appreciation of entomology here, and have a corner on that subject so far as the university is concerned. This institution opens its arms to you—every door and every place you want to go into is yours.

PRESIDENT SANDERSON: The next paper will be given by Mr. George A. Dean, Manhattan, Kan., on "Fatal High Temperatures for the Control of Mill Insects."

HEAT AS A MEANS OF CONTROLLING MILL INSECTS[1]

By GEORGE A. DEAN, *Manhattan, Kan.*

In connection with investigations relative to the inspection and fumigation of flour mills, the writer noticed on several occasions that the common mill insects were dead, although they were surrounded with an abundance of food. Upon further investigation it was observed that these insects were most frequently found dead in those parts of the mill where, owing to the surrounding conditions, they could easily have been subjected to a temperature varying from 105° to 120° F. for four or five hours per day and for a period of several days.

On looking over available literature relative to the control of this class of insects, it was found that the French long ago knew the value of heat and devised contrivances, called insect mills, for the heating of infested grain. Experiments made by Prof. F. M. Webster in 1883 to ascertain the amount of heat required to destroy the Angoumois grain moth gave these results, "a temperature of 140° F., continued for nine hours, literally cooks the larvæ or pupæ. A temperature of 130° F., for five hours, is fatal, as is also 120° for four hours, while 110° applied for six hours was only partially effective." It was also found in his experiments that wheat could be subjected to a temperature of 150° for eight hours without impairing its germinat-

[1]This paper embodies the results of some of the investigations undertaken by the writer in the prosecution of project No. 58, "Insects Injurious to Stored Grain and Stored Grain Products," of the Kansas State Agricultural Experiment Station.

The writer desires to acknowledge the valuable assistance rendered by Mr. R. M. Caldwell in carrying out laboratory experiments, and by Mr. Caldwell and Mr. F. B. Milliken in fumigating various mills with hydrocyanic acid gas, and in making trials of heat as a method of destroying mill insects in the large mill where the practical tests were made.

ing properties. In the second report of the state entomologist of New York, Prof. J. A. Lintner, in speaking of *Tribolium ferrugineum* infesting grain and flour says, "A moderate degree of heat, 120° to 130° F., continued for a few hours, would in all probability suffice to kill all the eggs, larvæ and pupæ in the material, while a higher temperature, perhaps 150° or more, would be needed for the beetles. Prof. F. H. Chittenden in his article on "Insects Injurious to Stored Grain" says, "Prior to the adoption of carbon disulphide as a fumigant, heat was relied upon in the destruction of these insects. A temperature of from 125° to 140° F., continued for a few hours, is fatal to grain insects, and wheat can be subjected to a temperature of 150° for a short time without destroying its germinating power."

Nearly all the experiments of this nature were made relative to the discovery of a method to destroy Angoumois grain moth, and from the results of these experiments some of the experimenters and other writers have assumed that many of the grain insects could probably be destroyed in the same manner, but it would require a higher temperature to destroy the adults than the larvæ or pupæ. Since this method of combating grain insects was not developed and given a practical test in a flour mill, and believing that the death of these insects in the Kansas mills was caused by a fatal maximum temperature, the next step was to determine this temperature and to ascertain whether it would be possible and practical to not only produce such a condition in a modern mill, but whether it would prove fatal to the insects therein.

In the first experiment about twenty-five individuals of both the adult and larvæ of *Tribolium confusum* were placed in a shell vial and covered with an inch of flour. A thermometer was placed in this vial with the bulb resting in the center of the flour. The vial containing the flour and various stages of *Tribolium confusum* was next suspended in a large bottle in such a manner as not to touch the sides of it. This bottle was then placed in a glass jar filled with water, and this glass jar was placed in a vessel filled with water. The heat was applied beneath this vessel. This arrangement reduced to a minimum the unequal distribution of the heat in the shell vial containing the insects. In raising the temperature from 80° to 90° no change was noticed in the action of these insects. At a temperature of about 96° the adults became uneasy and began running around rather rapidly. At a temperature of 100° the larvæ emerged and crawled over the flour, and the adults were running more rapidly than at 96°. At a temperature of 110° both larvæ and adults were frantic and were making every effort to escape, and these actions were continued until a temperature of 115° was reached. At this temperature both the larvæ and adults were becoming passive, and at a temperature of 118° all adults were lying on their backs apparently dead, while four or five larvæ showed very feeble movements. At a temperature of 119° there was no sign of life; however, the temperature was raised to 120° and then the insects were removed and given a chance to recover, but none did. This experiment was repeated several times and each time as soon as a temperature of from 119° to 120° was reached it proved fatal to all stages of the insects. It required from twelve to fifteen minutes to reach this fatal temperature.

Similar experiments were conducted and repeated with the larvæ, pupæ, and adults of *Silvanus surinamensis*, *Ephestia kuehniella*, *Tenebrioides mauritanicus*, and the adults of *Calandra oryza*. As soon as a temperature of 116° was reached it proved fatal to the adults of *Ephestia kuehniella* while it required a temperature of 118° to prove fatal to the larvæ and pupæ. A temperature of 118° was fatal to the adults of *Calandra oryza*, and a temperature of 119° proved fatal to all stages of *Silvanus surinamensis*. At a temperature of 120° the majority of the *Tenebrioides mauritanicus* perished, but it required a temperature of 120° for a period of three minutes to prove fatal to all.

In a second series of experiments a paraffin oven or incubator was used, and after the oven was heated to a required temperature, the insects were placed in it and the oven held to a constant temperature throughout the experiment. In this experiment about twenty-five specimens of the eggs, larvæ, pupæ and adults of *Tribolium confusum*, larvæ and pupæ of the *Ephestia kuehniella*, and the adults of *Calandra oryza*, and *Tenebrioides mauritanicus* were used. Experiments were made not only with these various stages of insects on top of the flour, but one and two inches below the surface. After a series of experiments it was found that a temperature of 115° for a period of twelve hours proved fatal to all the insects in their various stages.

