heaters with that of the heaters reported herein can be made from the data in tables 16 and 17.

One of the space heaters with an integral fan consisted of a gas-heated combustion chamber and heat exchanger in a decorative cabinet with an 18-in.-diameter disk fan in the back. The fan was driven by a 1/40-hp motor, which forced air through apertures in the heat exchanger and through a round adjustable grille in the front of the cabinet. The cabinet was 40 in. high by 26 in. wide by 16½ in. deep. The center line of the fan and grille was 27 in. above the floor. The heater fan delivered about 650 cfm.

The other space heater with an integral fan consisted of a combustion chamber and a heat exchanger in a case or cabinet and was heated with oil. The fan on one side drew hot air from the jacket space at about midheight of the combustion chamber and discharged it on the same side about 18 in. above the floor. All air entered the jacket space at the bottom. The cabinet was 45 in. high by 25 in. wide by 18 in. deep. The fan was driven by a 40-watt motor and delivered about 200 cfm. Both of these heaters were of interest because they were commercial models designed for quantity production.

TABLE 16. *Average temperatures in Test Bungalow for gas space heater with integral fan on the back tested in position 2* [a]

	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms
Outside temperature, °F	40	40	37	37	32	32	23	23
Wind velocity, mph					5	5	6	6
Height above floor, in.	Room temperature, °F							
2	64	60	65	59	63	58	60	55
30	69	68	70	68	70	68	68	67
60	80	73	85	77	86	75	91	76
78	83	75	89	78	90	79	94	81
94	85	77	91	79	92	80	98	82
	Maximum vertical temperature difference, °F							
2 to 60	16.3		19.9		22.7		30.2	
2 to 94	21.1		26.4		28.8		37.2	
	Maximum temperature difference between rooms, °F							
2	4.6		8.2		6.2		8.4	
30	2.3		3.9		3.5		3.8	
60	9.2		12.3		12.1		16.9	
78	8.7		13.2		12.2		14.9	
94	9.8		14.6		14.2		18.3	

[a] Data taken from tables 84, 85, 86, 87.

TABLE 17. *Average temperatures in Test Bungalow for an oil-fired space heater with integral fan tested in a position between 2 and 4 at an outside temperature of 32° F* [a]

Height above floor, inches	Living room	Other rooms
	Room temperature, °F	
2	68	63
30	80	74
60	94	80
78	101	83
94	104	85
	Maximum vertical temperature difference, °F	
2 to 60	26.2	
2 to 94	36.0	
	Maximum temperature difference between rooms, °F	
2	5.2	
30	7.2	
60	16.4	
78	21.5	
94	22.9	

[a] Data from table 88.

Results obtained with the gas heater with the integral fan on the back are listed in table 16. During the test the heater occupied position 2 in the living room with the grille adjusted as shown in figure 12. At an outside temperature of 32° F, the gas heater produced slightly smaller temperature differences between rooms at the 2-in. and 30-in. levels but considerably larger vertical temperature differences than heater A. The greater vertical temperature differences observed with the gas heater between the 30-in. and 60-in. levels in the living room are attributable to the horizontal discharge of warm air from the grille between 20 and 40 in. from the floor which affected the thermocouples at the 60-in. level. For a given temperature at the 60-in. level, the temperatures 2 in. above the floor were lower for the gas heater than for heater A. These results were probably caused in part by each of the following conditions that existed during the tests of the gas heater:

(a) Test Bungalow unenclosed, wind velocity 5 mph.

(b) Basement air temperature 3 deg F lower and attic temperature higher in most cases than for tests of heater A.

(c) Heater fan operated intermittently with intake level centered 27 in. above the floor.

Test results of the oil heater with a fan on the

side are contained in table 17. This heater occupied a position in the living room, chosen by a representative of its manufacturer, between position 2 and the hall. In addition to the grille on the right side, it also had a top outlet through which some warm air circulated by convection. The side grille discharged air toward the arch between the living room and the hall.

Much depends upon the power of a fan, but the results obtained with the heaters with fans suggest that the horizontal temperature differences between rooms are reduced proportionately more at the elevation in which the fan operates than at other heights above the floor. For example, the temperature differences between rooms were lower at levels of 2 in. and 30 in. above the floor with the heaters which had integral fans less than 30 in. above the floor than for heaters A and C with the fan placed about 72 in. above the floor. Also, the temperature differences between rooms from 60 in. above the floor to the ceiling for heaters A and C were smaller than for heaters with integral fans.

In general, the performances of the space heaters with integral fans were not superior from the standpoint of temperature distribution to those of heater A and heater C when used with a conventional desk fan on the mantel.

XV. Underfloor Return Plenum

Theoretically, the use of plenum chambers in basementless houses, whereby air returning to space heaters passes beneath rather than above floors, would seem to be desirable for preventing cold drafts near the floor. In actual practice, however, a space heater does not induce the desired air circulation in the plenum chamber.

The underfloor plenum system usually includes a grille in the floor near the outer walls, preferably under the windows, to receive cold air; a plenum chamber of some material like wallboard, insulation board, or wood attached to the bottom of the floor joists; and, a grille or opening whereby the air emerges from the plenum and ascends around the space heater. For tests of such a chamber, sheathing was supported on furring strips 3⅝ inches below the joists, thus permitting transverse air flow in the plenum. In this manner, air flow was established by the thermal or chimney effect around the heater. To increase this effect, the jacket around the heater was extended to the floor enclosing the grille or opening through which the air returned to the heater. The test system proved to be ineffective, as did several other observed installations where underfloor ducts or plenum chambers were formed of such materials as wallboard or wood. The numerous inevitable cracks in the constructions permitted so much leakage that air ascended not only around the heater but through the intended return grilles as well. The upward flow through the return grilles was evidently caused by the chimney action of the house itself, which is always considerable in a heated house in cold weather. The underfloor plenum might be successful if made of sheet metal, concrete, or even of paper applied with extreme care, but carpentry alone probably cannot be relied upon to give sufficient air tightness.

An underfloor return plenum was provided in the Test Bungalow during the program and, although the work was performed under laboratory conditions, as reported in table 18, the results were quite similar to those obtained in the field. Under test conditions, the plenum had no effect when the heater was unjacketed; for a heater with a jacket extending to the floor, the temperatures in the living zone were lowered from 1 to 4 deg F; and the temperatures near the ceiling varied. As indicated above, undesirable effects would presumably have been avoided if the plenum had been airtight.

TABLE 18. *Effect of an underfloor plenum on temperature distribution observed with type A space heater in position 4 at an outside temperature of 32° F* [a]

	Living room	Other rooms	Living room	Other rooms	Living room	Other rooms
Air return	Over floor		Through plenum		Through plenum	
Jacket	None		None		Floor length	
Heat output, Btu/hr.	22,200		21,800		21,900	
Height above floor, in.	Room temperature, °F					
2	71	66	71	67	68	65
30	77	72	74	71	70	68
60	80	76	78	74	76	73
78	83	78	80	78	80	78
94	86	82	84	82	84	84

[a] Data from tables 29, 81, and 82.

XVI. Effect of Insulation Under the Floor Joists

When the floor registers were sealed, the 1-in. sheets of insulating board that formed the bottom of the underfloor plenum provided insulation for the floor and created a dead-air space beneath it. Table 19 contains a comparison of the results obtained when the floor was insulated with the results obtained for an uninsulated floor.

TABLE 19. *Effect of insulation under floor joists on temperatures in a Test Bungalow with type A heater in position 4, at an outside temperature of 32° F* [a]

	Living room	Other rooms	Living room	Other rooms
Floor condition	Uninsulated		Insulated	
Heat output, Btu/hr	22,200		21,800	
Height above floor, in.	Room temperature, °F			
2	71	66	71	67
30	77	72	75	72
60	80	76	78	75
78	83	78	80	78
94	86	82	83	82

[a] Data from tables 29 and 83.

The average temperatures 2 in. above the floor were increased only about 1 deg F in four of the rooms, and were not increased at all at higher levels when the floor was insulated by the plenum. Two reasons why insulating the floor did not increase the temperatures more than was observed are:

(a) The air temperature in the plenum was nearer the basement air temperature than the upper floor surface temperature, indicating that the chimney action of the house caused a continual replacement of the air in the plenum with the cooler basement air through small openings and cracks in the wood floor and insulating board. Theoretically, this plenum temperature should have been about midway between the basement air temperature and the upper floor surface temperature if the plenum were airtight, but, as it was not, insulation probably would have been more effective had it been applied directly to the floor joists, thus isolating each joist space from the others instead of providing a plenum under the entire floor.

(b) A computation of the heat loss of the Test Bungalow, based on heat-transmission factors obtained with heat-flow meters and the temperatures observed with one of the space heaters used for this investigation, shows the following distribution of the heat loss without insulation under the floor joists:

	Percent
Outside walls	32.7
Inside walls (closet)	5.2
Windows and doors	31.3
Floor	14.9
Ceiling	9.0
Infiltration (by difference)	6.9
Total	100.0

Considering that nearly all infiltration loss was caused by inward leakage of cold air around windows and doors, the sum of the losses by transmission through the outside walls, windows, and doors and by infiltration was 70.9 percent of the total heat loss. In general, this loss took the form of a current of cold air falling down along the outside walls and flowing out across the floor, whereas only 14.9 percent of the heat was lost by direct transmission through the floor. In the case of an above-the-floor heating device, the current of cold air moved toward the heater above and near the floor. Insulation applied to the under side of the floor had no effect on the 70.9 percent of heat loss, but reduced the 14.9 percent of heat lost by transmission through the floor. That is, the heat loss of the outside walls and windows, and more specifically the temperature of the air moving down the walls near the floor, had a much greater effect on the floor temperature than the amount of insulation under the floor joists. The effects of these cold drafts are sometimes counteracted by radiant heat from a radiant heater or a warm ceiling surface. Recent information indicates that a blanket of warm air near the ceiling can cause the ceiling to radiate enough heat to the floor to warm it significantly.

XVII. Radius of Warmth Attainable With a Space Heater

In making tests on space heaters, the opportunity was afforded to obtain some information on the reactions of human individuals to a variety of temperature conditions. The available subjects were limited to the operating personnel, five adult men conventionlly dressed for work. They were comfortable at an air temperature of 65° F, 2 in. above the floor, and at temperatures up to 80° F at the 60-in. level. Complaints of cold feet were general after about an hour of slight activity with an air temperature of 60° F, 2 in. above the floor. An air temperature of 85° F or more at the 60-in. level became oppressive and usually caused noticeable perspiration in about an hour. Therefore, a *comfortable condition* was considered to exist whenever the temperature was at least 65° F, 2 in. above the floor, and the temperature not more than 80° F, 60 in. above the floor. It is presumed, of course, that the temperature always increases with height above the floor for the

heating methods under consideration. Also, based upon the above observations, a temperature of not less than 60° F, 2 in. above the floor, and a temperature of not more than 85° F, 60 in. above the floor, was considered a condition of *minimum acceptable comfort* for any floor area.

In figures 17 and 18, comfort conditions, as defined above, are indicated by the horizontal baselines. The horizontal line representing the maximum acceptable total temperature difference is also indicated on each chart. Figures 17 and 18 show that a total temperature difference of 15 deg F was exceeded in the living zone with every heater in any position for heat outputs greater than 20,000 Btu/hr for natural circulation and 22,000 Btu/hr when the fan was used in conjunction with the heater. A 25 deg F total temperature difference was exceeded in the living zone by a radiant heater in position 4, delivering 37,000 Btu/hr or more with natural circulation and about 39,500 Btu/hr or more with a circulating fan. The maximum outputs for a jacketed heater in the living room for a total temperature difference of 25 deg F were about 26,000 Btu/hr for natural circulation and 29,500 Btu/hr when a fan was used. The maximum heat outputs observed for the other heaters may be taken from figures 17 and 18.

