NATIONAL BUREAU OF STANDARDS REPORT

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REPORT ON

INSPECTION AND TESTS OF PLASTER

ALASKA NATIVE SERVICE HOSPITAL AND QUARTERS BUILDINGS

by

NOLAN D. MITCHELL

for the

BUREAU OF INDIAN AFFAIRS
U.S. DEPT. OF THE INTERIOR

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INSPECTION AND TESTS OF PLASTER
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ANCHORAGE, ALASKA

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SUMMARY

Visits to the buildings of the Alaska Native Service Hospital, Bureau of Indian Affairs Projects 501-228 and 501-228A, were made by the Chief, Chemistry of Mineral Products Section, and two members of the Building Technology Division of the National Bureau of Standards, for the purpose of examining the buildings for structural soundness and the condition of the plaster to determine, if possible, the cause of plaster cracking. Specimens of the plaster and plaster materials were obtained for tests.

Character and Location of Cracks

Approximately 99 percent of the cracks observed were in plaster applied to metal lath of partitions, furring, and suspended ceilings. The warped surfaces of the plaster adjacent to the cracks, as well as the patterns of the cracking, indicated that the white finish had shrunk. Some of the wider cracks were found to extend through the base coat plaster to the lath, indicating that the base coat plaster had also shrunk. The few cracks found to have resulted from structural defects were in plaster applied to monolithic concrete which had cracked from shrinkage.

Plaster Materials and Plaster

The materials used in the plaster and plaster bases were

analyzed and, except for the sand and water, were found to be of the quality specified. The colorimetric test indicated an excessive amount of organic material in the sand and the sand was finer than permitted by the specifications. A settling test indicated that, at times, there was an excessive amount of silt in the water used.

The proportion of the aggregates in the base coat plaster of six of the seven specimens taken from the partitions of the hospital building ranged from 2 1/2 to 4 1/2 ft^3 per bag (100 lb) of gypsum cement plaster. The vermiculite ranged from 2.0 to 3.9 ft^3 and the sand ranged from 0.12 to 0.70, the averages being, respectively, 3.0 ft^3 and 0.40 ft^3. The other specimen had 3.0 ft^3 of vermiculite aggregate per bag of gypsum cement plaster and no sand.

The proportions of hydrated lime in the white finish plaster ranged from 40 to 175 lb to each 50 lb of plaster of Paris (gauging plaster), the average being 95 lb of lime to 50 lb of gauging plaster. The wide variations in the proportions of materials indicated a lack of concern for following the specifications. The white finish plaster was stronger than the base plasters.

The weakening effect of sand added to a vermiculite gypsum cement plaster mix was shown by tests reported on September 17, 1952. In those tests, the tensile strength of a mixture of 1.7 ft^3 of vermiculite and 0.4 ft^3 of sand to 100 lb of gypsum cement plaster was 115 lb/in.^{2}, whereas, the strength of the plaster without the sand was 200 lb/in.^{2}. The addition

of sand to vermiculite aggregate was not in accordance with the specifications.

Job Conditions

Letters of the Project Engineer to the Contractor written during the application of the plaster indicated that better ventilation had been needed in the hospital building to accomplish proper drying of the plaster. There was also evidence in the building that water had coursed down the face of some of the plastered walls, probably from moisture condensed from the air. Under such conditions, the base coat plaster was not as strong when dry as it would have been had the drying been at a normal rate. At the time of the visit in February 1953, the moisture meter indicated that the plaster was then normally dry.

Plastering Practices

It is known in plastering practice that white finish plaster has a tendency to shrink on drying and that to avoid shrinkage cracking the finish should be applied over a strong base coat that has sufficient suction to withdraw excess water by capillarity, and, in addition, an after troweling should be performed while the gauging plaster is setting. Variations in the proportions of hydrated lime to gauging plaster of the white finish indicated that the amounts of materials were not measured or that the ingredients were not thoroughly mixed. Much cracking of plaster results from lack of thorough mixing of lime putty and gauging plaster, especially where the after

troweling is not done under proper conditions and at the proper time. Too rapid drying of white finish over wet base coat also tends to overstrain the surfacing material. It is possible that such causes were operating to some extent in both the hospital and quarters buildings to induce initiation of cracking.

In summary, it can be stated that a number of factors were involved in the cracking of the plaster. The relative effect of the known factors in causing the conditions found in the hospital and quarters buildings could not be definitely determined. Some of the factors were common to both buildings.

The gypsum cement plaster was retarded to give slow set when combined with aggregates; 5 1/4 hr with Alaska sand, 11 hr with Alaska sand and vermiculite mixture, 12 hr with vermiculite, and 10 1/2 to 24 hr with Ottawa sand. The consistency index of the neat gypsum cement plasters tested was in the range 50 1/2 to 52 1/2; and that of the two samples of gauging plaster 46 and 49, these quantities indicating that the water requirements for workability were 2 1/2 to 3 times that required for complete set of the plasters. The volumetric shrinkage of 2-in. cubes of these plasters ranged from 2.0 to 3.0 percent. The shrinkage was doubtless largely the result of the retarder used for slow set and the amount of water required for consistency.

Expanded vermiculite aggregate, likewise, requires a large amount of water to secure workability. The water glaze on the plaster keys of some of the specimens of lath and plaster from the hospital building gave evidence that the vermiculite-sand gypsum plaster had been applied very wet. It is known that vermiculite gypsum plasters are low in strength and must be applied and cured under closely controlled conditions if cracking of white finish plaster is to be avoided. There are relatively few examples where good results have been achieved when the plaster base was expanded metal lath on furring channels or on metal studs. Vermiculite plasters are also susceptible to relatively large volumetric changes as the result of changes in the relative humidity of the atmosphere.

The sand which was used as the only aggregate of the base coat plaster of the quarters building and as an additive to the vermiculite aggregate of the base coat plaster of the hospital building was finer in size than permitted by the specifications and was indicated by test to be unsuited for plaster aggregate. The resulting base coat plasters were low in tensile strength, and in tests of 2-in. cubes had 0.6 percent volumetric shrinkage. The proportions of aggregates to gypsum cement plaster were in excess of those usually found in good plastering practice.

The plaster base consisting of expanded metal lath and

either lightweight metal studs or strip steel channels did not have sufficient rigidity to hold the weak base coat plaster in position when subjected to the shrinkage effects of both the base coat and the white finish plasters, especially after cracking of the white finish plaster had been initiated. In the hospital building, the measured thickness of plaster on metal lath was rather uniformly 3/4 in. as specified, but in many locations in the quarters building the thickness was not more than two-thirds the thickness specified.

The evidence of long-continued dampness in the hospital building leads to the conclusion that during the application and curing of the base coats and white finish plaster the careful control of conditions necessary to prevent the cracking of vermiculite plaster on metal lath was lacking. The continuation of the damp condition probably caused the formation of the compounds nesquehonite ($MgCO_3 \cdot 3H_2O$) and epsom salts ($MgSO_4 \cdot 7H_2O$) within the white finish: compounds that are found in efflorescence of plaster and that could account for the excess of combined water found in analyses of the dried white finish plaster specimens taken from the third, fourth, and fifth stories.

There was evidence that high temperatures and rapid circulation of air were maintained for part of the time that the plastering operations were under way in the quarters building. Such a condition could lead to the too rapid drying of white finish plaster over damp base coat plaster with the result that cracking would be almost inevitable, particularly if the white finish plaster were stronger than the base coat.

The two extremes of long-continued dampness of plaster in the hospital building and the rapid drying of plaster in the quarters building by means of forced circulation of hot air were both contrary to accepted good practice in plastering. It is not known to what extent the practices employed by the plastering contractor were influenced by the specification requirement:

> "Every precaution shall be taken to prevent too rapid drying of the plaster and to that end windows shall be closed as soon as the plaster is applied, if necessary, and the under coats of plaster shall be sprayed with water as soon as partially set and as often as required."

The specified precaution for spraying with water was doubtless inserted to guard against possible dry-outs or the too rapid drying of sanded gypsum plaster. This is not wholly compatible with the best practice when vermiculite aggregate is used, for that aggregate carries a large excess of water and holds it rather tenaciously.

1. INTRODUCTION

In April 1952, the Bureau of Standards was requested to investigate the cracking of plaster in the Alaska Native Service Hospital then under construction at Anchorage, Alaska. Dr. Lansing S. Wells, Chief, Chemistry of Mineral Products Section, was assigned to make the investigation. He visited the project on April 25 and 26, 1952, and besides examinations of the condition of the plaster, took samples from the set plaster on the wall and conferred with the architect and representatives of the contractor, the Bureau of Indian Affairs, and the producers of the vermiculite plaster aggregate. The results of the investigation made at that time and subsequent tests of materials were reported in a letter dated June 16, 1952, to Mr. Edward A. Poynton, Chief, Branch of Buildings and Utilities, Bureau of Indian Affairs, and National Bureau of Standards Report 9.8/G-10015 dated September 17, 1952, to the Bureau of Indian Affairs, Department of the Interior, both signed by Lansing S. Wells, Chief, Chemistry of Mineral Products Section.

A further request from the Bureau of Indian Affairs, Department of the Interior, dated February 13, 1953, asked that a team of three be sent to Alaska to make inspections and tests to determine the cause of plaster cracking. The team consisting of Lansing S. Wells, William C. Cullen, and Nolan D. Mitchell arrived in Anchorage, in the forenoon of February 21,

and proceeded at once to make the inspections requested and to take samples of lath and plaster from the walls of the hospital building (Project No. 501-228) and the quarters building (Project No. 501-228A). Containers of samples of the gypsum plaster and lime bearing the dates of approval were requested to be forwarded to the National Bureau of Standards for test.

The members of this team were present at a conference held by representatives of the general contractors for the work and those of the Bureau of Indian Affairs on February 23, 1953. The General Contractor, Boespflug-Kiewit-Morrison, was represented by Messrs. DeGarmo, Miller, and Edsall, and the Bureau of Indian Affairs was represented by Messrs. Finley, Halvorson, Reimer, Featherstone, Burn, and others.

National Bureau of Standards Report 2585 "Report of Inspection of Plaster Work at Alaska Native Service Hospital and Tests for Quality and Characteristics of Plaster Materials" on inspections by Messrs. Wells, Cullen, and Mitchell and tests on plaster and aggregates, was submitted to the Bureau of Indian Affairs on June 19, 1953. Certain tests of materials were continued beyond the date of that report. The results of the tests, as well as a review of the previous inspections, are incorporated in this report.

2. EXAMINATION OF PLASTER, 1952

On April 25, 1952, a group which included Messrs. Harold B. Foss, Architect; Edward A. Poynton, Chief, Branch of Buildings

and Utilities; Harry Halvorson, Area Construction Engineer; V. P. Reimer, Project Engineer; J. C. Boespflug, representing Boespflug-Kiewit-Morrison, General Contractor; William Miller, Contractor's General Superintendent; Lansing S. Wells, Chief, Chemistry of Mineral Products Section, National Bureau of Standards; Melvin Quayle, Zonolite Company; and others inspected the plaster in various parts of the hospital building to observe its condition with respect to cracking. Dr. Wells reported on June 16, 1952, that:

> "From the inspection of the plastering it was evident that the cracking was general throughout the building where the plaster had been applied to metal lath. This condition had not occurred on the ceilings and other locations where plaster was applied to concrete. The cracks extended through the white coat and base coat to the metal lath. With the possible exception that some of the cracks radiated from the section where the metal lath was overlapped, there did not seem to be any definite pattern to the cracking. Cracking appeared to be more prevalent in the corridors and hallways than in the rooms, but appeared to be continuing, especially in the rooms."

