Parkinson and Cowan supply a very simple mechanism which records nett value. These instruments are of immense value to the gas-manufacturer as they promptly indicate any want of uniformity in the quality of the gas made, and this affords opportunity of rectifying a defect without delay. This is all the more important in these days when the uniformity of calorific value is so essential.

Carburetted water gas.—In most gas-works possessing a carburetted water gas plant this auxiliary to coal-gas is only used either as a stand-by or as an enriching agent. That it is much cheaper to manufacture than coal gas is, I believe, the general opinion of the outsider. With oil at a comparatively high figure, as it has been for some years, carburetted water gas is probably on an average slightly dearer than coal gas, candle for candle.

One cannot say that any important improvements in water-gas manufacture have been made in the last ten years.

Research work.—There have been no contributions of great practical importance to our knowledge of the chemistry of carbonizing.

Improvements have been mainly physical and mechanical. The reactions that take place in the retort are as yet but little understood.

I would remind you of the bold experiment made by the Birmingham Gas Department in erecting five years ago as a test-plant a complete gas-works carbonizing 24 tons of coal per day. Hitherto we have not published any results, chiefly for commercial reasons. I may confidently say, however, that the remarkable improvement in the carbonizing results of the different works of the Department is in large measure attributable to the test-works, and justifies the considerable expense of its erection and working.

DISCUSSION.

After some remarks by Dr. R. LESSING,

Mr. H. T. PINNOCK said he was pleased to see in the town gas industry that it was found necessary to use producer-gas for heating the retorts. For lighting purposes town gas held pride of place; but for power and heating purposes the claims of Mond gas must be considered. His experience was that suction gas did not come fully up to expectations; while the cost of labour and water, associated with such a plant, and the waste of time in starting up, took away much of the efficiency of the plant. He desired to know whether the new Fery spiral pyrometer was as accurate as the thermo-couple type.

Dr. DAVIDSON: Very nearly; they agree closely.

Mr. PINNOCK, continuing, said he regarded the recording calorimeter as a useful invention. His firm were unfortunately situated, in that they had an apparatus which no one else had. No one was able to work it, except the professor who made it. It was made to satisfy the requirements of the Board of Trade, in order that the gas might be tested at any time; and when an official came he would probably be unable to use it. He was much interested in Professor Burstall's new tar extracting fan. He understood a test had been made and that the fan brought out the last traces of tar from the gas.

Mr. N. P. BOOTH asked how to detect minute traces of carbon monoxide in air—this being a problem with which he was recently faced?

Mr. R. B. BATTY said he regarded Victoria Square, Birmingham, as the experimental lighting area and supposed it was the show place of what could be produced at Saltley. A friend of his, who knew Europe well, looked upon that part of Birmingham as the best gas lighted area he had ever seen. Alluding to the observations as to the naphthalene trouble the gas experts were to be congratulated upon getting rid of the nuisance. In the statistical record on the prices of gas Dr. Davidson was not ashamed to state the price charged at Sheffield. He was glad to hear that high pressure gas would be

given without any great cost or inconvenience to the gas department.

Mr. WALTER asked whether it was necessary to use specially designed retorts where, as in Germany, a higher working pressure was maintained in order to bring down the percentage of nitrogen in the gas; also whether the ordinary fire-clay retorts could be used in the above case.

Dr. DAVIDSON, in reply, said in the coal gas industry the best return to be obtained from ordinary gas-coal was a conversion of 25 per cent. of the calorific value from the solid into gaseous form. With regard to producer gas 75 per cent. could be obtained. It had been suggested that towns should be supplied with producer gas, rather than coal gas, by reason of the lower cost of production. One important consideration, however, was the heavy cost of distribution, as huge holders and mains were necessary for distributing producer gas. He was not aware of a satisfactory calorimeter for accurately testing producer gas. As to the retorts in use in Germany where a comparatively high pressure was maintained, they were of the ordinary fireclay type, as used in this country, and there was bound to be a certain leakage into the furnace and therefore loss of gas. The test for carbon monoxide was iodine pentoxide; the particulars being given in the *Journal of Gas Lighting* of June 22nd, 1909, p. 823. With reference to street lighting in Birmingham he was rather ashamed of it, with the exception of that in Victoria Square. They were very much behind Continental towns. In Germany where there was a lower grade gas incandescent lighting was far better. There the organisation and supervision of the lighting were superior, and the gas itself showed greater uniformity. When the new 24 in. main was laid in Birmingham the central streets would be much better lighted than they were to-day. On the question of price, Sheffield, which had a lower figure than Birmingham, was favourably situated, being near the coal mines. They paid three to four shillings per ton less for their coal than the Birmingham Corporation. They were also able to obtain a great deal of cheap slack. Sheffield was not however the lowest in price although it was the lowest in the list of the twenty-four largest towns. Widnes supplied gas at 1s. per 1,000 c. ft.