Since in practical use it would be impossible to actually heat a mill in a few minutes as in the first series of experiments, or subject them to such a sudden change as in the second series, a third set of experiments was conducted to determine the fatal temperature under conditions that could actually be produced in a mill. In these experiments the larvæ, pupæ, and adults of *Tribolium confusum*, the adults of *Silvanus surinamensis*, and *Ephestia kuehniella* were used. The various stages of the different insects were placed in shell vials, so that their actions under the slowly rising temperature of the oven could be observed. The heat was applied at 8 a. m. and the temperature noted at intervals of every half hour. The temperature at the

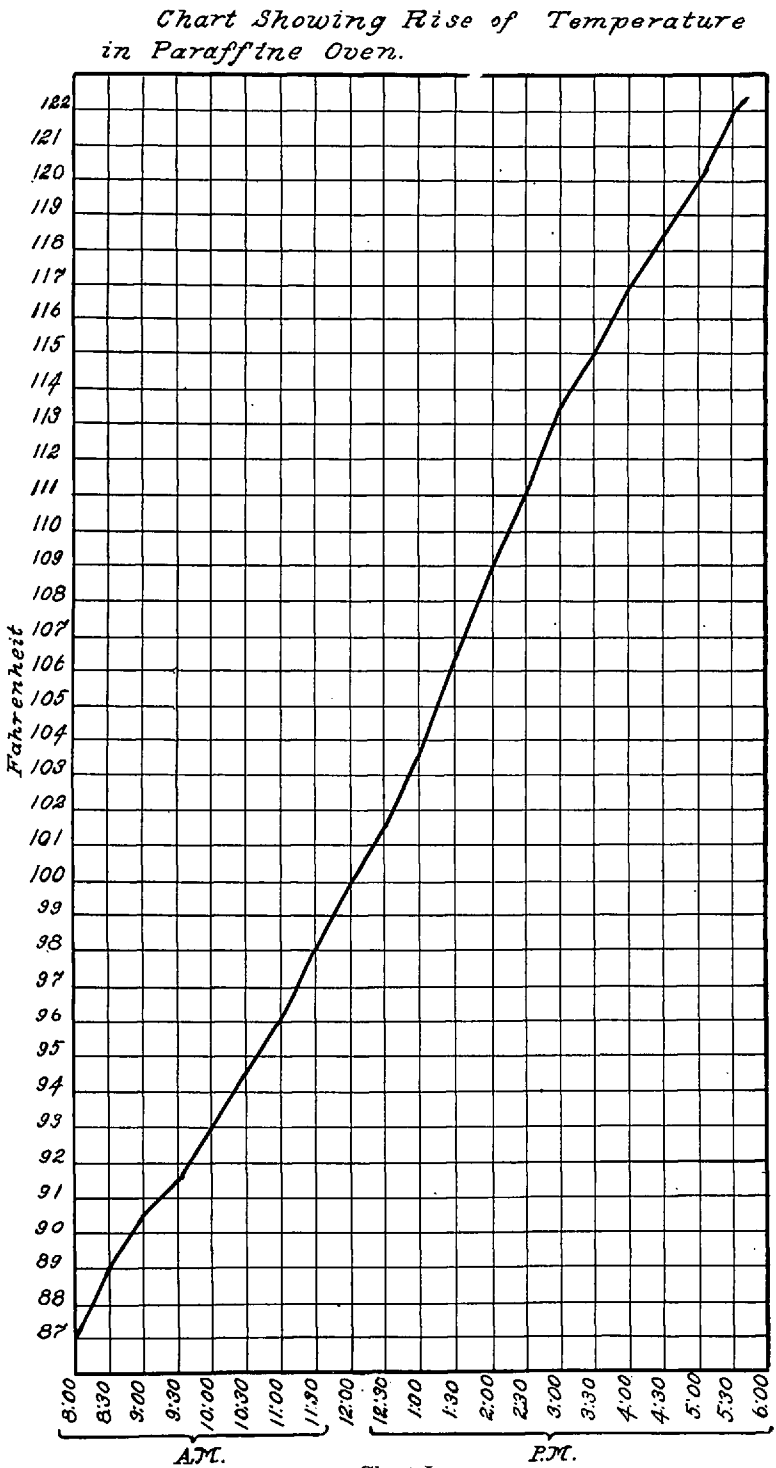
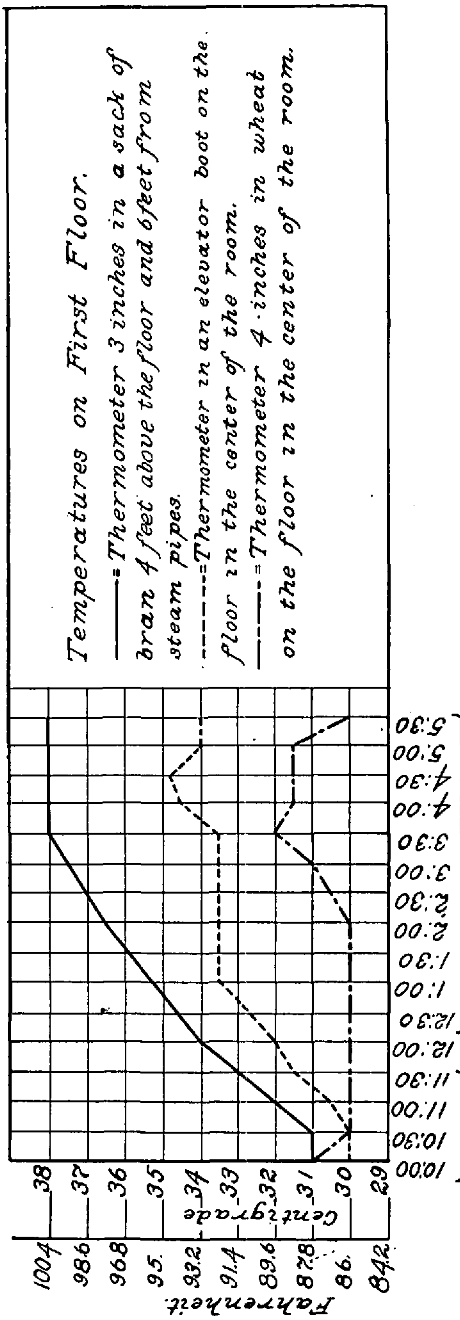


Chart Showing Rise of Temperature in Paraffine Oven.
Fahrenheit
122
121
120
119
118
117
116
115
114
113
112
111
110
109
108
107
106
105
104
103
102
101
100
99
98
97
96
95
94
93
92
91
90
89
88
87
8:00
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
12:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
A.M.
P.M.

Chart I



Temperatures on First Floor.
——— = Thermometer 3 inches in a sack of bran 4 feet above the floor and 6 feet from steam pipes.
- - - - - = Thermometer in an elevator boot on the floor in the center of the room.
—·—·— = Thermometer 4 inches in wheat on the floor in the center of the room.
Centigrade
38 37 36 35 34 33 32 31 30 29
Fahrenheit
100.4 98.6 96.8 95. 93.2 91.4 89.6 87.8 86. 84.2
10:00 10:30 11:00 11:30 12:00 12:30 1:00 1:30 2:00 2:30 3:00 3:30 4:00 4:30 5:00 5:30
A.M.
P.M.

