U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

REPORT BMS80

Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 4

by

PERCY A. SIGLER *and*
ELMER A. KOERNER

NATIONAL
BUREAU OF STANDARDS

The program of Research on Building Materials and Structures carried on by the National Bureau of Standards was undertaken with the assistance of the Central Housing Committee, an informal organization of governmental agencies concerned with housing construction and finance, which is cooperating in the investigations through a committee of principal technicians.

CENTRAL HOUSING COMMITTEE ON RESEARCH, DESIGN, AND CONSTRUCTION

Hugh L. Dryden, *Chairman.*
National Bureau of Standards.

Howard P. Vermilya, *Vice Chairman.*
Federal Housing Administration.

Vincent B. Phelan, *Secretary.*

Mary F. Taylor : *Assistant Secretaries* : Louise D. Card

Tirrell J. Ferrenz,
Federal Home Loan Bank Board.

John F. Donovan,
Farm Security Administration.

A. C. Shire,
United States Housing Authority.

George W. Trayer,
Forest Service (F. P. Laboratory).

Warren G. Noll,
Public Buildings Administration.

Rollo H. Britten,
Public Health Service.

Luther M. Leisenring,
Construction Division (War).

George E. Knox,
Yards and Docks (Navy).

Edward A. Poynton,
Office of Indian Affairs.

William R. Talbott,
Veterans' Administration.

Wallace Ashby,
Bureau of Agricultural Chemistry and Engineering.

NATIONAL BUREAU OF STANDARDS STAFF COMMITTEE ON ADMINISTRATION AND COORDINATION

Hugh L. Dryden, *Chairman.*
Mechanics and Sound.

Phaon H. Bates,
Clay and Silicate Products.

Gustav E. F. Lundell,
Chemistry.

Hobart C. Dickinson,
Heat and Power.

Addams S. McAllister,
Codes and Specifications.

Warren E. Emley,
Organic and Fibrous Materials.

Henry S. Rawdon,
Metallurgy.

The Forest Products Laboratory of the Forest Service is cooperating with both committees on investigations of wood constructions.

[For list of BMS publications and directions for purchasing, see cover page III.]

UNITED STATES DEPARTMENT OF COMMERCE · Jesse H. Jones, Secretary

NATIONAL BUREAU OF STANDARDS · Lyman J. Briggs, Director

BUILDING MATERIALS *and* STRUCTURES

REPORT BMS80

Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 4

by PERCY A. SIGLER *and* ELMER A. KOERNER

ISSUED MARCH 2, 1942

The National Bureau of Standards is a fact-finding organization; it does not "approve" any particular material or method of construction. The technical findings in this series of reports are to be construed accordingly.

UNITED STATES GOVERNMENT PRINTING OFFICE · WASHINGTON · 1942

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C. · PRICE 15 CENTS

Foreword

In order to obtain technical information and data on the relative ability of different types of floor coverings to withstand service, laboratory performance tests have been conducted at the National Bureau of Standards as part of a research program on building materials suitable for low-cost house construction. These performance tests have given information on the resistances of the floor cover to abrasion, indentation, and fracturing.

This report presents the results of a test on a fourth series of 40 floor-covering installations in the Bureau's floor-testing chamber, as a supplement to reports BMS34, BMS43, and BMS68. Photographs of the floor coverings, taken at the end of the test, are shown, and brief summaries of the manner in which the various installations performed are presented.

Lyman J. Briggs, *Director.*

Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 4

by Percy A. Sigler *and* Elmer A. Koerner

CONTENTS

ABSTRACT

A performance test was conducted in the floor-testing chamber of the National Bureau of Standards on a fourth series of 40 different installations involving 26 different floor coverings. Specimens of most of the floor coverings were installed on both a concrete and a wood subfloor. Included in the test were cork tiles, rubber tile containing aluminum oxide aggregate, asphalt tile, marbleized linoleums, felt-backed floor coverings having various wearing surfaces, strip maples, maple unit-block, pecan unit-block, asphalt mastic, coal-tar mastic, alumina cement-rubber latex composition, magnesium oxychloride composition, and 1:2:4 portland cement concrete. Different underlays and adhesives were also included in the test. The test installations are described and results showing the depth of the depressions in the floor coverings made by the equipment are presented in tables. Brief summaries of the manner in which the various installations performed are given, and their appearance at the end of the test is shown by photographs. A few generalized comments and conclusions are made.

I. INTRODUCTION

Laboratory performance tests of floor coverings installed in various ways have been conducted at the National Bureau of Standards to determine their relative ability to withstand severe treatments. The results may be used as a guide for predicting their probable performance in service. This report presents the results obtained on a fourth series of installations and supplements the published reports on the three previous series in BMS34, BMS43, and BMS68 (see cover page 3).

In a laboratory performance test it is possible to include and control many of the factors affecting performance and durability in service. However, it was not found possible to include all such factors in an accelerated test. No attempt, for example, was made to ascertain the effects of the periodic use of cleansing agents, the periodic application of protective coatings, or age.

Other laboratory investigations have been conducted on various floor coverings and adhesives to determine their relative merits with respect to specific properties. The results of some of these investigations have been published BMS14, BMS59, and BMS73 (see cover page 3).

II. FLOOR-TESTING CHAMBER, EQUIPMENT, AND PROCEDURE

The Bureau's floor-testing chamber provided a concrete circular track 4 feet wide and approximately 40 feet in diameter. The track was divided into 40 test spaces, 3 feet long. Concrete or strip-wood subfloors and the various floor coverings were installed in these spaces. The concrete subfloors had a steel-troweled finish. The strip-wood subfloors were blind-nailed with 8d cut nails to four wooden sleepers spaced 12 inches on centers. The sleepers were approximately parallel to the direction of travel of the testing equipment and were embedded in concrete.

Since the equipment and procedure used in making this performance test have been fully described in previously published reports, BMS43 and BMS68, they are only briefly presented here. Figure 1 shows the testing equipment and a portion of the circular track. The test consisted in subjecting the floor coverings to 48,000 cycles, or passages, of a two-wheeled platform truck, a "walking wheel" 4 feet in diameter, and two casters. The truck carried a total load of approximately 1,100 pounds and was equipped with a steel-tired wheel and a rubber-tired wheel. The walking wheel carried a load of approximately 275 pounds and was shod with eight wooden blocks covered with leather during the first half of the test and with No. 3 grit garnet cloth during the second half of the test.

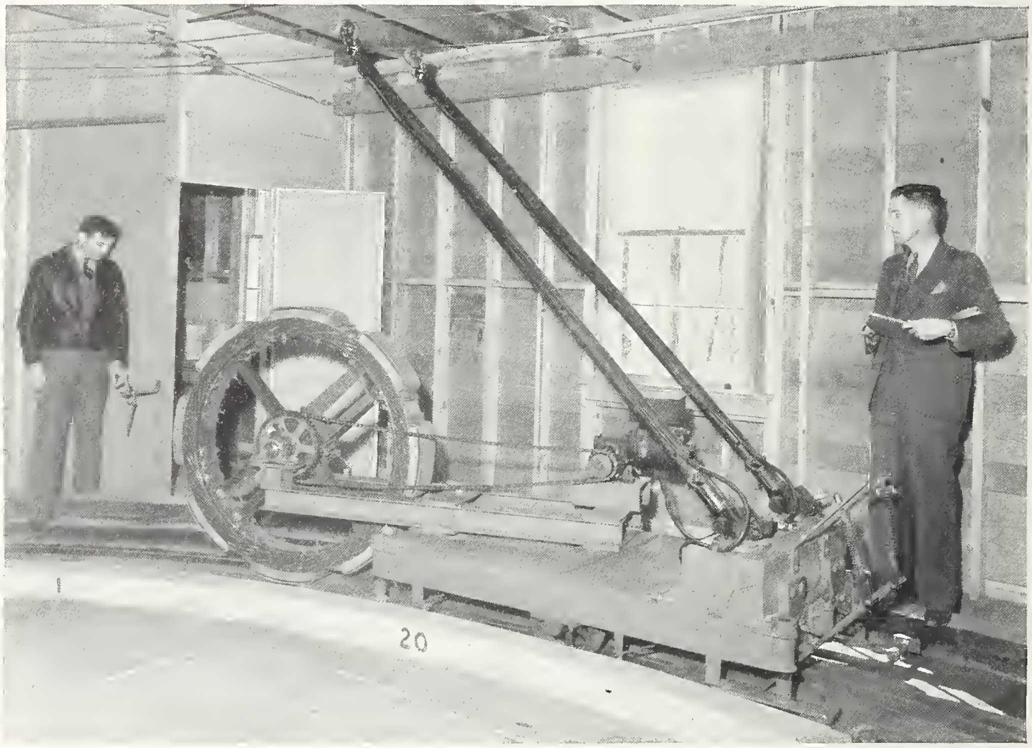

Figure 1.—*Testing equipment and portion of circular track.*

The two casters, attached to lever mechanisms mounted on the front of the truck, consisted of a 2-inch steel wheel with a ⅞-inch face loaded to 20 pounds and a 1-inch steel ball loaded to 10 pounds. The equipment was pushed around the track by the walking wheel at about 2 miles an hour. A dial depth gage was used to measure the depressions made in the floor coverings by the equipment. During the test the floor coverings were swept at least once a day to remove loose particles. At the end of the test the floor coverings were washed with soap and water and then photographed.

III. DESCRIPTION OF TEST INSTALLATIONS

Twenty-six different floor coverings and 10 different adhesives were included in this performance test. With a few exceptions, specimens of each floor covering were installed on both a concrete and a wood subfloor. A detailed outline of the 40 test installations is given in table 1.

IV. RESULTS

The average depths of the depressions in the floor coverings made by the two truck wheels and the walking wheel, at different stages of the performance test, are recorded in table 1.

