M.S. THESIS

Relation between Quantity of Manure
and Soil Temperature
Electrical Temperature Measurement

FRANK A. SPRAGG

1906

M. S. THESIS.

The Relation Between Quantity of Manure, and Soil Temperature.

Electrical Temperature Measurement.

by

Frank A. Spragg.

1906

Contents.

Introductory.

This investigation started with the spring term of 1905. It has been a gradual unfolding from beginning to end. Prof. Jeffery had tried the ordinary thermometers and methods of reading temperature in trying to carry out this investigation for a number of years, but found them too slow and very unsatisfactory. The first task was to select a method. Mr. H. L. Curtis had been using an electric method depending upon the principle of the thermopyle, to measure the waves of temperature through snow. This plan was adopted for this work and a series of readings was taken in May and June. Many apparently unaccountable variations crept in and made them unsatisfactory. It was evident that the method was not under perfect control. The connections showed a constantly varying resistance, all the thermo-couples were not at known temperatures; and it was found difficult to maintain a constant freezing point.

The fall term was spent experimenting on method and in scanning the electrical and physical literature in the library for ideas. Mr. Curtis referred us to an article (See page 65, Vol. XXI of the Physical Review) that helped greatly. During Christmas Holidays, a method was developed that was found reliable when reading to twentieths of a degree Fahrenheit. With it, 40 readings can be made in 45 minutes. This is but little over one minute to a reading. The ordinary glass thermometer takes five minutes and then only reads to half degrees. This electrical method is therefore five times as rapid and ten times as accurate.

Knowing that the heat produced in fermenting manure comes from the bodies of bacteria, it was desired to know how many bacteria were present in fresh horse manure, and how many at the end of 7 days and 14 days. When a chemist wishes to determine the sugar content of a plant, he determines the moisture in a part of the pulp and analyzes some juice pressed from the remainder. For every gram of moisture present, the plant contained a cubic centimeter of juice. Then with the percent of sugar in the juice known, he is able to compute the percent of sugar in the plant. It was in just this way that it was undertaken to determine the germ content of horse manure.

A lot of horse manure was obtained from the stable fresh. Some of it was taken to determine moisture. Out of another portion, through a steril cloth into a steamed dish, some of the juice was pressed out. Accurate dilutions of this juice was made by the same means as employed in bacterial water analysis. The dilutions used were: 1 to 100,000, 1 to 1,000,000, and 1 to 10,000,000. One cubic centimeter was plated out from each dilution in duplicate. As each germ produces a colony, the colonies were counted when large enough, and from this data the number of germs in a cubic centimeter of the original extract was computed. With the moisture content known, it was possible to compute the number of germs in a gram and from this the number in a pound of the horse manure.

A jar was filled with manure, like that used in the first determination. It was covered to prevent excessive evaporation, and allowed to ferment. At the end of 7 days and at the end of 14 days, the moisture was determined, similar counts were made, and the bacterial content computed.

The number of germs found in a pound of the fresh manure, if placed side by side, would make a tape 1/5000 of an inch wide and 17 miles long. By the end of a week, the number of bacteria in a pound would make a similar tape 21.65 miles long. During the second week, the death rate was so great that the living bacteria at the end would make a similar tape only 2.13 miles long.

These results were checked up in another way. Another lot of the same fresh horse manure was put in a jar, a thermometer inserted, and covered with air-dry soil to prevent evaporation. The temperature was read from day to day. It started from room temperature and rose approximately 2.5 degrees centigrade each day for four days. The temperature was then about stationary for a few days, and by the end of the second week was back nearly to room temperature. This very nicely confirms the results of the counts, and emphasizes the importance of using fresh manure if an increase of temperature is desired.

Side Lights.

A soil may obtain heat,(1) by the direct absorption of the sun's rays, (2) by warm water passing down into it, and (3) by changes that result in the decay of organic matter in the soil. In the last case the same quantity of heat is developed as though the material had been burned in the fire, for really, it is a fire. It is the oxidation of this organic matter in the bodies of multitudes of bacteria. A soil may lose temperature, (1) by radiation, (2) by conduction, and (3) by the evaporation of water from its surface.

In each experiment in this investigation, a soil in good tilth was used, containing, as near as can be judged, the proper amounts of air and moisture for maximum plant growth. The object is to determine the effect of different quantities of manure on the temperature of the soil, where the land is plowed six inches deep and the manure is well mixed with the soil. The jars used were six inches deep and eleven inches inside diameter. The soil was placed in these jars and treated with different quantities of manure, in proportion to tons per acre. The surface of a jar equalled .659954 square feet or .00001515 of an acre. Five tons are equal to 10,000 pounds. A jar that represents this amount must therefore contain .1515 pounds of manure. This manure was carefully mixed with the whole. A Thermo-couple was then planted so that the junction was not far from half the distance between the surface and the bottom of the jar. The soil was carefully packed around the glass tube through which the wires passed out. The surface of the soil was frequently cultivated, to produce a dust blanket and prevent evaporation, thus reducing the loss of heat. We wished to determine whether the heat generated by fermentation maintains a perceptibly higher temperature.

As we approach a consideration of the soil, we must think of it as a laboratory through which the material and forces of nature pass. In order that this laboratory may do its best work in supplying food for the plant, it needs a sufficient supply of raw material; it requires physical properties that will supply proper amounts of air and moisture and retain proper temperatures; and besides these it must have millions upon millions of the right kind of workers. These workers are microscopic organisms, and while they are digesting the raw material for the use of plants, they give off heat. If it were not for them, manure would lie in the soil unchanged and the present investigation could show no increase of temperature.

Prof. F. H. King states that "the nitrates of a soil do not develope until the temperature has risen above 41° F.; the action of the germs is extremely feeble at 54°; and they do not attain their maximum activity until a soil temperature of 98° has been reached." In another place under the head of "Best Soil Temperature for Germination", he gives a table of observed temperatures and remarks; "The two important facts fixed by these data are: (1) The soil temperature at which the seeds of most cultivated crops germinate best lie between 70° and 100° F. with an average of about 85° F. (2) The soil temperature below which germination does not take place are between 41° and 54° F." From this data, we see that when we get a soil temperature that will allow plants to grow, the workers of our "soil laboratory" begin to produce food for those plants. It is also evident that the temperatures for most rapid growth is much higher than we ordinarily get.

Some claim that by the addition of manure, crops, for example corn, can be grown on land that would otherwise be too cold. It is true in the case of the hot-bed. Is it true under field conditions? There appears to be almost no investigation along this line. Prof. King thinks that it is true, but he has probably not investigated it himself.

The agricultural literature of the library, has been searched for any investigation along this line. The Experiment Station Record appears to be silent on the subject. All that has been found is contained in pages 148-151 of Warington's "Physical Properties of the Soil". Half of this is hot-bed investigation. The only experiment directly on this subject was carried on by "Georgeson at the Imperial College at Tokota". The boxes, filled with his mixture, were set down in the soil. No mention is made of his running duplicates or repeating his experiment to verify results. His readings were probably made with a glass thermometer, inserted for each reading. Prof. Jeffery gave up that plan after two or three years of investigation here at the college. He found that the glass thermometer, that had to be inserted for each reading, was so slow and the sun changed the temperature of the plot so rapidly that it was not possible to reach definite and accurate conclusions.

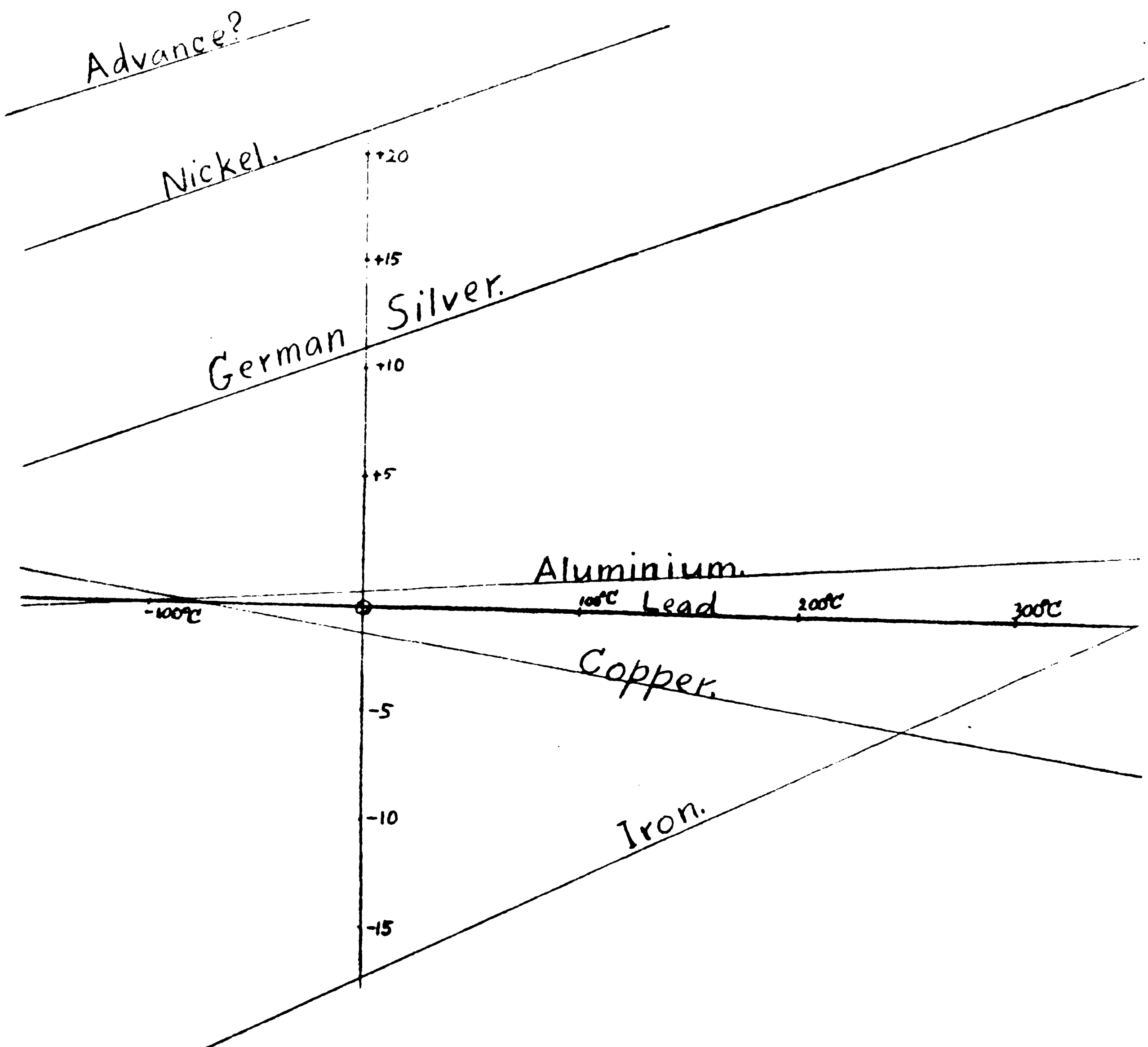
The Thermoelectric Couple.

Volta's law teaches that there is a contact difference of potential between two metals. This force lies dormant in an insulating medium like air, but manifests itself as current when those metals are plunged into an electrolyte, as sulphuric acid. This contact potential difference varies with temperature. The amount of variation for one degree is known as the thermoelectric power of those metals at that temperature. Thus at 18° the contact potential difference between iron and copper, is 146,000 microvolts, but at 18° the thermoelectric power of these metals is -13.7 microvolts. Therefore at 19° their contact potential difference would be 146,000 -13.7

microvolts, or at 20° 146,000 -27.4 microvolts.

Volta's law further teaches us that no current flows through a circuit of dissimilar metals when all the junctions are at the same temperature. In 1821 Seebeck found that a current flows in such a circuit, when one of the junctions differs in temperature from the other or others. Thus if a closed circuit be formed of iron and copper wires, one couple being at 18° and the other at 19°, the potential difference between the couples we have seen would be 13.7 microvolts. This would cause a current flow between the couples.

Cumming (1823) observed that an increasing the mean temperature, even with a constant temperature-difference, the potential difference between the junctions decreases, becomes zero, and finally increases in the other direction. Thus the thermoelectric power of copper and iron, which has been seen to be 13.7 microvolts at 19°, disappears at 274.5°. At higher temperatures, their relative position is reversed, the iron being now positive to the copper. If the temperature of one of the couples be 530° and the other 19°, their potential difference will be equal and opposite, and their algebraic sum will be zero. No current will flow. A temperature like 274.5°, at which the thermoelectric power of two metals disappears, is called the neutral point. In a thermoelectric diagram, lead is considered the axis of x. The thermoelectric powers with respect to lead, given in microvolts, are represented as ordinates and the temperatures as abscissas. All the metals are represented as straight lines. The points at which they cross each other and the lead line are the neutral points. At a given temperature, the algebraic difference of ordinates of two metals gives their thermoelectric power, or the potential difference for one degree. In order to find the total potential difference of two couples at different temperatures, it is only necessary to multiply their difference of temperature by the thermoelectric power of their mean temperature.



Thermoelectric Thermometer.

In this work, the "contact potential difference" lies dormant, as each couple is surrounded by an insolator or at least a medium that does not act upon it chemically. Use is however made of the "thermoelectric power". As this varies with the elements selected for the couple, the aim has been to select two that would be as far apart potentially as possible and yet be practical and obtainable at reasonable prices. Iron has been used as one of the elements throughout the investigation. In the preliminary experiment conducted in the spring of 1905, German-silver was the other element. In this kind of work, the Germans have gotten their best results with an alloy known as constantan. Constantan has two advantages over German-silver. (a) It is further from iron potentially, and (b) when iron-constantan couples are used, the curve between centimeters on the scale and temperature is nearly a straight line. On investigation, it was not found possible to obtain constantan in this country. A firm down in New Jersey makes wire that they call "advance". It has similar thermoelectric properties to constantan. During the fall of 1905 Mr. H. L. Curtis obtained some of this "advance" for his work and kindly let us have some. It was used in our later work.

For the elements of the couples, it is necessary that the wires be as near homogeneous as possible. An electromotive force may be generated at two dissimilar parts of the same wire. Outside of the temperature couples, there should be as few changes of metal as possible. Each change of metal constitutes a couple, and if they are at uncertain temperatures, parasitic electromotive forces are set up.

In a circuit including several different junctions, the total electromotive force is equal to their algebraic sum. In a closed circuit, there is produced a current equal to the quotient of the resultant electromotive force by the resistance. As we have seen above, in order to get a current, we must have couples at different temperature, They should be at definite temperatures. Freezing point is convenient for the cold junctions. Then the other junction may be at the temperature being measured. Into this circuit is then introduced a sensitive galvanometer and the thermoelectric thermometer is complete.