In order to study the radii of the comfortable areas around the several space heaters, the temperatures observed at each station for each of four heights were entered on a miniature floor plan of the Test Bungalow at the corresponding location. This revealed the variation in temperature within each room. The temperatures for four separate tests, two with natural air circulation and two with the desk fan in use, are shown in figures 19, 20, 21, and 22. On the two floor plans showing the temperatures 2 in. above the floor and 60 in. above the floor, respectively, the heater position is shown and isothermal lines are sketched in for 60° F on the former and 85° F on the latter. Therefore, all of the floor area between these two isotherms met the requirements of minimum acceptable comfort for the corresponding test conditions.

Similar isothermal lines were drawn for each test condition and each outside temperature. The average radius of the isothermal line through all the points at a temperature of 60° F, 2 in. above the floor, was determined by measuring from the center of the heater through the center of connecting interior doorways to the 60° F isotherm in each room.

Results of the measurements of radii of the 60° F isotherm are shown in figure 23 and figure 24. The average radius of the outer limit of the zone of minimum acceptable comfort for heaters with natural circulation is plotted against outside temperatures in figure 23, and the corresponding results for the tests with a fan are shown in figure 24. These radii of the comfort zone were ob-

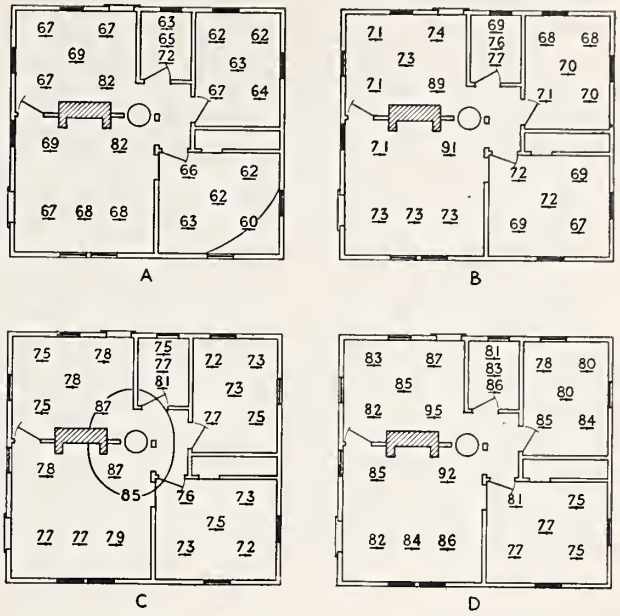

FIGURE 19. *Temperature distribution in the Test Bungalow at four levels shown on miniature floor plans for heater A without a jacket in position 4 with natural circulation of air for an outdoor temperature of 32° F.*

(*A*) Temperatures 2 in. above the floor, (*B*) temperatures 30 in. above the floor, (*C*) temperatures 60 in. above the floor, (*D*) temperatures 94 in. above the floor.

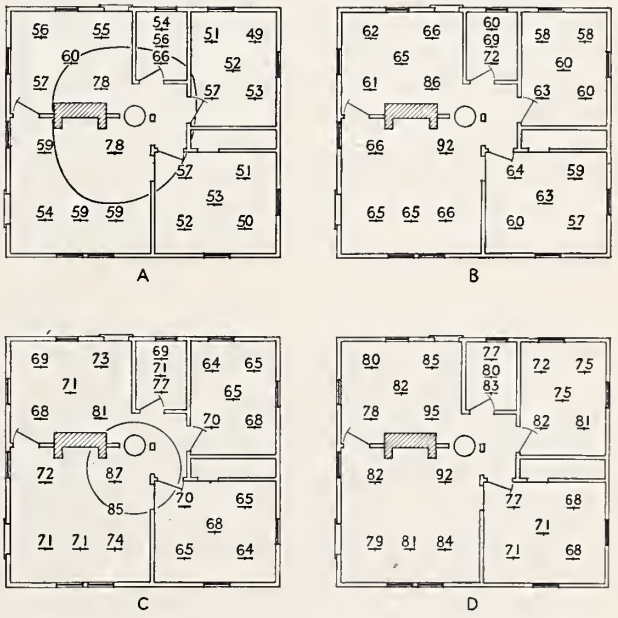

FIGURE 20. *Temperature distribution in the Test Bungalow at four levels shown on miniature floor plans for heater A without a jacket in position 4 with natural circulation of air for an outdoor temperature of 0° F.*

(*A*) Temperatures 2 in. above the floor, (*B*) temperatures 30 in. above the floor, (*C*) temperatures 60 in. above the floor, (*D*) temperatures 94 in. above the floor.

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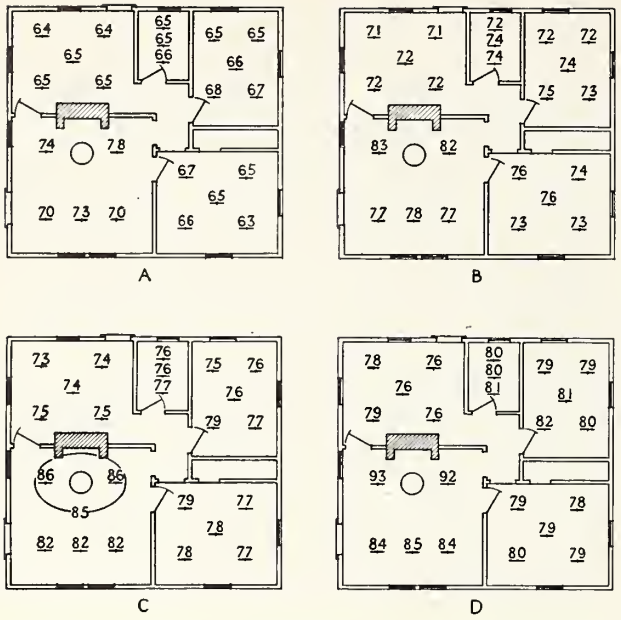

FIGURE 21. *Temperature distribution in the Test Bungalow at four levels shown on miniature floor plans for heater A with jacket 2 in position 2 with desk fan circulating the air for an outdoor temperature of 32° F.*

(*A*) Temperatures 2 in. above the floor, (*B*) temperatures 30 in. above the floor, (*C*) temperatures 60 in. above the floor, (*D*) temperatures 94 in. above the floor.

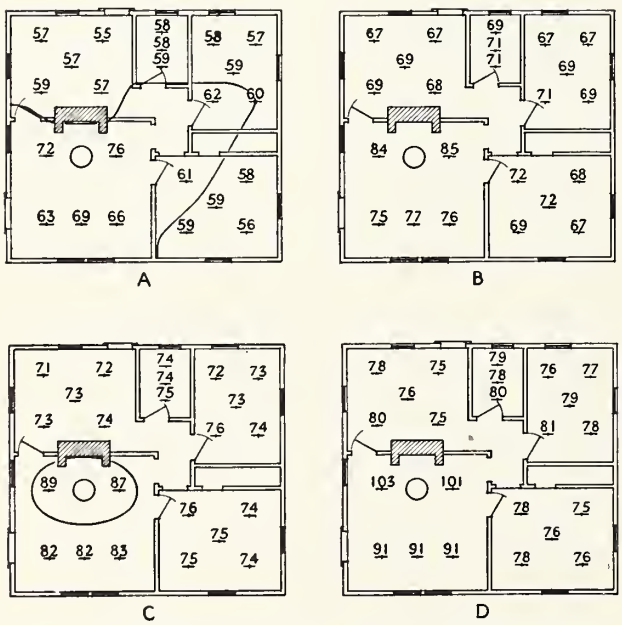

FIGURE 22. *Temperature distribution in the Test Bungalow at four levels shown on miniature floor plans for heater A with jacket 2 in position 2 with desk fan circulating the air for an outdoor temperature of 9° F.*

(*A*) Temperatures 2 in. above the floor, (*B*) temperatures 30 in. above the floor, (*C*) temperatures 60 in. above the floor, (*D*) temperatures 94 in. above the floor.

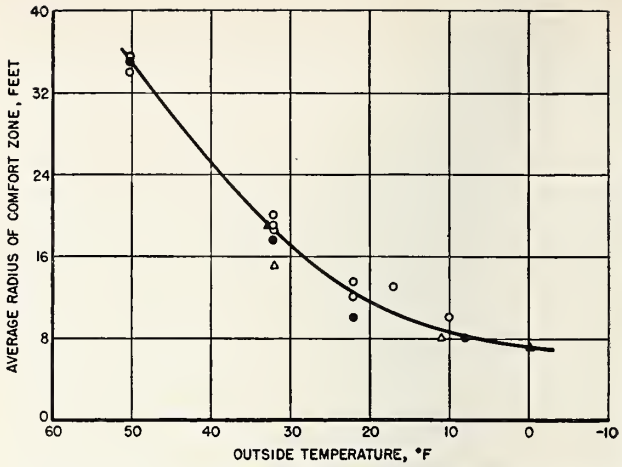

FIGURE 23. *Average radius of zone of minimum acceptable comfort for space heaters with natural circulation of air for a range of outdoor temperatures from 0° to 50° F.*

● Radiant heater in living room; ○ jacketed heaters in living room; ▲ radiant heater in position 4; △ jacketed heater in position 4.

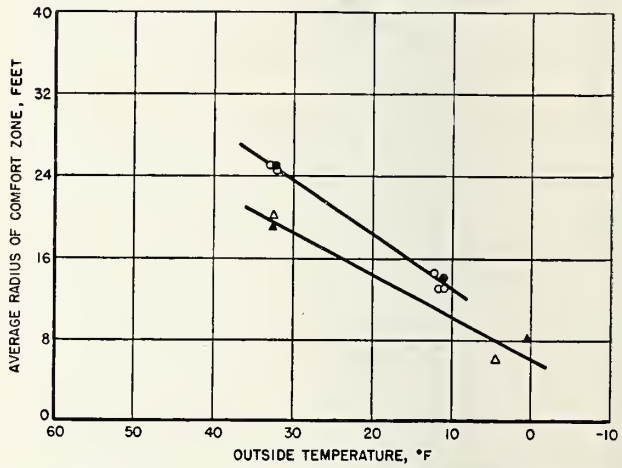

FIGURE 24. *Average radius of zone of minimum acceptable comfort for space heaters with desk fan circulating the air for a range of outdoor temperatures from 0° to 35° F.*

● Radiant heater in living room; ○ jacketed heaters in living room; ▲ radiant heater in position 4; △ jacketed heater in position 4.

tained by extrapolation for some of the tests at outside temperatures of 32° and 50° F, as illustrated by figure 21, where the 60° F isotherm was outside the limits of the building walls. The location of the 60° F isotherm in these cases was determined by continuing the observed gradient 2 in. above the floor in each room down to 60° F.

Considering figure 20, for example, the average radii of both the 60° F isotherm and the 85° F isotherm could obviously be lengthened by increasing the heat output of the space heater with a corresponding increase in the area that was overheated, and a similar but greater increase in area of the zone of comfort. Such an increase might be desirable under certain conditions if comfort in a particular location were the prime objective.

However, these tests were made to observe the degree of comfort obtainable in all rooms of a small house with little overheating of any of the occupied space.

Figure 23 shows that the radius of the zone of minimum acceptable comfort, as defined above, for both radiant and jacketed heaters in all positions with natural circulation can reasonably be shown by one curved line. The values of the radius ranged from about 7 ft for an outside temperature of 0° F to 19 ft for an outside temperature of 32° F. When the desk fan was used on the mantel, separate straight lines were used to show the results for position 4 and for the other positions as shown in figure 24. The values of the radius of the zone of minimum acceptable comfort ranged from 13 ft for an outside temperature of 10° F to 25 ft for an outside temperature of 32° F for heaters located in the living room with the fan located on the mantel. The radii of the comfort zones for heaters in position 4 were lower than for positions 1, 2, and 3 when the fan was used on the mantel. This was probably caused by the fact that the location on the mantel was not the best fan location for heaters in position 4. However, a given comfort radius for position 4 was more effective in warming several rooms than the same radius with the heater in the living room, because the comfort zone did not begin to extend into adjacent rooms until a radius in excess of the distance from the heater to the interior doors was attained with the heater located in the living room. Figure 23 and the results on which it is based apply only to homes with heat transmission characteristics similar to the Test Bungalow. For a house with a lower heat loss the comfort zone would be extended, and vice versa.

