sciousness, abnormal behaviour with catatonic features, and floccilation. As far as somatic symptoms are concerned, hypodynamia, ataxia, apraxia, dysarthria, and mydriasis were in the forefront.

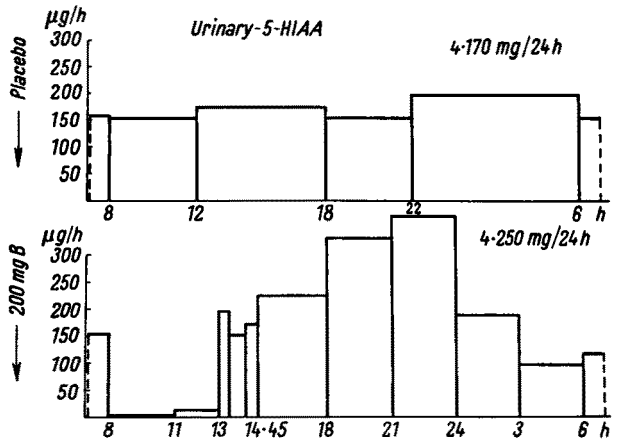

Fig. 1

Changes in the 5-HIAA excretion of one subject are shown in Figure 1. The changes found in the other experimental persons were of similar nature as far as the HIAA excretion and its relation to psychotic changes is concerned. Changes in the 17-ketosteroid excretion are shown in Figure 2.

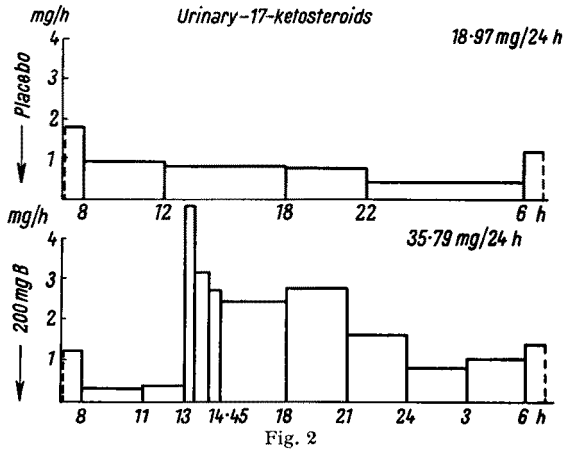

Fig. 2

Discussion.—Doses of 50 mg and 200 mg Benactyzine caused in all instances a symptomatic psychosis of the exogenous type as described by BONHOEFER, with hallucinations, illusions, impaired consciousness, and catatonic features in the behaviour. Motor changes were of a similar type as described in other publications after smaller doses of the drug.

According to the contemporary theory on psychoses[6], the observed psychotogenic effect of Benactyzine may be explained by its interference with the synaptic transmission due to its cholinergic action as well as its interference with serotonin metabolism. Evidence of an impaired serotonin metabolism is provided by the lowered 5-HIAA excretion in the urine and the marked agreement of these changes with the psychotic symptoms. So far it remains hypothetical whether the decarboxylation of 5-hydroxytryptophan is impaired or whether the oxidative deamination of serotonin is blocked. These considerations require further experimental evidence. The total excretion of 5-HIAA in 24 h was, however, not substantially affected. Factors of diuresis do not play any role under our conditions. Our results do not agree with those observed by BERGER *et al.* in animals[7].

The decrease of 17-ketosteroids in the two cases investigated also runs parallel with the maximum of psychotic changes. It can probably be explained by the potent anticholinergic action of Benactyzine. The subsequently increased excretion of 17-ketosteroids is probably due to stress, commonly found also in other experimental psychoses[8].

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Zusammenfassung

Benactyzin in Dosen 50–200 mg löste bei 7 Versuchspersonen experimentelle Psychose mit gleichzeitiger Herabsetzung von 5-Hydroxyindolylessigsäure im Harn aus. Die psychotogene Wirkung wird mit dem Eingriff in den Serotonin- und Acetylcholinmetabolismus erklärt.

[7] F. N. BERGER, G. L. CAMPBELL, C. D. HENDLEY, B. J. LUDWIG, and T. E. LYNES, Ann. N. Y. Acad. Sci. *66*, 686 (1957).
[8] H. HOAGLAND, Ann. N. Y. Acad. Sci. *66*, 445 (1957).

