# A TEMPERATURE STUDY OF DAIRY BARN FLOORS

by

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TABLE OF CONTENTS

| | Page |
|---|---|
| INTRODUCTION | 2 |
| CONSTRUCTION OF FLOORS | 3 |
| TESTING EQUIPMENT | 6 |
| CONDUCT OF INVESTIGATION | 7 |
| ANALYSIS OF DATA | 8 |
| TEMPERATURE STUDIES | 10 |
| CONCLUSIONS | 20 |
| ACKNOWLEDGMENT | 22 |

## INTRODUCTION

The degree of warmth of floors made of different materials is more or less directly related to their thermal conductivity or heat-conducting qualities. The rate at which the heat is carried away from the cow by the floor determines whether or not the floor is warm or cold. If a material is used that has a high relative conductivity, heat will travel away from the surface very rapidly. This makes the floor cold. On the other hand, if the relative conductivity of the material used in constructing the floor is low, heat will travel away from the surface more slowly, resulting in a warmer floor.

Rather than make a relative conductivity test of each floor material, studies were conducted to determine the actual surface temperature of each material in place in the floor while the cows were on the floors.

CONSTRUCTION OF THE FLOORS

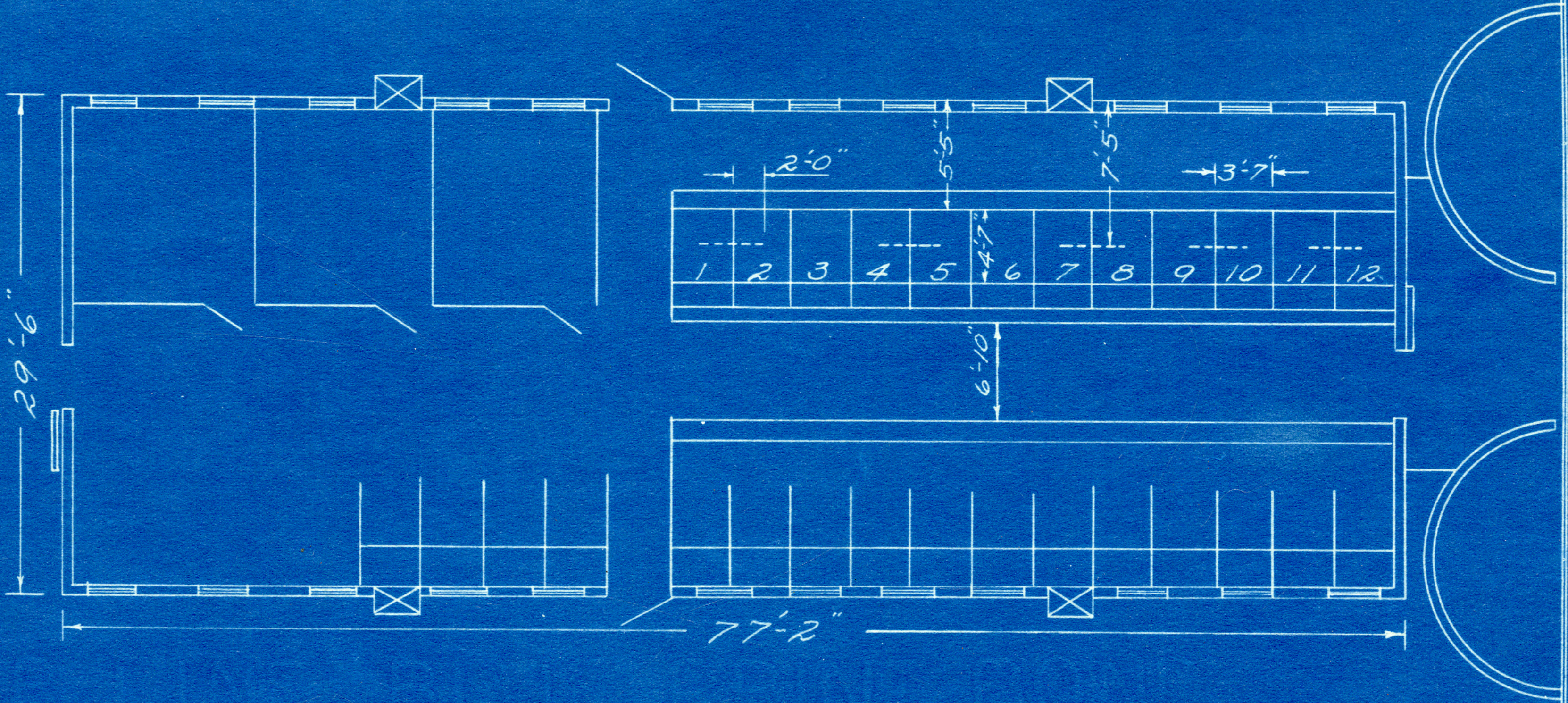
Six common floor materials - earth, plank, concrete, building tile, creosoted pine block and cork brick - were used in constructing the standing platform of the stalls. All concrete bases and subgrades were constructed from a mixture of one part Portland cement, two parts sand and four parts broken stone. The rest of the barn floor, including gutter, allies and curb, was made of concrete. The testing equipment was installed in the north wing of the College dairy barn (Figure 1, page 4).

