St. Lawrence Burns: gas analysis
Jutras, J. R.

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DIVISION OF BUILDING RESEARCH

ST. LAWRENCE BURNS
GAS ANALYSIS

by

J.R. Jutras

Report No. 157

of the

Division of Building Research

OTTAWA

December 1959

PREFACE

The circumstances that led to the carrying out of fire tests on eight buildings in the project known as the St. Lawrence Burns, and the objectives and the ways in which these were achieved are fully described in a general report. It constitutes the complete record of the planning and execution of the experiments, together with all general information. The details on each kind of measurement made, including the results obtained, are contained in separate companion reports of which this is one. All the results are combined and are discussed and final conclusions drawn in a summary report.

Duplication has been avoided as far as possible, and it will be necessary to refer to the general report in reading any of the other reports including this one for any information which is pertinent to more than one of them. A listing of all reports on the project follows this preface.

The participation of the British Joint Fire Research Organization in the experiment, the interest and support of the Federal Civil Defence authorities, the assistance of the Ontario Fire Marshal and his staff, and finally the complete co-operation and very considerable assistance extended by the Hydro-Electric Power Commission of Ontario are all gratefully acknowledged. It is a pleasure also to be able to record the special contribution made by members of the staff of the Fire Section who worked long hours, often under trying field conditions and at great personal inconvenience, to meet the many deadlines and to complete the project in a most satisfactory manner.

The author of this report is Dr. J.R. Jutras, research officer with the Fire Section of this Division who was responsible for the sampling and analysis of room atmospheres during the experiments.

Ottawa
December 1959

N.B. Hutcheon
Assistant Director

REPORTS ON THE ST. LAWRENCE BURNS

NO.	SUB-TITLE	AUTHOR
150	General Report	G. W. Shorter
151	Smoke and Sound Measurements	G. Williams-Leir
152	Temperature Measurements	G. Williams-Leir
153	Radiometer Measurements	J. H. McGuire
154	Ventilation Rate Measurements	J. H. McGuire
155	Resistance Thermometer Measurements	J. H. McGuire
156	Radiant Temperature of Openings	D. G. Stephenson
157	Gas Analysis	J. R. Jutras
158	Summary Report	G. W. Shorter and J. H. McGuire

ST. LAWRENCE BURNS

GAS ANALYSIS

by

J.R. Jutras

Early in 1958, a number of controlled burning experiments were carried out at Aultsville, Ontario, by the Fire Section of the Division of Building Research, National Research Council. The general details of these experiments, which involved the burning of six dwellings and two larger buildings, are described in the first of a series of reports published on the St. Lawrence Burns (1).

It was the purpose of these tests to study the development of fire in buildings and to determine, among other things, how rapidly a fire originating on the ground floor of a dwelling could affect the survival of occupants of upstairs bedrooms. The factors which have the most influence on the time during which such survival would remain a possibility are the heat dissipated during the fire and the vitiation of the atmosphere, either through the accumulation of smoke or through changes in the air composition.

Measurements of temperatures at various points inside the dwellings and of smoke density in the bedrooms and cellar have already been reported (2,3). This report describes that part of the operation concerned with the determination of oxygen and carbon monoxide concentrations in the two upstairs bedrooms (one with the door open and the other with the door closed) and in the cellar of each of the six dwellings. Plan views (Figs. 1 to 5, 7) show the location of the two bedrooms in each of the dwellings.

EXPERIMENTAL DETAILS

1. Analytical Instrumentation

When thought was given to the instrumentation required for the gas analysis, the fact that the burns would be carried out according to a rigid schedule, probably at the rate of one a day at some distance from the laboratory, was a major consideration. It ruled out the possibility of proceeding by spotsample analysis with an absorption apparatus of the Orsat type as was done in England during similar experiments (4), since a great number of gas samples would need to be collected in evacuated glass bottles and accumulated over a period of four to five days, with the added risk of breakages, leakages, and so on. Also, this method was not adequate for measuring low concentrations of carbon monoxide as was required in the present experiments.

The use of portable direct-reading instruments specially designed for the analysis of continuously flowing samples was therefore indicated. Such instruments were known to be available for carbon monoxide and oxygen, the two gases which have the most significance when evaluating the time during which an enclosure or room remains habitable. Two Carbon Monoxide Indicators (range 0 to 0.15 per cent) manufactured by Mine Safety Appliances and one Beckman Oxygen Analyzer, model C2P (range 0 to 25 per cent), were therefore obtained and were subsequently mounted on a table in the heated trailer which served as an instrument room during the operation. The analyzer was of the fast response type (95 per cent response in 7 seconds), but the indicators took as much as 30 seconds to reach equilibrium conditions following a change in carbon monoxide concentration.

2. Gas Sampling

(a) Sampling System

The gas sampling tube extended from the bedrooms to the instrument trailer, which was generally set at a distance of about 100 ft from the house to be burned. Its first section consisted of 3/8-in. ID copper tubing running horizontally from the centre of each bedroom to a point approximately 1 ft outside the front wall of the house. This section was installed some time before the burns. A second length of copper tubing of the same size was attached to this section immediately prior to the burn, and extended the sampling line from the second floor level to the ground and along the ground for a distance of between 10 to 20 ft from the house. From this point on, 1/4-in. ID Tygon flexible tubing was used and was connected at the trailer to the copper tubing (1/4-in. ID) leading to the analytical system.

A gas collector (Fig. 9) was fixed to the collecting end of the system and consisted of a metal can filled partly with glass wool to remove smoke particles from the gases and partly with calcium chloride to remove excess moisture and prevent clogging of the line through freezing.

(b) Sampling of Gases

The atmosphere of both bedrooms (or of the closed bedroom and the cellar) was sampled simultaneously, as shown in Fig. 10, at a constant rate of 1 cu ft per minute by means of two pressure-and-vacuum air pumps (Fisher No. 1-093) located in the trailer. The gases were directed into two reservoirs (13 by 10 by 7 in.) built separately around each pump and then vented to the atmosphere. At the start of the test, reservoir A was connected with the open bedroom and reservoir B with the closed bedroom. As soon as the carbon monoxide concentration in the former room reached 1.5 per cent (unless unforeseen events made it necessary to end the test sooner), reservoir A was connected with the cellar.

The total volume of each probe and reservoir system was calculated to be 0.4 cu ft, which meant a time lag of 24 seconds in the pumping of the gases from the house to the trailer.

3. Oxygen Determination

Owing to the fast response of the oxygen analyzer, only one instrument was required to follow the variations of oxygen concentration in the two rooms. The analyzer was therefore connected to the two reservoirs, and a two-way valve enabled the operator to switch from one to the other at regular intervals of 30 seconds.

One adverse feature of the fast response analyzer is that its sensing element is not internally protected, and flow rates of only 40 to 60 cc/min. (2×10^{-3} cfm) are specified. In order to afford the instrument proper protection and still keep the sampling lag to a minimum, samples were pumped by means of a small capacity pump (Redmond) at a rate of 0.04 cfm and the sampling line was provided with a short by-pass for the analyzer. Through it an air flow of 0.002 cfm was controlled by a needle valve and a flowmeter (Fig. 10). With this system, the time lag was found to be negligible (about 2 seconds).

4. Carbon Monoxide Determinations

The measurement of carbon monoxide concentrations necessitated the use of two indicators because their low sensitivity would not have allowed switching from one reservoir to the other at regular intervals of 30 seconds. One indicator was therefore branched permanently on each reservoir and samples were drawn in at a constant rate of 0.16 cfm by means of the pump built in the instrument. The time lag in pumping samples from the reservoirs to the indicators was negligible (3 seconds). Carbon monoxide concentrations were read directly off the two indicators every 30 seconds.

In order to allow, however, for the measurement of concentrations greater than 0.15 per cent (the maximum range of the indicators), dilution systems were provided on each sampling line (Fig. 10) by which air was brought in from the outside at a rate, pre-set by means of needle-valves, sufficient for a ten-fold dilution of the samples. This enabled concentrations of up to 1.5 per cent carbon monoxide to be determined. A constant temperature bath was also added to correct for any influence that variations in outside air temperature might have on the gas-air mixing ratio.

RESULTS

Oxygen and carbon monoxide concentrations have been determined at each of the six burns involving dwellings. Readings are tabulated in Appendix A.

Following corrections of all readings for time lags of approximately 30 seconds in the sampling of the gases and, in the case of the carbon monoxide determinations, of an additional 30 seconds to account for the slow response of the indicators, the measured concentrations have been plotted against time for each burn (Figs. 11 to 16) to show their actual variations during each test. Their mean variation in the dwellings lined with combustible material and in those lined with incombustible material is graphically shown in Figs. 17 and 18, respectively.

These graphs show that the accumulation of carbon monoxide and the corresponding depletion of oxygen were quite rapid in the open bedrooms of dwellings lined with combustible material, readings of 1 per cent carbon monoxide and 10 per cent oxygen being obtained within 2 1/2 minutes of the start of the test. The corresponding times for the dwellings lined with incombustible material are 4 minutes for 10 per cent oxygen and 8 minutes for 1 per cent carbon monoxide.

When the door of the bedroom is closed without special precautions to block air passages around the door, as was the case in these tests, the protection afforded against the deleterious effect of a fire affecting other sections of a house is clearly demonstrated by curves B of both Figs. 17 and 18, particularly of the latter, which concerns dwellings lined with incombustible material. In this case, it took nearly 15 minutes for the carbon monoxide to reach the 1 per cent level and as much as 20 minutes for the oxygen concentration to drop below 10 per cent. Corresponding times for the dwellings lined with combustible material were 5 and 13 minutes respectively.

It was in the cellar, however, that equivalent changes in atmospheric composition took the longest to be reached. In the combustible-lined houses, a 1 per cent carbon monoxide concentration was obtained only after a period of 11 minutes, and the oxygen level was still above 10 per cent 20 minutes after ignition. In the other category of dwellings, even after combustion had progressed for 32 minutes the atmosphere of the basement contained 0.75 per cent carbon monoxide and 18 per cent oxygen.

SURVIVAL TIMES

The exact levels at which lack of oxygen or low concentrations of carbon monoxide will rapidly cause unconsciousness are still not a matter of definite accord, since they are considerably altered by such variables as exertion, depth of respiration, excitement, fear, and other factors affecting bodily vigour.

The National Fire Protection Association Committee on Fire Gas Research has reported (4), however, that collapse occurs quickly when the oxygen concentration drops below 10 per cent. For the purpose of this study, this value was accepted as the limit under which a person would become unable to escape on his own effort. Survival times estimated on this basis are given in Table I.

On the other hand, when carbon monoxide is present, it is almost generally agreed (4) that death will occur when 60 to 80 per cent of the blood haemoglobin has been transformed into carboxy-haemoglobin. The time necessary for this condition to be reached will depend upon the relative amounts, or mass actions, of carbon monoxide and oxygen in the air breathed, and upon the intensity of the affinities of the two gases for haemoglobin. In general, to determine time of survival in atmospheres containing carbon monoxide, one resorts to a formula derived from actual data by Henderson and Haggard (5) by which fatal exposure to carbon monoxide can be predicted.

$$t \times K_{CO} = 9$$

where "t" is the time of exposure in minutes and "K_{CO}" the carbon monoxide concentration in per cent. Consciousness would, however, be lost at a much lower level of saturation of the blood, between 40 to 50 per cent according to Claudy (6). On this basis, time of survival, if taken to mean the time at which a person becomes helpless, would be considerably smaller than time of fatal exposure

Minchin (7) reports that collapse would occur when the product of the carbon monoxide concentration by time of exposure (in minutes) equals 4.5, that is

$$t \times K_{CO} = 4.5$$

The use of this formula is, however, only valid when the carbon monoxide concentration is constant. In the course of a fire, the proportion of carbon monoxide in the atmosphere varies constantly, and in order to take into account its cumulative absorption in the blood its concentration needs to be integrated with respect to time, that is

$$\int_0^t K_{CO}\, dt = 4.5$$

The areas under the curves given in Figs. 11 to 18 have therefore been integrated, and the times at which an area equivalent to 4.5 was obtained are listed in Table I. In many cases, these times exceed the period during which measurements were obtained for the tests. In these instances, constant values equal to the last reading obtained are assumed for the period during which no information was available.

These times may be compared with times, also listed in Table I, at which a 1.28 per cent carbon monoxide concentration was obtained. According to Hamilton and Johnstone (8), at this concentration there is an immediate effect and consciousness is lost.

It should be emphasized, however, that the survival times given in Table I are based on results of separate studies: one concerned with the sole effects of lack of oxygen on human beings, and the other with those of carbon monoxide in an otherwise normal atmosphere. In a burning building, where there is a simultaneous decrease of oxygen and increase of carbon monoxide, carbon monoxide absorption in the blood will be accelerated because of the lower oxygen pressure in the lungs. Consequently, shorter survival times than any of those listed in Table I should be expected.