Chart II

time the insects were placed in the incubator was 87°, or the same as the temperature of the place from which they were taken. The behavior of the various insects as the temperature gradually increased was most interesting. At 10.45 a. m., with a temperature of 95°, the larvæ and adults of *Tribolium confusum* began to appear uneasy, and their uneasiness increased rapidly with the rise of temperature. At 11.45 a. m. with a temperature of 99°, the adults of *Ephestia kuehniella* began to move and fly about with the same uneasiness. At 2.15 p. m. with a temperature of 110°, all stages of the different insects were most active and were making every effort to escape the heat. Even the pupæ were wriggling and struggling. At 3.45 p. m., with a temperature of 116.5°, the first adult of *Ephestia kuehniella* died, and at 4.30 p. m., with a temperature of 118.5°, all the moths were dead, and a few of the adults and larvæ of *Tribolium confusum*. At 5.15 p. m., with a temperature of 121°, all of the *Silvanus surinamensis* were dead, but two adults and five larvæ of *Tribolium confusum* were alive. At 5.30 p. m., with a temperature of 122°, two larvæ of *Tribolium confusum* were still alive, but these died eleven minutes later at a temperature of 122.5°. In this experiment fifteen insects of each stage were used. (Chart I.)

The Heat Method Put to a Test in a Modern Mill

Since the laboratory experiments demonstrated that this class of insects could be destroyed at a temperature not beyond that which could actually be produced within a modern mill, a flour mill was selected for a practical test. This mill had heavy brick walls and tight wooden floors. It had no basement, was four stories high, all stories were heated with steam, and were well filled with machinery. The packers, elevator boots, and pulley machinery were on the first floor; the rolls were on the second floor, and the purifiers, sifters, and bolters were on the third and fourth floors. It had a daily capacity of 600 barrels, and in its construction represented the average modern mill in the state of Kansas. The first floor, 38 feet wide, 63 feet long, and 12 feet high, with a capacity of 28,728 cu. ft., was heated by eight one and one-half-inch steam pipes, the radiating surface of which was 515 sq. ft. These pipes were arranged in eight coils near the ceiling along the two sides and across one end of the room. The pipes were placed near the ceiling in order not to obstruct the doorways. The second floor, the capacity of which was the same as that of the first, had one coil less of the steam pipes with a radiating surface of 450 sq. ft., but these seven coils were placed near the floor along the side walls and across one end. The third floor which was

13 feet high and with a capacity of 31,122 cu. ft. had six coils with a radiating surface of 386 sq. ft., and these were placed the same as those on the second floor. The fourth floor which was 18 feet high and with a capacity of 43,092 cu. ft., had only five coils with a radiating surface of 322 sq. ft. These pipes were arranged like those on the second and third floors.

TABLE SHOWING THE DIMENSIONS AND HEATING SYSTEM OF THE MILL

Floor	Dimensions	Capacity in cu. ft.	No. of coils of steam pipes	Diam. of steam pipes (in.)	Linear feet of steam pipes	Radiating surface of steam pipes (sq. ft.)	Location of steam pipes	Remarks
1	38 x 63 x 12	28,728	8	1½	1,312	514.96	Near ceiling	
2	38 x 63 x 12	28,728	7	1½	1,148	450.59	Near floor	There were no steam pipes across one end of each floor
3	38 x 63 x 13	31,122	6	1½	948	386.22	Near floor	
4	38 x 63 x 18	43,092	5	1½	820	321.85	Near floor	
	Total	131,670	26		4,264	1,673.62		

This mill was badly infested with all stages of *Tribolium confusum*, and slightly infested with several of the other common mill insects. In the first experiment no change of any sort was made in the heating system. Four thermometers were distributed on each floor in such a manner as to get the temperature not only in the open, but in different depths of flour, and in accumulations in different parts of the room. At 10 o'clock a. m., August 21, with the mill just as it had been shut down for Sunday, the steam was turned into the pipes, and since this mill was ordinarily heated with exhaust steam, the live steam had to be forced through the exhaust pipe, which prevented it from having more than two or three pounds pressure. The heat was applied from 10 a. m. to 5.30 p. m., and the temperatures of all the thermometers noted at intervals of every half hour. Although the day was very warm, reaching a maximum temperature of 95°, and the average temperature of the mill before the heat was applied was 89°, yet the mill did not heat rapidly, and by 5 o'clock there were only two or three places in the mill where a fatal temperature had been reached. On the first floor the highest temperature was 100.4°, while one thermometer in the bottom of an elevator boot registered only 94°.

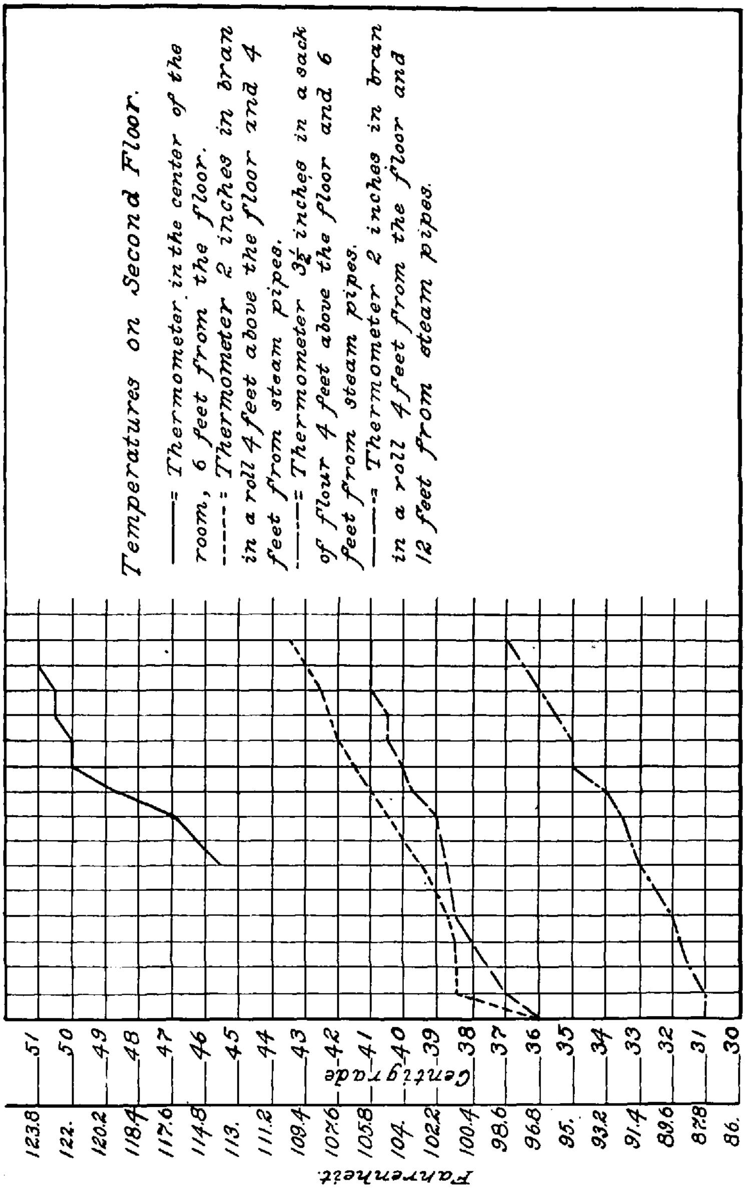

Temperatures on Second Floor.
——= Thermometer in the center of the room, 6 feet from the floor.
-----= Thermometer 2 inches in bran in a roll 4 feet above the floor and 4 feet from steam pipes.
-·-·-= Thermometer 3½ inches in a sack of flour 4 feet above the floor and 6 feet from steam pipes.
-··-= Thermometer 2 inches in bran in a roll 4 feet from the floor and 12 feet from steam pipes.
Fahrenheit
Centigrade
10:00
10:30
11:00
11:30
12:00
12:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
A.M.
P.M.