The standing platform of two stalls was surfaced with the same material, so that the temperature readings could be taken in duplicate. The construction of each platform is shown in Figure 2, page 5.

The standing platforms constructed of earth were replaced with concrete because of their insanitary condition.

The standing platforms of stalls 1 and 2 were constructed of a 5-inch layer of concrete over one layer of rubberoid roofing. The latter material was used to keep moisture from entering the floor from the subgrade and to act as an insulating agent.

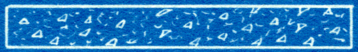
The standing platforms of stalls 4 and 5 were constructed of 2-inch pine planks laid over a 3-inch concrete base.




NORTH WING OF K.S.A.C. DAIRY BARN

Thermometers ----

FIG. 1

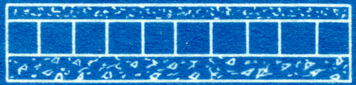


STALL NO.2

5" Of Concrete Over Rubberoid Roofing

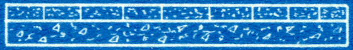
STALL NO.5

2" Plank Over 3" Concrete Base



STALL NO.7

4" Building Tile On 3" Concrete Base And Covered With 2" Of Concrete



STALL NO. 9

2" Cork Brick Over 3" Con-crete Base

STALL NO.11

4" Creosoted Pine Blocks On 3½" Concrete Base

CONSTRUCTION OF STALL PLATFORMS
FIG. 2

The cracks between the planks were filled with asphalt.

The standing platforms of stalls 7 and 8 were constructed of 4-inch building tile laid on a 3-inch concrete base. The tile were then covered with a 2-inch layer of concrete. The top layer of concrete was used to protect the tile against breakage.

The standing platforms of stalls 9 and 10 were constructed of 2-inch cork brick laid over a 3-inch concrete base. These bricks were made of ground cork and asphalt, moulded into units about the size of ordinary bricks. They were laid on a bed of sand-cement mortar and the joints were grouted with mortar.

The standing platforms of stalls 11 and 12 were constructed of 3-inch creosoted pine block laid on a $3\frac{1}{2}$-inch concrete base. The blocks were laid on the base after it was given a coating of hot asphalt. After the blocks were in place, hot asphalt was poured into the joints between the blocks, making the platform water-proof.

TESTING EQUIPMENT

Electric resistance thermometers operating on the thermocouple principle were placed in the surface of each floor in a position about even with the cow's udder when the cow was standing on the platform. The thermometer location is indicated by the dotted lines in Figure 1, page 4. The thermometer bulbs, which were about 10 inches long, were placed across the platform parallel with the gutter. In addition to the thermometers located in the surface of each floor, two others were located in the subgrade to show any lagging of the subgrade temperature. Wires were run from each thermometer to a place where the temperature indicator could be connected and read without disturbing the cow.

The temperature indicating device was a wheatstone bridge with the thermocouple in the floor as the unknown resistance of the bridge. The galvanometer was graduated so as to show the temperature of the thermocouple when the wheatstone bridge was balanced.

The thermometers were calibrated before and after each test. In this way all instrument and thermometer errors were corrected. The curves were plotted from corrected values.

## CONDUCT OF INVESTIGATION

Periods of extremely cold weather were selected for making the tests. In this way the influence of severe conditions on the floors was determined. Also the variations in floor temperatures were greater, which made comparison of the different materials much easier. Throughout the tests the temperature of the floors were taken hourly. Other things which had an influence upon the temperature, such as the cows lying down and getting up, and the opening and closing of windows and doors, were noted and recorded. The test was extended over a period of 24 days, divided into three tests of 4, 9, and 11 days respectively. The temperature of each test was plotted and curves were drawn. By having three tests, one served as a check on the other.