REFERENCES

1. Shorter, G.W. St. Lawrence Burns - General Report. N.R.C., DBR Internal Report No. 150, Nov. 1959.

2. Williams-Leir, G. St. Lawrence Burns - Temperature Measurements. N.R.C., DBR Internal Report No. 152, Dec. 1959.

3. Williams-Leir, G. St. Lawrence Burns - Smoke and Sound Measurements. N.R.C., DBR Internal Report No. 151, Dec. 1959.

4. Fire Gas Research Report. National Fire Protection Association, Committee on Fire Gas Research. NFPA Quarterly, 45: 280. 1952.

5. Henderson, Y. and H. W. Haggard. The Physiological Principles Governing Ventilation When the Air is Contaminated with Carbon Monoxide. J. Ind. Eng. Chem. 14: 229-236. 1922.

6. Claudy, W.D. Carbon Monoxide in Fire-Fighting. NFPA Firemen. V.21, n.6, 12, 13, and 22; n.7, 10-11. 1954.

7. Minchin, L.T. Mild Carbon Monoxide Poisoning as an Industrial Hazard. Ind. Chemist. 30: 381-385. 1954

8. Hamilton, A. and R. T. Johnstone. Industrial Toxicology. Oxford University Press. 1946.

TABLE I

Survival Times

Building No.	Type of Lining	Times in minutes for								
		10% Oxygen			$\int K_{co}\,dt = 4.5$			1.28 % CO		
		A*	B*	C*	A	B	C	A	B	C
1	incombustible	2.5	>13***	--	4.5	12.0	--	1.8	> 13	--
4	incombustible	3.6	21.0	--	7.0	14.8	--	12.1	14.8	--
7	incombustible	7.7	19.2	> 34	10.0	16.2	27.5	> 8	18.6	34.0
Mean for incombustible-lined buildings		4.6	>17.7	> 34	7.2	14.3	27.5	> 7.3	>15.5	34.0
		(4.2)*	(20.2)	(>34)	(8.0)	(14.5)	(27.5)	(12.1)	(18.6)	(34.0)
2	combustible	2.4	> 5	20.2	4.2	10.0	10.8	1.5	> 5	18.8
3	combustible	2.3	12.9	> 20	5.0	7.5	11.5	2.5	5.6	11.7
5	combustible	2.7	> 8	18.4	5.5	7.0	13.0	2.9	4.8	17.4
Mean for combustible-lined buildings		2.5	> 8.6	> 19.5	4.9	8.2	11.8	2.3	> 5.1	16.0
		(2.5)**	(12.9)	(>20)	(5.0)	(7.5)	(11.5)	(2.9)	(5.6)	(17.9)

*A open bedroom; B closed bedroom; C cellar

**TIMES in parenthesis have been obtained from graphs of mean concentrations on Figs. 17 and 18.

***All values preceded by ">" are based on the last reading obtained, where readings were discontinued before the particular criterion was reached.