It was observed from the several charts similar to figures 19 to 22 used to analyze the area of the comfort zone that the temperature at the center of any room at any level was nearly equal to the average temperature at the same level for the whole room. That is, if the 60° F isotherm passed through the center of a room, the average temperature 2 in. above the floor would be very close to 60° F.

XVIII. Mean Radiant Temperatures

Observations were made at the 30-in. level in the living room approximately 3 ft from the center of the south wall to compare the readings of an 8-in. globe thermometer, shielded thermocouples, and a thermocouple enclosed in a block of cork, as described earlier in this report. The mean radiant temperature was computed for this station from the globe thermometer indication and the temperature indicated by the shielded thermocouples by equating the heat gain or loss of the globe by radiation to the heat loss or gain by convection. The formula developed by Peclet [3] for blackened spheres of similar size was used to determine the heat transfer by convection.

The observed temperatures and the computed mean radiant temperatures are summarized in table 20 for the several heaters in positions 2 and 4, both with natural circulation and with the desk fan in operation. Results showed that the mean radiant temperature of the surroundings, as measured at this station, was about the same with natural circulation as with the fan in operation except for heater A with jacket 4 in position 4. In this instance, the mean radiant temperature was raised 4.1 deg F by the use of the fan. However, the fan raised the air temperature at the station 5 deg F or more in every case but one. For heater A with jacket 4 in position 4, the fan raised the air temperature around the globe 12.6 deg F. Thus, for this heater, the fan increased the air temperature in the living room and thereby increased the wall-surface temperatures sufficiently to raise the mean radiant temperature at the globe thermometer about 4 deg F. For all other tests, the fan had a comparatively slight effect on the mean radiant temperature in the living room.

Table 20 also shows that the mean radiant temperature was higher than the air temperature by several degrees in every case except when the heater was located in position 4 and the fan was running. In these instances, the air temperature exceeded the mean radiant temperature by 2.5 deg F for the radiant heater and 3.7 deg F for the jacketed heater.

TABLE 20. *Radiation and convection conditions in living room for space heaters with and without jackets, in two positions, with natural and forced circulation of air at an outside temperature of 32° F* [a]

Test	1	2	3	4	5	6	7	8
Heater	A	A	A	A	A	A	A	C
Jacket	None	None	1	2	3	4	4	(b)
Position	2	4	2	2	2	2	4	2
Temperature measurement	Temperature with natural circulation, ° F							
Air temperature	------	71.4	69.6	70.2	71.9	68.5	65.2	69.5
Globe thermometer	78.8	73.5	74.2	73.9	75.3	73.0	68.1	75.0
Mean radiant temperature	------	74.0	77.0	75.7	76.8	75.6	70.0	77.4
Cork-covered thermocouple	78.1	73.2	73.9	73.7	74.8	72.2	67.2	74.6
	Temperature with fan, ° F							
Air temperature	76.9	76.6	75.6	76.7	74.4	74.9	77.8	75.4
Globe thermometer	80.0	75.1	77.1	78.0	76.7	75.9	75.5	78.2
Mean radiant temperature	81.3	74.1	77.6	78.5	77.8	76.2	74.1	79.7
Cork-covered thermocouple	80.4	74.7	77.3	77.9	76.0	75.2	75.2	77.4

[a] Data from tables 26, 29, 34, 37, 48, 51, 53, 56, 59, 63, 65, 67, 69, 72, 74, 76, and 79.

[b] Cast iron.

No observations were made with the globe thermometer in the other rooms of the house. It is probable, however, that the mean radiant temperature was lower than the air temperature in the other rooms when the space heater was located in the living room. When the heater was located in position 4 (see fig. 2) some parts of the other rooms in direct view of the heater probably had higher mean radiant temperatures than air temperatures. Although the air temperatures and the mean radiant temperatures summarized in table 20 for different heaters and different positions indicate different degrees of comfort at this station, satisfactory conclusions about comfort throughout the house cannot be drawn from these data as the living room was the warmest room for all of the tests.

Because the comfort of an environment depends upon the heat exchange between the body and its surroundings, both by radiation and convection, instruments that are affected by both radiation and convection, such as the globe thermometer, are usual for studies of comfort when radiant heat is present in the environment. Work by Bedford and others [4] shows that variations in dry-bulb temperature can be compensated for by approximately equal counter changes, degree for degree, in mean radiant temperature to produce equivalent comfort for changes up to 6 deg F. Therefore, the globe thermometer indications, recorded in table 20, are probably better measures of comfort at each location than either the air temperature or the mean radiant temperature taken separately, since the globe thermometer reading was near the average of the air temperature and the mean radiant temperature in every case. The cork-covered thermocouples, as shown in table 20, indicated almost the same temperature as the one observed at the center of the globe for every test. Therefore, cork-covered thermocouples of the type used for these observations were considered to provide better indications of comfort than thermocouples shielded to measure the true air temperature.

XIX. Summary and Conclusions

The investigation of temperatures produced in the Test Bungalow with space heaters showed that a space heater is a satisfactory means of heating a small house and that the temperature difference between different points in the living zone can be kept within specified limits if the climate is not too severe and if the heater location and other characteristics of the installation are properly selected.

Tests of space heaters in the Test Bungalow established the general conclusions that the maximum total temperature differences produced in the living zone of a house by a space heater were almost directly proportional to the heat output and that the radius of the zone of comfort decreased as the outside temperature decreased. The conditions for acceptable comfort as defined under chapter XVII, Radius of Warmth Attainable with a Space Heater, may or may not be too severe, but it is believed that the results presented in figures 17, 18, 23, and 24 of this report show the temperature differences and the radii of the 60° F isotherm which are likely to occur when houses similar to the Test Bungalow in size, construction, and degree of insulation are warmed by space heaters. Houses with insulation in the walls or with storm windows and weatherstripping would have a lower heat loss per unit area than the Test Bungalow and could, therefore, be warmed at a lower outside temperature without exceeding a given temperature difference in the living zone. Figures 23 and 24 indicate that structures larger than the Test Bungalow could be warmed by a space heater for moderate outside temperatures.

In particular the results showed that the use of space heaters for comfort heating of several rooms should be limited both as to the heat loss of the structure and the distance from the heater to the center of the rooms to be warmed. It is concluded that for houses similar to the Test Bungalow in size, construction, and degree of insulation a space-heater installation, to provide the minimum acceptable comfort in the heated area, must comply with the following two requirements:

1. For any outside design temperature the distance from the heater to the center of any room to be heated should not exceed the radius shown in figures 23 and 24 for the type of heater and the heater location used.

2. The heat loss of the house at the design outside temperature should not exceed the heat output corresponding to a total temperature difference of 25 deg F, shown in figures 17 and 18, for that type of heater installation. For this total temperature difference, permissible heat-loss values ranged from 21,000 to 37,000 Btu/hr for the several heaters tested without a fan, whereas the permissible heat-loss values ranged from 27,000 to approximately 40,000 Btu/hr for heaters used in conjunction with a desk fan. If lower total temperature differences than 25 deg F are desired, the maximum heat losses should be correspondingly lowered in accordance with the curves in figures 17 and 18.

The data show that the following installation practices would increase the comfort attainable in a house with a space heater or would permit the use of space heaters in larger houses and in colder climates:

1. Selection of a heater location near the center of the house, with approximately equal oppor-

tunity for radiation and convection to each of the surrounding rooms, decreased the temperature difference between rooms. In producing temperature distributions approaching uniformity among the several rooms of the Test Bungalow, the heaters tested fell into the following order of decreasing acceptability:

(a) Jacketed heater near the center of the house.
(b) Radiant heater near the center of the house.
(c) Jacketed heater in living room.
(d) Radiant heater in living room.

A jacketed heater produced lower temperature differences between rooms, but a radiant heater in any of the four positions described produced slightly lower temperature differences between the 2- and 60-in. levels than did the jacketed heater.

2. Use of a double-walled jacket similar to jacket 4 decreased the temperature differences between rooms. For single jackets, the width of the air space did not materially affect the temperature distribution for widths from 2½ to 6 in.

3. Use of open transoms over interior doorways increased the heat delivered to the colder rooms.

4. Use of a fan to blow the warmed air toward the colder rooms raised the temperature in the living zone and decreased the temperature differences between rooms. The unattached desk fan used for the tests was as effective as the integrally mounted fans in improving the distribution of heat.

Other conclusions derived from the results of the tests may be summarized as follows:

1. A radiant heater located near the center of the house produced a given temperature condition in the living zone with 15 to 20 percent less heat output than a jacketed heater.

2. The size of the heater in the range likely to be used for residential heating had little bearing on the temperature distribution.

3. An underfloor plenum for the return of cold air to a space heater must be practically airtight to be effective. The wood constructions tested were not sufficiently airtight for the plenum.

4. Insulation applied to the floor joists was not effective in making the floors warmer. Indications were that cold sidewalls and windows made the floor cold because of the cold drafts which descended and passed across the floor. The draft action was independent of the floor insulation. It appeared that insulated exposed walls were necessary for warmer floors, instead of, or perhaps in addition to, insulated floors in basementless houses.

5. The mean radiant temperature in the living room was several degrees above the air temperature for every heater position tried when the air was circulated by natural convection. Use of the desk fan raised the air temperature several degrees but changed the mean radiant temperature in the living room very little, except when the heater with the double jacket was located near the center of the house.

There is need for further research on space heaters as observations similar to those described in this report could well be made with a space heater to warm a single large room, to warm a two-story structure with an open stair well, or to provide radiant panel heating by means of a thin blanket of hot air near the ceiling.

For reasons of economy and convenience, space heaters will, no doubt, continue to be used in large numbers in American homes. They will probably still be purchased and installed by individual home owners without analysis or qualitative prediction of their performance. However, when responsible organizations attempt to specify or to define conditions that will guarantee comfort, criteria become essential. The work described in this paper was conducted as a means of establishing the magnitude of temperature differences that exist in a typical house warmed by different space heaters and to provide a basis for the selection of reasonable limits of dwelling size, heat loss, and temperature variation.

XX. Selected References

[1] Flue-connected oil-burning space heaters, NBS Commercial Standard CS101-43 (1943).

[2] R. S. Dill and P. R. Achenbach, Temperature distribution in a test bungalow with various heating devices, NBS Building Materials and Structures Report BMS108 (1947).

[3] Chester W. Rice, Free convection of heat in gases and liquids II, Trans. Am. Inst. Elec. Engrs. (Feb. 1924).

[4] F. C. Houghten, S. B. Gunst, J. Suciu, Radiation as a factor in the sensation of warmth, Am. Soc. Heating Ventilating Engrs. Research Report 1172, Am. Soc. Heating Ventilating Engrs. Trans **47**, 93 (1941).

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Robert K. Thulman and L. E. Seeley, Heating low-cost houses, Am. Soc. Heating Ventilating Engrs. Trans. **45**, 489 (1939).

XXI. Appendix

The temperatures observed for 68 different test conditions are shown in tables 21 to 88, inclusive. The headings show the heater used, the type of jacket, the position of the heater, the outside temperature, the average heat output, and whether or not a fan was used in the tests.

The averages of all of the temperatures observed in individual rooms for levels 2, 30, 60, 78, and 94 in. above the floor are shown in the tables as well as the vertical temperature differences from 2 to 60 in. and from 2 to 94 in. above the floor on a room-by-room basis and the averages for all rooms; the maximum differences in temperature between any two rooms for the five levels are also given and the difference for each level between the living room and the average of the other four rooms for the tests with the heater in the living room.

The tables show the basement and attic temperatures as well as the globe-thermometer temperature and the mean-radiant temperature for one station in the living room when these observations were taken.

The tables may be grouped as follows:

Tests with natural circulation of air, tables 21 to 60 and tables 81 to 83:

Radiant heater A	Tables 21 to 30.
Radiant heater B	Tables 31 to 34.
Heater A with jacket 1	Tables 35 to 42.
Heater A with jacket 2	Tables 43 to 50.
Heater A with jacket 3	Tables 51 to 52.
Heater A with jacket 4	Tables 53 to 58.
Heater C with cast-iron jacket	Tables 59 to 60.
Heater A with underfloor plenum	Tables 81 to 83.