TABLE 1.—*Test installations and results of measurements for depth of compression and wear*

Test panel	Subfloor	Underlay	Bonding agent	Floor covering: Type and description [a]	Floor covering: Nominal thickness	Average depth of depression made by— Rubber-tired truck wheel: 10,000 cycles	Rubber-tired truck wheel: 48,000 cycles	Steel-tired truck wheel: 10,000 cycles	Steel-tired truck wheel: 48,000 cycles	Walking wheel: 24,000 cycles	Walking wheel: 48,000 cycles
					in.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
1	Concrete	None	Lignin paste	Cork tile [b]; high density; lacquer finish.	5/16	0.000	0.002	0.003	0.010	0.001	0.008
2	Strip-wood [c]	Lining felt [d]	do	do.[b]	5/16	.001	.002	.003	.009	.001	.016
3	Concrete	None	Copal resin cement	Cork tile [b]; dark shade; factory-applied varnish finish.	5/16	.002	.005	.006	.015	.003	.029
4	do	do	do	Cork tile [b]; light shade; factory-applied varnish finish.	5/16	.003	.007	.008	.016	.003	.014
5	Strip-wood [c]	Lining felt [d]	do	do,[b]	1/2	.002	.012	.007	.022	.003	.022
6	Concrete	None	Lignin paste	Rubber tile [b]; black; contained aluminum oxide aggregate.	1/8	.001	.001	.004	.008	.001	.010
7	Strip-wood [c]	Lining felt [d]	do	do,[b]	1/8	.000	.001	.010	.016	.005	.009
8	Concrete [e]	None	Asphalt emulsion, clay type.	Asphalt tile [b]; black	1/4	(f)	(f)	.004	.007	.006	.012
9	Strip-wood [c]	Lining felt [d]	do	do.[b]	1/4	.004	.007	.009	(g)	.002	.010
10	Concrete	None	Lignin paste	Marbleized linoleum; brown	3/32	.001	.001	.001	.009	.000	.002
11	Strip-wood [c]	Lining felt [d]	do	do	3/32	.001	.002	.009	.033	.005	.006
12	do.[c]	do,[d]	do	do	5/64	.001	.002	.005	.012	.005	.007
13	do.[c]	None	do	do	5/64	.001	.001	(g)	(g)	.002	.005
14	Concrete	do	do	Felt-backed; blue; wearing surface, marbleized linoleum composition.	3/32	.000	.001	.005	.018	.001	.002
15	Strip-wood [c]	do	do	do	3/32	.002	.002	.017	(g)	.003	.004
16	Concrete	do	Cumar resin cement	Felt-backed tile [b h]; mahogany; wearing surface, marbleized linoleum composition.	3/32	.000	.000	.005	.010	.000	.002
17	Strip-wood [c]	do	do	do,[b h]	3/32	.000	.001	.005	(g)	.001	.003
18	Concrete	do	Lignin paste	Felt-hacked tile [b]; maroon; wearing surface, cellulose nitrate composition.	3/32	.000	.000	.004	.015	.001	.002
19	Strip-wood [c]	do	do	do.[b]	3/32	.001	.002	.010	.033	.002	.003
20	Concrete	do	do	Felt base; black; corrugated wearing surface, asphalt composition.	5/64	.001	.007	.011	.039	.003	.018
21	Strip-wood [c]	do	do	do	5/64	.002	.004	.007	.025	.006	.024
22	Concrete	do	do	do	5/64	.001	.002	.010	.031	.003	.016
23	Strip-wood [c]	Plywood [i]	do	do	5/64	.002	.006	.008	.016	.004	.020
24	do.[c]	do.[i]	do	Felt base; red; wearing surface, enamel.	1/16	.004	.004	.008	(g)	.003	.008
25	do.[c]	Lining felt [j]	do	do	1/16	.009	.010	.018	.026	.008	.014
26	do.[c]	None	do	Felt base; brown; wearing surface, varnish over enamel.	3/64	.002	.002	.013	(g)	.002	(f)
27	Concrete	do	do	do	3/64	.000	.001	.005	.015	.000	.008
28	do	do	do	Felt-hacked; gray; wearing surface, resin-treated cotton-linters sheet.	1/16	.000	.002	.000	.015	.001	.005
29	do	do	do	No, 4 cotton duck [k]; green	3/64	.000	.002	.001	.013	.001	.006
30	Strip-wood [c]	Plywood [l]	do	do,[k]	3/64	.001	.002	.012	.039	.002	.006
31	Concrete [e]	None	Cut-back asphalt	Maple unit-block [bm]; flat back; metal splines at ends.	25/32	(f)	(f)	.002	.010	.001	.004
32	do.[e]	do	Warm asphalt	Pecan unit-block [b m]; hollow back; wood splines at ends.	25/32	(f)	(f)	.002	.012	.001	.007
33	Wood sleepers	do	Blind-nailed, 6d screw nails,	Strip Northern hard maple [m]; first grade; flat back.	25/32	.001	.002	.005	.018	.000	.002
34	do	do	Blind-nailed, 8d cut-nails,	Strip Southern hard maple [m]; first grade; flat back.	25/32	.000	.001	.003	.015	.001	.002
35	Concrete	do	Asphalt emulsion, clay type.	Asphalt mastic composition; dark gray; aggregate, burned volcanic ash and portland cement.	1/2	.001	.010	.033	.117	.006	.045
36A	Strip-wood [c]	do	do	Asphalt mastic composition; red; aggregate, burned volcanic ash and portland cement.	1/2	.002	-----	(g)	-----	-----	-----
36B	Gypsum mortar [n]	do	Floor covering as installed.	Coal-tar mastic composition [o]; gray; aggregate, gravel, sand and gypsum.	1/2	-----	.003	-----	.090	.006	.038

See footnotes at end of table.

Table 1.—*Test installations and results of measurements for depth of compression and wear*—Continued

Test panel	Subfloor	Underlay	Bonding agent	Floor covering: Type and description [a]	Floor covering: Nominal thickness	Average depth of depression made by— Rubber-tired truck wheel: 10,000 cycles	Rubber-tired truck wheel: 48,000 cycles	Steel-tired truck wheel: 10,000 cycles	Steel-tired truck wheel: 48,000 cycles	Walking wheel: 24,000 cycles	Walking wheel: 48,000 cycles
						in.	*in.*	*in.*	*in.*	*in.*	*in.*
37	Concrete	None	Floor covering as installed.	Alumina cement-rubber latex composition; red; aggregate, marble chips.	½	0.001	0.002	0.010	0.022	0.005	0.030
8	Strip-wood [c]	do	do	Alumina cement-rubber latex composition reinforced with expanded metal lath; red; aggregate, marble chips.	½	.001	.002	.010	.021	.002	.020
39	Concrete [p]	do	do	Magnesium oxychloride composition; natural gray; aggregate, granite chips and granite dust.	½	.000	.000	.001	.007	.000	.006
40				1:2:4 portland-cement concrete; aggregate, Potomac-river sand and gravel; interval between placing and troweling, 3 hr.; damp-cured for 6 days.	4	.000	.001	.006	.025	.000	.025

[a] Color listed is the predominating color.
[b] Size, 9 by 9 in,
[c] Edge-grained Douglas fir, 25/32 in, thick, with a 2 3/8-in, face.
[d] 1½ lb/yd [2] asphalt-saturated lining felt bonded to subfloor with lignin paste.
[e] Subfloor given a priming coat of cut-back asphalt,
[f] Accuracy of measurements was questionable owing to slight curling, or warping, of floor,
[g] Floor covering was too severely damaged to measure accurately.
[h] Back of tile had a factory-applied skim coat of cumar resin cement.
[i] Three plies of hardwood veneer with asphalt-saturated paper on both faces. Thickness, 3/16 in, Fastened to subfloor with screw-nails.
[j] ¾ lb/yd [2] dry lining felt bonded to subfloor with lignin paste.
[k] Furnished by the U, S, Department of Agriculture. Duck had been given fireproofing and waterproofing treatments.
[l] Douglas-fir plywood, ½ in, thick, 5-ply.
[m] Surface given 1 heavy coat of a sealer.
[n] Mortar fill of 1 part of gypsum and 2 parts of sand, ¾ in, thick, over concrete and sleepers. Surface given a priming coat of cut-back coal tar.
[o] Floor covering installed at 10,000 cycles to replace panel *36A* and thus exposed to a total of only 38,000 cycles.
[p] Steel-troweled surface of subfloor thoroughly chipped and primed with magnesium chloride solution.

It is of general interest to note the marked differences in the depressions and fractures caused by the two truck wheels. The steel-tired truck wheel damaged many of the floor coverings to an appreciable degree, whereas the rubber-tired truck wheel did very little damage. Also of interest is the tendency of most of the floor coverings to show greater depressions and fractures on wood subfloors than on concrete subfloors. These generalizations also apply to most of the installations previously tested.

The walking wheel surfaced with leather caused very little wear for the first 24,000 cycles. The small depressions appeared to result principally from compression. The average amount each floor covering was worn by 24,000 cycles of the walking wheel surfaced with abrasive cloth is shown in table 2. These values are the over-all averages, computed from the differences in the results at 24,000 and 48,000 cycles given in table 1, for each floor covering listed, irrespective of subfloor.

Figures 2 to 42 show the general condition of the floor coverings at the end of the test. The five paths shown, and labeled in figure 2, are, from left to right, those made by the rubber-tired truck wheel, *RT*; the steel-ball caster, *SB*; the walking wheel, *WW*; the steel-wheel caster, *SW*; and the steel-tired truck wheel, *ST*. The small white dots in the photographs are reference marks used in taking the depth measurements.

Table 2.—*Average wear of floor coverings caused by 24,000 cycles of the "walking wheel" surfaced with abrasive cloth* [a]

Floor coverings [b]	Average depth of wear
	Inches
Cork tile; 5/16 in.; high density	0.011
Cork tile; 5/16 in.; dark shade	.026
Cork tile; 5/16 in.; light shade	.011
Cork tile; ½ in.; light shade	.019
Rubber tile; ⅛ in.; black	.006
Asphalt tile; ¼ in.; black	.007
Marbleized linoleum; 3/32 in.; brown	.001
Marbleized linoleum; 5/64 in.; brown	.002
Felt-backed; 3/32 in.; blue; wearing surface, linoleum composition	.001
Felt-backed tile; 3/32 in.; mahogany; wearing surface, linoleum composition	.002
Felt-backed tile; 3/32 in.; maroon; wearing surface, cellulose nitrate composition	.001
Felt base; 5/64 in.; black; wearing surface, asphalt composition	.016
Felt base; 5/64 in.; black; wearing surface, asphalt composition	.014
Felt base; 1/16 in.; red; wearing surface, enamel	.005
Felt base; 3/64 in.; brown; wearing surface, varnish over enamel.	.008
Felt-backed; 1/16 in.; gray; wearing surface, resin-treated cotton-linters sheet	.004
Cotton duck; 3/64 in.; green	.004
Maple unit-block; 25/32 in	.003
Pecan unit-block; 25/32 in	.006
Strip northern maple; 25/32 in	.002
Strip southern maple; 25/32 in	.001
Asphalt mastic composition; ½ in.; dark gray	.039
Coal-tar mastic composition; ½ in.; gray	.032
Alumina cement-rubber latex composition; ½ in.; red	.021
Magnesium oxychloride composition; ½ in.; natural gray	.006
1:2:4 portland-cement concrete; 4 in	.025

[a] The relative value of a floor covering should not be based entirely on resistance to wear. Other factors should also be considered, such as cost, indentation characteristics, ease of maintenance, adherence to subfloors, resistance to tear and fracture, etc.
[b] See table 1 for detailed description.