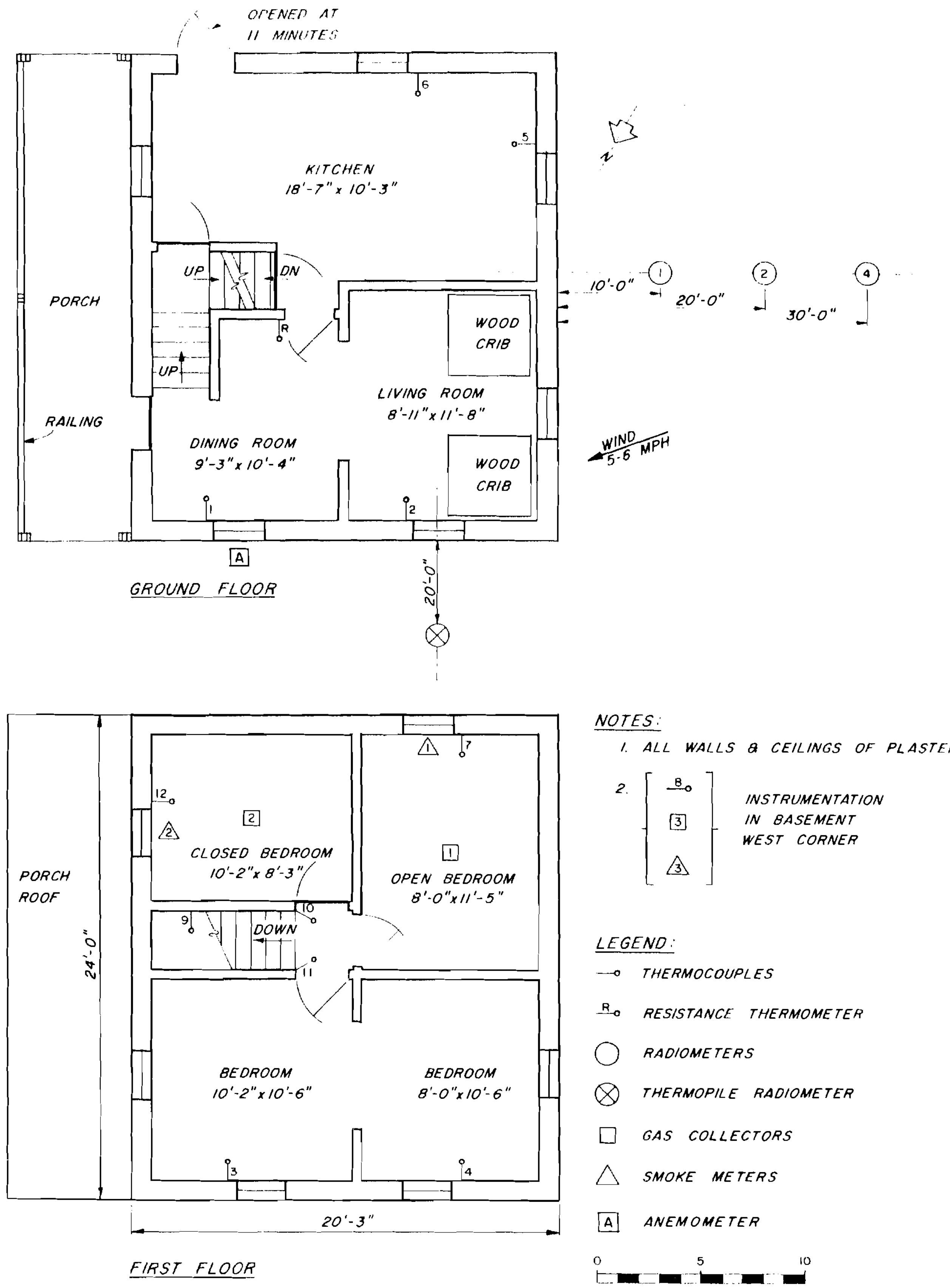


FIGURE 1 - BUILDING No. 1 - TWO - STOREY SOLID BRICK DWELLING

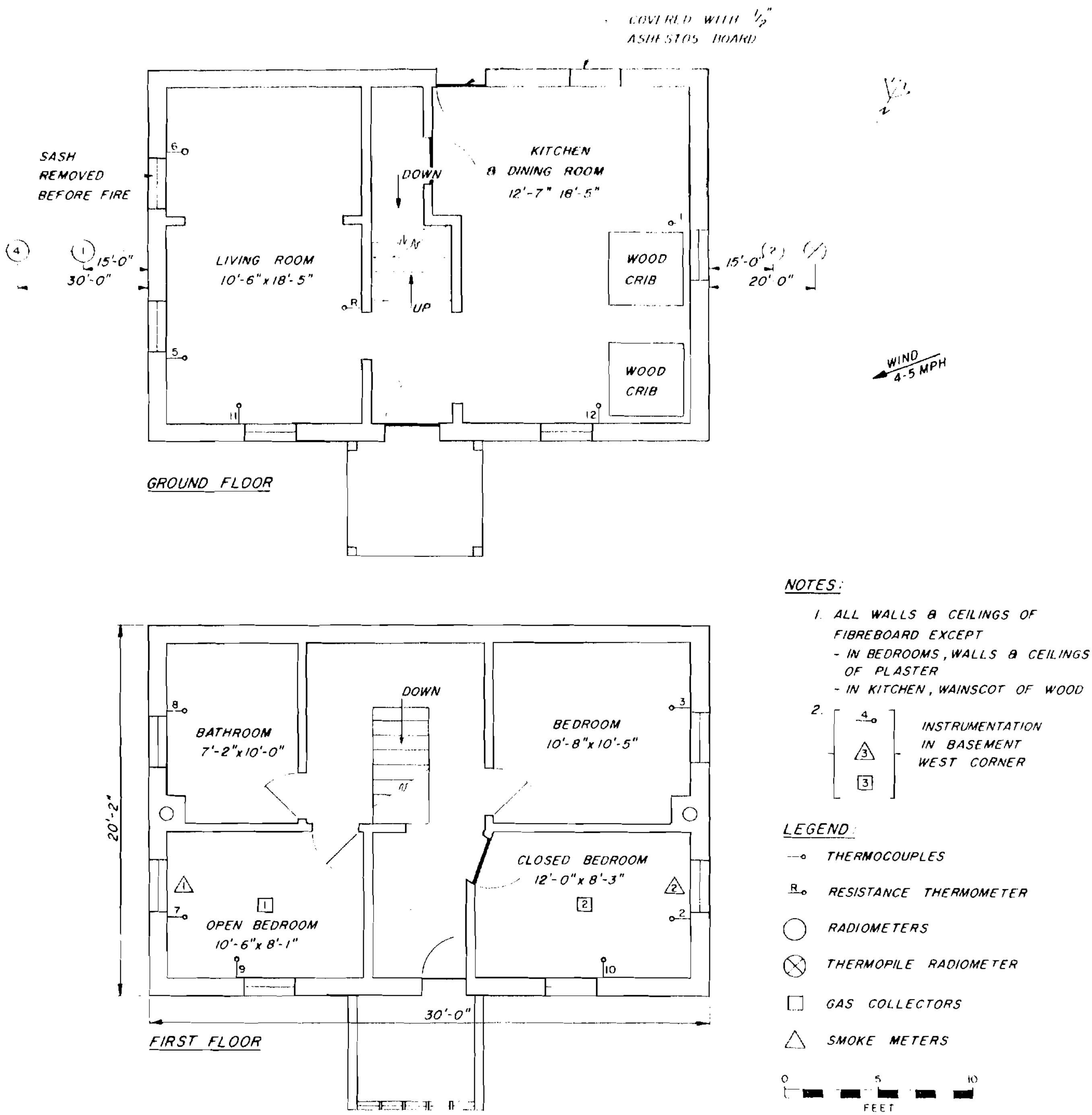


FIGURE 2 - BUILDING No. 2 - TWO-STOREY SOLID BRICK DWELLING

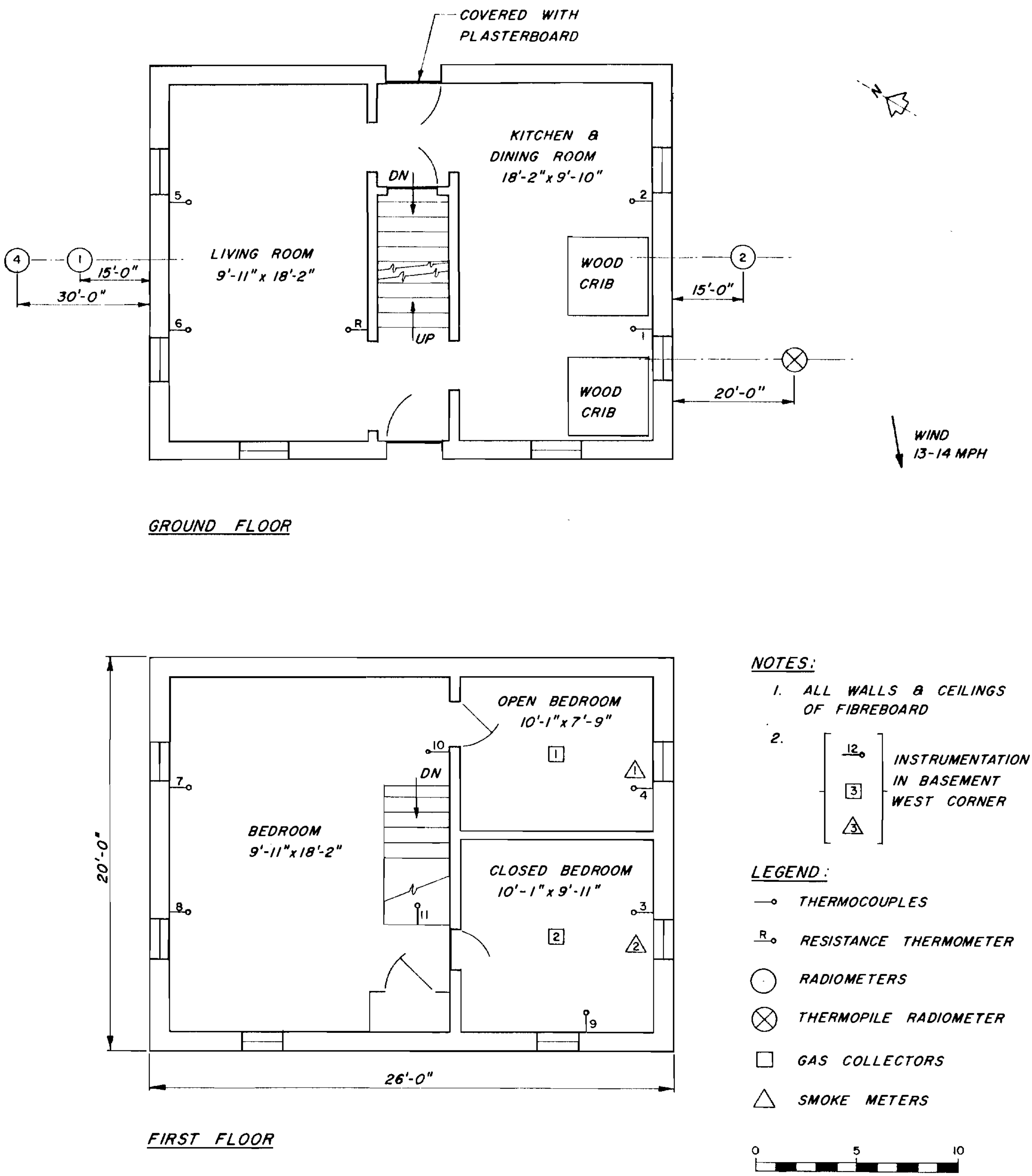


FIGURE 3 - BUILDING No. 3 - TWO-STOREY SOLID BRICK DWELLING

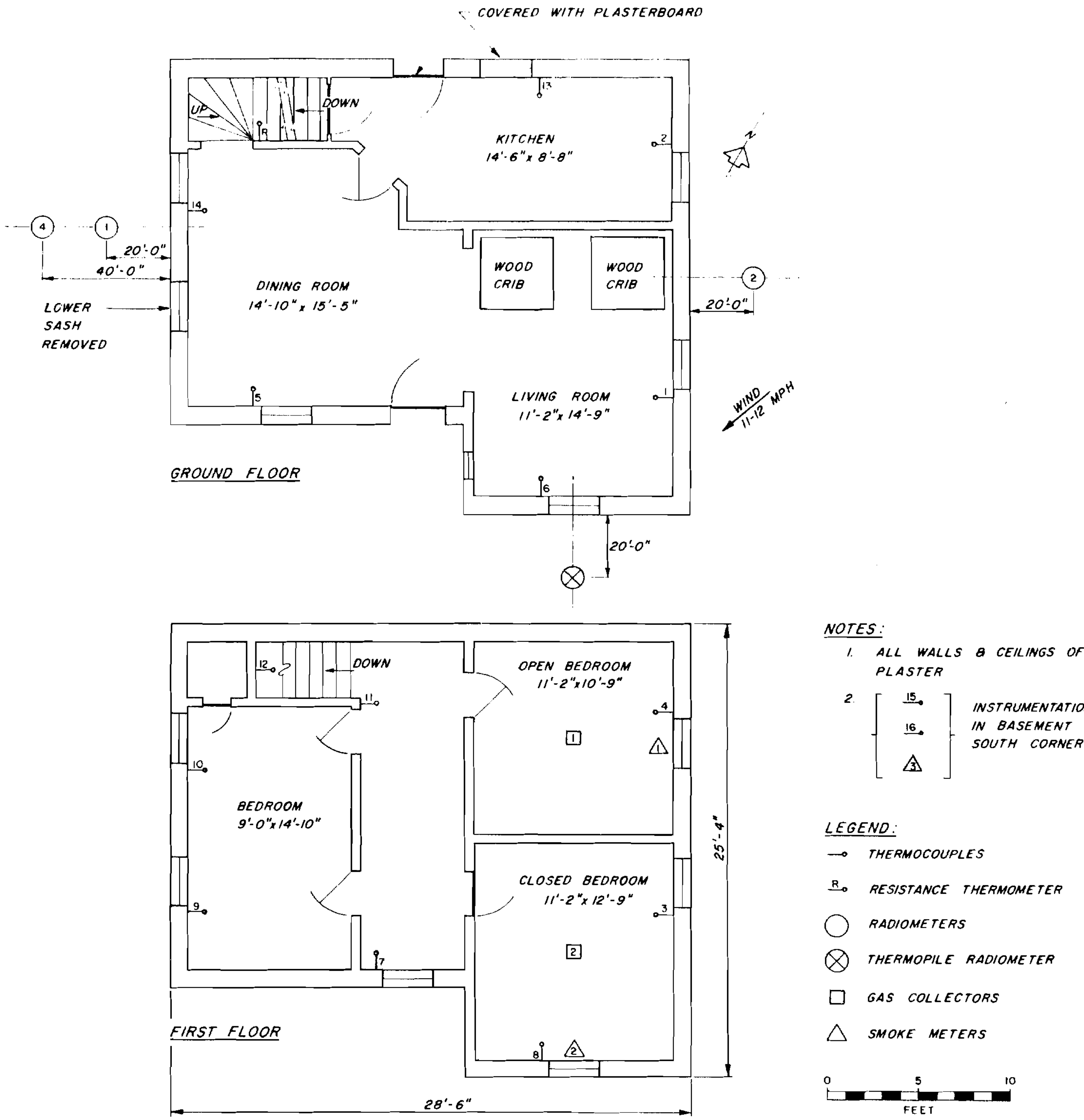


FIGURE 4 - BUILDING No. 4 - TWO - STOREY WOOD FRAME DWELLING WITH CLAPBOARD EXTERIOR AND BRICK INFILLING

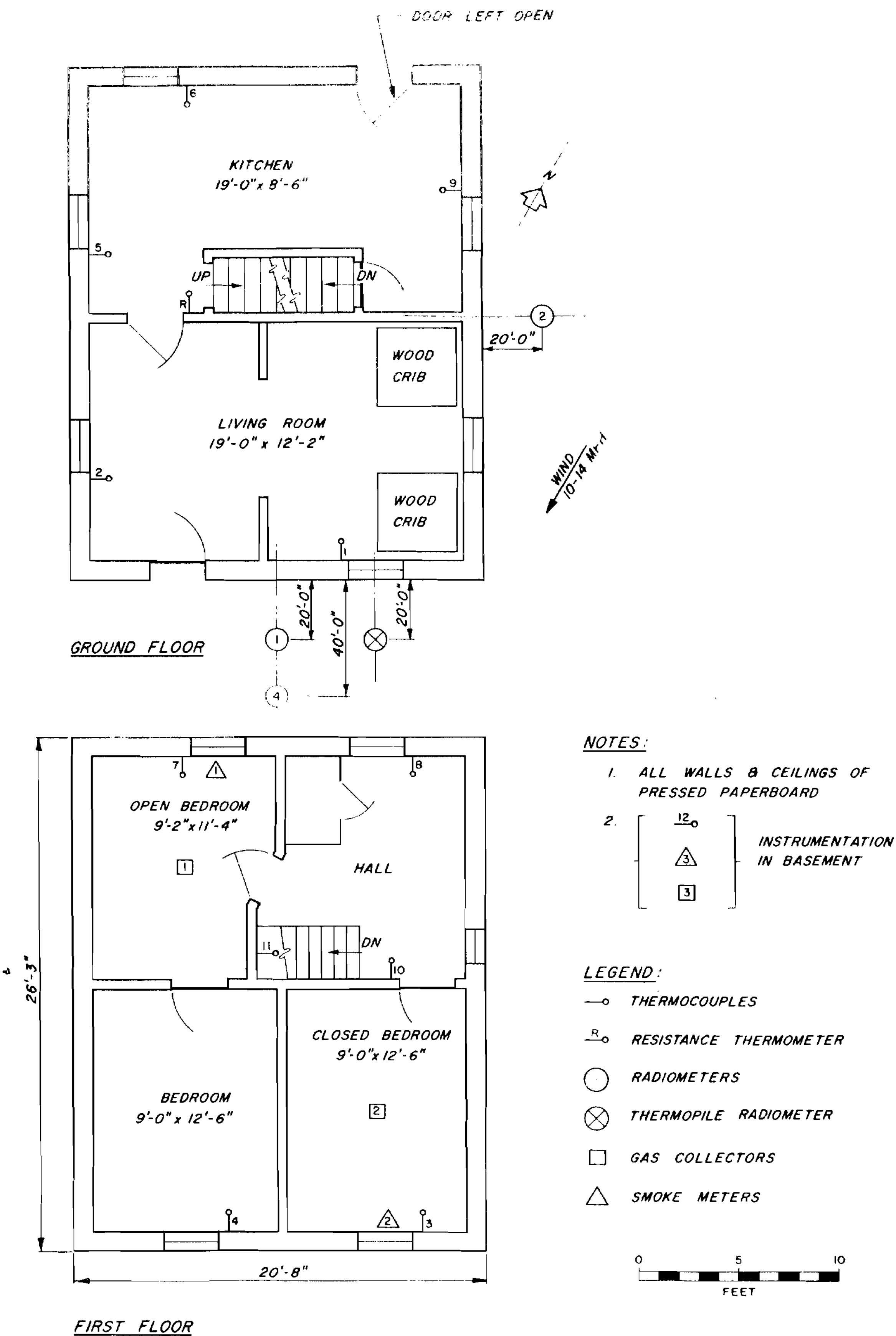


FIGURE 5 - BUILDING No. 5 - TWO - STOREY WOOD FRAME DWELLING WITH CLAPBOARD EXTERIOR

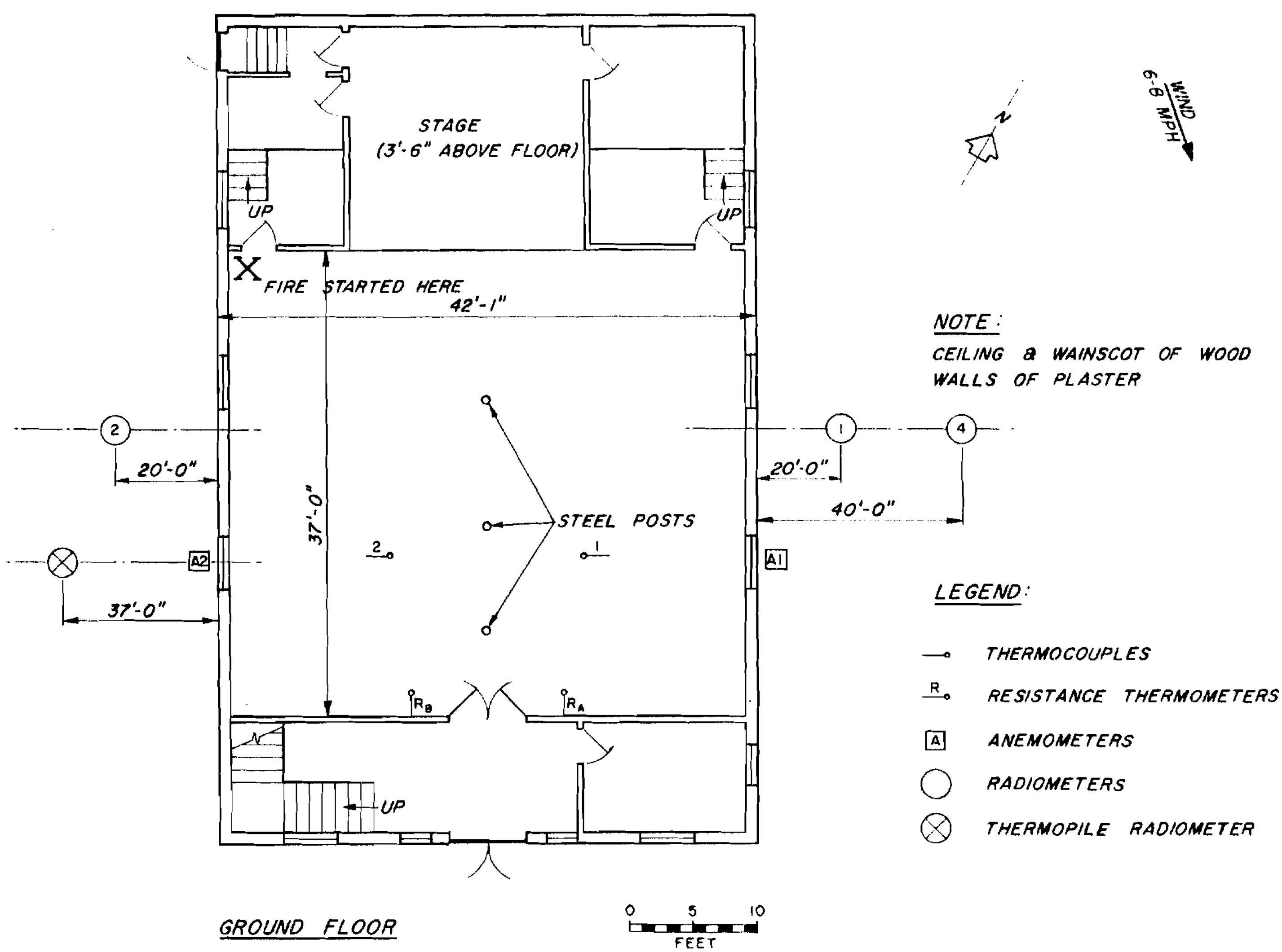


FIGURE 6 - BUILDING No. 6 - TWO - STOREY SOLID BRICK FRATERNITY HALL

FIGURE 6a - ELEVATIONS OF BUILDING No. 6 (FRATERNITY HALL)