Tests with detached fan, tables 61 to 80:

Radiant heater A	Tables 61 to 66.
Heater A with jacket 1	Tables 67 to 68.
Heater A with jacket 2	Tables 69 to 71.
Heater A with jacket 3	Tables 72 to 73.
Heater A with jacket 4	Tables 74 to 78.
Heater C with cast-iron jacket	Tables 79 to 80.

Tests with attached fans, tables 84 to 88:

Gas-fired heater	Tables 84 to 87.
Oil-fired heater	Table 88.

TABLE 21

Heater	A	Position	1
Outside temp	50.3° F	Heat output	13,900 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	78.2	67.9	66.9	68.5	65.1	13.1	11.1
30	82.3	72.0	71.2	74.0	70.8	11.5	10.3
60	83.0	74.2	74.2	76.5	73.4	9.6	8.4
78	87.5	75.4	76.5	77.2	76.1	12.1	11.2
94	89.1	77.4	79.4	79.0	78.4	11.7	10.5
	B. Vertical temperature difference, °F					Average for B	
2 to 60	4.8	6.3	7.3	8.0	8.3	6.9	
2 to 94	10.9	9.5	12.5	10.5	13.3	11.3	

Average basement temperature 54.4° F
Average attic temperature 58.8° F
Globe thermometer reading 82.0° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 22

Heater	A	Position	1
Outside temp	32.2° F	Heat output	21,400 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	76.7	61.0	59.4	61.9	57.4	19.3	16.8
30	81.6	66.1	65.0	67.1	64.1	17.5	16.0
60	82.6	69.3	69.6	71.2	68.0	14.6	13.1
78	89.4	71.4	73.3	72.7	72.2	18.0	17.0
94	91.2	74.4	78.1	76.5	76.0	16.8	14.9
	B. Vertical temperature difference, °F					Average for B	
2 to 60	5.9	8.3	10.2	9.3	10.6	8.9	
2 to 94	14.5	13.4	18.7	14.6	18.6	16.0	

Average basement temperature 49.4° F
Average attic temperature 47.9° F
Globe thermometer reading 83.6° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 23

Heater	A	Position	1
Outside temp	32.2° F	Heat output	21,400 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	77.5	62.0	60.0	62.5	58.6	18.9	16.7
30	82.8	67.4	65.9	68.8	65.4	17.4	15.9
60	83.7	70.5	70.5	72.1	69.4	14.3	13.1
78	90.3	72.6	73.9	73.5	73.3	17.7	17.0
94	92.3	75.5	78.6	77.0	76.9	16.8	15.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	6.2	8.5	10.5	9.6	10.8	9.1	
2 to 94	14.8	13.5	18.6	14.5	18.3	15.9	

Average basement temperature 49.1° F
Average attic temperature 49.1° F
Globe thermometer reading 84.2° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 24

Heater	A	Position	1
Outside temp	21.9° F	Heat output	26,500 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitchen	North bed-room	Soutb bed-room	Bath	Maxi-mum	Aver-age
2	74.7	57.2	55.6	58.4	53.5	21.2	18.5
30	82.9	63.4	62.5	64.5	61.3	21.6	20.0
60	83.9	67.2	67.6	69.4	66.0	17.9	16.3
78	92.0	69.8	72.2	71.4	71.2	22.2	20.8
94	93.6	73.3	78.0	76.0	75.4	20.3	17.9
	B. Vertical temperature differenee, °F					Average for B	
2 to 60	9.2	10.0	12.0	11.0	12.5	10.9	
2 to 94	18.9	16.1	22.4	17.6	21.9	19.4	

Average basement temperature 45.9° F
Average attie temperature 42.7° F
Globe thermometer reading 82.3° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 25

Heater	A	Position	1
Outside temp	8.3°F	Heat output	31,500 Btu/hr
Jacket	None	Fan used	No

Height ahove floor, in.	A. Average room temperature, °F					Horizontal temperature difference hetween rooms, °F	
	Living room	Kitehen	North bed-room	Soutb bed-room	Bath	Maxi-mum	Aver-age
2	72.5	52.2	51.6	54.5	48.8	23.7	20.7
30	81.8	59.3	58.0	61.0	56.8	25.0	23.0
60	83.2	63.7	64.1	66.2	62.1	21.1	19.2
78	92.3	66.7	69.6	68.7	68.1	25.6	24.0
94	93.9	70.7	76.1	73.9	72.6	23.2	20.6
	B. Vertical temperature difference, °F					Average for B	
2 to 60	10.7	11.5	12.5	11.7	13.3	11.9	
2 to 94	21.4	18.5	24.5	19.4	23.8	21.5	

Average basement temperature 41.9° F
Average attic temperature 35.8° F
Globe thermometer reading 82.1° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 26 [a]

Heater	A	Position	2
Outside temp	32.0° F	Heat output	22,100 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference hetween rooms, °F	
	Living room	Kitchen	North bed-room	South hed-room	Batb	Maxi-mum	Aver-age
2	77.0	62.5	61.2	63.5	59.0	18.0	15.4
30	82.2	68.1	66.8	70.0	66.0	16.2	14.5
60	84.0	71.1	71.6	73.6	70.2	13.8	12.4
78	89.9	73.0	74.9	74.6	74.4	16.9	15.7
94	92.0	75.6	79.1	77.8	78.1	16.4	14.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	7.0	8.6	10.4	10.1	11.2	9.5	
2 to 94	15.0	13.1	17.9	14.3	19.1	15.9	

Average basement temperature 49.2° F
Average attie temperature 48.6° F
Globe thermometer reading 78.8° F [b]

[a] Transoms over inside door open.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 27 [a]

Heater	A	Position	2
Outside temp	32.2° F	Heat output	21,800 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference hetween rooms, °F	
	Living room	Kitchen	North bed-room	Soutb bed-room	Bath	Maxi-mum	Aver-age
2	76.6	63.0	60.0	63.2	58.4	18.2	15.4
30	82.1	68.7	65.7	70.0	65.6	16.5	14.6
60	83.7	72.2	69.0	74.0	69.6	14.1	12.5
78	90.2	74.3	71.3	75.6	74.6	18.9	16.2
94	92.2	76.9	74.4	79.1	78.0	15.3	15.1
	B. Vertical temperature difference, °F					Average for B	
2 to 60	7.1	9.2	9.0	10.8	11.2	9.5	
2 to 94	15.6	13.9	14.4	15.9	19.6	15.9	

Average basement temperature 48.9° F
Average attic temperature 48.2° F
Globe thermometer reading 79.5° F [b]

[a] Transoms over inside doors elosed.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 28

Heater: A | Position: 3
Outside temp: 32.4° F | Heat output: 21,600 Btu/hr
Jacket: None | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	74.8	62.1	61.3	64.9	58.8	16.0	13.0
30	79.6	67.5	66.9	71.3	66.1	13.5	11.6
60	82.9	71.0	71.8	74.8	70.1	12.8	11.0
78	89.3	73.1	75.2	76.3	74.2	15.2	14.6
94	91.3	75.7	79.6	79.4	77.6	15.6	13.2
	B. Vertical temperature difference, °F					Average for B	
2 to 60	8.1	8.9	10.5	9.9	11.3	9.7	
2 to 94	16.5	13.6	18.3	14.5	18.8	16.3	

Average basement temperature 49.3° F
Average attic temperature 48.8° F
Globe thermometer reading 80.7° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 29

Heater: A | Position: 4
Outside temp: 32.0° F | Heat output: 22,200 Btu/hr
Jacket: None | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	70.7	70.3	63.4	62.6	66.9	8.1	
30	76.7	75.5	69.3	69.9	74.1	7.4	
60	79.6	78.7	74.0	73.6	77.4	6.0	
78	83.0	82.0	77.2	74.7	79.1	8.3	
94	85.7	86.5	81.4	77.0	83.3	9.5	
	B. Vertical temperature difference, °F					Average for B	
2 to 60	8.9	8.4	10.6	11.0	10.5	9.9	
2 to 94	15.0	16.2	18.0	14.4	16.4	16.0	

Average basement temperature 48.0° F
Average attic temperature 51.4° F
Globe thermometer reading 73.5° F [a]
Mean radiant temperature 74.0° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 30

Heater: A | Position: 4
Outside temp: 0.0° F | Heat output: 33,800 Btu/hr
Jacket: None | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	61.7	61.1	52.3	52.4	58.8	9.4	
30	70.7	67.9	59.6	60.3	67.0	11.1	
60	75.0	72.4	66.5	66.3	72.4	8.5	
78	80.1	78.2	71.3	67.7	74.3	12.4	
94	83.4	83.9	77.5	71.2	80.0	12.7	
	B. Vertical temperature difference, °F					Average for B	
2 to 60	13.3	11.3	14.2	13.9	13.6	13.3	
2 to 94	21.7	22.8	25.2	18.8	21.2	21.9	

Average basement temperature 37.9° F
Average attic temperature 35.7° F
Globe thermometer reading 65.8° F [a]
Mean radiant temperature 67.6° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 31 [a]

Heater: B | Position: 1
Outside temp: 32.3° F | Heat output: 21,500 Btu/hr
Jacket: None | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	75.9	62.0	61.3	63.8	59.1	16.8	14.3
30	81.8	67.7	66.3	69.0	65.2	16.6	14.7
60	84.5	70.7	70.8	73.0	69.5	15.0	13.5
78	91.7	73.1	74.5	74.6	74.0	18.6	17.6
94	95.7	76.0	79.9	78.9	77.8	19.7	17.5
	B. Vertical temperature difference, °F					Average for B	
2 to 60	8.6	8.7	9.5	9.2	10.4	9.3	
2 to 94	19.8	14.0	18.6	15.1	18.7	17.2	

Average basement temperature 50.5° F
Average attic temperature 49.7° F
Globe thermometer reading 82.4° F [b]

[a] Transoms over inside doors open
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 32 [a]

Heater	B	Position	1
Outside temp	32.2° F	Heat output	21,400 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	75.3	61.4	59.4	62.4	58.2	17.1	14.9
30	81.1	66.7	64.0	67.3	63.7	17.4	15.7
60	83.6	70.2	67.2	71.5	67.8	16.4	14.4
78	91.2	73.1	69.5	73.9	73.4	21.7	18.7
94	95.4	76.1	72.0	79.0	77.1	23.4	19.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	8.3	8.8	7.8	9.1	9.6	8.7	
2 to 94	20.1	14.7	12.6	16.6	18.9	16.6	

Average basement temperature 50.1° F
Average attic temperature 48.6° F
Globe thermometer reading 82.3° F [b]

[a] Principal heat source 24 in. above floor. Transoms closed.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 33 [a]

Heater	B	Position	1
Outside temp	32.1° F	Heat output	21,600 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	75.1	61.5	59.1	62.8	57.7	17.4	14.8
30	80.9	66.7	63.6	67.7	63.3	17.6	15.5
60	85.6	70.2	66.8	71.6	67.3	18.8	16.6
78	94.8	72.9	68.8	73.9	72.7	26.1	22.7
94	100.1	76.3	71.6	79.2	76.5	28.5	24.2
	B. Vertical temperature difference, °F					Average for B	
2 to 60	10.5	8.7	7.7	8.8	9.6	9.1	
2 to 94	25.0	14.8	12.5	16.4	18.8	17.5	

Average basement temperature 50.4° F
Globe thermometer reading 80.7° F [b]

[a] Principal heat source 39 in. above floor. Transoms closed.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 34

Heater	B	Position	2
Outside temp	33.4° F	Heat output	21,300 Btu/hr
Jacket	None	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	75.9	62.6	62.4	63.3	59.9	16.0	13.8
30	81.4	68.3	67.5	68.3	66.0	15.4	13.9
60	84.4	71.4	72.3	72.4	70.5	13.9	12.7
78	91.3	74.0	76.1	74.0	74.8	17.3	16.6
94	95.2	76.2	80.8	77.7	78.8	19.0	16.8
	B. Vertical temperature difference, °F					Average for B	
2 to 60	8.5	8.8	9.9	9.1	10.6	9.4	
2 to 94	19.3	13.6	18.4	14.4	18.9	16.9	

Average basement temperature 50.7° F
Average attic temperature 50.8° F
Globe thermometer reading 78.7° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in above floor.