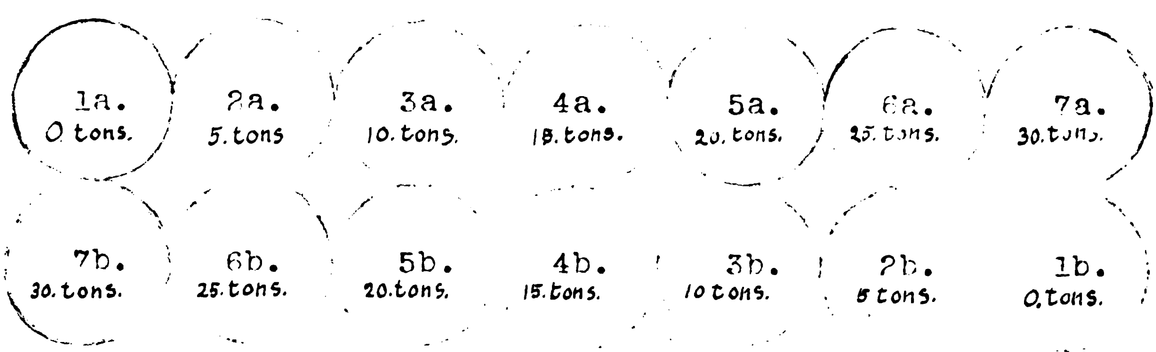
The most convenient form of galvanometer has a powerful permanent magnet, between whose poles is suspended a moveable coil through which the current passes. The metalic suspending wires are parts of the circuit, and the swinging parts carry a mirror to reflect some part of a stationary scale through a telescope. As the mirror swings, different parts of the scale are indicated, and the cross-hairs in the telescope allow fine reading.

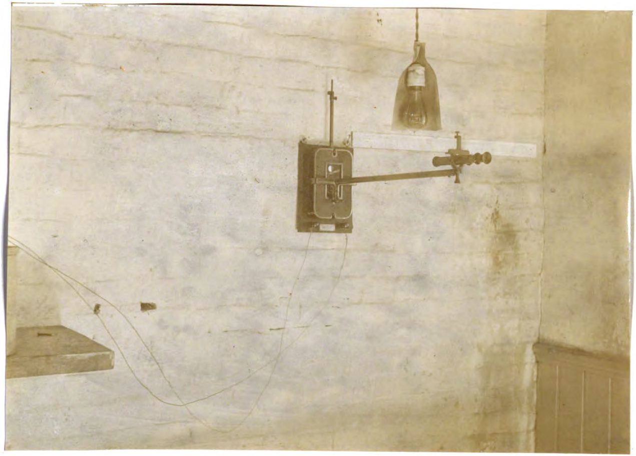
In order to do accurate work, the following points should be looked into. The moveable coil should be of German-silver or other low-temperature-coefficient wire, and should have a resistance of about 200 ohms. The coil must swing free. Not even filaments of silk, which stand out from the insolating covering of the metalic wires, should be allowed to rub on the poles of the magnet. The suspending wires must not be twisted. If they are, the zero point will be moveable. The suspending wires must also have a high elastic limit. For that it is necessary

that the metal should be hardened. German-silver is very commonly used. Phosphor-bronze also gives good results. When the poles of the galvanometer are connected by a short piece of copper wire, there should be no deflection. If a deflection is noticed in this way, it indicates that the instrument itself contains powerful thermoelectric couples and is of little or no value in this class of work. Finally, but not least, the instrument must be installed on a firm support. Very slight jars will swing the coil and make the readings uncertain.

Preliminary Experiment. (Spring 1905)

In this experiment, 14 jars were used. There were two jars with no manure, two with the equivalent of five tons to the acre, two with a ten tons equivalent, and so on down to the two jars containing an amount equal to a dressing of thirty tons to the acre. These jars were arranged on the floor in two rows, in such a manner as to place the duplicates as far apart as possible. At the opening of the experiment, each jar contained on an average of 3.37 pounds of moisture. A dust blanket was maintained on the surface, yet during the experiment they lost on an average .74 pounds of moisture. The following is the arrangement on the floor.



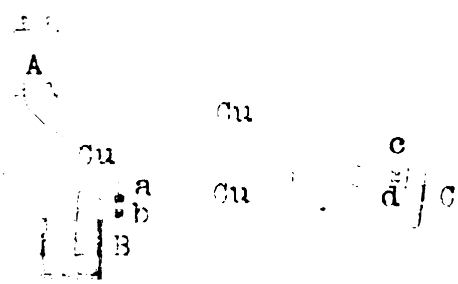


The Galvanometer and Scale.

A Thermoelectric Couple.

Couple in the Soil with Connections.

The principles and theory of the thermoelectric couple have been given. Mr. H. L. Curtis of the Physics Department had been using this method for the measurement of temperature in snow. He kindly gave us the general principles and lent us a galvanometer. He has also been very kind in making suggestions from time to time. Using iron and German-silver as the elements of the couples, we set up the apparatus according to the following diagram only that the line wires were vastly longer.



A is the galvanometer. B is a dish containing a mixture of ice and water surrounding the freezing-point or reference couple. C is a thermoelectric couple, placed in the soil. a, b, c, and d are mercury cups, used as connections. The line wires were all of copper.

In the light of the data given on bottom of page 9, it is evident that this method is defective. It contains two junctions of copper with iron and two junctions of copper with German-silver in the air at uncertain temperatures. In all the later work, the line wires were made of the same material as the elements of the couples to which they are attached, and where a couple existed in the air it was balanced by another like couple at the same temperature.

As this experiment was the beginning, many stumbling blocks naturally came in the way and had to be overcome by later work. During the experiment, it was found difficult to get the ends of the wires amalgamated, and on this account a varying resistance was introduced at the mercury connections. In later work, it was found that by coating the tips of the wires with solder they were then easily amalgamated, with acid and mercury. Throughout the entire investigation, the freezing point has been used as the point of reference, but in the preliminary experiment, no reliable method was discovered for maintaining a constant absolute freezing point. Two freshly mixed lots of ice and water may easily be a degree apart. In such a mixture, the ice is always below freezing and the water above. This difficulty was temporarily overcome by boring a hole in a block of ice and surrounding the thermoelectric couple with the water in this hole. The block of ice soon melted away and left things as bad as ever. In later work, it was found that the different couples gave slightly different reading at the same temperature and had to be standardized, or the relation between them determined. This was not discovered in the preliminary experiment.

Using the method as outlined above, the following readings were taken in centimeters of deflection. Usually two series were taken, the one just after the other and in the reverse order. The average between these were then recorded as below.

1 st. period.

Date	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27
1 a.	12.25	12.14	11.04	10.60	10.17	9.69	8.60	11.58	11.46	10.31
1 b.	11.95	11.78	10.89	10.70	10.00	9.52	8.23	11.40	11.16	10.60
2 a.	12.15	12.05	10.93	10.60	10.19	9.80	8.24	11.68	11.58	10.30
2 b.	11.85	11.84	10.97	10.70	9.96	9.30	8.30	11.50	11.18	10.24
3 a.	11.70	11.97	10.83	10.76	10.20	9.63	8.48	11.68	11.45	10.26
3 b.	11.92	11.87	11.02	10.73	9.73	9.70	8.72	11.59	11.30	10.37
4 a.	11.75	11.91	10.85	10.67	9.86	9.60	8.43	11.67	11.42	10.28
4 b.	11.90	11.94	11.01	10.81	10.03	9.72	8.57	11.63	11.43	10.30
5 a.	11.45	11.92	10.85	10.45	10.14	9.52	8.40	11.70	11.35	10.33
5 b.	11.80	12.02	11.15	10.95	10.14	9.93	8.80	11.63	11.53	10.44
6 a.	12.10	12.01	11.95	10.81	10.19	9.50	8.20	11.72	11.34	10.32
6 b.	12.20	12.11	11.29	11.03	10.21	10.40	8.90	11.70	11.63	10.47
7 a.	12.25	12.04	11.06	11.80	10.30	9.54	8.07	11.71	11.39	10.24
7 b.	12.40	12.22	11.43	11.33	10.29	10.19	9.10	11.80	11.70	10,50

Second period.

	5/29	5/30	5/31	6/1	6/2	6/3	6/5	6/6	6/7	6/8
1a.	11.50	11.50	11.69	11.30	11.67	11.70	12.29	13.30	12.66	11.98
1b.	11.30	11.20	11.18	10.96	11.5	11.22	12.13	13.25	12.50	11.56
2a.	11.51	11.54	11.65	11.31	11.67	11.57	12.25	13.28	12.61	11.95
2b.	11.39	11.28	11.18	11.00	11.53	11.24	12.11	13.20	12.50	11.61
3a.	11.56	11.50	11.56	11.29	11.67	11.42	12.20	13.30	12.60	11.86
3b.	11.38	11.38	11.18	11.10	11.60	11.24	12.11	13.20	12.58	11.67
4a.	11.55	11.52	11.45	11.28	11.68	11.38	12.17	13.18	12.60	11.85
4b.	11.41	11.48	11.26	11.12	11.60	11.26	12.09	13.00	12.62	11.74
5a.	11.55	11.51	11.43	11.24	11.68	11.38	12.18	13.30	12.58	11.73
5b.	11.48	11.55	11.38	11.22	11.68	11.29	12.12	13.35	12.67	11.89
6a.	11.47	11.48	11.40	11.24	11.68	11.38	12.23	13.32	12.60	11.71
6b.	11.54	11.58	11.48	11.32	11.77	11.44	12.21	13.35	12.70	11.93
7a.	11.49	11.41	11.40	11.17	11.70	11.39	12.37	13.21	12.65	11.62
7b.	11.59	11.72	11.62	11.42	11.88	11.44	12.30	13.36	12.77	12.01

On account of the light from a window passing diagonally across the block of jars, and because of other influences, it was found necessary to correct all the readings according to position, i.e. to determine what the temperature of each jar would have been, if it had occupied the position of some particular jar. This was determined in the following way, and computed for each period separately. The average difference between a pair of check jars gave us the difference of temperature in those jars "according to position". This was determined for each pair, and after a study of the sources of temperature radiated from the outside, it was possible to determine the average amount that each jar was warmer or colder than 4b, taken as the point of reference. Beginning with the correction for 1a, and giving them in the order that the jars are given in the table, the corrections for the first period are as follows:- -.12, .04, -.10, .08, -.09, .01, -.08, 0, -.04, -.04, 0, .08, .04, and -.12. The corresponding corrections for the second period, given in the same order, are: -.20, .07, -.17, .06, .14, .01, -.11, 0, 0, -.01, .04, -.04, .07 and -.07. The readings in the table

"Corrected according to Position" vary from the original readings by these amounts.

Corrected According to Position. (1st period)

Date	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27
1a.	12.13	12.02	10.90	10.48	10.05	9.57	8.48	11.46	11.34	10.19
1b.	11.99	11.82	10.93	10.74	10.04	9.56	8.27	11.44	11.20	10.64
2a.	12.05	11.95	10.83	10.50	10.09	9.70	8.14	11.58	11.48	10.20
2b.	11.88	11.87	11.00	10.73	9.99	9.33	8.33	11.53	11.21	10.27
3a.	11.61	11.88	10.74	10.65	10.11	9.54	8.39	11.59	11.36	10.17
3b.	11.93	11.88	11.03	10.74	9.74	9.71	8.73	11.60	11.31	10.38
4a.	11.67	11.83	10.77	10.59	9.78	9.52	8.35	11.59	11.54	10.20
4b.	11.90	11.94	11.01	10.81	10.03	9.72	8.57	11.63	11.43	10.30
5a.	11.41	11.88	10.81	10.41	10.10	9.48	8.36	11.66	11.31	10.29
5b.	11.76	11.98	11.11	10.91	10.10	9.89	8.76	11.59	11.49	10.40
6a.	12.10	12.01	11.95	10.81	10.19	9.50	8.20	11.72	11.34	10.32
6b.	12.02	12.03	11.21	10.95	10.13	10.32	8.82	11.62	11.54	10.89
7a.	12.29	12.08	11.10	10.84	10.34	9.58	8.11	11.74	11.41	10.28
7b.	12.28	12.10	11.31	11.21	10.17	10.07	8.98	11.68	11.58	10.38

Corrected According to Position. (Second period)

Date	5/29	5/30	5/31	6/1	6/2	6/3	6/5	6/6	6/7	6/8
1a.	11.30	11.30	11.49	11.10	11.47	11.50	12.09	13.10	12.46	11.78
1b.	11.37	11.27	11.25	11.03	11.65	11.29	12.20	13.32	12.57	11.63
2a.	11.34	11.37	11.48	11.14	11.50	11.40	12.08	13.11	12.44	11.78
2b.	11.45	11.34	11.24	11.06	11.59	11.30	12.17	13.26	12.56	11.67
3a.	11.42	11.36	11.42	11.15	11.53	11.28	12.06	13.16	12.46	11.72
3b.	11.39	11.39	11.20	11.11	11.61	11.25	11.12	13.21	12.59	11.68
4a.	11.44	11.31	11.34	11.17	11.57	11.27	12.06	13.07	12.49	11.74
4b.	11.41	11.48	11.26	11.12	11.20	11.26	12.09	13.00	12.62	11.74
5a.	11.55	11.51	11.43	11.24	11.68	11.38	12.18	13.30	12.58	11.73
5b.	11.47	11.44	11.38	11.21	11.68	11.28	12.11	13.34	12.66	11.88
6a.	11.51	11.52	11.44	11.28	11.72	11.42	12.27	13.36	12.64	11.75
6b.	11.50	11.54	11.44	11.28	11.73	11.40	12.17	13.31	12.66	11.89
7a.	11.56	11.48	11.47	11.24	11.74	11.46	12.34	13.28	12.72	11.69
7b.	11.52	1 .65	11.55	11.35	11.81	11.37	12.23	13.29	12.70	11.94

The columns for the different days differ considerably, in some cases. But, that is to be expected, as the mean temperature of the different days are sure to differ. What we are concerned with primarily, is the relation of the figures in a column, and whether the presence of manure causes a higher temperature to be maintained. One of the most apparent things about the figures in this preliminary experiment is the way in which they vary. We have applied corrections that these readings may be on the same basis with regard to heat radiated from the outside, but it does not appear to have improved matters. We had a sensitive instrument, and the telescope made it possible to read to a tenth of a millimeter, yet the method as used in this experiment has been shown to be defective. One of two things is evident. Either the temperatures are continually changing and do not conform to any definite law, or the apparatus as used did not read temperatures any more accurately than the common glass thermometer. The former is very improbable.

The following results are derived from the tables of corrected readings, by striking an average between those of the checks each day.

Total Average.

No.Tons.	5 tons.	10 tons.	15 tons.	20 tons.	25 tons.	30 tons.
12.06	11.96	11.77	11.78	11.78	12.11	12.28
11.92	11.91	11.88	11.88	11.93	12.02	12.09
10.92	10.91	10.88	10.89	10.96	11.58	11.20
10.61	10.61	10.69	10.70	10.66	10.88	11.02
10.04	10.04	9.92	9.90	10.10	10.16	10.25
9.56	9.51	9.62	9.62	9.68	9.91	9.82
8.37	8.23	8.56	8.46	8.56	8.52	8.54
11.45	11.55	11.59	11.61	11.62	11.67	11.71
11.27	11.34	11.33	11.48	11.40	11.44	11.49
10.42	10.23	10.27	10.25	10.34	11.35	11.33
11.33	11.39	11.40	11.42	11.51	11.50	11.54
11.28	11.35	11.37	11.44	11.47	11.53	11.56
11.37	11.36	11.31	11.30	11.40	11.44	11.52
11.06	11.10	11.13	11.14	11.22	11.28	11.29
11.56	11.54	11.57	11.38	11.68	11.72	11.77
11.39	11.35	11.26	11.26	11.33	11.41	11.41
12.14	12.14	12.09	12.07	12.14	12.22	12.28
13.21	13.18	13.18	13.03	13.32	13.33	13.28
12.51	12.50	15.52	12.55	12.62	12.65	12.71
11.70	11.72	11.70	11.74	11.80	11.82	11.83
224.17	223.92	224.04	223.90	225.32	228.5[illegible]	228.91
11.20	11.20	11.20	11.20	11.26	11.42	11.44
61.7° F	61.7°F.	61.7°F.	61.7°F.	61.9°F.	62.2°F.	62.3°F.

