NATIONAL RESEARCH COUNCIL

CANADA

DIVISION OF BUILDING RESEARCH

ST. LAWRENCE BURNS TEMPERATURE MEASUREMENTS

by

G. Williams-Leir

Report No. 152

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 Mr. G. Williams-Leir, research officer with the Fire Section of this Division who assisted in the initial planning of the project and was responsible for the measurements of temperature, smoke and sound.

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

TEMPERATURE MEASUREMENTS

by

G. Williams-Leir

House-burning experiments carried out at Aultsville, Ontario, in January and February 1958 by the Division of Building Research, National Research Council, assisted by other organizations, have been generally described by G.W. Shorter in DBR Internal Report 150. Temperature measurements were made in the course of these experiments and the present report describes the technique used and gives the results.

EQUIPMENT

Thermocouples of chromel and alumel were used. The 22-gauge twin wires were insulated individually with teflon (of distinguishable colours) and braided together with glass fibre, this combination having been selected as best satisfying the various requirements, i.e., resistance to abrasion, to water, and to heat.

1. Installation in Houses

Thermocouples were installed in the six houses in positions shown in the individual plans (Figs. 1 to 5, 7). In general, each one was located 4 ft from the floor and projected 8 in. from the wall to which the leads were stapled, the exception being thermocouples at ceiling level above the foot of the stairs and on the beams in the cellar.

The leads from each thermocouple were carried as directly as possible to the exterior wall of the house and to the upstairs windowsill level. From this point several feet of lead hung free and terminated in a Jones socket, four thermocouples to one eight-pin socket. This arrangement was adopted in order that the socket could be kept inside the window in relative safety from the time of installation until the day of the burn.

Compensating leads about 100 ft long carried the outputs of the thermocouples to the trailer in which the recorders were housed. These were of iron and "alloy 125", 19 strands each 30-gauge B & S, together equivalent to 17 gauge, coated with polyvinyl on each conductor and polyvinyl over-all. The leads were cabled together in fours with a Jones plug at each end. Four sockets on the outside of the trailer were wired with chromel and alumel to a terminal board on the inside wall behind the recorder and the input leads to the recorder were connected to this.

The recorder was a Leeds & Northrup self-balancing potentiometer with 16 channels, printing at 4-sec. intervals, with automatic cold junction compensation and scale range 0 to 2400°F. Thus a reading was taken for each thermocouple at 64-sec. intervals.

2. Installation in Two Halls

The positions of the thermocouples are shown on the plans of the community hall, Building No. 6, and on those of the school, Building No. 8 (Figs. 6 and 8). Only two thermocouples were used in each building; they were attached to the beams which had supported the upper floor (this floor had been removed before the burn). In each case the point selected was about half way from front to back of the hall and about half way from the side walls to the centre of the hall.

They were connected to the same recorder in the manner described for the houses. The only difference was that since there were only two thermocouples, eight of the 16 channels of the recorder were available for each. Thus the record contains a reading of each thermocouple at intervals of 8 instead of 64 seconds.

RESULTS OF BURNS OF HOUSES

To make the results as readily comparable as possible, the temperature readings have been averaged in groups, and the following is a key to Figs. 9 to 14 in which the results are given:

A	Over wooden crib by which the house was ignited
B	At ceiling level above foot of stairs
C	Remainder of ground floor
D	At head of stairs
E	In those bedrooms where the door was left open
F	In those bedrooms where the door was closed
G	In the cellar.

As is discussed in DBR Report No. 150, some of the houses had incombustible wall and ceiling linings, some had linings of combustible materials, and others had mixtures of both. Where necessary, additional boards had been used to finish the walls so that three were uniformly incombustible-lined and the other three were uniformly combustible-lined, at least as to the lower floor, the stairway, and the upstairs hall. Buildings No. 3 and 5 were in fact wholly lined with combustibles, but Building No. 2 had plaster in the bedrooms.

Buildings No. 1, 4 and 7 were wholly incombustible-lined. For brevity in this report the two groups of houses, incombustible-lined and combustible-lined, will be referred to as I and C houses respectively.

From the temperature graphs in Figs. 9 to 14 two further graphs have been prepared. On Fig. 17 the mean temperatures at each location are given for the three I houses; Fig. 18 gives the means for the C houses. The notation on these graphs is a combination of the two systems just described; for instance, IA indicates the mean temperatures above the igniting crib in the three houses with incombustible linings. Where the mean relies on but a single burn of the three, owing to the incompleteness of the individual temperature curves, the mean curve is given as a broken line.

1. Discussion of Burns of Houses

Comparison of curves IA and CA shows very little difference in the first 2 minutes in the temperatures above the igniting crib. This is evidence that the strength of the igniting source - the wooden crib simulating furniture - was reasonably similar in the two groups of houses. There would not have been time at this stage for the nature of the wall linings to have had appreciable influence on the development of the fire, although at later stages the C houses are hotter.

The nature of the wall linings has more influence farther from the source of ignition. Almost from the start CB is hotter than IB, and after 6 minutes CB reaches 1600°F while IB only reaches 520°F. The same is true in varying degrees of the other locations in the houses.

Perhaps the most satisfactory basis of comparison is in terms of time available for the escape of a hypothetical person in the house when the fire starts. In similar work it has been the practice to regard 300°F or 150°C as a threshold; below this temperature a person stands a chance if he can find a way out, but above it he rapidly becomes a victim.

The period from the start of the fire until a temperature of 300°F has been attained in any particular part of a house may thus be regarded as the "survival time, as limited by heat". Table I contains estimates of this, based on the records in Figs. 9 to 14. There are, of course, other aspects of a fire which may prevent escape, perhaps before heat does so. Carbon monoxide or lack of oxygen in the atmosphere may

lead to loss of consciousness. Dense smoke may prevent the victim from finding his way to safety. In other reports in this series, survival times as limited by these other factors are derived. Naturally the significant survival period is the shortest of the survival times as limited by each of these effects of this fire.

RESULTS OF BURNS OF TWO HALLS

The temperature records for Burn No. 6, the community hall, and Burn No. 8, the school, are given in Figs. 15 and 16. For each building the two records are quite similar, as might be expected since the thermocouple locations were symmetrical. It will be noticed, however, that Burn No. 6 took longer to become established, although the maxima of the curves are quite similar in respect of temperature, duration, and time of occurrence.

CONCLUSION

Further discussion of these results, considered together with the results obtained from other measurements, is contained in the Summary Report, DBR Internal Report No. 158.

TABLE I

SURVIVAL TIMES AS LIMITED BY HEAT

Burn Number	Survival times		
	Open bedrooms	Closed bedrooms (decimal minutes)	Cellar
Incombustible-lined houses:			
1	2.8	11.8	20.9
4	11.5*	16.5	16.2
7	2.1	11.3	16.6
Combustible-lined houses:			
2	1.5	7.8	-
3	1.7	-	-
5	2.2	9.1	4.2
Times taken from mean temperature curves for the two groups of houses:			
1,4,7 Incombustible	2.5*	11.7	16.6
2,3,5 Combustible	1.8	8.7	4.2

* It will be noticed that the time when the mean temperature passes 300°F differs from the mean of the three times when the individual temperatures passed 300°F. For example, in Burn No. 4 the temperature in the open bedroom approached 300°F at 3 minutes but did not pass 300°F until 11.5 minutes.