The cows used throughout the test were heifers weighing approximately 800 pounds, furnished by the Kansas State Agricultural College Dairy Department.

## ANALYSIS OF DATA

The results of the 4-day run are shown in Figure 3, page 9. The valleys in these curves show when the cows were standing up, while the peaks show the maximum temperature reached while the cows were lying down. All breaks in the curves are caused by the cow getting up or lying down. When the cows laid down, warming of the floor started immediately, and if the cows got up, cooling of the floors started immediately.

The rate at which the surface temperature raised is shown by the steepness of the curves. It will be noted that the temperature of the floors constructed of cork bricks, pine blocks and plank (stalls 5, 9, and 11) gave much steeper curves than those constructed of cement, and cement and building tile (stalls 2 and 7).

## TEMPERATURE STUDIES

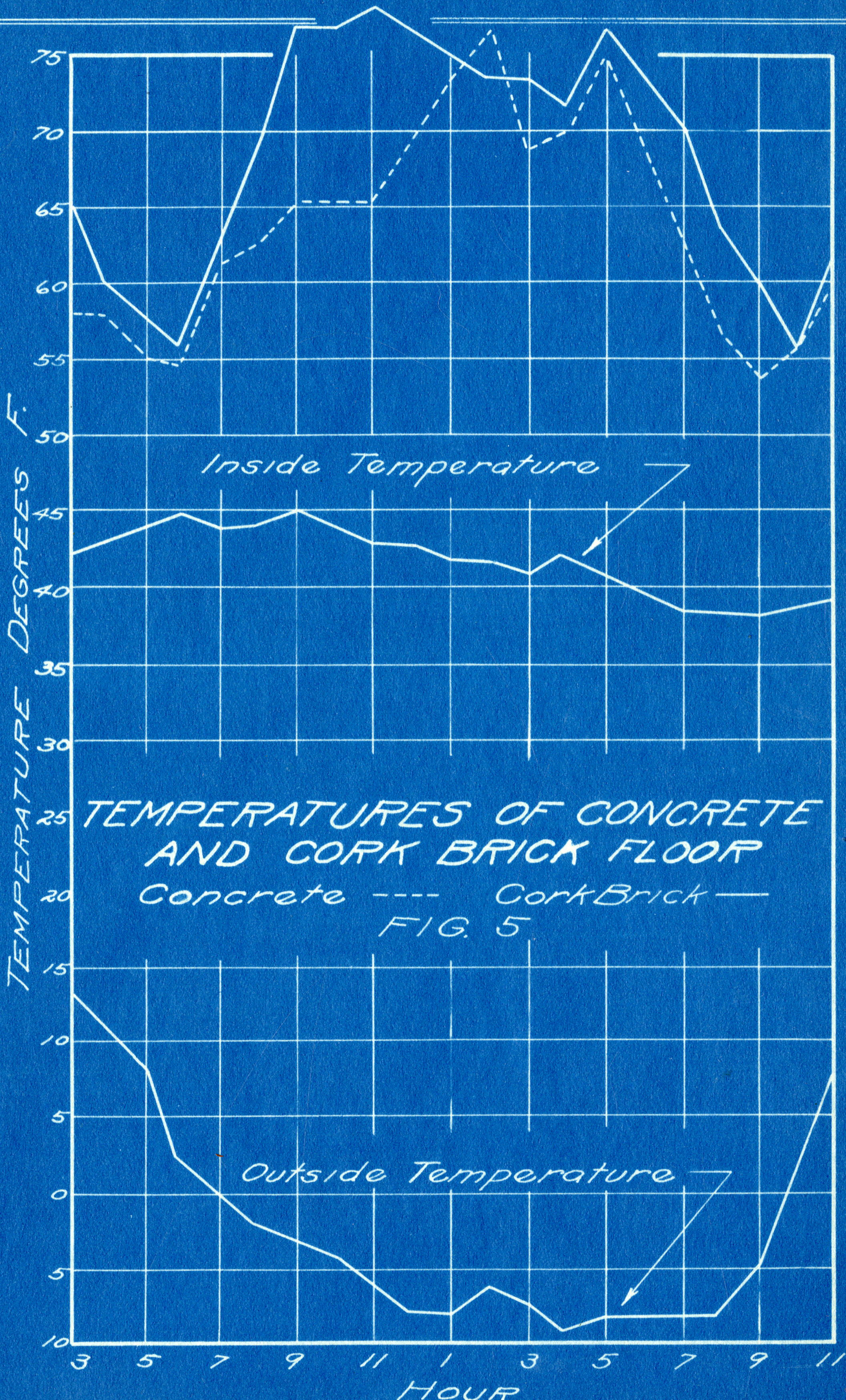
The maximum and minimum temperatures on the different floor surfaces did not vary a great deal so long as the cow's position on the different floors remained the same (Figure 3, page 9). At feeding time when all of the cows were standing up, or when they were turned out of the barn, the temperature on each of the floors dropped to practically the same minimum level, regardless of whether the floor was made of concrete or cork brick. Likewise after the cows had been lying on the floors all night, the maximum temperature reached on all floors was about the same, the widest variation being not over 5 to 10 degrees F.