Chart III

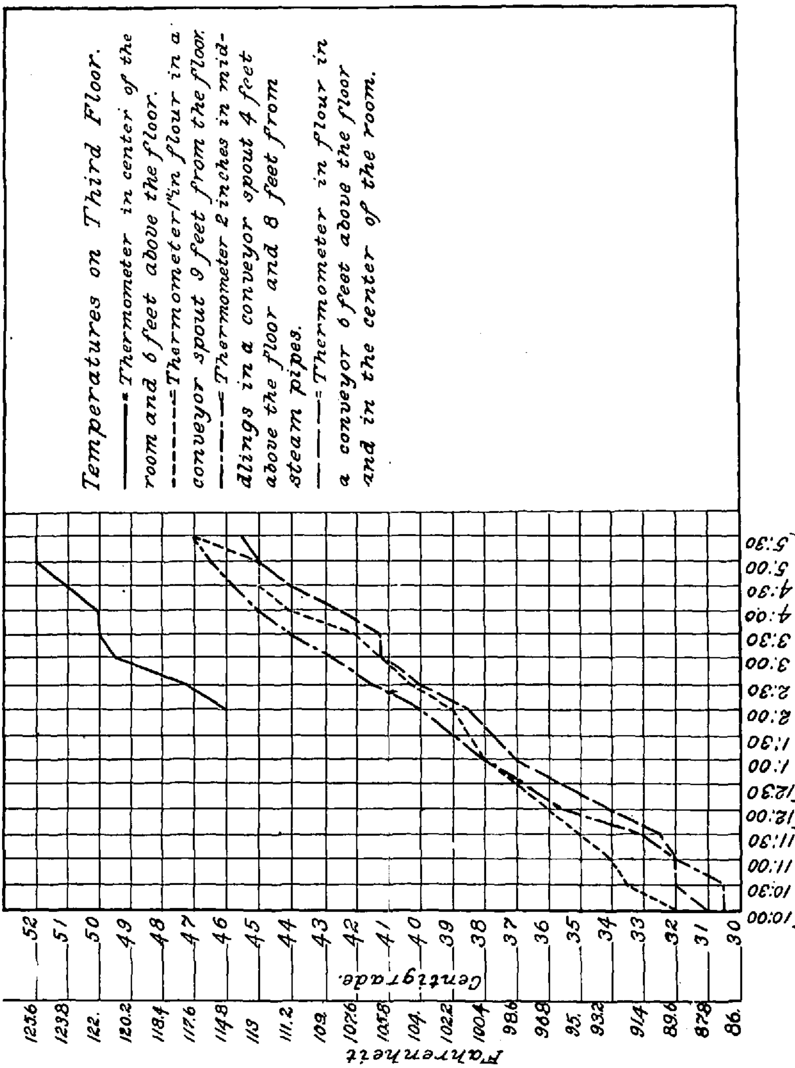

Temperatures on Third Floor.
——= Thermometer in center of the room and 6 feet above the floor.
------= Thermometer ½ in flour in a conveyor spout 9 feet from the floor.
—·—·= Thermometer 2 inches in middlings in a conveyor spout 4 feet above the floor and 8 feet from steam pipes.
— — —= Thermometer in flour in a conveyor 6 feet above the floor and in the center of the room.
Centigrade.
Fahrenheit
A.M.
P.M.
10:00
10:30
11:00
11:30
12:00
12:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30

Chart IV

(Chart II.) On the second floor the highest temperature, 123.8°, was registered by the thermometer hanging in the open, while the lowest temperature, 98.6°, was registered by a thermometer three and one-half inches in a sack of flour four feet above the floor. (Chart III.) On the third floor the thermometer in the open registered 125.6°, and the lowest temperature, 114°, was registered in a flour conveyor six feet above the floor. (Chart IV.) On the fourth floor the thermometer in the open registered 118.4°, and the lowest temperature, 107.6°, was registered by the thermometer two inches in flour in a conveyor near the floor. (Chart V.)

A hydrograph was placed on the second floor in the middle of the room. The relative humidity of this floor at 10 a. m., or just as the heat was applied was 93 per cent. From 10 a. m. to 12 m. there was a rapid decrease to 40 per cent, and from 12 m. to 5.30 p. m. there was a gradual decrease to 27 per cent.

Although the temperatures reached were disappointing, and no insects were killed on the first floor, yet on the third floor fully one third of the insects perished, and on the fourth floor about one fourth succumbed to the heat. Even the second floor showed that many insects had perished. The experiment proved the following: More time must be taken to reach the desired temperature; this temperature should be held several hours to allow the heat to penetrate all of the infested parts; there should be a water trap to draw off the water accumulated in the steam pipes; the steam should be turned on with some pressure so as to heat the mill more rapidly; the steam pipes should be near the floor in order to heat the room.

In the second experiment, made three weeks later, two changes were made in the heating system. A water trap was attached and arrangement made to turn the steam on directly and with pressure. The arrangement of the pipes in the mill was not altered. At 6 a. m., September 11, the mill was shut down and, after the thermometers were distributed as in the first experiment, the steam was turned on with ten to twelve pounds pressure. The heat was applied from 6 a. m., until 6 a. m. the day following, and the temperature of the sixteen thermometers noted at intervals of every half hour, save in a few cases when the readings were made at intervals of one hour. The average temperature in the mill at the time the heat was applied was about 90°, and the mean temperature during the day outside of the mill was 77°.

In nearly all parts of the mill the temperatures gradually increased, and at 3 o'clock p. m. fatal temperatures were reached in several parts. At 6 o'clock p. m. many of the insects had perished. At 9 o'clock p. m. fatal temperatures were indicated by nearly all the thermometers except on the first floor. However, realizing that it required time to heat through heavy machinery and to penetrate into several inches of flour, the heat was continued until 6 a. m., by which time it had penetrated the innermost recesses of the mill, save the first floor. On the first floor the highest temperature was 105°, while one thermometer in four inches of wheat near the floor registered only 96°. (Chart VI.) On the second floor the highest temperature, 133.5°, was registered by a thermometer hanging in the open, while the lowest temperature, 117.6°, was registered by a thermometer three inches in a sack of flour three feet above the floor. (Chart VII.) On the third floor the thermometer in the open registered 141°, and the lowest temperature, 129°, was registered in a flour conveyor spout four feet above the floor. (Chart VIII.) On the fourth floor the thermometer in the open registered 128.6°, and the lowest temperature, 118°, was registered by a thermometer in flour in a conveyor six feet above the floor. (Chart IX.)