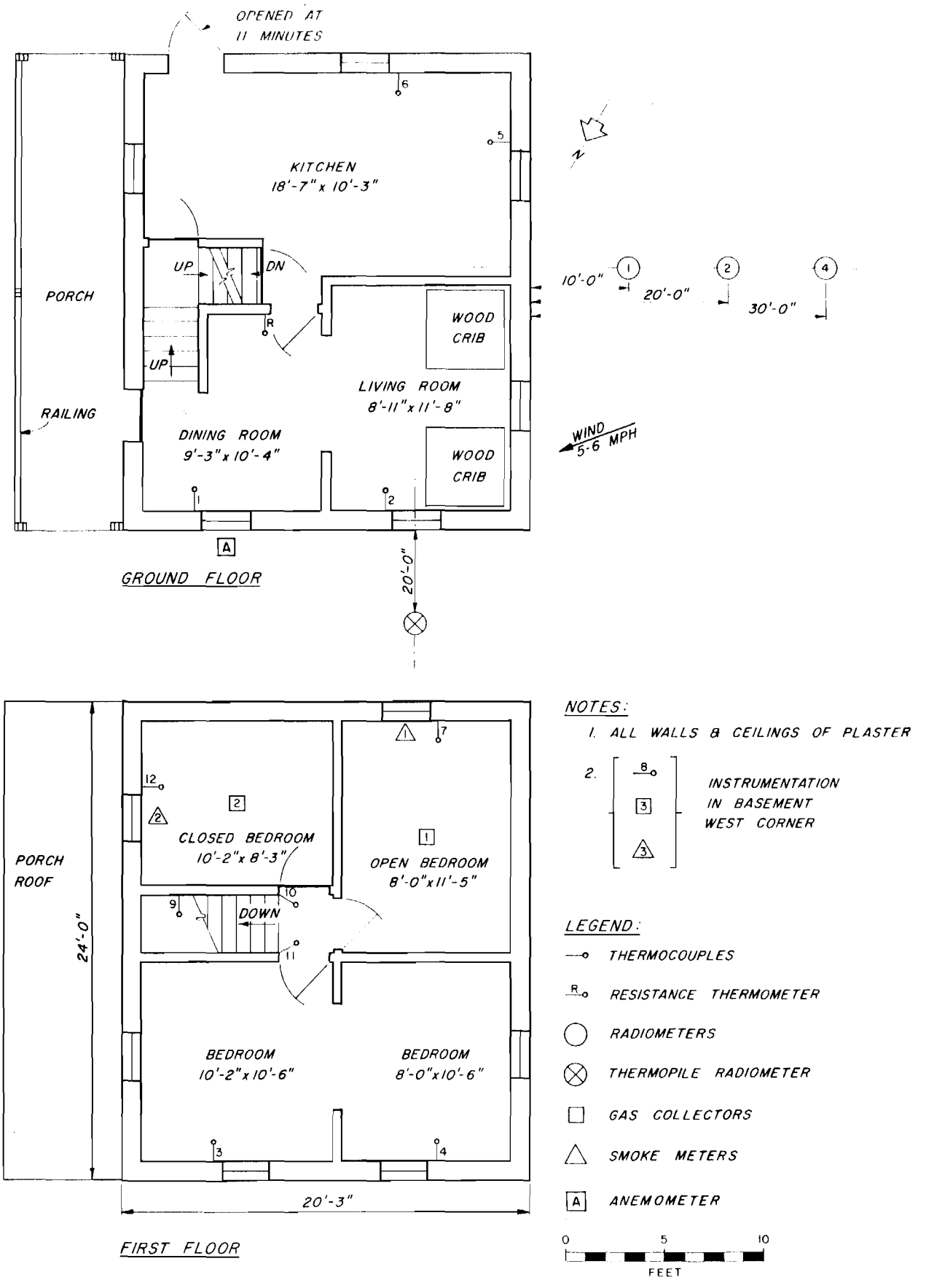


FIGURE 1 - BUILDING No. 1 - TWO-STOREY SOLID BRICK DWELLING

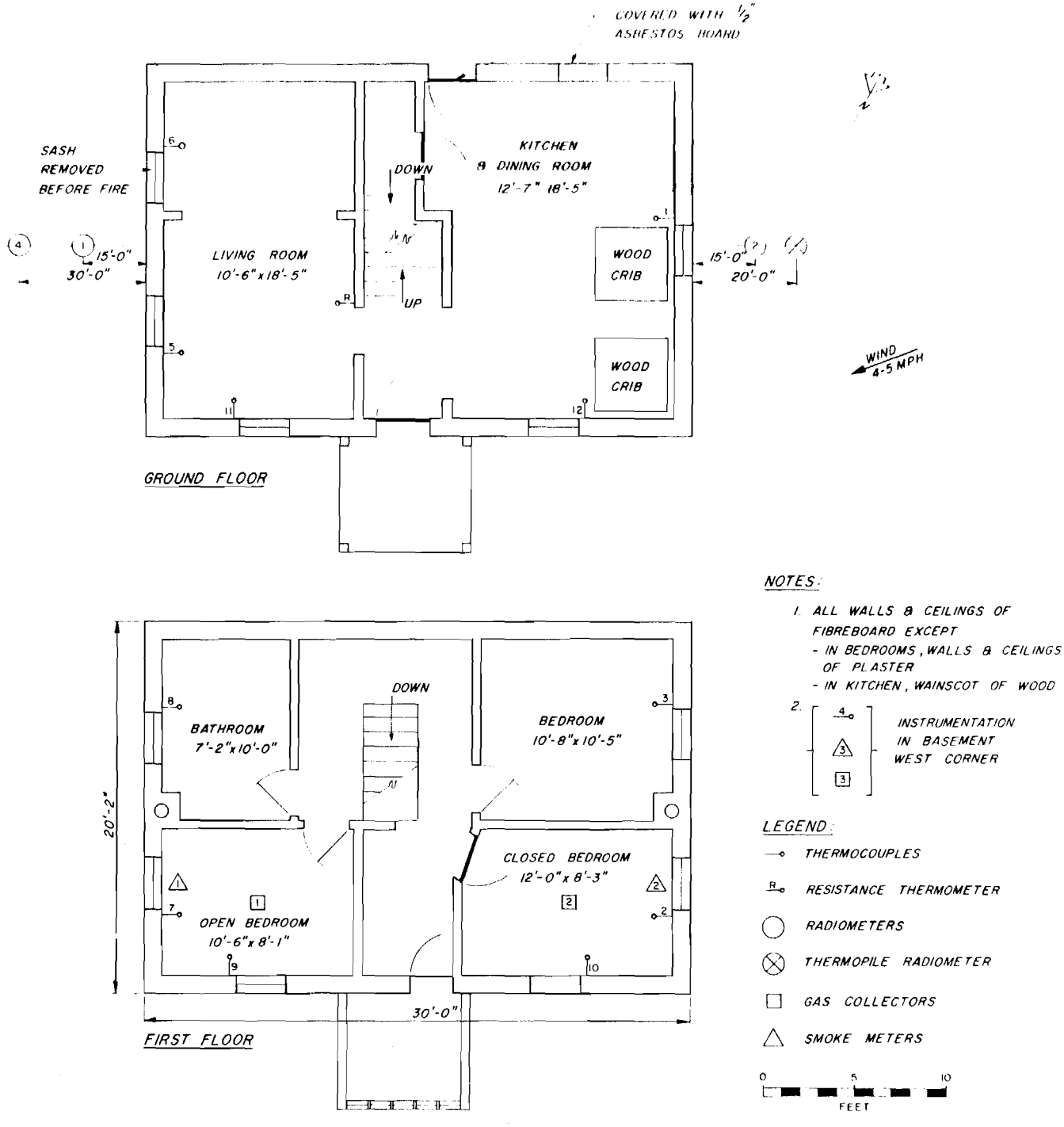
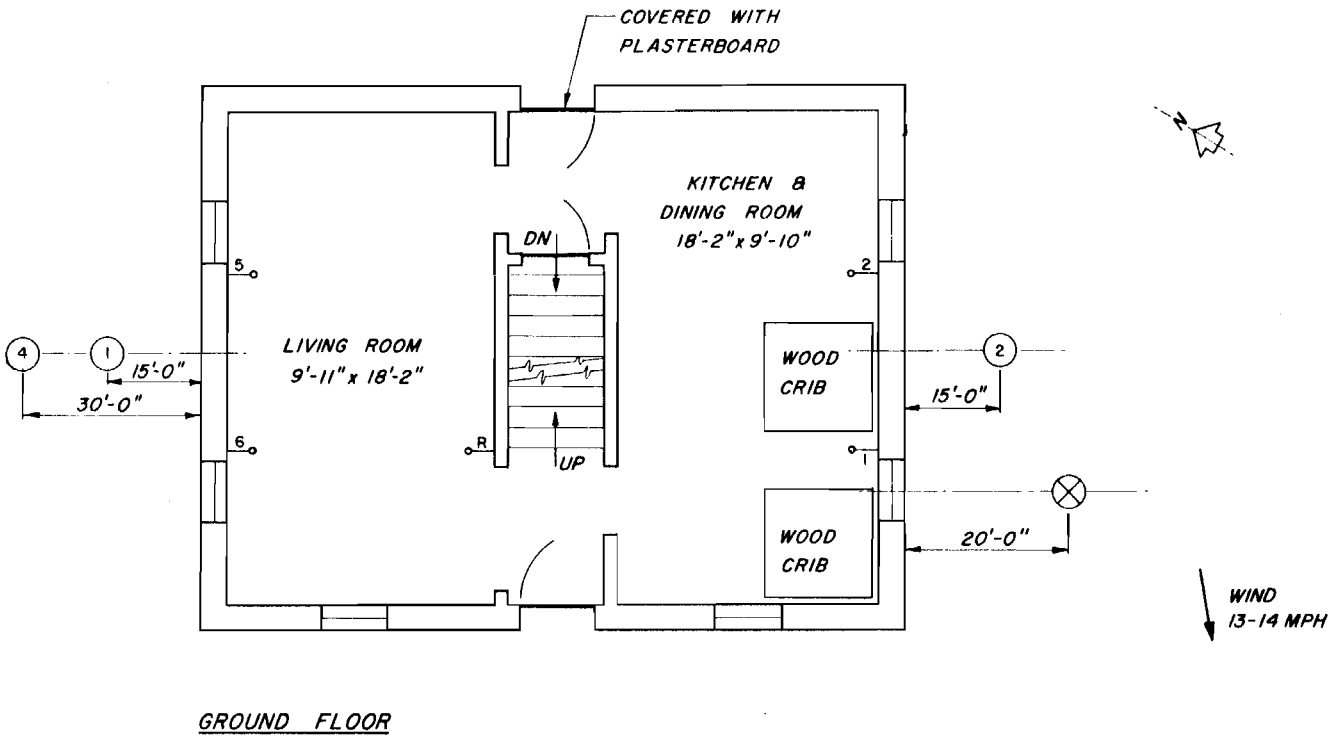
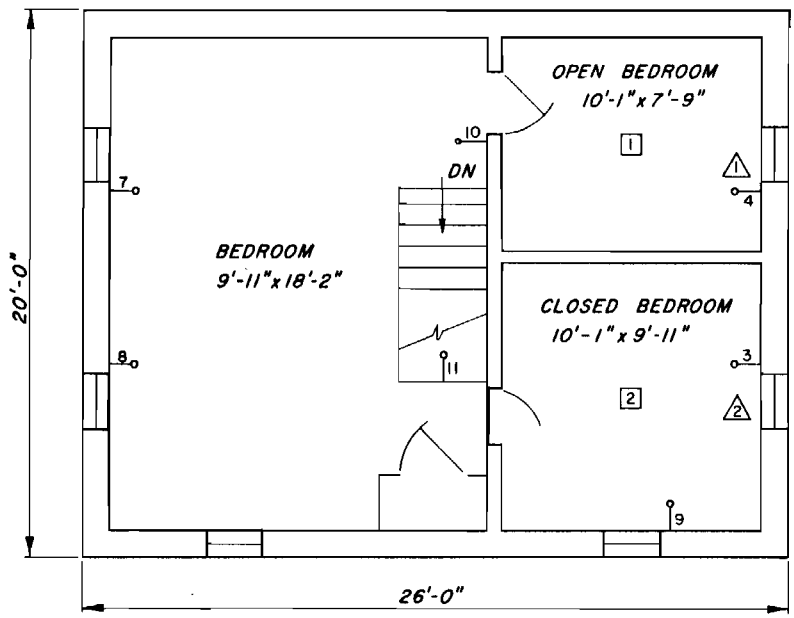


FIGURE 2 - BUILDING No. 2 - TWO-STOREY SOLID BRICK DWELLING





NOTES:

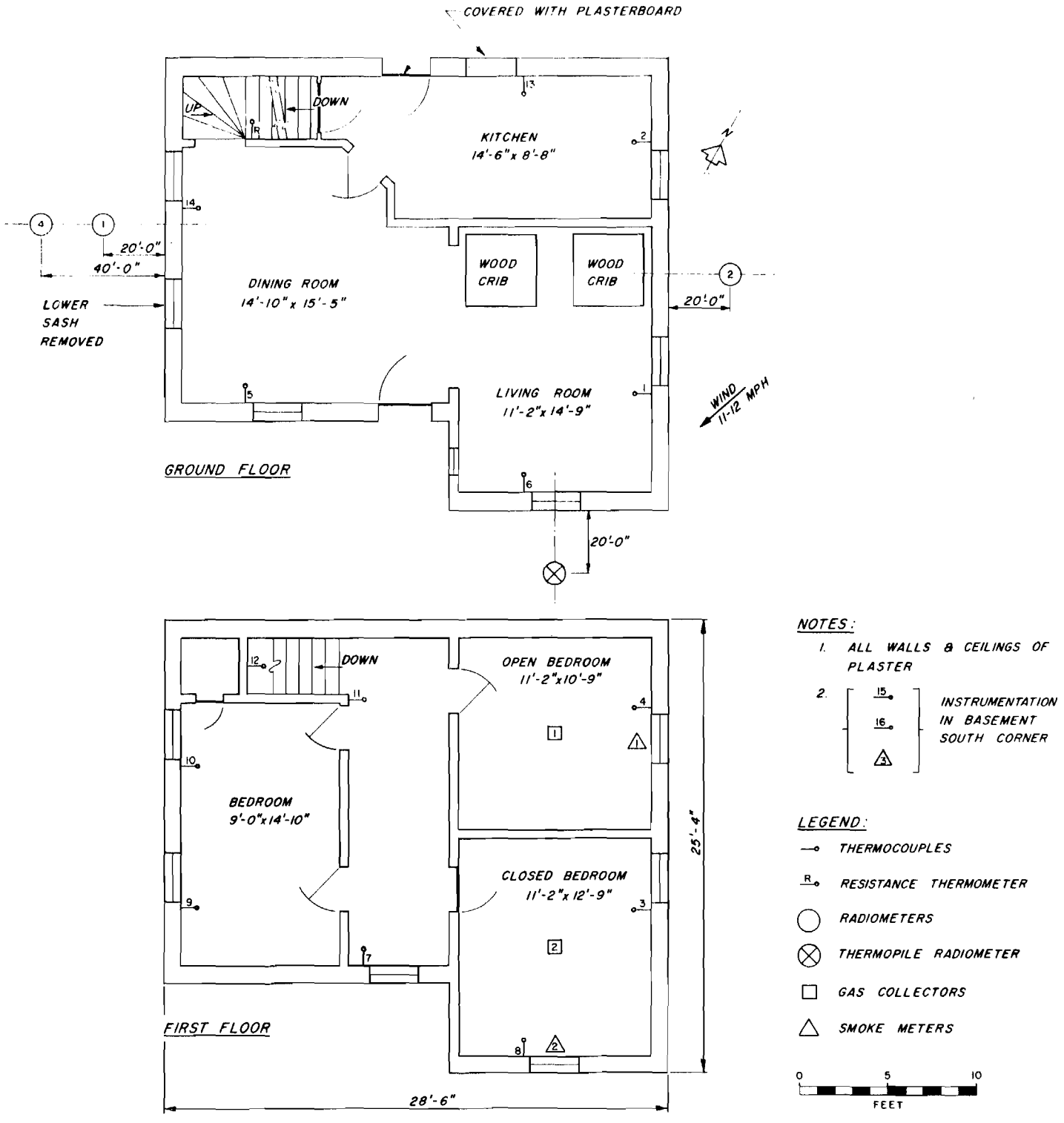
1. ALL WALLS & CEILINGS OF FIBREBOARD
2. 12, 3, 3 — INSTRUMENTATION IN BASEMENT WEST CORNER

LEGEND:

- THERMOCOUPLES
- RESISTANCE THERMOMETER
- RADIOMETERS
- THERMOPILE RADIOMETER
- GAS COLLECTORS
- SMOKE METERS

0 5 10 FEET

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



NOTES:

1. ALL WALLS & CEILINGS OF PLASTER
2. 15, 16, 3 — INSTRUMENTATION IN BASEMENT SOUTH CORNER

LEGEND:

- THERMOCOUPLES
- R — RESISTANCE THERMOMETER
- RADIOMETERS
- THERMOPILE RADIOMETER
- GAS COLLECTORS
- SMOKE METERS

0 5 10
FEET

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

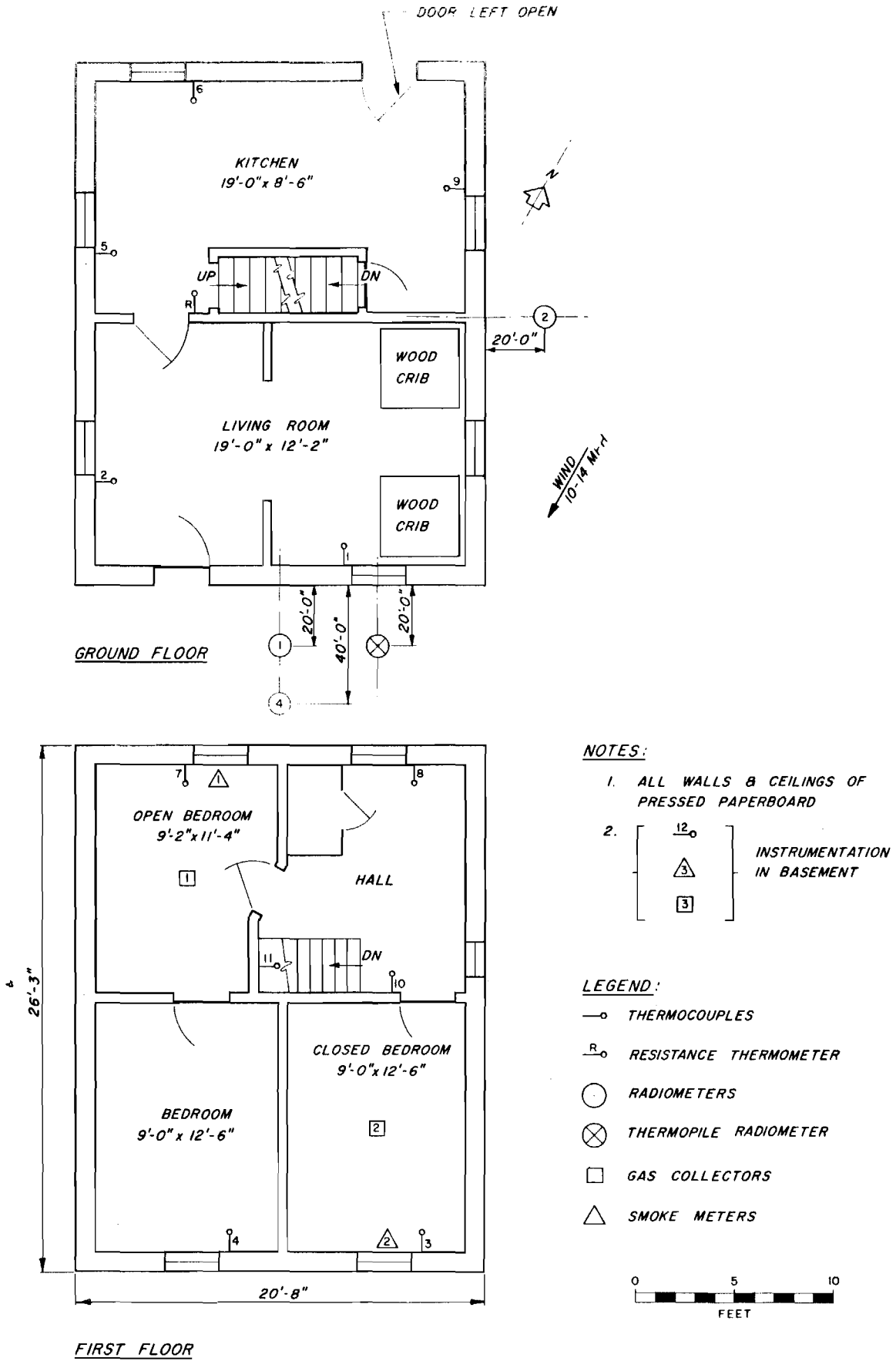


FIGURE 5 - BUILDING No. 5 - TWO - STOREY WOOD FRAME DWELLING WITH CLAPBOARD EXTERIOR

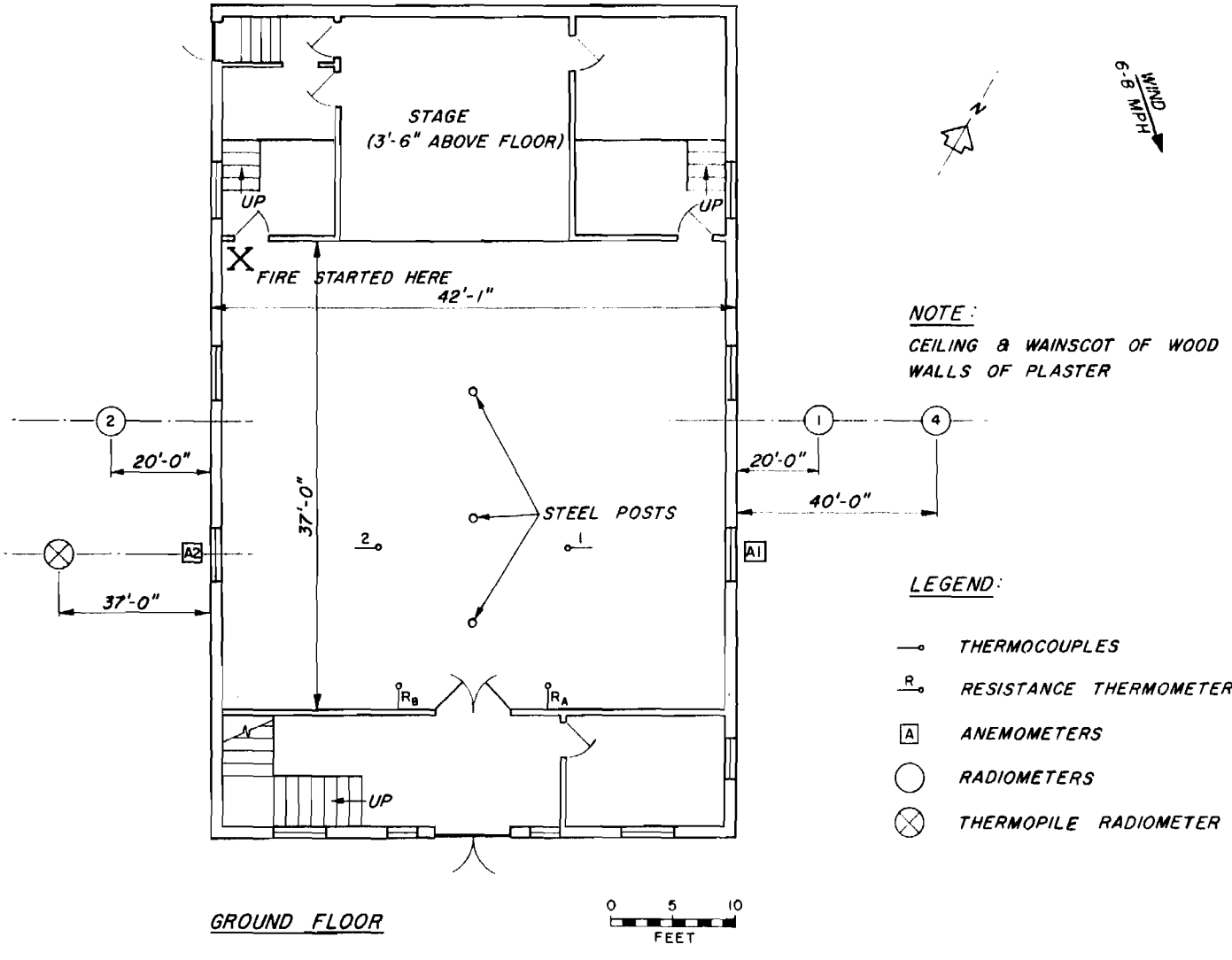
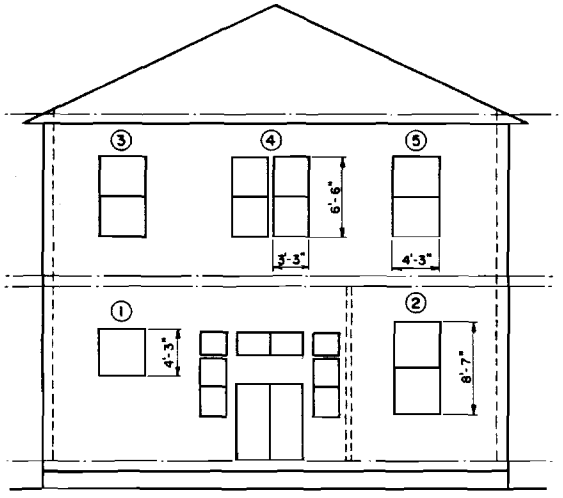
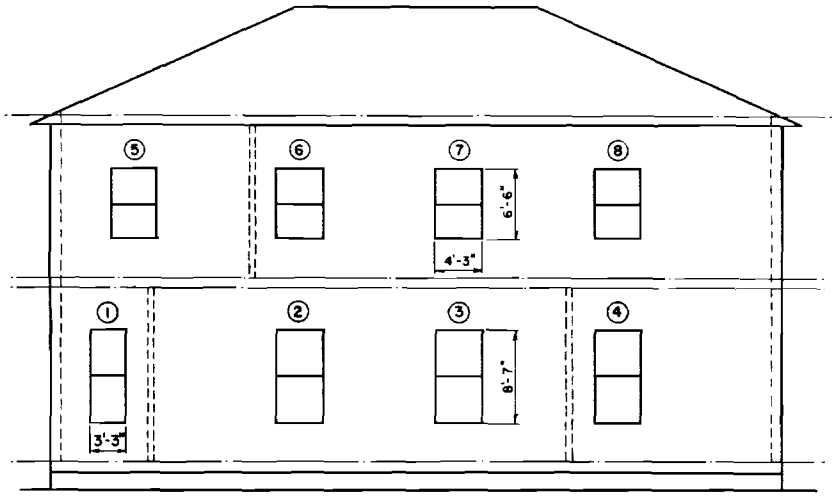