V. SUMMARY, AND DISCUSSION OF RESULTS

Brief summaries of the manner in which the various test installations performed are herewith presented.

1. Cork Tiles

The cork tiles as a whole showed good performance (see figs. 2, 3, 4, 5, and 6), with the probable exception of their resistance to abrasion (see table 2). There were no failures in bond or fractures along any of the paths. The high-density tile and the light-shade tiles showed better resistance to abrasion than the dark-shade tile. The lacquer finish on the high-density tile appeared slightly more durable than the varnish finish on the other tiles.

2. Rubber Tile

The ⅛-in. rubber tile containing an abrasive aggregate showed good performance (see figs. 7 and 8). Although some failure in bond occurred along the path of the steel-tired truck wheel, there were only a few fractures. The tile showed good resistance to abrasion.

3. Asphalt Tile

The ¼-in. asphalt tile gave good performance on a concrete subfloor but very poor performance on a strip-wood subfloor (see figs. 9 and 10). On a concrete subfloor there were no failures in bond or fractures along any of the paths. On a strip-wood subfloor with an underlay of saturated felt the tile was badly broken and crushed by the steel-tired truck wheel and was also fractured to a considerable extent by the walking wheel. The tile was not appreciably worn by the abrasive action of the walking wheel (see table 2).

4. Linoleums

The $\frac{3}{32}$-in. and $\frac{5}{64}$-in. marbleized linoleums performed well except along the path of the steel-tired truck wheel, where failures in bond and fractures occurred in different amounts for the several panels (see figs. 11, 12, 13, and 14). A comparison of figures 13 and 14 demonstrates the advisability of using a lining felt with linoleum on strip-wood subfloors. Where no lining felt was used failures in bond and fractures occurred at an early stage of the test (see fig. 14). The marbleized linoleums showed very good resistance to abrasion (see table 2).

5. Felt-Backed Floor Coverings With Wearing Surfaces

(*a*) *Marbleized Linoleum Composition*

The $\frac{3}{32}$-in. felt-backed floor coverings in sheet and tile form having an available wearing surface of marbleized linoleum composition approximately 0.045 in. thick performed much better on concrete subfloors than when bonded direct to strip-wood subfloors (see figs. 15, 16, 17, and 18). The wearing surfaces showed very good resistance to abrasion (see table 2).

(*b*) *Cellulose Nitrate Composition*

The $\frac{3}{32}$-in. felt-backed tile with an available wearing surface of cellulose nitrate composition approximately 0.045 in. thick also performed much better on a concrete subfloor than when bonded direct to a strip-wood subfloor (see figs. 19 and 20). Impressions of the strip-wood subfloor were plainly visible on the surface of the floor covering. The tile showed very good resistance to abrasion (see table 2).

(*c*) *Asphalt Composition*

The felt-base floor coverings having a corrugated wearing surface of asphalt composition performed unsatisfactorily (see figs. 21, 22, 23, and 24). The wearing surface was pitted and excessively compressed or pushed to the side by the steel-tired truck wheel. One of the floor coverings was also grooved considerably by the two casters. Furthermore, the corrugated wearing surfaces did not show good resistance to abrasion (see table 2). A plywood underlay materially improved the evenness and thus the appearance of thin floor coverings over strip-wood subfloors (compare figs. 22 and 24).

(*d*) *Enamel*

The felt-base floor coverings with an enamel wearing surface approximately 0.005 in. thick were in unserviceable condition at the end of the test (see figs. 25, 26, 27, and 28). However, taking into consideration the thinness of the

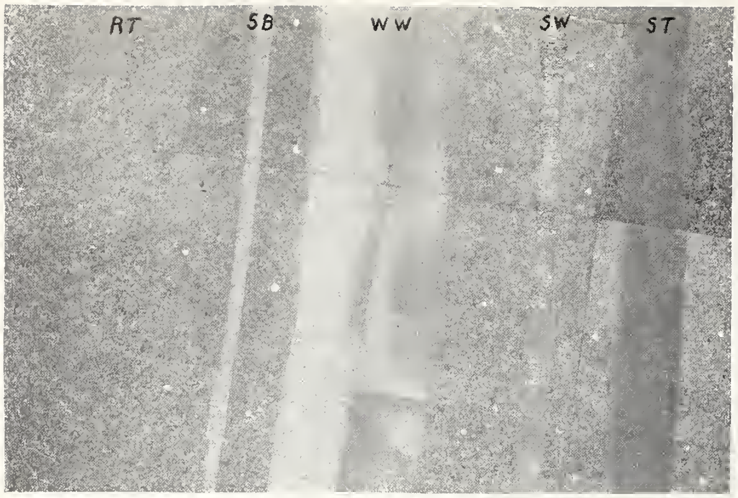

FIGURE 2.—$\frac{5}{16}$-*in. cork tile, high density on concrete subfloor* (*test panel 1*).

FIGURE 3.—$\frac{5}{16}$-*in. cork tile, high density, on felt underlay and strip-wood subfloor* (*test panel 2*).

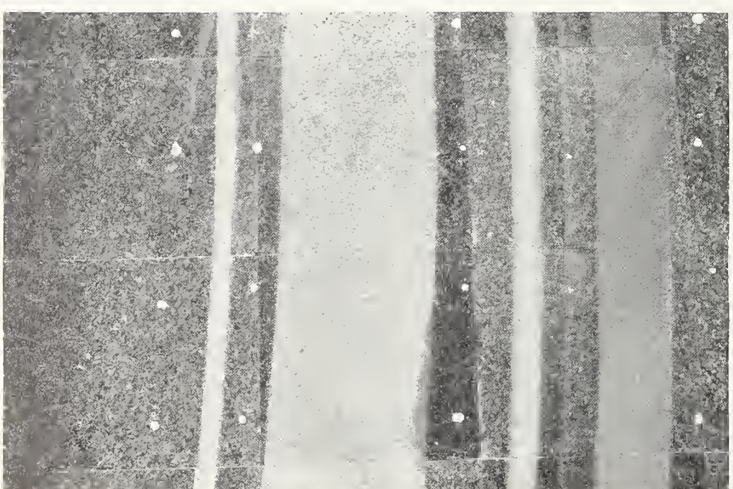

FIGURE 4.—$\frac{5}{16}$-*in. cork tile, dark shade, on concrete subfloor* (*test panet 3*).

FIGURE 5.—$\frac{5}{16}$-*in. cork tile, light shade, on concrete subfloor (test panel 4).*

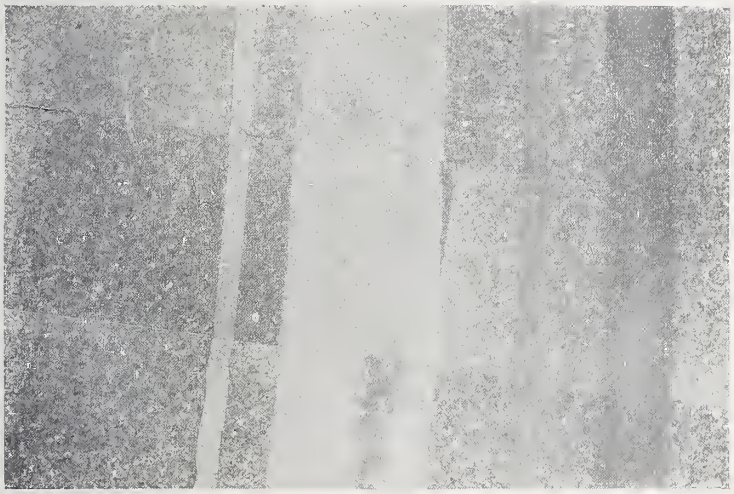

FIGURE 6.—$\frac{1}{2}$-*in. cork tile, light shade, on felt underlay and strip-wood subfloor (test panel 5).*

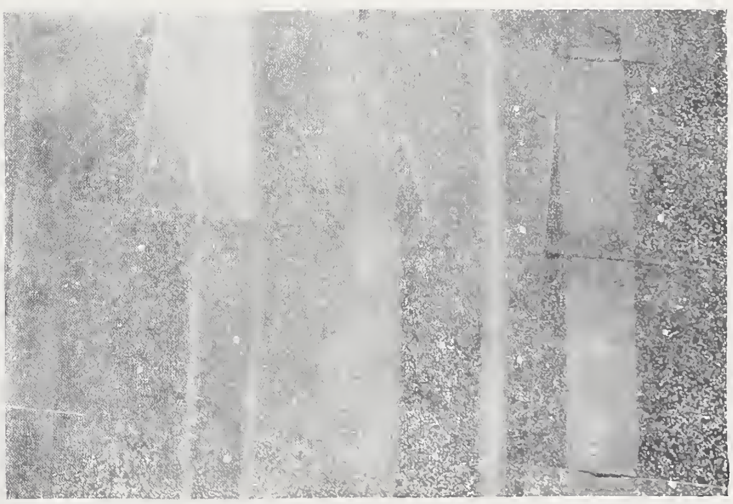

FIGURE 7.—$\frac{1}{8}$-*in. rubber tile, containing aluminum oxide aggregate, on concrete subfloor (test panel 6).*