Based on Dr. Well's knowledge of the properties of plaster and supplemented by conversations with those familiar with what had occurred on the job, he reported as follows:

> "The plastering contractor apparently attempted to give a good job. However, he elected to use vermiculite in lieu of sand, on the basis that, in his opinion, the sand in the vicinity of Anchorage was not particularly well suited for plastering; only later to put some of this sand in the mixture of gypsum plaster, vermiculite, and water. The addition of sand seems to have been made because the plaster mix without sand tended to 'roll' under the trowel. In my opinion, this tendency arose primarily from the fact that

initially too much water had been added to the mix. Thus, the mix was a combination of gypsum plaster, vermiculite, sand, and, apparently, too much water. .....

"From what could be learned at the Hospital at Anchorage, it is my belief that conditions were far from ideal for the satisfactory drying of the plaster. Although the building was heated so that no freezing occurred, nevertheless, the building was not adequately ventilated to remove moisture from the building during the drying period.

"It was observed in many instances that the base coats of plaster were still damp below the white coat, which appeared to be surface dry, and often had been painted. This suggests that the white coat had been applied to base coats that were too wet. Although it is not necessary to wait until the base coats are 'bone dry' (for then they must be slightly wetted) before applying the white coat, nevertheless they should be at least partially dry. .....

"An examination of the sample of set plaster shipped to the Bureau revealed imprinted rust marks in excess of those normally seen on hardened sanded plaster applied over metal lath. This is a further indication that the plaster was moist for a longer period of time than is usual in the case of sanded gypsum plaster.

"Incidentally, it should be mentioned that this sample was taken from an area over which the flat metal lath had been overlapped and from which there had been radiating cracks. It is my belief that this radiation of the cracks from the overlapped area of the metal lath can be explained on the basis that over this overlapped area the plaster is thinner than in adjoining areas. Consequently, the plaster over the overlapping dried sooner than that over the thicker plaster over the adjoining areas and, therefore, the shrinkage cracks first formed there and radiated from foci within the overlapped area.

"As stated previously, there was little or no cracking of plaster over the areas where the plaster had been applied to the underside of the reinforced concrete floor slabs. It was stated that the concrete

in the building had been poured for a considerable period of time before the plastering was undertaken, and that the concrete had dried well. It is suggested that the dry concrete absorbed enough water from the very wet plaster to reduce the moisture content of the plaster after it had been applied and before it had set to reduce the shrinkage on further drying very greatly. Furthermore, the probability of cracking would be reduced on a solid plaster base such as concrete, as compared with a more flexible base such as metal lath."

3. EXAMINATION OF PLASTER, 1953

The examination of plaster on February 21, 22, and 23, 1953, was made by Messrs. Wells, Mitchell, and Cullen. The condition was essentially the same as revealed by figures 1 to 11, inclusive, which show the pattern of the cracking of plaster applied on metal lath. The cracks observed on suspended ceilings of plaster applied on metal lath were of the same pattern but fewer than those in partitions having metal lath on metal studs as the plaster base. The cracking of plaster in the hospital building was more extensive than found in the quarters building. The direction of the cracks in the hospital, figures 1 to 8, was observed to be of a more random pattern than in the quarters building figures 9 to 11. In the quarters building the cracking of wall plaster was ordinarily more vertical in direction than otherwise. It was likewise observed in the hospital building that where sand was mixed with the vermiculite aggregate, the cracks appeared to be closer spaced than where vermiculite alone was used as the plaster aggregate. There was no evidence in the quarters building of the plaster having

remained in a wet condition for an extended period, as was evident in the hospital building where streaks remained, indicating that water had condensed on the partition and coursed down the surface.

3.1 Inspection of Quarters Building Plaster.

Inspection of the quarters building (Project 501-228A) was begun on February 21, 1954, and continued during the forenoon of February 22; 15 of 20 rooms visited and the corridors in the helps' quarters were found to have cracks in the plaster applied on metal lath. Plaster applied on reinforced concrete, apparently, had no cracks except where the concrete was cracked. Cracks were observed in rooms Nos. 200, 201, 207, 209, 212, 214, 215, 217, 303, 309, 311, 321, 325, 329, 331, and in the walls of the corridor in the vicinity of room 303. A number of the cracks extended from the corners of the electrical outlet boxes, and the direction of the major wall cracks, as previously mentioned, was usually more or less vertical. Several of the larger cracks were intersected by smaller cracks extending laterally from the larger ones. There were some examples of cracks in random direction forming a pattern known as "map cracking." In a few of the rooms and at some places in the corridors of the quarters buildings, figures 9 and 11, horizontal cracks indicated the height at which the plastering operation from the scaffold stopped.

Not only were there cracks in the plaster on metal

lath but a number of the ceramic tiles in the wainscots of bathrooms were found to be broken; and, in a number of places, wall tiles were found to be loose from the backing of portland cement plaster on metal lath. A tier of the wall tiles was removed from the wainscot in one location and three horizontal cracks in the cement plaster base were observed to be spaced about a foot apart in the height of the wainscot. These cracks extended through the neat cement setting mortar and the mortar base course made of portland cement and hydrated lime. The cracking of the base course of mortar for the tile wainscot was attributed to shrinkage.

3.2 Inspection of Hospital Building and Plaster.

The inspection of the hospital building (Project 501-228) and plaster was begun on February 22 and continued on the 23rd and 24th. An inspection of the exterior of the monolithic concrete building walls was made before the inspection of the condition of the plaster was begun. Thin cracks were seen below the first-story windows. Several of the cracks extended through the window sills or extended downward from the corner of the window opening. Nearly all of the cracks seen were on the south and west walls of the building. There were a few cracks in the east wall, but these appeared to be smaller than those seen on the south and west sides. The cracks in the exterior walls are doubtless the result of shrinkage of the monolithic concrete. There was no discernable evidence of unequal settlement of the foundation.

Approximately 60 percent of the rooms and all the corridors were visited. Cracks were found in almost all of the metal lath and plaster partitions inspected. There were also cracks in the lath and plaster furring for pipe spaces. A very large proportion of the plastered walls had been painted. In some instances, the painting had been done after the plaster had cracked. Many of the cracks, however, appeared to have occurred subsequent to the application of the paint, indicating that the cracking had been progressive.

Figures 1 to 8, inclusive, show the typical pattern of cracking of the plaster in the hospital building. In some instances, the principal cracks were in long curves (Fig. 4), many reaching to the metal electrical outlet boxes, (Figs. 5, 6, and 7). It is likely that many of these cracks started at the outlet boxes.

Samples of plaster for analysis were taken without lath from the basement corridor and from one room in each of the six stories. Other plaster samples for stability measurements were removed from the walls and included the metal lath and plaster keys back of the lath, as shown in the figures 12, 13, and 14. These specimens were about 16 in. square and the presence or absence of water glaze showed that the water content of the plaster mix varied considerably. The differences in water content were also indicated by differences in the length and appearance of the plaster keys. Five of the lath-and-plaster specimens were sawed into 3-in. wide strips to determine changes in length that might occur when they were

exposed in atmospheres having high or low humidity; and also how they were affected by changing from high to low humidity; and vice versa.

During the conference among representatives of the contractor and the Bureau of Indian Affairs, Mr. DeGarmo cited the increases in the number of visible cracks in each of several rooms between October 15, 1952, and February 23, 1953, the time of the conference. This information indicated that the cracking rate, which had increased during the winter months, was aggravated by the low relative humidity which, on February 23, ranged from 17 to 28 percent in various parts of the building. As examples of the increase of cracking, Mr. DeGarmo stated that on October 15, 1952, room 507 had 3 cracks and on February 23, 19; that on October 15, 1952, room 511 had 1 crack, and on February 23, 16. The progress of cracking in several other rooms was reported to be of about the same order.

4. TESTS OF MATERIALS, 1952 SERIES

Materials collected for tests in 1952 consisted of sand from Anchorage, Alaska, recovered from the project site, and a piece of plaster taken from the wall of the fifth story corridor, south wing, of the hospital building. Other materials from the project were U. S. Gypsum Company's Red Top gypsum cement plaster, fibered; Boulder Canyon Miracle Lime, produced by U. S. Lime Products Corporation, Henderson, Nevada; and expanded vermiculite, produced by Vermiculite

Northwest, Inc. at Portland, Oregon. The gypsum cement plaster, hydrated lime, and sand were tested for conformity with the requirements of appropriate specifications.

4.1 Gypsum Cement Plaster

The gypsum cement plaster was tested in accordance with Federal Specification SS-P-402 with additional tests for tensile strength of plaster mixes (using normal consistency determined under Federal Specification SS-P-402).

Table 1. Analysis of gypsum cement plaster
(Fines, 96.81 percent of total)
[Basis, sample dried at 45°C]

Fines	Composition	Calculated compounds
	Percent	Percent
CaO	37.42	- -
$CaSO_4 \cdot \frac{1}{2}H_2O$ calculated from CaO	- -	96.92
SO_3	49.66	- -
$CaSO_4 \cdot \frac{1}{2}H_2O$ calculated from SO_3	- -	89.88
H_2O combined	5.83	- -
$CaSO_4 \cdot \frac{1}{2}H_2O$ calculated from H_2O	- -	93.92
$CaSO_4 \cdot \frac{1}{2}H_2O$ of sample (89.88 x 0.9681)	- -	87.01

Table 2. Characteristics of plaster

Composition of mix				Normal consistency, water	Time of set	Tensile strength
Aggregate		Plaster	Water			
Kind	Weight	Weight	Volume			
	g	g	ml	Percent	hr.	lb/in.^{2}
Ottawa sand	225	75	54	18	12	--
Ottawa sand	200	100	60	20	--	245
Anchorage sand	225	75	58½	19½	5¼	--
Vermiculite	17	100	78½	67	12	200
Vermiculite, Anchorage sand	17) 40)	100	89½	57	11	115

4.2 Aggregates.

<u>Tests of sand from Project 501-228, Anchorage, Alaska.</u> The sand was tested by the methods of the specifications indicated beside each test:

Specific gravity and absorption (ASTM Designation C128-42)
Specific gravity 2.65
Absorption 1.8 percent
Organic impurities (ASTM C35-52T56 and C40-48)
Color of hydroxide solution: Jet black, indicated as unsuitable for use in interior plaster because of high percentage of organic impurities.

Table 3. Sieve analysis of sand
(ASTM Designation C136-46)

Sieve	Passing	Retained
No.	Percent	Percent
3/8 in.	100	0
4	100	0
8	95	5
16	90	10
30	80	20
50	43	57
100	11	89
200	5[1]	95

[1]Determination made in accordance with the method of ASTM Designation C117-49.

Table 4. Soundness of sand
(ASTM Designation C88-46)
[Solution, magnesium sulfate]

Sieves		Corrected loss
Passing	Retained	
No.	No.	Percent
4	8	0.2
8	16	0.2
16	30	0.6
30	50	2.5
	Total	3.5

Sands finer than No 50 sieve were not subjected to the soundness test.