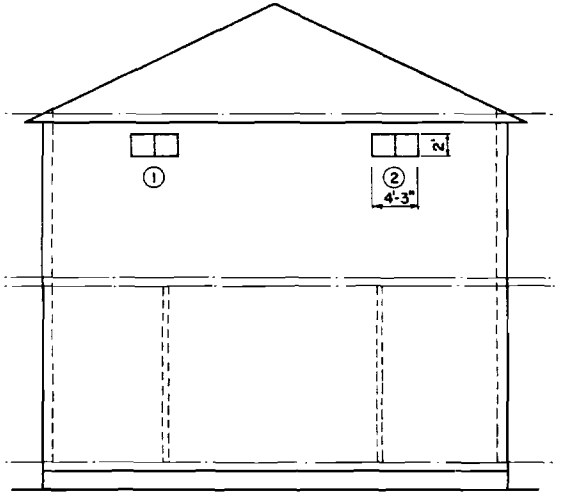
FIGURE 6 - BUILDING No. 6 - TWO - STOREY SOLID BRICK FRATERNITY HALL



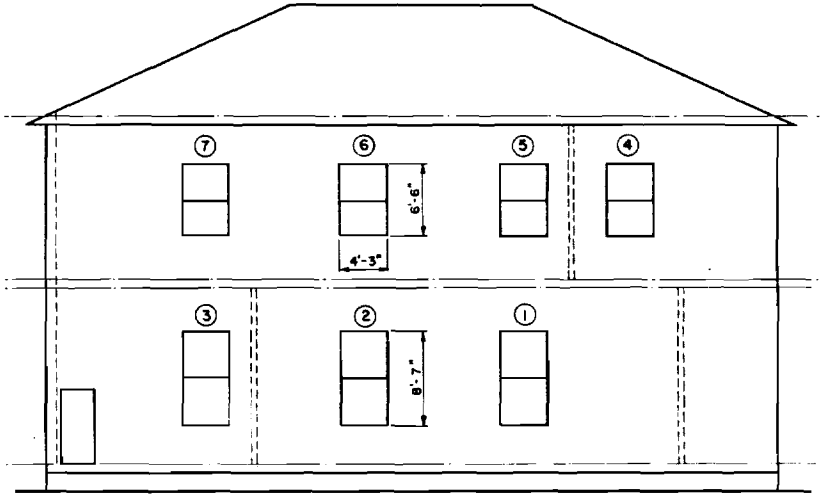
FRONT ELEVATION



EAST ELEVATION



REAR ELEVATION



WEST ELEVATION

0 5 10
FEET

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

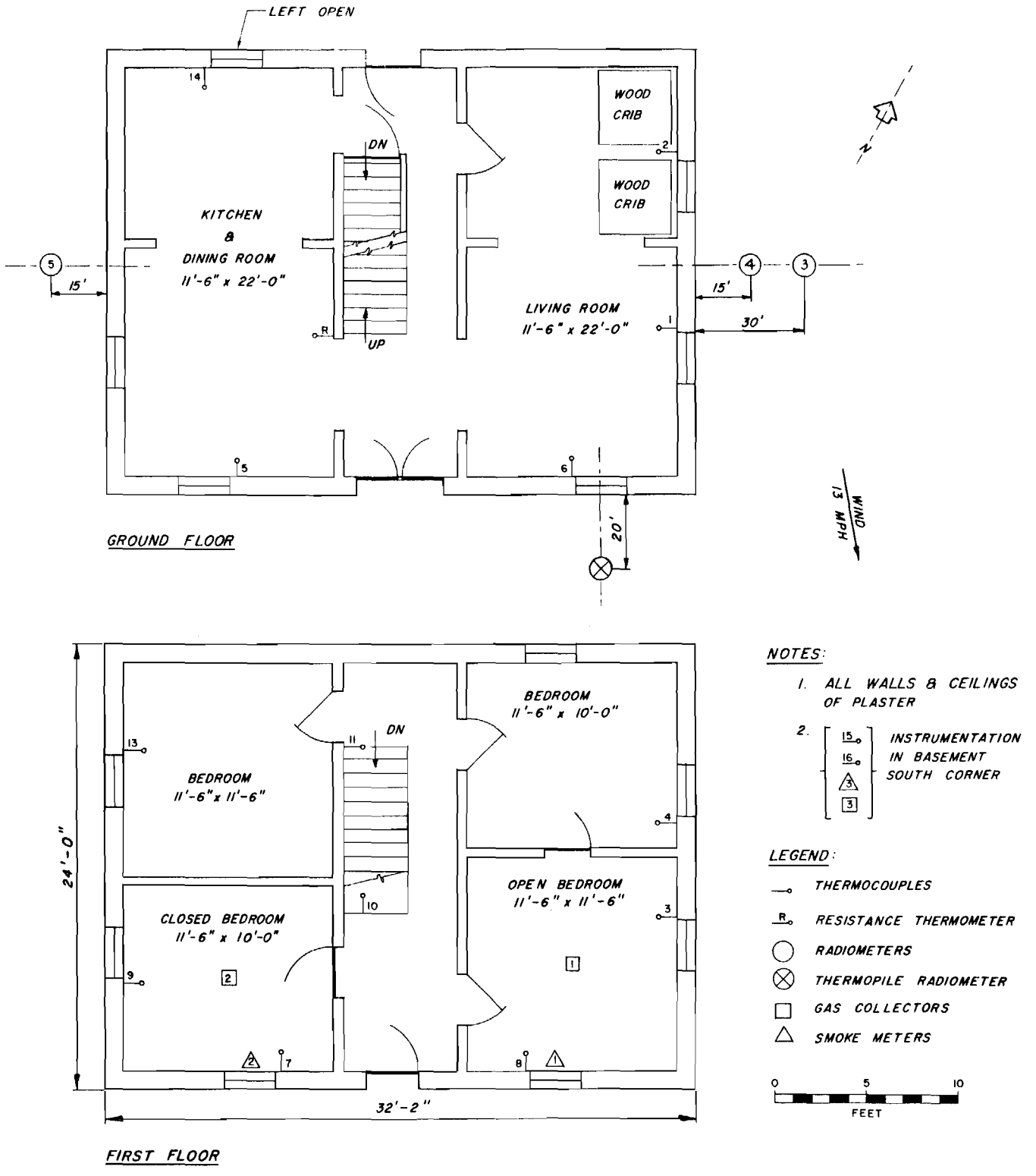


FIGURE 7 - BUILDING No. 7 - TWO - STOREY SOLID BRICK DWELLING

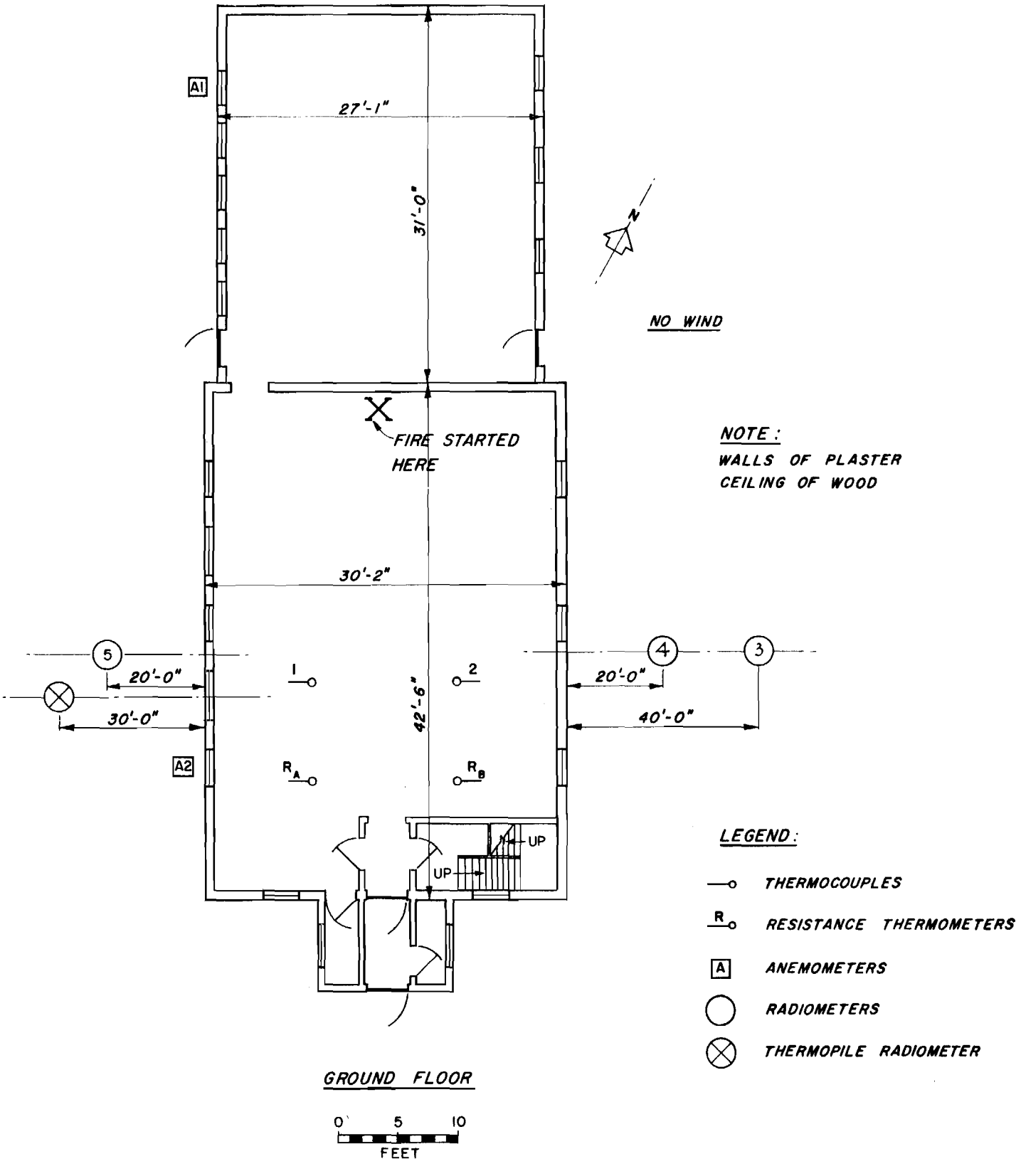
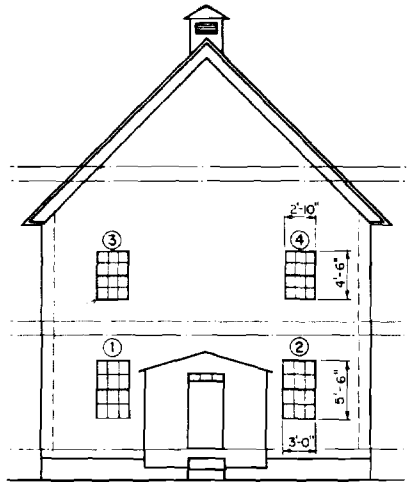
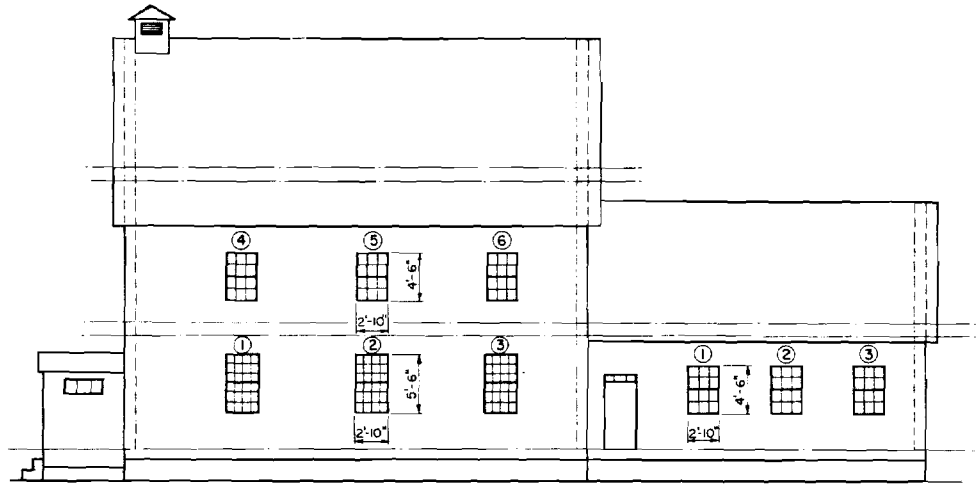


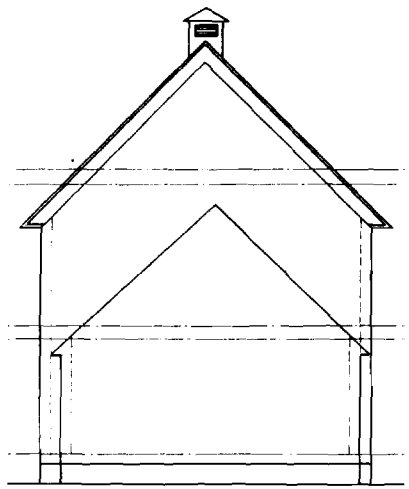
FIGURE 8 - BUILDING No. 8 - TWO - STOREY SOLID BRICK SCHOOL WITH ONE - STOREY EXTENSION AT REAR