Below the line we have the total, the average readings in centimeters and the corresponding temperature. The corresponding temperatures were worked out for the entire range from freezing point up. They were determined for points about five degrees apart. In determining a point, a good glass thermometer and one of the couples were placed together in a well mixed lot of water so handled as to be of constant temperature for two or three minutes. During that time, the readings of galvanometer and of the glass thermometer were carefully taken. With this data at hand, a curve was plotted between centimeters of deflection and temperature on cross-section paper. The corresponding temperatures given above were taken from the curve.

In the later work, a temperature scale was worked out and the readings were temperatures.

These results show no rise of temperature due to the presence of five, ten or fifteen tons of fresh horse manure to the acre over that maintained by the soil that had no manure added to it. With quantities equal to twenty, twenty-five and thirty tons to the acre, there has been a slightly higher temperature maintained.

In the face of all imperfections, this experiment was an experience that made the following work possible. In itself, it is only valuable in so far as it confirms the later and more accurate work.

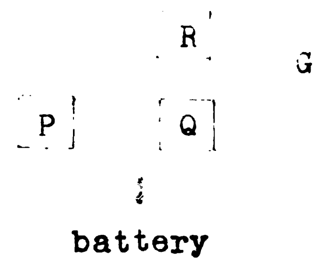
Perfecting the Method.

From the results of the preliminary experiment, it was evident that the method was not under perfect control. Accurate work must be done, and therefore the method must be perfected. Accordingly, our time for the next six months was employed in studying the method, and seeking to eliminate from our apparatus all factors of error. The result was the apparatus according to the following outline, going into use during the last week of 1905.

Our Apparatus.

The galvanometer used in the remainder of this investigation was manufactured by Leeds and Northrup Co., Philadelphia, Pa. It has an internal resistance of 134 ohms. This resistance is below the ideal, but as the instrument has been very carefully

made, no error was detected that could be assigned to low resistance. Its sensitiveness was tested as follows: The diagram shows the set up of apparatus. G is the galvanometer.



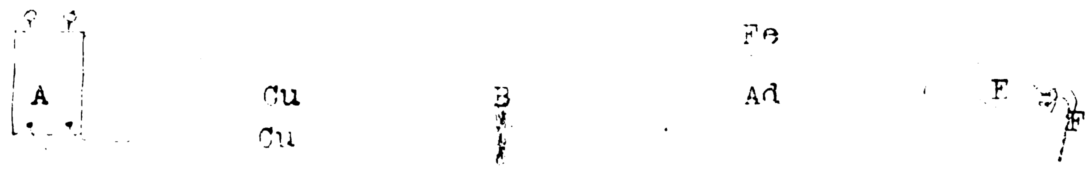
R is a constant additional resistance in the galvanometer circuit of 100,000 ohms. The battery had an internal E.M.F. of about two volts. P and Q were resistance boxes with P+Q always equal to 1,000 ohms. The scale on the galvanometer was set so that the zero point was exactly in the center and over the bar. The scale was then made rigidly perpendicular with the telescope. The parallax was marked out of the telescope, and the scale and telescope were together turned so that the mirror appeared exactly in the center when looking through the telescope. The suspension was now turned so that zero would coincide with the cross hairs in the telescope. Beginning with a resistance of 10 ohms in Q the resistance in Q was increased 10 ohms at each reading, also changing P so that P+Q was always equal to 1,000 ohms. The E.M.F. in the galvanometer circuit began with $\frac{Q}{P+Q}$ times 2 = .02 of a volt. In the following readings, it was multiplied by 2, 3, 4 etc. The results were:

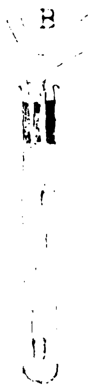
Resistance in Q	E.M.F.	Current strength.	Deflection.
10.	.02	.00000197	8.5 mm.
20.	.04	.00000394	17.0 "
30.	.06	.00000592	25.6 "
40.	.08	.00000789	33.8 "
50.	.10	.00000986	42.3 "
60.	.12	.00001184	50.9 "
70.	.14	.00001381	59.2 "
80.	.16	.00001578	67.7 "
90.	.18	.00001775	76.3 "
100.	.20	.00001972	84.9

A close examination of the readings shows that they do not vary more than .3 mm. from a regular series with 8.5 mm. as the difference. At 100 ohms resistance in Q, the reading is 84.9. This is almost exactly 10 times 8.5. The personal factor in reading may amount to as much as .3 mm. From these figures, it is seen that a current of .0000023 will move the swinging parts so as to indicate 1 mm. on the scale.

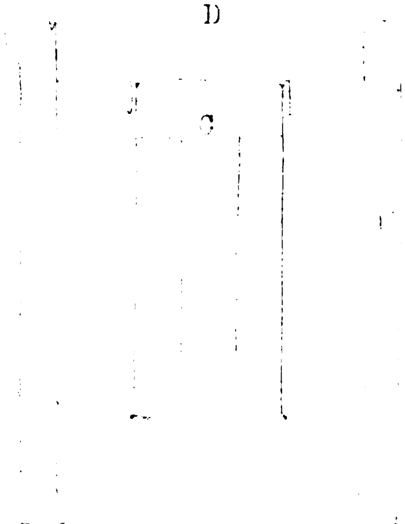
When it came time to calibrate the instrument, it was found that nearly the whole scale was needed to get the range of temperature desired. Taking out the lower suspending parts, the upper suspending wire with the swing parts were turned to the left 20 cm. on the scale. The lower suspending parts were then replaced and adjusted until the swinging parts were once more at 20. This took the twist out of the suspending parts, and gave us a zero at 20. This also gave a range on the temperature scale from freezing point to 87° F.

After the scale was worked out and the couples standardized, it was desired to determine thelimit of accuracy. The electric thermometer was then found sensitive to .02° F and reliable to .05° F. Then all the reading in the experiments that followed were taken, making no attempt to read closer than .05° F.





The arrangement of parts as finally adapted is according to the diagram, only that the line wires are vastly longer. A is the galvanometer. B is a test tube corked and filled with coal oil. C is a can having a cover fitting over it. It was filled nearly full of distilled water and frozen. Then a hole was melted out of the center of the ice with a hot iron, a little larger than the test tube B. The hole in the ice was filled with distilled water, the cover placed on the can, and the can packed in ice in the jar D. Any ice will do to pack the can in, as it simply keeps the distilled water ice on the inside from thawing out. The jar D can now be packed in a snow bank, if the experiment is running during the winter, or in the summer it may be packed in ice in a fiber pail and set in a well iced refrigerator when not in use. By this means, our standard freezing point is kept from day to day. When it comes time to take a set of readings, the jar is set on a shelf near the test tube B, which is always in the circuit. The lid is taken off the can, and B is inserted in the distilled water surrounded by distilled-water ice. It will now take 20 minutes for the kerosene in the tube to take the freezing point. (Our practice has been to set the couples before breakfast and take the readings after.)



It will be noticed that two thermocouples are located in B. The line wires from A to B are both copper. The intention here is to have the junctions with the galvanometer so related, that where there is a thermocouple giving a certain electromotive force, there will be another of equal power set against it, so that the resultant electromotive force will be zero. Then if the temperature of the different parts of the galvanometer is the same, there is no error from this source. At B, the end of one of the copper line wires is carefully twisted and soldered to the end of an iron line wire. The end of the other copper line wire is likewise secured to the end of an "advance" line wire. Through the cork in the test tube B, there are two glass tubes passing down into the coal oil. The copper-iron couple is passed down through one, and the copper-advance couple is passed down through the other. The wires in the tubes are held apart by slivers of wood, thus preventing any connection except at the soldered junctions. The iron and advance line wires have their other ends amalgamated, and dip into mercury cups on E. F is a thermocouple like those located in the experiment jars. The ends of the elements are carefully amalgamated and dip into the mercury cups. The iron line wire and iron element dip into the same cup, likewise the "advance" line wire and the "advance" element dip into the other mercury cup. By this means, two equal but opposite couples are produced in a mercury cup, and for example the electromotive force generated in the iron-mercury couple will be neutralized by that produced by the mercury-iron couple.

Considering the circuit as a whole, all the electromotive force that effects to produce current is generated by the temperature couple F, as contrasted with the two couples in B. Because the mercury cups are moved from place to place and connected up with one temperature couple at a time, the length of the line wires remain the same and therefore the resistance of the circuit is a constant. As the temperature of the couples in B is constant, the resultant electromotive force of the circuit depends solely upon the temperature of the temperature couple F, and since the current equals the E.M.F. divided by the resistance, the current is also dependent upon the temperature of F. The deflection of the galvanometer depends upon the current, and therefore depends entirely upon the temperature of the temperature couple.

Forty iron-advance couples were made each like any other, so far as could be told. To make a couple, about eight inches of iron and the same length of "advance" wire were taken. One end of each of the two wires were carefully twisted together and soldered. This junction was passed down through a four-inch piece of glass tube, so that the soldered junction was just outside. This end of the tube was filled with sealing wax. The wires in the tube were held apart by slivers of wood and the tube was filled with paraffin. The loose ends of the elements were bent so that, when the glass tube is inserted in the soil, the tips of the elements would be just right to dip into the mercury cups as described above. A glued strip of paper reached between the wires and held them at the right distance apart. The tips were now carefully amalgamated and the couple is finished.

The next task is to calibrate the instrument and determine the relationship between deflection and temperature. To do this, one of the couples was taken as a standard. It was put in water in a beaker which was surrounded by water, and with the thermocouple was placed the best glass thermometer in the laboratory. Before proceeding, the accuracy of this glass thermometer was tested. The temperature of the water in the beaker was so regulated as to be constant for two minutes, and during that time the deflection of the galvanometer was watched. In this way a definite galvanometer reading was obtained for temperatures about five degrees apart. If not certain, the experiment was repeated until sure of results. From these results, a curve was plotted between centimeters on the scale and temperature. With the curve and other data at hand, a temperature scale was made on a strip of drawing paper. This paper was then glued to a piece of wood of the same size as the original scale, and took its place on the galvanometer. Results were now checked by comparing these readings with those on our standard glass thermometer. When properly adjusted, the next step is to standardize the remaining 39 couples, i.e. to determine how much higher or lower a reading with one of them would be than with the couple originally taken as the standard. It was found that eight of the 40 couples were exactly together, and that the others needed slight corredtions. This correction was determined as follows: Twenty of the couples, including the standard, were placed in a jar of water at room temperature, and held in position by a large cork. The jar

was surrounded by water also at room temperature. Four series of temperatures were taken with this lot in the same order, and an average of the four readings was considered the temperature as indicated by each couple under question. The experiment was repeated with the remaining twenty couples and the standard. (21 couples) On another day when the room temperature was considerably different, the experiment was repeated to determine whether the correction was a constant at different temperatures. It was found to be practically so. For convenience, the correction was then placed on the paper portion of the couple. Then in the future when reading with one of these couples, the standardized reading could be obtained directly from the apparent reading.

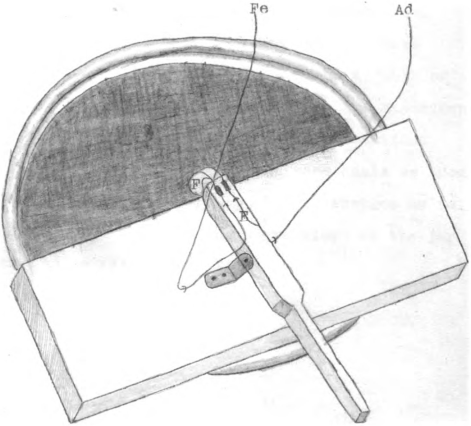


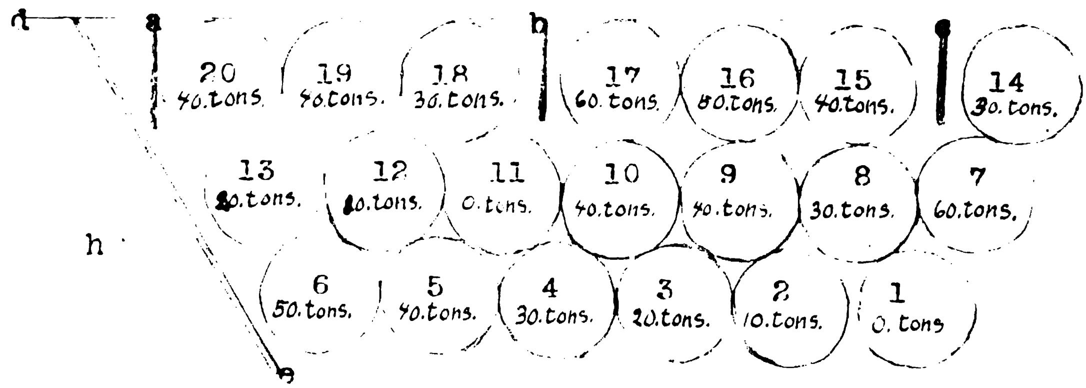
Table of Corrections.

No.	Cor.	No.	Cor.	No.	Cor.	No.	Cor.
1.	.0	11.	+.05	21.	-.25	31.	-.05
2.	-.1	12.	-.05	22.	-.05	32.	-.1
3.	+.1	13.	-.05	23.	-.15	33	+.15
4.	-.05	14.	.0	24.	-.25	34.	+.2
5.	.0	15.	-.35	25.	-.15	35.	+.05
6.	.0	16.	.0	26.	-.15	36.	-.15
7.	+.1	17.	-.05	27.	-.05	37.	-.1
8.	-.25	18.	-.2	28.	+.05	38.	+.15
9.	-.25	19.	.0	29.	-.05	39.	-.15
10.	+.05	20.	+.05	30	-.2	40.	.0

The corrections just given are expressed in degrees F. and carry the proper sign. No. 1. was taken as the standard couple and used to work out the temperature scale on the galvanometer. The readings of all other couples are referred to its readings, hence the corrections. It will be noticed that numbers 5, 6, 14, 16, 19 and 40 needed no correction. i.e. the temperatures indicated by them were the same as those indicated by No.1. On the other hand No. 2 reads a tenth of a degree too high. The standardized readings in the experiments that follow are the apparent readings with the corrections applied. That puts all the readings on the same basis as though they had been made by couple number one, but it enables us to have a couple in each jar that has the temperature of the jar at all times and can be read at any time.

Second Experiment.