The most important factor affecting the warmth of the floors was the rate at which they warmed up after the cows laid down on them. For example, two cows in adjoining stalls, one surfaced with concrete, the other with creosoted pine blocks, laid down at 8 P.M. By 10 P.M. the surface temperature of the pine block floor had raised from 50 to 80 degrees F., a rise in temperature of 30 degrees in two hours, while the surface of the concrete floor never reached 75 degrees F. until 3 A.M. the following morning. A great amount of heat was required from 8 until 3 A.M., a period of 7 hours, and then the surface was not as warm as that on the other floor. Seven to eight hours were required to warm the concrete floor 25 degrees as compared to warming the pine block floor 30 degrees in 2 hours.

All of the different floor materials have been compared to concrete, since concrete is a widely used and well known material.

The floor containing building tile, while probably drier than the solid concrete floor, was no warmer (Figure 4, page 12). It was just as slow to warm up as the concrete floor because of the 2-inch layer of concrete over the tile. This layer of concrete acted very similar to the solid concrete floor in that its conductivity was high, thus conducting the heat away from the surface and from the cow at a much more rapid rate than the cow was able to supply it. From the curve it will be noticed that the maximum temperature of 75 degrees was not reached until about 4 A.M. All of the breaks in the curves are traceable to the position of the cows, whether up or down. As long as she was down the temperature rose, and when she stood up the temperature of the floor dropped. It will be noted, from the curve, that cows were up and down several times during the night. This of course slowed down considerably the warming-up process. The cows on these two floors got up oftener than those on the other floors.

The cork brick floor was considerably warmer than the concrete floor because of its low conductivity. Figure 5,