FRONT ELEVATION



EAST ELEVATION



REAR ELEVATION

WEST ELEVATION

0 5 10
FEET

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

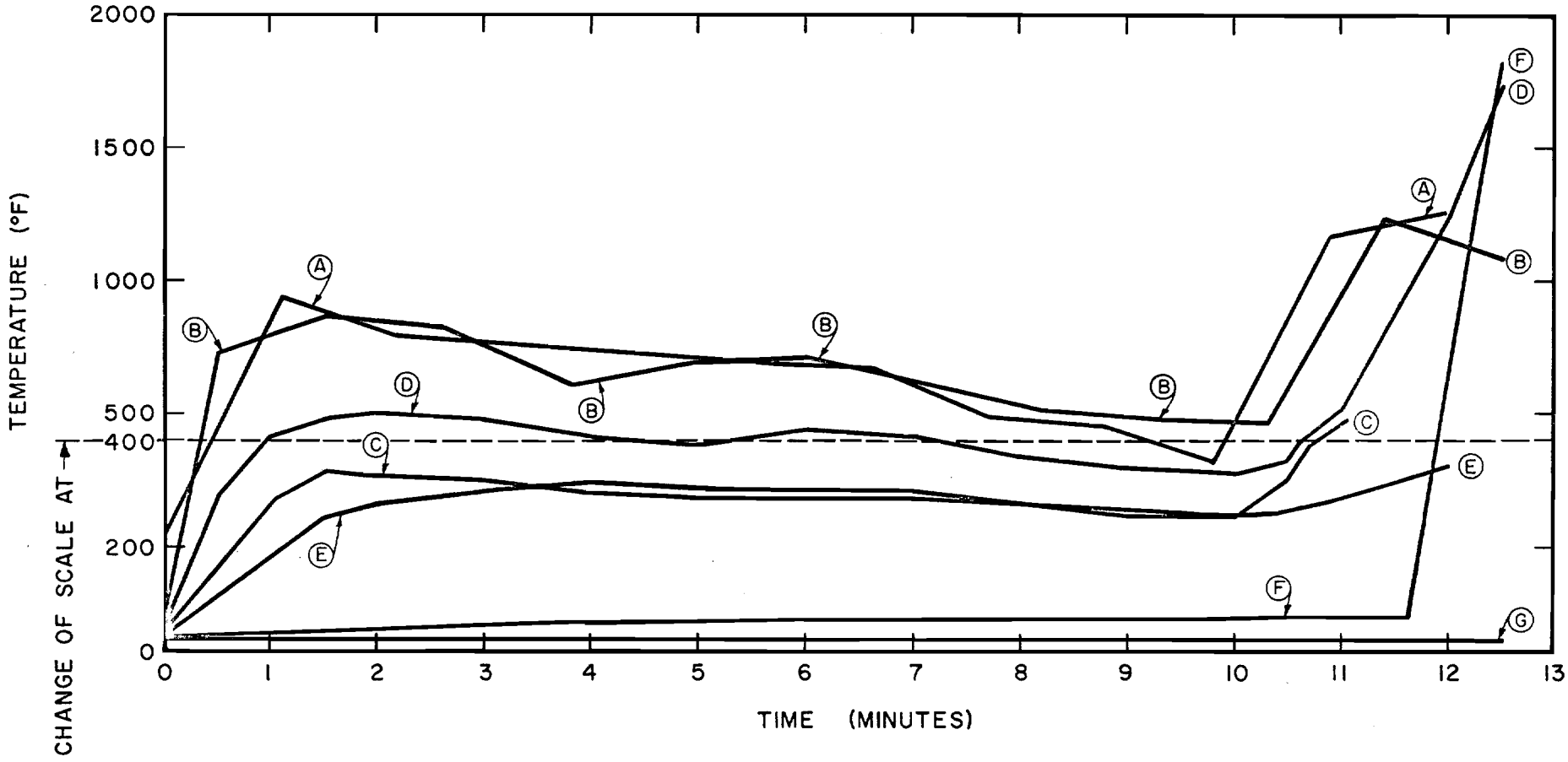


FIGURE 9 TEMPERATURES IN BURN I

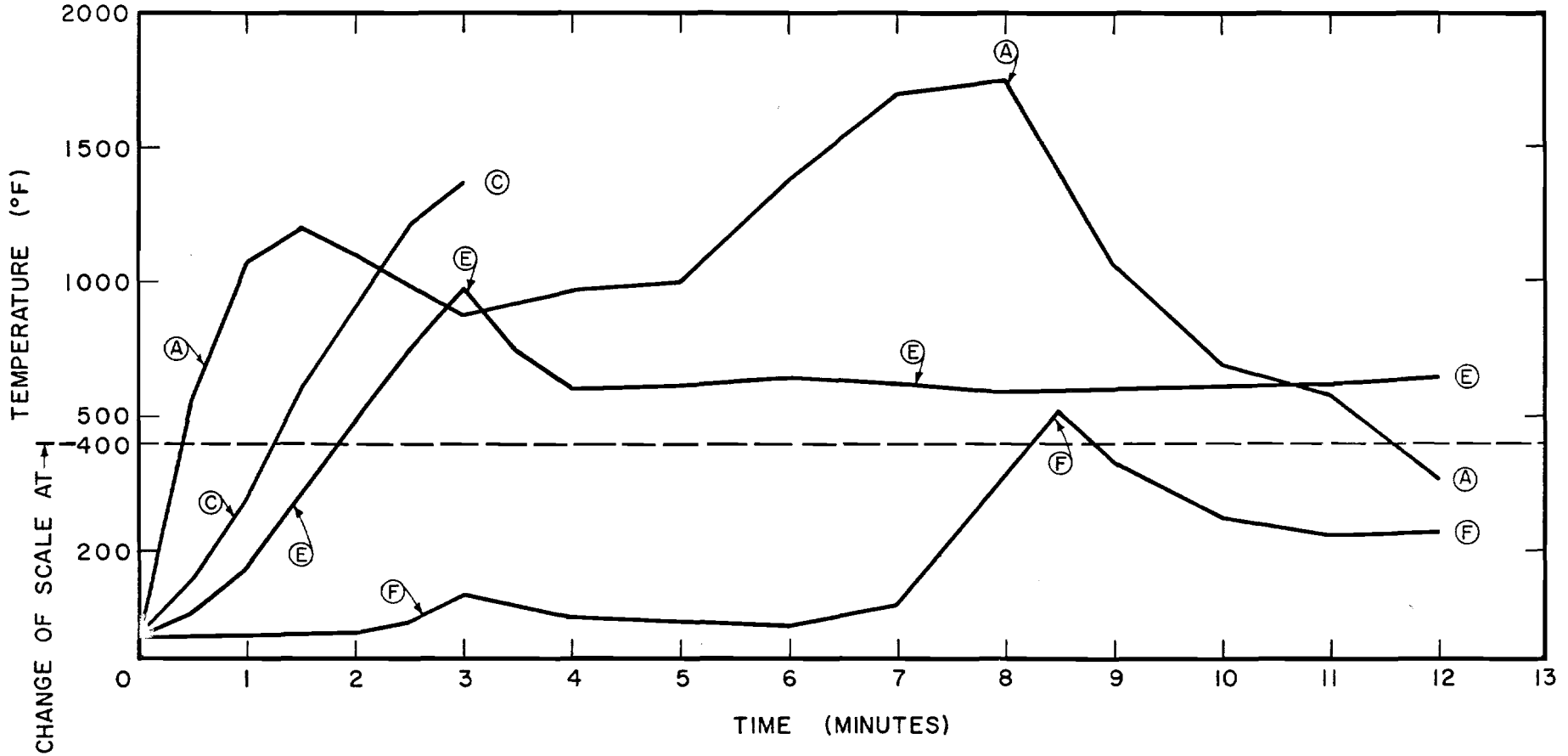


FIGURE 10 TEMPERATURES IN BURN 2
THERMOCOUPLES AT B & D WERE OMITTED IN THIS HOUSE.
G WAS FAULTY THROUGHOUT.