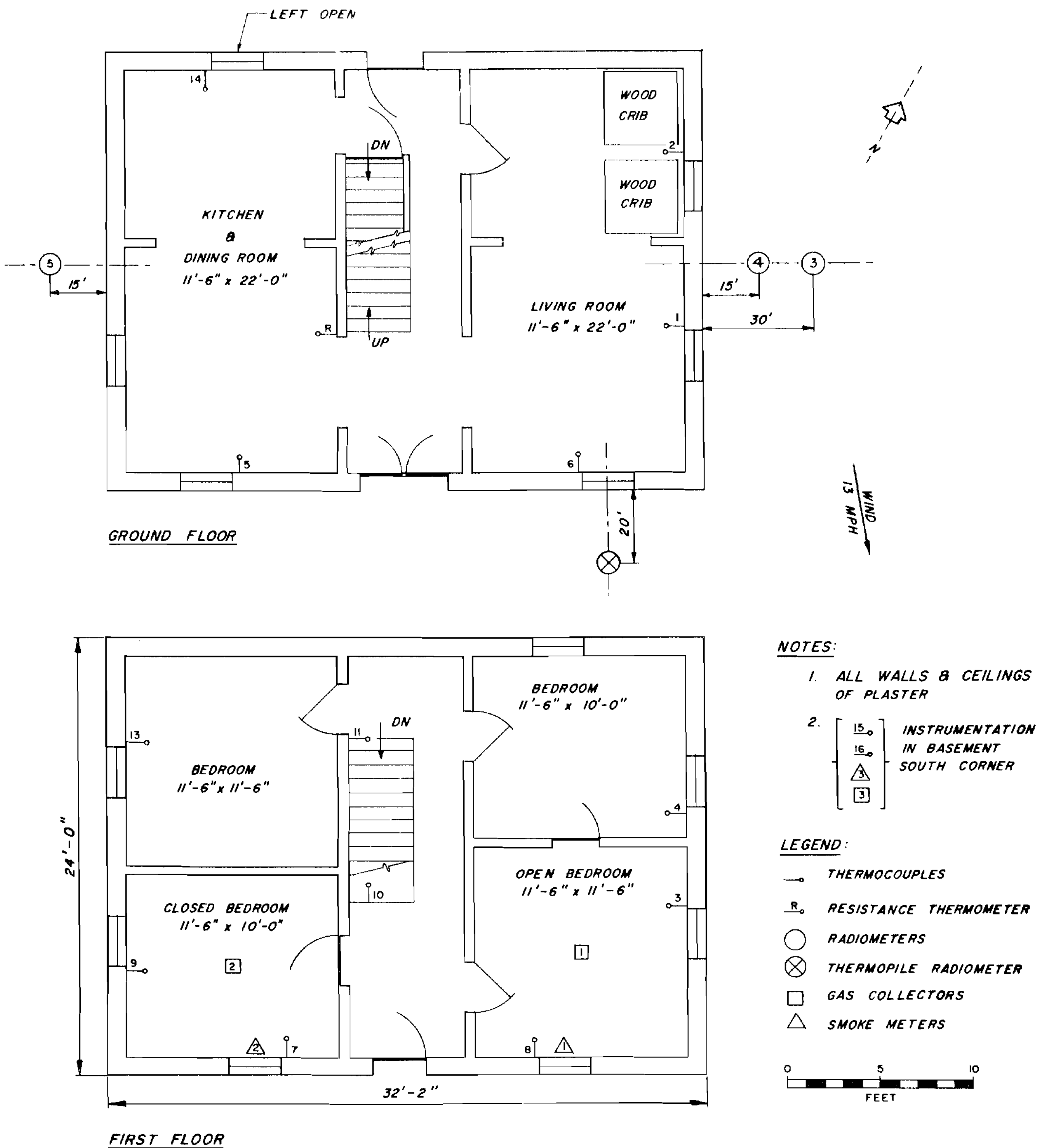


FIGURE 7 - BUILDING No. 7 - TWO - STOREY SOLID BRICK DWELLING

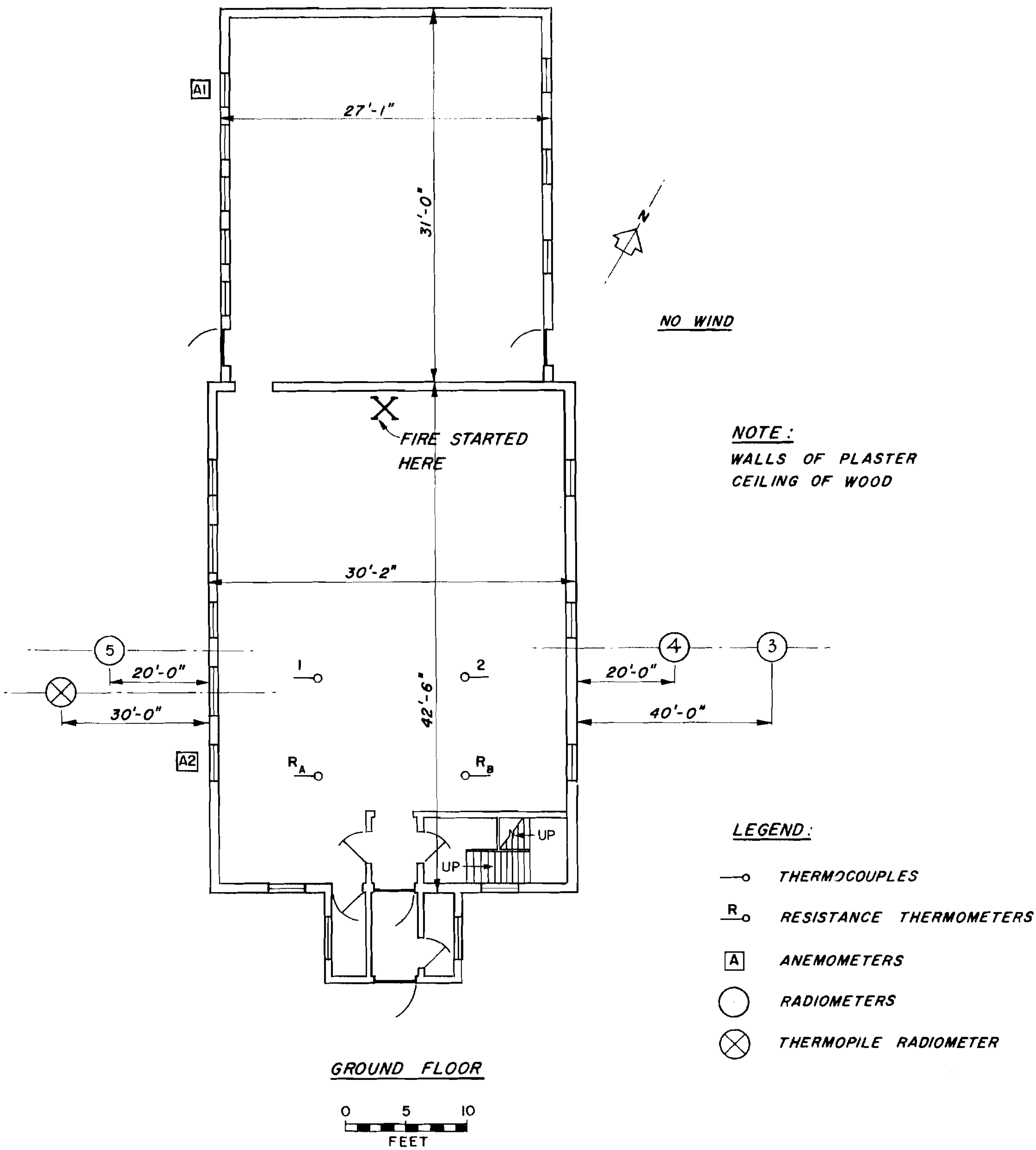
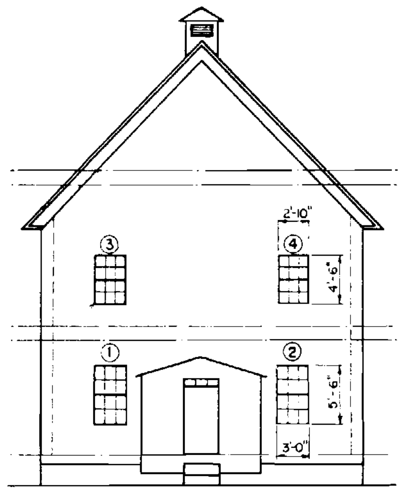
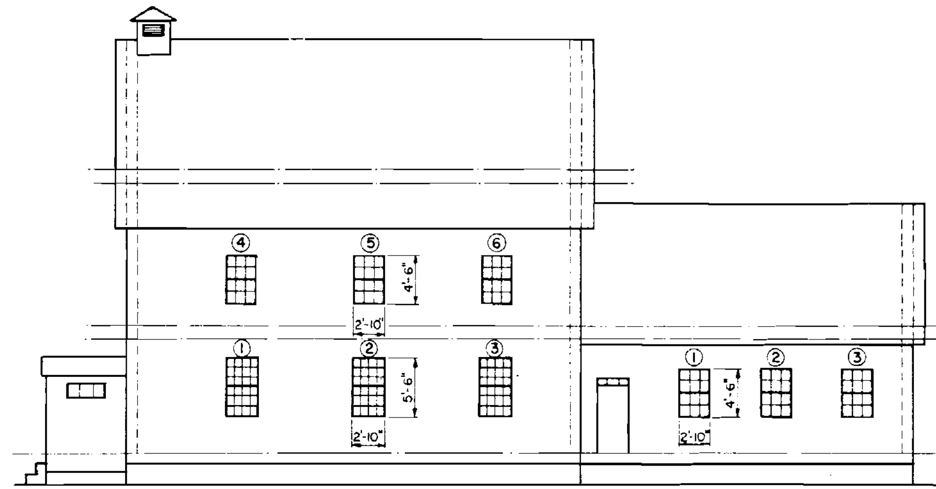


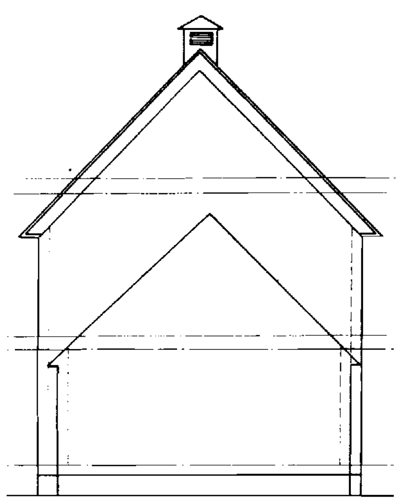
FIGURE 8 - BUILDING No. 8 - TWO - STOREY SOLID BRICK SCHOOL WITH ONE - STOREY EXTENSION AT REAR



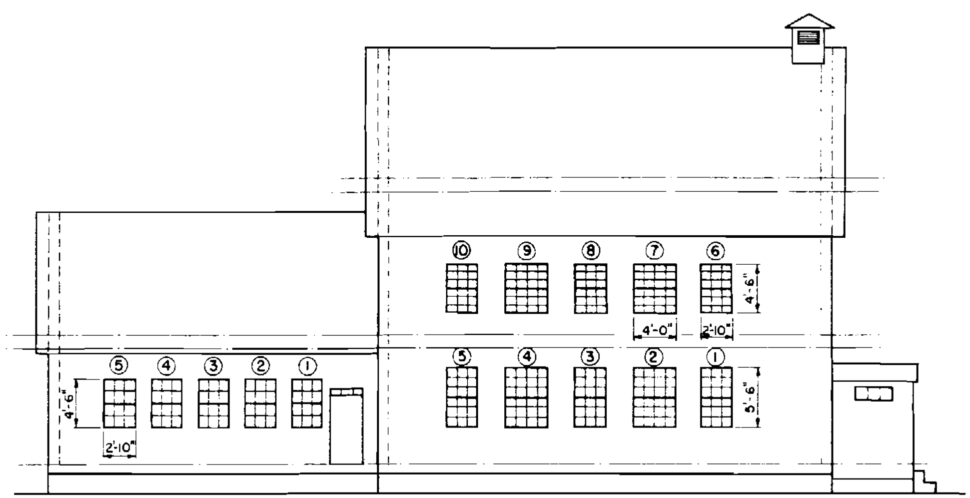
FRONT ELEVATION



EAST ELEVATION



REAR ELEVATION



WEST ELEVATION

0 5 10
FEET

FIGURE 8a – ELEVATIONS OF BUILDING No. 8 (SCHOOL)

