U.S. Department of Commerce, Bureau of Standards

RESEARCH PAPER RP596

Part of Bureau of Standards Journal of Research, Vol. 11, September 1933

FIRE HAZARD OF DOMESTIC HEATING INSTALLATIONS

By G. Q. Voigt

ABSTRACT

Tests were conducted with stoves, furnaces, and their pipes, spaced at different distances from unprotected partitions, ceilings, and floors, and the maximum temperatures thereon measured, in an attempt to determine by experimental means the fire hazard involved. Protections of sheet metal, asbestos, or brick were then applied and the closest distance determined that would be safe from the standpoint of ignition of the wood. It was found that stoves for house heating should be spaced not less than 24 inches from walls faced with wood. If bright sheet metal is applied to the walls, the spacing can be decreased to 12 inches. Similarly, plastered wood stud partitions, while requiring a spacing of not less than 18 inches if unprotected, may be spaced at 9 inches if bright sheet metal is applied.

If stoves are without ashpits or if ashpits are heated to near redness, an air space of 5 inches or more was indicated as necessary between the stove and a wood floor, in addition to ¼-inch thick incombustible insulation applied under sheet metal over the exposed portion of the floor. With the firebox resting directly on the floor, temperatures high enough to cause ignition of wood were transmitted through a 4-inch brick base.

Tests with smokepipes indicated that a clearance of 12 inches from ceiling or joists was adequate. Where smokepipes pass through combustible partitions, either a ventilated air space of not less than 4 inches, or 2 inches of insulation all around the pipe, was found necessary.

Furnaces for hot-water installations and their pipes were found to present little hazard to adjacent construction as fired with either coal, oil, or gas. The hazard from warm-air heating ducts was found to be moderate, protections being required only where they enter floors or partitions relatively close to the furnace. In the case of the "pipeless" furnace the down-draft of cold air around the warm-air duct protects the adjacent construction, the hazard with this equipment resulting mainly from placing combustible materials on the warm-air register or locating the latter beneath or too close to partitions.

Tests with a gas range having an oven without insulation indicated that 6-inch separation between the side of the oven and a wood partition gives reasonably safe conditions.

CONTENTS

I. INTRODUCTION

An annual fire loss for the country, as a whole, of about $20,000,000 is reported as caused by stoves, furnaces, boilers, and their pipes, or between 9 and 10 percent of the loss from all known causes. If heating installations are responsible for the same proportion of these fires, the causes of which could not be ascertained, the total fire loss per year from such installations would be about $45,000,000. Such fires result from placing stoves, furnaces, and other heating equipment too near combustible walls, partitions, and ceilings, or from absence of adequate protection for floors. Definite information on the required spacings of heating equipment from unprotected combustible construction and on the protections needed for closer spacings has been lacking, the requirements in building codes being based largely on the judgment of men experienced in fire protection and fire underwriting.

Tests were undertaken to determine the practicability of evaluating the fire hazards of such installations by laboratory methods. In such tests it is not necessary to introduce conditions which actually result in ignition, since the temperatures to which adjacent combustible materials are heated, are a measure of the hazard.

For a proper degree of safety, temperatures on exposed wood construction frequently exceeding 125° C. (257° F.) should probably be avoided, although apparently no decided hazard is involved if they occasionally reach 150° C. (302° F.). The determination of experimental conditions and general planning of the tests were based in part on information obtained in a survey of fires from such equipment occurring in the District of Columbia during the period 1928 to 1930. The information was obtained from reports on such fires, inspections of the premises affected, and inspection and tests of installations considered hazardous.

The tests were confined to domestic househeating and cooking equipment, and were made with the types most commonly used. Smokepipes, stoves, and furnaces were tested in relation to the fire hazard to adjacent partitions, ceilings, and platforms. Several types of protection for such combustible constructions were tested in cases where it appeared that such protection was necessary to avoid unduly large spacings between the construction and the appliance. The practical aspects have been kept in mind throughout

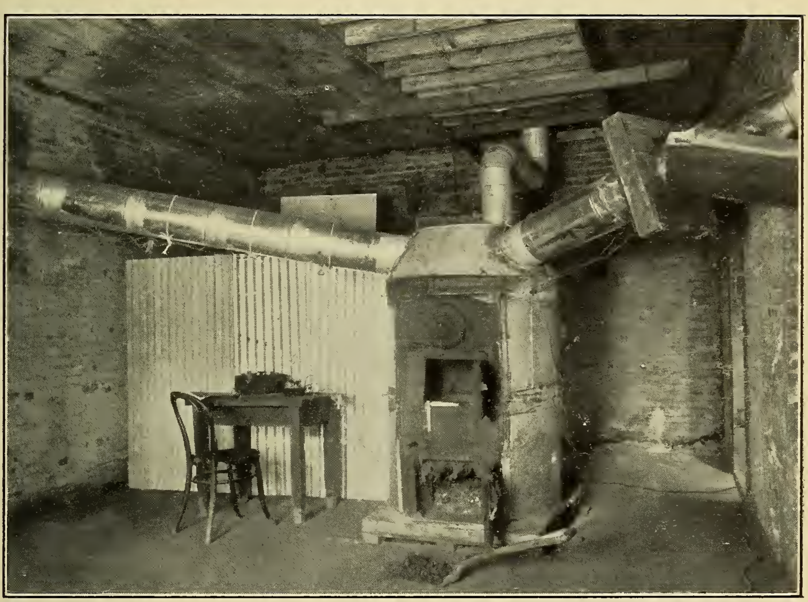

FIGURE 1.—*Warm-air heating unit.*

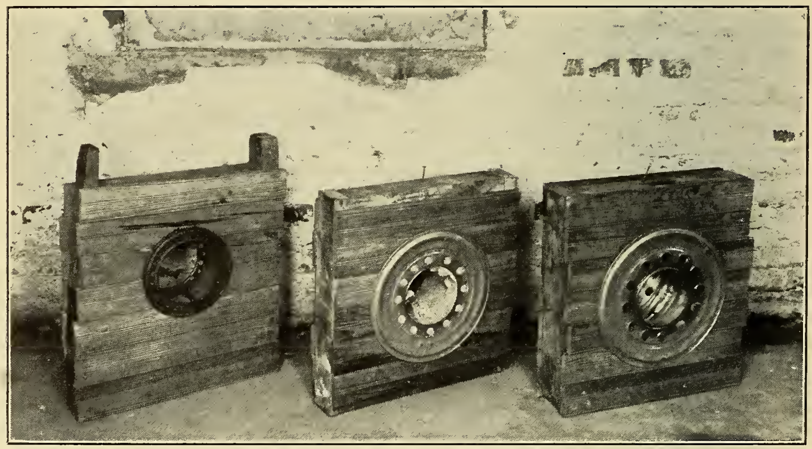

FIGURE 4.—*Smokepipe thimbles.*

so that compliance with any requirements based on the results of these tests can be had at minimum inconvenience and expense.