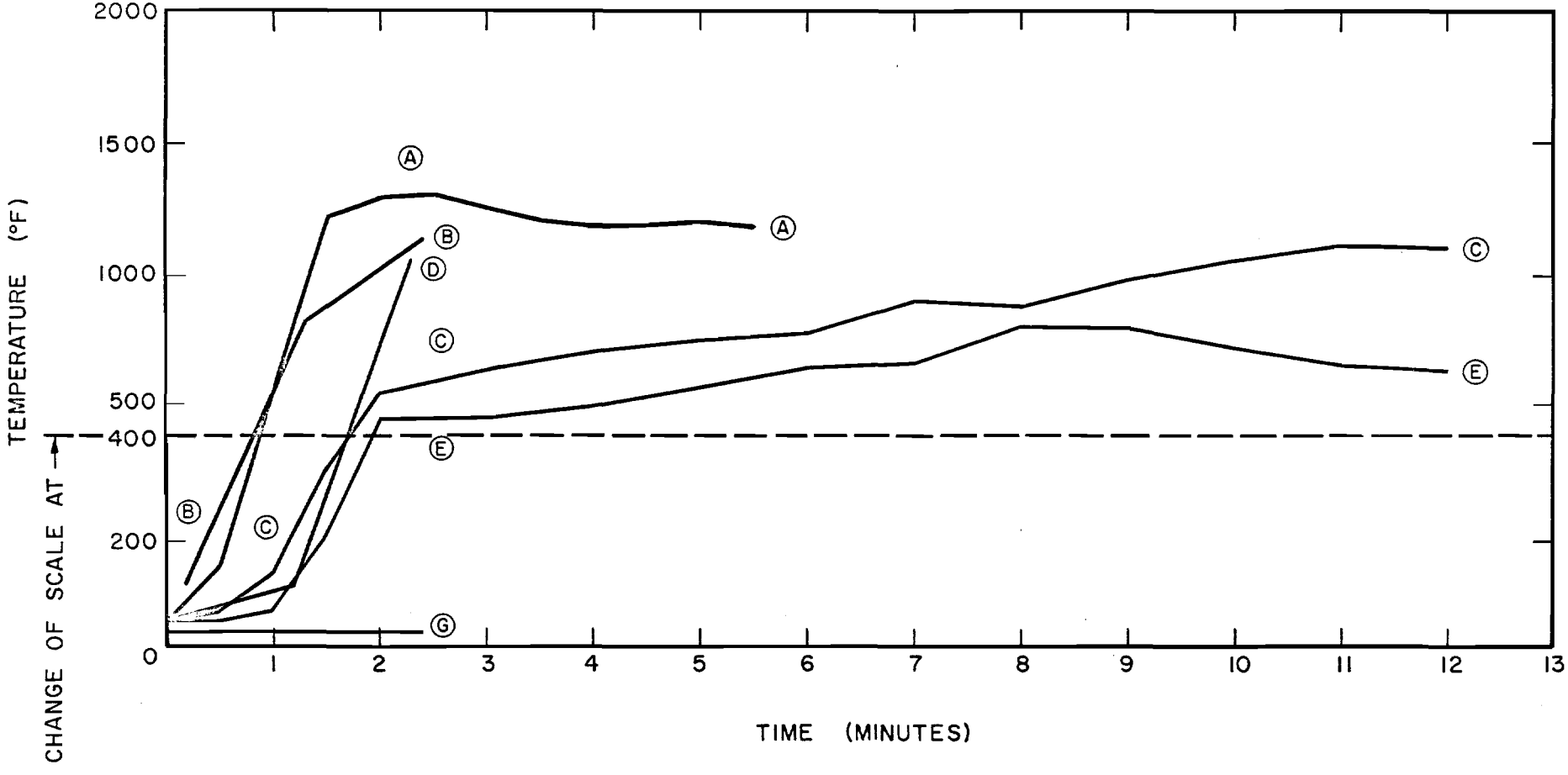


FIGURE 11 TEMPERATURES IN BURN 3
THERMOCOUPLES AT F WERE FAULTY THROUGHOUT

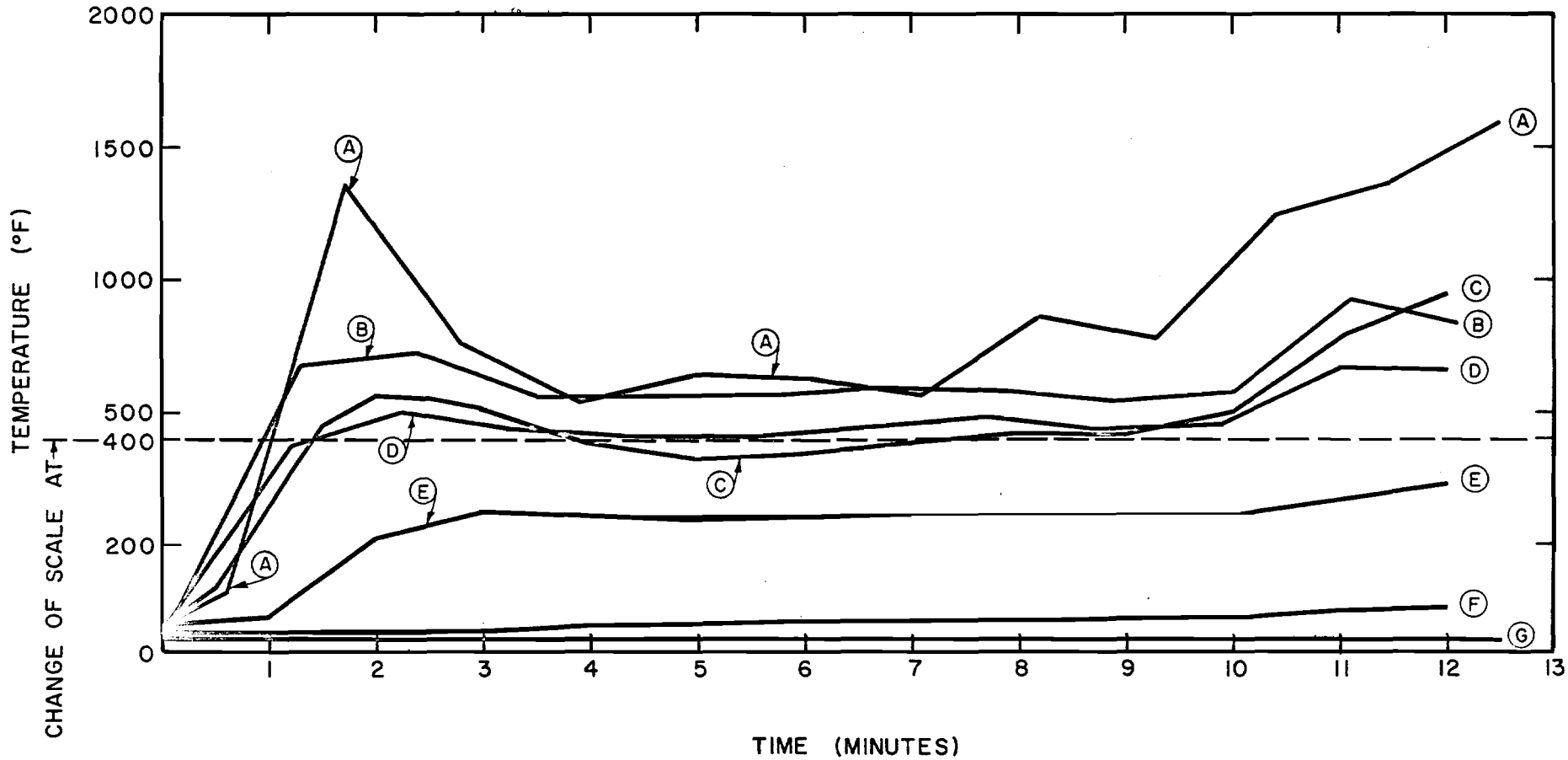


FIGURE 12 TEMPERATURES IN BURN 4

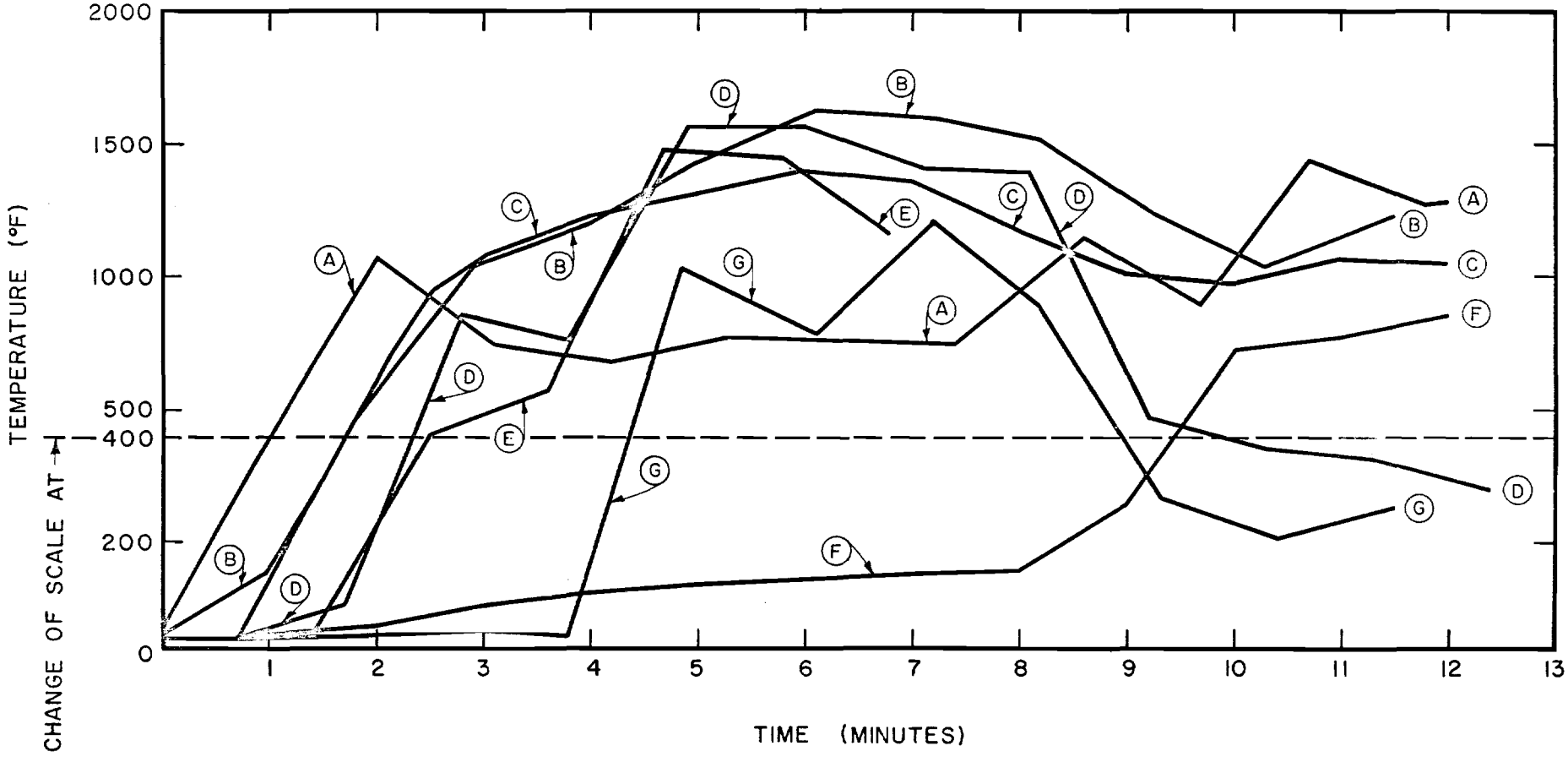


