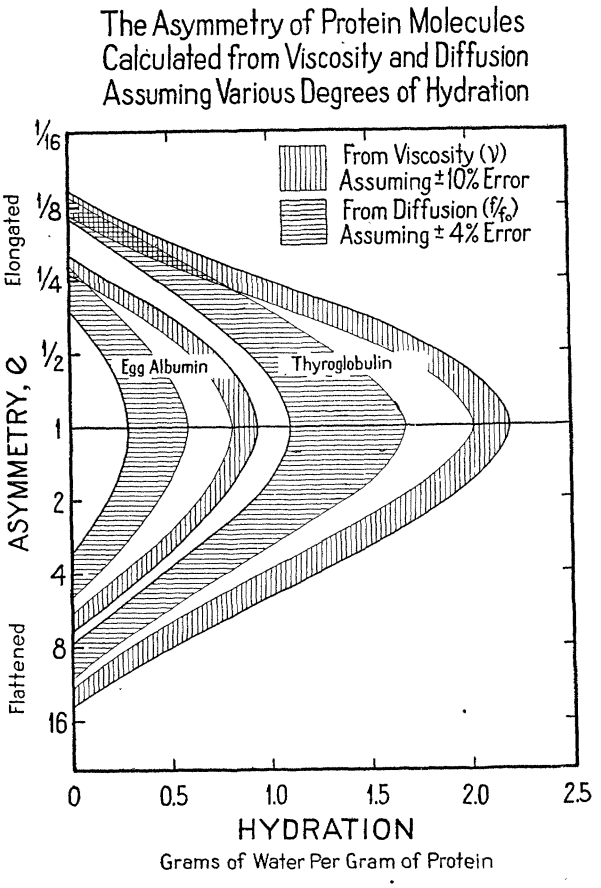
mentation and diffusion. The agreement seems to be generally good on the assumption that the protein molecules can be approximated by rigid elongated ellipsoids.



In an attempt to evaluate the importance of hydration and to determine whether any choice can be made between the elongated and flattened shapes, values of ρ were calculated from viscosity and from sedimentation and diffusion, assuming that the protein carried varying amounts of water. It also seemed desirable to consider the influence of experimental error, so that the values of f/f_o were taken to be subject to $\pm$ 4 per cent. error, and values of ν to $\pm$ 10 per cent. error. The areas included between pairs of such curves would then include the possible choices for shape and hydration. Such curves for egg albumin[10] and thyroglobulin are given in Fig. 1. They were chosen as well-characterized examples of fairly symmetrical and fairly asymmetrical molecules. The shape of these curves is such that they never cross sharply, but it can be said that, for these two cases, hydration greater than 0.5 grams of water per gram of protein, and the flattened shape, seem relatively improbable.[11]

It should be further emphasized that all the equations mentioned above only apply to measurements of the viscosity which are made in the region of complete Brownian movement. Any orientation will reduce ν, and hence $1/\rho$ or ρ if these equations are misused. This may be well illustrated by the case of tobacco mosaic virus, where measurements in capillary tube viscometers give values of ν of about 80.[3,4] However, this must be much too low, as it is known that double refraction of flow is obtained under such conditions of flow. Robinson[12] has made measurements in a Couette viscometer and found that ν approaches 1,500 as the velocity gradient approaches zero. This would correspond to an axial ratio of about 160, assuming a rod-like shape.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN ELECTRONIC RELAY FOR HEAT CONTROL[1]

THERE are a large number of biological and chemical processes whose study requires the temperature of the materials to be held within very narrow limits. While several methods for temperature control have been described they have the disadvantage of being rather elaborate and expensive when the temperature is to be held to 0.02° C. To overcome these disadvantages, we developed the electronic relay whose circuit is given in Fig. 1. It controls a bath temperature to 0.02° C.,[2] requires only a 115-volt power source which can be either a-c or d-c, and permits only a few microamperes to pass through the thermoregulator contacts. The parts of the apparatus were bought at a radio shop for less than six dollars.

The device operates as follows: When the temperature of the thermostat is too low, the circuit through

[1] Contribution from the Department of Electrical Engineering and the Research Laboratory of Physical Chemistry, No. 451, Massachusetts Institute of Technology.