The hydrograph was placed on the second floor in the middle of the room. The relative humidity of this floor at 6 a. m., or just as the heat was applied, was about 72 per cent. During the first few hours there was a rapid decrease to less than 40 per cent, and during the afternoon and through the entire night there was a very gradual decrease to 12 per cent.

After a very careful examination of the three upper floors, all parts of the mill, even the deepest accumulations in the most inaccessible parts, failed to show live insects, save in one corner on the upper floor. In several places where there were accumulations inaccessible to hydrocyanic acid gas, the conveyor or the bins were torn open, and after being carefully inspected, did not reveal a live insect, but showed that thousands had perished. In a sample room on the third floor there were hundreds of samples of grain in paper and cloth bags, tin cans, and sealed glass jars. These were badly infested; but all of the insects were killed by the heat. On the fourth floor there was a large flour conveyor running the entire length of the mill, and in this conveyor the accumulation of flour which was from three to five inches in depth was badly infested, but, after tearing it open from one end almost to the other, it was found that all of the insects had perished. Nearly three weeks later a second examination was made of the mill and no live insects of any sort were found above the first story.

In a mill, flour accumulates in recesses, and insects breed in places inaccessible to the gas or vapor of any fumigating material, but heat passes through all of these obstructions and penetrates the innermost recesses. The writer has fumigated many mills with hydrocyanic acid gas, but in no case has the fumigation proved so successful as

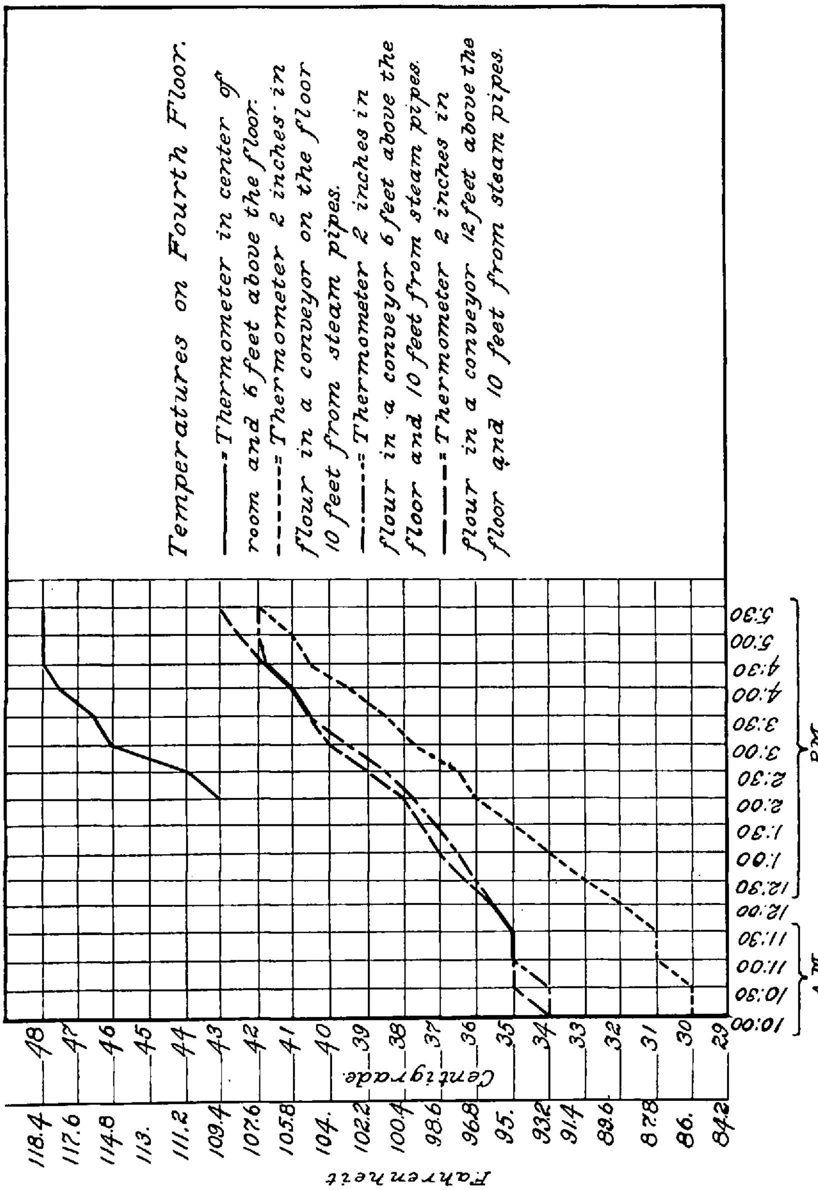

Temperatures on Fourth Floor.
——— = Thermometer in center of room and 6 feet above the floor.
- - - - - = Thermometer 2 inches in flour in a conveyor on the floor 10 feet from steam pipes.
—·—·— = Thermometer 2 inches in flour in a conveyor 6 feet above the floor and 10 feet from steam pipes.
— — — = Thermometer 2 inches in flour in a conveyor 12 feet above the floor and 10 feet from steam pipes.
Centigrade
Fahrenheit
A.M.
P.M.