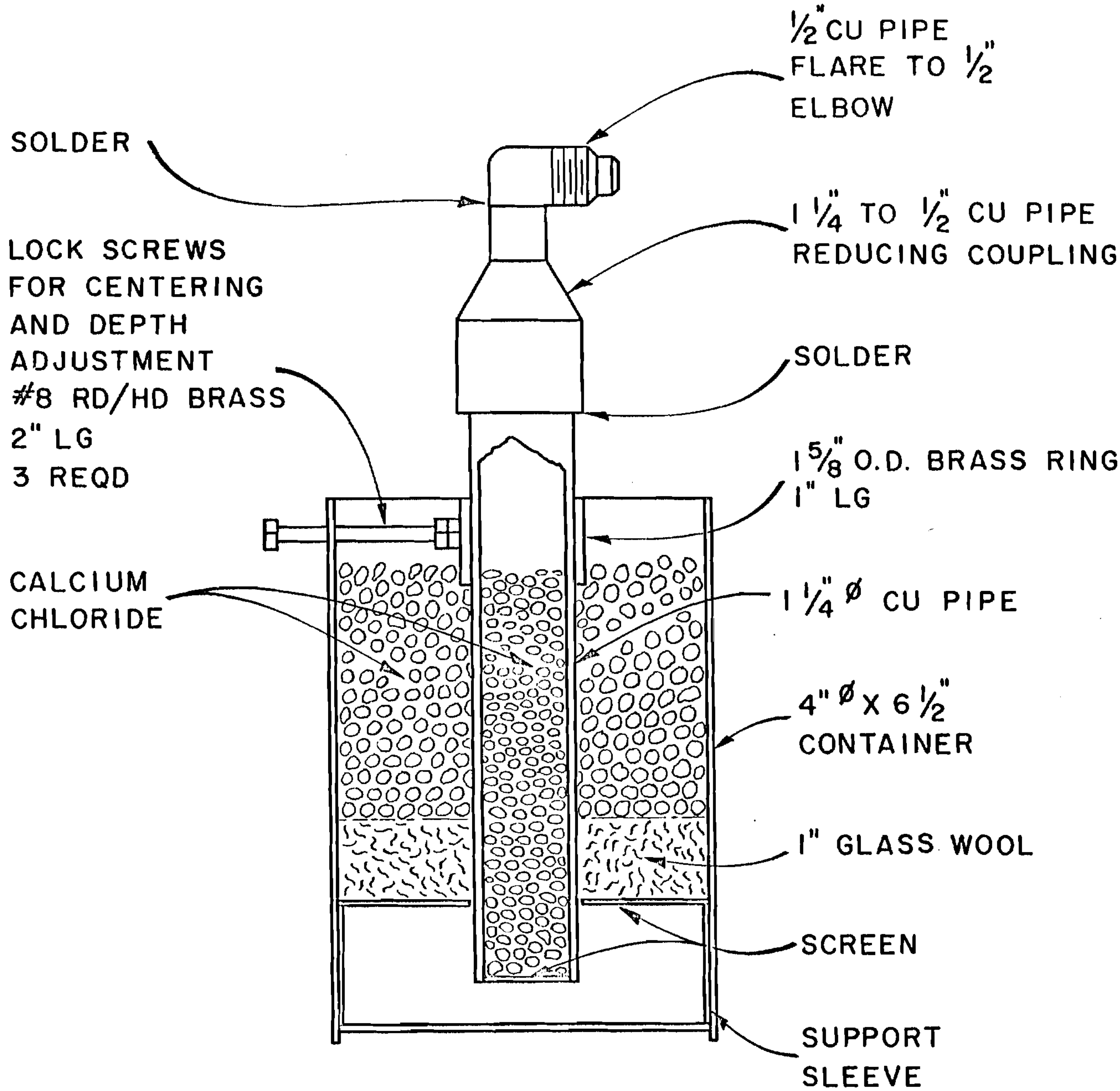


FIGURE 9 GAS COLLECTOR

BR 2029-1

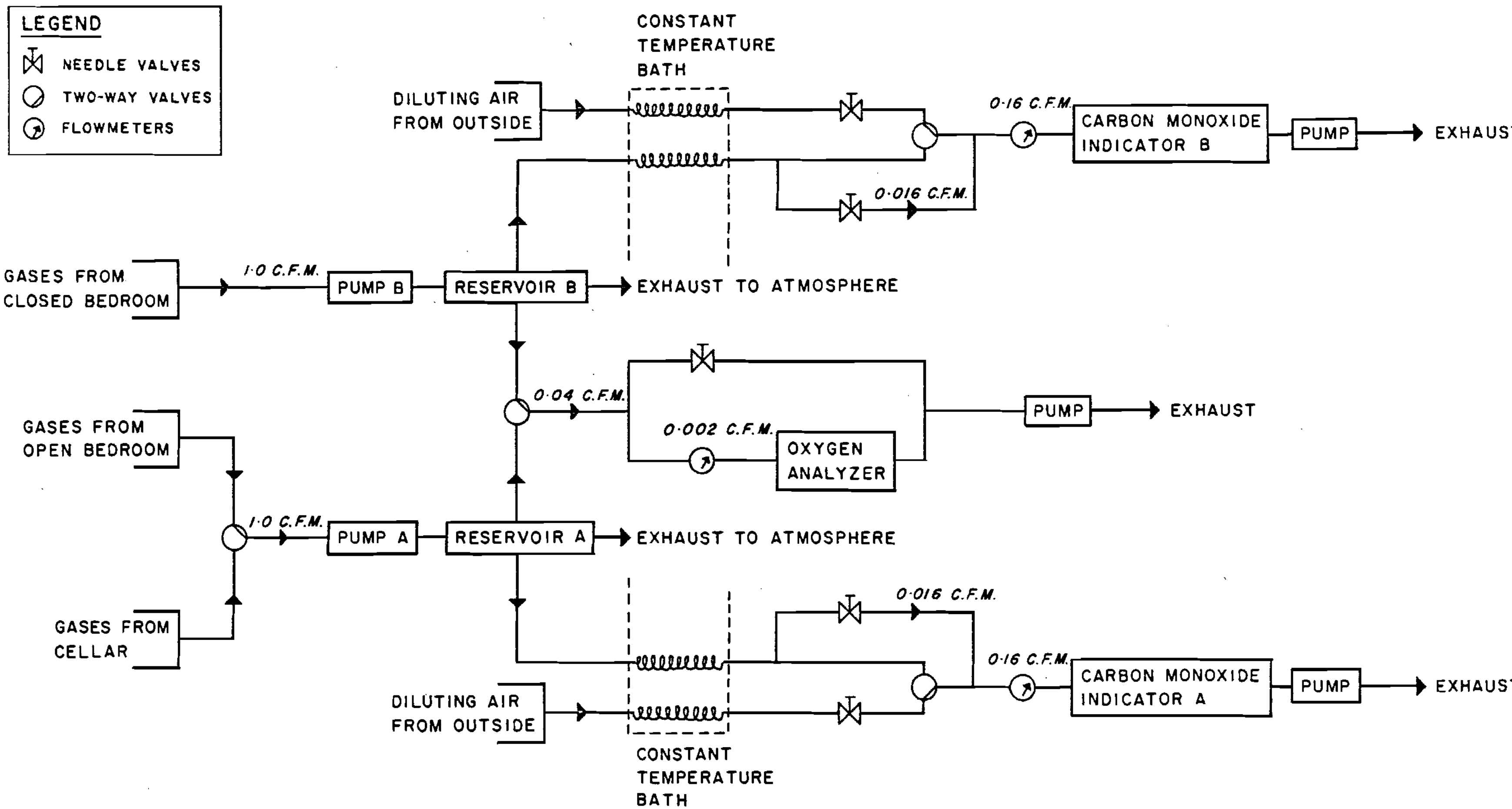


FIGURE 10 FLOW DIAGRAM OF ANALYTICAL SYSTEM

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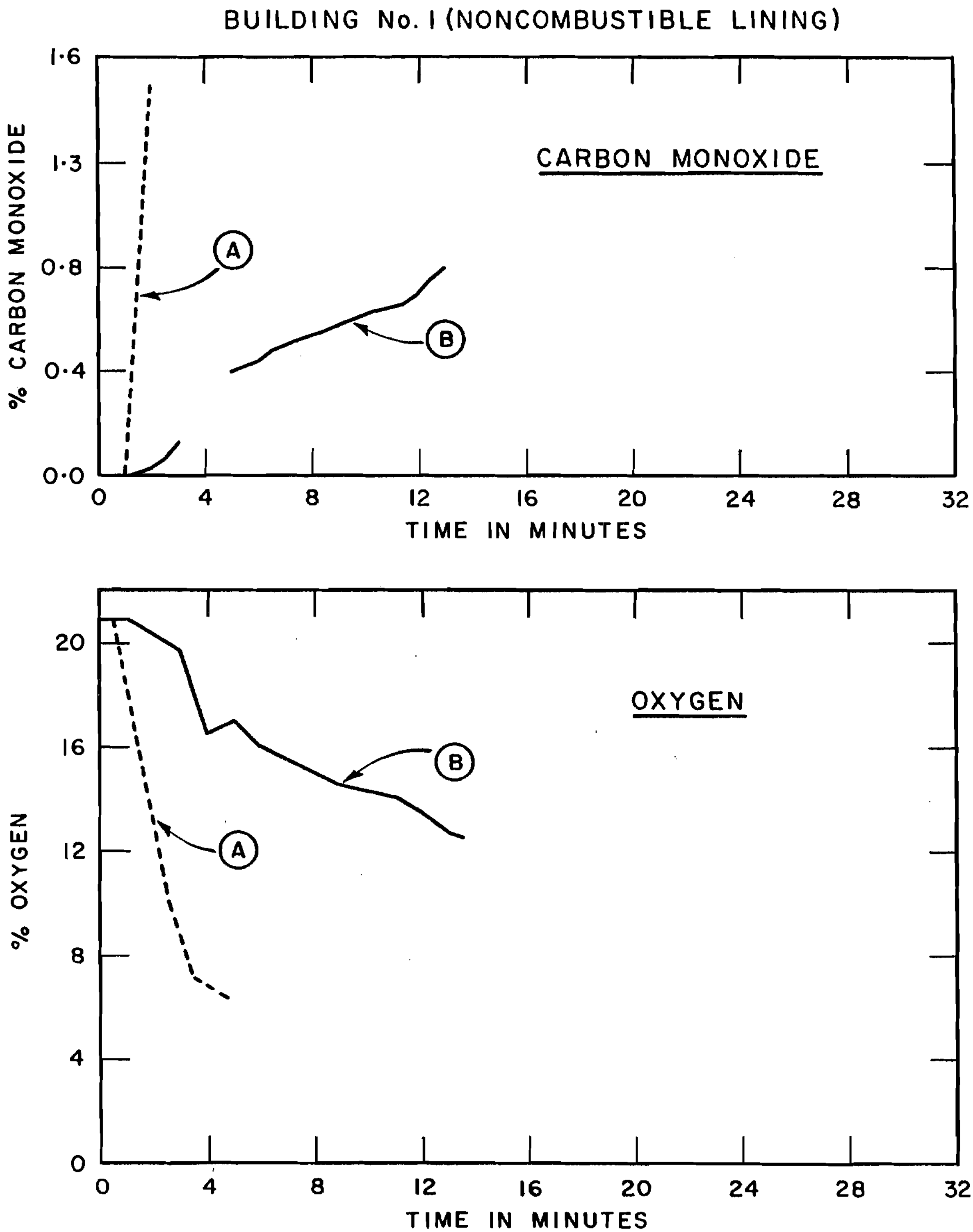

FIGURE II

CARBON MONOXIDE AND OXYGEN CONCENTRATIONS IN (A) OPEN BEDROOM AND (B) CLOSED BEDROOM OF BUILDING NO. I DURING BURN. GRASS FIRE CUT OFF GAS SAMPLING LINE TO CELLAR EARLY IN TEST.