II. TESTS TO DETERMINE SMOKEPIPE HAZARDS

1. EQUIPMENT AND TESTING METHODS

The tests in this and all succeeding series were conducted within a chamber 15 by 29 feet in plan with ceiling height of about 10 feet. To eliminate chance effects of drafts, all the shutters of the chamber were kept closed except the one in the end farthest away from the equipment tested, which was kept partially open to supply the air necessary for the best combustion conditions and also to regulate the temperature of the room.

Preliminary tests made on several types of commonly used stoves and heaters indicated that the highest smokepipe temperatures were obtained when a sheet-metal stove with 6-inch smokepipe was used, with 12-inch lengths of oak fireplace wood as fuel. This stove was oval-shaped in plan, 23 by 15 inches, and 22½ inches high, with a 3-inch diameter draft opening at the bottom. A circular cover on the top was opened partly to give the draft required for maximum smokepipe temperatures. The cast-iron removable legs spaced the stove base 5 inches above the wood floor platform. The distance from platform to ceiling was 8 feet 8 inches. The 6-inch smokepipe rising vertically from the stove was turned by an elbow, the distance between the top of the elbow and the ceiling or joists being varied by changing the vertical rise. The smokepipe temperatures were measured on the horizontal pipe immediately adjacent to the elbow. At a horizontal distance of 11 feet from the rear of the stove the smokepipe was again turned vertically into a chimney in the roof of the chamber, above which it was allowed to project about 2 feet.

Temperatures were measured with iron-constantan thermocouples of no. 24-gage wire. The welded junctions were placed at the center of a circular coil of the wire, the approximate coiled length being 200 or more diameters of the wire used. These were fastened on the top exterior surface of the smokepipe under a thin sheet of mica about 0.002 inch thick by asbestos cord tied around the pipe. Vertically above each of these locations were fastened thermocouples under thin sheets of mica, one on the surface of the wood joist, which was 8 inches deep, and others on either side of the joist on the lower side of the ceiling boards.

Further tests were made with a warm-air furnace having an 8-inch smokepipe spaced 12 inches from the exposed construction. The furnace fire box was 20 inches in diameter and the outer jacket of 26-gage galvanized steel was 40 inches in diameter. At the bottom rear of this jacket a recirculating opening for air intake, 8 by 24 inches, was made. The fire was started by paper and wood and thereafter semibutuminous coal, in lumps and powdered form combined, was used as fuel. A view of the equipment is shown in figure 1.

Temperatures were also measured on smokepipes of some installations in service. These measurements were confined chiefly to oil and gas burners recently installed in former coal-fired central heating units.

4551—33——4

2. RESULTS OF TESTS

Temperature data are given in table 1 and figures 2 and 3 for tests with the exposed construction spaced 6, 10, 12, 18, and 24 inches above the smokepipes. The temperatures shown by the upper curves are those obtained on the smokepipe. The lowest curve represents the room temperature during the test. The intermediate curves give the

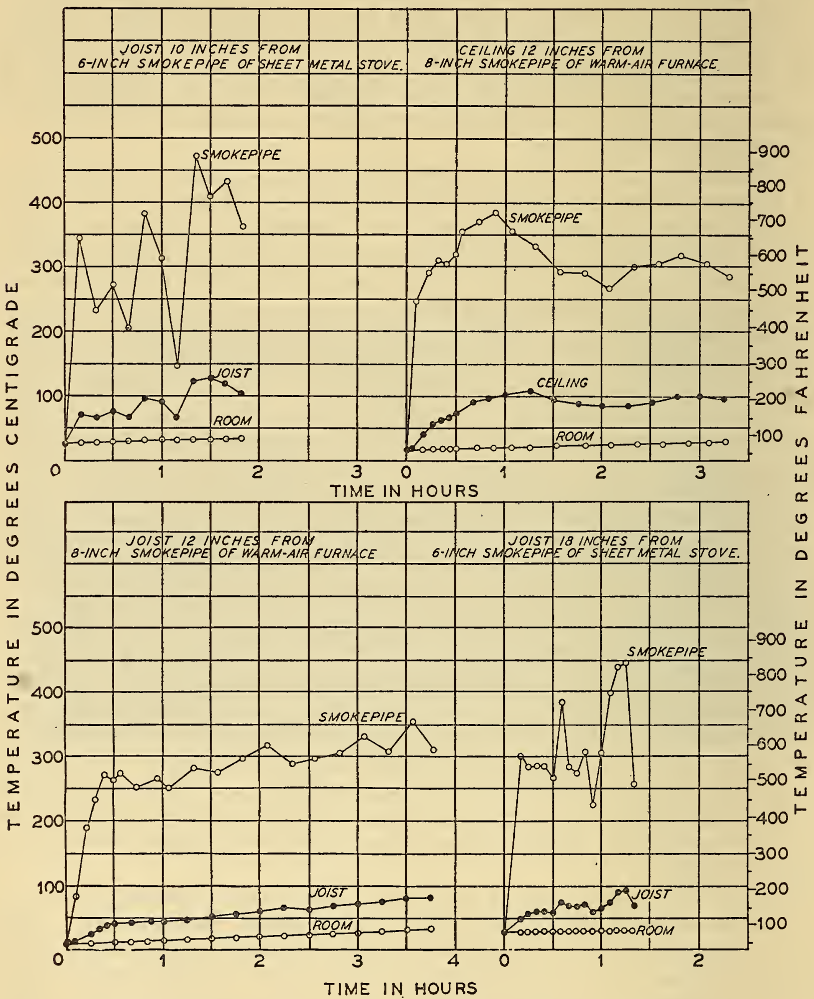

Figure 2.—*Time-temperature curves from tests with smokepipes.*

temperatures measured on the surface adjacent to the smokepipe. Tests of longer durations than those shown indicated that substantially no higher temperatures resulted. The maximum temperature measured on the surface of the smokepipe was 483° C. (901° F.) This is appreciably above the ignition temperature of most common combustible materials and hence it is apparent that fires may occur readily when combustibles are in contact with or very near to smokepipes.

