products are invaluable. Warrington and Winogradsky, in their isolation of the nitrifying organisms which convert nitrogenous matter into nitrites and nitrates, have thrown great light on the absorption of nitrogen by plants. Recently Winogradsky has described an organism which converts the nitrogen of the air directly into nitrates. Again, there are a number of germs that are ordinarily found in water or the soil which will reduce nitrates to nitrites or ammonia, as well as some pathogenic germs usually present in the soil which will flourish in artificial media in an atmosphere of nitrogen. We know that a subsoil, freshly turned, will not be productive until it has been exposed for some length of time to the air and moisture and to the action of the germs of the air. The plant does not take up directly in the form in which it exists in the soils, the mineral matter that it needs for its growth, but only when that is modified to a simpler form can it be utilized. Phosphorus is one of the elements which, whether combined in albuminoids or mineral salts, seems to be necessary for the growth of the germ, and is also necessary for the life of plants. By closely following the gradual changes in the artificial cultures of germs, we can arrive at a more definite understanding of the assimilation of mineral matter by the plant, as well as the fixation of carbon, the formation of starch and sugar, and possibly also, as has been suggested, of the building up of alkaloids.

I have only mentioned a few of the many directions in which a conjoint study of bacteria and their products are important with the desire of emphasizing the interest attaching to such investigations. It is along this line of research that the solution of many of the problems of life that have been a puzzle to both physiologist and chemist undoubtedly lies.

DETERMINATION OF THE CRYSTALLIZABLE SUGAR IN THE BEET.[1]

BY H. PELLET.

TRANSLATED AND ABSTRACTED BY G. L. SPENCER, WASHINGTON, D. C.

THIS is an extensive article including a résumé of practically all that has been written by the leading authorities upon

[1] Read before the World's Congress of Chemists, August 22, 1893.

the subject, in addition to original methods by the author. The paper is divided into five parts.

The first part contains a brief outline of the methods employed for the determination of sugar since the beginning of the industry, or in fact since the work of Margraff on the beet in 1747, and includes the literature of 1886.

In the second part is included a review of the principal prizes which have been awarded for researches on the estimation of sugar in the beet.

In the third part is given a résumé of the different methods which may be applied for the direct determination of the sugar, and the principal details of the new cold and warm aqueous methods, as applied in the manufacture of sugar and the analysis of mother beets.

In the fourth part is given an examination of the matters existing in the beet which influence the determination of the sugar, notably raffinose, pectic substances and asparagine.

Finally, in the fifth part, note is made of the purchase and sale of beets according to their quality, and an examination of the various methods employed for this purpose is included.

This abstract relates simply to that portion of the third part of the paper which includes methods original with the author.

PROCESSES WHICH MAY BE APPLIED TO THE ANALYSIS OF THE BEET FOR THE DIRECT DETERMINATION OF THE CRYSTALLIZABLE SUGAR WHICH IT CONTAINS.

The different methods may be divided into two classes, namely, chemical and physical (polariscopic). As the polariscopic methods are those usually employed we will omit a description of the chemical. The polariscopic methods may be divided into two groups; those employing alcohol as a solvent for extracting the sugar and those employing water. The process employing water, with which we shall specially deal, is that devised by the author and known as the method of instantaneous aqueous diffusion in the cold. In the instantaneous method, it is essential to obtain the beet pulp in an extremely fine state of division. Ordinary rasps cannot be employed for this purpose. For the analysis by this method the following rasps are recommended: First, for the analysis of entire beets, the conical rasps of Pellet and Lomont as arranged by Keil; second, for the analysis of fragments of beets such as fresh cuttings for the diffusion process, the apparatus of R. Kiehle, of Leipzig; third, for the analysis of seed beets, or mother beets, in seed selection, the apparatus of Keil and Dolle, known as the *foret-râpe*. The rasp used in connection with the apparatus of Hanriot is applicable.

As has been stated, for this process the pulp must be in a very fine state of division, not merely forming a cream, but the particles must be regularly even. A suitable amount of the pulp, proper precautions being taken to protect it, is weighed into a flask of a definite volume. If the normal weight for the German instruments, 26.048 grams, is used the volume should be 201.35 cc., or if 25.87 grams of pulp be taken the volume should be 200 cc. The pulp is passed into the special flask with the assistance of a jet of water, then five to seven cc. of subacetate of lead (30° B.) are added and a little ether to reduce the foam, the flask being agitated with a rapid circular motion at the same time. The volume is now completed to 200 or 201.35 cc. as the case may be, and the contents of the flask thoroughly mixed. Filter and polarize after having acidulated the liquid with one or two drops of glacial acetic acid. A 400 mm. tube is used for the observation and gives the reading directly, corrected for the increase in volume of the solution. The diffusion is instantaneous and complete, permitting the filtration to be made as soon as the flask has been filled to the graduation and the contents thoroughly mixed. It is never necessary to heat the solution in order to insure complete diffusion, unless the water should be extremely cold, approximating 0° C. For all ordinary laboratory temperatures, the water will be sufficiently warm.