BR 2029-3

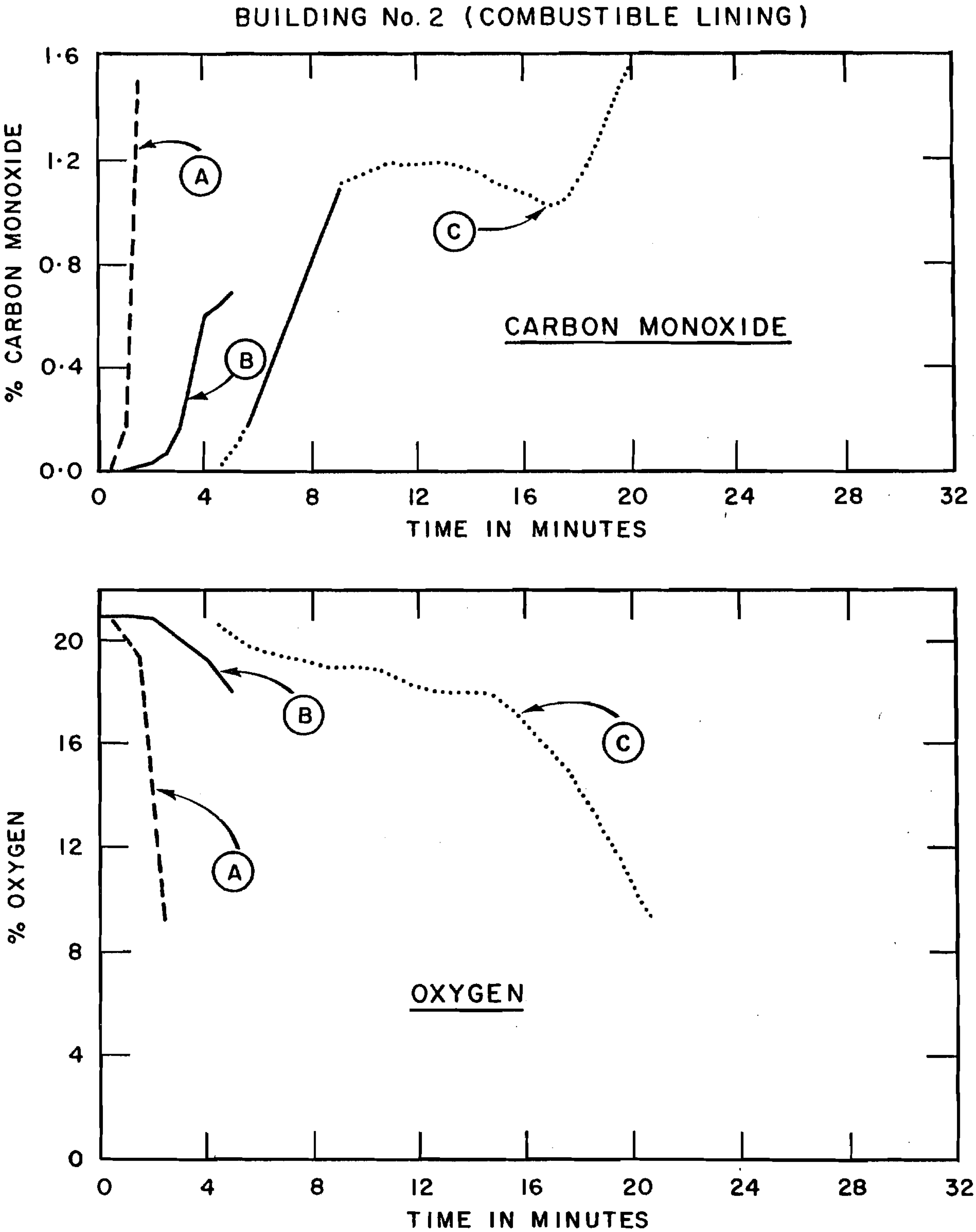

FIGURE 12

CARBON MONOXIDE AND OXYGEN CONCENTRATIONS IN (A) OPEN BEDROOM (B) CLOSED BEDROOM AND (C) CELLAR OF BUILDING NO. 2 DURING BURN

BR 2029-4

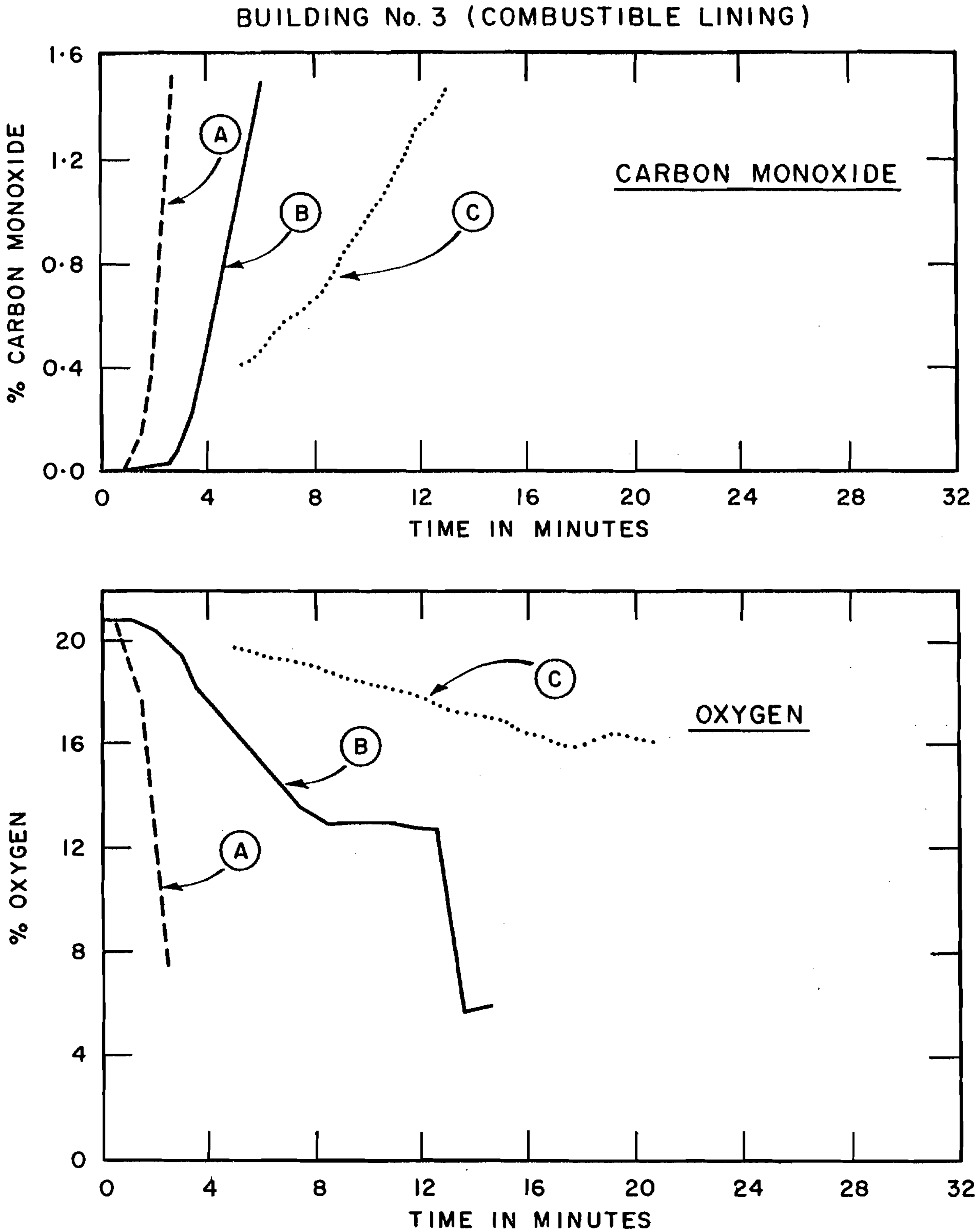

FIGURE 13

CARBON MONOXIDE AND OXYGEN CONCENTRATIONS IN (A) OPEN BEDROOM (B) CLOSED BEDROOM AND (C) CELLAR OF BUILDING NO. 3 DURING BURN

BR 2029-5

BUILDING No. 4 (NONCOMBUSTIBLE LINING)

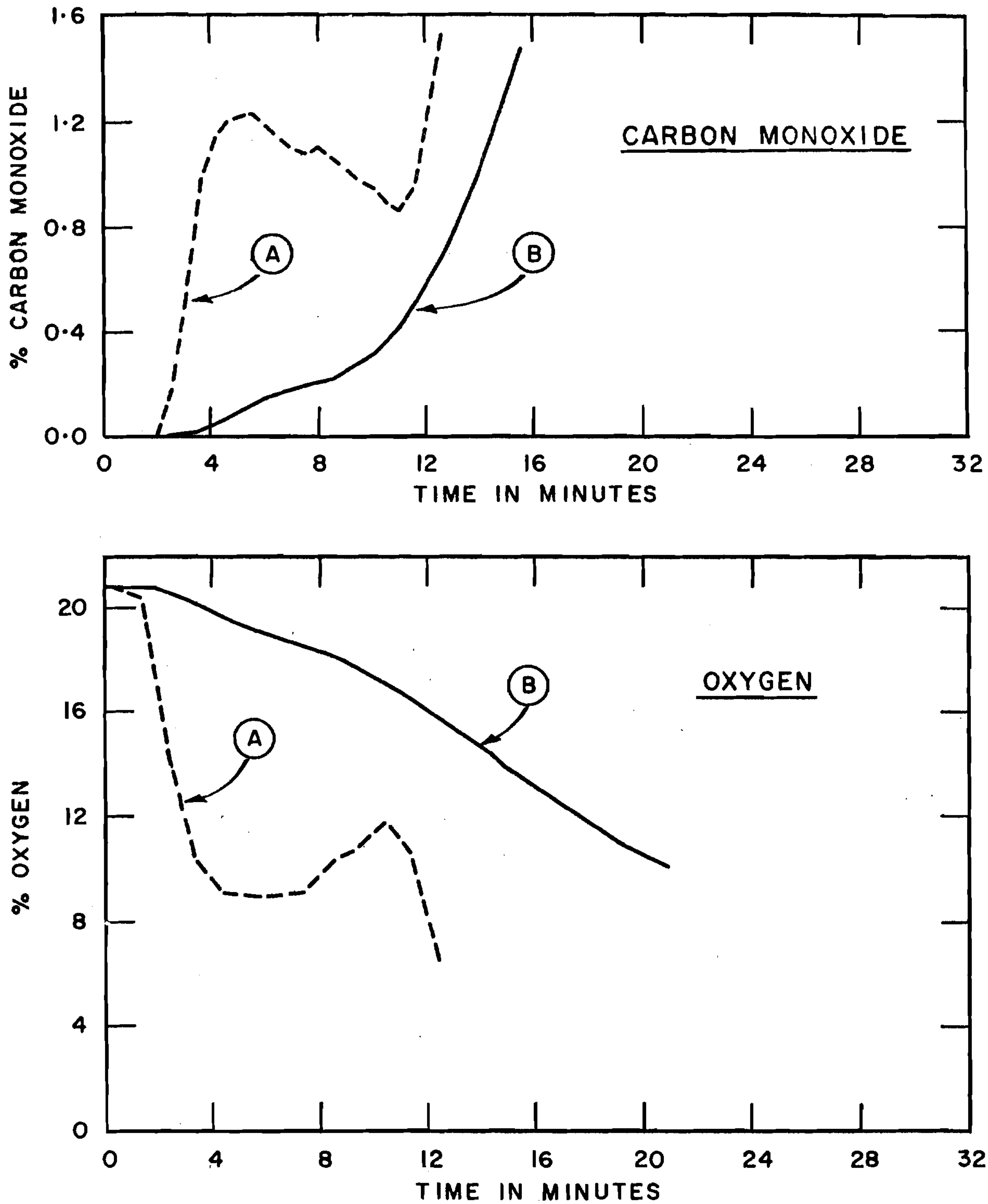

FIGURE 14

CARBON MONOXIDE AND OXYGEN CONCENTRATIONS IN (A) OPEN BEDROOM AND (B) CLOSED BEDROOM OF BUILDING NO. 4 DURING BURN. NO DETERMINATIONS WHERE MADE IN THE PARTLY EXCAVATED CELLAR

