CXX. A LABORATORY APPARATUS FOR THE WET GRINDING OF PLANT TISSUES OUT OF CONTACT WITH AIR.

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In extracting the proteins from potato tubers great difficulty is experienced on account of the action of oxygen on tyrosine, causing in the early stages of the experiment the formation of melanin, the removal of which is difficult once it has been formed. An apparatus has therefore been devised in which the tubers may be finely pulped and the pulp filtered in the absence of oxygen, the exclusion of the latter being sufficiently thorough for the filtered juice to be of only a faint blue colour[1] instead of the intense black colour resulting when oxygen is present.

Since the yield of protein is likely to be proportional to the number of cells of which the walls are broken, a high degree of efficiency of grinding was also desirable. It was secured by means of a rapidly rotating alundum wheel tearing apart the tissues of the tuber. Turgid potato tubers have, in fact, been pulped with the machine at a rate of about 1 kg. per hour sufficiently finely to rupture almost every cell wall, without, however, breaking the starch granules.

Since the machine seems capable of application to many biochemical problems a brief description and diagram are given below in the hope that it may be of use to other workers.

An inverted glass bell-jar *A*, which serves as a receiver for the pulp, is suspended by its rim through a circular hole in a table *B*, a ring of rubber, *C*, acting as a cushion between the two. The bell-jar is held securely in position by the brass plate *D*, which is firmly attached to the table by means of three bolts and thumb screws *F* (one only shown in the diagram). A second ring of rubber *E*, placed between the brass plate and the bell-jar, serves to make an air-tight joint between them. Passing through the centre of the plate *D*, is a shaft and bearing *H*, which carry the alundum grinding wheel, *G*, on the lower end, and at the upper end can be connected by a leather band to a $\frac{1}{4}$ H.P. motor.

[1] This blue colour forms the subject of a note published in the *Annals of Botany*.

The potatoes to be ground up are inserted through a cylindrical brass tube *I*, which is fitted tightly into a hole in the brass plate *D* by means of screws, so that its basal end almost touches the grinding wheel. The tube is made in sections which may be screwed together so that its length may be altered at will. A second but much shorter brass tube of the same diameter, *J*, is soldered into a second hole in the plate lying just to the side of the first: this, for the sake of convenience in drawing, is shown out of position in the diagram. A piece of strong rubber tubing *K* (the inner tube of a small motor-bicycle is of a convenient size and curvature for the purpose) is attached to the brass tube *J*, and is closed at its free end with a block of wood *L*, into which

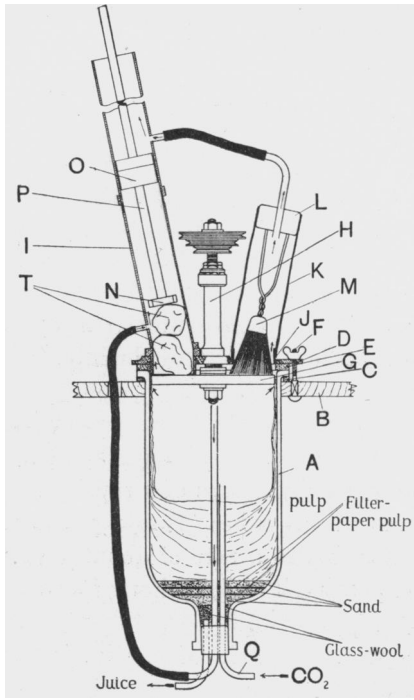

Fig. 1.

is fitted the handle of a steel wire brush *M*. The rubber tube is sufficiently long for the brush, in a position of rest, to be just free of the grinding wheel, but it allows sufficient freedom of movement to permit the brush to be brought down on the surface of the rotating wheel to clean it without either discontinuing the grinding or risking the introduction of oxygen. The three parts of the apparatus are connected up together, by means of glass and rubber as shown in the diagram, in such a way that the whole of the air in the apparatus can be replaced by an inert gas, not lighter than air, which enters under slight pressure by the inlet tube *Q*, passes in the directions indicated in the diagram by arrows, and finally emerges from the top of the tube *I*. In the case under consideration carbon dioxide was used to displace the air, though it is probable

that nitrogen might have served equally well. During an experiment a continuous stream of gas is kept passing through the apparatus in order to displace any air that may be carried in when the potatoes are introduced into the tube *I*. The tubers are lowered slowly, one at a time, to the base of the tube *I* on the end of a long skewer with a corkscrew end, which may be disengaged from the potato by unscrewing. Not more than two tubers at a time are put in the tube, otherwise there is a risk of jamming. They are pressed