In this and the following experiments, the measuring apparatus is as has just been outlined. The jars in this experiment were set on a basement floor against the wall.



d-d is the wall of the room. a, b and c are supports for a case of glassware. e is a window set on the floor on edge to shield the jars from the radiated heat of the steam pipes in the direction of h. The numbers of the jars in the diagram show the arrangement on the floor and will aid in explaining a number of points in the following tables. In this set there are ten different experiments. Jars 1 and 11, are duplicates and contain no manure. The numbers having the same unit's figure in each case are the duplicate jars.

After the jars were made up and the couples planted, a dust blanket was maintained on the surface to help in preventing evaporation and therefore loss of temperature.

General Conditions.

In this experiment, the weight of the soil was in each case eighteen pounds, and it contained 2.79 pounds of moisture per jar at the opening of the experiment. Horse manure was used. In all the jars except 9, 10, 19 and 20 it was fresh from the stables. In 9 and 19, the manure had been fermented 7 days, and in the case of 10 and 20 the manure had been allowed to ferment 14 days. The manure was mixed with the soil in all cases except 8 and 18. In these two cases it was put in a single layer just under the junction of the couple. The following table sets forth the other features.

No.	Wt. of jar.	Wt. of manure.	Tons per A.	Moisture in manure.	Total wt. of jar.	Total moisture.	Total wt. at end.	Loss of moisture.
1.	8.9	0.0	0.	0.00	26.9	2.79	25.50	1.40
2.	8.3	0.3	10.	0.22	26.6	3.01	25.00	1.60
3.	8.3	0.6	20.	0.45	26.9	3.24	24.85	2.05
4.	9.1	0.9	30.	0.67	22.0	3.46	26.10	1.90
5.	9.1	1.2	40.	0.80	28.3	3.68	26.30	2.00
6.	8.7	1.5	50.	1.12	28.2	3.91	26.00	2.20
7.	8.6	1.8	60.	1.34	28.4	4.13	26.40	2.00
8.	8.2	0.9	30.	0.67	27.1	3.46	25.65	1.45
9.	8.7	1.2	40.	0.91	27.9	3.70	26.25	1.65
10.	8.2	1.2	40.	2.76	27.4	3.55	25.70	1.70
11.	8.8	0.0	0.	0.00	26.8	2.79	25.40	1.40
12.	8.9	0.3	10.	0.22	27.2	3.01	25.55	1.65
13.	8.4	0.6	20.	0.45	27.0	3.24	25.25	1.75
14.	8.5	0.9	30.	0.67	27.4	3.46	25.75	1.65
15.	8.1	1.2	40.	0.87	27.3	3.68	25.4	1.90
16.	8.7	1.5	50.	1.12	28.2	3.91	26.3	1.90
17.	9.0	1.8	60.	1.34	28.8	4.13	26.85	1.95
18.	8.4	0.9	30.	0.67	27.3	3.46	25.80	1.50
19.	8.5	1.2	40.	0.91	27.7	3.70	26.00	1.70
20.	8.6	1.2	40.	0.76	27.8	3.55	26.25	1.55

Standardizied Readings. (First week)

No.	12/27/05	12/28/05	12/29/05	12/30/05	12/31/05
1.	70.80	69.40	70.95	73.10	71.90
2.	70.80	70.80	71.15	73.70	72.20
3.	70.95	71.00	71.25	74.10	72.30
4.	70.90	70.85	70.90	74.85	73.25
5.	70.85	70.75	70.80	75.15	73.70
6.	70.70	70.90	71.00	75.20	73.60
7.	73.60	73.40	73.25	73.70	72.25
8.	73.25	73.05	73.15	73,10	71.65
9.	71.55	71.70	72.50	72.95	71.35
10.	71.95	72.05	72.85	73.45	71.95
11.	70.85	70.75	71.30	72.75	71.35
12.	70.50	70.45	71.00	72.95	71.55
13.	70.60	70.55	71.15	73.45	71.75
14.	74.15	73.90	73.95	72.00	70.60
15.	73.70	73.40	73.50	72.45	70.85
16.	73.45	73.45	73.90	73.10	71.40
17.	74.55	72.70	74.30	73.20	71.50
18.	74.40	73.75	73.95	73.40	71.30
19.	70.95	72.30	72.75	72.65	71.10
20.	72.20	72.25	73.75	73.10	71.30

Second week.

No.	1/1/06	1/2/06	1/3/06	1/4/06	1/5/06	1/6/06	1/7/06
1.	73.00	72.90	75.30	71.75	70.95	70.70	71.50
2.	73.75	73.70	76.20	72.30	71.75	71.15	72.40
3.	73.75	73.70	76.70	71.90	71.40	71.65	72.50
4.	74.85	74.85	77.90	73.15	72.55	72.70	73.20
5.	75.35	75.20	78.30	73.50	72.75	72.85	73.30
6.	75.35	75.20	78.30	73.60	72.50	72.65	73.40
7.	73.60	73.40	75.70	72.40	71.10	70.75	71.30
8.	73.30	73.00	75.35	72.05	71.00	70.70	71.55
9.	72.70	72.75	75.20	72.25	71.05	70.75	71.55
10.	73.30	73.45	75.85	72.75	71.85	71.35	72.15
11.	72.90	72.95	75.55	73.25	71.25	71.15	71.85
12.	73.25	73.25	75.85	72.50	71.25	71.30	72.25
13.	73.65	73.65	76.55	72.65	71.35	71.35	72.15
14.	71.55	71.50	74.10	70.50	69.70	69.40	70.00
15.	71.70	71.95	74.35	70.65	69.75	69.70	70.15
16.	72.40	72.40	74.70	71.40	70.40	70.00	70.60
17.	72.75	72.75	75.05	71.90	70.85	70.40	70.85
18.	72.60	72.60	75.20	71.95	71.40	71.10	71.40
19.	72.55	72.80	75.30	72.40	71.75	71.10	71.20
20.	73.05	73.05	75.95	73.55	71.10	70.85	71.05

Standardized Readings.

Third Week.

No.	1/8/06	1/9/06	1/10/06	1/11/06	1/12/06	1/13/06	1/14/06
1.	73.75	69.50	69.10	70.60	73.40	72.95	74.00
2.	74.55	70.40	69.85	71.20	73.90	73.60	74.70
3.	74.90	70.40	69.80	71.60	74.60	74.05	75.35
4.	75.55	70.95	70.35	72.10	74.95	74.65	73.85
5.	75.90	71.05	70.30	72.25	75.30	74.95	76.24
6.	75.80	71.05	70.40	72.30	75.25	75.10	76.30
7.	73.70	69.50	69.20	70.35	73.00	72.75	73.70
8.	73.75	69.95	69.50	70.70	73.15	72.95	73.85
9.	73.65	69.95	69.60	70.45	72.95	72.95	73.75
10.	74.40	70.55	70.15	71.05	73.65	73.70	74.55
11.	74.00	70.15	69.55	70.95	73.55	73.35	74.35
12.	74.35	70.25	69.65	71.15	73.85	73.75	74.85
13.	74.60	69.65	69.30	71.20	74.15	73.85	75.25
14.	73.25	67.90	67.65	68.95	71.65	70.50	72.40
15.	72.55	68.35	67.85	69.30	71.75	70.85	72.35
16.	72.95	69.00	68.70	69.60	72.00	71.50	72.70
17.	73.30	69.35	69.05	69.85	72.15	71.80	72.95
18.	73.50	69.90	69.50	70.70	73.10	72.60	73.70
19.	73.50	69.75	69.50	70.40	72.80	72.65	73.70
20.	73.85	69.05	69.80	70.45	73.35	72.95	74.30

Fourth Week

No.	1/15/06	1/16/06	1/17/06	1/18/06	1/19/06	1/20/06	1/21/06
1.	75.10	72.90	73.10	72.45	72.15	75.20	
2.	75.40	73.30	73.60	73.00	72.70	75.70	
3.	76.35	73.75	73.95	73.40	73.20	76.30	
4.	76.75	74.00	74.35	73.70	73.55	76.65	
5.	77.15	74.25	74.60	73.90	73.80	77.05	
6.	77.25	74.40	74.65	74.00	73.80	77.15	
7.	74.60	72.60	72.80	73.30	71.80	74.65	
8.	74.55	72.85	73.05	72.50	72.05	74.65	
9.	74.25	72.65	72.90	72.50	72.00	74.80	
10.	75.05	73.30	73.70	73.25	72.70	73.35	
11.	75.05	73.10	73.35	72.85	72.50	75.30	
12.	75.50	73.45	73.60	73.15	72.85	75.65	
13.	76.05	73.45	73.35	73.10	72.90	76.05	
14.	73.50	71.40	71.50	71.05	70,65	73.45	
15.	73.30	71.55	71.65	71.25	70.85	73.30	
16.	73.40	71.80	71.90	71.60	71.20	73.65	
17.	73.50	71.95	72.15	71.90	71.25	73.85	
18.	74.30	72.80	72.80	72.60	72.05	74.65	
19.	74.30	72.75	72.80	72.50	72.05	74.70	
20.	75.05	72.75	72.60	72.50	72.25	73.25	

Standardized Readings.

Fifth Week.

No.	1/22/06	1/23/06	1/24/06	1/25/06	1/26/06	1/27/06	1/28/06
1.	79.10	76.60	74.10	73.10	73.85	73.55	75.10
2.	79.55	76.90	74.50	73.50	74.10	73.70	74.80
3.	80.10	77.30	74.85	73.90	74.65	74.15	75.70
4.	80.30	77.70	75.15	74.10	74.90	74.40	75.80
5.	80.80	77.90	75.35	74.25	75.10	74.70	76.20
6.	81.10	78.30	75.45	74.40	75.30	74.90	76.20
7.	78.40	76.45	73.70	72.50	73.30	72.95	74.10
8.	78.75	76.45	74.10	73.05	73.65	74.25	74.40
9.	78.50	76.45	74.10	73.00	73.70	73.05	74.05
10.	79.25	77.10	74.70	73.65	74.55	73.80	74.85
11.	79.10	76.75	74.45	73.55	74.25	73'80	75.10
12.	79.70	77.15	74.70	73.75	74.55	74.05	75.25
13.	79.95	77.40	74.65	73.75	74.80	74.05	73.35
14.	77.20	74.95	72.45	71.15	71.90	71.65	72.85
15.	77.35	75.20	72.75	71.75	72.30	71.65	72.75
16.	77.50	85.35	73.20	72.20	72.80	72.20	73.10
17.	77.65	75.75	73.45	72.40	73.10	72.35	73.35
18.	78.35	76.30	74.10	73.25	73.80	73.15	74.10
19.	78.55	76.50	74.00	73.15	73.80	73.25	74.15
20.	79.10	76.85	74.10	73.20	74.05	73.45	74.55

The readings just given are the actural temperatures at the center of each jar each day at about 7-30 A.M. They are in the rough, but a number of things can be observed from them as they are. The arrangement of the jars is given on page 27. It was noted that there is a radiation coming from the direction of "h". For this reason, the jars at this end of the line should be warmer. They are. If the increase of temperature was entirely due to increasing quantities of manure, No. 7 would be warmer than No. 6, and No. 14 would be warmer than No. 13. The reverse is true. The jars in the front row have two reasons for being continuously warmer, vis. increasing quantities of manure, and coming nearer the source of radiated heat. In the second row, 7 to 10 have irregular quantities of manure, but jar No. 11 has no manure. Although nearer the source of radiation, No. 11 is in general not warmer but colder than No. 10. This shows that there is an

influence due to the manure. In order to determine how great this effect is, it is first necessary to determine what the temperatures of the jars would have been could they have occupied the same position. This was worked out for each week, and No. 10 was taken as the point of reference. The average difference of temperature for the week between each pair of check jars was taken as the difference of temperature between them according to position. With this data, and the nearness to the source of radiation it is possible to find the average amount that each jar is warmer or colder than No. 10 during the week. When these corrections are applied to the "standardized readings" the results become those "corrected according to position".

Corrected According to Position.

First Week.

No.	12/27/05	12/28/05	12/29/05	12/30/05	12/31/05
1.	71.90	70.50	72.05	74.20	73.00
2.	71.45	71.45	71.80	74.35	72.85
3.	71.45	71.45	71.75	74.60	72.80
4.	71.20	71.15	71.20	75.15	73.65
5.	71.15	71.05	71.10	75.45	74.00
6.	70.95	71.15	71.25	75.45	73.85
7.	73.00	72.80	72.75	73.10	71.65
8.	72.85	72.65	72.75	72.70	71.25
9.	72.00	72.15	72.95	73.60	71.80
10.	71.95	72.05	72.85	73.45	71.95
11.	71.80	71.70	72.25	73.70	71.30
12.	71.60	71.55	72.10	74.05	72.65
13.	71.50	71.45	72.05	74.35	72.65
14.	73.70	73.45	73.50	71.55	70.15
15.	73.50	73.15	73.25	72.20	70.60
16.	72.90	72.90	73.35	72.55	71.15
17.	74.00	72.15	73.65	72.65	70.95
18.	73.50	73.85	73.05	72.50	70.40
19.	71.45	72.80	73.25	73.15	71.60
20.	72.35	72.40	72.90	73.25	71.45

Second Week.

No.	1/1/06	1/2/06	1/3/06	1/4/06	1/5/06	1/6/06	1/7/06
1.	73.15	73.05	75.45	71.90	71.10	70.85	71.65
2.	73.55	73.50	76.00	72.10	71.55	70.95	72.20
3.	73.55	73.50	76.50	71.70	71.20	71.45	72.30
4.	74.10	74.10	77.15	72.40	71.80	71.95	72.45
5.	75.60	74.45	77.55	72.75	72.00	72.10	72.55
6.	75.60	74.45	77.55	72.85	71.75	71.90	72.65
7.	74.90	74.70	77.00	73.70	72.40	72.05	72.60
8.	73.85	73.80	76.15	72.85	71.80	71.50	72.35
9.	73.00	73.05	75.50	72.55	71.35	71.05	71.85
10.	73.40	73.45	75.85	72.75	71.85	71.35	72.15
11.	72.90	72.95	75.55	72.25	71.25	71.15	71.85
12.	73.25	73.25	75.85	72.55	71.25	71.30	72.25
13.	73.45	73.45	76.35	72.45	71.15	71.15	71.95
14.	74.05	74.00	76.50	73.00	72.20	71.90	72.50
15.	73.80	74.05	76.45	72.75	71.85	71.80	72.20
16.	74.30	74.30	76.60	73.30	72.30	72.00	72.50
17.	74.35	74.35	76.65	72.50	72.45	72.00	72.45
18.	73.55	73.55	76.15	72.90	72.35	72.05	72.35
19.	72.90	73.15	75.65	72.75	72.10	71.45	71.55
20.	73.50	73.50	76.40	73.00	71.55	71.30	71.50

Third Week.