Tests of vermiculite aggregate. The bulk density 11.22 lb/ft^3 of vermiculite aggregates was determined by the jigging method, 1/10 ft^3 measure (ASTM Designation C29-42). (Note: The bulk density of this specimen was 10 percent greater than for the samples received later.)

4.3 Hydrated Lime

The hydrated lime was tested in accordance with methods in Federal Specification SS-L-351 with additional tests for free CaO+MgO and autoclave expansion and was found to meet the requirements for type S hydrated dolomitic lime.

Table 5. Analysis of hydrated lime
(Basis, sample dried at 45°C)

Characteristics	
Fineness:	Percent
Passing sieve No.30	100.0
Passing sieve No.200	91.4
Oxides	
CO_2	0.10
H_2O	27.08
CaO	43.76
MgO	28.88
SiO_2	0.20
R_2O_3	0.41
Total	100.43
Compound composition	
$CaCO_3$	0.23
$Ca(OH)_2$	57.65
$Mg(OH)_2$	41.78
H_2O	0.16
SiO_2	0.20
R_2O_3	0.41
Total	100.43
Computed constituents	
CaO+MgO (anhydrous basis)	99.00
CO_2 (anhydrous basis)	0.14
CaO+MgO unhydrated	0.00
Linear expansion	
Expansion in autoclave[1]	0.07
Plasticity	
	Index
Determination by ASTM C110-49	480

[1]The autoclave expansion bar was fabricated of lime and portland cement in the ratio of 1 to 1 and tested according to Federal Specification SS-C-158C

4.4 Tests of Plaster Mixes

A piece of finished plaster with keys broken, but otherwise intact, was stripped from the lath of the corridor wall, fifth floor, south wing, of the hospital building on April 26, 1952. It was 8- by 9-in. in size and 3/4 in. thick.

Linear changes from wetting and drying. The specimen was prepared for test by drilling holes into which reference points for a 5-in. Whittemore strain gage were cemented with Densite plaster. The specimen plaster was moistened at the holes before the reference-point pins were cemented into place. The specimen thus prepared was exposed to drying in the air of the laboratory for 24 hr before the initial measurement with the Whittemore gage was made. After the initial measurement of length between gage points was made, the specimen was subjected alternately to soaking in a saturated solution of calcium sulfate ($CaSO_4$) and drying in an oven at 50°C. Measurements were made at the end of each half of each wetting and drying cycle, when the specimen had reached constant weight. The linear changes of the gage length of the specimen, based on the initial measurement, were as shown in table 6.

Table 6. Dimensional changes of set plaster specimen (Minus quantities indicate shrinkage)

Condition of specimen	Linear change of gage length	
	Total change	Differences, reading to reading
	Percent	Percent
Air dried for 24 hr (Base length 5 in.)	0.000	- -
Dried to constant weight at 50°C.	-0.060	-0.060
Wet	-0.004	+0.056
Dry, 2nd cycle	-0.080	-0.076
Wet	-0.022	+0.058
Dry, 3rd cycle	-0.088	-0.066
Wet	-0.036	+0.052
Dry, 4th cycle	-0.102	-0.066

This plaster specimen showed continued shrinkage superimposed on the alternate shrinkage and expansion of the drying and wetting cycle. The specimen was only 0.024 percent longer in the wet condition at the end of the third cycle, than when in the dry condition at the end of the first drying at 50°C, although the change of length between the wet and dry condition averaged about 0.067 percent.

4.5 Expansion Test Bars.

Bar specimens made of plaster mixes of gypsum cement plaster and vermiculite and others made of gypsum cement plaster, vermiculite, and Anchorage sand were cast in steel molds described in ASTM Designation C227-52T, figure 2, with

inset stainless steel reference points. The specimens were 1 in. square by 11 3/8 in. long with 10 in. length between the inner ends of the reference points. The bar specimens were measured as soon as removed from the molds and at intervals thereafter, as shown in table 7. They were stored in the laboratory maintained at 73°F (23°C) with relative humidity at 50 percent until the interval immediately preceding the last reading, in which latter interval the relative humidity of the container in which the bars were stored, was 30 percent, the temperature remaining 73°F (23°C).

Table 7. Length changes of expansion test bars of gypsum plaster mixes
(Minus quantities indicate shrinkage)

Composition of plaster mixes	Bar identification 1	1A	2	2A
Gypsum cement plaster, g	200	200	200	200
Vermiculite (expanded), g	34	34	34	34
Water, ml	78	156	90	177
Sand (Anchorage), g	-	-	80	80
Age of specimen	Linear changes relative to original 10 in. length between reference points			
Days	Percent	Percent	Percent	Percent
1	-	0.000	-	0.000
2	0.000	0.004	0.000	0.004
3	0.007	0.003	0.001	-0.003
4	0.013	-0.019	.007	- .017
5	.016	- .020	.014	- .-18
6	.007	- .019	.014	- .017
7	- .008	- .021	.008	- .018
8	- .012	--	- .010	--
9	- .010	--	- .008	--
10	--	- .020	--	- .017
14	- .006	--	- .002	--
17	- .014	--	- .010	--
18	- .015	- .019	- .011	- .017
28	--	- .022	--	- .020
38[1]	--	- .022	--	- .019
51[2]	- .015	--	- .011	--
56	- .022	- .027	- .018	- .023

[1]Bars 1A and 2A stored 18 days in a container the relative humidity of which was held at 30 percent after this reading.

[2]Bars 1 and 2 stored 5 days in 30 percent relative humidity.

5. TESTS OF MATERIALS, 1953 SERIES

5.1 Materials.

Specimens of materials received from Projects 501-228 and 501-228A included approved samples of fibered gypsum cement plaster, gypsum cement plaster, not fibered, medium set gauging plaster and hydrated lime. Other materials from the projects included sand from a lot delivered to the job, seven specimens of plaster taken from six rooms and one corridor for determinations of proportions of aggregates and plaster mixes, six specimens of lath and plaster cut from the walls of the hospital building and two from the walls of the quarters building. Visual examination and a settling test indicated that large quantities of silt were present in the water available on the site. Additional materials for test were purchased from dealers in Seattle, Washington, who had supplied plaster, lime, and aggregates for the project. These materials included U. S. Gypsum Company's Red Top fibered gypsum cement plaster, gypsum cement plaster, unfibered, and Red Top gauging plaster; U. S. Lime Products Corporation's Miracle hydrated lime; and sand from a dealer in Anchorage, Alaska.

5.2 Tests of Plasters.

Gypsum cement plasters, fibered and unfibered. The specimens of approved plaster samples were tested and analyzed to determine whether they conformed to the requirements of Federal Specification SS-P-402 and for other characteristics.

Table 8. Characteristics of U.S. Gypsum Red Top plasters and plaster mixes (Basis, samples dried at 45 °C; proportions by weight)

Sample designation	Type	Consistency	Time of set	Consistency	Tensile strength	Two-inch cubes		Neat plaster	
						Compressive strength	Shrinkage	$CaSO_4 \cdot \frac{1}{2}H_2O$	Insoluble
			hr		psi	psi	percent	percent	percent
Gypsum cement, plaster, fibered,[1] 1:2 Ottawa sand	N	20	24	-	190	-	-	90.0	-
Gypsum cement plaster, unfibered,[1] 1:2 Ottawa sand	N	19½	10½	-	225	-	-	90.3	-
Gauging plaster, medium set	G	46	2¼	-	540	-	-	93.0	-
Gauging plaster[2,3,5]	G	49	2	-	540	2470	2.00	98.3	-
Gypsum cement plaster, fibered,[2] 1:2 Ottawa sand	N	18½	7½	21½	240	1190	-	92.8	[4]3.85
Gypsum cement plaster, 1:2 Alaska sand[5]	N	21	5¼	23½	185	1030	0.6	-	-
Gypsum cement plaster, Fed. Spec. SS-P-401,[5]	N	50½	8	50½	350	1930	2.1 2.3 (avg. of two lots)	-	-
Gypsum cement plaster, 150g needle for consistency[5]	N	-	-	52½	365	1880	3.0	-	-

[1] Retained sample of plaster approved for project 501-228.

[2] Sample purchased from dealer who supplied material for project.

[3] All of 25g sample of gauging plaster passed through No.100 sieve.

[4] Average of 5 determinations, namely, 3.73, 3.80, 3.85, 3.89 and 3.98 percent.

[5] Cubes made from the four plasters and plaster mixes showed decided shrinkage.

5.3 Tests of Aggregates

Sand. Two lots of sand were received from Alaska. The sieve analyses were as shown in table 9.

Table 9. Sieve analyses of two lots of sand and proportions as recombined for use in plaster specimens

Sieve	Retained on sieve		
	Lot 1	Lot 2	Recombined lot
No.	Percent	Percent	Percent
8	5.9	6.9	5.0
10	12.1	11.9	5.0
30	23.5	27.35	10.0
50	39.7	39.7	40.0
100	18.8	13.9	40.0

The sand from the two lots received from Alaska were separated by sieving and recombined to give approximately the same gradation as the sample taken from the project in April, 1952. (See table 3.) The magnetic content of the sand found by making six determinations was approximately 4 percent.

Vermiculite. One bag (4 ft^3) of expanded vermiculite was received from Vermiculite Northwest, Inc. This material was checked for bulk density by filling a 10-gal measure. It was found by two determinations to weigh 10.1 lb/ft^3 and its magnetic content, as determined by means of an Alnico magnet, nil.

The sand as recombined for size and vermiculite of the above lot were used to make plaster specimens for expansion bars and specimens to show the flexing of lath and plaster under various conditions of relative humidity.

5.4 Tests of Hydrated Lime

Samples from projects. Two cans of hydrated lime submitted by the Contractor for approval of the Project Engineer were received from Anchorage, Alaska. Notations on one of the cans indicated that the material had been approved for use.

Sample from dealer. A bag of Miracle Brand hydrated lime, manufactured by U. S. Lime Products Corporation, Henderson, Nevada, was received from Pioneer Sand and Gravel Company, 901 Fairview North, Seattle, Washington. This was the same brand of hydrated lime as was used for the white coat finish of both the hospital building and the quarters building.

These three lots of lime were analyzed for conformity with the requirements of Federal Specification SS-L-351 with the results shown in table 10.

5.5 Proportions of Aggregates in Base Coat Plasters

Specimens of plaster removed from the metal lath plaster base at the project, after having the white finish removed, were analyzed for the proportions of aggregates with the results shown in table 11. After having the plaster dissolved by ammonium acetate the residue was washed, dried, and weighed. The magnetic content of the residue was separated by the use of a magnet, and weighed. From the known insoluble content of the gypsum cement plaster and the magnetic content of the aggregate, it was possible to compute the volumes of vermiculite and sand in relation to the gypsum cement in the set plaster samples.

