sure, volume, and temperature are determined as stated above. In order to increase the range the tube B is raised and lowered arbitrarily during the experiment.

In the hands of the undergraduate student this apparatus has been found to give results agreeing to 0.1 per cent.

In the above the expansions of the glass, mercury, and rod have been disregarded, these corrections being beyond the scope intended. By making these corrections, which may be done with comparative ease and accuracy, more exact results may be obtained. The coefficients of volume and pressure expansion may then also be determined and may be assigned as advanced problems.

A DOUBLE AIR THERMOMETER.

BY THOS. E. DOUBT,
Armour Institute of Technology.

Those who have worked with the Regnault type of constant volume air thermometer know from trying experience how liable it is to breakage. For advanced students or those engaged in special investigation this is not a matter of great importance. But for the instructor in high school or college who has large classes and thinks it very desirable that the student should gain an intimate knowledge of the effects of heat upon gases, the frequent repair and consequent loss of time to both student and instructor are matters for serious consideration.

It is with the idea of furnishing a design for a useful and inexpensive instrument not subject to breakage that the following description is offered and not with the notion of presenting much that is original.

Description of the Constant Volume Air Thermometer.

The cylindrical glass bulb A of about 400 cc. is sealed to the tube B by means of a portion of capillary tubing P. The outside diameter of B and P is uniform to where it is sealed to A. C is connected with B by a flexible tube and is movable along the scale M, upon which the readings for the height of the mercury column are taken. The bulb A is enclosed in a copper tank D which is covered with felt E to prevent radiation. The tank is heated by a Bunsen burner applied to the extension pipe, F. T indicates a thermometer for taking the temperature of the bath surrounding the bulb A. The volume of air in the bulb A is kept

constant by adjusting the height of the tube C so that the mercury in the tube B remains in contact with the enamel glass point at P.

If one has the older type of instrument it may be seen at a glance how to reconstruct it at slight expense. The bulb A and the connecting glass tube B can be secured from a glass worker for about two dollars. The important item is to see that the region around P is well annealed. In one instance the tube was

broken three times before mounting but since assembling it has been in use continuously by regular students for over two years without accident.

When the air in the bulb is dry and the mercury clean very consistent and accurate results may be obtained with this instrument without excessive care. An instruction sheet somewhat like the following might be furnished the student.

Fill the metal jacket with cracked ice or with cold tap water. Suspend two mercury thermometers reading 0-100 in tenths of degree from a ring stand by means of wire, placing the thermometer bulbs close to the bulb of the air thermometer. Read the barometer, the top of each column of mercury, and both thermometers. The water in the jacket may be heated to any temperature below boiling by applying the flames of a Bunsen burner to the extension tube. Adjust the surface of the mercury in B to just touch the point P.

Take readings for 10 degrees as the temperature is rising and also while the temperature is falling. Stir the water in the jacket thoroughly before each reading.

Plot a curve with the temperature as abscissas and the pressures as ordinates and extend the curve until it intersects the X axis. The point of intersection indicates the temperature at which the air pressure would become zero if it continued to decrease uniformly. This is called the absolute zero of the air thermometer.

The pressure of the air, p_1 , at the temperature t_1 is given by the equation $p_1 = p_0 (1 + at_1)$. P_0 is the pressure of the air at 0° C and a is the pressure coefficient of air at constant volume. Similarly $P_2 = P_1 (1 + at_2)$. By eliminating P_0 from these two equations a , the coefficient of air pressure at constant volume may be found.

$$a = \frac{p_2 - p_1}{p_1 t_2 - p_2 t_1}$$

Calculate the value of a for each pair of readings. Find the average value of a and the per cent variation of each value of a from this average.

What would be the effect of the presence of other gases, or of moisture upon the value of a ?

What is the effect of the expansion of glass upon a ?

How could you correct for this?