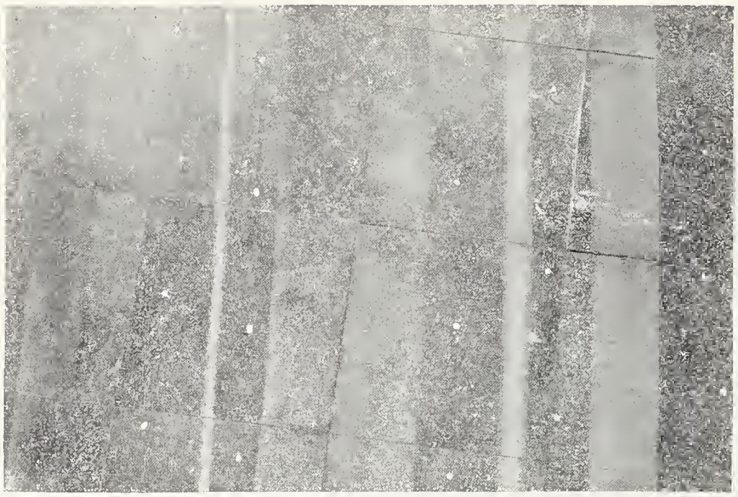

FIGURE 8.—⅛-*in. rubber tile, containing aluminum oxide aggregate, on felt underlay and strip-wood subfloor (test panel 7).*

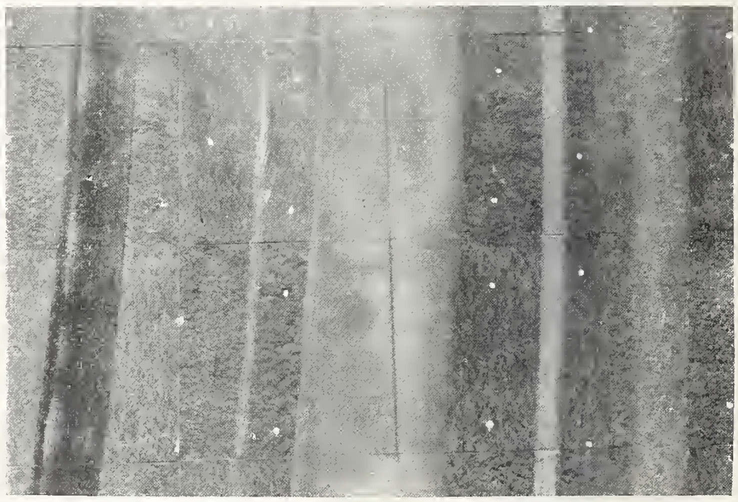

FIGURE 9.—¼-*in. asphalt tile on concrete subfloor (test panel 8).*

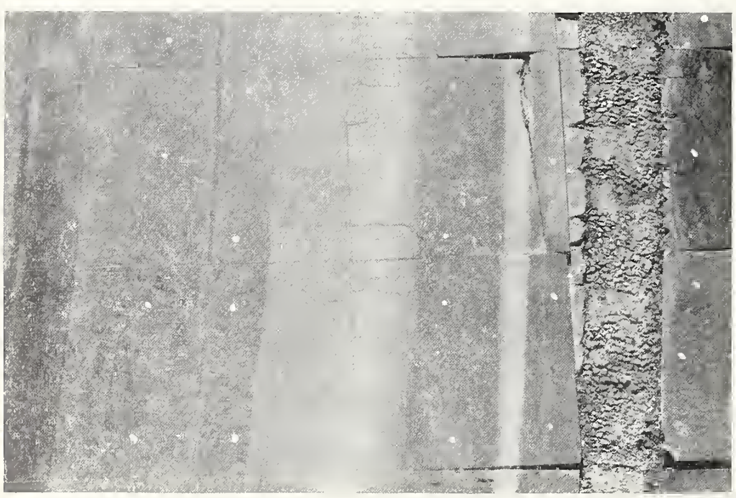

FIGURE 10.—¼-*in. asphalt tile on felt underlay and strip-wood subfloor (test panel 9).*

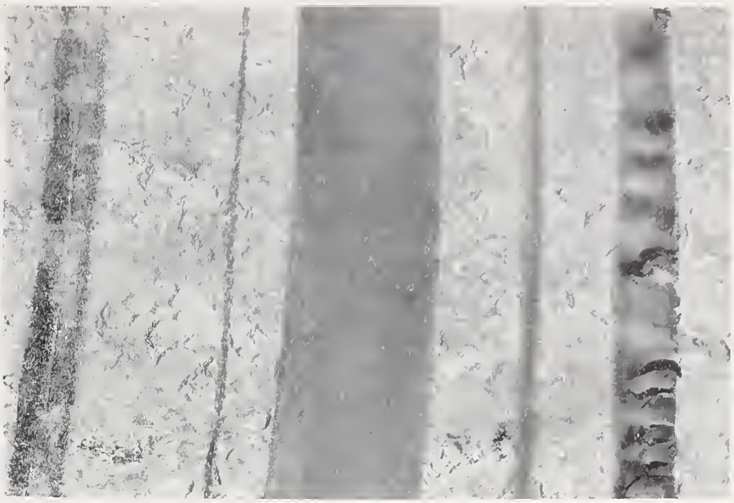

FIGURE 11.—$\frac{3}{32}$-*in. marbleized linoleum on concrete subfloor (test panel 10).*

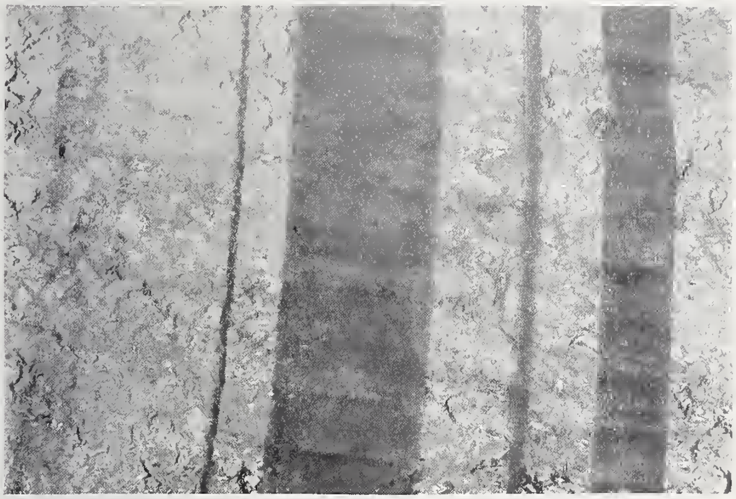

FIGURE 12.—$\frac{3}{32}$-*in. marbleized linoleum on felt underlay and strip-wood subfloor (test panel 11).*

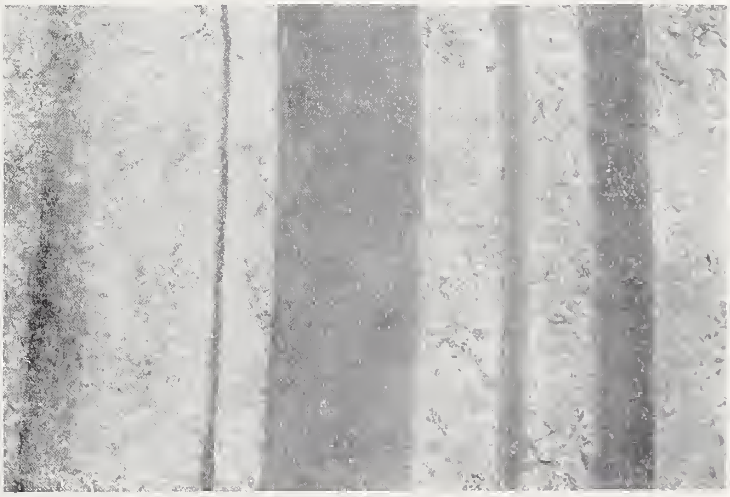

FIGURE 13.—$\frac{5}{64}$-*in. marbleized linoleum on felt underlay and strip-wood subfloor (test panel 12).*

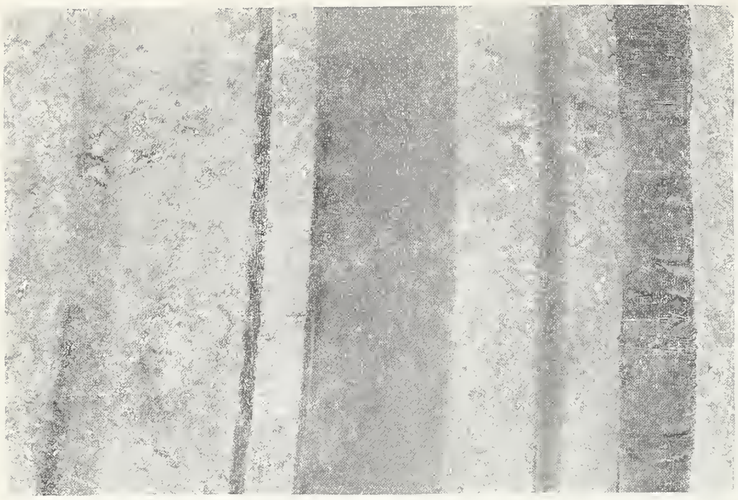

Figure 14.—$\frac{5}{64}$-*in. marbleized linoleum cemented direct to strip-wood subfloor (test panel 13).*

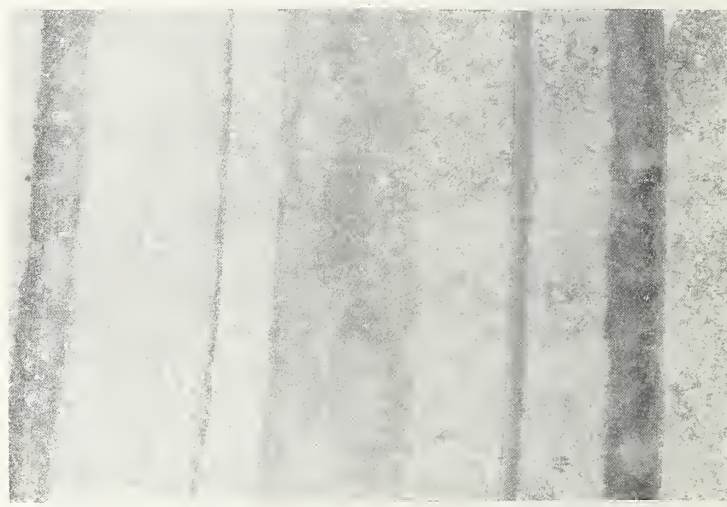

Figure 15.—$\frac{3}{32}$-*in. felt-backed floor covering, with wearing surface of marbleized linoleum composition, on concrete subfloor (test panel 14).*