Table 10. Characteristics of U. S. Lime Products Corporations's "Miracle" lime, used in white finish plaster for Alaska Native Service Hospital, Anchorage, Alaska.
(Basis, samples dried at room temperature)

Analyses			
Characteristics	Sample designation[1]		
	Lot 1	Lot 2	Lot 3
Fineness:	Percent	Percent	Percent
Passing sieve No. 30	100.0	100.0	100.0
Passing sieve No. 200	95.1	93.2	93.2
Oxides			
CO_2	0.50	0.69	1.85
H_2O	26.47	26.51	25.50
$SiO_2+R_2O_3$	0.85	0.63	0.69
CaO	42.87	43.31	43.32
MgO	29.68	29.44	28.39
Total	100.37	100.58	99.75
Compound Composition			
$CaCO_3$	1.14	1.57	4.21
$Ca(OH)_2$	55.80	56.06	54.12
$Mg(OH)_2$	41.77	41.70	39.95
MgO	0.81	0.62	0.78
$SiO_2+R_2O_3$	0.85	0.63	0.69
Total	100.37	100.58	99.75
Computed Constituents			
CaO+MgO, nonvolatile basis	99.3	99.0	98.7
CO_2, nonvolatile basis	0.70	0.94	2.55
MgO on basis of CaO+MgO	40.9	40.5	39.6
MgO, hydrated	97.3	97.9	97.3
CaO+MgO, unhydrated	0.81	0.62	0.78
Linear expansion			
Expansion in autoclave	-	-	0.03
Plasticity			
	Index	Index	Index
Determination by ASTM C110-49	480	580	430

[1] The can containing material of lot 1 was labeled: "General Contractor--Boespflug-Kiewit-Morrison; Subcontractor--Steeves & Wilson; Subject--Anchorage Hospital Project 501-228; Manufacturer--U. S. Lime Products Corp.; Material--Miracle Lime."

The can for lot 2 was labeled "United States Lime Products Corp., Boulder Canyon Miracle Lime, Dolomitic Pressurized Hydrated Lime; Contr.--Steeves & Wilson; Quarters Bldg., Alaska Hospital; checked 11/13/51 by H.H." (Probably Harry Halvorson)

Lot 3 was from a bag of "Miracle" Hydrated Lime purchased from Pioneer Sand and Gravel Co., Seattle, Washington

Table 11. Analysis of base coat plasters for proportions of aggregates by the ammonium acetate method and magnetic content.

Sample Designation	Weight of sample	Total insoluble	Total insoluble	Magnetic content extracted	Proportion of sand in aggregate	Aggregates; per 100 lb of gypsum cement	
						Vermiculite, 10 lb/ft^3	sand, 100 lb/ft^3
	g	g	Percent	g	Percent	Ft^3	Ft^3
B hall	9.9905	4.6338	46.78	0.1565	-	-	-
Do.	10.0025	4.5300	45.29	.1580	-	-	-
Average	9.9965	4.5819	46.04	0.1568	90.0	3.0	0.70
N12	9.9875	3.2155	32.20	.0318	-	-	-
Do.	10.0010	3.4143	34.14	.0320	-	-	-
Average	9.9943	3.3149	33.17	0.0319	26.2	3.2	.12
E106	9.9860	2.5108	25.14	-	-	-	-
Do.	10.0005	2.6432	26.43	0.0000	-	-	-
Do.	10.0015	2.6422	26.42	.0000	-	-	-
Average	9.9996	2.5991	26.00	0.0000	0.0	3.0	.00
N245	9.9900	3.4605	34.64	0.0500	-	-	-
Do.	10.0007	3.5407	35.40	.0375	-	-	-
Average	9.9954	3.5006	35.02	0.0438	35.0	3.1	.17
E316	9.9925	5.4580	54.99	0.1240	-	-	-
Do.	10.0005	4.5940	45.94	.1250	-	-	-
Do.	10.0000	4.6195	46.20	.1265	-	-	-
Average	9.9978	4.8905	49.04	0.1252	66.8	3.9	.58
S438	9.9900	4.4018	44.06	0.0915	-	-	-
Do.	10.0002	4.4860	44.86	0.0915	-	-	-
Average	9.9951	4.4439	44.46	0.0915	73.0	2.0	.53
W504	9.9800	3.4795	34.86	0.0650	-	-	-
Do.	10.0005	3.7210	37.21	.0560	-	-	-
Average	9.9903	3.6003	36.04	0.0603	45.3	2.7	.23

5.6 White Finish Plaster

Analysis of specimens. The white finish plaster analyzed for proportions of lime and gauging plaster had been removed from the specimens used in making determinations of the proportions of plaster and aggregates of the base coat plaster. The results of the analyses are given in table 12. There were wide variations in the proportions, but in no case was the proportion of lime putty to gauging plaster excessive. The computation was made on the assumption that 1 ft^3 of lime putty contained 45 lb of dry hydrated lime and 1 ft^3 of dry gauging plaster weighed 65 lb.

An examination of the compound composition in table 12 in which an excess of H_2O is reported for the plaster specimens from the three upper stories of the hospital building, which were among the first plastered, has led to the conclusion that in the continued presence of excessive moisture nesquehonite ($MgCO_3 \cdot 3H_2O$) and epsom salts ($MgSO_4 \cdot 7H_2O$) had been formed. Such reactions have been described in National Bureau of Standards Research Paper RP1538 "Function of Carbon Dioxide in Producing Efflorescence on Plaster and Cement Products" (May 1943).

Table 12. Analysis of white finish plaster from hospital building
(Basis, material dried at 45°C)

Analyses							
Sample designations[1]	B Hall	N12	E106	N245	E316	S438	W504
Oxides							
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
CO_2	11.87	10.02	11.52	10.02	10.62	12.22	4.41
H_2O (combined)	21.16	16.47	17.54	18.27	23.34	17.47	21.01
$SiO_2+R_2O_3$	1.12	1.21	0.60	0.61	2.18	1.09	0.70
CaO	35.62	34.95	36.87	32.70	34.58	34.51	32.24
MgO	18.02	10.57	14.89	14.83	16.86	12.44	12.77
SO_3	12.49	27.23	18.99	23.69	12.70	22.38	29.03
Compound composition							
$CaSO_4 \cdot 2H_2O$	26.86	58.55	40.84	50.94	27.31	48.13	62.43
$CaCO_3$	26.99	22.79	26.20	22.79	14.15	27.27	10.03
$Ca(OH)_2$	15.52	4.11	11.74	4.41	26.06	5.00	8.31
$Mg(OH)_2$	26.07	10.42	19.88	21.16	24.39	18.00	18.47
MgO	3.72	3.37	1.15	0.20	0.00	0.00	0.00
H_2O excess	0.00	0.00	0.00	0.00	[2] 6.19	[2] 0.62	[2] 0.22
$SiO_2+R_2O_3$	1.12	1.21	0.60	0.61	2.18	1.09	0.70
Total	100.28	100.45	100.41	100.11	100.28	100.11	100.16
MgO of lime							
Proportion: $\frac{MgO}{CaO+MgO}$	41.4	40.0	38.7	[3] 47.9	39.6	39.8	[3] 51.7
Hydrated	79.4	68.1	92.3	98.7	100.0	100.0	100.0
Lime putty in mix							
Proportion of putty to $CaSO_4 \cdot \frac{1}{2}H_2O$	Ratio 3.5	Ratio 0.95	Ratio 2.0	Ratio 1.3	Ratio 3.3	Ratio 1.4	Ratio 0.81
White finish plaster							
Thickness	in. $\frac{1}{64}$ - $\frac{1}{16}$	in. $\frac{1}{16}$ - $\frac{3}{32}$	in. $\frac{1}{32}$ - $\frac{1}{16}$	in. $\frac{1}{32}$	in. $\frac{1}{32}$ - $\frac{1}{16}$	in. $\frac{1}{16}$	in. $\frac{1}{64}$ - $\frac{1}{16}$

[1] Letters in sample designations signify, respectively: B, basement; N, north; E, east; S, south; W, west, and figures denote room numbers as given on the architectural plans.

[2] The excess H_2O may be attributed to nesquehonite ($MgCO_3 \cdot 3H_2O$), epsom salts ($MgSO_4 \cdot 7H_2O$), or the unidentified minerals.

[3] Samples N245 and W504 shown apparently abnormally high percentages of MgO in the lime. Possibly some vermiculite from the base coat was carried into the white finish plaster in the troweling. If so, this would upset the validity of the calculations which were based on the assumption that the white finish plaster consisted wholly of lime and gypsum.

There is a high degree of probability that the same reactions had occurred in other stories of the building, but in the calculations of compositions the evidence is masked as long as any magnesium oxide (MgO) appears to remain unhydrated. This type of reaction would occur in the more favorable locations, rather than uniformly throughout the white finish plaster, and may account for initiation of cracking and the closer spacing of plaster cracks near the floors.

5.7 Expansion Tests

Expansion of test bars. Bar specimens of plaster mixes consisting of 20 parts gypsum cement plaster, 8 parts vermiculite, and 5 parts Alaska sand by weight were cast with stainless steel reference points in the ends in steel molds as described and shown in figure 2 of ASTM Designation C227-52T. The length of the bars between reference points was 10 in. A strip of wet cardboard was placed in the bottom of the mold to make the bars 1- by 7/8-in. in cross section. Immediately upon removal from the molds, bars A and B expanded in length 0.03 and 0.02 percent, respectively, as shown in figure 15. A 1/16-in. thick white finish was applied to the side which had been molded against the cardboard. After application of the white finish, the bars were laid horizontally in a humidity chamber on a continuous support and without restraint other than their own weight. The specimens continued to expand as shown in figure 15. Under the influence of relative humidities ranging from 93 to 97 percent, at 72°F, bars A

and B had increased in length by 0.130 and 0.156 percent, respectively, in two weeks. The bars were then placed in a chamber, the relative humidity of which ranged from 30 to 18 percent, for the next four weeks. During the first two weeks of this period, the length of the bars decreased by 0.046 and 0.048 percent, respectively. During the next two weeks, the shrinkage in length of each amounted to 0.007 percent. The subsequent changes in conditions of storage and lengths of bars are shown by the graph, figure 15.

5.8 Stability of Lath and Plaster from the Hospital Building

Changes in length of specimens. Five of the 16- by 16-in. specimens of lath and plaster cut from the partitions of the basement, first, third, and fifth stories of the hospital building were sawed into 3-in. wide strips and subjected alternately to high-and-low or low-and-high humidity at nearly constant temperatures. Changes in length between gage points 10 in. apart on $\frac{1}{4}$-in. diameter brass discs cemented to the front and back surfaces of the plaster were measured by means of an optical comparator. The comparator was calibrated against a 10-in. invar standard bar at the time each set of readings was made.

Two chambers having controlled humidity were used for storage of specimens between readings. The specimens were transferred from one chamber to the other at the time of making the measurements. The cycles of storage and the percentages of relative humidity are shown by the graphs at the top of figures 18 and 19. The length changes from reading

to reading are shown as percentages of the 10-in gage length.

Certain anomalies are apparent in the graphs. For example, although the relative humidity of the chamber (Fig. 19) was about 30 percent, the average increase in the lengths of the specimens was approximately 0.05 percent. An exception to this trend was the shrinkage on the key side of the specimen marked 7 & 8C which showed a slight decrease in length. The general trend was for expansion of the plaster when exposed to high relative humidity, and shrinkage when the humidity was lowered. Some of the anomalies can be attributed to internal cracking of the plaster when the strains induced between the plaster and lath could no longer be resisted by the plaster. There was no decided difference in the deformations of the specimens cut in horizontal strips, length-wise of the lath, in comparison with those cut vertically, that is, transversely to the lath. The deformations on the back or key side of the specimens were usually, but not always, smaller than those on the finish side.