TABLE 35

Heater	A	Position	1
Outside temp	32.1 °F	Heat output	22,700 Btu/hr
Jacket	1	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	71.2	60.4	61.0	61.5	58.6	12.6	10.8
30	76.7	65.8	65.8	67.6	65.2	11.5	10.6
60	81.1	70.3	71.4	72.3	70.7	10.8	9.9
78	93.2	74.2	78.0	74.6	76.9	19.0	17.3
94	99.0	78.2	84.2	79.4	81.1	20.8	18.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	9.9	9.9	10.4	10.8	12.1	10.6	
2 to 94	27.8	17.8	23.2	17.9	22.5	21.8	

Average basement temperature 48.9°F
Average attic temperature 51.6°F
Globe thermometer reading 76.3°F [a]
Mean radiant temperature 80.0°F [a]

[a] Center of south side of living room 3 ft from wall. 30 in. above floor.

Table 36

Heater	A	Position	2
Outside temp	50.5 °F	Heat output	13,600 Btu/hr
Jacket	1	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	74.2	67.4	67.3	67.4	65.8	8.4	7.2
30	77.6	71.7	71.5	72.8	71.2	6.4	5.8
60	80.8	74.4	75.2	76.1	74.6	6.4	5.7
78	88.5	76.2	78.8	77.5	78.2	12.3	10.8
94	91.9	78.7	82.8	79.8	81.0	13.2	11.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	6.6	7.0	7.9	8.7	8.8	7.8	
2 to 94	17.7	11.3	15.5	12.4	15.2	14.4	

Average basement temperature 54.4°F
Average attic temperature 60.9°F
Globe thermometer reading 76.5°F [a]
Mean radiant temperature 77.8°F [a]

[a] Center of southb side of living room 3 ft from wall, 30 in. above floor.

Table 37 [a]

Heater	A	Position	2
Outside temp	32.4° F	Heat output	22,600 Btu/hr
Jacket	1	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	70.8	60.9	61.7	64.0	59.3	11.5	9.3
30	76.0	66.5	66.5	68.0	65.0	11.0	9.5
60	80.2	70.9	73.4	73.7	71.5	9.3	7.8
78	91.0	74.0	78.3	74.9	77.7	17.0	14.8
94	95.4	77.7	82.4	79.2	81.3	17.7	15.3
	B. Vertical temperature difference, ° F					Average for B	
2 to 60	9.4	10.0	11.7	9.7	12.2	10.6	
2 to 94	24.6	16.8	20.7	15.2	22.0	19.9	

Average basement temperature 48.8° F
Average attic temperature 51.9° F
Globe thermometer reading 74.2° F [b]
Mean radiant temperature 77.0° F [b]

[a] Transoms over inside doors open.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 38

Heater	A	Position	2
Outside temp	32.4° F	Heat output	28,200 Btu/hr
Jacket	1	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	Nortb bedroom	South bedroom	Bath	Maximum	Average
2	74.7	63.4	63.9	64.1	61.1	13.6	11.6
30	80.7	70.2	69.9	71.5	69.3	11.4	10.5
60	86.4	75.2	76.5	77.2	75.8	11.2	10.2
78	99.4	79.3	83.5	79.6	82.7	20.1	18.1
94	104.2	82.7	91.2	84.6	87.7	21.5	17.6
	B. Vertieal temperature difference, ° F					Average for B	
2 to 60	11.7	11.8	12.6	13.1	14.7	12.8	
2 to 94	29.5	19.3	27.3	20.5	26.6	24.6	

Average basement temperature 48.9° F
Average attic temperature 54.2° F
Globe thermometer reading 78.6° F [a]
Mean radiant temperature 81.2° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 39

Heater	A	Position	2
Outside temp	22.0° F	Heat output	26,400 Btu/hr
Jacket	1	Fan used	No

Heigbt above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitcben	Nortb bedroom	South bedroom	Batb	Maximum	Average
2	68.8	57.7	58.2	58.4	55.3	13.5	11.4
30	75.3	64.2	64.2	65.3	63.4	11.9	11.0
60	80.9	69.4	70.9	71.3	69.8	11.5	10.5
78	92.9	73.4	78.1	74.2	76.3	19.5	17.4
94	99.5	77.5	85.6	79.3	81.0	22.0	18.6
	B. Vertical temperature difference, °F					Average for B	
2 to 60	12.1	11.7	12.7	12.9	14.5	12.8	
2 to 94	30.7	19.8	27.4	20.9	25.7	24.9	

Average basement temperature 43.5° F
Average attic temperature 48.0° F
Globe thermometer reading 72.5° F [a]
Mean radiant temperature 75.5° F [a]

[a] Center of southb side of living room 3 ft from wall, 30 in. above floor.

TABLE 40

Heater	A	Position	2
Outside temp	17.3° F	Heat output	29,300 Btu/hr
Jacket	1	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	69.7	57.8	58.6	59.1	56.1	13.6	11.8
30	76.0	64.4	64.5	65.7	64.0	12.0	11.3
60	82.1	69.9	71.8	72.1	70.9	12.2	11.9
78	96.6	74.4	79.5	75.2	77.9	22.2	19.8
94	101.6	78.8	86.7	80.6	82.9	22.8	19.3
	B. Vertieal temperature differenee, °F					Average for B	
2 to 60	12.4	12.1	13.2	13.0	14.8	13.1	
2 to 94	31.9	21.0	28.1	21.5	26.8	25.9	

Average basement temperature 44.2° F
Average attie temperature 47.5° F
Globe thermometer reading 73.7° F [a]
Mean radiant temperature 76.4° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 41

Heater	A	Position	3
Outside temp	32.4°F	Heat output	23,000 Btu/hr
Jacket	1	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	70.6	61.2	61.9	62.7	59.5	11.1	9.3
30	74.8	66.8	66.9	69.3	66.2	8.6	7.5
60	80.7	71.3	73.1	74.6	71.8	9.4	8.0
78	92.9	75.4	80.0	77.5	77.5	17.5	15.3
94	97.7	79.0	86.4	81.9	81.7	18.7	15.4
	B. Vertieal temperature differenee, °F					Average for B	
2 to 60	10.1	10.1	11.2	11.9	12.3	11.1	
2 to 94	27.1	17.8	24.5	19.2	22.2	22.2	

Average basement temperature 48.2° F
Average attie temperature 51.9° F
Globe thermometer reading 75.1°F [a]
Mean radiant temperature 78.0°F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 42 [a]

Heater		Position	2
Outside temp	32.5°F	Heat output	22,800 Btu/hr
Jacket	1	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	71.5	61.8	60.1	62.4	59.2	12.3	10.6
30	76.5	67.6	65.3	68.8	66.1	11.2	9.5
60	82.0	72.4	69.6	74.3	71.5	12.4	10.0
78	94.3	76.7	72.9	77.1	79.4	21.4	17.8
94	98.7	80.4	77.7	81.8	83.1	21.0	17.9
	B. Vertieal temperature differenee, °F					Average for B	
2 to 60	10.5	10.6	9.5	11.9	12.3	11.0	
2 to 94	27.2	18.6	17.6	19.4	23.9	21.3	

Average basement temperature 49.0°F
Average attie temperature 51.7°F
Globe thermometer reading 74.8°F [b]
Mean radiant temperature 77.6°F [b]

[a] Transoms elosed.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 43

Heater	A	Position	1
Outside temp	50.2° F	Heat output	14,200 Btu/hr
Jacket	2	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	74.2	66.6	66.2	66.7	64.5	9.7	8.2
30	77.9	71.0	70.6	72.7	70.4	7.5	6.7
60	81.3	74.1	74.0	76.2	74.1	7.3	6.7
78	88.5	76.3	77.4	77.8	77.6	12.2	11.2
94	92.1	79.0	81.7	80.4	80.3	13.1	11.7
	B. Vertieal temperature differenee, °F					Average for B	
2 to 60	7.1	7.5	7.8	9.5	9.6	8.3	
2 to 94	17.9	12.4	15.5	13.7	15.8	15.1	

Average basement temperature 52.3° F
Average attic temperature 59.9° F
Globe thermometer reading 78.7° F [a]
Mean radiant temperature 81.0° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 44

Heater: A | Position: 1
Outside temp: 32.2° F | Heat output: 23,000 Btu/hr
Jacket: 2 | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	72.2	61.7	61.4	62.0	59.5	12.7	11.0
30	77.5	67.6	66.7	69.0	66.3	11.2	10.1
60	82.6	72.5	72.0	74.4	72.0	10.6	9.9
78	93.4	76.0	77.4	76.8	77.7	17.4	16.4
94	98.6	79.7	83.6	81.2	81.6	18.9	17.1
	B. Vertical temperature difference, °F					Average for B	
2 to 60	10.4	10.8	10.6	12.4	12.5	11.3	
2 to 94	26.4	18.0	21.2	19.2	22.1	21.4	

Average basement temperature 48.2° F
Average attic temperature 51.6° F
Globe thermometer reading 77.5° F [a]
Mean radiant temperature 80.4° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 45

Heater: A | Position: 1
Outside temp: 32.5 °F | Heat output: 26,700 Btu/hr
Jacket: 2 | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	76.3	64.0	64.0	64.6	61.3	15.0	12.8
30	82.3	71.2	70.6	72.6	71.2	11.7	10.9
60	87.7	76.9	75.7	78.6	77.6	12.0	10.5
78	100.9	81.5	82.1	81.2	82.3	19.7	19.1
94	106.7	85.0	85.0	85.9	87.2	21.7	20.9
	B. Vertical temperature difference, °F					Average for B	
2 to 60	11.4	12.9	11.7	14.0	16.3	13.3	
2 to 94	30.4	21.0	21.0	21.3	25.9	23.9	

Average basement temperature 48.8 °F
Average attic temperature 54.4 °F
Globe thermometer reading 82.5 °F [a]
Mean radiant temperature 86.8 °F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 46

Heater: A | Position: 1
Outside temp: 21.9 °F | Heat output: 28,200 Btu/hr
Jacket: 2 | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	71.3	58.0	58.8	59.6	56.4	14.9	13.1
30	77.7	65.5	64.9	67.4	64.8	12.9	12.0
60	83.9	71.8	71.2	73.9	71.8	12.7	11.7
78	96.5	76.1	77.9	76.9	78.4	20.4	19.2
94	102.4	80.2	85.6	82.3	83.0	22.2	19.6
	B. Vertical temperature difference, °F					Average for B	
2 to 60	12.6	13.8	12.4	14.3	15.4	13.7	
2 to 94	31.1	22.2	26.8	22.7	26.6	25.9	

Average basement temperature 44.2 °F
Average attic temperature 48.9 °F
Globe thermometer reading 77.1 °F [a]
Mean radiant temperature 81.7 °F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 47

Heater: A | Position: 1
Outside temp: 17.0 °F | Heat output: 31,100 Btu/hr
Jacket: 2 | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	73.2	59.7	60.2	60.9	57.9	15.3	13.5
30	80.3	67.4	66.8	69.1	66.6	13.7	12.9
60	87.7	74.0	74.4	76.2	73.8	13.9	13.1
78	100.6	78.6	81.0	79.7	80.6	22.0	20.6
94	106.7	83.2	87.8	84.8	85.3	23.5	21.4
	B. Vertical temperature difference, °F					Average for B	
2 to 60	14.5	14.3	14.2	15.3	15.9	14.8	
2 to 94	33.5	23.5	27.6	23.9	27.4	27.2	

Average basement temperature 44.4 °F
Average attic temperature 48.4 °F
Globe thermometer reading 79.9 °F [a]
Mean radiant temperature 85.0 °F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 48