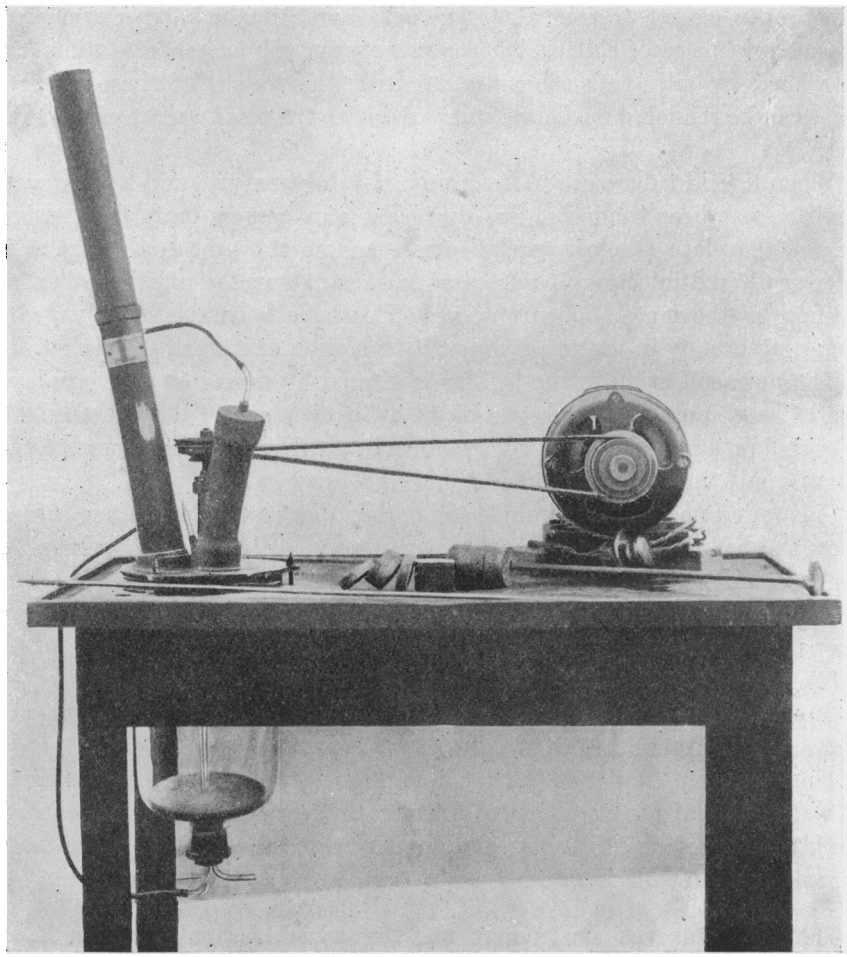

Fig. 2.

down against the grinding wheel by means of a plunger, the end *N* of which is about half the area of the cross section of the tube; this is sufficiently large to prevent the slipping of the end past a tuber and small enough to cause no serious introduction of oxygen when the plunger is pushed into the tube. A cylindrical piece of lead *O*, is screwed on to the rod *P*, of the plunger, about

half-way up its length to weight it: additional perforated leaden cylinders may be slipped over the rod to increase the pressure on the tubers. The wheel is spun at about 1500 revolutions per minute by means of a $\frac{1}{4}$ H.P. electric motor. The resulting pulp is quite white and is sufficiently liquid to run down the sides of the bell-jar, if turgid tubers are used, without the addition of any water.

As stated above, this material can be pulped at a rate of 1 kg. per hour. When the pulp is examined under a microscope it is seen that every cell has been broken except occasional "stone cells" and, in the case of each tuber, the last thin piece of skin which passes between the base of the tube *I* and the wheel; by adjusting the parts carefully the weight of these unground pieces can be rendered negligible compared with the total weight of the tubers used.

When flaccid tubers are to be ground it is necessary to add a little water. Provision has been made for this by means of a narrow brass tube, passing through the plate *D*, close to the spindle and to the tube *I*, through which water or filtered juice may be dropped so as to fall on the rotating wheel and be flung on the material being pulped. This tube is completely plugged up when not actually in use to prevent the formation of a small air-pocket.

The pulp collecting in the bell-jar is filtered by means of alternate layers of filter paper pulp and sand, two layers of the former and three of the latter, supported on a plug of glass wool as shown in the diagram. This gives a filtrate which is only very slightly turbid.

It is found necessary to bubble the carbon dioxide through ether before it enters the bell-jar. In this way the foam into which the wheel "whips" the pulp is discharged.

If the residual pulp be shaken with water and allowed to settle it is possible to separate mechanically:

(1) cell-wall material which floats away readily;
(2) starch grains;
(3) any unground pieces of skin.

These facts suggest that the machine might be used for the separation of cell-wall material for its chemical examination, and that by its means the starch content of potato tubers and similar material might be estimated by a simple mechanical separation.

The apparatus was constructed from the writer's design by Messrs F. and T. Mercer, Apparatus Makers, St Albans, to whom he wishes to express his best thanks for the care and skill exercised by them in its construction.