It will be observed that the lengths of the specimens were usually increased with increases in relative humidity and decreased when the humidity was lowered. When dampened at 18½ weeks, the expansion brought the length up to approximately the same state as was reached in the earlier stages of the test under the influence of high relative humidity.

5.9 Plaster from Quarters Building

Examination of plaster specimens. The two 16- by 16-in. specimens cut from the walls of the quarters building were

examined for friability and thickness of plaster as well as the condition of the lath. The plaster had been applied in three coats: scratch, brown, and finish coats. There were voids in the furrows in some parts of the scratch coat where the brown coat plaster had not filled the scratch furrows, and there appeared to be a plane of weakness in one specimen between the scratch and brown coats. The gypsum plaster seemed to be weak and somewhat more friable than is the case with the usual gypsum plaster as applied to metal lath. The white finish was decidely stronger than the base coats.

The measured thickness of the base coats plus the white finish plaster from the face of the expanded metal lath to the face of the white finish as determined by 20 measurements on the two specimens was 0.54 in. The plaster keys on the backs of the metal lath varied widely in depth and appearance. Water glaze was apparent on the keys of one of the two specimens of lath and plaster. The lath from the quarters building where the plaster had been stripped from it, showed less corrosion than was found on the lath from the hospital building.

In addition to the measurements of plaster thickness on the two specimens obtained from the quarters building, measurements were made by Chief Area Engineer, William Featherstone in May 1954, by drilling into the plaster and measuring from the surface to the lath with a depth gage. The thicknesses of the plaster of partitions and ceilings as measured by gages inserted into 101 drilled holes ranged from 1/4 to

1 1/8 in., the average being 0.66 in. At 68 of the 101 points where the measurements were made, the depth from the surface to the lath was less than specified, and at 19 points it was in the range of 1/4 to 1/2 in., the average of the latter range being 0.44 in. Inasmuch as the strength of the plaster in resisting bending varies as the square of the thickness, it can be assumed without question that the deficiency in thickness was a factor in the development of the plaster cracks.

Sand used in plaster for quarters building. A retained sample of sand for the quarters building, Project 501-228A, marked "Submitted by McDougall-Dixon & Pardue" was subjected to a sieve analysis with the following results: 0.1 percent was retained on the No. 8 sieve, 3.2 percent on the No. 16 sieve, 27.3 percent on the No. 30 sieve, and 77.0 percent on the No. 50 sieve. When subjected to the ASTM Test for Organic Impurities (ASTM Designation C40-48), the color of the sodium hydroxide solution in which the sand was tested was darker than the No. 5 (darkest) reference color, in fact the color was almost jet black. A sample of the sand was washed with running water until the effluent appeared clear and then subjected to the same test. The sodium hydroxide solution on this sample was slightly darker than the No. 4 reference color.

The ASTM Specification C35-52T states that:

> "Sand, when subjected to the colorimetric test for organic impurities, shall develop a color no darker than the standard, unless it is established by adequate tests that the impurities causing the color are not harmful to plaster."

The color of the standard reference No. 2 is that produced

> "by adding 2.5 ml. of a 2 per cent solution of tannic acid in 10 per cent alcohol to 97.5 ml. of a 3 per cent sodium hydroxide solution."

5.10 Strength of Sanded Gypsum Plaster

Comparison of strengths of plasters with sand aggregates. Tests were made to compare the tensile strengths of sanded gypsum plasters made with 1 part of fibered gypsum cement plaster to 3 1/3 parts by weight of sand. One lot was made with graded Ottawa standard sand and the other with washed sand from Anchorage, Alaska. The average tensile strength of the five specimens of the first lot was 150 lb/in.^{2} and for the six specimens of the second lot, 125 lb/in.^{2}. The strength of the plaster made with the sand from Anchorage, Alaska, was 5/6 that of plaster made with Ottawa sand. The minimum permissible strength of sanded scratch coat plaster under Federal Specification SS-P-402 is 125 lb/in.^{2}. Therefore, the mixture used for the tests met the specification requirements for strength of scratch coat plaster.

FIGURE 1. PROJECT 501-228. WALL SECTION OF ROOM N-125 (DINING ROOM). THE CRACK PATTERN IS TYPICAL OF STEEL-STUD WALLS AND HUNG CEILINGS IN THE FIRST STORY. THE 9-BY 15-FT. WALL AREA SHOWN REQUIRED 86 LIN. FT. OF REPAIR.

FIGURE 2. PROJECT 501-228. WALL OF ROOM W-149 (WAITING ROOM), A TYPICAL STEEL-STUD CONSTRUCTION, THE CRACK PATTERN OF WHICH WAS THE SAME AS IN OTHER AREAS. THE 11-BY 20-FT. AREA SHOWN REQUIRED 139 LIN. FT. OF REPAIR.

FIGURE 3. PROJECT 501-228. NORTH WALL OF ROOM E-202. CRACK PATTERN AND CONDITION TYPICAL OF ALL STEEL-STUD WALLS ON SECOND FLOOR. THIS WALL REQUIRED 90 LIN. FT. OF REPAIR FOR THE 8-BY 5-FT. SECTION SHOWN.

FIGURE 4. PROJECT 501-228. CORRIDOR E-501; 99% OF CRACKS THROUGH TO LATH. THIS WALL REQUIRED 73 LIN. FT. OF REPAIR ON 9-BY 10-FT. AREA SHOWN.

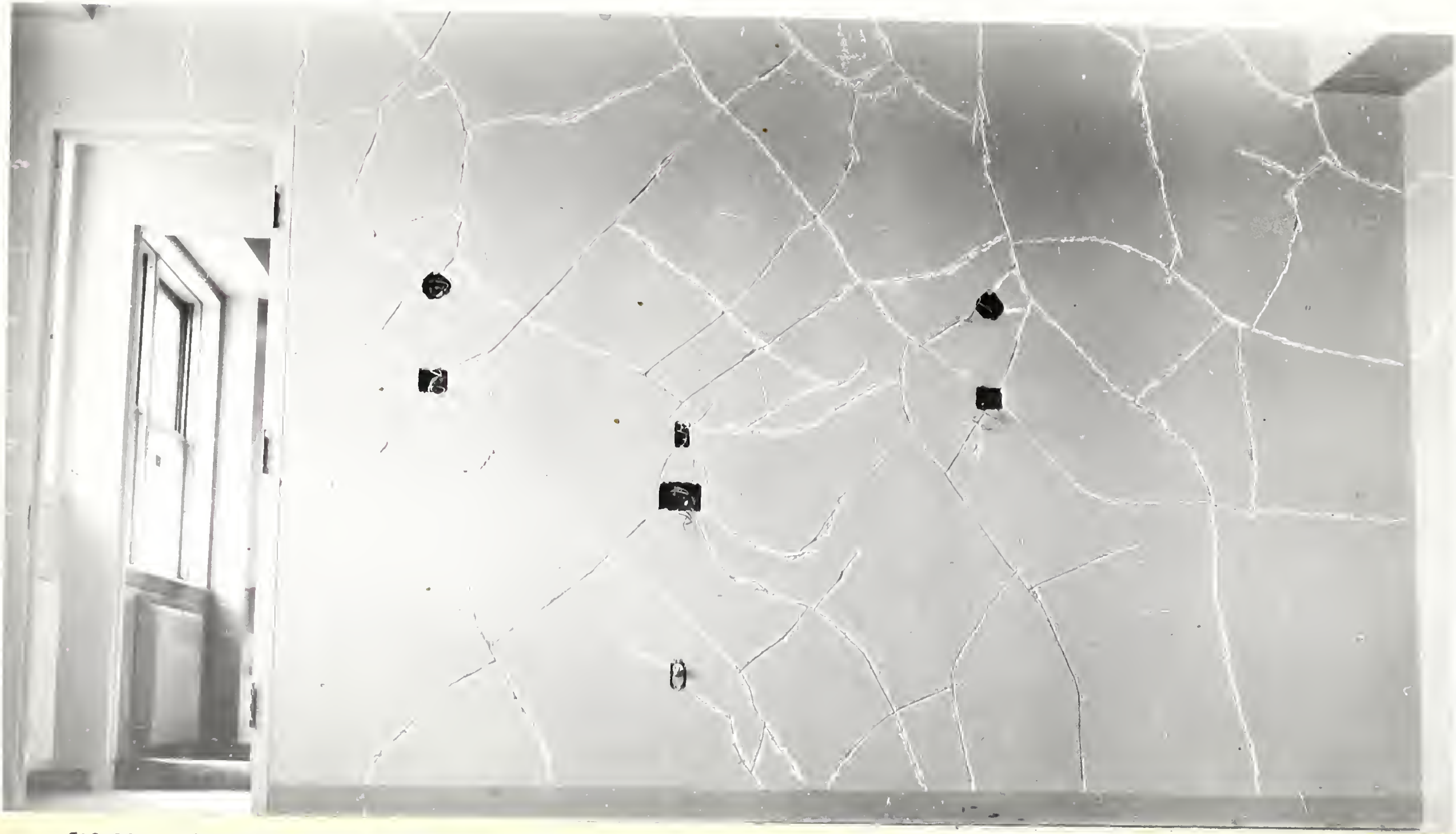

FIGURE 5. PROJECT 501-228. NORTH WALL OF ROOM N-518 (PRINTED REVERSED) SHOWING CRACKS GROOVED READY TO BE FILLED.

FIGURE 6. PROJECT 501-228. SOUTH AND CORRIDOR WALLS OF ROOM N-518 (PRINTED REVERSED) SHOWING CRACKS GROOVED READY TO BE FILLED.

FIGURE 7. PROJECT 501-228. NORTH WALL OF ROOM 518 NEAR DOORWAY, FIG. 5, SHOWING CRACKS DEVELOPED AFTER HAVING BEEN REPAIRED TWICE PREVIOUSLY. PHOTOGRAPHED OCTOBER 28, 1952.

414-11

ANCHORAGE HOSPITAL - PROJECT 501-228
North 518 showing fracture after being
repaired twice - taken October 28, 1952

FIGURE 8. PROJECT 501-228. S-100, (SOUTH CORRIDOR) NEAR LAUNDRY ENTRANCE SHOWING CONDITION OF PLASTER ON OCTOBER 22, 1952.

414-1

ANCHORAGE HOSPITAL - PROJECT 501-228

S-100 near laundry entrance

taken October 22, 1952

FIGURE 9. PROJECT 501-228A. PATTERN OF CRACKING, NORTH WALL OF ROOM E-240, QUARTERS BUILDING ON NOVEMBER 17, 1952.

418-6

ANCHORAGE QUARTERS - PROJECT 501-228A

Room E-240, north wall,

taken November 17, 1952

FIGURE 10. PROJECT 501-228A. PATTERN OF CRACKING OF PLASTER OF WALL, ENTRANCE ROOM OF THE QUARTERS BUILDING ON NOVEMBER 19, 1952. THE WARPED PLASTER AT MARGINS OF THE CRACKS HAD BEEN SANDED OFF IN PREPARATION FOR REPAIR. NOTE CLOSER SPACING OF THE CRACKS AT THE BOTTOM OF THE WALL.