The maximum smokepipe temperatures obtained with oil and gas conversion burners in hot water house heating systems were much lower than those obtained with the wood and coal-fired stoves and

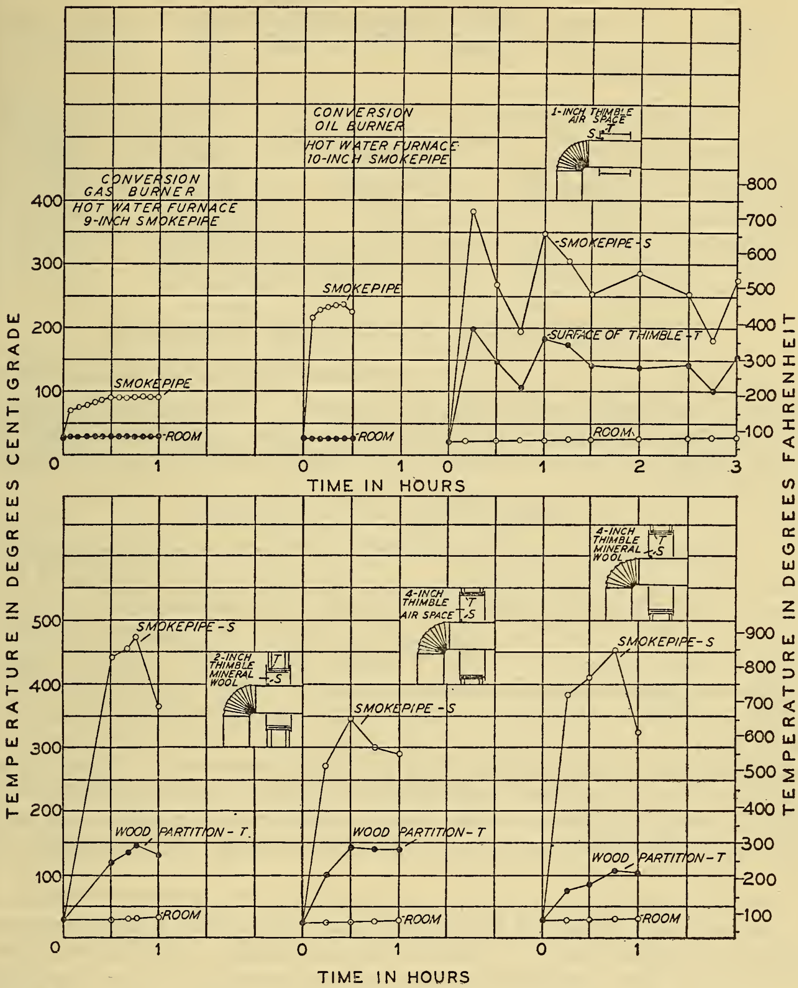

FIGURE 3.—*Time-temperature curves from tests with smokepipes and thimbles.*

warm-air furnaces, even though rate of gas and oil input was increased beyond that attained in normal operation. Temperatures measured on smokepipes of coal-fired hot-water installations and not herein reported, were also relatively low, indicating that the type of heating equipment as well as the fuel used are important in this connection.

TABLE 1.—*Temperature data from smokepipe tests*

Appliance	Fuel	Diameter smokepipe	Exposed construction	Spacing from smokepipe	Maximum temperatures					
					On smokepipe		On construction		Room	
					°C.	°F.	°C.	°F.	°C.	°F.
		Inches		*Inches*						
Sheet-metal stove	Wood	6	Wood ceiling	6	483	901	152	306	30	86
Do	do	6	Wood joist	10	468	874	126	259	28	82
Hot-air furnace	Wood and coal	8	Wood ceiling	12	381	718	109	228	29	84
Do	do	8	Wood joist	12	353	667	81	178	31	88
Sheet-metal stove	Wood	6	do	18	448	838	88	190	29	84
Do	do	6	do	24	318	604	74	165	28	82
Conversion burner	Oil	9			236	457			23	73
Do	Gas	10			92	198			27	81

III. TESTS WITH SMOKEPIPE THIMBLES

Ventilated and insulated thimbles were tested with various thicknesses of insulation and widths of air space. Conditions for testing were generally the same as in the tests with smokepipes described in the preceding section, except that a short horizontal run of smokepipe was used.

1. DESCRIPTION OF THIMBLES

As previously observed, maximum smokepipe temperatures were obtained when the sheet-metal stove was fired with 12-inch oak fireplace wood. For this reason, this stove was used in the tests with thimbles. The thimbles tested were inserted in sections of partitions, 2 feet 6 inches by 2 feet 6 inches, faced with ¾-inch tongue-and-groove pine ceiling boards attached to 2- by 4-inch wood studs giving a 3¾-inch closed air space, thus simulating wood stud construction.

Figure 4 shows the various thimbles that were tested. The thimble with 4-inch air space was tested both with and without mineral wool filling in the air space. The 1-inch thimble was tested only with the vented air space and the 2-inch thimble only with insulation in the air space.

The only thimble available commercially was the type made of two telescoping pieces of tin-coated sheet steel, with 1-inch air space vented by ½-inch holes. The 2-inch and 4-inch thimbles were patterned after this thimble and were made especially for these tests by a local tinsmith. The 2-inch thimble had ¾-inch-diameter vent holes, and the 4-inch thimble had 1-inch holes. All thimbles were made to receive a 6-inch smokepipe.

2. RESULTS OF TESTS

Table 2 and figure 3 give the maximum temperatures measured on the combustible material nearest the stovepipe and in contact with the thimble. When only the vented air space was used the resulting temperatures appeared rather excessive so resort was had to insulation. Mineral wool was inserted in the air space to a density of about 8 lbs. per cubic foot. In some tests with the 4-inch thimble a 1-inch cylindrical tile sleeve was placed over the smokepipe within the thimble.

TABLE 2.—*Results of tests with smokepipe thimbles*

[Appliance: Sheet-metal stove with 6-inch smokepipe]

Radial width of annular space (inches)	Thimble air space (inches)	Insulation	Maximum temperatures					
			On smoke-pipe		On construction		Room	
			° C.	° F.	° C.	° F.	° C.	° F.
1	[1] 1	None	382	720	198	388	21	70
2	None	2 inches mineral wool	473	883	144	291	31	88
4	None	1 inch tile, 3 inches mineral wool	364	687	101	214	26	79
4	3	1 inch tile	304	579	150	302	30	86
4	4	None	346	655	144	291	27	81
4	None	4 inches mineral wool	426	799	105	221	29	84

[1] Thimble freely exposed, not enclosed in partition.

Some tests were also made with vented 1-inch and 2-inch thimbles in horizontal position (smokepipe vertical), and the temperatures found in general were below those found with the thimble in a vertical position due apparently to greater convection through the thimble. However, the passing of smokepipes through floors involves fire hazards against which a thimble cannot afford protection.

IV. TESTS WITH WARM-AIR FURNACES

1. EQUIPMENT

For one series of tests the warm-air furnace previously described and shown in figure 1 was used. Tests were made with the ends of the two 10-inch warm-air supply ducts both open and closed. The usual furnace has more than two warm-air ducts, but they may be shut off to such an extent as to introduce conditions comparable to those obtaining with two ducts. The fuel and method of operation were generally the same as described under section II for this type of heater.

A partition with a 10-inch diameter hole was placed on one warm-air duct 3 feet from the jacket, the partition having a closed air space between the studs. In one test, protection in the form of asbestos millboard was wrapped around the duct where it passed through the partition.

The "pipeless" furnace data were obtained with an installation in a dwelling. The fire box was 24 inches in diameter and the outer sheet-metal jacket was 30 by 36 inches at the floor level. Wood fuel was used followed by hard coal, and finally a combination of the two. The radiation dome during a portion of the test became visibly red.