No.	1/8/06	1/9/06	1/10/06	1/11/06	1/12/06	1/13/06	1/14/06
1.	74.00	69.75	69.35	70.85	73.65	73.20	74.25
2.	74.25	70.10	69.55	70.90	73.60	73.30	74.40
3.	74.50	70.00	69.40	71.20	74.20	76.65	74.95
4.	74.70	70.10	69.50	71.25	74.10	73.80	75.00
5.	75.05	70.20	69.45	71.40	74.45	74.10	75.40
6.	75.15	70.50	69.85	71.75	74.70	74.55	75.75
7.	75.00	70.80	70.50	71.65	74.30	74.05	75.00
8.	74.55	70.75	70.70	71.50	73.95	73.75	74.65
9.	73.95	70.25	69.90	70.75	73.25	73.25	74.05
10.	74.40	70.55	70.15	71.05	73.65	70.70	74.55
11.	74.00	70.15	69.55	70.95	73.55	73.35	74.35
12.	74.10	70.00	69.40	70.90	73.60	73.50	74.60
13.	74.40	69.45	69.10	71.00	73.95	73.65	75.05
14.	74.60	70.25	70.00	71.30	74.00	72.85	74.75
15.	74.60	70.40	69.90	71.35	73.80	72.90	74.40
16.	74.60	70.65	70.35	71.25	73.65	73.15	74.35
17.	74.90	70.95	70.65	71.45	73.80	73.50	74.55
18.	74.45	70.85	70.45	71.65	74.05	73.65	74.65
19.	74.10	70.35	70.10	71.00	73.40	73.25	73.30
20.	74.30	69.50	70.25	70.90	74.80	73.40	74.75

Fourth Week.

No.	1/15/06	1/16/06	1/17/06	1/18/06	1/19/06	1/20/06	1/21/06
1.	75.25	73.05	73.25	72.60	72.30	75.35	
2.	75.20	73.10	73.40	72.80	72.50	75.50	
3.	75.95	73.35	73.55	73.00	72.80	75.90	
4.	76.15	73.40	73.75	73.10	72.95	76.05	
5.	76.40	73.50	73.85	73.15	73.05	76.30	
6.	76.50	73.65	73.90	73.25	73.05	76.40	
7.	75.95	73.95	74.15	73.65	73.15	76.00	
8.	75.60	73.90	74.10	73.55	73.10	75.70	
9.	74.80	73.20	73.45	73.05	72.55	75.35	
10.	75.05	73.30	73.70	73.25	72.70	75.35	
11.	75.00	73.05	73.30	72.80	72.45	75.25	
12.	75.45	73.45	73.55	73.10	72.80	75.60	
13.	76.00	73.40	73.30	73.05	72.85	76.00	
14.	75.85	73.75	73.85	73.40	73.00	75.80	
15.	75.70	73.95	74.05	73.65	73.25	75.70	
16.	75.60	74.00	74.10	73.80	73.40	75.85	
17.	75.55	74.00	74.20	73.95	73.30	75.90	
18.	75.40	73.90	73.90	73.70	73.15	75.75	
19.	74.80	73.55	73.30	73.00	72.55	75.20	
20.	75.50	73.20	73.05	72.95	72.70	75.70	

Fifth Week.

No.	1/22/06	1/23/06	1/24/06	1/25/06	1/26/06	1/27/06	1/28/06
1.	79.30	76.80	74.30	73.30	74.05	73.75	75.30
2.	79.50	76.85	74.45	73.45	74.05	73.65	74.75
3.	79.75	76.95	74.50	73.55	74.30	73.80	75.35
4.	79.75	77.15	74.60	73.65	74.35	73.85	75.25
5.	79.90	77.00	74.45	74.35	74.20	73.80	75.30
6.	80.15	77.35	74.50	73.45	74.35	73.95	75.25
7.	79.60	77.50	74.90	73.70	74.50	74.15	75.30
8.	79.90	77.60	75.25	74.20	74.80	74.40	75.55
9.	79.05	77.00	74.65	73.55	74.25	73.60	74.60
10.	79.25	77.10	74.70	73.65	74.55	73.80	74.85
11.	79.05	76.70	74.40	73.50	74.20	73.75	75.05
12.	79.35	76.80	74.35	73.40	74.10	73.70	74.90
13.	79.70	77.15	74.40	73.50	74.55	73.80	75.10
14.	79.50	77.25	74.75	73.45	74.20	73.95	75.15
15.	79.40	77.25	74.80	73.80	74.35	73.70	74.80
16.	79.30	77.15	75.00	74.00	74.60	74.00	74.90
17.	79.15	77.25	74.95	73.90	74.60	73.85	74.85
18.	79.35	77930	75.10	74.25	74.80	74.15	75.10
19.	79.00	76.95	74.45	73.60	74.25	73.70	74.60
20.	79.40	77.15	74.40	73.50	74.35	73.75	74.85

The temperatures just given are the calculated results that the jars should have shown if all parts of the room could have been constantly at the same temperature. Besides the constant influence due to the fermentation of the manure, there are a few irregularities due to accidental causes. To overcome these, an average is taken between the checks each day. Besides this, the average temperature of the jars as a whole varies from day to day. Now in order to get the average effect of the manure maintained throughout the experiment, a "total average" is struck. That is an average of the daily averages for each pair of jars.

In the table that follows, the results in a column are the daily averages of the corrected temperatures for the check jars at the head of the column. The first column at the left are the jars with no manure. Following are those with 10, 20, etc. tons per acre according to the experiment outlined on page 28.

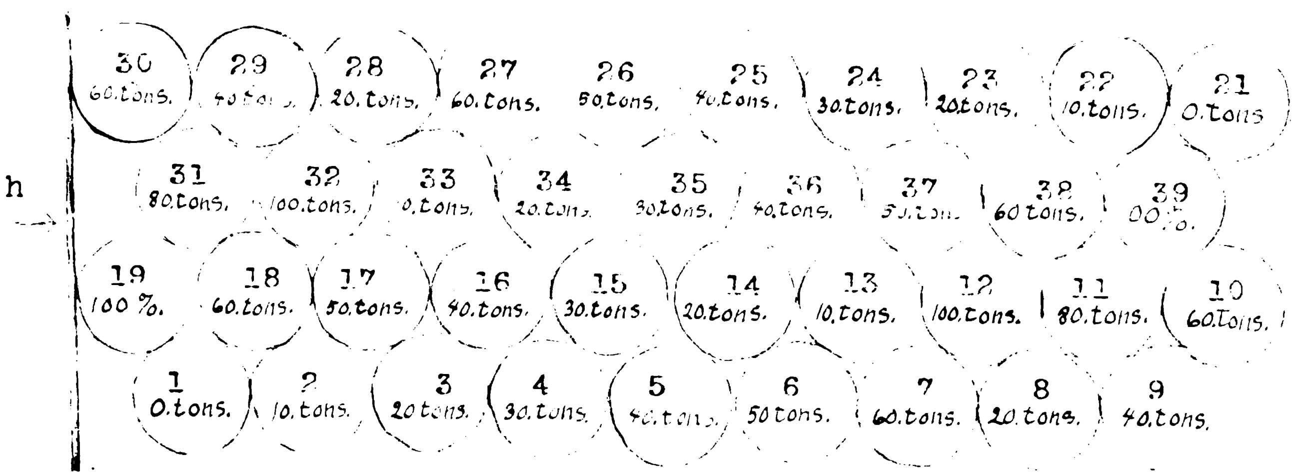
The results show: an increase of .15° F. for the first ten tons of fresh horse manure per acre, an increase of .1° F. for the fourth ten tons, and an increase of .05° F. for the sixth ten tons. Those seven columns represent conditions where the manure is mixed with the surface six inches. In the eighth column, we have thirty tons plowed under, and the results show it to be equal to forty tons mixed in. In the remaining two columns, the manure had been fermented 7 and 14 days before use. The results show the heating value of 40 tons to be less than that of twenty tons of fresh manure. This is also vividly shown in the introduction. The first eight columns all come from the same lot of manure. As the other two are collected at different times, they are different lots.

Total Average.

1 & 11	2&12	3&13	4&14	5&15	6&16	7&17	8&18	9&19	10&20
71.85	71.52	71.47	72.45	72.32	71.92	73.50	73.17	71.72	72.15
71.10	71.50	71.47	72.30	72.10	72.02	72.47	73.25	72.47	72.22
72.15	71.95	71.95	72.35	72.17	72.30	73.20	72.90	73.10	72.87
73.95	74.20	74.47	73.35	73.67	74.00	72.85	72.60	73.27	73.95
72.15	72.75	72.72	71.90	72.30	72.35	71.30	70.85	71.70	71.70
73.02	73.40	73.50	74.07	74.70	74.95	74.62	73.70	72.95	73.40
73.00	73.37	73.47	74.05	74.25	74.37	74.52	73.67	73.10	73.47
75.50	75.92	76.42	76.82	77.00	77.07	76.82	76.15	75.57	76.22
72.07	72.32	72.07	72.70	72.75	73.07	73.10	72.87	72.65	72.87
71.17	71.40	71.17	72.00	71.92	72.03	72.42	72.07	71.72	71.70
71.00	71.12	71.30	71.92	71.95	71.95	72.02	71.97	71.25	71.32
71.75	72.22	72.12	72.47	72.37	72.57	72.52	72.35	71.70	71.82
74.00	74.17	74.45	74.65	74.82	74.87	74.95	74.50	74.02	74.35
69.95	70.05	69.72	70.17	70.30	70.57	70.87	70.80	70.30	70.02
69.45	69.47	69.25	69'75	69.75	70.10	70.57	70.57	70.00	70.20
70.90	70.90	71.10	71.27	71.37	71.50	71.55	71.57	70.87	70.97
73.60	73.60	74.07	74.05	74.12	74.17	74.05	74.00	73.32	74.22
73.27	73.40	73.65	73.32	73.50	73.85	73.77	73.65	73.25	73.55
74.30	73.50	75.00	74.87	74.90	75.05	74.77	74.65	73.17	74.65
75.12	75.32	75.97	76.00	76.05	76.05	75.75	75.50	74.80	75.27
73.05	73.57	73.37	73.57	73.72	73.82	73.97	73.90	73.37	73.25
73.27	73.47	73.42	73.80	73.95	74.00	74.17	74.00	73.37	73.37
72.70	72.95	73.02	73.25	73.40	73.52	73.80	73.62	73.02	73.10
72.37	72.65	72.82	72.97	73.15	73.22	73.22	73.12	72.55	72.70
75.30	75.55	75.95	75.92	76.00	76.12	75.95	75.72	75.27	75.52
79.17	79.42	79.72	79.62	79.65	79.72	79.37	79.62	79.02	79.32
76.75	76.82	77.05	77.20	77.17	77.25	77.37	77.45	76.97	77.12
74.35	74.40	74.45	74.67	74.62	74.75	74.92	75.17	74.55	74.55
73.40	73.42	73.52	73.50	74.07	73.72	73.80	74.22	73.57	73.57
74.12	74.07	74.42	74.27	74.27	74.47	74.55	74.80	74.05	74.45
73.75	76.67	73.80	73.90	73.75	73.97	74.00	74.27	73.65	73.77
75.17	74.82	75.22	75.20	75.05	75.07	75.07	75.32	74.60	74.85
2342.70	2347.59	2352.05	2358.33	2361.08	2364.38	2365.83	2361.77	2348.17	2351.89
73.21	73.36	73.50	73.69	73.78	73.88	73.93	73.80	73.38	73.59

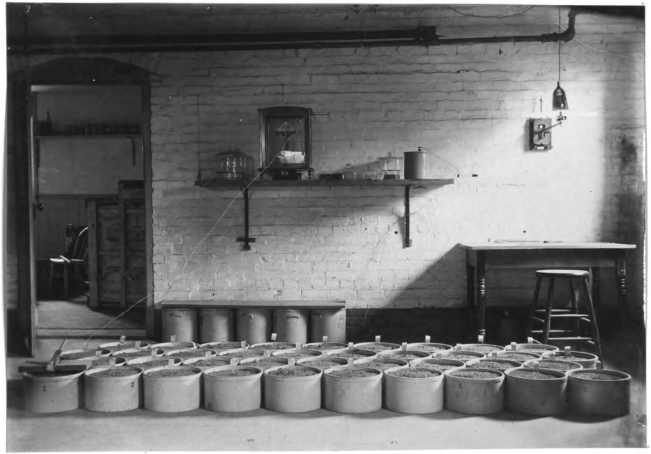
Third Experiment.

With the exception of numbers 20 and 40, all the thermocouples that were originally made up were put into use. This experiment is really three being run at the same time. The one is on horse manure, a second on cow manure, and a third on sheep manure. The numbers of the check jars differ from one another by twenty. Nos. 1 and 21 are the jars with no manure. Following comes 10 to 60 tons of fresh horse manure per acre. Then comes 20 to 100 tons of fresh cow manure per acre. Following comes 10 to 60 tons of fresh sheep manure per acre. The last jar in each series, namely 19 and 39, are straight cow manure covered over with a little dust to lessen evaporation.



The above is the arrangement of the jars on the floor, being set out as near the center of the room as possible, but still receiving radiated heat from the direction of h. It will be noticed that the arrangement places the check jars as far apart as possible and therefore gives a basis for determining differences of temperature on account of position. The table that follows sets forth the other features of the experiment.

The method and steps for the caluclation of results are the same as was used in the last experiment, and therefore are not outlined here.



Full set-up in Third Experiment.

Conditions at Opening of Experiment. (2/8/06)

No.	Wt. of jar.	Wt. of soil.	Wt. of Manure.	Tons per A.	Kind of manure.	Total Wt. of jar.	Moisture in soil.	Moisture in manure.
1.	8.85	19.0	0.0	0.0	Horse	27.85	2.34	0.0
2.	8.3	18.7	0.3	10.	"	27.30	2.30	0.22
3.	8.3	18.4	0,6	20.	"	27.30	2.26	0.43
4.	9.0	18.1	0.9	30.	"	28.00	2.22	0.65
5.	9.0	17.8	1.2	40.	"	28.00	2.19	0.87
6.	8.55	17.5	1.5	50.	"	27.55	2.15	1.09
7.	8.60	17,2	1.8	60.	"	27.25	2.11	1.31
8.	8.25	18.4	0.6	20	Cow	27.25	2.26	0.50
9.	8.60	17.8	1.2	40.	"	27.60	2.19	1.00
10.	8.25	17.2	1.8	60.	"	27.25	2.11	1.51
11.	8.70	17.60	2.4	80.	"	27.70	2.04	2.01
12.	8.90	16.0	3.0	100.	"	27.90	1.96	2.51
13.	8.25	18.7	0.3	10.	Sheep	27.25	2.30	0.22
14.	8.50	18.4	0.6	20	"	27.50	2.26	0.44
15.	8.25	18.1	0.9	30.	"	27.25	2.22	0.66
16.	8.25	17.8	1.2	40.	"	27.75	2.19	0.88
17.	8.80	17.50	1.5	50	"	27.80	2.15	1.10
18.	8.50	17.2	1.8	60.	"	27.50	2.11	1.32
19.	----	----	----	100%	Cow			
21.	8.60	19.0	0.0	00.	-----	27.60	2.34	0.00
22.	8.55	18.70	0.3	10.	Horse	27.55	2.30	0.22
23.	8.35	18.4	0.6	20.	"	27.35	2.36	0.43
24.	8.30	18.1	0.9	30.	"	27.30	2.22	0.65
25.	9.00	17.8	1.2	40.	"	28.00	2.19	0.85
26.	9.10	17.5	1.5	50.	"	28.10	2.15	1.09
27.	8.80	17.8	1.8	60.	"	27.80	2.11	1.31
28.	8.55	18,4	0.6	20.	Cow	27.55	2.26	0.50
29.	8.25	17.8	1.2	40.	"	27.25	2.19	1.00
30.	8.45	17.2	1.8	60.	"	27.45	2.11	1.51
31.	8.20	16.6	2.4	80.	"	27.20	2.04	2.01
32.	8.80	16.0	3.0	100	"	27.80	1.96	2.51
33.	7.90	18.7	0.3	10.	Sheep	26.90	2.30	0.22
34.	8.40	18.40	0.6	20.	"	27.40	2.26	0.44
35.	8.70	18.1	0.9	30.	"	27.70	2.22	0.66
36.	8.50	17.8	1.2	40.	"	27.50	2.19	0.88
37.	8.30	17.5	1.5	50.	"	27.30	2.15	1.10
38.	8.50	17.2	1.8	60.	"	27.50	2.11	1.32
39.	----	----	---	100%	Cow	----	---	-----

Standardized Readings. First Week.