Chart V

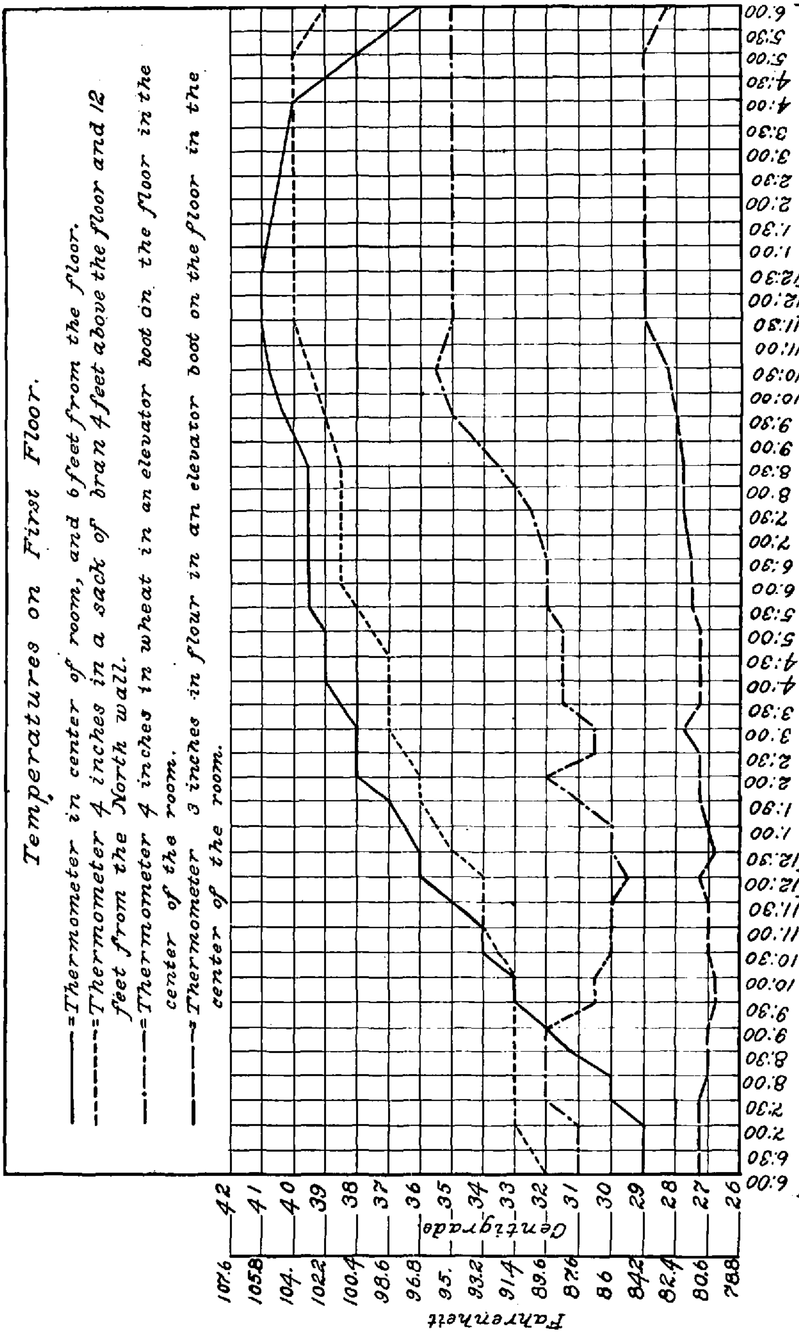

Temperatures on First Floor.
——— = Thermometer in center of room, and 6 feet from the floor.
- - - - = Thermometer 4 inches in a sack of bran 4 feet above the floor and 12 feet from the North wall.
—·—·— = Thermometer 4 inches in wheat in an elevator boot on the floor in the center of the room.
— — — = Thermometer 3 inches in flour in an elevator boot on the floor in the center of the room.
Centigrade
Fahrenheit
A.M.
P.M.
A.M.

Chart VI

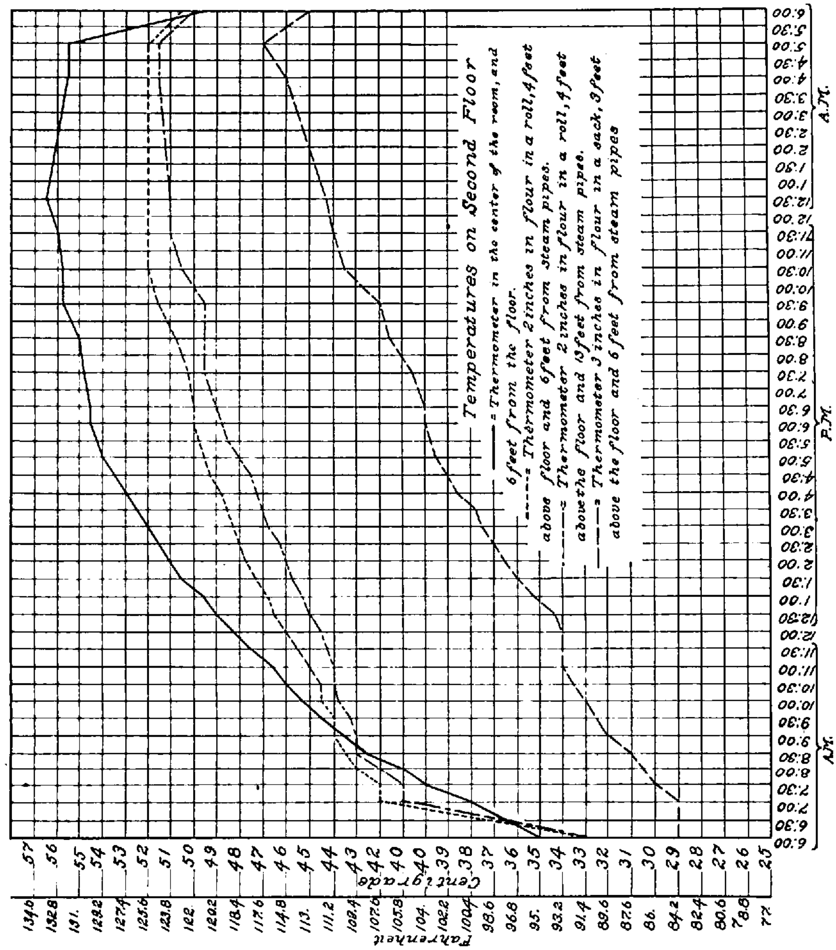

Temperatures on Second Floor
— = Thermometer in the center of the room, and 6 feet from the floor.
- - - = Thermometer 2 inches in flour in a roll, 4 feet above floor and 6 feet from steam pipes.
- · - · = Thermometer 2 inches in flour in a roll, 4 feet above the floor and 13 feet from steam pipes.
— - — = Thermometer 3 inches in flour in a sack, 3 feet above the floor and 6 feet from steam pipes
Centigrade
Fahrenheit
A.M.
P.M.