2. TEMPERATURES OF DUCTS

Table 3 and figure 5 give the temperatures at the several locations indicated, in tests with the warm-air furnace. These charts show that the temperature of the air within the ducts near the furnace is

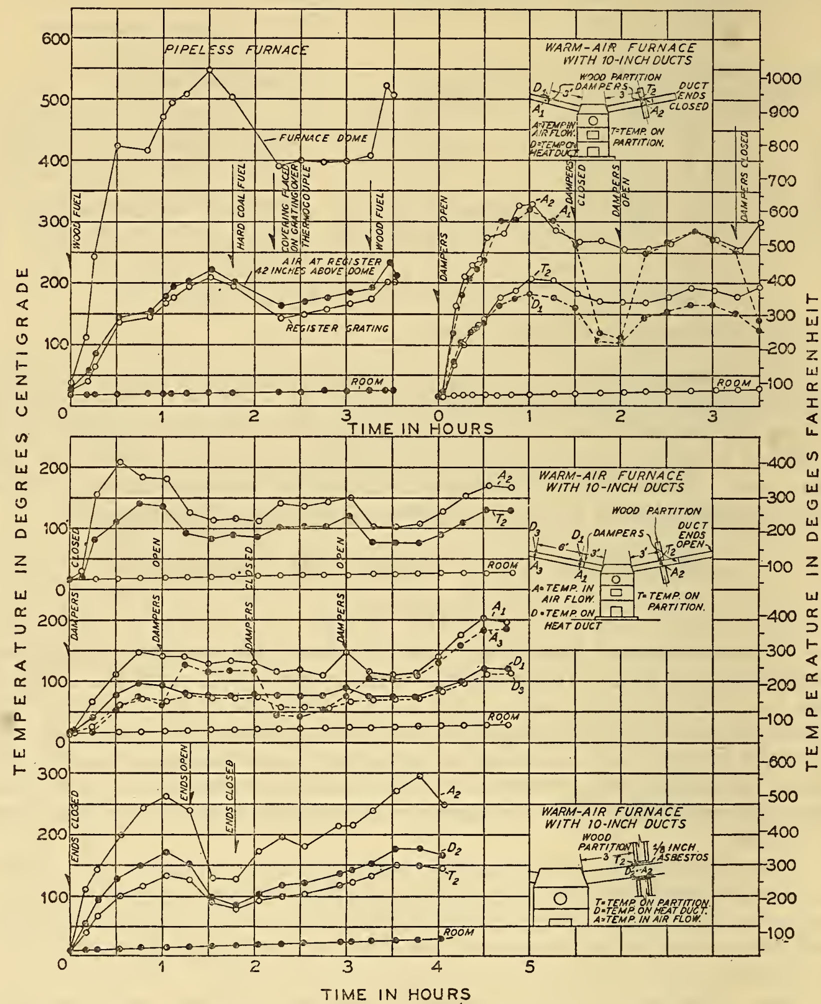

FIGURE 5.—*Time-temperature curves from tests with warm-air furnaces.*

sufficiently high to cause ignition of combustible material. The temperature gradient of the air within the duct was small when dampers were open, and whereas with dampers closed the temperature of the air in the duct near the furnace was higher, it decreased sharply with increased distance from the furnace.

TABLE 3.—*Results of tests with warm-air furnace*

[Appliance: Warm-air furnace with 10-inch circular ducts]

Ends of ducts	Damper	Maximum temperatures											
		Air in duct			On exterior surface of duct			On wood partition				Room	
		Distance	° C.	° F.	Distance	° C.	° F.	Insulation on duct	Distance	° C.	° F.	° C.	° F.
		Feet			*Feet*				*Feet*				
Closed	Open	3	328	622	3	182	360	None	3	208	406	27	81
Open	do	3	202	396	3	120	248	None	3	132	270	27	81
Do	do	9	183	361	9	112	234	None				27	81
Do	Closed	9	75	167	9	70	158	None				27	81
Closed	Open	3	297	567	3	178	352	⅛-inch asbestos millboard.	3	148	298	27	81

The difference between the temperature of the heated air within the duct and that on the exterior surface of the duct became greater as the temperature in the air flow increased. This same effect existed but to a smaller degree, between the partition temperature and that of the exterior of the protected duct in proximity thereto. Temperatures obtaining with protection around the duct where it passes through a partition are shown in figure 5, when asbestos millboard one eighth inch thick and weighing about one half lb./ft.^{2} was wrapped around the duct.

Figure 5 and table 4 show the temperatures measured at given locations on a "pipeless" furnace system. Due to the passage of cold air downward around the outside of the central heating duct, the temperatures in the space around the central warm air duct were all below the hazardous range. The maximum temperature recorded on the register grating 2 inches outside the periphery of the central warm air heating duct and at point of contact with the wood flooring, was 50° C. (122° F.). The condition most likely to introduce hazards occurs when furniture, rugs, or clothing are placed on the warm-air register, or when combustible partitions are located in or too close to the warm-air flow. Temperatures in the air flow at the floor level reached 233° C. (451° F.).

TABLE 4.—*Results of tests with "pipeless" furnace*

Fuel	Maximum temperatures							
	Radiating dome		Warm air at register		Register grating		Room	
	° C.	° F.	° C.	° F.	° C.	° F.	° C.	° F.
Wood	547	1,017	222	432	209	409	21	70
Hard coal	[1] 408	766	[1] 191	376	173	344	26	79
Wood and coal	523	973	233	451	200	392	26	79

[1] Register partly covered by wood board producing slight banking of air flow.

V. FLOOR PROTECTIONS

1. TESTING EQUIPMENT

The base supporting the heating equipment was 4 by 4 feet and made of ¾-inch tongue and groove pine boards nailed to three 2- by 4-inch wood joists. For the tests with asbestos and sheet metal protection the boards were in single thickness with the joists set edgewise. The other protection was of clay common bricks set on edge, the thickness inclusive of the mortar being 4 inches. The boards were applied in double layer to the joists laid flatwise. The air space between the boards and the concrete floor was either open, closed at the ends, or filled with dry sand. The thermocouples were placed on the bottom of the stove and also next to the wooden flooring over which the protection was placed. The sheet-metal stove described under section II, fired with wood, was used in all tests for which temperature data are reported.

2. RESULTS OF TESTS

Observations with the cast-iron coal stove with legs and having an ash box integral with the stove, indicated no hazard to a wood floor separated by an air space from the bottom of the stove. The same was true for a water-jacketed heater that was tested.

With the sheet-metal stove raised 5 inches above the floor and the floor protected with ⅛-inch thick asbestos millboard under black iron, a temperature of 175° C. (347° F.) was reached on the wood (table 5). With the 5-inch air space and the ¼-inch asbestos protection under sheet metal, the temperatures on the surface of the floor reached a maximum of 120° C. (248° F.) (fig. 6). The results with the brick protection are also given in table 5 and figure 6. With the double board floor no very decided difference in temperature on its upper surface was found for open, closed, and filled spaces beneath it. The fires in the sheet-metal stove in direct contact with the brick can be taken also as representative of a moderate condition of fire exposure to constructions beneath braziers and fireplaces.