Heater	A	Position	2
Outside temp	32.3 °F	Heat output	22,000 Btu/hr
Jacket	2	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	70.8	61.3	61.4	61.6	59.4	11.4	9.9
30	75.7	66.8	66.6	68.1	66.2	9.5	8.8
60	81.2	71.5	72.7	73.4	71.7	9.7	8.9
78	90.9	74.7	77.8	75.8	77.0	16.2	14.6
94	95.1	78.4	83.3	79.8	81.1	16.7	14.4
	B. Vertical temperature difference, °F					Average for B	
2 to 60	10.4	10.2	11.3	11.8	12.3	11.2	
2 to 94	24.3	17.1	21.9	18.2	21.7	20.6	

Average basement temperature 48.3 °F
Average attic temperature 51.7 °F
Globe thermometer reading 73.9 °F [a]
Mean radiant temperature 75.7 °F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 49

Heater	A	Position	2
Outside temp	12.2°F	Heat output	31,900 Btu/hr
Jacket	2	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	69.4	57.2	57.8	58.2	55.3	14.1	12.3
30	76.6	65.0	64.5	66.0	64.2	12.4	11.7
60	84.1	71.5	72.6	73.6	71.8	12.6	11.7
78	96.3	75.9	79.2	76.8	78.6	20.4	18.7
94	101.0	80.6	86.5	82.4	83.7	20.4	17.7
	B. Vertical temperature difference, °F					Average for B	
2 to 60	14.7	14.3	14.8	15.4	16.5	15.1	
2 to 94	31.6	23.4	28.7	24.2	28.4	27.3	

Average basement temperature 41.8° F
Average attic temperature 45.6° F
Globe thermometer 74.0° F [a]
Mean radiant temperature 77.2° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 50

Heater	A	Position	2
Outside temp	9.8°F	Heat output	33,500 Btu/hr
Jacket	2	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	67.8	54.8	55.7	56.3	53.2	14.6	12.8
30	75.3	62.5	62.0	63.6	61.9	13.4	12.8
60	82.8	69.6	70.7	71.8	70.2	13.2	12.3
78	95.1	74.0	78.5	75.0	77.5	21.1	18.8
94	99.1	78.5	85.2	80.7	82.8	20.6	17.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	15.0	14.8	15.0	15.5	17.0	15.5	
2 to 94	31.3	23.7	29.5	24.4	29.6	27.7	

Average basement temperature 41.6° F
Average attic temperature 42.7° F
Globe thermometer reading 72.1° F [a]
Mean radiant temperature 75.8° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 51

Heater	A	Position	2
Outside temp	32.7° F	Heat output	22,300 Btu/hr
Jacket	3	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	71.6	62.4	62.0	62.5	60.1	11.5	9.8
30	76.9	68.4	67.7	69.9	67.4	9.5	8.5
60	83.2	73.1	73.7	75.1	72.8	10.4	9.5
78	90.8	76.1	77.9	77.3	77.7	14.7	13.5
94	93.9	79.2	82.7	80.9	81.3	14.7	12.9
	B. Vertical temperature difference, °F					Average for B	
2 to 60	11.6	10.7	11.7	12.6	12.7	11.9	
2 to 94	22.3	16.8	20.7	18.4	21.2	19.9	

Average basement temperature 48.3° F
Average attic temperature 52.2° F
Globe thermometer reading 75.3° F [a]
Mean radiant temperature 76.8° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 52

Heater	A	Position	2
Outside temp	9.9° F	Heat output	31,700 Btu/hr
Jaeket	3	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	66.4	55.2	55.5	56.6	53.7	12.7	11.1
30	74.8	63.6	62.8	65.2	62.7	12.1	11.2
60	83.9	70.2	70.6	72.5	70.0	13.9	13.1
78	93.2	74.1	76.1	75.5	76.2	19.1	17.8
94	96.8	78.1	81.3	80.3	80.5	18.7	16.7
	B. Vertical temperature difference, °F					Average for B	
2 to 60	17.5	15.0	15.1	15.9	16.3	16.0	
2 to 94	30.4	22.9	25.8	23.7	26.8	25.9	

Average basement temperature 40.8° F
Average attic temperature 42.4° F
Globe thermometer reading 72.5° F [a]
Mean radiant temperature 75.5° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 53

Heater	A	Position	2
Outside temp	32.3 °F	Heat output	22,200 Btu/hr
Jacket	4	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	68.5	61.2	62.1	61.8	59.7	8.8	7.3
30	73.3	66.6	66.7	67.7	66.2	7.1	6.5
60	81.0	71.2	72.8	73.2	72.0	9.8	8.7
78	93.9	75.3	78.9	76.0	78.0	18.6	16.8
94	99.2	79.5	83.8	78.9	82.4	20.3	18.0
	B. Vertical temperature difference, °F					Average for B	
2 to 60	12.5	10.0	10.7	11.4	12.3	11.2	
2 to 94	30.7	18.3	21.7	17.1	22.7	22.1	

Average basement temperature 48.9° F
Average attic temperature 52.9° F
Globe thermometer reading 73.0° F [a]
Mean radiant temperature 75.6° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 54

Heater	A	Position	2
Outside temp	32.7 °F	Heat output	26,000 Btu/hr
Jacket	4	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	73.1	64.4	65.3	64.6	62.4	10.7	8.9
30	78.7	70.8	70.8	71.8	70.2	8.5	7.8
60	87.7	76.2	78.0	78.2	77.2	11.5	10.3
78	102.7	80.8	85.3	81.1	84.1	21.9	19.9
94	108.5	85.3	93.3	86.9	89.5	23.2	19.7
	B. Vertical temperature difference, °F					Average for B	
2 to 60	14.6	11.8	12.7	13.6	14.8	13.5	
2 to 94	35.4	20.9	28.0	22.3	27.1	26.7	

Average basement temperature 49.0° F
Average attic temperature 55.8° F
Globe thermometer reading 78.4° F [a]
Mean radiant temperature 79.6° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 55

Heater	A	Position	2
Outside temp	11.8° F	Heat output	32,100 Btu/hr
Jaeket	4	Fan used	No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	65.5	55.3	56.8	56.4	53.3	12.2	10.0
30	72.1	62.8	62.8	64.0	61.7	10.4	9.3
60	83.5	69.5	71.7	71.9	71.1	14.0	12.7
78	101.2	75.7	80.7	76.2	79.8	25.5	23.1
94	107.1	81.1	90.1	83.1	85.7	26.0	22.1
	B. Vertical temperature difference, ° F					Average for B	
2 to 60	18.0	14.2	14.9	15.5	17.8	16.1	
2 to 94	42.6	25.8	33.3	26.7	32.4	32.2	

Average basement temperature 40.3° F
Average attic temperature 45.8° F
Globe thermometer reading 71.4° F [a]
Mean radiant temperature 75.6° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 56

Heater: A | Position: 2
Outside temp: 31.9° F | Heat output: 21,700 Btu/hr
Jacket: 4 | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	64.6	62.4	60.5	59.8	58.8	5.8	
30	68.2	66.6	64.7	65.1	65.0	3.5	
60	74.8	73.0	71.7	71.1	71.8	3.7	
78	82.2	81.1	77.2	73.8	78.1	8.4	
94	86.7	88.7	83.4	77.6	82.6	11.1	
	B. Vertical temperature difference, °F					Average for B	
2 to 60	10.2	10.6	11.2	11.3	13.0	11.3	
2 to 94	22.1	26.3	22.9	17.8	23.8	22.6	

Average basement temperature 48.8° F
Average attic temperature 50.1° F
Globe thermometer reading 68.1° F [a]
Mean radiant temperature 70.0° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 57

Heater: A | Position: 4
Outside temp: 32.4° F | Heat output: 24,100 Btu/hr
Jacket: 4 | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	67.9	65.8	63.2	61.8	61.9	6.0	
30	72.3	70.6	68.3	68.4	69.6	4.0	
60	79.4	78.7	75.9	74.7	76.7	4.7	
78	87.6	87.1	82.0	77.1	81.7	10.5	
94	93.0	95.0	88.6	81.7	88.6	13.3	
	B. Vertical temperature difference, °F					Average for B	
2 to 60	11.5	12.9	12.7	12.9	14.8	13.0	
2 to 94	25.1	29.2	25.4	19.9	26.7	25.3	

Average basement temperature 48.5°F
Average attic temperature 53.5° F
Globe thermometer reading 71.3°F [a]
Mean radiant temperature 71.8°F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 58

Heater: A | Position: 4
Outside temp: 11.0° F | Heat output: 31,700 Btu/hr
Jacket: 4 | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	61.6	58.8	56.2	55.2	55.3	8.3	
30	66.9	65.1	62.4	62.5	64.1	4.5	
60	76.6	75.9	72.2	71.0	73.6	5.6	
78	85.9	86.9	80.8	74.8	80.3	12.1	
94	92.4	95.5	89.1	80.7	88.9	14.8	
	B. Vertical temperature difference, °F					Average for B	
2 to 60	15.0	17.1	16.0	15.8	18.3	16.4	
2 to 94	30.8	36.7	32.9	25.5	33.6	31.9	

Average basement temperature 40.9°F
Average attic temperature 44.7°F
Globe thermometer reading 65.4°F [a]
Mean radiant temperature 67.4°F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 59

Heater: C | Position: 2
Outside temp: 32.7 °F | Heat output: 21,600 Btu/hr
Jacket: Cast iron | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	70.9	61.5	61.7	62.3	58.8	12.1	9.8
30	76.2	67.3	66.6	68.7	66.1	10.1	9.0
60	82.9	72.6	73.5	74.5	72.6	10.3	9.6
78	94.3	75.9	78.9	76.6	77.4	18.4	17.1
94	99.7	78.9	85.8	80.5	81.9	20.8	17.9
	B. Vertical temperature difference, °F					Average for B	
2 to 60	12.0	11.1	11.8	12.2	13.8	12.2	
2 to 94	28.8	17.4	24.1	18.2	23.1	22.3	

Average basement temperature 49.0 °F
Average attic temperature 52.9 °F
Globe thermometer reading 75.0 °F [a]
Mean radiant temperature 77.4 °F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 60

Heater: C | Position: 2
Outside temp: 14.2 °F | Fan used: No
Jacket: Cast iron

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	68.8	55.8	56.2	56.9	52.6	16.2	13.4
30	76.2	63.6	62.3	65.0	61.7	14.5	13.0
60	85.9	71.6	72.1	73.9	70.8	15.1	13.8
78	98.8	76.3	79.6	77.6	77.9	22.5	20.9
94	107.4	80.9	88.7	83.7	82.9	26.5	23.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	17.1	15.8	15.9	17.0	18.2	16.8	
2 to 94	38.6	25.1	32.5	26.8	30.3	30.7	

Average basement temperature 40.8 °F
Average attic temperature 46.5 °F
Globe thermometer reading 74.5 °F [a]
Mean radiant temperature 80.4 °F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 61

Heater: A | Position: 2
Outside temp: 32.3°F | Heat output: 22,000 Btu/hr
Jacket: None | Fan used: Yes [a]

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	77.6	63.1	63.8	64.5	58.5	19.1	15.1
30	83.9	69.3	68.1	71.6	64.1	19.8	15.6
60	83.6	71.5	69.3	74.3	66.3	17.3	13.2
78	86.3	72.7	70.6	75.0	68.0	18.3	14.7
94	88.6	74.8	72.9	76.5	68.3	20.3	16.1
	B. Vertical temperature difference, °F					Average for B	
2 to 60	6.0	8.4	5.5	9.8	7.8	7.5	
2 to 94	11.0	11.7	9.1	12.0	9.8	10.7	

Average basement temperature 48.8°F
Average attic temperature 47.8°F
Globe thermometer reading 80.4°F [b]

[a] Fan at transom between living room and hall.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 62

Heater: A | Position: 2
Outside temp: 32.0°F | Heat output: 22,200 Btu/hr
Jacket: None | Fan used: Yes [a]