TEMPERATURES OF CONCRETE AND CORK BRICK FLOOR

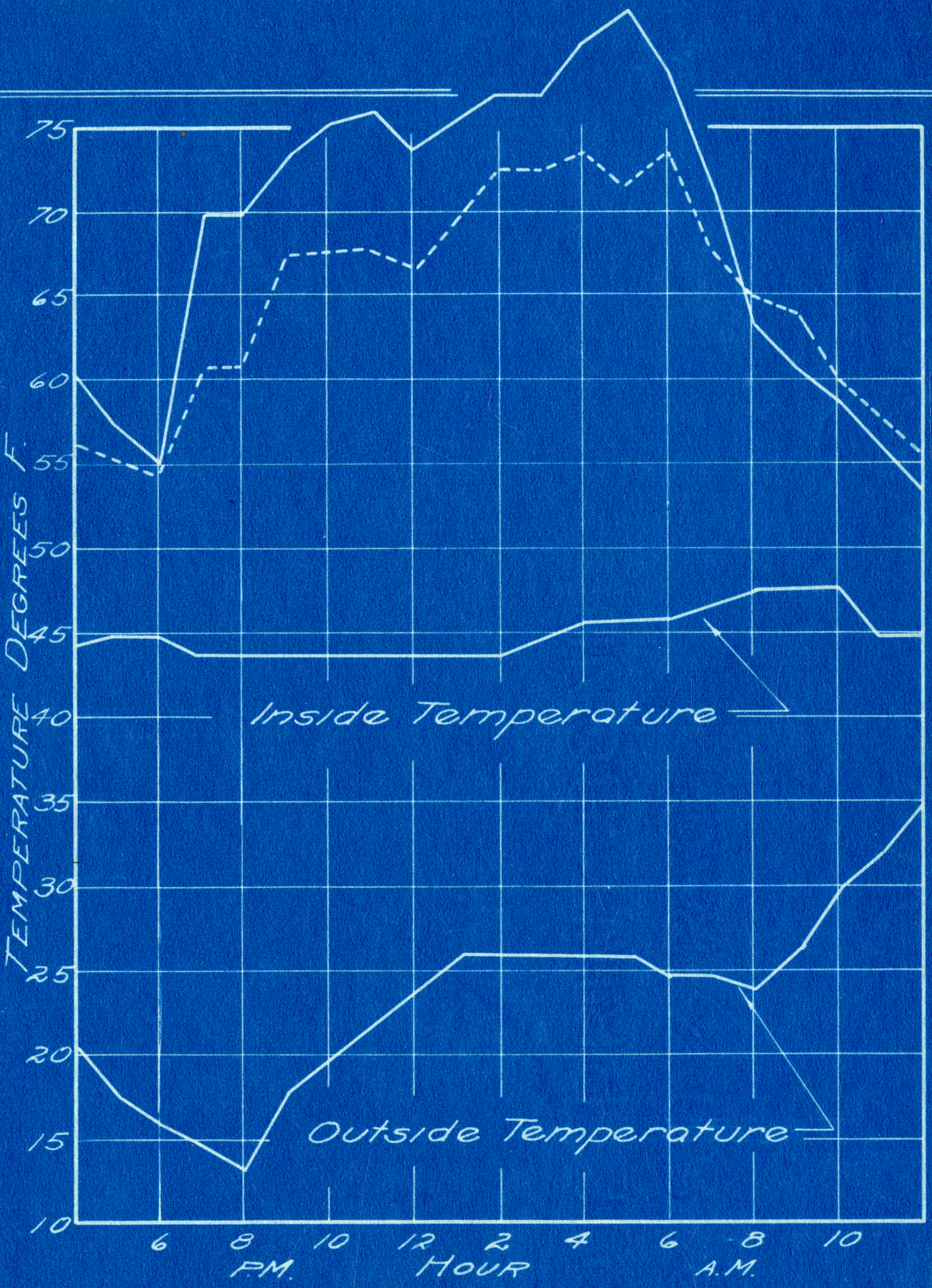
Concrete ---- CorkBrick —

FIG. 5

page 13, shows that only 3 hours were required for the cork brick floor to be warmed from 57 degrees to 77 degrees, while 8 hours were required to warm the concrete floor the same amount. Other instances may be cited where the temperature rise of the cork floor was much higher, but this particular case is taken because the position of the cows on the two floors was practically the same. The rate of rise on the cork brick floor was about 6.6 degrees F. per hour, while the temperature rise on the concrete floor was only 2.5 degrees F. per hour.

A comparison of the temperatures of the creosoted pine block floor and the concrete floor is shown in Figure 6, page 15. These curves were chosen because at this particular time the position of the cows on these two floors was practically the same. The temperature rise for the two floors during the first hour after the cow had laid down was 15 degrees F. for the pine block floor and about 7 degrees for the concrete floor.

The minimum temperature of these two floors is shown to be about the same at 6 P.M., while the maximum temperatures differed only about 10 degrees between 4 and 5 A.M. Even though the maximum and minimum temperatures were very nearly the same, the block floor is shown to be much warmer in that within one hour the temperature on the floor was 70 degrees F. while 7 hours were required before the tempera-