PRO LABORATORIO

Acceleration of Drying of Biological Material from the Frozen State by the Use of High Frequency Dielectric Heating

In vacuum drying from the frozen state, of either histological specimens or large volumes of biological materials such as plasma proteins, it is necessary to supply the thermal energy needed for the sublimation of ice. Otherwise, the continued removal of heat (more than 600 calories/g of water) lowers the temperature of the material to a point where the vapor pressure of the ice is so low that drying proceeds at an extremely slow rate, possibly lengthening the drying time from a few hours to over a day. Systems of supplying energy that are dependent on the conduction of heat through the material or on the contact of electrodes have the disadvantage of possible local overheating and rapid drying near the origin of the energy, creating a layer of dried material that acts as an insulating barrier which prevents the further penetration of energy. Some of these problems can be overcome by supplying the necessary energy in the form of infra-red radiation[1] which will penetrate the walls of the container without heating them unduly and yet heat the sample, but energy supplied in this way may still heat the already dried material sufficiently to damage it. In theory, an ideal method of supplying energy would be the use of ultra high fre-

[6] M. RINKEL and H. C. SOLOMON, J. clin. exp. Psychopathol. *18*, 313 (1957).

[1] W. H. ZAMZOW and W. R. MARSHALL, JR., Chem. Eng. Progr. *48*, 21 (1952).

quency radio energy[2] to heat the material, since no contact with a heating element or electrode is needed; and if the proper wavelengths are employed, the resulting dielectric heating should occur only in those portions of the material containing water and not in the dried material or in the walls of the container.

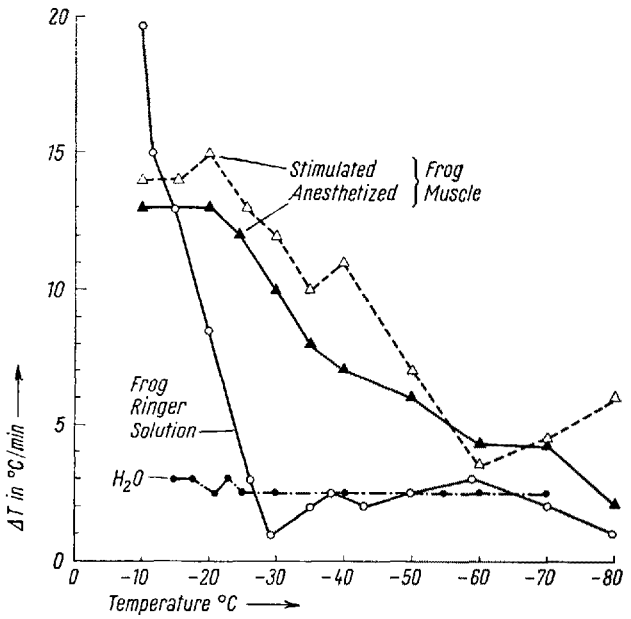

Fig. 1.—Dielectric heating of H_2O, frog Ringers solution, and frog sartorius muscle at different temperatures produced by 30-cm radio waves. At each temperature the high frequency power was turned on for 1 min and the change in temperature recorded. Power to antenna, 10 watts. The material was initially frozen in liquid nitrogen.

The drying apparatus was similar in design to that used by JANSEN[3]. It consisted of a U tube trap which was immersed in liquid nitrogen; one arm of the trap led to a vacuum pump, while the other was connected to a vacuum guage and carried in the thermocouple wires which led to a recording galvanometer. In operation, a tissue sample with a diameter of about 3 mm was impaled upon the thermocouple, and frozen in liquid nitrogen or cold isopentane; the apparatus was rapidly assembled, and the vacuum pump started. The high frequency radio energy was generated by a 'Radar' oscillator which was tuned to a wavelength of about 30 cm (1×10^9 cycles/s). The power was conveyed through a coaxial cable to a small antenna, one end of which was hooked around the drying apparatus at the same level as the tissue. The power being transmitted, as indicated by a watt meter in the cable, was controlled by changing the power input to the transmitter.

In an attempt to elucidate the mechanism of dielectric heating of biological materials at these wavelengths and temperatures, uncomplicated by the extraction of heat that occurs *in vacuo*, heating rates were studied at atmospheric pressure as a function of temperature. The heating of muscle does not appear to be due only to the absorption of energy by pure ice, which is very small, or to the absorption which occurs in salt solutions due to ionic conductivity (Fig. 1). The frequency is rather high and the temperature too low for the absorption to be due to the relaxation of protein dipoles. Probably the best explanation for dielectric heating under these conditions is that the energy is being absorbed by bound water, as FREYMANN[4] has suggested. This is further supported by the fact that both wet cellulose as well as sugar solutions have heating curves similar to muscle.