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	76.3	63.5	62.7	64.3	62.1	14.2	13.1
30	82.1	70.0	68.1	71.3	67.7	14.4	12.8
60	83.5	72.1	71.3	74.2	70.6	12.9	11.4
78	84.9	73.1	72.5	74.9	73.0	12.4	11.5
94	86.0	74.5	74.7	76.3	74.4	11.6	11.0
	B. Vertical temperature difference, °F					Average for B	
2 to 60	7.2	8.6	8.6	9.9	8.5	8.6	
2 to 94	9.7	11.0	12.0	12.0	12.3	11.4	

Average basement temperature 51.8°F
Average attic temperature 48.0°F
Globe thermometer reading 79.4°F [b]
Mean radiant temperature 81.2°F [b]

[a] Fan at ceiling over fireplace mantel.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 63

Heater: A | Position: 2
Outside temp: 32.1 °F | Heat output: 22,000 Btu/hr
Jacket: None | Fan used: Yes [a]

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	76.8	64.3	63.1	64.8	62.3	14.5	13.2
30	83.6	70.8	68.7	71.8	69.2	14.9	13.5
60	83.1	73.0	72.0	74.7	72.2	11.1	10.1
78	83.6	74.0	73.4	75.1	74.0	10.2	9.5
94	84.1	75.5	75.5	75.8	75.6	8.6	8.5
	B. Vertical temperature difference, °F					Average for B	
2 to 60	6.3	8.7	8.9	9.9	9.9	8.7	
2 to 94	7.3	11.2	12.4	11.0	13.3	11.0	

Average basement temperature 51.7° F
Average attic temperature 48.4° F
Globe thermometer reading 80.0° F [b]
Mean radiant temperature 81.3° F [b]

[a] Fan on fireplace mantel.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 64

Heater: A | Position: 2
Outside temp: 11.2° F | Heat output: 31,600 Btu/hr
Jacket: None | Fan used: Yes [a]

Heigbt above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitcben	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	76.6	58.7	58.2	60.7	57.2	19.4	17.9
30	85.8	67.0	65.8	69.1	65.9	20.0	18.8
60	84.1	69.7	70.3	73.1	70.0	14.4	13.3
78	83.9	70.8	72.0	73.6	72.4	13.1	11.7
94	86.1	72.7	74.8	73.9	74.3	13.4	12.2
	B. Vertieal temperature difference, °F					Average for B	
2 to 60	7.5	11.0	12.1	12.4	12.8	11.2	
2 to 94	9.5	14.0	16.6	13.2	17.1	14.1	

Average basement temperature 46.8° F
Average attie temperature 39.1° F
Globe thermometer reading 79.8° F [b]
Mean radiant temperature 83.0° F [b]

[a] Fan on fireplaee mantel.
[b] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 65

Heater: A | Position: 4
Outside temp: 32.0° F | Heat output: 21,800 Btu/hr
Jacket: None | Fan used: Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	69.9	68.1	63.1	68.3	66.1	6.8	
30	77.3	74.1	69.8	75.1	74.3	7.5	
60	78.5	76.0	72.9	76.9	76.9	5.6	
78	78.7	77.2	74.7	77.1	77.0	4.0	
94	78.8	77.9	76.6	77.6	78.6	2.2	
	B. Vertieal temperature difference, °F					Average for B	
2 to 60	8.6	7.9	9.8	8.6	10.8	9.1	
2 to 94	8.9	9.8	13.5	9.3	12.5	10.8	

Average basement temperature 48.3° F
Average attie temperature 49.3° F
Globe thermometer reading 75.1° F [a]
Mean radiant temperature 74.1° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 66

Heater: A | Position: 4
Outside temp: 0.7° F | Heat output: 34,300 Btu/hr
Jacket: None | Fan used: Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitchen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	62.1	60.3	55.1	58.5	58.8	7.0	
30	74.3	69.9	64.3	69.8	70.2	10.0	
60	76.5	73.4	68.5	73.5	73.3	8.0	
78	76.7	74.9	70.4	74.0	73.7	6.3	
94	77.3	76.1	73.7	75.7	75.5	3.6	
	B. Vertieal temperature difference, °F					Average for B	
2 to 60	14.4	13.1	13.4	15.0	14.5	14.1	
2 to 94	15.2	15.8	18.6	17.2	16.7	16.7	

Average basement temperature 39.0° F
Average attie temperature 35.2° F
Globe thermometer reading 69.6° F [a]
Mean radiant temperature 68.3° F [a]

[a] Center of soutb side of living room 3 ft from wall, 30 in. above floor.

Table 67

Heater: A | Position: 2
Outside temp: 32.1° F | Heat output: 22,600 Btu/hr
Jacket: 1 | Fan used: Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitchen	North bed-room	Soutb bed-room	Bath	Maxi-mum	Aver-age
2	71.2	62.9	63.1	63.5	62.7	8.5	8.1
30	78.5	70.7	70.0	71.7	70.5	8.5	7.8
60	81.8	73.7	73.3	74.9	73.6	8.5	7.9
78	84.3	75.2	74.9	75.6	75.5	9.4	9.0
94	88.6	77.3	77.1	76.2	77.3	12.4	11.6
	B. Vertieal temperature difference, °F					Average for B	
2 to 60	10.6	10.8	10.2	11.4	10.9	10.8	
2 to 94	17.4	14.4	14.0	12.7	14.6	14.6	

Average basement temperature 49.0° F
Average attie temperature 50.3° F
Globe thermometer reading 77.1° F [a]
Mean radiant temperature 77.6° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 68

Heater	A	Position	2
Outside temp	11.0° F	Heat output	31,300 Btu/hr
Jaeket	1	Fan used	Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	68.0	56.2	59.5	58.8	58.5	11.8	9.7
30	76.4	66.0	68.9	68.9	69.1	10.4	8.2
60	82.0	70.8	72.9	73.3	72.7	11.2	9.6
78	85.3	72.3	74.5	74.2	75.1	13.0	11.3
94	94.0	74.7	76.6	75.1	76.6	19.3	18.2
	B. Vertieal temperature differenee, ° F					Average for B	
2 to 60	14.0	14.6	13.4	14.5	14.2	14.2	
2 to 94	26.0	18.5	17.1	16.3	18.1	19.2	

Average basement temperature 41.3° F
Average attie temperature 42.5° F
Globe thermometer reading 74.0° F [a]
Mean radiant temperature 75.8° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 69

Heater	A	Position	2
Outside temp	32.5°F	Heat output	22,600 Btu/hr
Jaeket	2	Fan used	Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	72.8	64.5	66.0	65.2	65.1	8.3	7.6
30	79.3	71.6	73.3	74.3	73.2	7.7	6.2
60	83.5	74.1	76.6	77.6	76.4	9.4	7.3
78	84.8	75.2	77.9	78.4	78.3	9.6	7.3
94	87.6	77.0	79.9	78.9	80.0	10.6	8.6
	B. Vertieal temperature differenee, °F					Average for B	
2 to 60	10.7	9.6	10.6	12.4	11.3	10.9	
2 to 94	14.8	12.5	13.9	13.7	14.9	14.0	

Average basement temperature 49.2°F
Average attie temperature 51.5°F
Globe thermometer reading 78.0°F [a]
Mean radiant temperature 78.5°F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 70

Heater	A	Position	2
Outside temp	12.1°F	Heat output	31,900 Btu/hr
Jaeket	2	Fan used	Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	68.3	56.9	59.6	58.8	58.9	11.4	9.7
30	77.1	67.0	69.5	69.9	70.1	10.1	8.0
60	83.2	71.4	73.8	74.6	73.9	11.8	9.8
78	86.6	73.0	75.7	75.6	76.5	13.6	11.4
94	92.9	75.6	78.2	76.6	78.5	17.3	15.7
	B. Vertical temperature difference, °F					Average for B	
2 to 60	14.9	14.5	14.2	15.8	15.0	14.9	
2 to 94	24.6	18.7	18.6	17.8	19.6	19.9	

Average basement temperature 41.1°F
Average attie temperature 43.5°F
Globe thermometer reading 75.2°F [a]
Mean radiant temperature 76.2°F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 71

Heater	A	Position	2
Outside temp	9.4° F	Heat output	33,400 Btu/hr
Jaeket	2	Fan used	Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	69.2	56.9	59.1	58.5	58.6	12.3	10.9
30	79.4	67.8	68.5	69.5	70.1	11.6	10.4
60	84.7	72.5	73.3	73.6	74.2	12.2	11.3
78	88.0	74.4	75.4	75.4	76.7	13.6	12.5
94	95.4	76.9	78.2	76.5	78.8	18.9	17.8
	B. Vertieal temperature differenee, °F					Average for B	
2 to 60	15.5	15.6	14.2	15.1	15.6	15.2	
2 to 94	26.2	20.0	19.1	18.0	20.2	20.7	

Average basement temperature 41.4°F
Average attie temperature 42.6°F
Globe thermometer reading 76.6°F [a]
Mean radiant temperature 78.2°F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 72

Heater ..... A | Position 2
Outside temp ..... 32.4° F | Heat output ..... 22,100 Btu/hr
Jacket ..... 3 | Fan used ..... Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	71.3	62.8	64.4	63.5	63.6	8.5	7.7
30	77.4	70.4	72.0	72.1	72.3	7.0	5.7
60	83.1	74.0	75.3	75.6	75.5	9.1	8.0
78	86.7	75.3	76.6	76.4	77.6	11.4	10.2
94	91.7	77.5	78.6	77.6	79.0	14.2	13.5
	B. Vertical temperature difference, °F					Average for B	
2 to 60	11.8	11.2	10.9	12.1	11.9	11.6	
2 to 94	20.4	14.7	14.2	14.1	15.4	15.8	

Average basement temperature 48.3° F
Average attic temperature 51.6° F
Globe thermometer reading 76.7° F [a]
Mean radiant temperature 77.8° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 73

Heater ..... A | Position 2
Outside temp ..... 12.4° F | Heat output ..... 30,900 Btu/hr
Jacket ..... 3 | Fan used ..... Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	67.4	56.8	59.8	58.8	59.7	10.6	8.6
30	77.7	67.0	69.3	69.5	70.2	10.7	8.7
60	82.9	70.9	73.2	73.7	73.3	12.0	10.1
78	85.0	72.2	74.6	74.5	75.5	12.8	10.8
94	90.1	74.6	77.0	75.3	77.2	15.5	14.1
	B. Vertical temperature difference, ° F					Average for B	
2 to 60	15.5	14.1	13.4	14.9	13.6	14.3	
2 to 94	22.7	17.8	17.2	16.5	17.5	18.3	

Average basement temperature 41.0° F
Average attic temperature 43.0° F
Globe thermometer reading 74.4° F [a]
Mean radiant temperature 74.8° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 74

Heater ..... A | Position 2
Outside temp ..... 32.4° F | Heat output ..... 22,700 Btu/hr
Jacket ..... 4 | Fan used ..... Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	69.5	62.7	64.4	63.9	63.7	6.8	5.8
30	76.0	70.4	71.9	73.1	72.2	5.6	4.1
60	82.6	73.4	75.2	76.4	75.4	9.2	7.5
78	85.2	74.8	76.3	77.2	77.2	10.4	8.8
94	91.3	76.7	78.8	77.8	78.8	14.6	13.3
	B. Vertical temperature difference, ° F					Average for B	
2 to 60	13.1	10.7	10.8	12.5	11.7	11.8	
2 to 94	21.8	14.0	14.4	13.9	15.1	15.8	

Average basement temperature 48.6° F
Average attic temperature 51.7° F
Globe thermometer reading 75.9° F [a]
Mean radiant temperature 76.2° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

TABLE 75

Heater ..... A | Postion 2
Outside temp ..... 13.4° F | Heat output ..... 31,300 Btu/hr
Jacket ..... 4 | Fan used ..... Yes

Height above floor, in.	A. Average room temperature, ° F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	65.5	56.6	62.5	59.1	58.9	8.9	6.2
30	73.8	67.4	70.3	71.0	72.0	6.4	3.6
60	83.6	72.1	75.0	75.9	75.9	11.5	8.9
78	87.9	73.6	77.0	76.8	78.9	14.3	11.3
94	96.3	76.2	80.2	77.4	80.3	20.1	17.8
	B. Vertical temperature difference, ° F					Average for B	
2 to 60	18.1	15.5	12.5	16.8	17.0	16.0	
2 to 94	30.8	19.6	17.7	18.3	21.4	21.6	