No.	2/12/06	2/13/06	2/14/06	2/15/06	2/16/06	2/17/06
1.	73.30	77.75	73.85	70.80	69.60	72.85
2.	71.90	76.50	72.90	69.15	68.00	71.10
3.	71.90	76.05	72.95	69.20	68.40	71.45
4.	71.85	75.55	73.15	70.20	68.90	71.80
5.	71.35	75.00	72.80	70.35	69.05	71.55
6.	71.90	75.75	72.90	70.80	69.10	71.60
7.	70.70	74.60	72.30	70.40	69.00	70.80
8.	69.00	73.05	70.65	68.55	68.00	69.40
9.	68.75	73.15	70.40	67.85	66.65	69.00
10.	70.85	75.75	72.45	69.35	68.00	70.65
11.	71.70	76.50	73'40	70.75	69.25	71.55
12.	72.35	76.75	73.90	71.25	69.95	72.35
13.	72.95	76.00	73.35	71.15	70.10	72.10
14.	73.05	77.00	74.20	71.40	70.40	73.00
15.	73.95	77.50	74.65	71.65	70.65	73.70
16.	74.00	78.25	75.00	71.40	70.70	73.85
17.	74.15	78.60	74.90	71.00	70.85	73.45
18.	74.65	79.00	75.00	71.50	71.00	73.95
19.	76.80	81.65	77.90	75.45	74.60	77.10
21.	72.45	77.65	73.70	69.95	69.55	72.55
22.	73.15	78.45	74.45	70.40	70.25	73.20
23.	74.10	79.20	75.30	70.95	70.95	74.10
24.	74.90	79.70	75.85	71.50	70.75	74.55
25.	75.80	80.80	76.65	71.65	71.10	75.25
26.	77.05	82.45	77.55	71.80	71.20	76.20
27.	78.25	83.40	78'35	73.00	72.00	76.95
28.	77.05	82.60	77.65	72.80	72.10	76.80
29.	78.05	83.60	78.50	73.30	73.00	77.70
30.	80.55	86.00	80.50	75.45	74.70	79.80
31.	78.35	83.30	78.55	74.50	73.65	77.55
32.	76.60	81.60	77.05	72.50	72.00	76.00
33.	75.65	79'60	75.75	72.00	70.80	74.95
34.	75.25	79.75	76.00	72.20	70.60	75.10
35.	74.75	79.40	75.90	72.00	70.55	74.85
36.	74.50	79.10	75.80	72.55	71.00	74.60
37.	74.45	78.60	75.25	72.15	70.70	73.90
38.	73.25	78.05	74.65	71.40	70.25	73.10
39.	73.50	78.35	73.90	70.05	68.85	72.60

Standardized Readings. Second Week.

No.	2/19/06	2/20/06	2/21/06	2/22/06	2/23/06	2/24/06
1.	80.00	81.05	83.00	Window	78.95	82.40
2.	79.65	80.95	82.95	opened	78.55	82.15
3.	78.85	80.35	82.20	and left	77.80	81.35
4.	78.30	79.75	81.75	so for	77.25	80.75
5.	77.70	79.00	80.90	some	76.45	80.00
6.	77.30	78.60	80.55	reason.	76.10	79.65
7.	76.70	78.05	79.90	Readings	75.30	78.80
8.	75.25	76.70	78.85	not	74.15	77.75
9.	74.45	75.90	78.00	safe to	73.45	77.10
10.	74.75	76.60	78.20	draw	74.10	77.45
11.	75.90	77.30	79.30	conclu-	74.35	78.10
12.	76.90	78.00	80.00	sions	74.90	78.65
13.	76.45	77.60	79.40	from.	74.75	78.25
14.	76.20	78.20	79.95		75.25	78.80
15.	77.80	79.00	80.85		75.85	79.60
16.	78.60	79.85	81.75		76.60	80.45
17.	79.60	70.80	82.80		77.20	81.25
18.	80.00	81.10	83.20		77.60	81.85
19.	80.80	81.90	84.40		77.60	83.25
21.	74.90	76.25	78.25		73.85	77.65
22.	75.65	77.10	79.05		74.45	78.25
23.	76.50	77.70	79.55		74.95	78.80
24.	76.85	78.00	79.85		75.05	78.90
25.	77.45	78.55	80.50		75.65	79.65
26.	78.15	79.40	81.50		76.35	80.40
27.	78.95	80.30	82.40		77.05	81.15
28.	78.70	79.85	82.15		76.75	81.05
29.	79.25	80.45	82.75		77.35	81.85
30.	80.00	79'80	83.30		78.05	82.60
31.	80.50	81.35	83.70		77.60	82.40
32.	80.05	81.00	83.15		77.05	81.70
33.	78.65	79.65	81.55		76.05	79.90
34.	78.35	79.40	81.20		75.95	79.55
35.	77.85	78.85	80.60		75.55	79.40
36.	77.70	78.65	80.50		75.50	78.80
37.	77.20	78.20	80.10		74.90	78.80
38.	76.45	77.65	79.55		74.60	78.45
39.	75.75	77.40	79.60		74.65	78.85

Standardized Readings. Third Week.

No.	2/26/06	2/27/06	2/28/06	3/1/06	3/2/06	3/3/06
1.	82.20	81.80	73.30	77.80	82.00	82.15
2.	81.70	81.10	73.10	77.40	81.60	81.20
3.	81.20	80.05	72.70	76.70	80.55	80.35
4.	80.95	79.45	72.55	76.30	79.90	79.75
5.	80.30	78.45	72.10	75.50	79.10	79.10
6.	79.80	78.00	71.60	75.10	78.55	78.50
7.	79.25	77.10	79.75	74.35	77.80	77.75
8.	78.30	76.15	69.75	73.30	76.65	76.90
9.	77.45	75.40	69.05	72.60	75.95	76.10
10.	77.65	75.55	69.10	72.80	76.15	76.35
11.	78.45	76.15	69.75	73.40	76.90	77.10
12.	79.10	76.70	70.35	73.90	77.35	77.70
13.	78.75	76.60	70.55	73.85	77.25	77.35
14.	79.25	77.00	70.95	74.40	77.80	78.10
15.	80.10	77.75	71.40	74.95	78.50	78.65
16.	80.70	78.55	71.70	75.70	79.25	79.30
17.	81.75	79.10	71.80	76.20	80.05	80.05
18.	82.00	79.90	71.75	76.80	80.80	81.20
19.	84.50	81.75	71.20	78.80	83.40	83.45
21.	77.70	76.00	69.45	73.20	76.40	76.55
22.	78.30	76.55	69.85	73.65	77.15	77.25
23.	78.85	77.00	70.35	74.05	77.45	77.55
24.	79.00	77.00	70.55	74.20	77.60	77.50
25.	79.60	77.75	70.85	84.85	78.20	78.15
26.	80.30	78.45	71.25	75.50	78.90	78.85
27.	81.00	79.20	71.60	76.15	79.75	79.45
28.	80.95	79.25	71.40	76.15	79.75	79.15
29.	81.60	79.80	71.70	76.75	80.25	79.60
30.	82.35	80.40	72.20	77.40	81.00	30.45
31.	82.75	80.20	7o.65	77.20	81.15	80,85
32.	82.00	79.40	71.40	76.45	80.25	50.10
33.	81.45	78.15	71.05	75.55	79.10	79.00
34.	80.35	78.00	70.25	75.40	78.75	78.65
35.	79.75	77.45	71.15	74.85	78.10	78.20
36.	79.70	77.30	71.20	74.70	77.80	78.20
37.	79.20	76.65	70.60	74.00	77.15	77.50
38.	78.75	76.30	70.00	73.70	76.95	77.25
39.	79.40	77.35	70.05	74.45	78.10	77.85

Standardized Readings. Fourth Week.

No.	3/5/06	3/6/06	3/7/06	3/8/06	3/9/06	3/10/06
1.	68.00	70.25	71.10	70.10	70.55	70.20
2.	67.75	69.75	70.65	69.50	70.20	69.85
3.	67.40	69.60	70.40	69.20	70.00	69.85
4.	67.20	69.30	70.15	68.95	69.65	69.55
5.	66.90	69.35	70.10	68.95	69.40	69.45
6.	66.30	68.75	69.45	68.25	68.75	68.75
7.	66.10	68.35	69.10	67.90	68.40	68.40
8.	65.20	67.45	68.20	66.95	67.35	67.45
9.	64.40	66.95	67.65	66.35	66.50	66.58
10.	64.10	67.05	68.00	66.35	66.80	67.45
11.	65.20	67.70	68.60	67.55	67.55	67.85
12.	66.25	68.50	69.40	68.30	68.40	68.95
13.	66.30	68.70	69.65	68.70	68.75	69.45
14.	66.60	69.20	70.25	69.30	69.85	70.05
15.	66.70	69.60	70.65	69.55	69.65	70.55
16.	66.60	69.65	70.75	69.80	70.10	70.55
17.	66.75	70.20	71.45	70.55	70.80	71.45
18.	66,75	70.25	71.50	70.50	70.95	71.40
19.	66.70	71.95	73.90	73.20	73.10	74.30
21.	63.25	67.20	67.95	66.95	67.05	66.90
22.	63.75	67.60	68.50	67.45	67.55	67.45
23.	63.95	63.35	69.28	68.20	68.45	68.45
24.	64.30	68.70	69.65	68.60	68.70	69.00
25.	64.00	69.10	70.10	69.05	69.15	69.50
26.	63.75	69.45	70.50	69.35	69.60	70.00
27.	63.90	69.90	71.00	70.00	70.25	70.70
28.	63.50	70.05	71.10	70.15	70.55	70.95
29.	63.15	70.45	71.70	70.55	71.05	71.45
30.	63.00	70.95	72.10	70.95	71.65	71.80
31.	64.65	71.05	72.45	71.70	72.00	72.45
32.	64.75	70.00	72.10	71.30	71.50	72.35
33.	65.65	70.15	71.45	70.55	70.85	71.65
34.	65.65	69.90	71.05	70.35	70.45	71.10
35.	65.75	69.65	70.70	69.95	70.00	70.70
36.	65.95	69.85	70.70	70100	69.90	70.60
37.	65.60	69.25	70.00	69.35	69.25	69.90
38.	65.15	69.25	69.15	69.35	68.30	68.50
39.	63.90	69.25	69.30	68.20	68.10	68.20

Standardized Readings. Fifth Week.

No.	3/12/06	3/13/06	3/14/06	3/15/06	3/16/06	3/17/06
1.	67.15	67.95	68.90	66.30	67.15	73.95
2.	66.90	67.00	68.40	65.90	66.80	72.80
3.	66.75	66.50	68.20	65.85	66.65	72.05
4.	66.60	66.55	67.85	65.65	66.20	71.45
5.	66.35	66.40	67.45	65.50	65.90	70.85
6.	65.40	65.70	63.70	64.55	65.05	70.40
7.	64.95	65.00	66.05	64.10	64.60	69.75
8.	63.90	64.05	65.85	63.15	63.55	69.00
9.	63.35	63.60	64.55	62.30	63.05	68.60
10.	63.90	64.55	65.15	63.00	63.65	68.80
11.	64.45	64.85	65.70	63.75	64.25	69.25
12.	65.45	65.65	66.45	64.75	65.10	69.50
13.	66.05	66.15	66.85	65.50	65.60	69.60
14.	66.90	66.95	67.60	66.35	66.35	70.10
15.	67.55	67.40	68.25	66.90	66.90	70.50
16.	67.60	67.50	68.50	66.95	67.30	71.10
17.	68.50	68.30	69.35	67.90	68.00	71.75
18.	68.45	68.60	69.40	67.65	68.15	72.60
19.	70.60	70.50	72.60	70.80	70.60	75.25
21.	63.90	64.65	75.20	63.05	63.85	69.15
22.	64.45	65.15	65.85	63.60	74.45	69.65
23.	65.40	65.75	66.55	64.70	65.25	69.95
24.	66.00	77.35	66.95	65.35	65.70	70.10
25.	66.45	66.75	67.45	65.75	66.20	70.65
26.	66.85	67.35	67.90	66.10	66.75	71.20
27.	67.60	67.75	68.55	66.85	67.[illegible]5	71.80
28.	67.80	68.05	68.95	67.25	67.85	72.25
29.	68.35	68.55	69.50	67.75	68.55	73.05
30.	68.85	69.30	70.15	68.20	69.25	74.60
31.	69.75	69.80	70.80	69.30	69.75	73.80
32.	69.20	69.20	70.00	68.80	69.10	72.35
33.	68.80	68.60	69.45	68.35	68.55	71.45
34.	68.25	68.10	68.85	67.80	67 95	71.05
35.	67.80	67.80	68.30	67.25	67.45	70.55
36.	67.75	67.65	68.25	67.10	67.35	70.30
37.	66.90	67.00	67.50	66.40	66.60	69.65
38.	65.45	65.75	66.45	64.90	65.55	69.45
39.	64.95	65.35	66.65	64.25	65.15	70.20

Corrected According to Position. First Week.