TEMPERATURES OF CONCRETE AND PINE BLOCK FLOOR

Concrete ----- Pine Block ——

FIG. 6

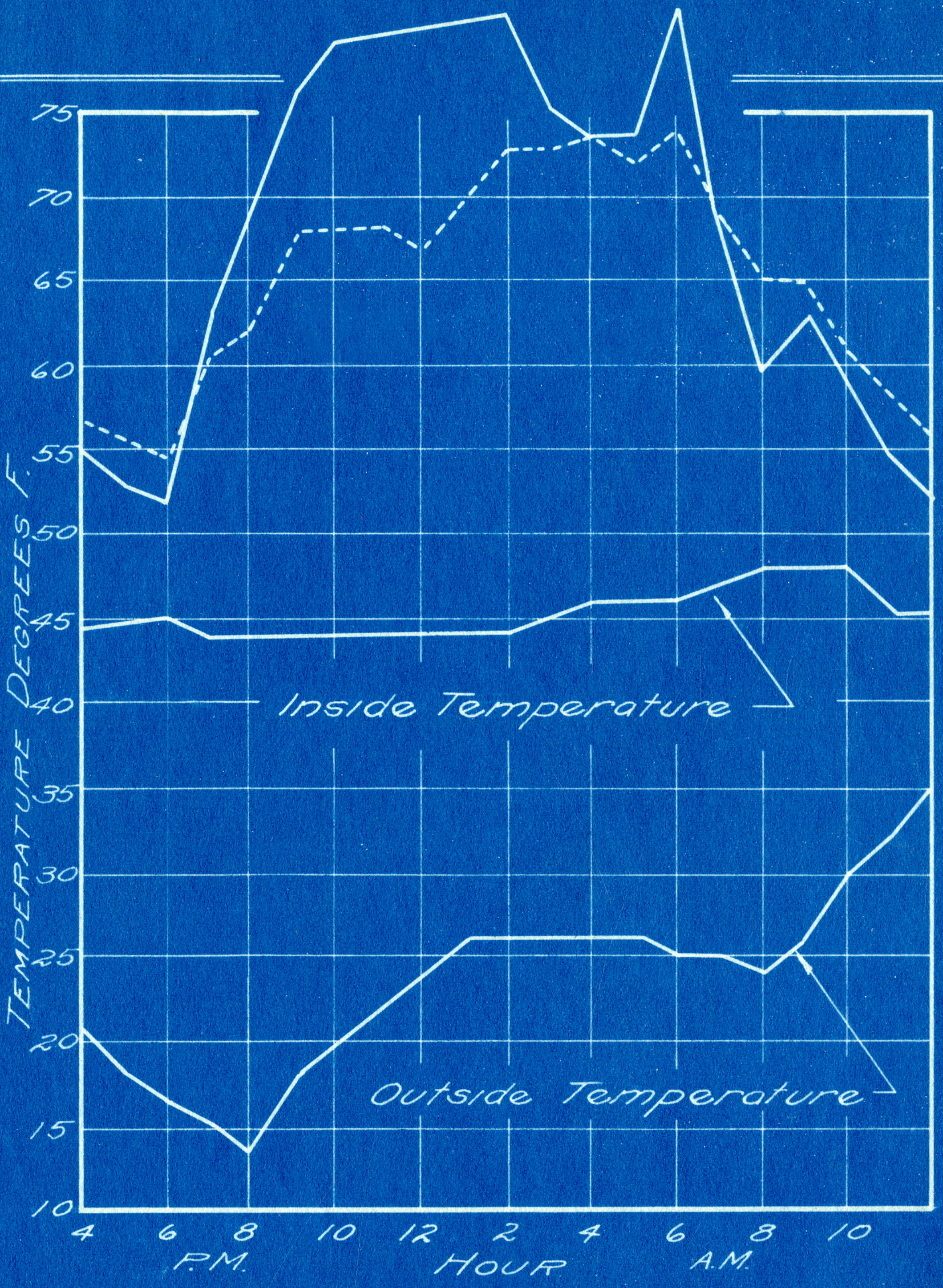
ture on the concrete floor reached 70 degrees.

A comparison of the temperatures on the pine plank floor and the concrete floor is shown in Figure 7, page 17. The temperature on the plank floor raised from $52\frac{1}{2}$ degrees to 70 degrees F. in 2 hours, a raise of $17\frac{1}{2}$ degrees. On the other hand, 7 hours were required to bring the temperature of the concrete floor from 55 degrees F. to 70 degrees F. Again it is shown that there is not a great deal of difference between the maximum and minimum temperatures of the two floors.

The curves in Figure 8, page 18, were drawn to show a comparison of the temperatures on the cork brick and pine block floors. This example was used not because of any outstanding rise in temperatures, but because the cows on these two floors were up and down through practically the same periods of time. In making comparisons of the different floors, it was rather difficult to find periods when all the cows were lying down or standing up at the same time throughout the night.

In making a study of these two floors it was found that the surface temperatures were practically the same. This indicates that the heat-conducting qualities of the two materials were about equal. So far as warmth was concerned, there was little in favor of one material over the other.