The amount of heating that occurs at a fixed power input and a fixed temperature in the process of drying is a function of the rate at which heat is being removed by the sublimation of ice (Fig. 2). At a pressure of 1 atmosphere, the heating is very rapid since there is little sublimation. However, at low pressures, during the early phases of drying when the escape of water vapor from the surface is very rapid, the heating effect is much less marked due to the rapid extraction of heat. Later in the drying process, the shell of dry material which surrounds the remaining ice inhibits the rate of sublimation, and rapid heating occurs when the power is applied. Finally, when the material is completely dry, there is no heating at all. In practice, the power is adjusted so that the tissue is held at a fixed temperature during the course of drying.

Histological examination of tissue sections taken from material which had been dried with the aid of dielectric heating showed no evidence of artifact formation due to exposure to the radio energy. There was no evidence of localized overheating either at the surface or in the center. The tissue did not show any tendency to explode due to internal vapor pressure nor was there any evidence of ionization discharge seen, two technical difficulties which GREAVES[2] suggested might occur with the use of dielectric heating. The possibility that heating in this way might cause protein denaturation was investigated by drying small frog muscles with the aid of dielectric heating and studying the contraction which occurs when they are rehydrated. In all cases, the rehydration contraction was identical with that seen in muscles which had not been heated in this way during drying and similar in most respects to the contraction of living muscle[5], indicating

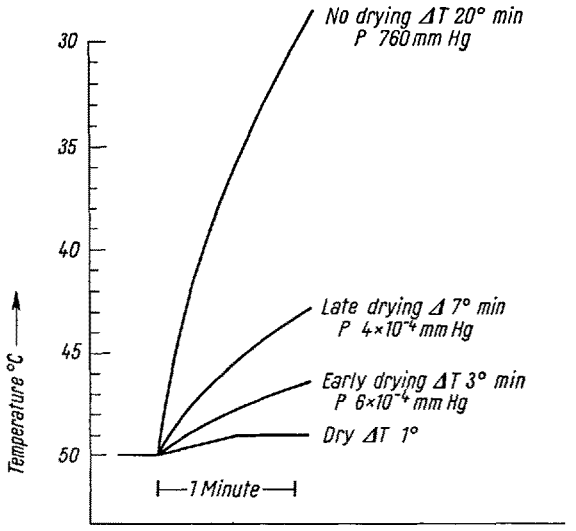

Fig. 2.—Superimposed tracings from a recording galvanometer showing variation in heating rates of muscle produced by a 1-min exposure to radio energy at —50° C at different times in the drying cycle. Power to antenna, 30 watts.

[2] R. I. N. GREAVES, in *Biological Applications of Freezing and Drying* (Academic Press, New York 1954), p. 87.

[3] M. T. JANSEN, Exp. Cell Res. *7*, 318 (1954).

[4] M. FREYMANN and R. FREYMANN, J. Phys. Radium *15*, 165 (1954).

[5] A. L. HOPKINS, Fed. Proc. *14*, 75 (1955); J. cell. comp. Physiol. *51*, 67 (1958).

that exposure to high frequency radio energy has not denatured the proteins of the contractile system. The possibility that this might occur due to resonant absorption of the dry proteins[6] led to the abandonment of the use of microwaves which were employed in the preliminary phases of this study[7]. Most routine drying of tissue and plasma proteins can be done in the temperature range of efficient heating for these wavelengths although it is somewhat high to prevent completely the formation of histological artifacts. If the same relationship exists between wavelength and temperature of maximum absorption as exists in silica gel[4], then the use of an oscillator generating longer wavelengths should be capable of heating tissues at lower temperatures. Even with the present equipment it has been possible to reduce the time required to reach complete dryness by more than one half, as indicated by a modification of the technique described by PATTEN[8].

This work was made possible by the generous loan of the necessary equipment from the Bird Electronic Corporation of Cleveland (Ohio).

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Department of Anatomy, Western Reserve University, Cleveland (Ohio), June 12, 1958.

Zusammenfassung

Die dielektrische Heizung mittels 30-cm-Funkwellen kann gebraucht werden, um die Trocknung von biologischem Material in gefrorenem Zustand zu beschleunigen. Diese Wellenlängen heizen nur jenen Teil des Materials, welcher Wasser enthält, und erwärmen oder verletzen das trockene Material nicht.