Average basement temperature 40.3° F
Average attic temperature 45.3° F
Globe thermometer reading 74.0° F [a]
Mean radiant temperature 75.5° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor

Table 76

Heater	A	Position	4
Outside temp	32.1° F	Heat output	22,100 Btu/hr
Jaeket	4	Fan used	Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	69.0	64.9	62.7	68.9	62.3	6.7	
30	76.5	72.8	69.8	75.4	71.7	6.7	
60	79.9	76.7	73.1	77.4	75.4	6.8	
78	80.8	78.2	74.8	77.7	76.9	6.0	
94	81.1	79.1	76.9	78.1	78.4	4.2	
	B. Vertieal temperature differenee, ° F					Average for B	
2 to 60	10.9	11.8	10.4	8.5	13.1	10.9	
2 to 94	12.1	14.2	14.2	9.2	16.1	13.2	

Average basement temperature 48.9° F
Average attie temperature 50.2° F
Globe thermometer reading 75.5° F [a]
Mean radiant temperature 74.1° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 77

Heater	A	Position	4
Outside temp	31.7° F	Heat output	24,700 Btu/hr
Jaeket	4	Fan used	Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	72.4	66.8	64.2	67.7	64.7	8.2	
30	79.0	74.9	72.0	75.5	74.1	7.0	
60	81.5	79.0	76.0	78.2	77.7	5.5	
78	82.8	80.8	77.9	78.5	80.2	4.9	
94	83.9	83.5	80.3	78.9	82.8	5.0	
	B. Vertieal temperature differenee, °F					Average for B	
2 to 60	9.1	12.2	11.8	10.5	13.0	11.3	
2 to 94	11.5	16.7	16.1	11.2	18.1	14.7	

Average basement temperature 49.1° F
Average attie temperature 51.6° F
Globe thermometer reading 78.3° F [a]
Mean radiant temperature 77.5° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 78

Heater	A	Position	4
Outside temp	4.5° F	Heat output	33,900 Btu/hr
Jaeket	4	Fan used	Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	60.3	56.8	55.1	57.0	55.7	5.2	
30	70.8	67.5	63.6	68.1	69.1	7.2	
60	79.3	77.8	66.7	73.3	75.1	12.6	
78	83.9	81.0	68.3	74.4	77.9	15.6	
94	85.8	83.9	71.5	77.3	80.7	14.3	
	Vertieal temperature differenee. °F					Average for B	
2 to 60	19.0	21.0	11.6	16.3	19.4	17.5	
2 to 94	25.5	27.1	16.4	20.3	25.0	22.9	

Average basement temperature 38.7° F
Average attie temperature 38.6° F
Globe thermometer reading 69.4° F [a]
Mean radiant temperature 68.4° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 79

Heater	C	Position	2
Outside temp	32.2° F	Heat output	20,300 Btu/hr
Jaeket	Cast iron	Fan used	Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature differenee between rooms, °F	
	Living room	Kitehen	North bed-room	South bed-room	Bath	Maxi-mum	Aver-age
2	71.2	62.6	62.2	64.3	61.9	10.2	8.7
30	77.9	70.3	68.9	73.1	70.2	9.0	7.3
60	82.5	73.5	73.0	76.3	74.1	9.5	8.3
78	86.1	74.9	74.7	77.0	76.2	11.4	10.4
94	93.5	76.6	77.6	77.3	77.2	16.9	16.3
	B. Vertical temperature differenee, ° F					Average for B	
2 to 60	11.5	10.9	10.8	12.0	13.1	11.6	
2 to 94	22.3	14.0	15.4	13.0	16.2	16.2	

Average basement temperature 48.8° F
Average attie temperature 51.2° F
Globe thermometer reading 78.2° F [a]
Mean radiant temperature 79.7° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 80

Heater: C | Position: 2
Outside temp: 13.8° F | Fan used: Yes
Jacket: Cast iron

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	67.5	56.9	58.2	59.5	57.0	10.6	9.6
30	75.9	67.1	67.0	70.6	68.9	8.9	7.5
60	83.3	72.1	72.3	75.3	73.6	11.2	10.0
78	88.9	73.8	74.5	76.4	76.4	15.1	13.6
94	97.9	76.0	78.0	77.3	77.7	21.9	20.6
	B. Vertical temperature difference, °F					Average for B	
2 to 60	15.8	15.2	14.1	15.8	16.6	15.5	
2 to 94	30.4	19.1	19.8	17.8	20.7	21.6	

Average basement temperature 41.3° F
Average attic temperature 45.3° F
Globe thermometer reading 75.4° F [a]
Mean radiant temperature 77.7° F [a]

[a] Center of south side of living room 3 ft from wall, 30 in. above floor.

Table 81

Heater: A | Position: 4 [a]
Outside temp: 31.9° F | Heat output: 21,800 Btu/hr
Jacket: None | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	70.5	71.3	63.8	65.3	66.6	7.5	
30	74.0	76.3	67.5	69.3	71.6	8.8	
60	77.5	77.9	71.2	73.2	74.2	6.7	
78	80.1	82.5	74.6	76.1	77.1	7.9	
94	83.5	89.8	79.3	79.8	79.7	10.5	
	B. Vertical temperature difference, °F					Average for B	
2 to 60	7.0	6.6	7.4	7.9	7.6	7.3	
2 to 94	13.0	18.5	15.5	14.5	13.1	14.9	

Average basement temperature 47.4° F
Average attic temperature 53.8° F

[a] Heater over register, with underfloor plenum.

Table 82

Heater: A | Position: 4
Outside temp: 31.8° F | Heat output: 21,900 Btu/hr
Jacket: 3 [a] | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	67.8	67.6	63.5	65.0	63.5	4.3	
30	70.3	70.6	66.6	68.3	68.2	4.0	
60	75.8	76.2	71.4	73.1	72.8	4.8	
78	79.8	82.9	76.1	77.1	77.6	6.8	
94	83.5	90.0	82.0	82.6	81.2	8.8	
	B. Vertical temperature difference, °F					Average for B	
2 to 60	8.0	8.6	7.9	8.1	9.3	8.4	
2 to 94	15.7	22.4	18.5	17.6	17.7	18.4	

Average basement temperature 47.8° F
Average attic temperature 54.5° F

[a] Jacket extended down to floor over register with underfloor plenum.

Table 83 [a]

Heater: A | Position: 4
Outside temp: 31.7° F | Heat output: 21,800 Btu/hr
Jacket: None | Fan used: No

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	71.0	71.1	64.4	66.6	66.0	6.7	
30	75.0	74.9	68.4	70.0	72.7	6.6	
60	78.2	78.0	72.0	74.2	75.2	6.2	
78	79.5	82.9	75.0	76.3	78.0	7.9	
94	82.7	86.9	79.6	80.9	80.5	7.3	
	B. Vertical temperature difference, °F					Average for B	
2 to 60	7.2	6.9	7.6	7.6	9.2	7.7	
2 to 94	11.7	15.8	15.2	14.3	14.5	14.3	

Average basement temperature 48.9° F
Average attic temperature 53.2° F

[a] Floor insulated with 1-in. Celotex, spaced 3⅝ in. from floor joists.

Table 84

Heater: Gas-fired [a] | Position: 2
Outside temp: 32 °F [b] | Heat output Btu/hr: Intermittent
Jacket: See fig. 12 | Fan used: Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	62.9	58.2	57.7	61.2	56.7	6.2	4.4
30	70.1	69.3	67.7	68.4	66.6	3.5	2.1
60	85.6	77.3	74.8	74.7	73.5	12.1	10.5
78	89.6	81.6	78.1	77.6	77.4	12.2	10.9
94	91.7	82.6	79.5	78.7	77.5	14.2	12.1
	B. Vertical temperature difference, °F					Average for B	
2 to 60	22.7	19.6	17.1	13.5	16.8	17.9	
2 to 94	28.8	24.4	21.8	17.5	20.8	22.7	

Average basement temperature 45.6° F
Average attic temperature 59.8° F

[a] Gas-fired space heater, thermostatically controlled, with attached fan.
[b] North wind 5 mph.

Table 85

Heater: Gas-fired [a] | Position: 2
Outside temp: 23.0 °F [b] | Heat output Btu/hr: Intermittent
Jacket: See fig. 12 | Fan used: Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	60.3	55.9	54.7	56.9	51.9	8.4	5.4
30	68.3	68.7	66.6	66.2	64.5	3.8	1.8
60	90.5	79.8	76.2	75.6	73.6	16.9	14.2
78	93.6	84.2	80.3	78.7	79.1	14.9	13.0
94	97.5	86.5	82.4	80.0	79.2	18.3	15.5
	B. Vertical temperature difference, °F					Average for B	
2 to 60	30.2	23.9	21.5	18.7	21.7	23.2	
2 to 94	37.2	30.6	27.7	23.1	27.3	29.2	

Average basement temperature 43.0° F
Average attic temperature 42.5° F

[a] Gas-fired space heater, thermostatically controlled, with attached fan.
[b] North wind 6 mph.

Table 86

Heater: Gas-fired [a] | Position: 2
Outside temp: 37 °F | Heat output Btu/hr: Intermittent
Jacket: See fig. 12 | Fan used: Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	64.8	59.4	58.4	62.3	56.6	8.2	5.6
30	70.1	68.9	67.8	68.9	66.2	3.9	2.2
60	84.7	76.2	74.4	74.3	72.4	12.3	10.4
78	89.4	80.0	77.6	76.7	76.2	13.2	11.8
94	91.2	81.8	79.1	78.0	76.6	14.6	12.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	19.9	16.8	16.0	12.0	15.8	16.1	
2 to 94	26.4	22.4	20.7	15.7	20.0	21.0	

Average basement temperature 46.5° F
Average attic temperature 61.0° F

[a] Gas-fired space heater, thermostatically controlled, with attached fan.

Table 87

Heater: Gas-fired [a] | Position: 2
Outside temp: 40°F | Heat output Btu/hr: Intermittent
Jacket: See fig. 12 | Fan used: Yes

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	63.5	60.5	59.7	61.9	58.9	4.6	3.3
30	69.2	68.0	67.0	68.0	66.9	2.3	1.7
60	79.8	74.1	72.3	73.2	70.7	9.1	7.2
78	83.0	76.2	75.0	75.5	74.3	8.7	7.8
94	84.6	78.0	76.8	77.0	74.8	9.8	7.9
	B. Vertical temperature difference, °F					Average for B	
2 to 60	16.3	13.6	12.6	11.3	11.8	13.1	
2 to 94	21.1	17.5	17.1	15.1	15.9	17.3	

Average basement temperature 49.5°F
Average attic temperature 54.5°F

[a] Gas-fired space heater, thermostatically controlled, with attached fan.

Table 88

Heater: Oil-fired [a] | Position: Near 2
Outside temp: 32°F | Fan used: Yes
Jacket: See fig. 13

Height above floor, in.	A. Average room temperature, °F					Horizontal temperature difference between rooms, °F	
	Living room	Kitchen	North bedroom	South bedroom	Bath	Maximum	Average
2	68.0	63.4	63.1	63.7	62.8	5.2	4.8
30	79.8	75.6	73.0	73.8	72.6	7.2	6.0
60	94.2	84.2	77.8	78.9	78.1	16.4	14.4
78	100.7	89.6	79.2	80.6	82.0	21.5	17.9
94	104.0	92.9	81.1	82.6	82.2	22.9	19.3
	B. Vertical temperature difference, °F					Average for B	
2 to 60	26.2	20.8	14.7	15.2	15.3	18.4	
2 to 94	36.0	29.5	18.0	18.9	19.4	24.3	

Average basement temperature 51.1°F

[a] Manually operated oil-fired space heater with attached fan.

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BUILDING MATERIALS AND STRUCTURES REPORTS

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