ANCHORAGE QUARTERS - PROJECT 501-228A

Room of entrance of quarters building taken November 17, 1952

4/8-1

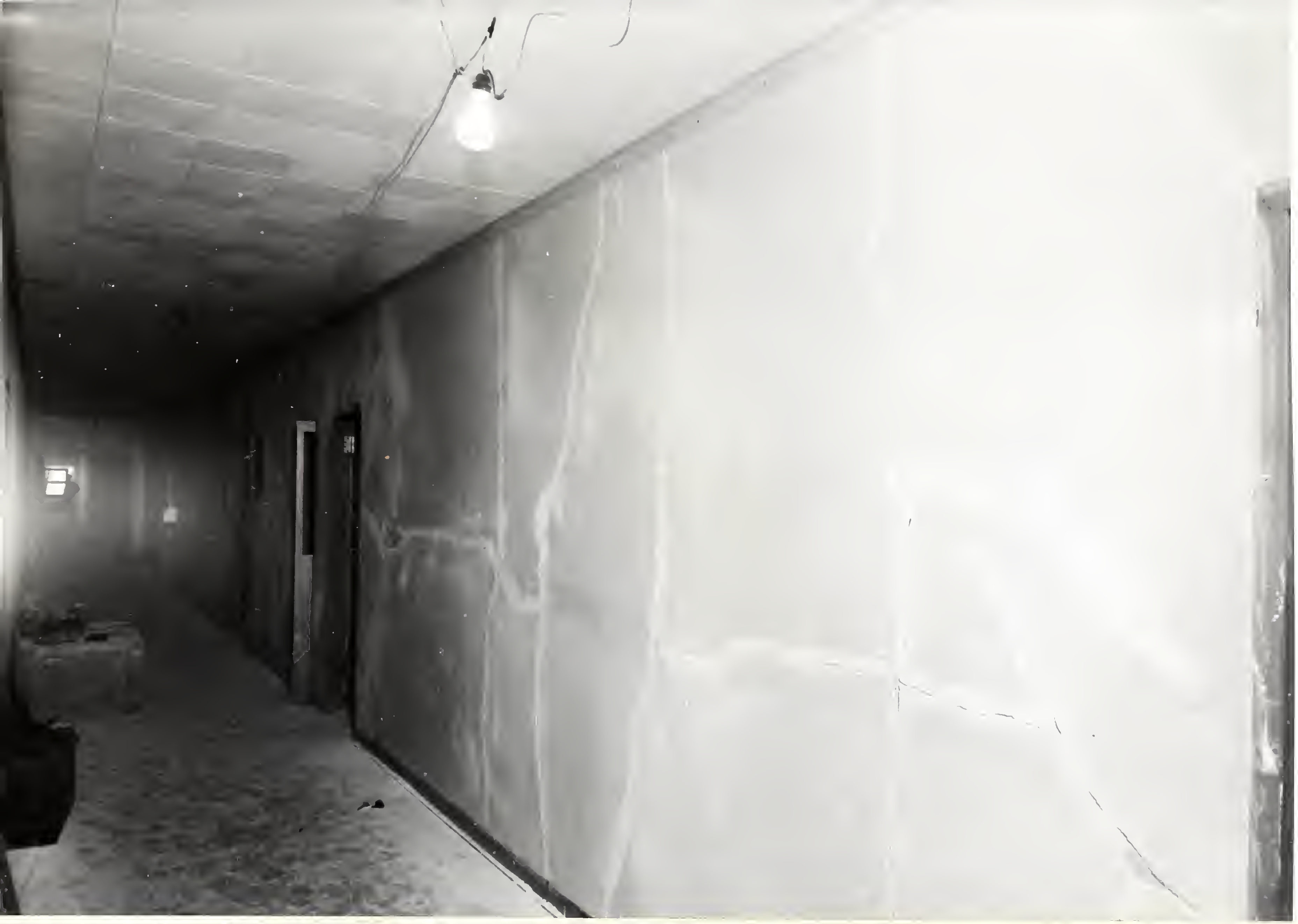

FIGURE 11. PROJECT 501–228A. PATTERN OF CRACKING IN THE WALL OF THE NORTH-WING CORRIDOR, SECOND FLOOR OF QUARTERS BUILDING ON NOVEMBER 17, 1952. THIS WAS TYPICAL OF CRACKS IN THE CORRIDOR PARTITIONS.

418-7

ANCHORAGE QUARTERS - PROJECT 501-228A

2nd floor, north wing corridor
east wall, taken November 17, 1952

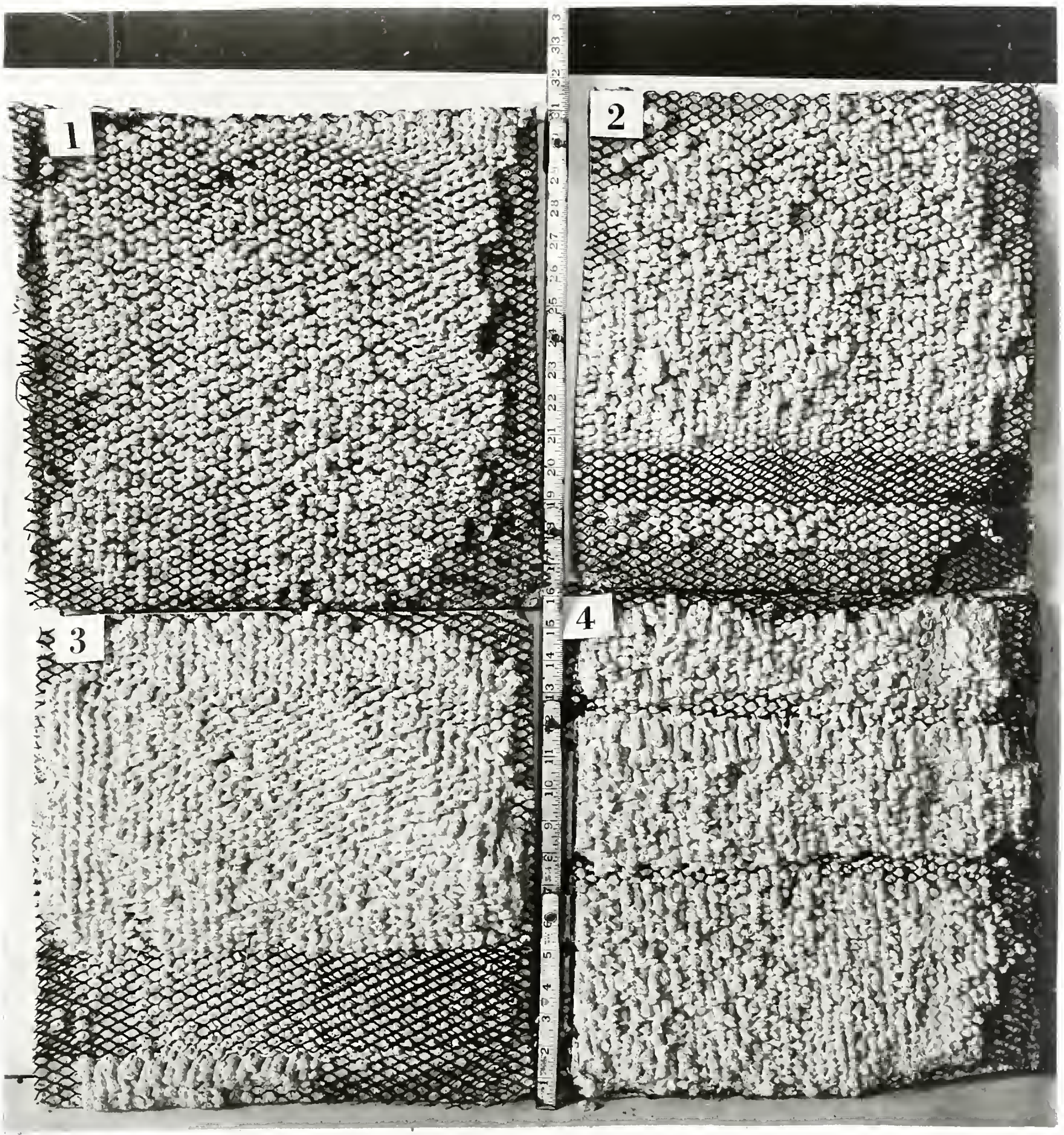

FIGURE 12. PROJECT 501-228. SPECIMENS OF PLASTER FROM WALLS OF (1) ROOM W-318, (2) CORRIDOR WALL OF BASEMENT BETWEEN DOORS OF ROOMS 7 AND 8, (3) ROOM W-132, AND (4) LINEN CLOSET S523 SHOWING PLASTER KEYS.

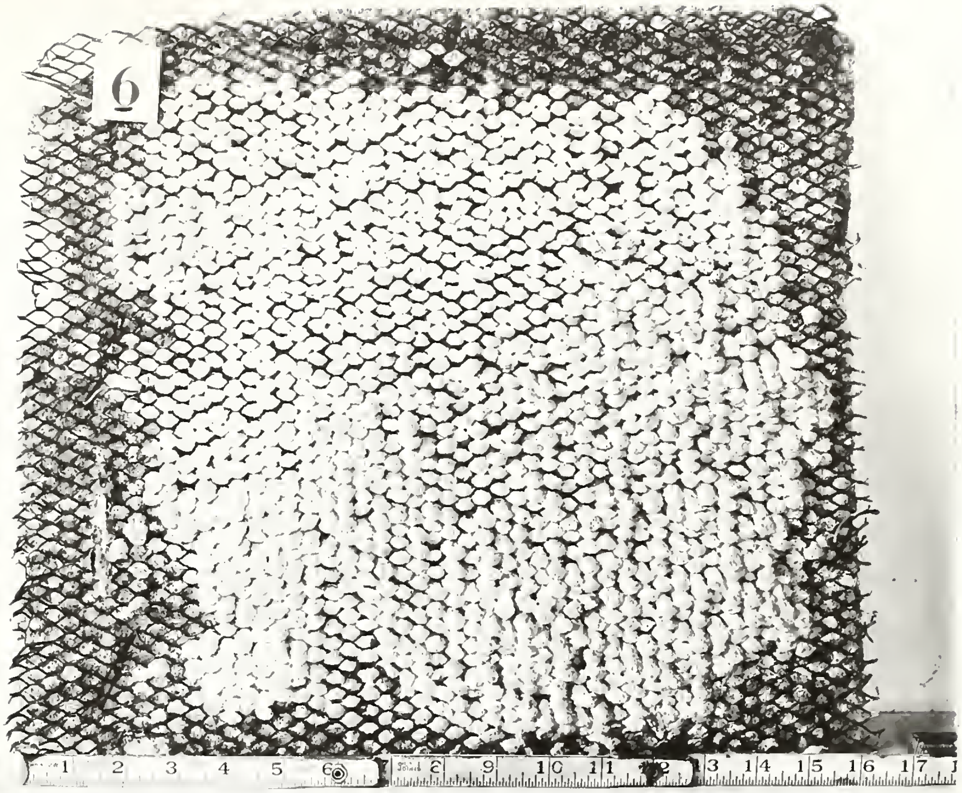

FIGURE 13. PROJECT 501-228. SPECIMEN OF LATH AND PLASTER TAKEN FROM WALL OF LINEN CLOSET N-308 SHOWING WHERE KEYS ARE BROKEN HOW RUST STAINS PENETRATE PLASTER KEYS.