TABLE 5.—*Results of tests with floor protections*

[Appliance: Sheet-metal stove without ash pit]

Spacing inches	Protection	Maximum temperatures					
		On stove base		On construction		Room	
		° C.	° F.	° C.	° F.	° C.	° F.
5	1 sheet 20-gage black iron. Two ⅛-inch sheets asbestos millboard.	399	750	120	248	28	82
Stove base on iron	1 sheet 20-gage black iron			202	396	30	86
5	1 sheet 20-gage black iron. One ⅛-inch sheet asbestos.			175	347	22	72
8¾	do			116	241	24	75
Stove base on brick	4 inches of brick on wood platform. Open air space below platform and stove not sanded around bottom.	495	923	182	360	16	61
Do	4 inches of brick on wood platform. Closed air space below platform and stove not sanded around bottom.	495	923	173	343	21	70
Do	4 inches of brick on wood platform. Open air space below platform and stove sanded around bottom. Ashes in stove before test.	342	648	182	360	23	73
Do	4 inches of brick on wood platform. Open air space below platform and stove sanded around bottom. No ashes in stove before test.	475	887	242	468	17	63
Do	4 inches of brick on wood platform. Closed air space below platform and stove sanded around bottom.	481	898	224	435	26	79
Do	4 inches of brick on wood platform. Air space filled with sand and stove sanded around bottom.	622	1,152	243	469	26	79

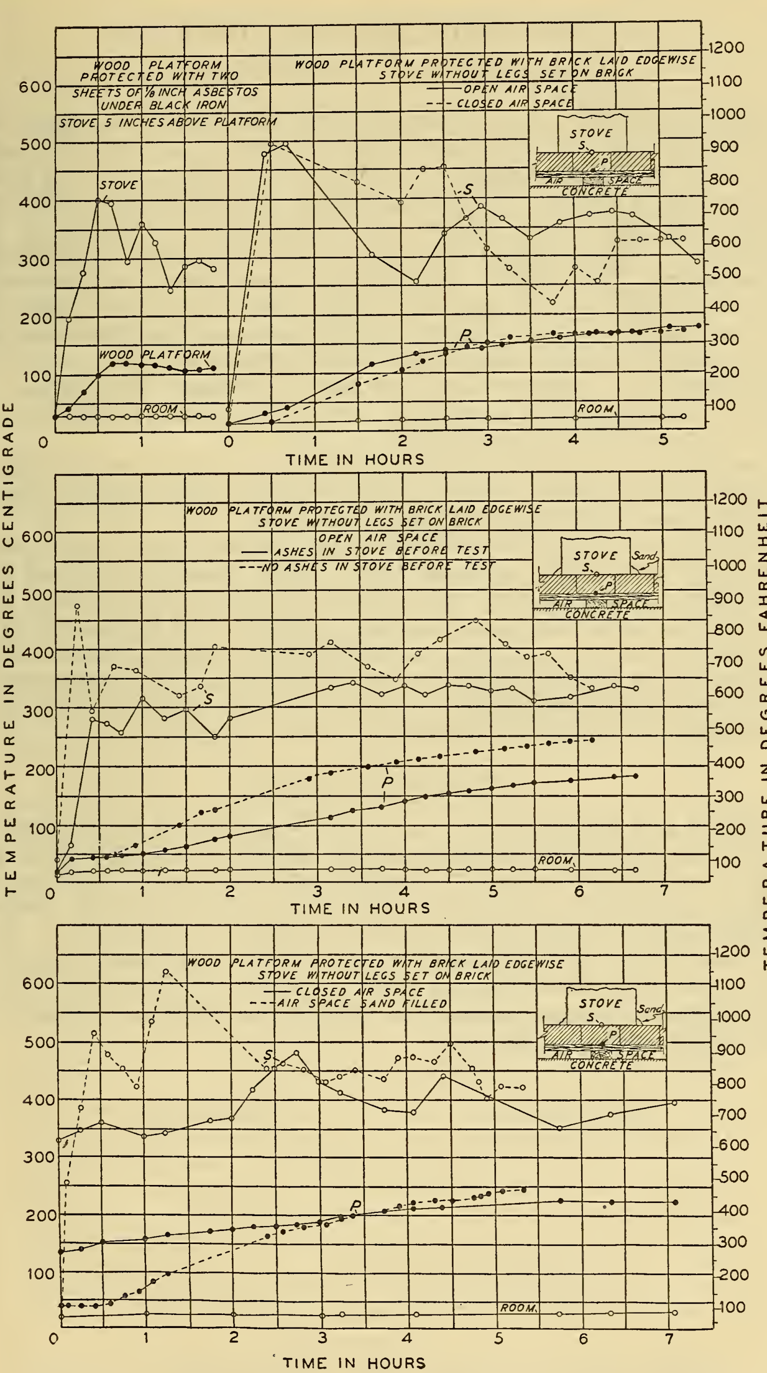

FIGURE 6.—*Time-temperature curves from tests with floor protections.*

VI. TESTS WITH WALL PROTECTIONS

1. EQUIPMENT AND TESTING METHODS

The heating unit used in tests of this series was a cast-iron coal stove about 3 feet 8 inches high with a firebox 16 inches in diameter at the middle and 12 inches at the grate level. This stove was found to give higher surface temperatures than the sheet-metal stove, although the latter gave higher temperatures on the surface of the smokepipe. One partition was placed at the back and one at the side of the stove. The highest temperatures were found on the side of the stove and the side partition, hence only the results from this location are given on the charts, measurements on the other partition serving to give supplemental data. The fuel used was lump coal of the semibituminous character and obtained through the Bureau of Mines. It appeared to give higher firebox temperatures than several other soft coals that were tried.

The thermocouples were placed under sheets of mica on the hottest portion of the firebox, those on the partition being located directly opposite them, also under thin sheets of mica.

Partitions of one type were made of tongue and groove pine sheathing nailed to one side of wood studs. The others were faced with 1 : 3 sanded gypsum plaster nine sixteenths inch thick over wood lath or with plaster of the same kind seven eighths inch thick applied on expanded metal lath. Metal sheets serving as protection were nailed directly to the exposed face or to wood strips placed to form open or closed air spaces, the distance from the stove to the face of the partition being 12 inches in all tests with such protections.

2. RESULTS OF TESTS

Table 6 and figure 7 give results with unprotected wood partition spaced 12, 24, and 30 inches from the stove. They also show the relative performance of black and galvanized sheet iron, the galvanized metal giving greater protection. The maximum temperature reached on the firebox of the cast-iron stove was 661° C. (1,222° F.). It is seen that in all but two of the tests with this equipment, maximum stove temperatures of around 600° C. (1,112° F.) obtained. It is believed that this represents severe exposure conditions as applied to household heating appliances.