BR 2029-6

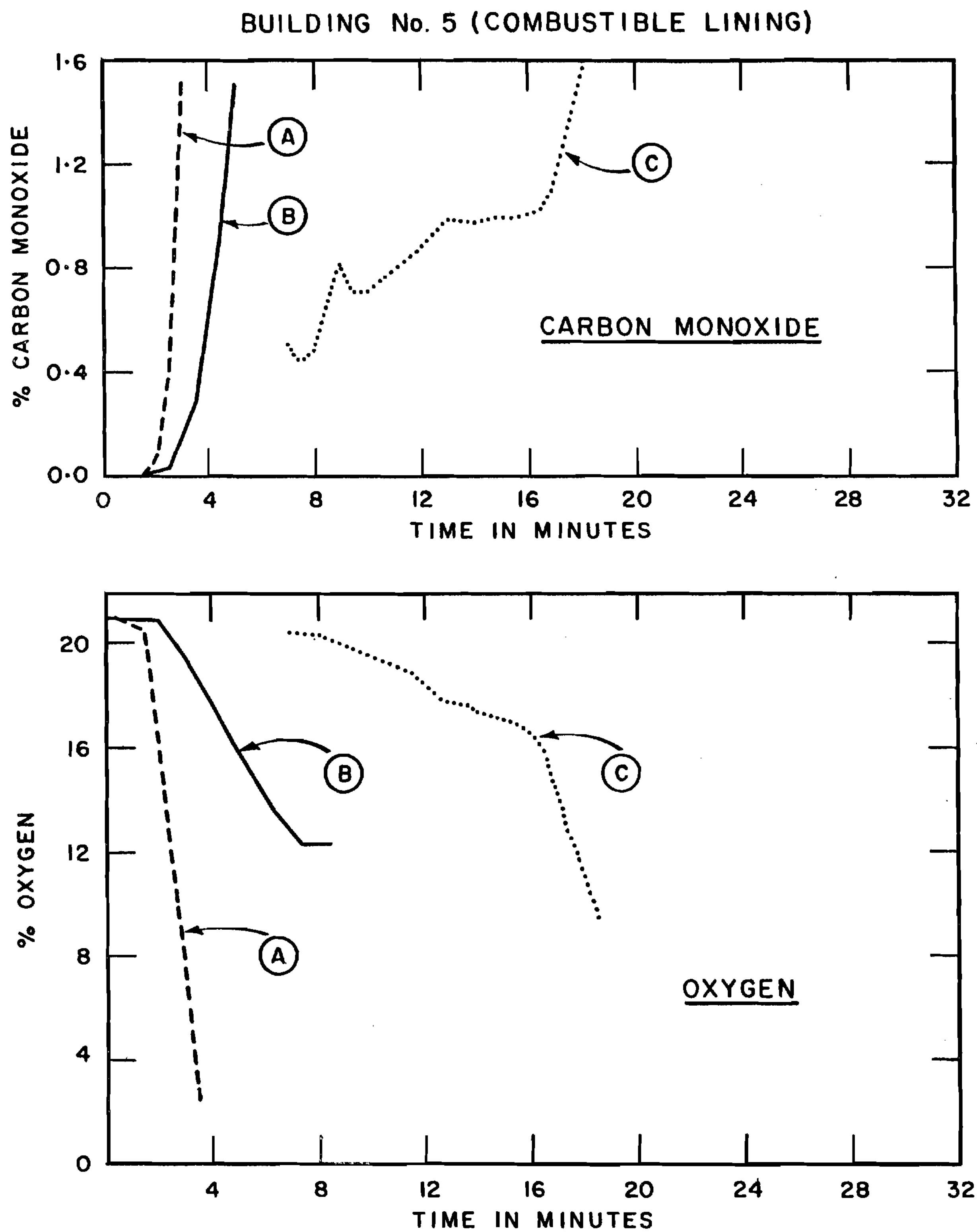

FIGURE 15

CARBON MONOXIDE AND OXYGEN CONCENTRATIONS IN (A) OPEN BEDROOM (B) CLOSED BEDROOM AND (C) CELLAR OF BUILDING NO. 5 DURING BURN.

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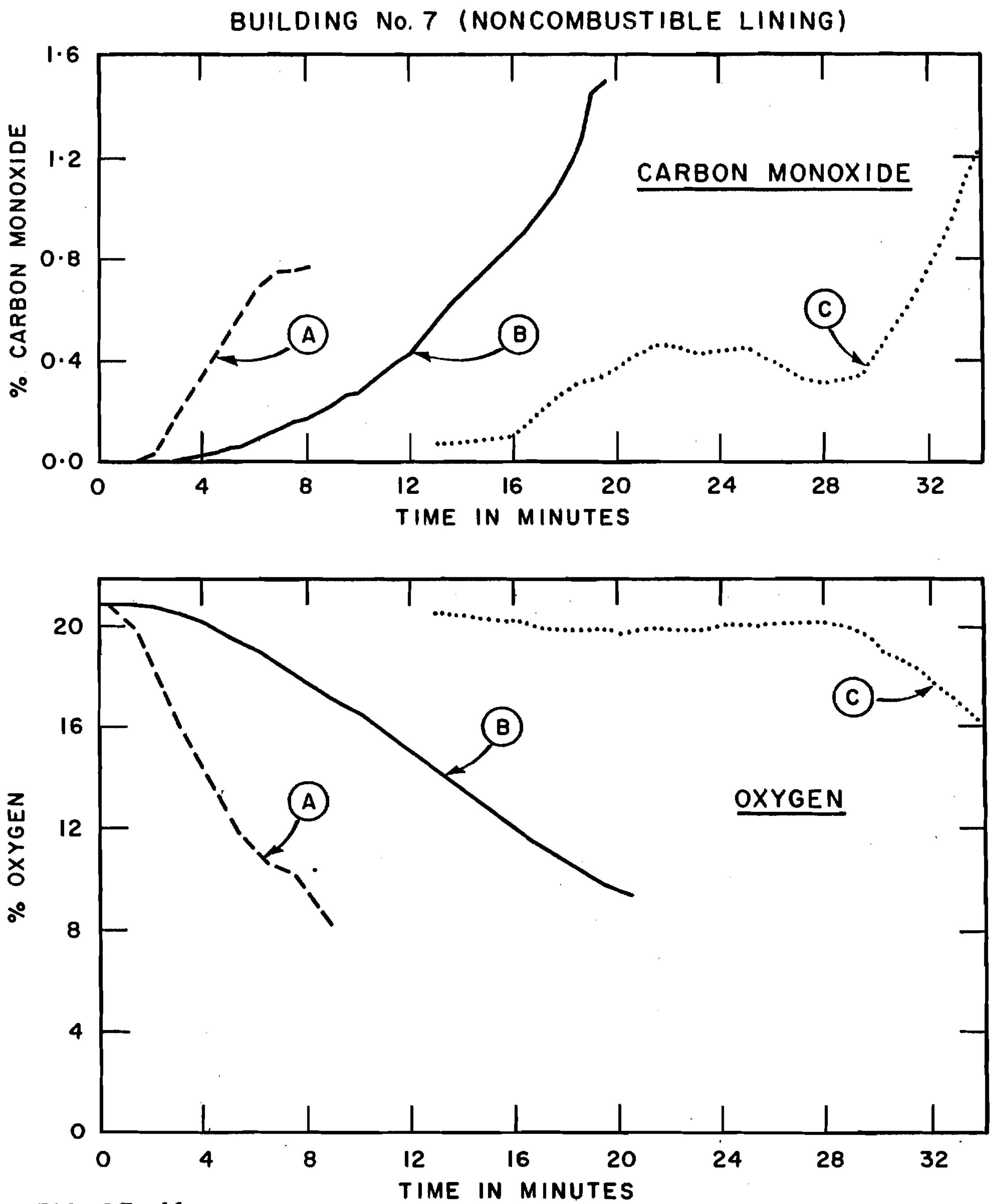

FIGURE 16

CARBON MONOXIDE AND OXYGEN CONCENTRATIONS IN (A) OPEN BEDROOM (B) CLOSED BEDROOM AND (C) CELLAR OF BUILDING NO. 7 DURING BURN.

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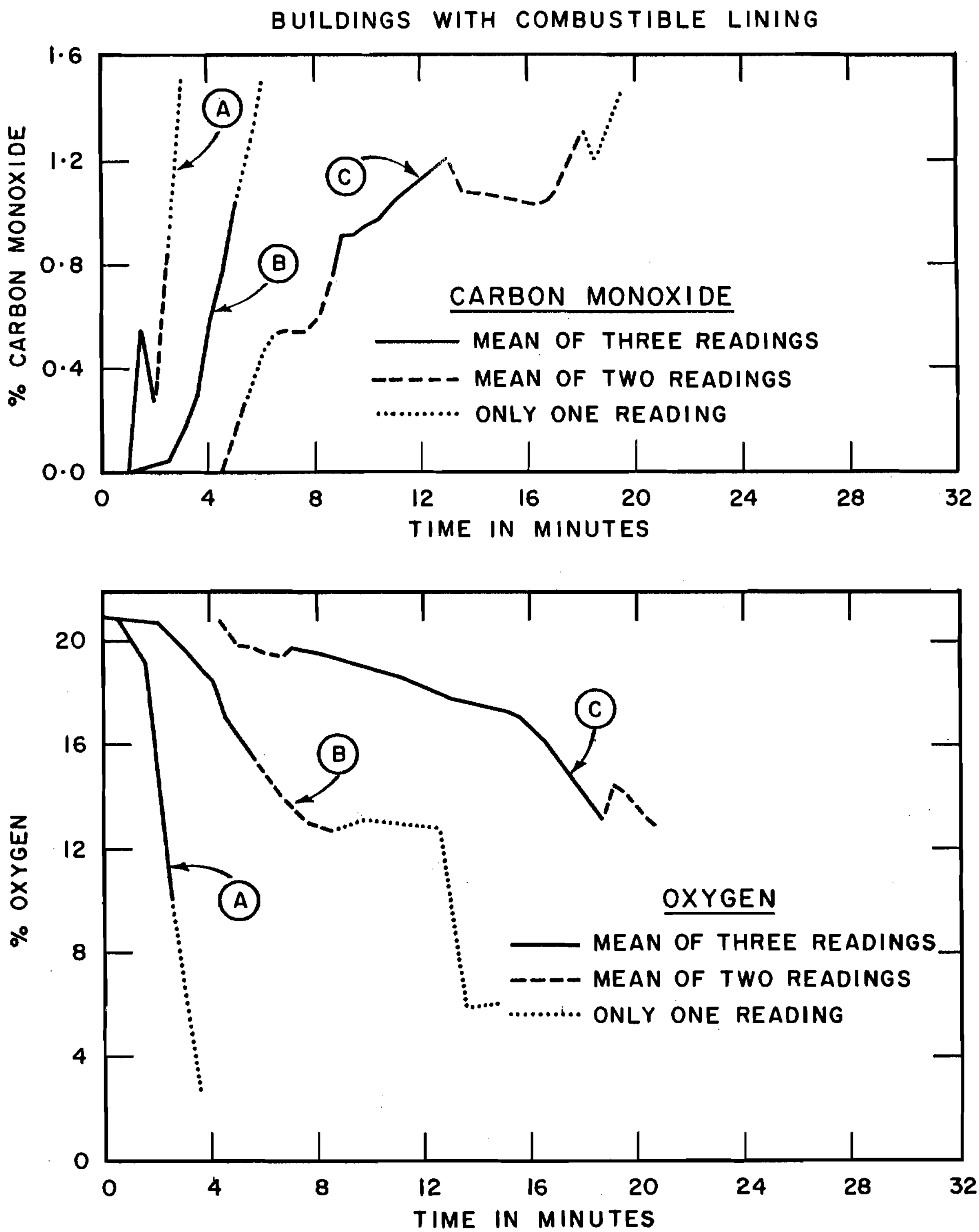

FIGURE 17

MEAN CONCENTRATIONS OF CARBON MONOXIDE AND OXYGEN IN (A) OPEN BEDROOM (B) CLOSED BEDROOM AND (C) CELLAR OF BUILDINGS LINED WITH COMBUSTIBLE MATERIAL

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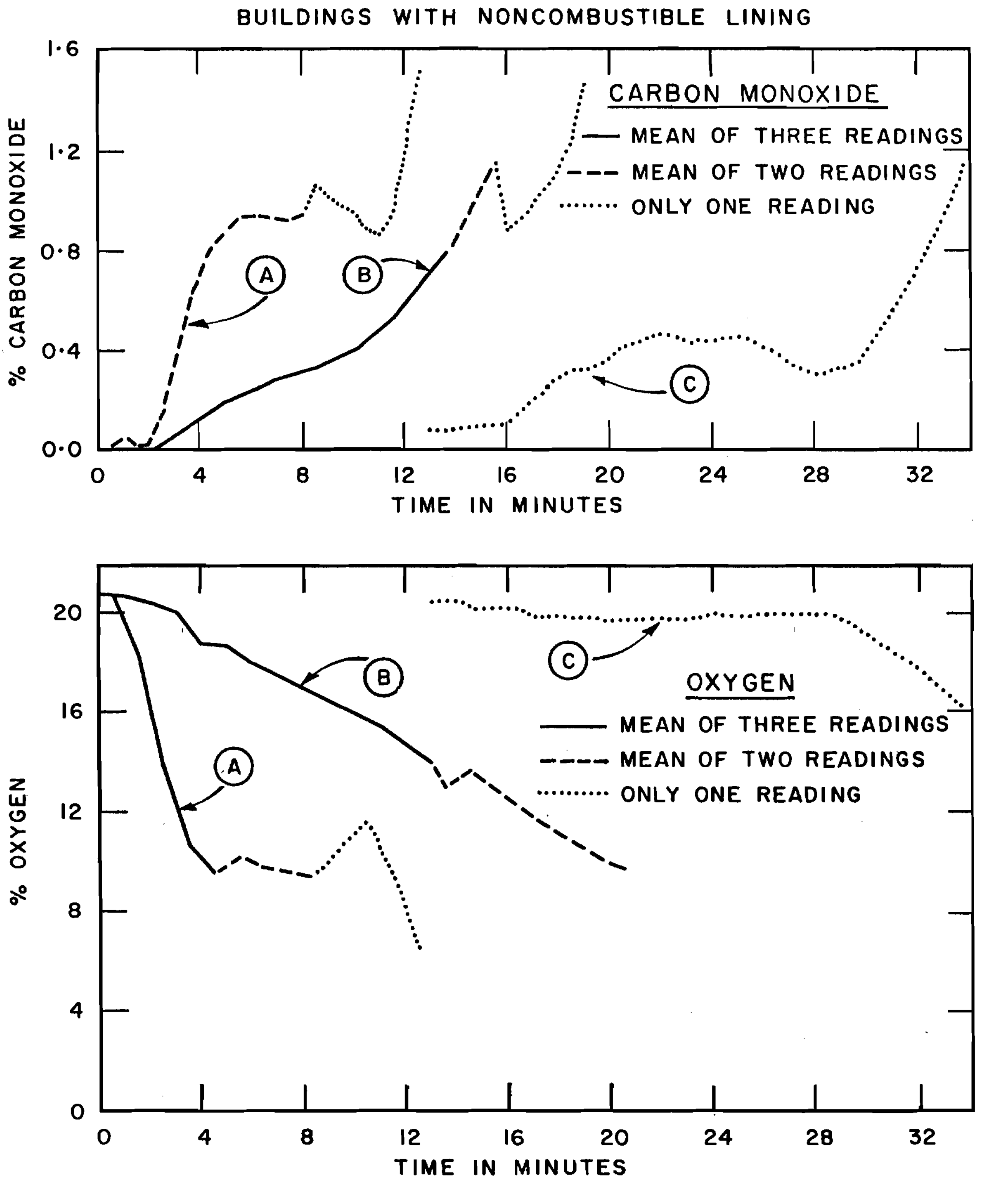

