Whence

$$x = \zeta / z_1,$$

$$y = \frac{\eta z_1 - \zeta y_1}{z_1^2},$$

$$z = \frac{\xi z_1^2 - \zeta (x_1 z_1 - y_1^2) - \eta y_1 z_1}{z_1^3}.$$

The exceptional cases are where $z_1 = 0$. That is, ϕ can be so chosen as to convert any vector into any other except those lying in the plane of (α, β), which is converted into itself, the line $x_1 \alpha$ being converted into itself. The cubic of ϕ is $(\phi - x)^3 = 0$. We may write $\phi \rho = x \rho + (y y_1 + z z_1) \alpha + y z_1 \beta$.

Hence the effect of any ϕ is to move the terminal point of ρ along its line in either direction, and then slide this extremity along a plane parallel to (α, β). Thus the infinite number of strains, which belong to this infinite group of strains, and that have the same x, represent a group of shears. Space nor time permit a fuller treatment of this interesting line of application of this algebra. The application of the other algebras might similarly be deduced.

I may say in closing that the natural classification of these algebras referred to by Professor Benjamin Peirce, who regarded his own classification as Linnean, is pointed to by these representations of the algebras.

ILLINOIS COLLEGE, Dec. 23, 1895.

VARIATION OF A STANDARD THERMOMETER. BY CHAS. T. KNIPP.

During the term just past I made a number of observations on a standard thermometer. The problem that presented itself was to observe the variations in a standard thermometer under given conditions, and the minimum limit of conditions that would produce the same.

Having a delicate cathetometer at hand, that reads directly to $\frac{1}{50}$ and accurately to $\frac{1}{100}$ of a mm., no hesitancy was felt in making the observations, feeling assured that the slightest variations in the reading of the thermometer could be detected.

The thermometer that was in question was one of Queen & Co's standardized thermometers of the centigrade scale, graduated in tenths over a range of 100 degrees. The bulb is cylindrical in form, thus having a maximum, or tending towards a maximum surface and consequently increased sensitiveness.

The thermometer was tested and standardized by the above named company on the 10th of October. After standardizing it was put in a brass case lined with a rubber tube. The tube is closed at the lower end and is some shorter than the thermometer, so that a little pressure is required to push it in far enough to allow the cap to screw on firmly. This pressure is directly on lower end of bulb, and is more than a person would at first think. By repeated tests I found it equivalent to 240 grams, or a little over a half pound. Such a pressure acting continuously for some length of time would certainly change the shape of the bulb, and consequently the zero mark.

The length of the bulb is 25 mm. Its volume is approximately .3 cu. cm., as near as can be ascertained by measurement of its dimensions. The weight of the thermometer is 43 grams.

On the 16th of November, after a period of five weeks, the pressure was released, the thermometer placed in an ice and water bath and the exact position of the mercury column noted. Observations were made twice per week from that date, the last one being Saturday, December 21. Great care was taken in making these observations. The bulb was placed in an ice and water bath, while the stem for five inches above the zero mark was packed with finely broken ice. The added water was to equalize the pressure on the bulb. An aperture in the side of the vessel, through which passed a tube, the outer end of which guarded by a plane glass window made it possible to readily observe the mercury column, and yet have it completely surrounded with ice. Each observation extended over a period of three hours. To guard against jarring, the cathetometer and vessel holding the thermometer were placed on a stone pier.

The apparatus was allowed to stand for one hour before taking a reading, after which readings were taken every half hour. It was observed that when great accuracy was expected, all of an hour is required as the glass is very slow to take up the temperature of the melting ice and adjust itself accordingly, while the mercury takes up the temperature in a very few minutes. The first readings, therefore, are always too low. Before taking a reading the stem was jarred to facilitate the adjustment of the mercury. To prevent radiation the vessel was covered with a towel. After putting ice in the vessel it was thoroughly washed with distilled water. This last precaution was at first overlooked and the result was that the readings were far too low, *i. e.*. the melting mixture was made colder by its containing foreign substances.

We would naturally expect that the pressure on the lower end of the bulb would considerably change its size, and that a pressure of over a half pound could not continue long without considerably altering the size, volume and accuracy of the thermometer. In the case under discussion the volume of the bulb would be increased by pressure on lower end. Also since the length of the bulb is 25 mm.

and only 4 mm. in diameter it would stand a greater strain before yielding than it would were it any other shape.

Considering it as above, the first reading would naturally be expected to be a mimimun, for as the volume of the bulb is a maximum the mercury stands lowest in the stem, and the readings on subsequent observations would increase until a fairly stationary point is reached, indicating that the bulb has regained its normal volume.

The first reading taken Saturday, November 16th, showed the thermometer to be in error 0.1479°. The second reading taken on the following Wednesday was 0.1528°. The third, taken on the following Saturday, was 0.1540°, and the fourth, taken on Wednesday, November 24th, was 0.1553°. These readings are each the mean of four and five separate observations. They show a gradual increase in the length of the mercury column which is in direct accordance with what was first expected, *i. e.*, that the pressure on the bottom of the bulb would increase the size of the same and which in consequence would lower the mercury column.

The part that seems strange to me, and that I can assign no direct reason for, is the behavior of the seven subsequent readings that were taken extending over a period of three and one-half weeks. The fifth reading shows a slight decrease, and so also does the sixth reading show a decrease compared with the fifth, after which it oscillated, as it were, about a mean of 0.1493°. The greatest deviation above this mean being .0036, and the greatest below .0026 of a degree.

It was found that the position in which the thermometer was kept had no appreciable effect upon its readings.

Graphical Representation of the Law of Falling Bodies.

By F. P. Stauffer.

[Abstract.]

It was shown that by subdividing a right-angled triangle by lines parallel to the hypotenuse and the sides into similar smaller triangles, the following could be graphically represented—the distance traversed each second, the velocity at the end of each second, the effect of gravity each second.