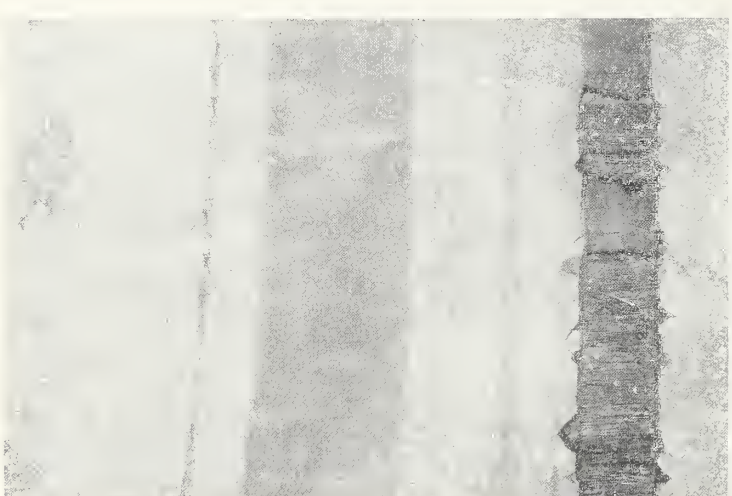

Figure 16.—$\frac{3}{32}$-*in. felt-backed floor covering, with wearing surface of marbleized linoleum composition, cemented direct to strip-wood subfloor (test panel 15).*

FIGURE 17.—$\frac{3}{32}$-*in. felt-backed tile, with wearing surface of marbleized linoleum composition, on concrete subfloor (test panel 16).*

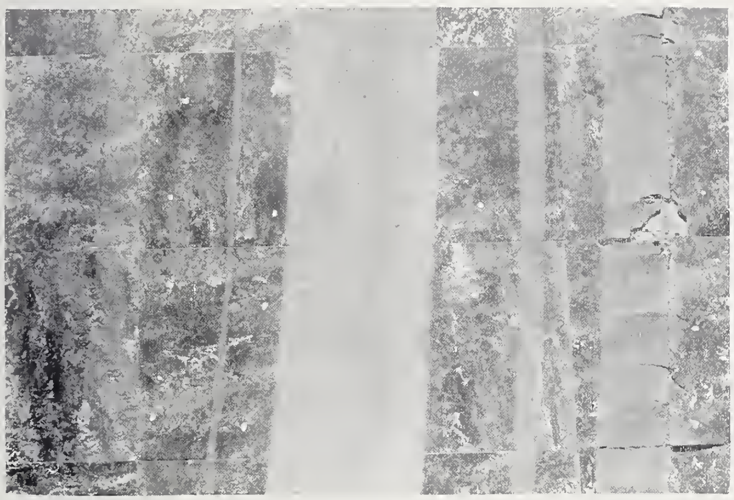

FIGURE 18.—$\frac{3}{32}$-*in. felt-backed tile, with wearing surface of marbleized linoleum composition, cemented direct to strip-wood subfloor (test panel 17).*

FIGURE 19.—$\frac{3}{32}$-*in. felt-backed tile, with wearing surface of cellulose nitrate composition, on concrete subfloor (test panel 18).*

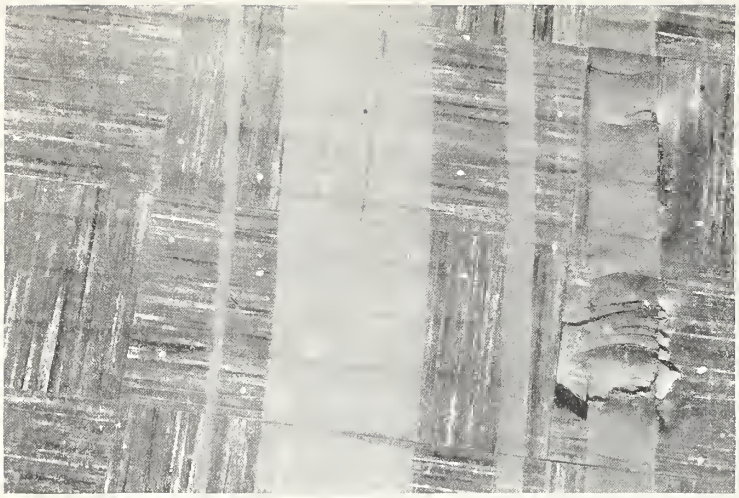

FIGURE 20.—$\frac{3}{32}$-*in. felt-backed tile, with wearing surface of cellulose nitrate composition, cemented direct to strip-wood subfloor (test panel 19).*

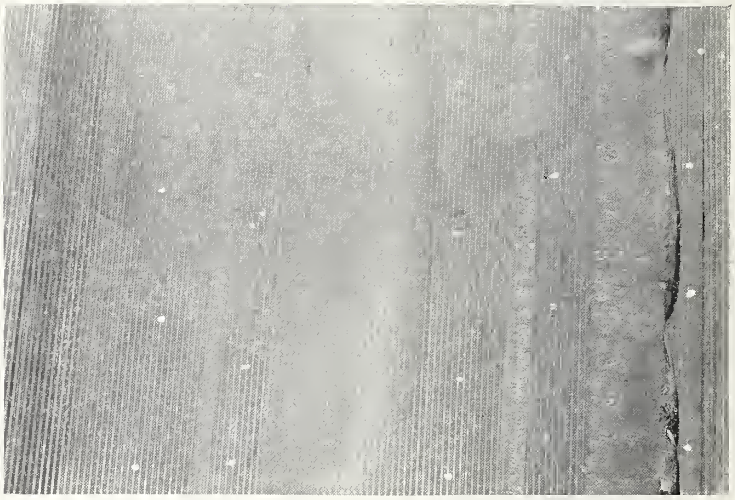

FIGURE 21.—$\frac{5}{64}$-*in. felt-base floor covering, with corrugated wearing surface of asphalt composition, on concrete subfloor (test panel 20).*

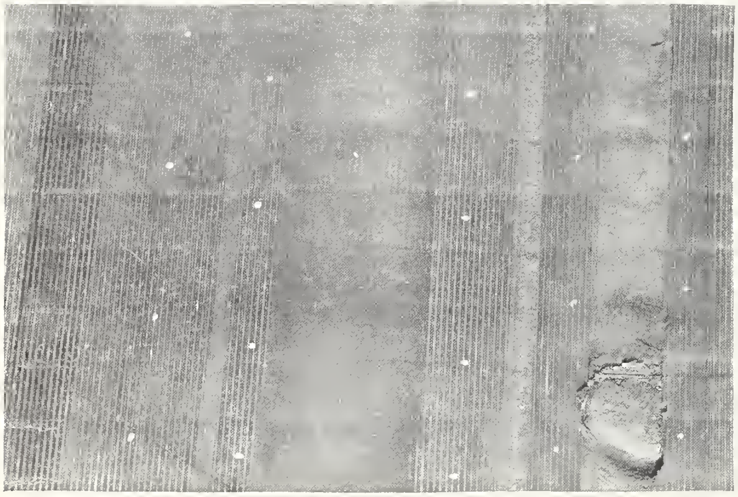

FIGURE 22.—$\frac{5}{64}$-*in. felt-base floor covering, with corrugated wearing surface of asphalt composition, cemented direct to strip-wood subfloor (test panel 21).*

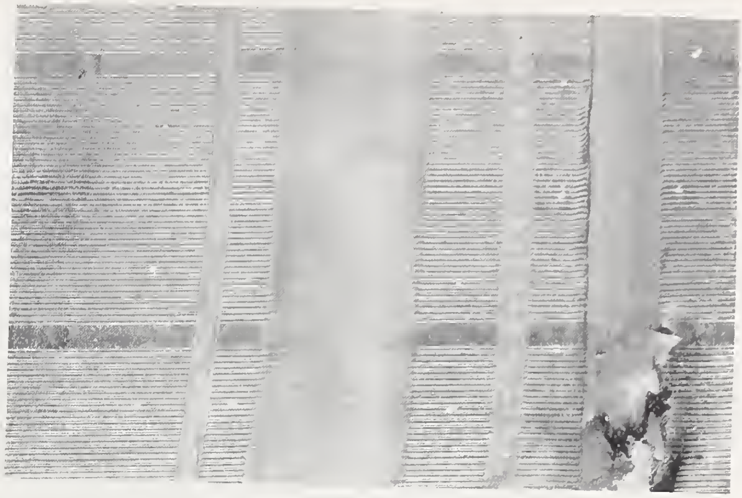

FIGURE 23.—$\frac{5}{24}$-*in. felt-base floor covering, with corrugated wearing surface of asphalt composition, on concrete subfloor (test panel 22).*

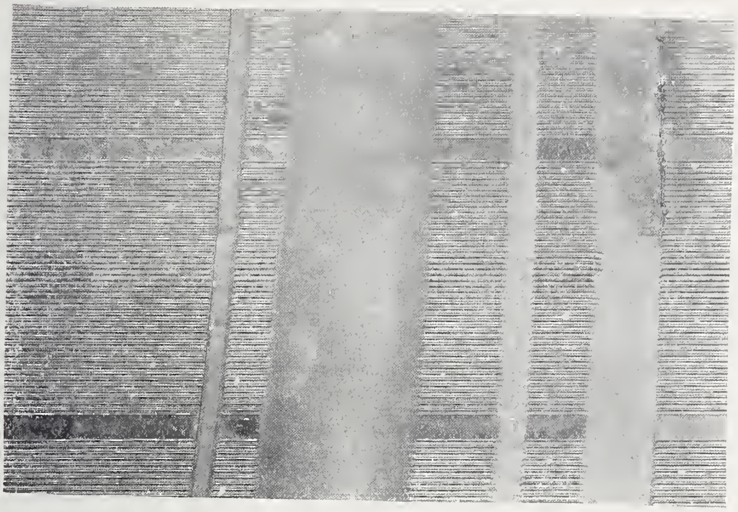

FIGURE 24.—$\frac{5}{64}$-*in. felt-base floor covering, with corrugated wearing surface of asphalt composition, on plywood underlay and strip-wood subfloor (test panel 23).*

FIGURE 25.—$\frac{1}{16}$-*in. felt-base floor covering, with wearing surface of enamel, on plywood underlay and strip-wood subfloor (test panel 24).*