[6] B. COMMONER, J. TOWNSEND, and G. E. PAKE, Nature *174*, 689 (1954).
[7] A. L. HOPKINS, Anat. Rec. *127*, 310 (1957).
[8] S. F. PATTEN, JR., and A. L. HOPKINS, Exp. Cell Res. *14*, 647 (1958).

PRO LABORATORIO

A Convenient Cell for the Determination of the Electrophoretic Velocity of Microscopic Particles

Two forms of cell have been commonly used for determining the electrophoretic velocity of suspended particles by the microscopic method. The all-glass *flat* cell of ABRAMSON[1] is excellent but is very difficult, and therefore expensive, to construct and is fragile. (*Cemented* flat cells are unsatisfactory because of the considerable danger of contamination.) The cylindrical all-glass cell of MATTSON[2] is easier to construct but has certain disadvantages. Firstly, an optically clear 'window' must be ground and polished on the upper side of the cell and, unless the grinding is carried almost to the inner bore and the polishing is of good standard, it is impossible to get particles near the bottom of the cell in clear focus. Secondly, the optical resolution for very small particles is necessarily poor because of the presence of the plano-cylindrical lens formed by the wall of the tube. Thirdly, the lens effect also introduces an important focussing error in measurements of the positions of particles within the cell[3]. It is highly desirable to determine the velocity of particles at a series of accurately known depths from top to bottom of the cell in order to obtain a correct elimination of electro-osmotic flow (for theory and examples see ABRAMSON *et al.*[1]).

A modified cylindrical cell which overcomes these difficulties with little loss of precision and which can readily be constructed in any laboratory is described below. Except for a tiny cemented window, it is constructed throughout of sealed 'Hysil' or similar resistance glass.

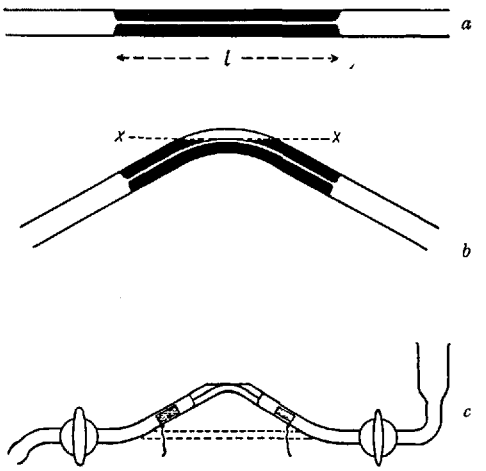

Fig. 1.—Construction of electrophoresis cell

A 5-cm length of precision-bore (e.g. 1 mm) capillary tube is first joined to wider tubing, as in Figure 1*a*, and the length of capillary *l* determined. The capillary is then bent at the middle into an arc of radius about 2·5 cm until the two ends make an angle of about 120° C (Fig. 1*b*). Great care is taken to avoid constricting the bore, and to this end a close-fitting soft copper wire can be inserted before bending and be pulled out afterwards.

Next, the corner of the bend is ground away along the plane *xx* by pressing it against a rotating glass plate carrying coarse carborundum powder moistened with water. When the glass has been ground almost down to the inner wall, the carborundum is changed to a fine grade and the grinding carried on cautiously, with frequent inspections, until a very small hole is pierced into the inner bore, when the grinding is stopped. The hole should be no larger than will fill the field of view of the microscope to be used (e.g. 4-mm objective, with 20× eyepiece). On to this hole a small piece of thin microscope cover-glass is sealed—for example, with Canada balsam—to form a window. This allows particles to be seen at any depth with perfect definition and no focussing error.

The cell is completed by bending the side tubes and fitting cylindrical platinized platinum foil electrodes, small stopcocks and arrangements for filling and emptying as shown in Figure 1*c*. Two glass rods (not shown) are also sealed across either side of the bend to strengthen it. It is convenient to connect the electrodes to platinized bands deposited on the outsides of the tubes and to solder light connecting leads to these bands.

[1] H. A. ABRAMSON, L. S. MOYER, and M. H. GORIN, *Electrophoresis of Proteins* (Reinhold Publishing Corp., New York 1942).
[2] S. MATTSON, J. phys. Chem. *32*, 1532 (1928); *37*, 223 (1933).
[3] A. M. BUSWELL and T. E. LARSON, J. phys. Chem. *40*, 833 (1936). – D. C. HENRY, J. chem. Soc. *1938*, 997.