Chart VII

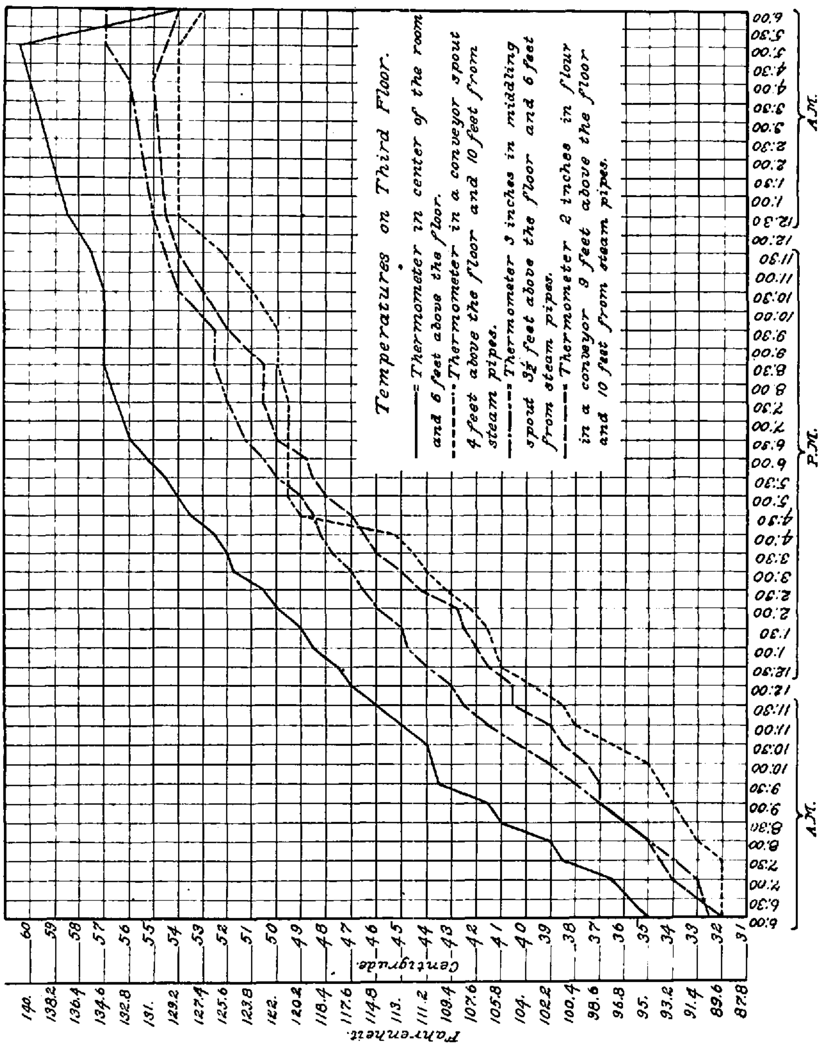

Temperatures on Third Floor.
——— = Thermometer in center of the room and 6 feet above the floor.
- - - - - = Thermometer in a conveyor spout 4 feet above the floor and 10 feet from steam pipes.
—·—·— = Thermometer 3 inches in middling spout 3½ feet above the floor and 6 feet from steam pipes.
— — — = Thermometer 2 inches in flour in a conveyor 9 feet above the floor and 10 feet from steam pipes.
Centigrade.
Fahrenheit.
A.M.
P.M.
A.M.

Chart VIII

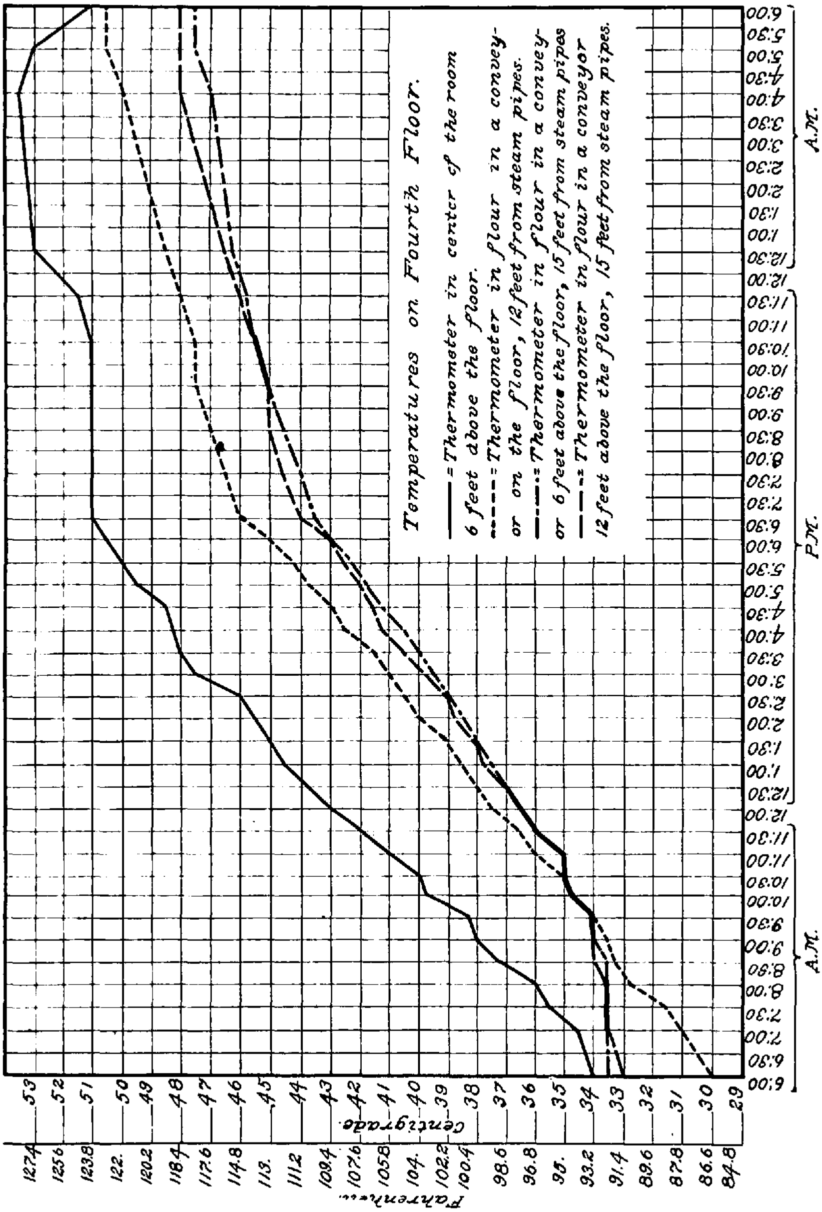

Temperatures on Fourth Floor.
——— = Thermometer in center of the room 6 feet above the floor.
- - - - = Thermometer in flour in a conveyor on the floor, 12 feet from steam pipes.
—·—· = Thermometer in flour in a conveyor 6 feet above the floor, 15 feet from steam pipes
— — = Thermometer in flour in a conveyor 12 feet above the floor, 15 feet from steam pipes.
A.M.
P.M.
A.M.
Centigrade
Fahrenheit

Chart IX

the heating of this mill, and in this case with a few alterations in the arrangement of the steam pipes, and with some additional radiating surface, this would be the most efficient, convenient, and least expensive method. To fumigate with hydrocyanic acid gas, requires from two to three days, and this long shut-down; with the additional cost of material, is a large item of expense besides being dangerous to the life of the operator, while with the heat, since it can be applied from Sunday morning until Monday morning, there is no loss of time, very little expense, and no danger to the life of the operator.

President Sanderson: Any discussion?

Mr. Washburn: You do not mention anything about the eggs of *Ephestia*.

Mr. Dean: This mill was not infested with the Mediterranean flour moth.

Mr. Washburn: But you do not know whether you can free a mill of eggs by this method.

Mr. Dean: Since this mill showed no live insects three weeks later, I believe all eggs were killed in the upper stories.

Mr. Washburn: Then there are enough eggs in the lower story to restock the entire mill.

Mr. Dean: The point is this, Professor Washburn, if those pipes had gone down to the lower floor we could have had as high temperatures there as on the upper floors.

Mr. Washburn: Have you tried it in the winter time in Kansas?

Mr. Dean: No. In the second experiment the temperature was 77° outside.