[10] The value of ν chosen for egg albumin for this calculation was 5.4, rather than 5.7 as used by Polson. The choice of this value is discussed by Oncley, *Proc. N. Y. Acad. Sci.*, in press.

[11] For a discussion of solvation on the basis of viscosity measurements, see also H. Mark and R. Simha, *Jour. Phys. Chem.*, in press.

[12] J. R. Robinson, *Proc. Roy. Soc. Lond.*, A170: 519, 1939.

[2] Heidt, *Jour. Am. Chem. Soc.*, 61: 3455, 1939.

its thermoregulator is open; there is thereby no electrical connection between points A and B, and the control grid of the type 25L6 tube is at approximately the same potential as the cathode. Under this condition the tube has a low plate resistance, the plate current is very large and the relay (Dunco, Catalogue No. ABTX1) is energized, causing the relay contacts to close. The closed contacts permit current to flow through the heater in the thermostat, thus raising its

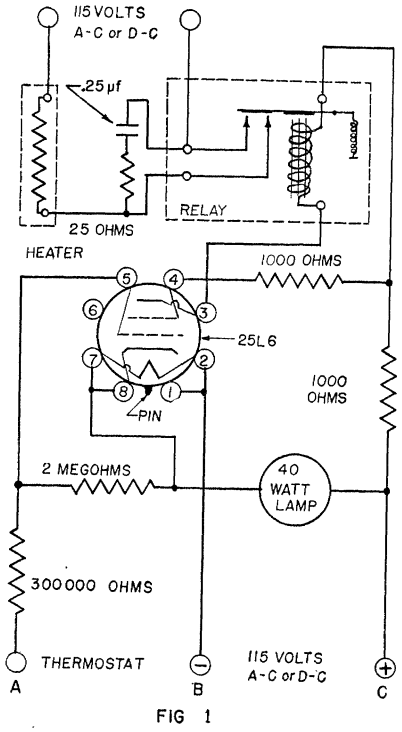

FIG 1

temperature. When the temperature has been increased sufficiently, the contacts in the thermoregulator close the electrical connection between points A and B and thereby make the control grid about 25 volts negative with respect to the cathode. Under this condition the tube has a very high plate resistance, causing the plate current to fall to practically zero. The relay is thus de-energized, its contacts open, and the heating current is interrupted.

The 0.25 μf capacitor is rated for 400 volts d-c and the resistors for two watts. The 25L6-GT tube and its octal socket are sketched as viewed from the tube. The numbers are added to aid in assembling the apparatus simply by reference to the pin fixing the position of the tube in the socket whose No. 6 prong is not used. If it is possible, the point B and the thermostat should be grounded. The current through the heater may be controlled by inserting lamp bulbs or other resistors in series with it. The relay contacts are rated to carry six amperes.

When the device is put into operation and the line voltage applied, the filaments of the tube will require about a minute to reach their operating temperature. The relay will then close if the contact between A and B is open and the tension in the relay spring has been properly adjusted. It is probable that the spring tension will have to be adjusted when the relay is first put into operation, and readjusted if the source is changed from a-c to d-c. Except for a semi-monthly check, the relay needs no attention after this initial adjustment.

The first 25L6 tube lasted nearly two years. The remainder of the apparatus is still in use after operating almost continuously for over three years.

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INEXPENSIVE MICROPHOTOGRAPHIC RECORDS

IN a recent issue of SCIENCE[1] it is suggested that a nail be driven through the lens of a Univex camera in order to obtain a focus with a microscope. I have been using a Univex camera without destroying the lens and without using up the entire film for one picture. If the camera is placed in the same position as the eye after focussing the microscope the camera will be in focus. By pasting a paper or tin tube on the front of the camera it may be placed in position by sliding this tube down over the eye end of the microscope. It is necessary to remove the back of the camera and use ground glass only while pasting on the tube, in order to center it. The tube may be pasted on with so-called "liquid solder" or any other quick-drying nitrocellulose adhesive. If the tube is painted black inside the camera may be used to take pictures of apparatus or experimental animals as well as for photomicrographs.

A label in lead pencil is photographed with the specimen. The time of exposure is usually about 1 second, and about 5 seconds is all that is required to place the camera, make the exposure and remove the camera.

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[1] E. M. Abrahamson, SCIENCE, 91: 510, 1940.

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