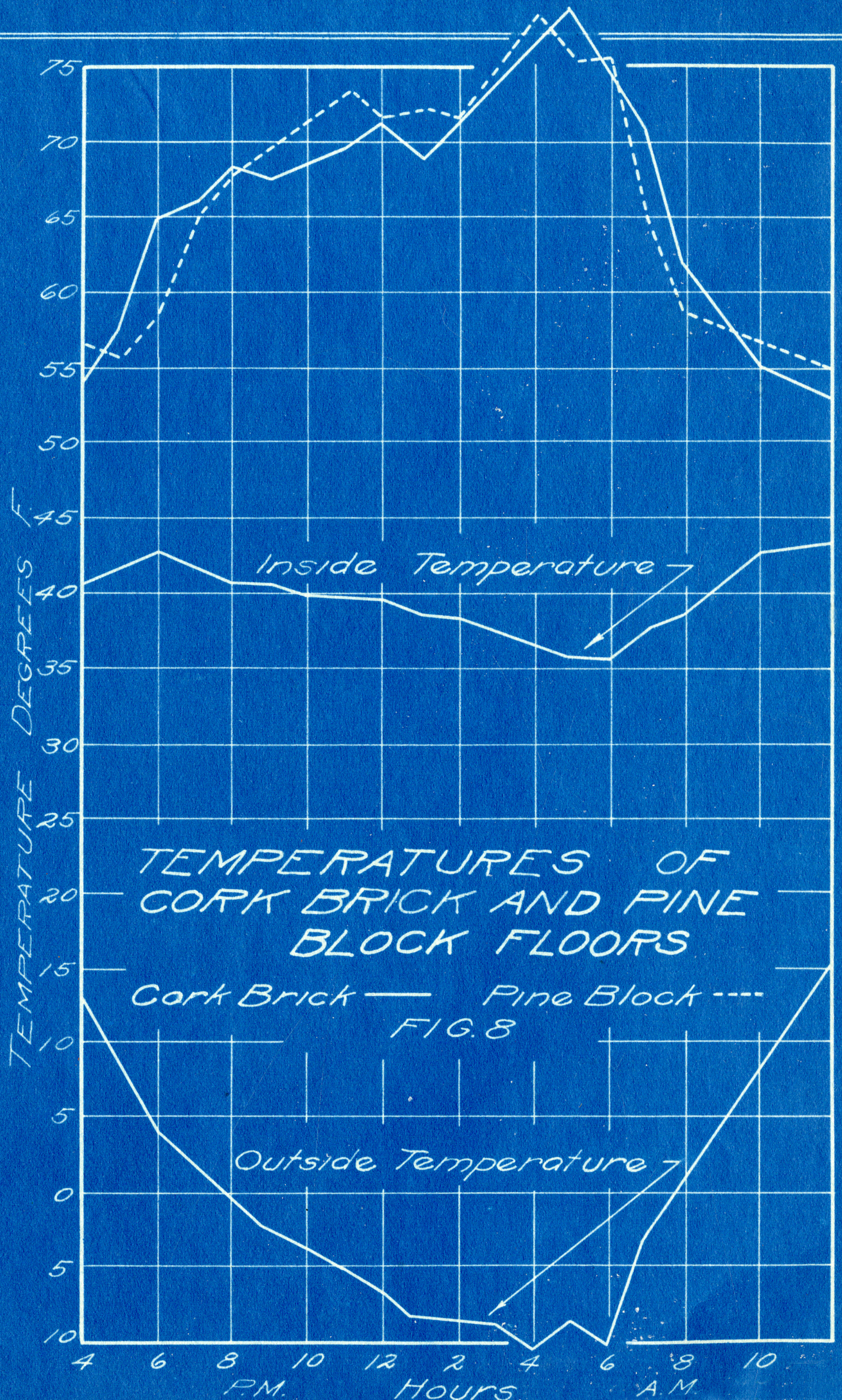
The curves in Figure 9, page 19, were drawn to show the