Mr. Washburn: My point is this, with the method of piping in a mill, that in the winter it would be hard to get the temperatures required in the lower stories.

Mr. Dean: All the mills would have to put in more radiation, but that would cost less than shutting down for fumigation two or three days.

Mr. Washburn: In fumigating with hydrocyanic acid gas they only shut down from Saturday night to Sunday morning. They do it when they are cleaning the mill, and part of the cleaning process with many millers is fumigating with hydrocyanic acid gas.

A Member: I find that the employees in mills undertake fumigation with hesitancy.

Mr. Dean: I have heard men state that they would quit the job before they would touch it. In the case of fumigation the mill has to be cleaned out, and prepared for fumigation, but with this other method it is not necessary to clean out the accumulations and some millers state that they would rather spend $2,000 or $3,000 for heating apparatus than to spend $500 or $600 every year for fumigation.

MR. WASHBURN: It seems to me that this is a most excellent paper. At the same time I do not see how they estimate the expense of fumigating at such a high figure because the material is not very expensive.

MR. DEAN: When you use 1,500 pounds of cyanide the material counts up, to say nothing of the two or three days shut down.

MR. WASHBURN: In Canada in a very large mill, we used a ton of material, but even that expense would have been trebled if they had to pipe the mill. Of course, if you can reach *Tribolium* buried two, or three, or four inches in flour, you have done a good work. The gas would not go through a sack of bran.

MR. DEAN: They removed a large roll and the insects were killed in the accumulation back of the machinery which was two inches thick.

MR. WASHBURN: Some millers have a wrong idea as to hydrocyanic acid gas. I have run to earth four or five stories of men killed by accident. One or two men have been killed by bisulfid of carbon, but I have yet to find a single individual killed by hydrocyanic acid gas. Several men, to my knowledge, use this once or twice a year, when they clean, but they never successfully reach *Tribolium*, that insect is so insidious, and if heat will do it, it is a good thing.

MR. HEADLEE: I cannot forbear raising the question as to whether, if the mills are tight and properly heated during the summer season, and all the insects killed, there would be any necessity for heating during the winter.

MR. LOWE: The point which interested me particularly in this paper presented by Mr. Dean, is the fact that the insects were killed in the sealed container. I have a mill and big seed store placed at my disposal, and I have been experimenting with a new product which we have, but have not obtained any good results, particularly in the spouts, and in the inaccessible parts, but I shall now test the idea Mr. Dean has brought out and hope by our next meeting to bring some corroborative results.

MR. WASHBURN: I would like to ask Mr. Dean if this method will kill the eggs.

MR. DEAN: In the experiments in the laboratory where it required from 8 in the morning until 5 o'clock in the afternoon to reach the high temperature, we had eggs and larvæ, and the eggs perished before the larvæ. Eggs subjected to a temperature of 120° for fifteen minutes were killed. It takes a longer time to penetrate mill products.

MR. WASHBURN: I was thinking of the spouts, elevators, etc.

Mr. Dean: If the egg is subjected to a temperature of 120° it perishes in a short time.

Mr. Washburn: No injury to mill products?

Mr. Dean: None.

Mr. Lowe: Do the insects leave the flour when they are about to die?

Mr. Dean: I will say this, I saw a great many dead insects on the floor. They became uncomfortable and rushed out into the hot air. They did not get far and never reached the window and many times did not go four or five inches.

Mr. Smith: This promises to be a very beneficial and useful method, and it occurs to me that in large stores which frequently have insect pests, if this method was available it would be a blessing, especially to tobacco factories and the like. I should like to ask Mr. Dean if he has made any experiments outside of mills, and on other insects.

Mr. Dean: The experiment was tried only on the five mill insects stated in the paper. Of course, these experiments are going to be continued.

Mr. Sanborn: I would like to ask Mr. Dean if he thinks this method might not be of considerable importance in the treatment of nursery stock for San José scale.

Mr. Dean: I can say nothing definite on this phase of the subject, but simply make the assumption that I cannot believe any insect is going to stand very much heat.

Mr. Shafer: I think the last statement by Mr. Dean is very true. In histology one of the very best methods of fixing insects is by heat. You can fix the parts of an insect quicker by heat, perhaps, than by any other method that has yet been found. If you go above 150° you get the tissues fixed all the way through and if you do that, of course, you kill the insect. Another point, in regard to the penetration of hydrocyanic acid gas: In the work we had to do with that gas we had a little thing come up, which shows why the gas does not penetrate. I took the percentage of gas in a certain amount of air at the beginning of the experiment, and at the end and found the last precentage of the gas very low. It would fall very rapidly, and if I had 77 per cent in a half hour it might fall to 5 per cent, that is the gas was reducing rapidly—the higher precentage of gas the more rapidly it would fall. Now, if you had some substance like flour which contains moisture, it would be taken up by that moisture, and I think these two reasons would account for the fact that the gas does not penetrate. In the case of carbon bisulfid my experience has been that it does not reduce at all, and I believe, if given time, it would go through.

Mr. Smith: I think that every person who has been West knows that there are some spots on the Pacific coast where it is so hot that it actually bakes the scales on the trees.

Mr. Sanders: I would like to ask Mr. Dean if he has had any objection from millers in respect to danger from fire.

Mr. Dean: I will state that where this experiment was conducted there was one of the most intelligent millers I ever met, and it was his opinion that you could go up to 150° or 160° without danger. No oil waste should be left in the mill. You do not have to go up to a temperature of 150°,—130° is plenty high enough.

Mr. Washburn: You would have to convince the insurance company, probably, that there was no danger. They refuse to allow the use of carbon bisulfid, and I suppose they would possibly object to heat.

Mr. Dean: As you say, there is a chance for an objection there, but we can easily prove what the combustion point is. Carbon bisulfid is out of the question in a mill. It does not go up where the flour moth is. With hydrocyanic acid gas in the laboratory we killed the eggs in three inches of flour by subjecting them to the same strength as in the mill, but at three and a half inches some escaped. The larvæ of Tribolium perished at four inches.

President Sanderson: I should like to ask Mr. Dean if he has looked into the matter as to whether these insects exist in the mills in southern Arizona.

Mr. Dean: I have not investigated that at all, but I do not know of any mills in Arizona.

President Sanderson: I am sure we have all been intensely interested in this paper. It is particularly so to me, and I am sure that if heat will destroy these insects, it will destroy others. We will now have a paper by Mr. S. J. Hunter.

THE GRIESA RESEARCH FELLOWSHIP IN ENTOMOLOGY AT THE UNIVERSITY OF KANSAS

An Announcement by S. J. Hunter

Mr. W. S. Griesa, proprietor of Mt. Hope Nurseries, Lawrence, Kan., has established the Griesa Research Fellowship in Entomology in memory of his father, the late A. C. Griesa. In establishing this fellowship it was the wish of the founder that the holder should devote himself to a fundamental investigation of one of the several entomological problems ever present with nurserymen.