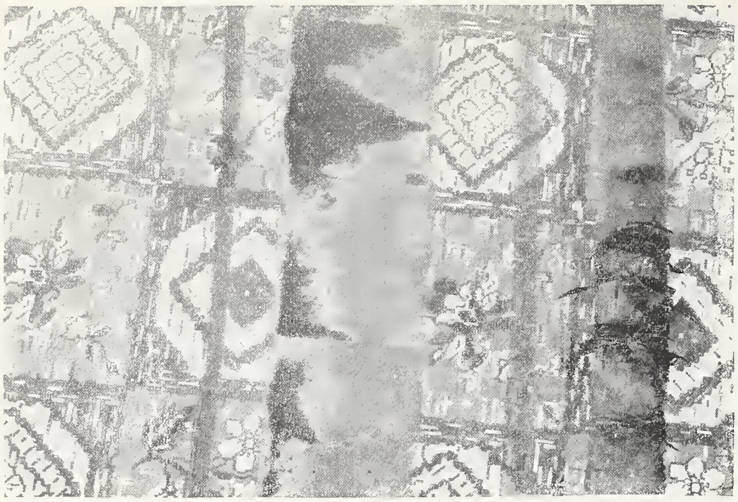

FIGURE 26.—$\frac{1}{16}$-*in. felt-base floor covering, with wearing surface of enamel on felt underlay and strip-wood subfloor (test panel 25).*

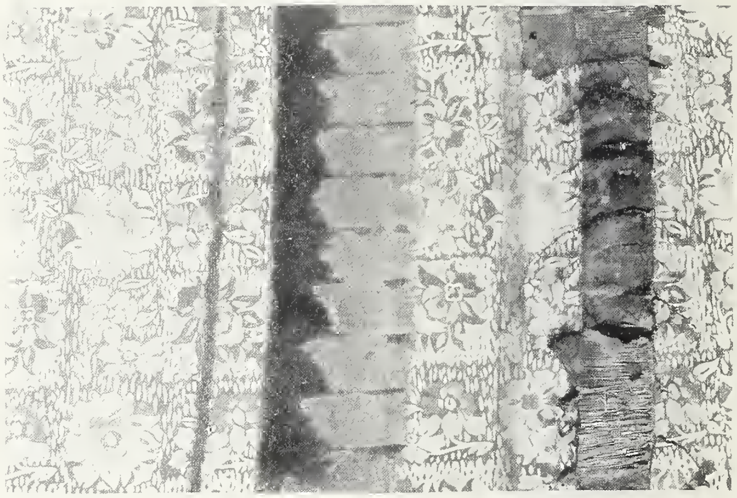

FIGURE 27.—$\frac{3}{64}$-*in. felt-base floor covering, with wearing surface of varnish over enamel, cemented direct to strip-wood subfloor (test panel 26).*

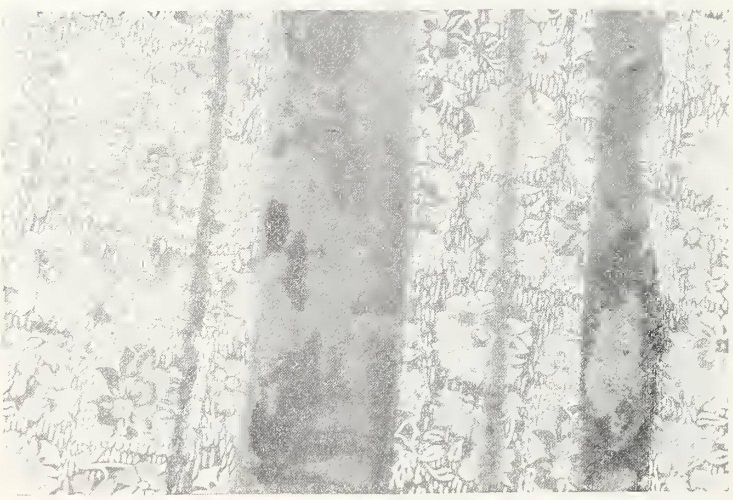

FIGURE 28.—$\frac{3}{64}$-*in. felt-base floor covering, with wearing surface of varnish over enamel, on concrete subfloor (test panel 27).*

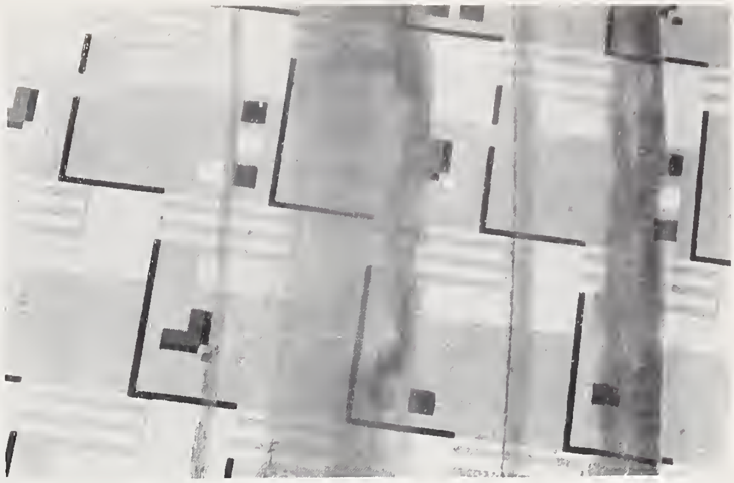

FIGURE 29.—$\frac{1}{16}$-in. felt-backed floor-covering, with wearing surface of resin-treated cotton-linters sheet, on concrete subfloor (test panel 28).

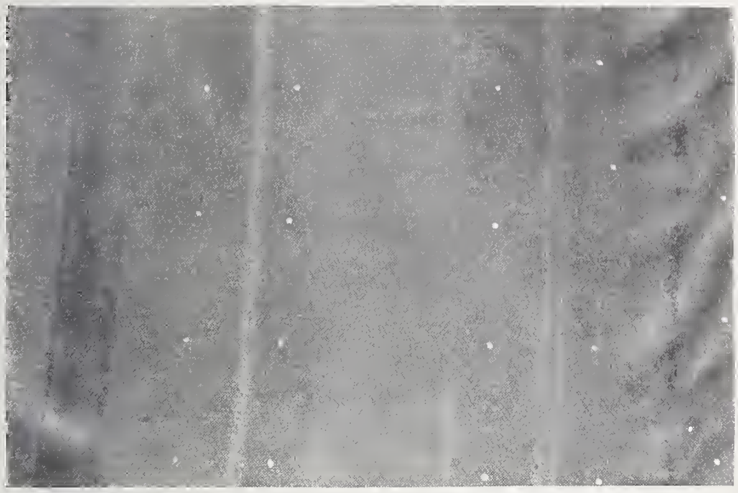

FIGURE 30.—$\frac{3}{64}$-in. cotton duck on concrete subfloor (test panel 29).

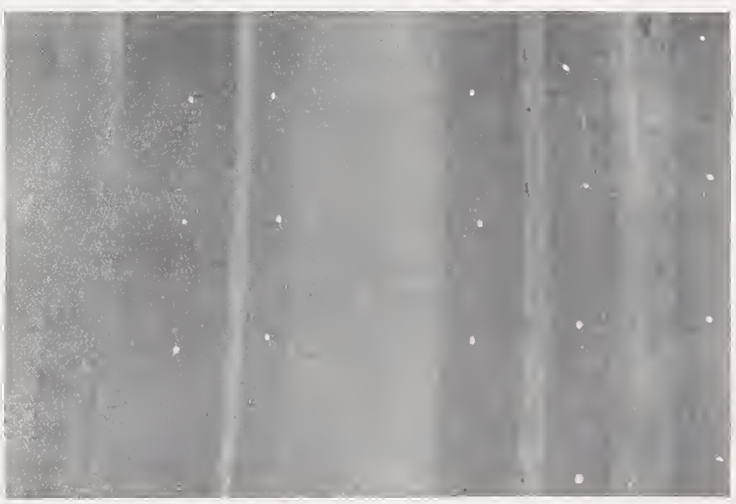

FIGURE 31.—$\frac{3}{64}$-in. cotton duck on plywood underlay and strip-wood subfloor (test panel 30).

FIGURE 32.—$^{25}/_{32}$-*in. maple unit-block on concrete subfloor (test panel 31).*

FIGURE 33.—$^{25}/_{32}$-*in. pecan unit-block on concrete subfloor (test panel 32).*

FIGURE 34.—$^{25}/_{32}$-*in. strip northern maple on wood sleepers (test panel 33).*

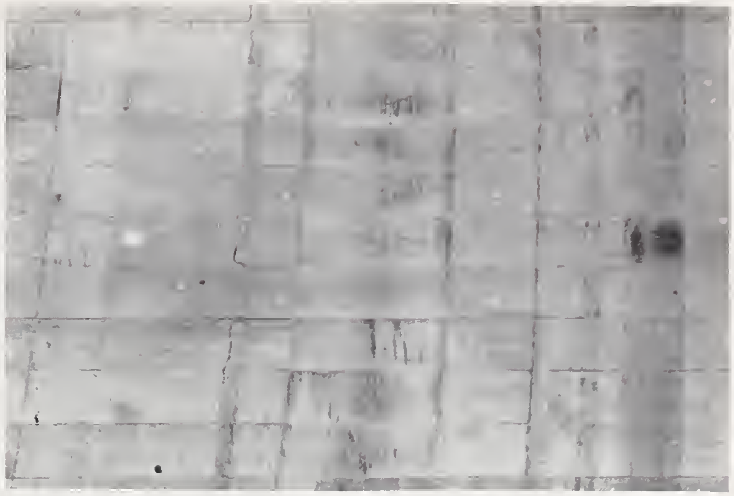

FIGURE 35.—$^{25}/_{32}$-*in. strip southern maple on wood sleepers (test panel 34).*

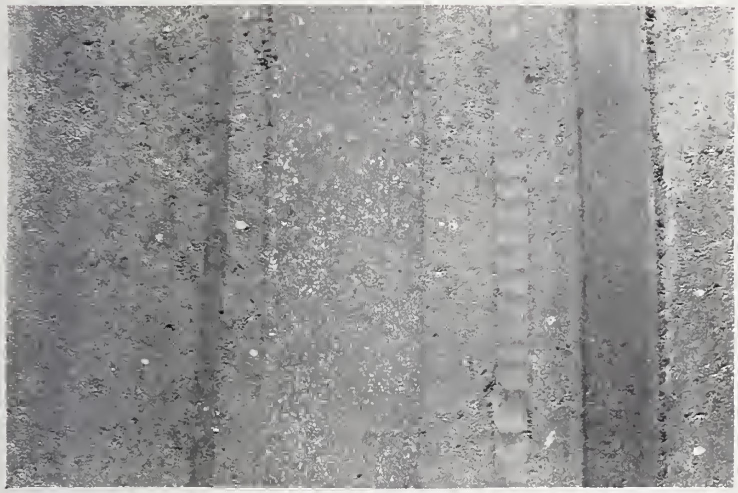

FIGURE 36.—½-*in. asphalt mastic composition on concrete subfloor (test panel 35).*