FIGURE 13 TEMPERATURES IN BURN 5

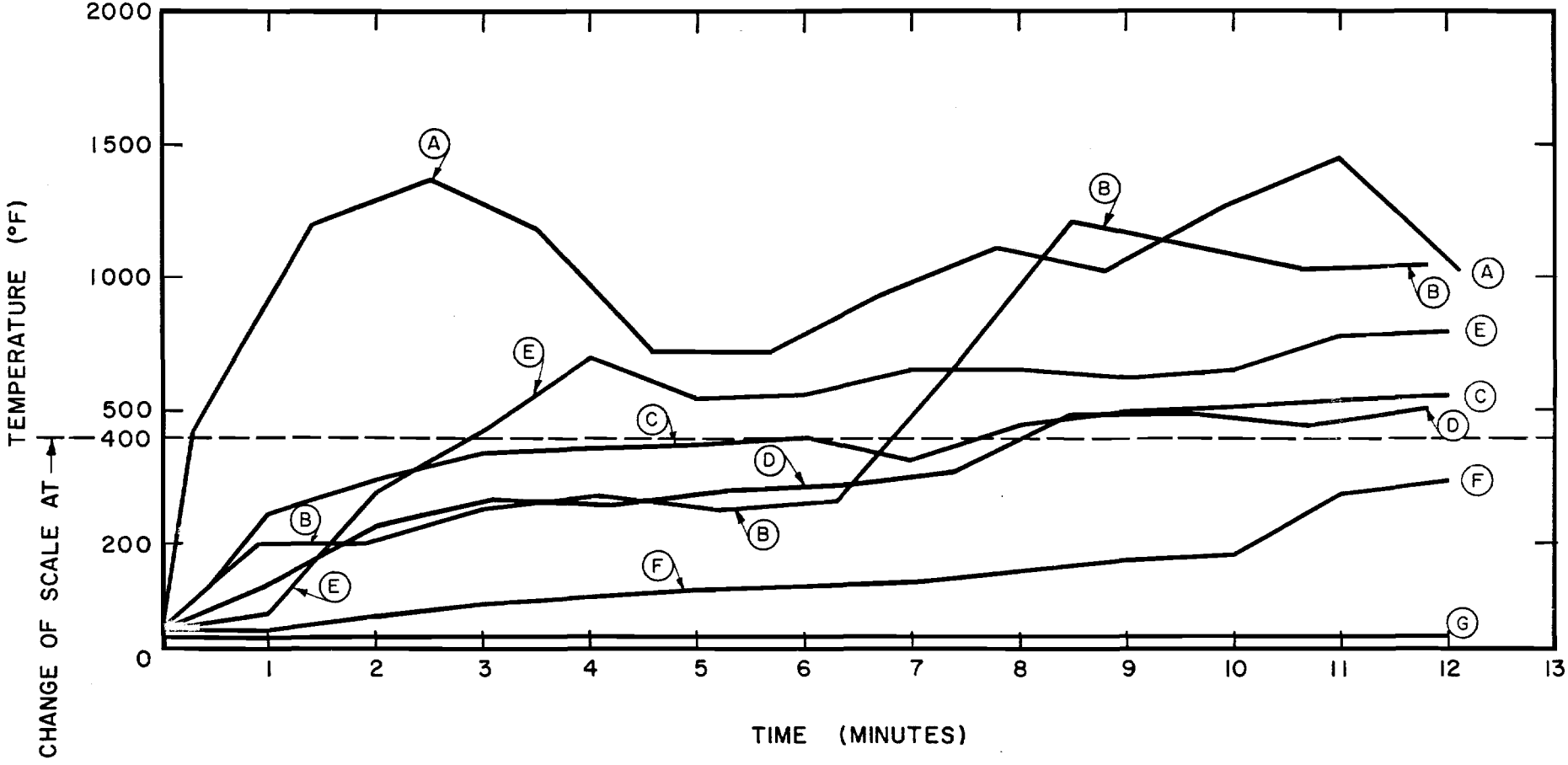


FIGURE 14 TEMPERATURES IN BURN 7

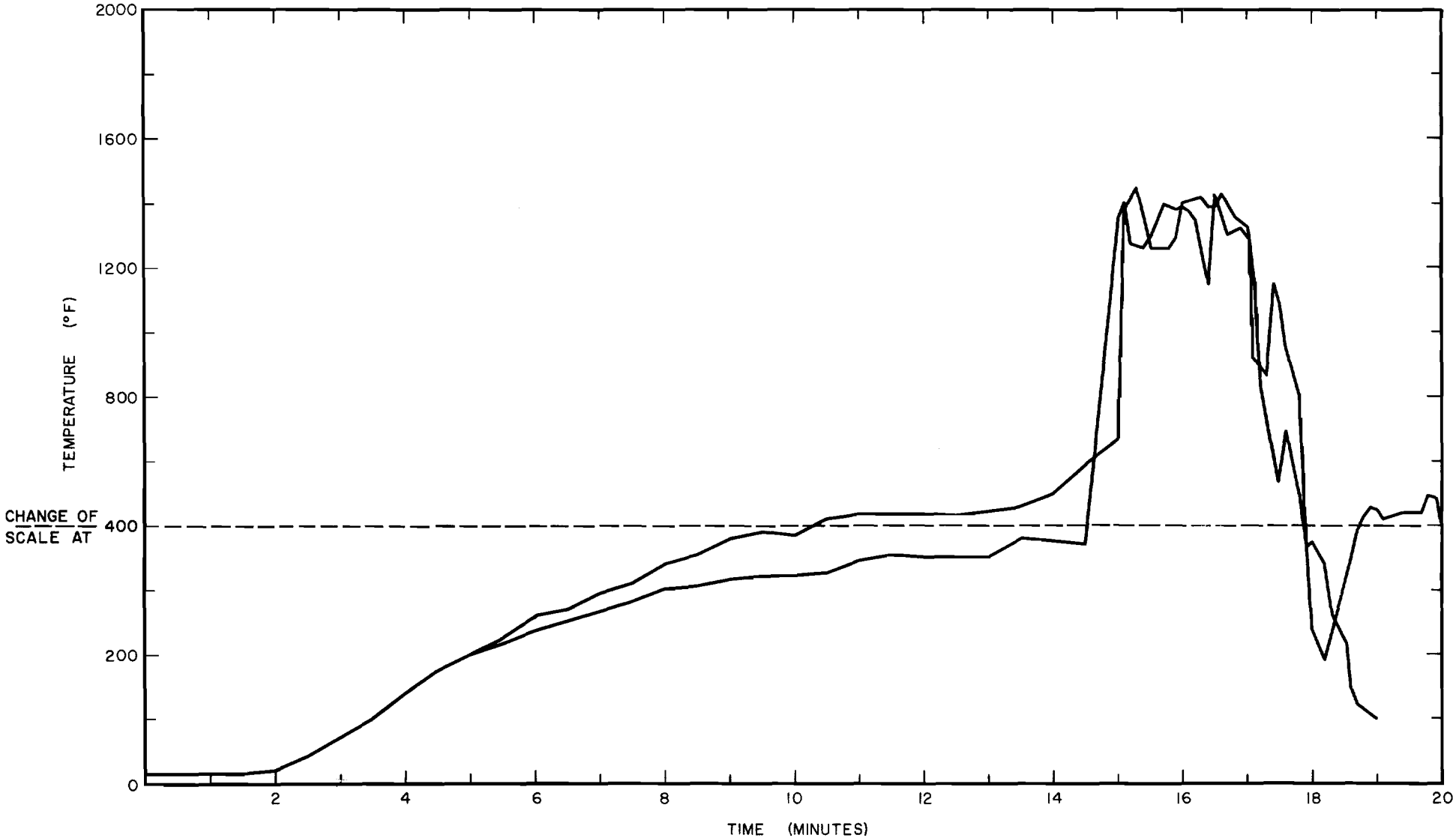


FIGURE 15 TEMPERATURES IN BURN 6 (AULTSVILLE FRATERNITY HALL)