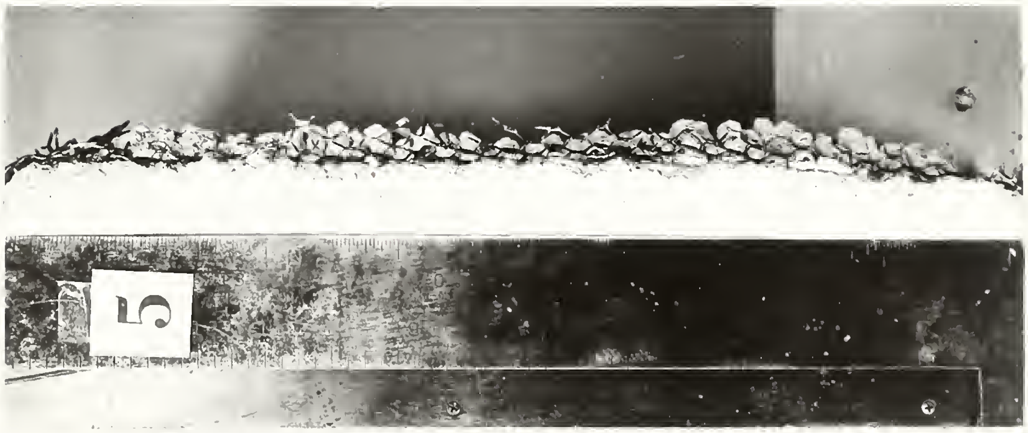

FIGURE 14. PROJECT 501-228. EDGE VIEW OF SPECIMEN FROM LINEN CLOSET SHOWING CURVATURE OF SURFACE AND THICKNESS OF PLASTER.

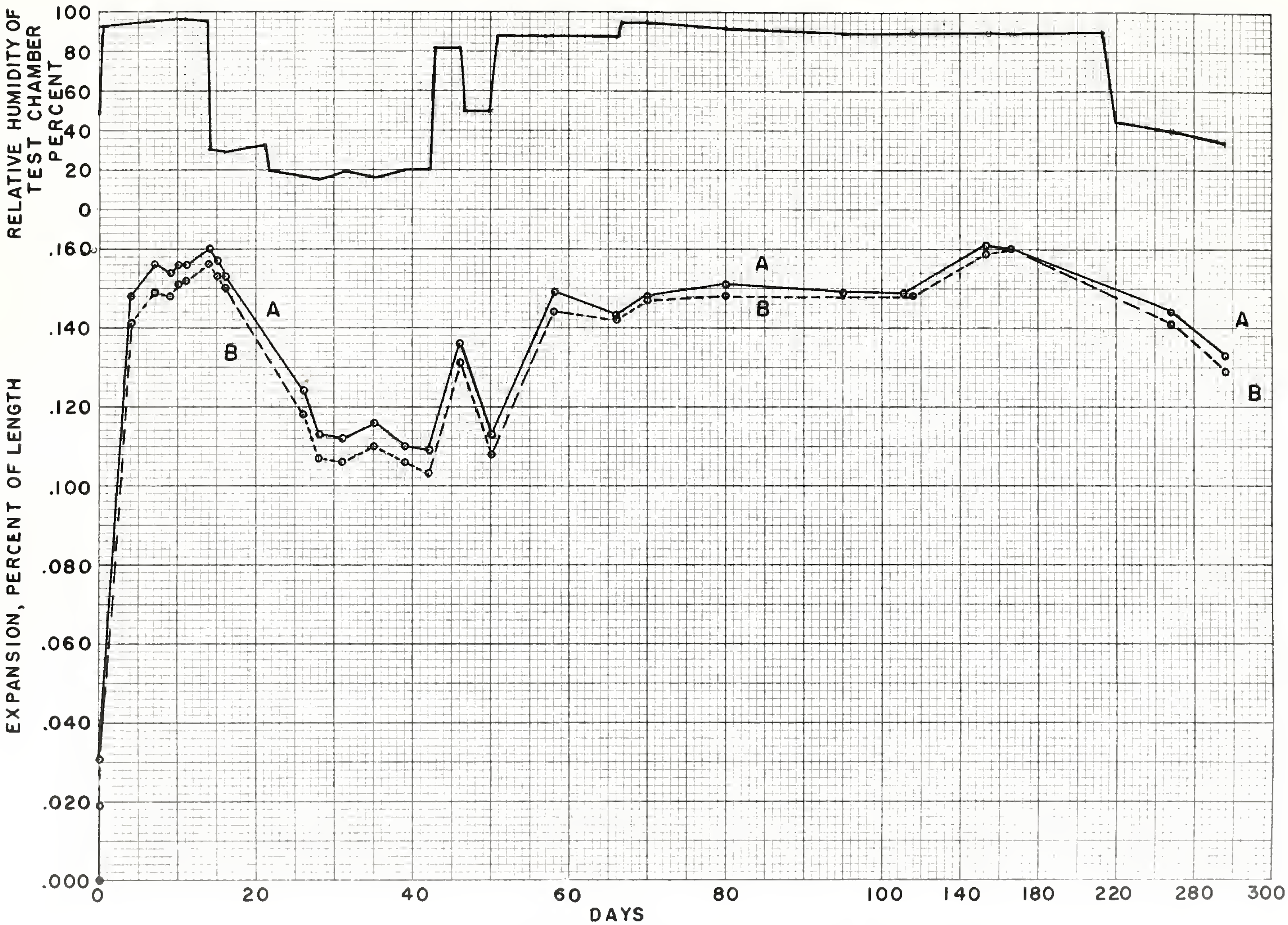

FIGURE 15. EXPANSION AND CONTRACTION OF BARS OF VERMICULITE-SAND-GYPSUM PLASTER WITH CHANGES IN THE HUMIDITY OF THE ATMOSPHERE OF THE STORAGE CHAMBER.

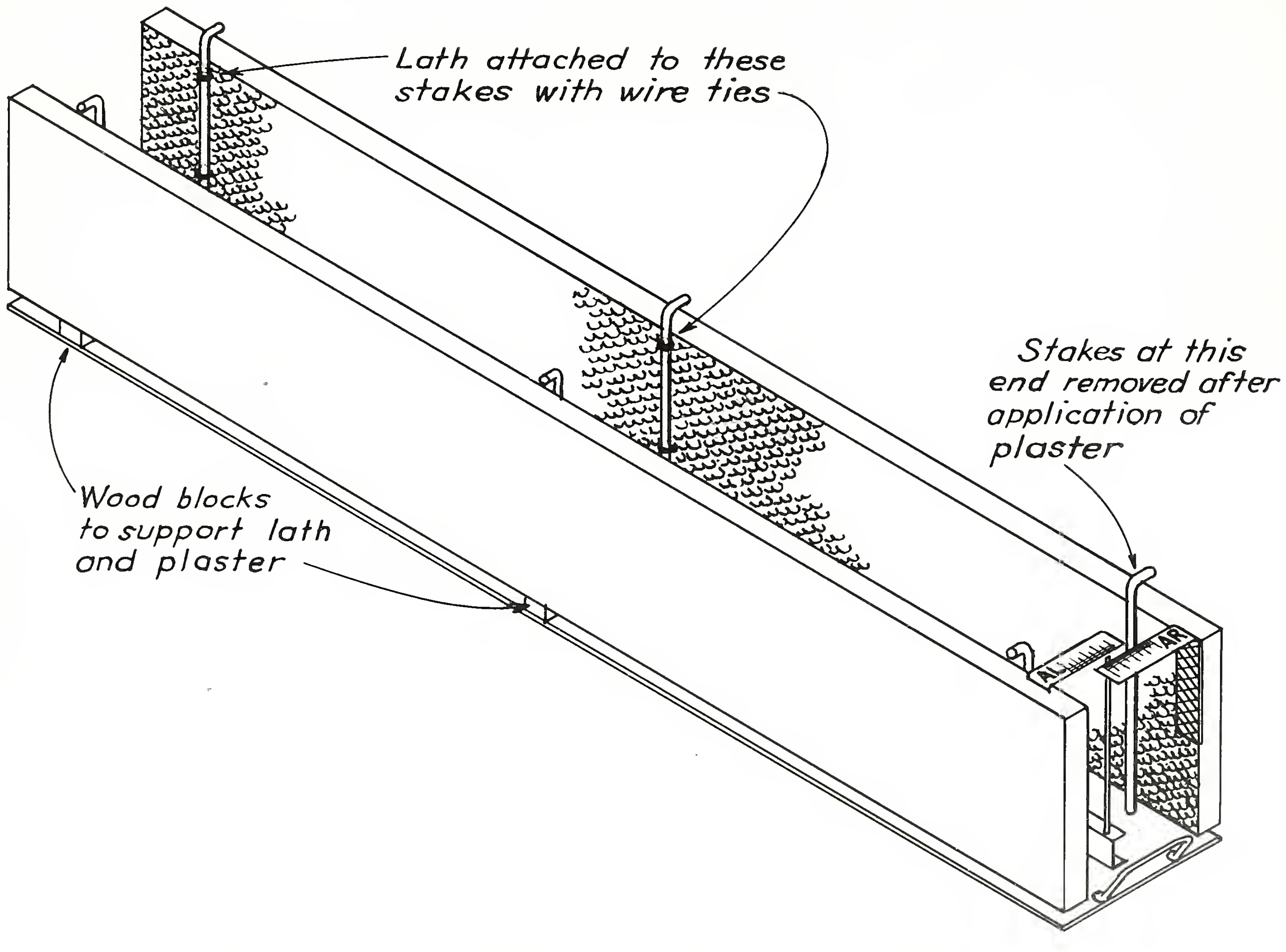

FIGURE 16. TEST SET-UP FOR MEASURING THE EFFECT OF HUMIDITY ON LATH AND PLASTER.