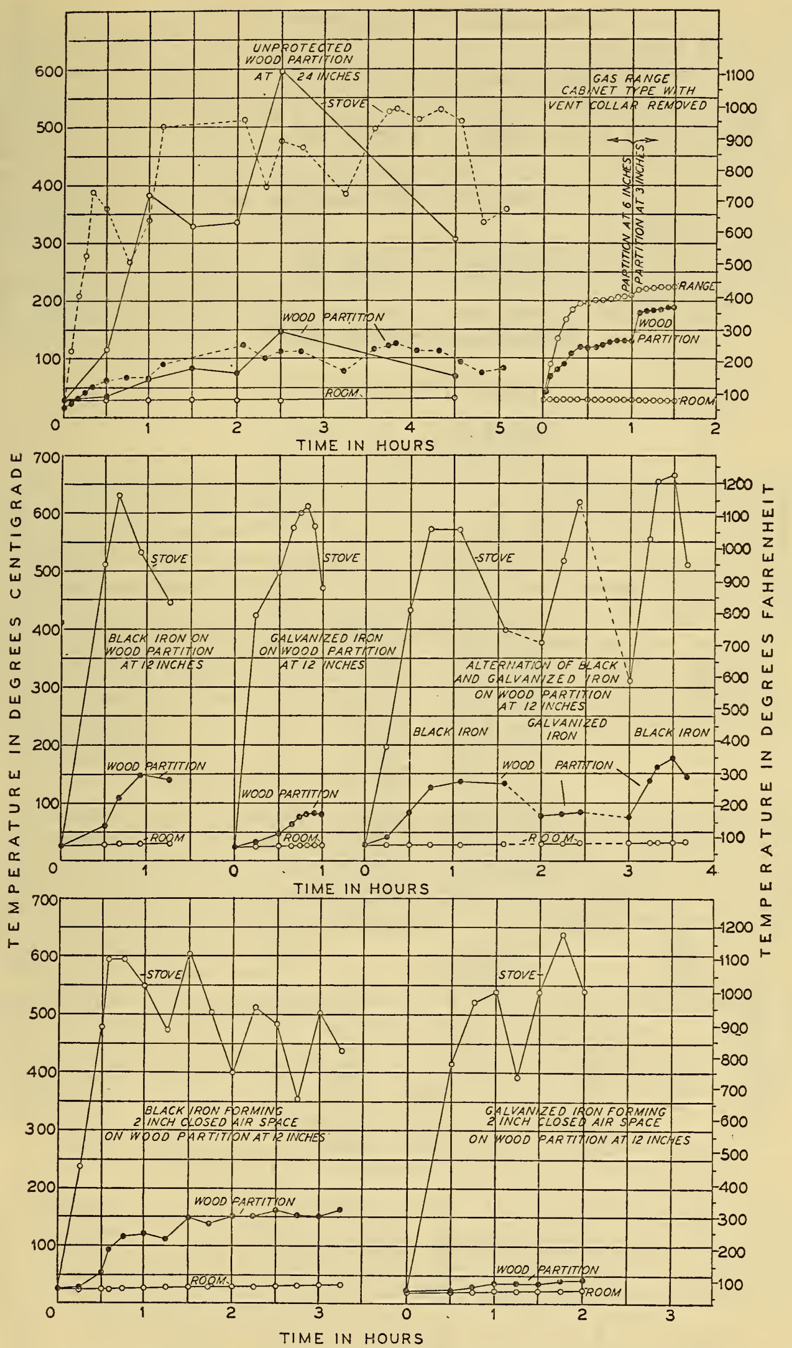

FIGURE 7.—*Time-temperature curves from tests with wood partition.*

TABLE 6.—*Results of tests with wall protections*

Appliance	Fuel	Exposed construction		Protection	Air space	Maximum temperatures					
		Kind	Spacing (inches)			On stove		On construction		Room	
						° C.	° F.	° C.	° F.	° C.	° F.
Cast-iron stove	Coal	Tongue and groove wood partition.	12	None		536	997	213	415	26	79
Do	do	do	24	do		602	1,116	148	298	31	88
Do	do	do	30	do		659	1,218	116	241	34	93
Do	do	do	12	20-gage black iron against partition		661	1,222	177	351	29	84
Do	do	do	do	20-gage black iron 1 inch from partition	Closed	521	970	115	239	33	91
Do	do	do	do	do	Open	607	1,125	92	198	27	81
Do	do	do	do	20-gage black iron 2 inches from partition	Closed	602	1,116	148	298	27	81
Do	do	do	do	20-gage galvanized iron against partition		615	1,139	85	185	27	81
Do	do	do	do	20-gage galvanized iron 2 inches from partition	Closed	635	1,175	44	111	27	81
Sheet-metal stove	Wood	⅞-inch plaster on wood lath.	do			307	585	148	298	30	86
Do	do	do	6			366	691	189	372	27	81
Cast-iron stove	Coal	do	9	20-gage black iron against partition		628	1,162	189	372	37	99
Do	do	do	9	20-gage galvanized iron against partition		618	1,144	81	178	38	100
Do	do	do	18	None		634	1,173	159	318	44	111
Do	do	⅞-inch plaster on metal lath.	9	20-gage galvanized iron against partition		610	1,130	74	165	39	102
Do	do	do	12	None		618	1,144	195	383	30	86
Do	do	do	18	do		593	1,099	144	291	32	90

The tests with the plastered partitions (figs. 8 and 9) indicate that without metal protection, the limit of safe temperatures on the wood lath or stud is reached with the stove spaced 18 inches away, whereas, with galvanized metal over the plaster, no temperature over 81° C. (178° F.) was obtained with the partition only 9 inches from the stove. A little higher temperature obtained on the wood lath than on wood studs supporting plaster on metal lath.

In tests with a water-jacketed heater, intended for installation within the rooms to be heated, no temperatures on its surface over 100° C. were obtained. This type of heater appears to present little hazard from the standpoint of ignition of adjacent partitions provided the gaskets between the water coils surrounding the fire pot remain tight and the system is maintained full of water.

VII. GAS RANGES

1. TESTING METHODS

The appliance used in these tests was a cabinet-type gas range with an uninsulated oven box. This range had a rated capacity of approximately 24,000 B.t.u. per hour, with an overload capacity of 50 percent. City gas, 600 B.t.u. per cubic foot, was used as fuel. The effective heat production during the tests was approximately 32,200 B.t.u. per hour, burning gas at the rate of 60 cubic feet per hour. In some of the tests a 90° elbow attached to the vent at the top rear of the oven served to direct the exhaust gases upward. A wood partition similar to those used in the tests described in section VI was spaced 3 or 6 inches away from the rear vertical surface of the gas oven.

2. RESULTS

It is seen (fig. 7) that the maximum temperature indicated on the range proper for a typical run was 225° C. (437° F.) and was obtained with the elbow detached and the partition spaced 3 inches from the oven, the maximum temperature on the wood being 188° C. (370° F.). For the 6-inch spacing the maximum temperature on the partition was 133° C. (272° F.).

When the elbow was in place, the temperature on the surface of the partition did not rise as rapidly as when it was removed, since the latter condition allowed more of the hot exhaust gases to enter the space between the range and the partition. The maximum temperatures finally attained were, however, nearly the same for the two conditions.