TEMPERATURES OF CONCRETE AND PLANK FLOOR

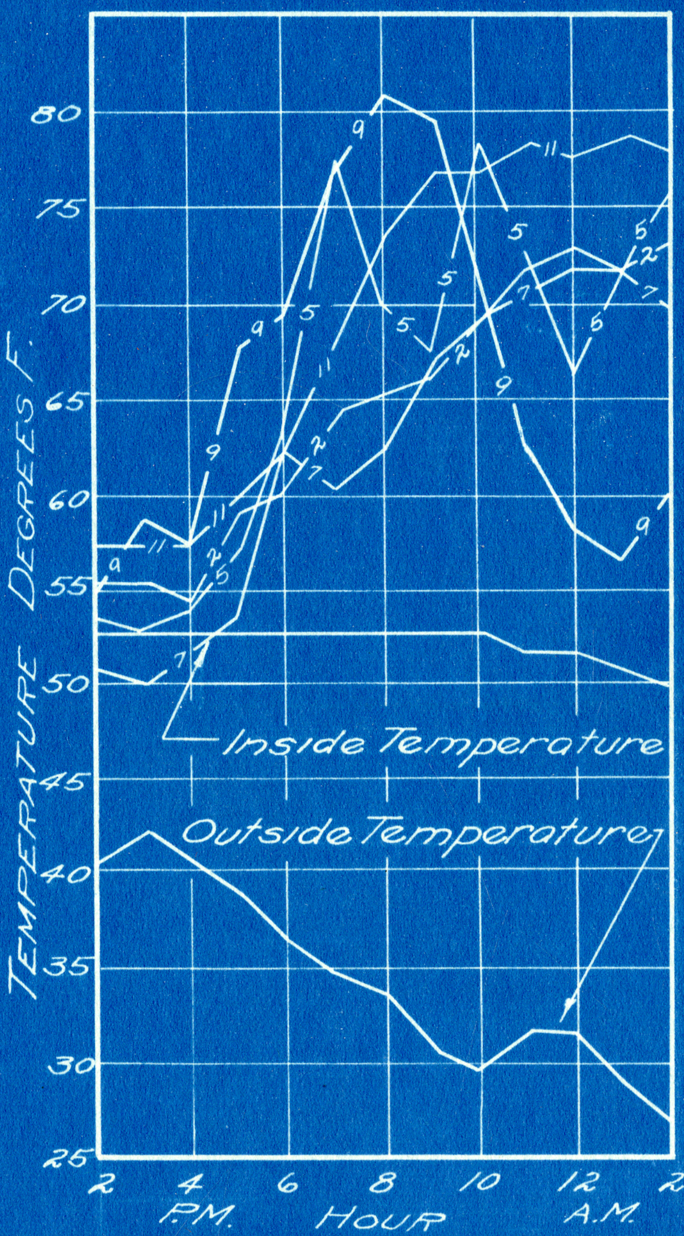
Concrete ---- Plank ——

FIG. 7




TEMPERATURES OF CORK BRICK AND PINE BLOCK FLOORS

FIG. 8




TEMPERATURE RISE ON STALL FLOORS

Concrete 2 Hollow Tile 7 Plank 5
Cork Brick 9 Wood Block 11

FIG. 9

steepness of the curves, which is an indication of the rate of warming for the different materials. Here the temperature is shown to rise much faster on the plank, cork brick and pine block floors (stalls 5, 9 and 11 respectively) than on the concrete and concrete and building tile floors (stalls 2 and 7 respectively).

The rate of temperature rise on the first three floors mentioned is shown to be about the same, and the rise on the other two is about the same. A relatively short time is required for warming the floors constructed of these materials as compared to concrete and building tile.

## CONCLUSIONS

Whether or not the dairy barn stalls should be surfaced with a material having low heat-conducting characteristics depends upon the winter temperature of the region in which the barn is located.

For Kansas conditions a floor constructed entirely of concrete would probably be more practical since the temperatures in this State are hardly ever below zero. If zero weather does occur it is of very short duration. During these periods a heavier bedding might be used over the concrete floor, thus providing a warmer place for the cow to lay.

In States farther north where low winter temperatures of long duration are encountered, stall materials of low heat conductivity might be used, thus providing a much warmer floor.

The cost of cork brick and wood blocks is approximately 50 cents per square foot. Material for covering cow stall floors will be approximately $5.00 per cow. If this cost is distributed over the usual term of service, the yearly cost per cow is very small.

For general farm use it is unnecessary and inadvisable to cover the entire barn floor with wood blocks or cork brick. Instead, the standing platform should be of this material and the remainder of the floor, the gutters, alleys and mangers may well be of concrete. By using wood blocks or cork brick in the stall only, the cost of their installation will be only a fraction of that for the entire floor.

Although a floor constructed of wood plank is much warmer than a concrete floor, it is insanitary, is relatively short lived, and when worn offers a possibility of injury to stock from splinters. Its unfavorable features outweigh its favorable ones, so this material should be considered as unsuited to the purpose.

The life of a floor made of creosoted pine block is about twice that of one made of cork brick; however, a wet cork brick floor is not as slippery as one made of pine block.

## ACKNOWLEDGMENT

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