No.	2/12/06	2/13/06	2/14/06	2/15(06	2/16/06	2/17/06
1.	75.10	79.55	75.65	72.60	71.40	74.65
2.	75.15	79.75	76.15	72.40	71.35	74.35
3.	75.00	79.25	76.15	72.40	71.60	74.65
4.	74.80	78.50	76.10	73.15	71.85	74.75
5.	74.50	78.15	75.95	73.50	72.20	74.70
6.	74.80	78.65	75.80	73.70	72.00	74.50
7.	74.25	78.15	75.85	73.95	72.55	74.35
8.	74.05	78.10	75.70	73.60	73.05	74.45
9.	74.20	78.60	75.85	73.30	72.10	74.45
10.	74.40	79.30	76.00	73.90	71.55	74.20
11.	74.35	79.15	76.05	73.40	71.90	74.20
12.	74.55	78.95	76.10	73.45	72.15	74.55
13.	75.15	78.20	75.55	73.35	72.30	74.[illegible]0
14.	74.70	78.65	75.85	73. 05	72.05	74.65
15.	75.10	78.65	75.80	72.80	71.80	74.85
16.	74.85	79.10	75.85	72.25	71.55	74.70
17.	75.15	79.60	75,90	72.00	71.85	74.45
18.	76.30	80.65	76.65	73.15	72.65	75.60
19.	74.95	79.80	76.05	73.60	72.75	75.25
21.	74.65	79.85	75.90	72.15	71.75	74.75
22.	74.70	80.00	76.00	71.95	71.80	74.75
23.	74.85	79.95	76.05	71.70	71.70	74.85
24.	75.20	80.00	76.15	71.80	71.05	74.85
25.	75.45	80.45	76.30	71.30	70.75	74.90
26.	75.90	81.30	76.40	70.65	70.05	70.05
27.	76.10	81.25	76.20	70.85	69.85	74.80
28.	75.45	81.00	76.05	70.70	70.50	75.20
29.	75.45	81.00	75.90	70.70	70.40	75.10
30.	75.85	81.30	75.80	70.75	70.00	75.10
31.	75.55	81.50	75.75	71.70	70.85	74.75
32.	75.60	80.60	76.05	71.50	71.00	75.00
33.	75.65	79.60	75.75	72.00	70.80	74.95
34.	75.25	79.75	76.00	72.20	70.60	75.10
35.	75.00	79.65	76.15	72.25	70.80	75.10
36.	74.80	79.40	76.10	72.85	71.30	74.90
37..	75.10	79.25	75.90	72.80	71.35	74.55
38.	75.65	80.45	77.05	73.80	72.65	75.50
39.	74.95	79.80	75.35	71.50	70.30	74.05

Corrected According to Position. Second Week.

No.	2/19/06	2/20/06	2/21/06	2/22/06	2/23/06	2/24/06
1.	77.40	78.45	80.40	Some one	76.35	78.80
2.	77.45	78.75	80.75	opened	76.35	79.95
3.	79.35	78.85	80.70	the	76.30	79.85
4.	77.80	79.15	81.15	window	76.65	80.15
5.	78.00	79.30	81.20	at one	76.75	80.30
6.	78.00	79.50	81.25	end of	76.80	80.35
7.	76.30	79.65	81.50	the block	76.26	80.46
8.	77.55	79.00	80.95	of jars,	76.45	80.65
9.	77.70	79.15	81.25	the day	76.70	80.35
10.	77.80	79.65	81.25	or even-	77.15	80.50
11.	78.50	79.90	81.90	ing befor	76.95	80.70
12.	78.85	79.95	81.95	Readings	76.85	80.60
13.	77.75	78.90	80.70	are out	76.05	79.55
14.	77.45	80.45	81.20	of propor	76.50	77.05
15.	77.95	79.15	81.00	tion and	76.00	79.75
16.	78.05	79.30	81.20	therefore	76.05	79.90
17.	78.30	79.50	81.50	useless.	75.90	79.95
18.	78.35	79.45	81.55		75.95	80.20
19.	78.50	79.60	82.10		75.30	80.95
21.	77.20	78.55	80.55		76.15	79.95
22.	77.30	78.85	80.80		76.20	80.00
23.	77.60	78.80	80.65		76.05	79.90
24.	78.10	79.25	81.10		76.30	80.15
25.	78.20	79.30	81.25		76.40	80.40
26.	78.25	79.50	81.60		76.45	80.50
27.	78.35	79.70	81.80		76.45	80.55
28.	77.85	79.00	81.30		75.90	80.20
29.	77.95	79.15	81.45		76.05	80.55
30.	78.50	78.30	81.80		76.55	81.10
31.	79.00	79.85	82.20		76.10	80.90
32.	79.10	80.05	82.20		76.10	80.75
33.	78.10	79.10	81.00		75.50	79.35
34.	78.35	79.40	81.20		75.95	79.55
35.	78.20	79.20	80.95		75.90	79.75
36.	78.35	79.30	81.15		76.15	79.45
37.	78.45	79.45	81.35		76.15	80.05
38.	78.20	79.40	81.30		76.35	80.20
39.	77.60	79.25	81.45		76.50	80.70

Corrected According to Position. Third Week.

No.	2/26/06	2/27/06	2/28/06	3/1/06	3/2/06	3/3/06
1.	79.50	79.10	70.60	75.10	79.30	79.45
2.	79.55	78.95	70.95	75.25	79.45	79.05
3.	79.85	78.70	71.35	75.35	79.20	79.00
4.	80.10	78.60	71.70	75.45	79.05	78.90
5.	80.15	78.30	71.95	75.35	78.95	78.95
6.	80.10	78.30	71.90	75.40	78.35	78.80
7.	80.25	78.10	71.75	75.35	78.80	78.75
8.	80.35	78.20	71.80	75.35	78.70	78.95
9.	80.30	78.25	71.90	75.45	78.80	78.95
10.	80.40	78.30	71.85	75.55	78.90	79.10
11.	80.60	78.30	71.90	75.55	79.05	79.25
12.	80.75	78.35	72.00	75.55	79.00	79.35
13.	79.85	77.70	71.65	74.95	78.35	78.65
14.	79.90	77.65	71.60	75.05	78.45	78.75
15.	80.25	77.90	71.55	75.10	78.65	78.80
16.	80.10	77.95	71.10	75.10	78.65	78.70
17.	80.70	78.05	70.75	75.15	79.00	79.00
18.	80.50	78.50	70.25	75.30	79.30	79.70
19.	82.05	79.30	68.75	76.35	80.95	81.00
21.	80.00	78.30	71.75	75.50	78.70	78.85
22.	80.05	78.30	71.60	75.40	78.90	79.00
23.	80.20	78.35	71.70	75.40	78.80	78.90
24.	80.25	78.25	71.80	75.45	78.85	78.75
25.	80.30	78.45	71.55	75.55	78.90	78.85
26.	80.40	78.55	71.35	75.60	79.00	78.95
27.	80.50	78.70	71.10	75.65	79.25	78.95
28.	80.40	78.40	70.85	75.60	79.20	78.60
29.	80.70	78.80	70.70	75.75	79.25	78.60
30.	80.75	78.80	70.60	75.80	78.40	78.85
31.	81.25	78.70	70.15	75.70	79.65	79.35
32.	81.25	78.65	70.65	75.70	79.50	79.35
33.	80.90	77.60	70.50	75.00	78.55	78.45
34.	80.35	78.00	70.25	75.40	78.75	78.65
35.	80.10	77.80	71.50	75.20	78.45	78.55
36.	80.15	77.75	71.65	75.15	78.25	79.65
37.	80.45	77.90	71.85	75.25	78.40	78.75
38.	80.50	78.05	71.75	75.45	78.70	79.00
39.	81.25	79.2P	71.90	76.30	79.95	79.70

Corrected According to Position. Fourth Week.

No.	3/5/06	3/6/06	3/7/06	3/8/06	3/9/06	3/10/06
1.	67.05	69.30	70.15	69.15	69.60	69.25
2.	67.40	69.40	70.30	69.15	69.85	69.50
3.	67.35	69.55	70.35	69.15	69.95	69.80
4.	67.60	69.70	70.55	69.35	70.05	69.95
5.	67.75	69.20	70.95	68.80	70.25	70.30
6.	67.80	70.25	70.95	69.75	70.25	70.25
7.	67.85	70.10	70.85	69.65	70.15	70.15
8.	67.40	69.65	70.40	69.15	69.55	69.55
9.	67.55	70.10	70.80	69.50	69.65	69.70
10.	66.75	69.70	70.65	69.50	69.45	70.10
11.	67.50	70.00	70.90	69.85	79.85	70.15
12.	67.80	70.05	70.95	69.85	69.95	70.50
13.	67.40	69.80	70.75	69.80	69.85	70.55
14.	67.25	69.85	70.90	69.95	69.90	70.70
15.	67.00	70.90	70.95	69.85	69.95	70.85
16.	66.95	70.00	71.10	70.15	70.35	70.90
17.	66.05	69.50	70.75	69.85	70.10	70.75
18.	66.20	69.70	70.95	69.95	70.40	70.85
19.	65.10	70.35	72.30	71.60	71.50	72.70
21.	65.80	69.75	70.50	69.50	69.60	69.45
22.	65.90	69.75	70.65	69.60	69.70	69.60
23.	65.55	69.95	70.85	69.80	70.05	70.05
24.	65.65	70.05	71.00	69.95	70.05	70.35
25.	65.40	70.50	71.50	70.45	70.55	70.90
26.	64.85	70.55	71.60	70.45	70.70	71.10
27.	64.55	70.55	71.65	70.65	70.90	71.35
28.	63.40	69.95	71.00	70.05	70.45	70.85
29.	62.80	70.10	71.35	70.20	70.70	71.10
30.	62.95	70.90	72.05	70.90	71.60	71.75
31.	63.95	70.35	71.75	71.00	71.30	71.75
32.	64.00	70.00	71.50	70.70	70.90	71.75
33.	65.30	69.80	81.10	70.20	70.50	71.30
34.	65.65	69.90	61.05	70.35	70.45	71.10
35.	66.05	69.95	71.00	70.25	70.30	71.00
36.	66.40	70.30	71.15	70.45	70.35	71.05
37.	67.20	70.85	71.60	70.95	70.85	71.50
38.	67.70	70.80	71.80	71.90	70.85	71.05
39.	66.85	71.20	72.25	71.15	71.05	71.15

Corrected According to Position. Fifth Week.

No.	3/12/06	3/13/06	3/14/06	3/15/06	3/16/06	3/17/06
1.	66.10	66.90	67,85	65.25	66.10	72.90
2.	66.75	66.85	68.35	67.75	66.60	72.65
3.	67.15	66.90	68.60	66.25	67.05	72.45
4.	67.60	67.55	68.85	66.65	67.20	72.45
5.	67.95	68.00	69.05	67.10	67.50	72.45
6.	68.05	68.35	69.35	67.20	67.70	73.05
7.	68.50	68.55	69.60	67.65	68.10	73.30
8.	66.90	67.05	68.85	66.15	66.55	72.00
9.	67.35	67.60	68.55	66.30	67.05	72.60
10.	67.85	68.50	69.10	66.95	67.60	72.75
11.	68.10	68.50	69.35	67.40	67.90	72.90
12.	68.45	68.65	69.45	67.75	68.10	72.50
13.	66.95	67.05	67.75	66.40	66.50	70.50
14.	67.25	67.30	68.05	66.70	66.70	70.45
15.	67.60	67.45	69.30	66.95	66,95	70.55
16.	67.75	67.65	68.65	67.10	67.10	71.25
17.	68.15	67.95	69.00	67.55	67.65	71.40
18.	68.20	68.35	69.15	67.30	67.90	72.35
19.	67.90	67.80	69.90	68.10	67.90	72.55
21.	66.45	67.20	67.75	65.60	66.40	71.70
22.	66.60	67.30	68.00	65.75	66.60	71.80
23.	67.20	67.55	68.35	66.50	67.05	71.75
24.	67.65	68.00	68.60	67.00	67.35	71.75
25.	67.85	68.15	68.85	68115	67.60	72.05
26.	68.10	68.60	69.15	67.35	68.00	72.45
27.	68.55	68.70	69.50	70.80	68.50	72.75
28.	67.20	67.45	68.35	66.65	67.25	71.65
29.	67.30	67.50	68.45	68.70	67.50	72.70
30.	67.60	68.05	68.90	66.95	68.00	73.35
31.	68.25	68.30	69.30	67.80	68.25	72.30
32.	68.60	68.60	69.40	68.20	68.50	71.75
33.	67.15	66.95	67.80	66.70	66.90	69.70
34.	67.35	67.20	67.95	68.90	67.05	70.15
35.	67.60	67.60	68.10	67.05	67.25	70.35
36.	67.95	67.95	68.45	67.30	67.55	70.50
37.	68.00	68.10	68.60	67.50	67.70	70.75
38.	67.90	68.20	68.90	67.35	68.00	71.90
39.	67.90	68.30	69.60	67.25	68.10	73.15

Total Average on Horse Manure Experiments

No Tons.	10 Tons.	20 Tons.	30 Tons.	40 Tons.	50 Tons.	60 Tons.
74.87	74.92	74.97	75.00	74.87	75.35	75.17
79.70	79.87	79.60	79.25	79.30	79.97	79.70
75.77	76.07	76.10	76.12	76.12	76.10	76.02
72.37	72.17	72.05	72.47	72.40	72.17	72.90
71.57	71.52	71.65	71.45	71.47	71.02	71.20
74.70	74.55	74.75	74.80	74.80	74.87	74.57
77.30	77.37	78.47	77.95	78.10	78.32	78.32
78.50	78.80	78.82	79.20	79.30	79'50	79.67
80.47	80.77	80.67	81.12	81.22	81.42	81.65
76.25	76.27	76.17	76.47	76.57	76.62	76.67
79.75	79.97	79.87	80.15	80.35	80.42	80.47
79.75	79.80	80.02	80.17	80.22	80.25	80.37
78.70	78.62	78.52	78.42	78.37	78.42	78.40
71.17	71.25	71.58	71.55	71.75	71.68	71.42
75.30	75.32	75.37	75.45	75.45	75.50	75.50
79.00	79.17	79.00	78.95	78.92	78.92	79.02
79.17	79.02	78.95	78.82	78.90	78.90	78.85
66.42	66.65	66.45	66.62	66.57	66.35	66.70
69.52	69.57	69.75	69.87	79.85	70.40	70.32
70.32	70.47	70.60	70.77	71.22	71.27	71.25
69.32	69.37	69.47	69.65	70.12	70.10	70.15
69.60	69.77	70.00	70.05	70.40	70.47	70.52
69.35	69.55	70.07	70.15	70.60	70.67	70.75
66.27	66.67	67.17	67.62	67.90	68.07	68.52
67.05	67.07	67.22	67.77	68.07	68.47	68.62
67.80	68.12	68.47	68.72	68.95	69.25	69.55
65.42	66.75	66.37	66.82	67.12	67.27	67.72
66.57	66.62	67.05	67.25	67.55	67.87	68.32
72.30	72.07	72.12	72.10	72.25	72.75	73.02
2124.35	2128.14	2131.24	2134.95	2138.81	2142.19	2145.34
73.25	73.38	73.49	73.62	73.75	73.86	73.97

This shows result even more constant than in the last experiment. That is the increase shown for thelast ten tons is more nearly the same as that shown for the first ten tons. The size of the results is almost identical, being an average of .12°F. increase of temperature for each ten tons of manure.

Total Average for Cow Manure Experiment.