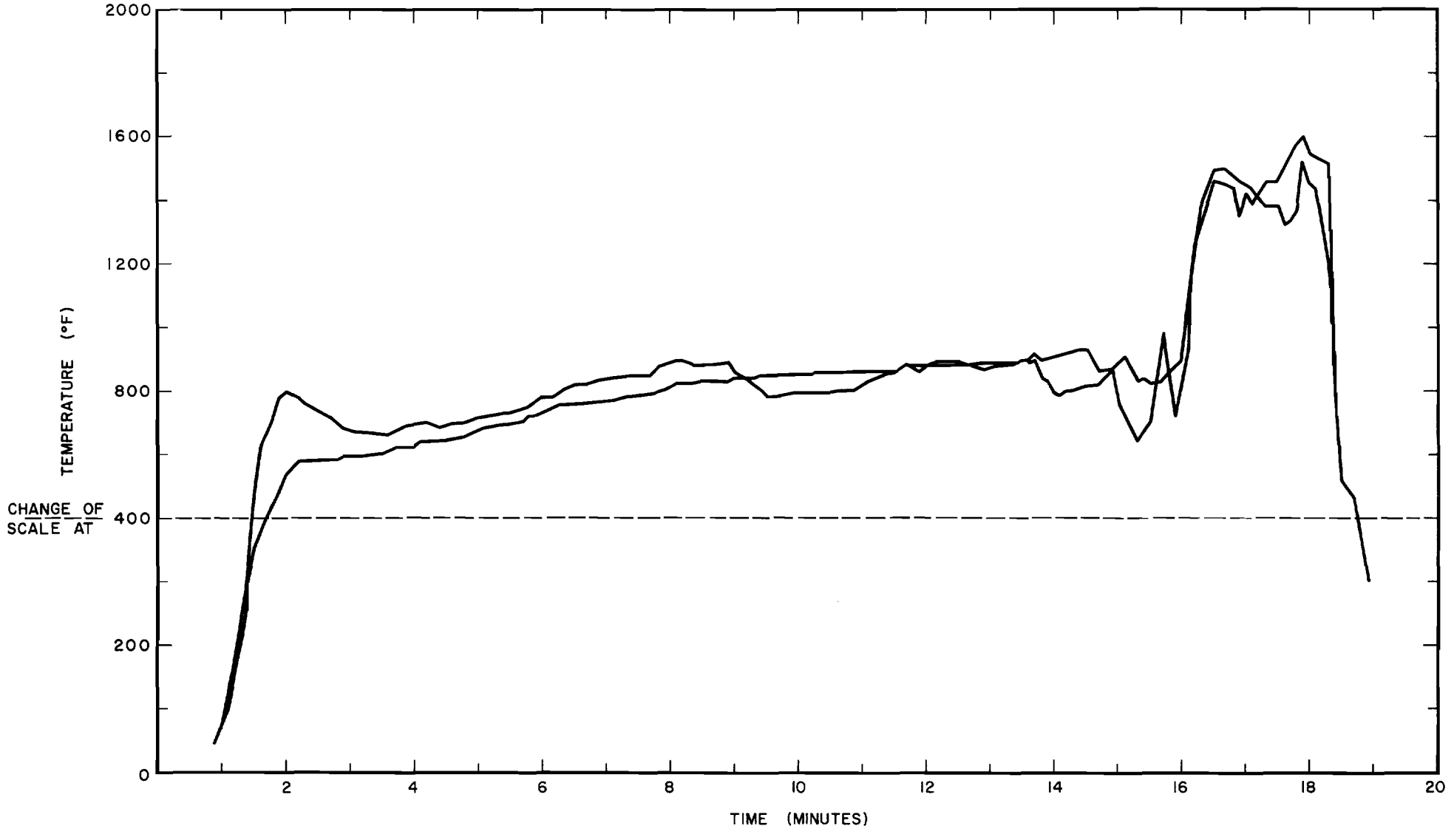


FIGURE 16 TEMPERATURES IN BURN 8 (AULTSVILLE SCHOOL)

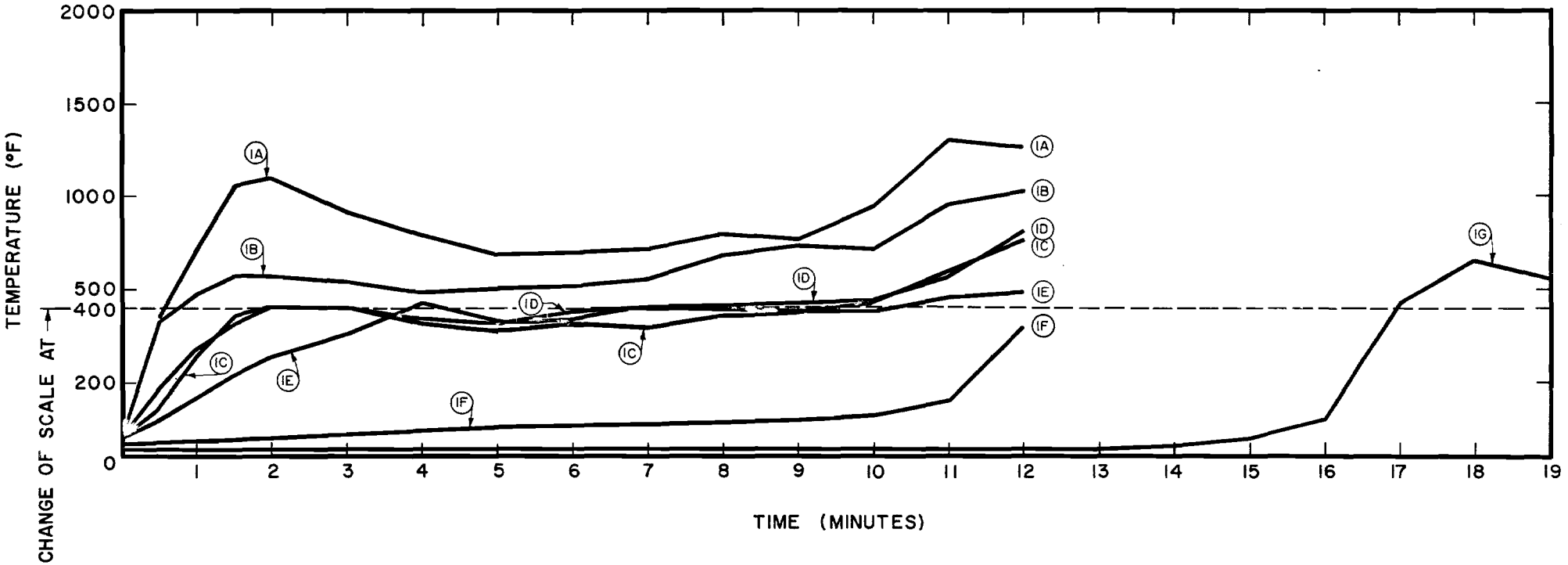


FIGURE 17 TEMPERATURE MEANS FOR THREE HOUSES WITH INCOMBUSTIBLE LININGS

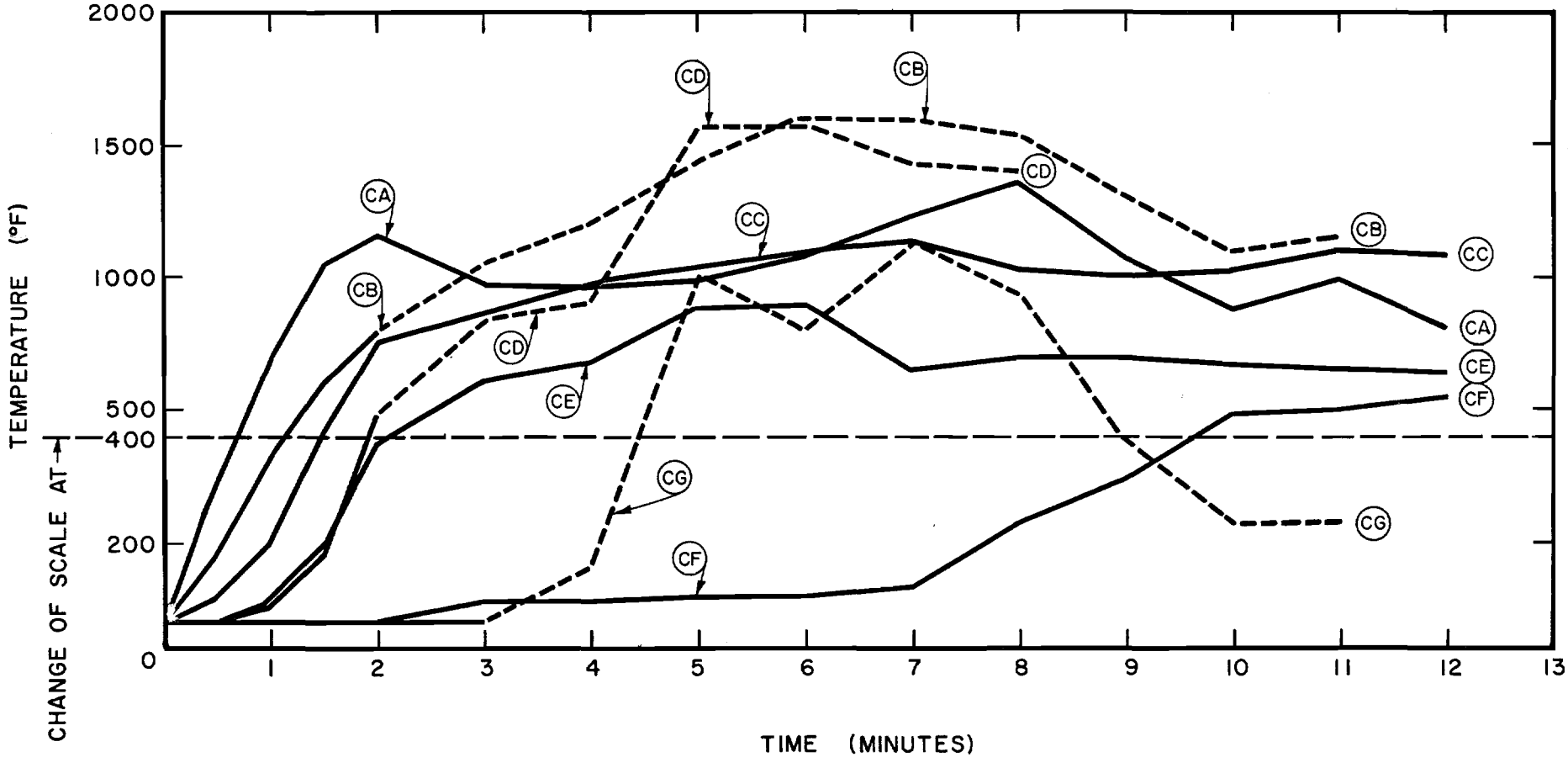


FIGURE 18 TEMPERATURE MEANS FOR THREE HOUSES WITH COMBUSTIBLE LININGS