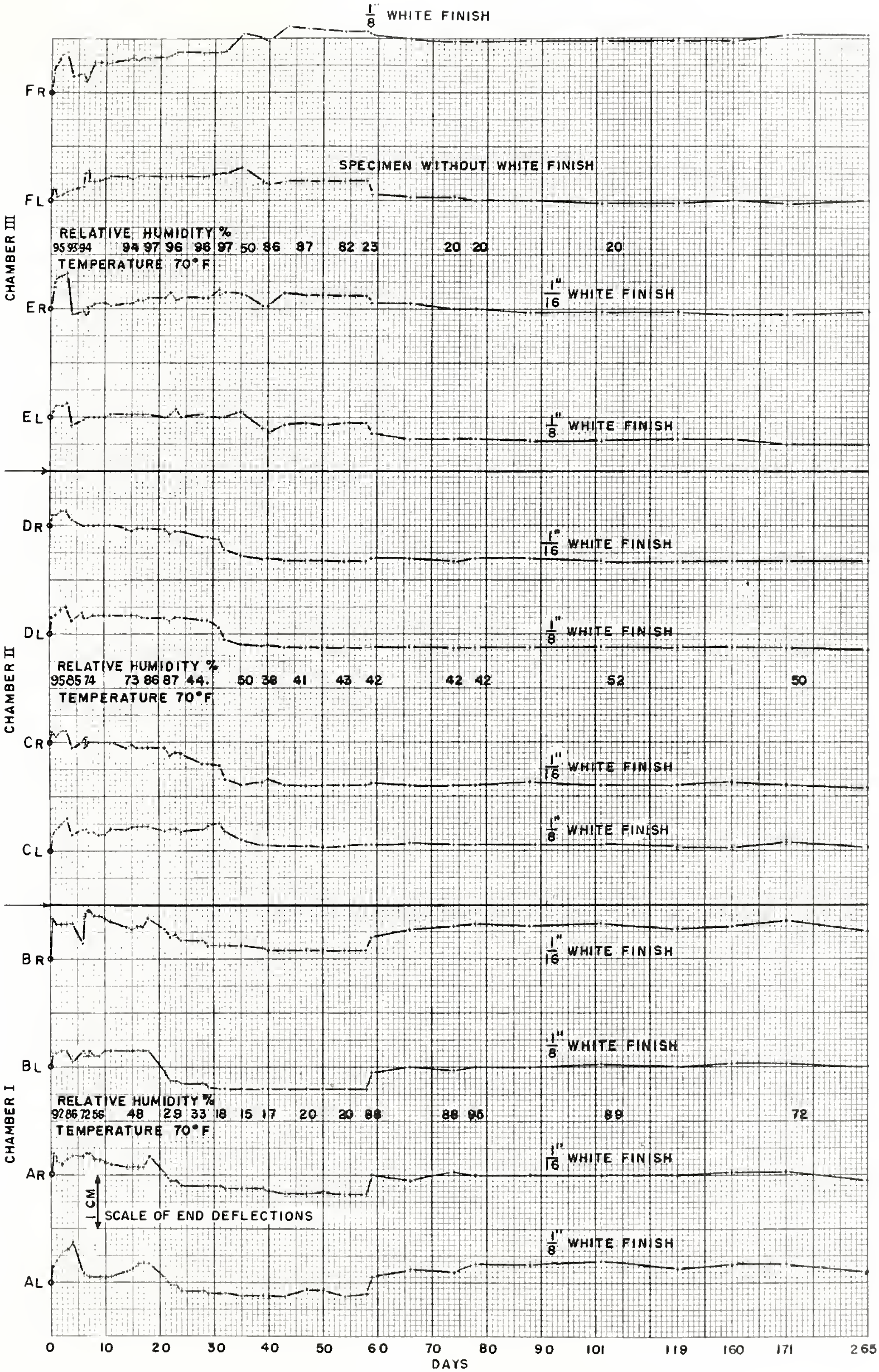

FIGURE 17. FLEXING OF LATH AND PLASTER SPECIMENS RESULTING FROM CHANGES IN THE RELATIVE HUMIDITY OF STORAGE CHAMBERS HELD AT 70°F. SEE FIGURE 16 FOR MOUNTING OF SPECIMENS.

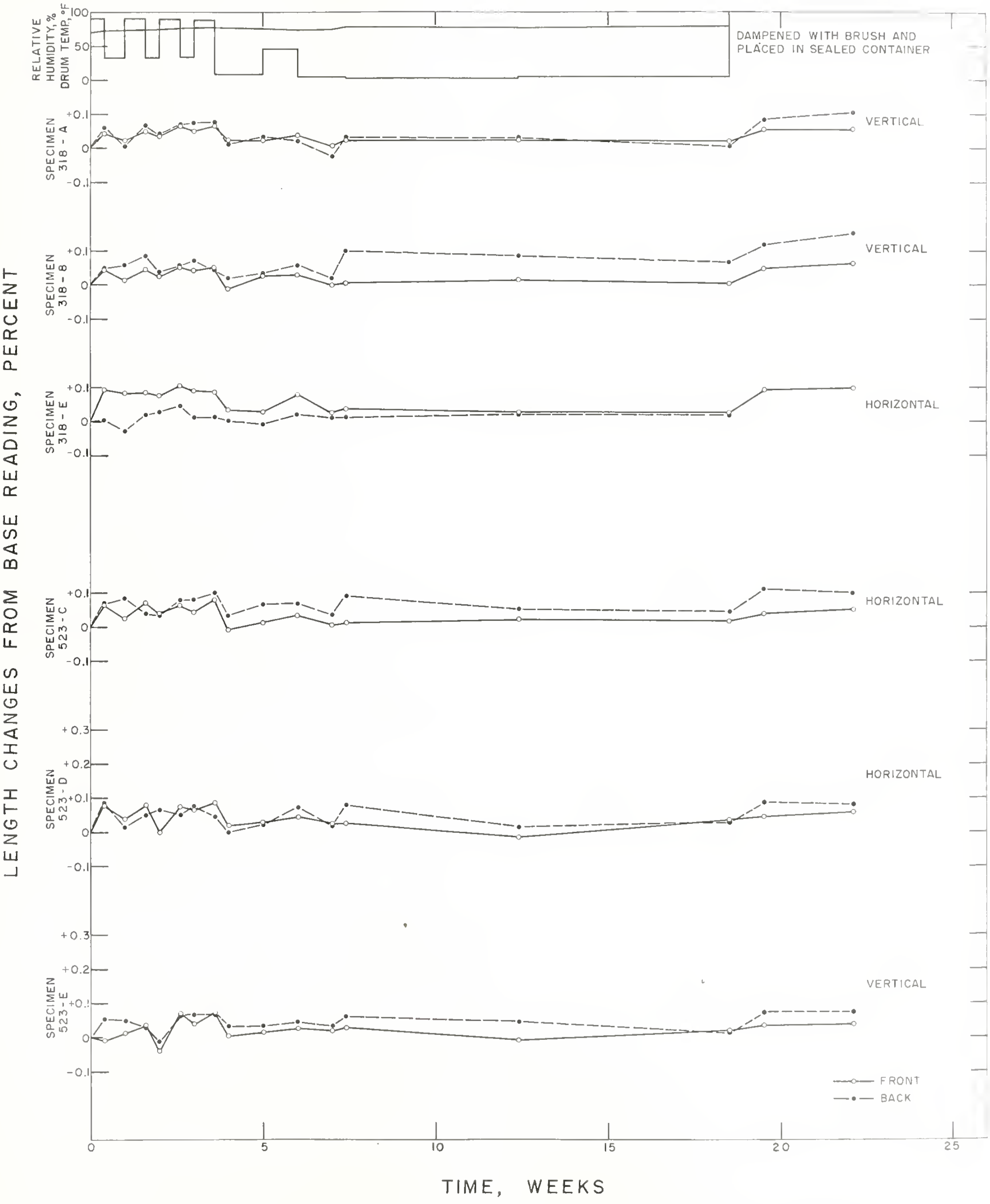

FIGURE 18. EXPANSION AND CONTRACTION OF LATH AND PLASTER SPECIMENS FROM HOSPITAL BUILDING AS THE RESULT OF CHANGE IN RELATIVE HUMIDITY AND DAMPENING. THE NUMBERS OF SPECIMENS CORRESPOND TO THE ROOM LOCATIONS SHOWN ON THE BUILDING PLAN.

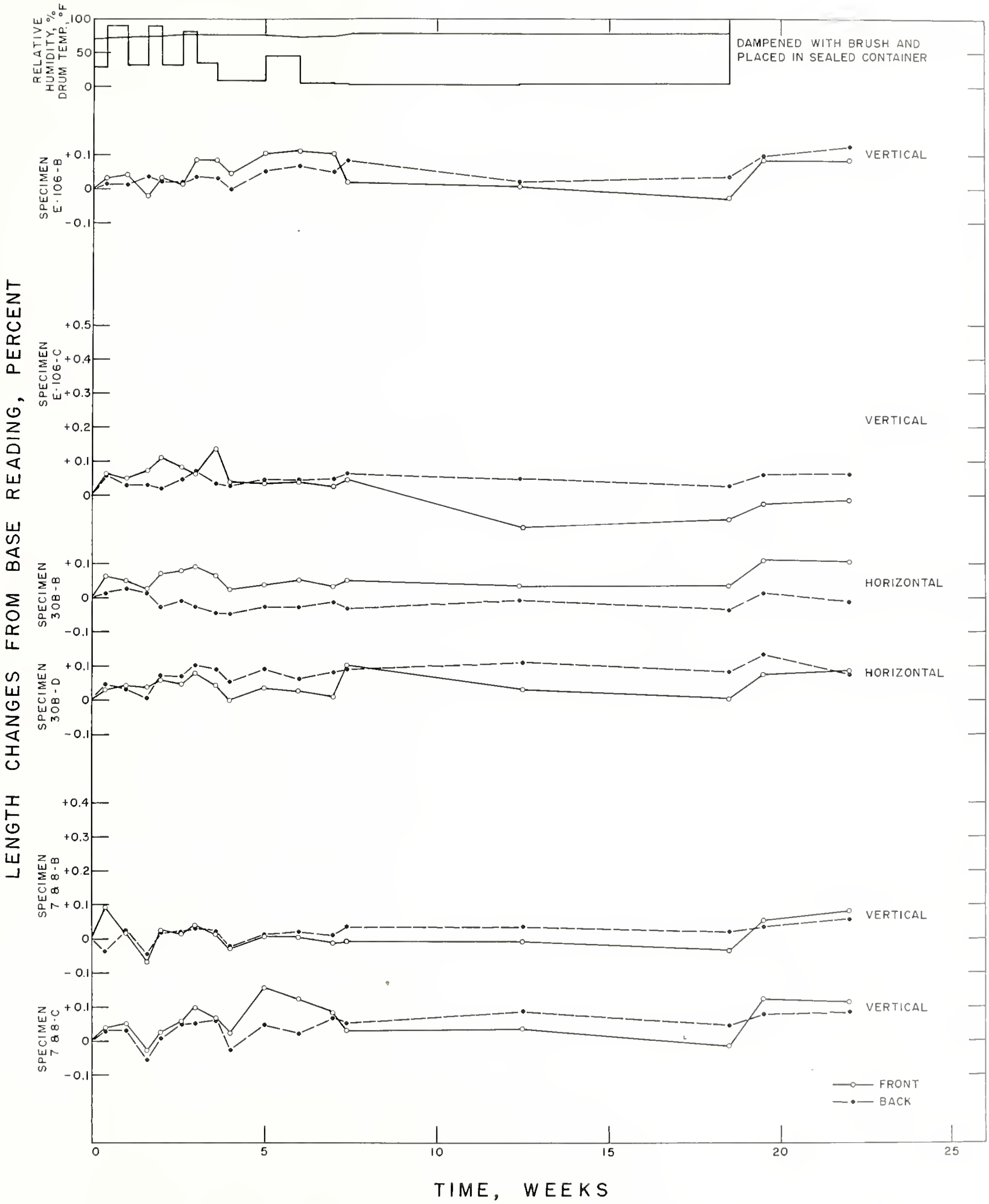

FIGURE 19. EXPANSION AND CONTRACTION OF LATH AND PLASTER SPECIMENS FROM HOSPITAL BUILDING AS THE RESULT OF CHANGES IN RELATIVE HUMIDITY AND DAMPENING. THE NUMBERS OF SPECIMENS CORRESPOND TO ROOM LOCATIONS SHOWN ON THE BUILDING PLAN. SPECIMENS MARKED 7 AND 8 WERE FROM THE BASEMENT CORRIDOR.

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