No Tons.	20 Tons.	40 Tons.	60 Tons.	80 Tons.	100 Tons.	100%
74.87	74.75	74.82	75.12	74.95	75.07	74.95
79.70	79.55	79.80	80.30	80.32	79.77	79.85
75.77	75.87	75.87	75.90	75.90	76.07	75.70
72.37	72.15	72.50	72.32	72.55	72.27	72.55
71.57	71.77	71.20	70.77	71.37	71.37	71.52
74.70	74.82	74.75	74.65	74.47	74.77	74.65
77.30	77.70	77.82	78.15	78.75	78.97	78.05
78.50	79.00	79.15	78.97	79.87	80.00	78.92
80.47	81.12	81.35	81.52	82.05	82.07	81.77
76.25	76.17	76.37	76.85	76.52	76.97	75.90
79.85	80.12	80.45	80.80	80.80	80.67	80.82
79.75	80.37	80.45	80.57	80.92	81.00	81.65
78.70	78.30	78.52	78.57	78.50	78.50	79.25
71.17	71.32	71.30	71.22	71.02	71.35	70.32
75.30	75.47	75.60	75.67	75.62	75.62	76.32
79.00	78.95	79.02	79.15	79.35	79.25	80.45
79.17	78.77	78.77	78.97	79.30	79.35	80.35
66.42	65.40	65.17	64.85	65.72	65.90	65.97
69.52	79.80	70.10	70.30	70.17	70.02	70.77
70.32	70.70	71.07	71.35	71.32	71.22	72.27
69.32	69.60	69.85	70.20	69.92	70.27	71.37
69.60	70.00	70.17	70.02	70.57	70.42	71.27
69.35	70.25	70.40	70.92	70.95	71.62	71.92
66.27	67.05	67.32	67.72	68.17	68.52	67.90
67.05	67.25	67.55	68.27	68.40	68.62	68.05
67.80	68.60	68.50	69.00	69.32	69.42	69.75
65.42	66.40	67.50	66.95	67.60	67.97	67.67
66.57	66.90	67.27	67.80	68.07	68.30	68.00
72.30	71.82	72.30	72.05	72.60	72.15	72.85
2124.35	2129.97	2134.94	2139.93	2145.07	2147.67	2150.81
73.25	73.33	73.62	73.79	73.96	74.05	74.17

These results are a little more irregular than those for the horse manure, but still are quite constant. It is noticeable that the results are not as high as for the horse manure. The heating value of 60 tons is about equal to 40 tons of horse manure, or of 80 tons to 60 tons of horse manure. One of the surprising things is that the straight cow manure has maintained a temperature but slightly above that of 100 tons, and it looks like a member of the series.

Total Average for Sheep Manure Experiment.

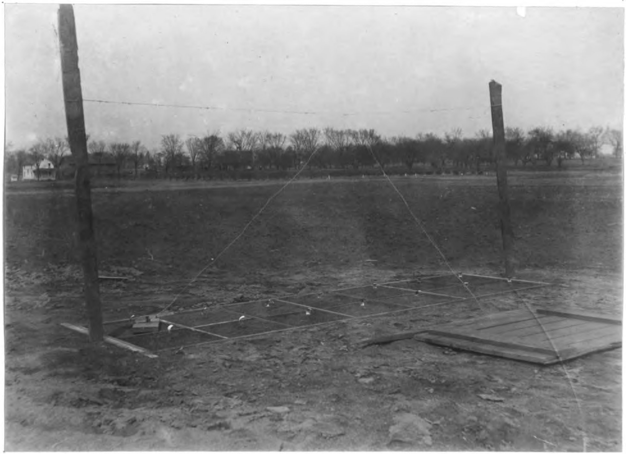
No Tons.	10 Tons.	20 Tons.	30 Tons.	40 Tons.	50 Tons.	60 Tons.
74.87	75.40	74.97	75.05	74.82	75.12	75.97
79.70	78.90	79.20	79.15	79.25	79.42	80.55
75.77	75.65	75.92	75.97	75.97	75.90	76.85
72.37	72.67	72.62	72.52	72.55	72.40	73.47
71.57	71.55	71.32	71.30	71.42	71.60	72.65
74.70	74.62	74.87	74.97	74.80	74.50	75.55
77.30	77.92	77.90	78.07	78.20	78.37	78.27
78.50	79.00	79.92	79.17	79.30	79.47	79.42
80.47	80.85	81.20	80.97	81.17	81.42	81.42
76.25	75.75	76.22	75.95	76.10	76.02	76.15
79.85	79.45	77.90	79.75	79.67	80.00	80.20
79.75	80.37	80.12	80.17	80.12	80.57	80.50
78.70	77.65	77.82	77.85	77.85	77.97	78.22
71.17	71.07	70.92	71.52	71.37	71.30	71.00
75.30	74.97	75.12	75.15	75.12	75.20	75.37
79.00	78.45	78.60	78.55	78.45	78.70	79.00
79.17	78.55	78.70	78.67	79.17	78.87	79.35
66.42	66.35	66.45	66.52	66.67	66.62	66.95
69.52	69.80	69.82	70.42	70.15	70.17	70.25
70.32	70.92	70.97	70.97	71.12	71.17	71.32
69.32	70.00	70.15	70.05	70.30	70.40	70.92
69.60	70.17	70.17	70.12	70.40	70.47	70.62
69.35	70.92	70.90	70.92	70.97	71.12	70.95
66.27	67.05	67.30	67.60	67.85	68.07	68.05
68.05	67.00	67.25	67.52	67.75	68.02	68.27
68.80	67.77	68.00	68.70	68.55	68.80	69.02
65.42	66.55	66.80	67.00	67.20	67.52	67.32
66.57	66.70	66.87	67.10	67.50	67.67	67.95
72.30	70.15	70.30	70.45	70.87	71.07	72.12
2124.35	2126.20	2128.35	2132.15	2134.66	2137.93	2147.68
73.25	73.31	73.39	73.52	73.61	73,72	74.05

Taken as a whole, these results are approximately equal to those under horse manure. With the exception of the last figure, they are slightly lower.

When one thinks of it, it is almost surprising to see how closely the results under the three manures check up.

The Fourth Experiment. (field).

Since the results of the different experiments conducted in the laboratory check up so nicely, it was desires to see how they compared with actual field conditions. This experiment was installed in the open field entirely away from any large buildings that may break the winds and where the sun was not shut off at any time of the day' A small building (about five by six feet ground space) was moved out there to shelter the instrument. Inside the building, a post was set three feet in the ground. This was to support the galvanometer and prevent the winds from shaking it. About a rod north of the building, a barrel was set in the ground and covered with a door. This contained the freezing-point couples and furnished a place to set the standardout of the sunshine. A short distance and just north of the barrel the experiment boxes were located. Ten inches of the field soil was sifted that it might be uniform and four inches of it was put back for a uniform base. Inch boards divided the surface six inches into fourteen compartments 17 by 17.5 inches inside measurement. Two were filled with the sifted soil, two had at the rate of ten tons of fresh horse manure per acre well mixed with the soil, and the others had at the rate of 20, 30, 40, 50, and 60 tons per acre in duplicate. The couples installed in this experiment were numbers 1 to 7 and 11 to 17, those with the same units figure being placed in the check boxes. The arrangement of the boxes was the same as in the preliminary experiment.



Showing Boxes, Couples, Connection and wiring to Standard Zero.

A more Distant View, showing Instrument House.

The first problems that faced us was the sun effects, and the best time of day at which to read the temperature. (It was found that as soon as the sun was up the soil began to be perceptibly warmed, and while reading the series, the temperature of the first member of the series was changed.) It was finally decided to read the temperatures at the maximum each day. That is when the absorption and radiation balanced each other. To determine this time, a number of readings was taken each day, during the first week. The time of the maximum was found to change with the kind of day. If the sun had been out during the forenoon and clouded up about noon, the best time to read was found to be about 1 P. M. If the sun shone all day, this time was changed to about 3-30 to 4 P. M. If it was cloudy in the forenoon and the sun shone in the afternoon, the maximum was found to be about 5-30 P. M. These times are not the maximums at the surface, but three inches below the surface. With this data at hand, judgment was used in striking the maximum during the remaining two weeks of the experiment. The following are the maximum readings.

Standardized Readings. (1st Week.)

No. of box.	4/24/06	4/25/06	4/26/06	4/27/06	4/28/06
1.	54.65	62.35	63.85	69.20	67.70
2.	57.60	63.90	64.10	70.30	67.70
3.	57.55	64.30	68.80	70.20	68.10
4.	56.90	63.80	64.45	70.25	68.05
5.	57.65	64.15	64.70	70.50	68.10
6.	59.10	66.35	66.20	71.65	69.05
77.	58.15	66.15	66.65	71.15	69.30
11.	57.45	64.15	65.50	68.55	67.35
12.	57.85	64.55	65.35	68.70	67.70
13.	57.30	68.85	64.00	69.65	67.30
14.	57.45	64.25	64.40	70.00	68.05
15.	58.85	65.10	65.30	71.50	69.00
16.	58.10	64.60	65.40	72.00	69.00
17.	57.75	64.90	65.25	71.60	68.80

Standardized Readings. (2nd. Week.)

	4/30/06	5/1/06	5/2/06	5/3/06	5/4/06	5/5/06
1.	71.10	64.20	57.80	64.30	67.80	59.65
2.	71.55	64.20	58.30	66.00	68.50	60.30
3.	71.20	64.20	58.35	66.50	68.00	60.55
4.	70.85	63.65	58.25	66.50	68.60	60.40
5.	71.60	63.60	58.50	66.75	68.60	60.65
6.	71.80	64.40	57.80	67.10	68.70	61.10
7.	72.45	65.00	58.30	66.40	68.90	61.10
11.	70.70	64.50	57.30	66.00	68.40	60.30
12.	71.15	64.10	57.75	66.40	68.40	60.40
13.	71.15	64.40	58.45	67.50	68.70	60.90
14.	71.40	64.00	58.40	67.10	68.50	60.80
15.	73.05	64.90	58.15	67.50	69.50	61.10
16.	73.10	64.90	58.90	67.80	70.50	61.60
17.	72.70	64.50	58.20	67.10	69.10	61.00

Standardized Readings. (3rd. Week.)

	5/7/06	5/8/06	5/9/06	5/10/06	5/11/06	5/12/06
1.	47.55	50.35	48.45	57.20	67.10	71.20
2.	48.15	50.55	48.80	57.40	67.40	71.20
3.	48.60	50.65	48.95	57.60	67.60	71.30
4.	48.70	50.60	49.20	57.60	67.90	71.30
5.	48.50	50.50	49.00	58.60	67.65	71.30
6.	48.40	50.30	49.00	57.60	67.70	71.30
7.	48.65	50.80	48.90	57.60	67.70	71.20
11.	48.15	49.90	49.10	57.10	66.90	71.10
12.	48.30	50.50	49.25	57.20	67.15	71.00
13.	48.95	50.90	49.40	57.25	67.10	70.90
14.	48.95	51.30	49.55	57.30	67.50	70.90
15.	48.50	50.90	49.70	57.35	68.25	71.20
16.	48.80	50.90	49.75	57.50	68.40	71.30
17.	48.20	50.60	49.80	59.40	68.40	71.20

Total Average.

No Tons.	10 tons.	20 tons.	30 tons.	40 tons.	50 tons.	60 tons.
56.05	57.72	57.42	57.17	58.25	58.60	57.95
63.25	64.07	64.07	64.02	64.62	65.47	65.52
64.67	64.72	64.40	64.42	65.00	65.80	65.95
68.87	69.50	69.97	70.12	71.00	71.82	71.57
67.52	67.70	67.70	68.05	68.55	69.02	69.05
70.90	71.35	71.17	71.12	72.82	72.45	72.57
64.35	64.15	64.35	63.82	64.25	64.65	64.75
57.55	58.02	58.40	58.32	58.32	58.35	58.25
65.15	66.20	67.00	66.80	67.12	67.45	66.75
67.95	68.45	68.35	68.55	69.05	69.50	69.00
59.97	60.35	60.72	60.60	60.87	61.35	61.05
47.87	48.22	48.77	48.82	48.50	48.60	48.42
50.12	50.52	50.77	50.85	50.70	50.60	50.60
48.77	49.02	49.17	49.35	49.35	49.35	49.35
57.15	57.30	57.42	57.45	57.47	57.55	57.50
67.00	67.27	67.35	67.70	67.95	68.05	68.05
71.15	71.10	71.10	71.10	71.30	71.30	71.20
1048.29	1055.66	1058.13	1058.26	1064.62	1069.91	1077.33
61.66	62.09	62.24	62.25	62.62	62.93	63,37

These results show about twice the effects that were noticed in the laboratory. This was anticipated early in the experiment and readings were taken at or before sunrise on April 24th., May 1 st., May 2nd., and May 9th. The following are the average of these early readings.

Total Average. (Early Morning)

No tons.	10 tons.	20 tons.	30 tons.	40 tons.	50 tons.	60 tons.
38.92	38.82	39.00	39.42	39.30	39.22	39.20
52.32	52.52	53.00	52.97	53.07	53.75	54.25
56.52	56.62	56.92	56.82	56.65	56.67	57.15
36.17	36.40	36.77	36.77	36.30	36.60	36.80
183.93	184.36	185.69	185.98	185.32	186.05	187.40
45.98	46.09	46.42	46.49	46.33	46.52	46.85

There were not enough of these readings taken to work the irregularities out of the average, but it is noticeable that the early morning effects are almost exactly the same as those observed in the laboratory. This shows that the sun in some way had an additional effect about equal to that of the manure or possibly greater. Examining the plots, it was noticed that those with the greater amounts of manure were somewhat darker. Prof. Smith suggested color effect, and accordingly a color experiment was tried. Two plots were prepared of muck, and two more were prepared of the soil in the field. The couples placed in them were respectively, 22, 27, 29 and 31. In the first part of the experiment, these plots were left with their natural color. The first readings in the table were taken 27 hours after the couples were installed and show that the temperatures had had time to adjust themselves. The weather was cloudy

all the time except on the last three days, vis. May 10th, 11th, and 12th. On the 12th, it was also very windy and the colors had been dulled by sand drifting over them.

Color Experiment.

Kind of soil.		Muck.		Field soil.	
No. of thermo-couple		22.	27	29	31
5/5/06	4-30 P. M.	56,65	56.95	56.35	56.50
5/7/06	5-30 "	47.15	47.60	46.10	46.15
		Uncovered.	Lime cover.	Muck cover.	Lime cover
5/8/06	4-30 P. M.	48.65	46.30	59.35	48.00
5/9/06	5-30 A. M.	39.55	40.00	36.55	36.30
"	1 P. M.	46.25	44.25	47.45	45.00
5/10/06	3-30 "	54.00	47.25	56.30	52.50
5/11/06	4-20 "	58.90	51.40	61.90	58.20
5/12/06	3-30 "	63.30	58.00	66.85	66.10

From this we see that the color of the surface has a great effect on temperature, even in cloudy weather. It undoubtedly accounts for the additional effects obtained in the manure experiment at the time of the maximum daily temperature.

Summary and Conclusion.

Taking an average of all the results found in the total averages of the different experiments, we find that 60 tons of fresh manure per acre causes the soil to be but 72/100 of a degree warmer than the soil to which no manure has been added. That is 12/1000 of a degree for each ton per acre. In the introduction, it was pointed out that about 9/10 of the germ life in fresh horse manure dies off during the first two weeks of fermentation. When such a manure is added to the soil, it has a chance to get a supply of soil bacteria, but the second experiment shows that it takes 40 tons of such manure to be equal in heating effect to 20 tons of fresh manure. From these results it will appear that manure that has laid in the pile for two weeks would maintain an increased temperature of 6/1000 of a degree only for each ton per acre. The third experiment shows that the effects of cow and sheep manures are both lower than that of horse manure. It would be interesting to learn to what extent the fermentation of well rotted manure would effect the temperature of a soil to which it is added.