In order to make a large number of analyses per day, by this process, a filtration rack having six, twelve, or twenty-four holes, should be employed, also a continuous polariscope tube which will be described later on. Twelve to twenty flasks should be taken at once to the polariscope.

Among the different possible sources of error in the estimation of the sugar in the beet, those belonging only to the aqueous method will be here considered. In the aqueous process there is, of course, a possibility of the digestion or diffusion being incomplete, but this is very rare, since, owing to the simplicity of the operation, the flasks will always stand a sufficient time to obtain complete diffusion. In using the apparatus in the cold there is no danger at all of error, since a preliminary trial should be made to ascertain whether the pulp is sufficiently fine, and whether the water is of the proper temperature. There is a possibility of the solution of pectic substances which rotate the plane of polarization to the right. This error can only result from an insufficient amount of sub-acetate of lead. This inconvenience is easily avoided. The presence of pectic bodies may be shown in the following manner: Extract the pulp with cold water in large excess or with alcohol; treat the residue with boiling water and concentrate the liquid. This liquid will give a decided right-handed polarization amounting to more than 6.87 per cent. sugar on the weight of the beet. The same liquid, treated by sub-acetate of lead in sufficient quantity, will always polarize zero. Our work in this case is confirmed by Messrs. Chevron, Droixhe, and Weisberg.

Alcohol acts as sub-acetate of lead upon pectic matters and precipitates them entirely. It is for this reason that in the alcoholic solution two or three drops of sub-acetate of lead are sufficient for clarification, and for the complete precipitation of the pectic matters. It is hence easy to see how different results may be obtained in using the alcoholic or the water method upon the same pulp. Such differences might amount to from two to three per cent. of sugar calculated on the weight of the beet. As we have become better acquainted with the sources of error, the experiments have been repeated, and the adversaries of the aqueous method have all recognized that there are no plus polarizing substances in the beet not precipitable by lead and which are only thrown down completely, as they have stated, by alcohol.

In 1886 and 1887 many chemists published articles in which they attempted to demonstrate that alcohol, in fact, furnished results lower than those obtained by the water method, and which they then attributed to some particular substances precipitable by alcohol, and not by the sub-acetate of lead. But all have acknowledged later on that there were evidently diverse causes of error in their experiments, and have published statements reviewing those made in their first papers, and have shown perfect concordance between the alcoholic and aqueous methods, when properly carried out. This is quite valuable, since at first the aqueous methods were vigorously attacked by critics who now acknowledge their reliability. There is still another possible source of error in the aqueous method in the cold. This is caused by air bubbles remaining attached to the pulp, and may be due to an insufficient use of ether, to ether being replaced by alcohol, to insufficient agitation, or to other faulty manipulations. This error, it may be seen, is easily obviated. Numerous parallel experiments have demonstrated that the aqueous instantaneous method in the cold, gives practically the same results as those obtained by either the alcoholic or the hot water methods.

APPLICATION OF THE INSTANTANEOUS AQUEOUS DIFFUSION PROCESS IN THE COLD TO THE EXAMINATION OF MOTHER BEETS.

A portion of the pulp may be removed from the beet by the *foret-râpe* of Keil and Dolle and analyzed as described. This requires simply a weighing and the usual manipulation. A simpler method, and one which will be described more in detail, obviates all weighings. In this method of working, that is without weighing, 8,300 analyses per day have been made in the establishment of Mr. Legras, and in the sugar house of Vaux sous Laon.

In the analysis of beet mothers without the use of a balance, the sound invented by Lindeboom is employed. This sound is so arranged that by the movement of a lever, a knife is made to penetrate the beet and remove a portion of it. A proper arrangement is provided for inclining the beet at a proper angle to the knife. The knife is arranged with parallel blades which are adjustable, and which will remove a cylindrical portion of the beet of a size which is perfectly under the control of the operator. After adjusting the knife to cut a cylinder of a certain size, which is determined by the convenience of the operator, it may be used for a number of samples and will cut a cylinder of practically the same weight at all times. The weights of the following cylinders cut in this way will give an idea of the accuracy of this method:

No.	Weight, grams.
1	6.245
2	6.265
3	6.290
4	6.370
5	6.245
6	6.285
7	6.365
8	6.250
9	6.335
10	6.240
11	6.330
12	6.390
13	6.370
14	6.270
15	6.310
16	6.300

Average, 6.304 grams.