VIII. GENERAL SUMMARY AND CONCLUSIONS

The work reported includes tests with typical installations of household heating and cooking appliances chosen as representative after a survey of fires that had resulted from such installations. They were operated in the tests to produce the maximum heating conditions that might occasionally occur.

The determination of proper spacings and other protections to be applied is dependent on the hazard certain attained temperatures represent. The combustible material usually exposed is wood in the form of building members or finish or as wood lath under plaster.

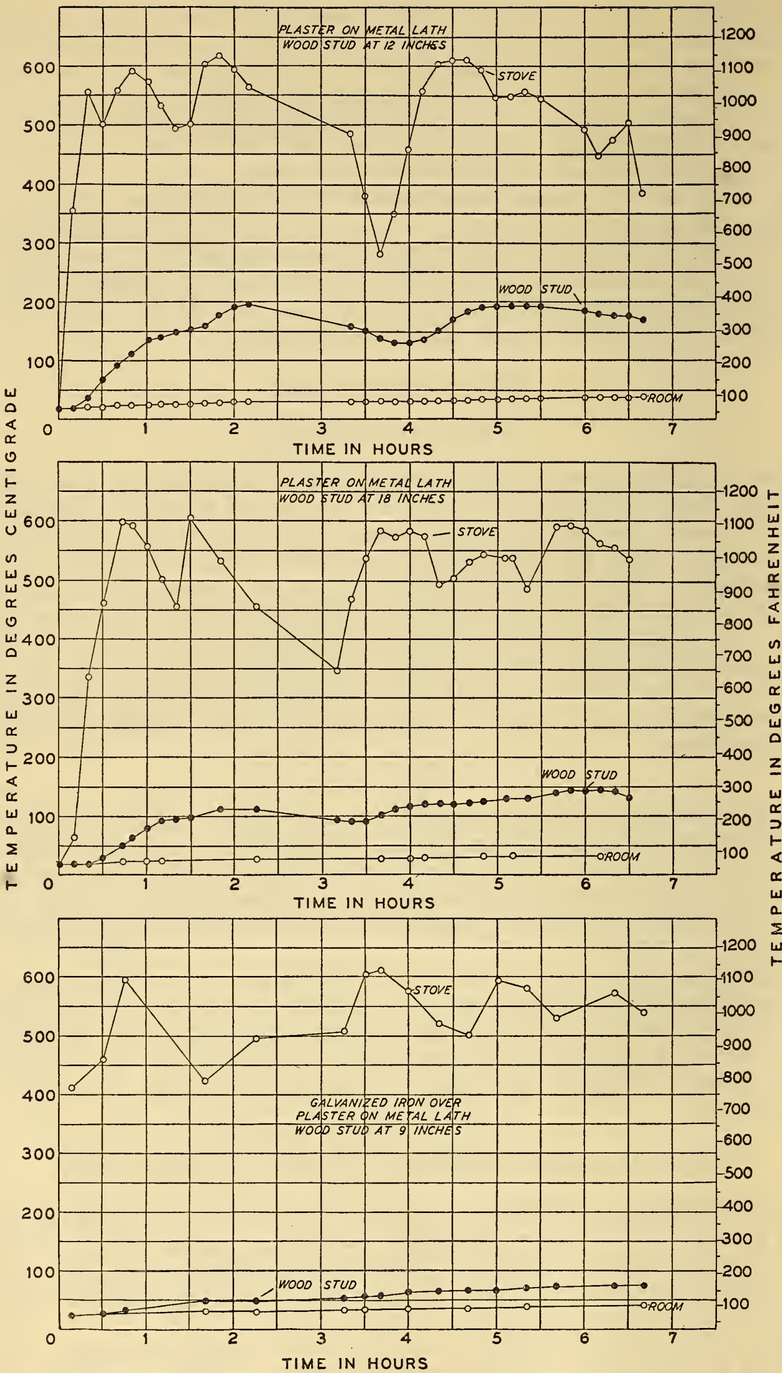

FIGURE 8.—*Time-temperature curves from tests with wood stud partition faced with plaster on metal lath.*

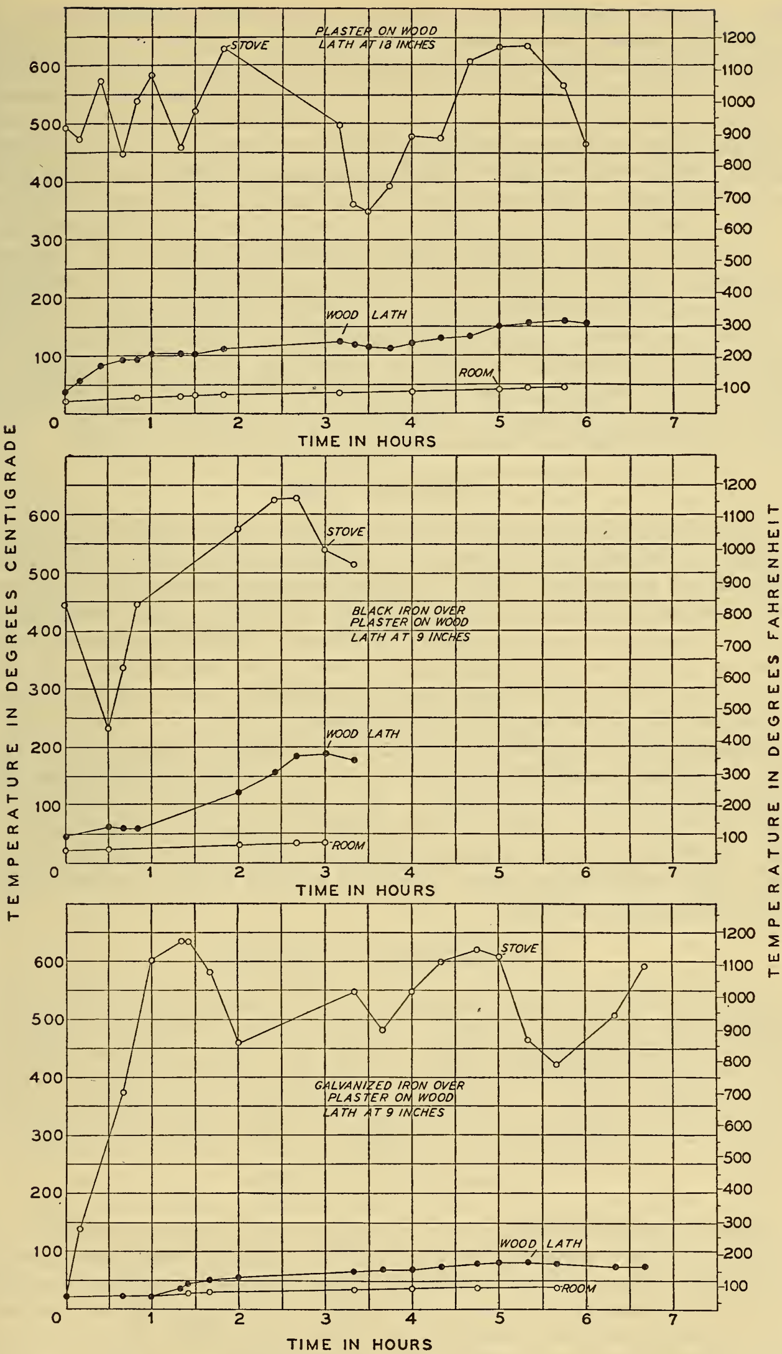

FIGURE 9.—*Time-temperature curves from tests with wood stud partitions faced with plaster on wood lath.*

The highest temperature to which wood can be safely exposed is apparently a function of the size and condition of the sample, the air supply, duration of the exposure, and possibly other conditions. Ignition of wood from contact with low-pressure steam pipes has been claimed, but a careful inquiry into the conditions present leaves doubt as to whether the wood actually ignited from the given source of heat. For short-time exposure of wood, ignition can occur from temperatures in the approximate range 250° to 300° C. (482° to 572° F.).