FIGURE 37.—½-*in. asphalt mastic composition on strip-wood subfloor (test panel 36A).*

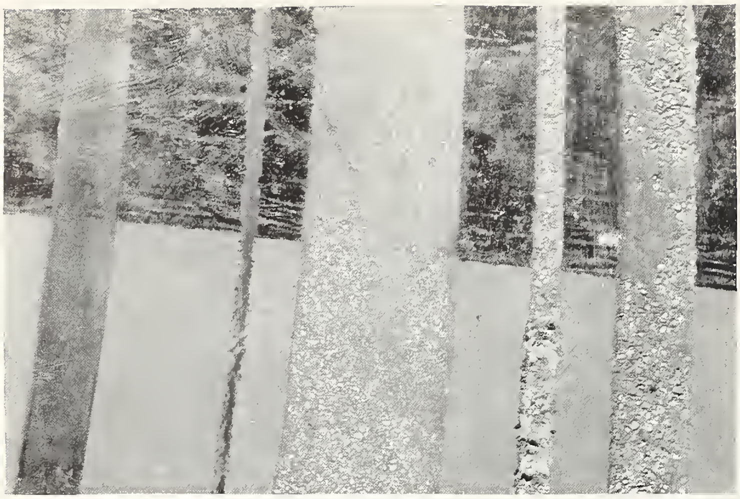

FIGURE 38.—½-*in. coal-tar mastic composition on gypsum-mortar subfloor (test panel 36B).*

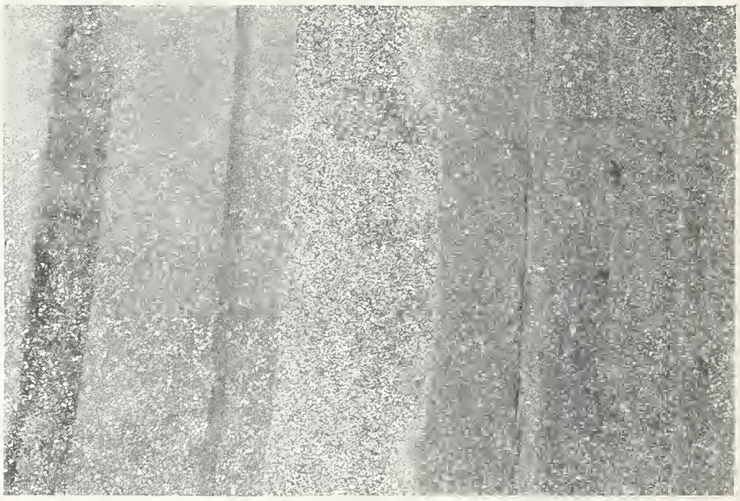

FIGURE 39.—½-*in. alumina cement-rubber latex composition on concrete subfloor (test panel 37).*

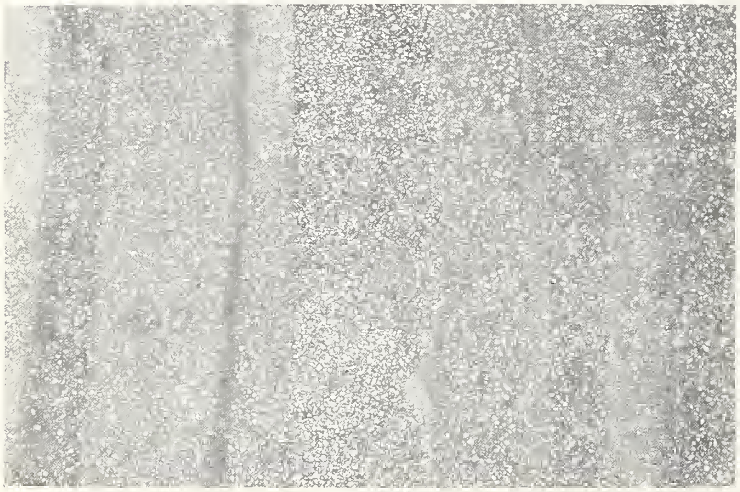

FIGURE 40.—½-*in. alumina cement-rubber latex composition on strip-wood subfloor (test panel 38).*

Figure 41.—½-in. magnesium oxychloride composition on concrete subfloor (test panel 39).

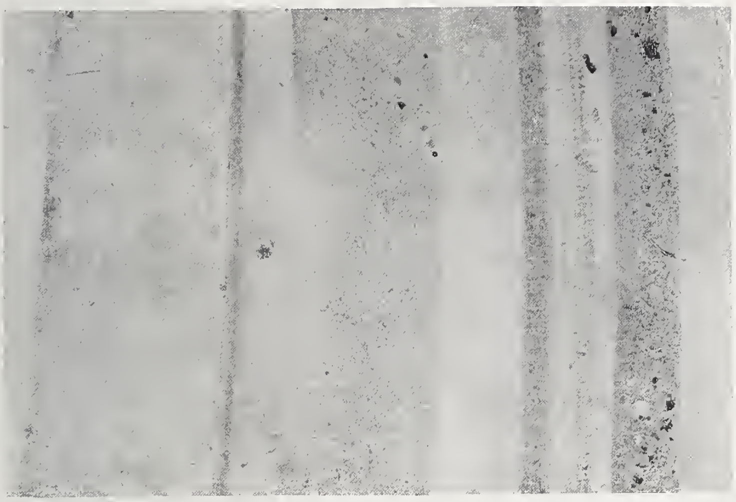

Figure 42.—4-in. portland-cement concrete, 1:2:4 mix (test panel 40).

available wearing surface, their low initial cost, and the type of service for which they are designed, their performance was fair. These floor coverings were severely damaged by the steel-tired truck wheel, but the rubber-tired truck wheel caused very little damage. The enamel coatings were worn through in spots by the walking wheel in approximately 31,000 cycles, or 7,000 cycles after the wheel had been covered with abrasive cloth. A comparison of figures 25, 26, and 27 presents additional evidence of the improvements in evenness and distribution of wear when an underlay of plywood or felt is used with felt-base floor coverings over strip-wood subfloors.

(*e*) *Resin-Treated Cotton-Linters Sheet*

The 1/16-in. felt-backed floor covering with a wearing surface consisting of a resin-treated cotton-linters sheet approximately 0.015 in. thick withstood the test fairly well (see fig. 29). There was some failure in bond to the concrete subfloor and some fracturing of the floor covering. The wearing surface showed good resistance to abrasion (see table 2).

6. Cotton Duck

The cotton duck performed well with respect to tearing or fracturing and resistance to abrasion (see figs. 30 and 31, and table 2). On a concrete subfloor there was considerable failure in bond. On 1/2-in. Douglas-fir plywood the depth of the path made by the steel-tired truck wheel was appreciable. The cotton duck accumulated dirt and became badly soiled. It would be difficult to keep clean.

7. Maple and Pecan Unit-Blocks

The maple unit-block and the pecan unit-block gave very good preformance (see figs. 32 and 33). There was very little evidence of damage along any of the paths. The maple showed slightly better resistance to abrasion than the pecan (see table 2).

8. Strip Maple

It would be difficult to distinguish between the performance of the strip northern maple and that of the strip southern maple, both performed very well and showed very good resistance to abrasion (see figs. 34 and 35, and table 2).

9. Asphalt and Coal-Tar Mastics

The asphalt mastic floors and the coal-tar mastic floor did not perform well in this test. The asphalt mastic on a concrete subfloor was compressed and grooved to a considerable extent by the steel-tired truck wheel and the steel-wheel caster (see fig. 36 and table 1). The asphalt mastic on a strip-wood subfloor was so badly damaged that it was necessary to remove it at 10,000 cycles in order to continue the test (see fig. 37). The coal-tar mastic on a gypsum-mortar subfloor was excessively pitted and grooved by the steel-tired truck wheel and the steel-wheel caster (see fig. 38 and table 1). The asphalt mastic and the coal-tar mastic showed poor resistance to abrasion (see table 2).

10. Alumina Cement–Rubber Latex Composition

The alumina cement–rubber latex composition floor with an aggregate of marble chips gave good performance, especially as a monolithic type of floor over a strip-wood subfloor (see figs. 39 and 40). Although the steel-tired truck wheel and the steel-wheel caster made moderate depressions in the floor, there was no evidence of fracturing. The floor was worn to a moderate degree by the walking wheel (see table 2.)

11. Magensium Oxychloride Composition

The magnesium oxychloride composition floor with an aggregate of granite chips and granite dust showed very good performance (see fig. 41). It was worn to only slight extents by the steel-tired truck wheel and the walking wheel (see table 1 and 2).

12. Portland-Cement Concrete

The 1:2:4 portland-cement concrete floor performed fairly well (see fig. 42). It was pitted and worn somewhat by the steel-tired truck wheel and the walking wheel (see tables 1 and 2).

VI. RECOMMENDATIONS AND CONCLUSIONS

Some of the more generalized recommendations and conclusions that may be drawn from the several series of performances tests are:

Where trucking is to be done, equipping the truck with rubber-tired wheels in preference to steel-tired wheels would be of marked benefit to the durability of almost all types of floor coverings.

The use of felt, or preferably plywood, underlays with thin floor coverings over strip-wood subfloors is desirable from the standpoint of both durability and appearance of the surface. The removal of felt-backed floor coverings cemented directly to strip-wood subfloors is extremely difficult and involves high costs in labor. Where a dry-felt underlay has been used, removal is much easier. Lignin paste is satisfactory for bonding lining felts to wood subfloors. It is partially soluble in water and can be readily removed after dampening moderately. Asphalt-saturated lining felt is more durable than dry lining felt under severe traffic conditions, such as trucking. However, its removal is much more difficult.

In general, the results of the several performance tests indicate that, of the various types of floor coverings tested, maple, pecan, oak, ½-in. rock-elm plywood, ⅛-in. rubber, ⅛-in. linoleum, and the magnesium oxychloride monolithic floor with an aggregate of granite chips and granite dust are durable floor coverings even under severe service. They showed very good resistance to abrasion, indentation, and fracturing. The above floor coverings are among those having a high initial cost. Among those having a lower initial cost, the felt-backed floor coverings having wearing surfaces of linoleum composition, cellulose nitrate composition, and resin-treated cotton-linters sheet showed very good resistance to abrasion. The thickness of their available wearing surface is sufficient to withstand normal wear for a reasonable length of time. For certain types of occupancy, such as would be encountered in most homes, they should render satisfactory and economical service. It should not be concluded that the other floor coverings tested do not have merit. Some possess special properties to a high degree, which may be essential to meet certain conditions. An example would be cork tile if a high comfort value is important.