If one will consider a beet of average richness as containing fifteen per cent. sucrose the minimum weight given in the above list would show 14.85 sugar and the maximum 15.2, an extreme difference of 0.35 or 0.15 to 0.20 above and below the mean. These figures approximate the required weight with sufficient accuracy for actual practice and for use with the special apparatus devised by Hanriot, we have found it a very valuable adjunct. Hanriot's apparatus is so arranged that the sample of beet, of the required weight, when placed in a proper receptacle is transferred to a mill where it is ground to a fine pulp. Immediately after grinding, by a suitable manipulation of a valve and rubber bulb containing water, the fine pulp is washed into the sugar flask and is ready for analysis. The Hanriot apparatus is then quickly washed, by means of a special valve arrangement, and is ready for another sample. Preliminary to commencing the analytical work, the sound is adjusted to give the most convenient weight of pulp, for the polariscope in use. This may be 6 grams, 5.12 grams, or 4.05 grams, according to the requirements of the instrument. But little adjustment is necessary to so set the knives that they will cut a cylinder of the proper diameter and length to give the required weight. In this class of analysis, it is unnecessary to take account of the influence of the volume of the marc of the beet.

In the analysis of seed beets, Mr. Hanriot has suggested the use of electric signals for assorting the roots. Electric contacts are arranged on the scale of the instrument so that when this is turned to a certain point, corresponding to a certain richness of the beet, a signal will be sounded on a bell, and when turned to a certain other point a signal will be sounded on a bell of different tone, indicating in general the richness of the sample and showing the workmen how to distribute the roots.

CONTINUOUS TUBE FOR THE POLARIZATION OF ALL SOLUTIONS.

In many cases the manufacturer of sugar, the refiner or the seed producer, is obliged to make a very large number of analyses of the same class and as rapidly as possible. The work required in seed selection is an example. In this industry it is often necessary to make 3,000, 4,000, 5,000, and even 8,000 or more analyses of mother beets in a day.

With ordinary apparatus it is admitted that with one polariscope a single observer may make from 500 to 600 or even 1,000 analyses in a day, provided one has a sufficient number of observation tubes, that is, from twenty to fifty. The continuous tube permits this work with much less labor, far greater rapidity and requires but one observation tube. This instrument was devised especially for use in the analysis of mother beets.

Many difficulties were overcome before this tube was constructed in a satisfactory form. As now used there is a small tube at each extremity, one of which is termed the funnel and connects directly and exactly at the extremity of the observation tube against the glass; the other is a similar tube but is placed at a slight angle with the observation tube. This small tube connects with the sink and is used to get rid of the solutions after they have been polarized. This arrangement of the observation tube permits the displacement of one solution by another. In practice, the observation tube is never removed from the polariscope. At the start it is filled with water, slightly acidulated with acetic acid, care being taken to remove all air bubbles. The solution to be observed is now passed in at the funnel tube displacing the water, driving it out through the tube at the opposite end. When another solution is ready for examination, it is simply necessary to pour it into the funnel and, as before, displace the preceding solution. The chemist at the polariscope will at first observe striae, which diminish rapidly, and finally the solution will become perfectly clear. As soon as the liquid becomes clear the observation may be made. While the chemist is entering the reading in his note book, an assistant introduces a new solution at the funnel, and the instrument is ready for another observation. In this way an observer can easily make four readings in a minute, but even if he could make but two, he would attain a speed twice as great as is possible with the ordinary polariscopic methods and with far less labor. In the analysis of beet mothers, where a slight difference is of no importance, an observer can easily make from six to ten readings per minute.

A special disposition of the apparatus may be made which permits filling the tube by siphonage. In this way from eight to twelve solutions per minute may be polarized.

EXPERT TESTIMONY.

BY WM. P. MASON.

A NUMBER of years ago several very able articles appeared in *Nature*, upon the subject of Expert Testimony, showing how desirable it is to have the scientific witness removed as far as possible from the position of a partisan, and suggesting that such an end could be best obtained by having the experts employed by the bench rather than by the bar. Some recent experiences of my own, which I beg permission to recount, call to my mind those "Nature" articles very forcibly. A poison case in which I was lately employed, may be roughly outlined as follows:

Much arsenic and a very little zinc were found in the stomach.

The body had not been embalmed, but cloths wrung out in an embalming fluid containing zinc and arsenic had been spread upon the face and chest.

Medical testimony showed that no fluid could have run down

[1] Read at the Baltimore meeting, December 28, 1893.