No authentic cases of ignition of wood either in the laboratory or as exposed for long periods around heating installations at temperatures below 150° C. (302° F.), have been obtained. As a tentative measure of hazard, temperatures frequently exceeding 125° C. (257° F.) should probably be considered hazardous, but temperatures might occasionally reach 150° C. (302° F.) without creating a hazard necessary to be recognized in a building code or fire-prevention ordinance. The hazard created by the different appliances and effectiveness of the protections tested will be interpreted on the above basis.

1. SMOKE PIPES

Dwelling-house heating units have relatively small smoke pipes usually not exceeding 9 inches in diameter. Temperatures on such surfaces up to 483° C. (901° F.) were obtained in the tests. Separations between smoke pipe and ceiling or ceiling joist of 12 inches appear to give the needed degree of safety. The recommended clearance of 12 inches should be on all sides of the smoke pipe. In other than household heating appliances, this clearance may not be adequate as indicated by fires caused by such installations.

Many fires are caused by careless installation of smoke pipes in long runs resulting in separation at the joints. Riveted joints and short horizontal runs are preferable. The deterioration of smoke pipes from the corrosive effects of the furnace gases is another cause of fire. In no case should a smoke pipe pass through a ceiling, floor, or roof. This condition is known to invite hazards even when protections such as thimbles are used.

2. SMOKE-PIPE THIMBLES

The tests indicate that where smoke pipes pass through combustible partitions a vented air space of not less than 4 inches is needed or insulation with incombustible materials such as mineral wool not less than 2 inches thick. The use of a 1-inch vented thimble, which is generally the only one obtainable, resulted in temperatures on the combustible construction up to 200° C. (392° F.) as indicated in figure 3.

3. WARM-AIR DUCTS

With the ends of ducts closed a maximum temperature on the outside of the freely exposed duct of 182° C. (360° F.) was measured at 3 feet from the furnace. At the same distance and for the same conditions except for inclosure of the duct within a partition, the temperature on its surface was 208° C. (406° F.). With the ends of the ducts closed there was a decided fall in temperature of the duct with increase in distance from the furnace. With the ends open the maximum temperature on the duct did not exceed 120° C. (248° F.), but there was little difference in the temperature between points 3 feet and 9 feet from the furnace. In general, the tests indicated that protections are needed on warm-air ducts only for the more severe conditions such as location of partitions or of outlets through the floor, close to the furnace.

The danger from "pipeless" furnaces consists mainly in the placing of combustible material on the warm-air register over the duct or locating combustible constructions within the path or too close to the warm-air current.

4. FLOOR PROTECTION

Stoves, in which the fire box forms a part of the lower surface or where the lower surfaces are heated by hot coals from the fire box, constitute a hazard to combustible floor construction below. The tests indicate that adequate protection can be obtained with one fourth inch of asbestos or equivalent material placed under sheet metal. This can be conveniently done by filling in under the crimped edges of the sheet-metal bases obtainable for the purpose. This assumes the presence of an air space of not less than 5 inches between the stove and the floor. Where the fire box or ash pit is supported directly on the floor, the base should be built entirely of incombustible materials. Temperatures hazardous from the standpoint of ignition of wood are transmitted through a 4-inch thick brick base. The tests indicate the possibility of ignition of wood forms left under brick or concrete arches supporting fireplaces.

5. WALL PROTECTION

Without any protection a minimum spacing of stoves from combustible walls and partitions of 24 inches is apparently necessary. With the heating surface at 12 inches from the construction, black iron gives fair protection, although much better protection is given by galvanized iron because of its lower absorption of radiant heat. A closed air space gives some added protection as compared with that afforded by the metal applied directly to the wall. The vented air space is more effective than the closed air space, although affording opportunity for the accumulation of lint and other combustible materials between the sheet metal and the wall.

The difference in effectiveness between black iron and galvanized iron was very marked both as applied directly to the wall and as forming one side of closed air spaces. However, galvanized iron will deteriorate and in time lose some of its heat-reflecting properties. Surfaces permanently brighter than galvanized iron would apparently give better protection. The protecting sheet should project not less than 1 foot beyond the heating surface in all directions.

The plaster did not afford protection to the supporting construction to the extent that might be expected. This is due to the absorption of the long radiant heat waves to greater extent than by surfaces such as zinc-coated metal. With no metal covering, a spacing from heating equipment, not covered with insulation or water jackets, of 18 inches would be required. With zinc-coated metal protection over the plaster and a spacing of 9 inches, the temperatures obtained on the wood were considerably below those that can be considered as hazardous.

4551—33——5

The tests with a gas range having an oven without insulation indicated that a 6-inch separation between the side of the oven and a wood partition gives reasonably safe conditions. Fires have been known to result from spacing the oven 1 inch from the wall. The tests indicated excessive wall temperatures where the oven was spaced 3 inches from the wall.

6. SCOPE OF APPLICATION OF RESULTS

The results apply mainly to heating devices of the types and sizes used in private dwellings. For larger heating units, smoke pipes, and air ducts, the results may not apply without modification. With increase in the area of the heating surface higher maximum temperatures on the exposed surface would be expected for the same temperature on the heating surface. There is also possibility that the temperature of the appliance as well as of the smoke outlets and ducts may be higher for the larger installation. In general, however, the larger installations do not present a decided hazard because of the insulation applied over the heating units and their segregation within fire-resistive enclosures.

No attempt has been made to cover the hazards of portable heating and cooking devices such as portable oil stoves, gas stoves, electric heaters, and hot plates. The hazard of such devices is caused not only by the temperatures to which the nearby construction is exposed but also by the possibility of breakage of fuel-supply lines and overturning or damage to the equipment.

IX. ACKNOWLEDGMENTS

Acknowledgment is made to Mr. G. Haller for assistance in the survey and for information relative to many pertinent fire hazards encountered by him as fire inspector in the District of Columbia. Acknowledgment is also made to Mr. S. H. Ingberg, chief, fire-resistance section of the Bureau of Standards, for valuable suggestions in planning the tests.

Washington, July 17, 1933