Asphalt tiles require an even and rigid subfloor such as is obtained in even-troweled concrete. Asphalt tiles on strip-wood subfloors are likely to crack and fracture even under foot traffic. A plywood subfloor would be preferable to a strip-wood subfloor. Asphalt tiles are among the few types which can be successfully installed on basement floors which have not been thoroughly waterproofed.

Most floors of the monolithic type are likely to crack and fracture under moderately heavy traffic when laid over a strip-wood subfloor. Alumina cement-rubber latex compositions appear to be exceptions.

The generous cooperation of various manufacturers in furnishing materials for test is gratefully acknowledged.

WASHINGTON, December 9, 1941.

○

BUILDING MATERIALS AND STRUCTURES REPORTS

On request, the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., will place your name on a special mailing list to receive notices of new reports in this series as soon as they are issued. There will be no charge for receiving such notices.

An alternative method is to deposit with the Superintendent of Documents the sum of $5, with the request that the reports be sent to you as soon as issued, and that the cost thereof be charged against your deposit. This will provide for the mailing of the publications without delay. You will be notified when the amount of your deposit has become exhausted.

If 100 copies or more of any report are ordered at one time, a discount of 25 percent is allowed. Send all orders and remittances to the *Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.*

The following publications in this series are available by purchase from the Superintendent of Documents at the prices indicated:

BMS1	Research on Building Materials and Structures for Use in Low-Cost Housing	10¢
BMS2	Methods of Determining the Structural Properties of Low-Cost House Constructions	10¢
BMS3	Suitability of Fiber Insulating Lath as a Plaster Base	10¢
BMS4	Accelerated Aging of Fiber Building Boards	10¢
BMS5	Structural Properties of Six Masonry Wall Constructions	15¢
BMS6	Survey of Roofing Materials in the Southeastern States	15¢
BMS7	Water Permeability of Masonry Walls	10¢
BMS8	Methods of Investigation of Surface Treatment for Corrosion Protection of Steel	10¢
BMS9	Structural Properties of the Insulated Steel Construction Co.'s "Frameless-Steel" Constructions for Walls, Partitions, Floors, and Roofs	10¢
BMS10	Structural Properties of One of the "Keystone Beam Steel Floor" Constructions Sponsored by the H. H. Robertson Co	10¢
BMS11	Structural Properties of the Curren Fabrihome Corporation's "Fabrihome" Constructions for Walls and Partitions	10¢
BMS12	Structural Properties of "Steelox" Constructions for Walls, Partitions, Floors, and Roofs Sponsored by Steel Buildings, Inc	15¢
BMS13	Properties of Some Fiber Building Boards of Current Manufacture	10¢
BMS14	Indentation and Recovery of Low-Cost Floor Coverings	10¢
BMS15	Structural Properties of "Wheeling Long-Span Steel Floor" Construction Sponsored by the Wheeling Corrugating Co	10¢
BMS16	Structural Properties of a "Tilecrete" Floor Construction Sponsored by Tilecrete Floors, Inc	10¢
BMS17	Sound Insulation of Wall and Floor Constructions	10¢
Supplement to BMS17, Sound Insulation of Wall and Floor Constructions		5¢
BMS18	Structural Properties of "Pre-Fab" Constructions for Walls, Partitions, and Floors Sponsored by the Harnischfeger Corporation	10¢
BMS19	Preparation and Revision of Building Codes	15¢
BMS20	Structural Properties of "Twachtman" Constructions for Walls and Floors Sponsored by Connecticut Pre-Cast Buildings Corporation	10¢
BMS21	Structural Properties of a Concrete-Block Cavity-Wall Construction Sponsored by the National Concrete Masonry Association	10¢
BMS22	Structural Properties of "Dun-Ti-Stone" Wall Construction Sponsored by the W. E. Dunn Manufacturing Co	10¢
BMS23	Structural Properties of a Brick Cavity-Wall Construction Sponsored by the Brick Manufacturers Association of New York, Inc	10¢
BMS24	Structural Properties of a Reinforced-Brick Wall Construction and a Brick-Tile Cavity-Wall Construction Sponsored by the Structural Clay Products Institute	10¢
BMS25	Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs	15¢
BMS26	Structural Properties of "Nelson Pre-Cast Concrete Foundation" Wall Construction Sponsored by the Nelson Cement Stone Co., Inc	10¢
BMS27	Structural Properties of "Bender Steel Home" Wall Construction Sponsored by The Bender Body Co	10¢
BMS28	Backflow Prevention in Over-Rim Water Supplies	10¢
BMS29	Survey of Roofing Materials in the Northeastern States	10¢
BMS30	Structural Properties of a Wood-Frame Wall Construction Sponsored by the Douglas Fir Plywood Association	10¢

[List continued on cover page IV]

BUILDING MATERIALS AND STRUCTURES REPORTS

[Continued from cover page III]

BMS31	Structural Properties of "Insulite" Wall and "Insulite" Partition Constructions Sponsored by The Insulite Co	15¢
BMS32	Structural Properties of Two Brick-Concrete-Block Wall Constructions and a Concrete-Block Wall Construction Sponsored by the National Concrete Masonry Association	10¢
BMS33	Plastic Calking Materials	10¢
BMS34	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 1	10¢
BMS35	Stability of Sheathing Papers as Determined by Accelerated Aging	10¢
BMS36	Structural Properties of Wood-Frame Wall, Partition, Floor, and Roof Constructions With "Red Stripe" Lath Sponsored by The Weston Paper and Manufacturing Co	10¢
BMS37	Structural Properties of "Palisade Homes" Constructions for Walls, Partitions, and Floors, Sponsored by Palisade Homes	10¢
BMS38	Structural Properties of Two "Dunstone" Wall Constructions Sponsored by the W. E. Dunn Manufacturing Co	10¢
BMS39	Structural Properties of a Wall Construction of "Pfeifer Units" Sponsored by the Wisconsin Units Co	10¢
BMS40	Structural Properties of a Wall Construction of "Knap Concrete Wall Units" Sponsored by Knap America, Inc	10¢
BMS41	Effect of Heating and Cooling on the Permeability of Masonry Walls	10¢
BMS42	Structural Properties of Wood-Frame Wall and Partition Constructions With "Celotex" Insulating Boards Sponsored by The Celotex Corporation	10¢
BMS43	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 2	10¢
BMS44	Surface Treatment of Steel Prior to Painting	10¢
BMS45	Air Infiltration Through Windows	10¢
BMS46	Structural Properties of "Scot-Bilt" Prefabricated Sheet-Steel Constructions for Walls, Floors, and Roofs Sponsored by The Globe-Wernicke Co	10¢
BMS47	Structural Properties of Prefabricated Wood-Frame Constructions for Walls, Partitions, and Floors Sponsored by American Houses, Inc	10¢
BMS48	Structural Properties of "Precision-Built" Frame Wall and Partition Constructions Sponsored by the Homasote Co	10¢
BMS49	Metallic Roofing for Low-Cost House Construction	10¢
BMS50	Stability of Fiber Building Boards as Determined by Accelerated Aging	10¢
BMS51	Structural Properties of "Tilecrete Type A" Floor Construction Sponsored by the Tilecrete Corporation	10¢
BMS52	Effect of Ceiling Insulation on Summer Comfort	10¢
BMS53	Structural Properties of a Masonry Wall Construction of "Munlock Dry Wall Brick" Sponsored by the Munlock Engineering Co	10¢
BMS54	Effect of Soot on the Rating of an Oil-Fired Heating Boiler	10¢
BMS55	Effects of Wetting and Drying on the Permeability of Masonry Walls	10¢
BMS56	A Survey of Humidities in Residences	10¢
BMS57	Roofing in the United States—Results of a Questionnaire	10¢
BMS58	Strength of Soft-Soldered Joints in Copper Tubing	10¢
BMS59	Properties of Adhesives for Floor Coverings	10¢
BMS60	Strength, Absorption, and Resistance to Laboratory Freezing and Thawing of Building Bricks Produced in the United States	15¢
BMS61	Structural Properties of Two Nonreinforced Monolithic Concrete Wall Constructions	10¢
BMS62	Structural Properties of a Precast Joist Concrete Floor Construction Sponsored by the Portland Cement Association	10¢
BMS63	Moisture Condensation in Building Walls	10¢
BMS64	Solar Heating of Various Surfaces	10¢
BMS65	Methods of Estimating Loads in Plumbing Systems	10¢
BMS66	Plumbing Manual	20¢
BMS67	Structural Properties of "Mu-Steel" Prefabricated Sheet-Steel Constructions for Walls, Partitions, Floors, and Roofs Sponsored by Herman A. Mugler	15¢
BMS68	Performance Test of Floor Coverings for Use in Low-Cost Housing: Part 3	15¢
BMS69	Stability of Fiber Sheathing Boards as Determined by Accelerated Aging	10¢
BMS70	Asphalt-Prepared Roll Roofings and Shingles	15c
BMS71	Fire Tests of Wood- and Metal-Framed Partitions	20¢
BMS72	Structural Properties of "Precision-Built, Jr." Prefabricated Wood-Frame Wall Construction Sponsored by the Homasote Co	10¢
BMS73	Indentation Characteristics of Floor Coverings	10¢
BMS74	Structural and Heat-Transfer Properties of "U. S. S. Panelbilt" Prefabricated Sheet-Steel Constructions for Walls, Partitions, and Roofs Sponsored by the Tennessee Coal, Iron & Railroad Co	15¢
BMS75	Survey of Roofing Materials in the North Central States	15¢
BMS76	Effect of Outdoor Exposure on the Water Permeability of Masonry Walls	15¢
BMS77	Properties and Performance of Fiber Tile Boards	10¢
BMS78	Structural, Heat-Transfer, and Water-Permeability Properties of Five Earth-Wall Constructions	20¢
BMS79	Water-Distributing Systems for Buildings	15¢
BMS80	Performance Tests of Floor Coverings for Use in Low-Cost Housing: Part 4	15¢