FIGURE 18

MEAN CONCENTRATIONS OF CARBON MONOXIDE AND OXYGEN IN (A) OPEN BEDROOM (B) CLOSED BEDROOM AND (C) CELLAR OF BUILDINGS LINED WITH INCOMBUSTIBLE MATERIAL

BR 2029-10

APPENDIX A

Readings obtained on oxygen and carbon monoxide concentrations in the closed bedroom, open bedroom, and cellar of each of the six dwellings during the "St. Lawrence Burns".

ST. LAWRENCE BURNS

GAS ANALYSIS

Building No. 1 9 January 1958

Time		Closed Bedroom		Open Bedroom		Cellar	
Min	Sec	% CO	% O_2	% CO	% O_2	% CO	% O_2
0	00	0.00	20.9	0.00	20.9		
0	30	0.00	20.9	0.00			
1	00	0.00		0.00	20.8		
1	30	0.00	20.9	0.02			
2	00	0.00		0.15+	15.5		
2	30	0.01	20.3				
3	00	0.03			10.1		
3	30	0.07	19.7				
4	00	0.13			7.1		
4	30		16.5				
5	00				6.5		
5	30		17.3				
6	00	0.40					
6	30	0.42	16.3				
7	00	0.44					
7	30	0.48	15.5				
8	00	0.51	15.2				
8	30	0.53	15.0				
9	00	0.54	14.7				
9	30	0.55	14.5				
10	00	0.58	14.5				
10	30	0.60	14.3				
11	00	0.62	14.2				
11	30	0.64	14.1				
12	00	0.65	13.7				
12	30	0.66	13.5				
13	00	0.70	13.1				
13	30	0.76	12.7				
14	00	0.80	12.5				
14	30	0.79					

Closed Bedroom — NOTE

Measurements discontinued. Sampling line cut off by fire.

Open Bedroom — NOTE: Before dilution system started operating effectively, concentration was above 1.5%.

Cellar — NOTE

No readings obtained. Sampling line cut off by grass fire.

ST. LAWRENCE BURNS

GAS ANALYSIS

Building No. 2 　　　　　　　　　　　　　　　　13 January 1958

Time	Closed Bedroom		Open Bedroom		Cellar	
Min Sec	% CO	% O_2	% CO	% O_2	% CO	% O_2
0 00	0.00	20.9	0.00	20.9		
0 30	0.00	20.9	0.00			
1 00	0.00		0.00	20.7		
1 30	0.00	20.9	0.00			
2 00	0.00			19.3		
2 30	0.01	20.8	1.5+			
3 00	0.02			9.4		
3 30	0.06	20.0				
4 00	0.15	19.6				
4 30		19.3				
5 00	0.60					20.5
5 30	0.63	18.0			0.00	
6 00	0.68					19.8
6 30					0.15+	
7 00						19.4
7 30						19.3
8 00						19.2
8 30						19.2
9 00						18.9
9 30						19.0
10 00					1.10	18.9
10 30					1.14	18.9
11 00					1.14	18.8
11 30					1.14	18.5
12 00					1.18	18.3
12 30					1.18	18.2
13 00					1.18	18.0
13 30					1.19	18.0
14 00					1.19	17.9
14 30					1.17	17.9
15 00					1.16	17.9
15 30					1.13	17.7
16 00					1.11	17.3
16 30					1.09	16.6
17 00					1.07	16.1
17 30					1.04	15.6
18 00					1.02	15.0
18 30					1.04	14.3
19 00					1.12	13.3
19 30					1.20	12.4
20 00					1.32	11.8
20 30					1.45	10.4
21 00					1.5+	9.5

NOTE

Measurements discontinued. Sampling line cut off by fire.

ST. LAWRENCE BURNS

GAS ANALYSIS

Building No. 3 | 14 January 1958

Time	Closed Bedroom		Open Bedroom		Cellar	
Min Sec	% CO	% O_2	% CO	% O_2	% CO	% O_2
0 00	0.00	20.9	0.00	20.9		
0 30	0.00	20.9	0.00			
1 00	0.00		0.00	20.8		
1 30	0.00	20.9	0.00			
2 00	0.00		0.00	17.8		
2 30	0.02	20.5	0.15			
3 00	0.02		0.47	7.6		
3 30	0.03	19.5	1.30			
4 00	0.11	18.3				
4 30	0.25					
5 00	0.48	17.2				
5 30	0.70					19.8
6 00	0.95	16.1				
6 30	1.21				0.42	19.5
7 00	1.50	14.9			0.45	
7 30					0.53	19.3
8 00		13.6			0.58	
8 30					0.62	19.1
9 00		13.0			0.66	
9 30					0.72	18.7
10 00		13.1			0.81	
10 30					0.90	18.4
11 00		13.1			0.98	
11 30					1.04	18.2
12 00		12.9			1.14	
12 30					1.24	17.9
13 00		12.8			1.34	
13 30					1.38	17.4
14 00		5.8			1.47	
14 30						17.2
15 00		6.0				
15 30						17.0
16 00						16.7
16 30						16.5
17 00						16.4
17 30						16.2
18 00						16.0
18 30						16.1
19 00						16.3
19 30						16.5
20 00						16.4
20 30						16.3
21 00						16.3

ST. LAWRENCE BURNS

GAS ANALYSIS

Building No. 4 | 15 January 1958

Time	Closed Bedroom		Open Bedroom		Cellar	
Min Sec	% CO	% O_2	% CO	% O_2	% CO	% O_2
0 00	0.00	20.9	0.00	20.9	No determinations made	
0 30	0.00	20.8	0.00			
1 00	0.00		0.00	20.8		
1 30	0.00	20.8	0.00			
2 00	0.00		0.00	20.4		
2 30	0.00	20.8	0.00			
3 00	0.00		0.01	14.5		
3 30	0.00	20.4	0.17			
4 00	0.01		0.55	10.2		
4 30	0.02	19.9	0.91			
5 00	0.05		1.11	9.1		
5 30	0.07	19.4	1.20			
6 00	0.10		1.22	9.0		
6 30	0.13	19.0	1.24			
7 00	0.15		1.20	9.0		
7 30	0.16	18.7	1.15			
8 00	0.18		1.10	9.2		
8 30	0.20	18.4	1.08			
9 00	0.21		1.10	10.3		
9 30	0.22	18.0	1.07			
10 00	0.25		1.02	10.8		
10 30	0.28	17.4	0.98			
11 00	0.31		0.95	11.8		
11 30	0.36	16.9	0.89			
12 00	0.42		0.86	9.6		
12 30	0.50	16.2	0.94			
13 00	0.60		1.23	6.6		
13 30	0.68	15.5	1.5+			
14 00	0.79					
14 30	0.89	14.8				
15 00	1.03	14.4				
15 30	1.18	13.9				
16 00	1.35	13.6				
16 30	1.48	13.3				
17 00		12.9				
17 30		12.6				
18 00		12.2				
18 30		11.9				
19 00		11.6				
19 30		11.2				
20 00		10.9				
20 30		10.6				
21 00		10.4				
21 30		10.1				

ST. LAWRENCE BURNS

GAS ANALYSIS

Building No. 5 16 January 1958

Time	Closed Bedroom		Open Bedroom		Cellar	
Min Sec	% CO	% O_2	% CO	% O_2	% CO	% O_2
0 00	0.00	20.9	0.00	20.9		
0 30	0.00	20.9	0.00			
1 00	0.00		0.00	20.9		
1 30	0.00	20.9	0.00			
2 00	0.00		0.00	20.5		
2 30	0.00	20.9	0.00			
3 00	0.01		0.06	12.3		
3 30	0.03	19.5	0.41			
4 00	0.15		1.50	2.7		
4 30	0.28	17.7				
5 00	0.65	16.7				
5 30	0.97					
6 00	1.50	15.1				
6 30						
7 00		13.5				
7 30						20.4
8 00		12.3			0.50	
8 30					0.44	20.3
9 00		12.3			0.48	
9 30					0.65	19.9
10 00					0.81	19.7
10 30					0.70	19.5
11 00					0.70	19.3
11 30					0.75	19.0
12 00					0.79	18.8
12 30					0.83	18.4
13 00					0.87	17.9
13 30					0.93	17.7
14 00					0.98	17.6
14 30					0.97	17.3
15 00					0.97	17.2
15 30					0.98	17.1
16 00					0.99	16.9
16 30					0.99	16.5
17 00					1.00	15.9
17 30					1.02	14.5
18 00					1.12	12.9
18 30					1.32	11.3
19 00					1.5+	9.7

ST. LAWRENCE BURNS

GAS ANALYSIS

Building No. 7 — 5 February 1958

Time	Closed Bedroom		Open Bedroom		Cellar	
Min Sec	% CO	% O_2	% CO	% O_2	% CO	% O_2
0 00	0.00	20.9	0.00	20.9		
0 30	0.00	20.9	0.00			
1 00	0.00		0.00	20.8		
1 30	0.00	20.9	0.00			
2 00	0.00		0.00	19.8		
2 30	0.00	20.8	0.01			
3 00	0.00		0.03	17.5		
3 30	0.00	20.6	0.11			
4 00	0.01		0.20	15.4		
4 30	0.02	20.2	0.26			
5 00	0.03		0.35	13.5		
5 30	0.04	19.6	0.43			
6 00	0.06		0.51	11.8		
6 30	0.07	19.1	0.61			
7 00	0.09		0.68	10.7		
7 30	0.12	18.5	0.73			
8 00	0.14		0.76	10.2		
8 30	0.17	17.8	0.76			
9 00	0.18		0.77	8.9		
9 30		17.1				
10 00	0.23	16.9				
10 30	0.27	16.6				
11 00	0.28					
11 30	0.32	15.9				
12 00	0.36					
12 30	0.40	15.1				
13 00	0.43					
13 30	0.50					20.5
14 00	0.56	13.9			0.07	
14 30	0.62				0.07	20.4
15 00	0.67	13.2			0.08	
15 30	0.72				0.08	20.2
16 00	0.77	12.4			0.09	
16 30	0.82				0.09	20.2
17 00	0.88	11.7			0.11	
17 30	0.92				0.15	19.9
18 00	0.98	11.1			0.20	
18 30	1.05				0.24	19.8
19 00	1.13	10.5			0.28	
19 30	1.24				0.31	19.9
20 00	1.46	9.8			0.32	
20 30	1.50				0.34	19.7
21 00		9.4			0.37	
21 30					0.41	19.8
22 00					0.43	19.9
22 30					0.46	19.8
23 00					0.46	19.8
23 30					0.44	19.8
24 00					0.43	19.9
24 30					0.43	20.0
25 00						20.0
25 30						20.0
26 00					0.45	20.0
26 30					0.42	20.1
27 00					0.40	20.1
27 30					0.37	20.1
28 00					0.34	20.1
28 30					0.32	20.1
29 00					0.31	20.0
29 30					0.32	19.9
30 00					0.33	19.6
30 30					0.35	19.2
31 00					0.43	18.9
31 30					0.51	18.6
32 00					0.58	18.3
32 30					0.68	17.9
33 00					0.77	17.4
33 30					0.87	17.0
34 00					1.00	16.6
34 30					1.13	16.1
35 00					1.28	15.6
35 30					1.43	14.4
36 00						12.0
36 30						11.6