Canadian Section.

Meeting held at Montreal on Friday, October 22, 1909.

DR. MILTON HERSEY IN THE CHAIR.

ETHYL ALCOHOL FROM SAWDUST AND OTHER WOOD WASTE.

BY PROF. R. F. RUTTAN, M.D.

The action of the zymose of yeast upon glucose and certain other fermentable sugars is the one source of the ethyl alcohol of commerce. It therefore follows that the problem of how to produce ethyl alcohol in a more economic manner can only be solved by finding a new and cheaper method of obtaining solutions of fermentable sugars.

The fermentable sugars employed in the preparation of alcohol have been derived hitherto from a number of sources, which may be generally stated to be (1) the products of the hydrolysis of starch and allied substances by means of an amylase; (2) solutions of sugar obtained directly from fruits, &c., and the non-crystallizable by-products of sugar works, &c.

The cost of alcohol from these sources is much too great to enable it to compete with other products in many fields where it could be used to great advantage. This is due, not so much to the cost of manufacture as to the cost of the raw material from which the fermentable sugar is obtained. The most economical source of starch on this Continent is Indian corn, yet this raw material costs at

present \$21.60 per ton. One ton of corn gives about 90 gallons of alcohol of 94 per cent. at a cost of 24 cents per gallon for raw material. About two gallons of raw molasses produce 1 gallon of 94 per cent. alcohol, and this raw material costs 21—22 cents. The raw material of (German alcohol) has been estimated to cost 20 to 21 cents. per gallon of alcohol of this strength.

There is a process in which a waste product of nominal commercial value is the raw material from which fermentable sugars can be obtained. The actual cost of sawdust and other wood waste to any industry is difficult to estimate. In some localities, where the quantity of waste is not great, a local market for it has been established, and in most forms it has been disposed of at a small profit. The larger mills, now that electricity is of such general application, have in many cases increased their power and find an economic outlet for all forms of wood waste as fuel for generating this power. There remain, however, the great majority of the large sawmills of this continent where the wood waste has either to be disposed of by sawdust burners at a cost of about 20 cents. per ton, or allowed to accumulate in heaps upon the land, or is turned into an adjoining stream to be a nuisance and an injury for many years, if not for generations.

Any industry employing wood waste situated in the vicinity of a large mill of the last-mentioned class, should be able to obtain waste for the cost of transportation and handling which under moderately favourable conditions should not exceed 30—50 cents per ton.*

As I shall later explain, one ton of sawdust or other comminuted wood waste calculated to a dry basis can be made to yield about 20 gallons of alcohol of 94 per cent. This then reduces the cost of raw material from 20—24 cents to 2 or 2½ cents per gallon of alcohol.

That fermentable sugar can be produced from wood has been known to chemists for nearly a century. Braconnet as early as 1819, by heating wood cellulose with sulphuric acid, produced a pulp which contained glucose. The sulphuric acid, however, could not be economically removed. Since then no process has been devised until quite recently for hydrolysing cellulose and allied bodies economically.

Numerous attempts have been made to solve this problem and the list of patents on the subject is a large one. Prior to 1900, when the Classen patents were taken out, the hydrolysing effect of many acids on starch and the celluloses had been studied and the processes patented. C. Pope, for instance, in 1898 obtained a patent for hydrolysing starch and obtaining fermentable sugar by sulphuric acid, and Einar Simonsen in 1898 a patent to make sugar or glucose from sawdust by the action of dilute sulphuric acid (see this J., 1898, 365, 481, 1164). Sulphurous acid had long been used to make wood pulp from comminuted wood before these patents; it was also well known that when sulphurous acid was heated with wood, sulphuric acid was always formed which took part in the reaction, and its action was prevented in pulp-making by the use of calcium bisulphite, the sulphuric acid combining with the calcium as it was produced.

Dr. Alexander Classen of the Polytechnic School of Aachen, stated in 1900 that sulphurous acid in aqueous solution under pressure converted the cellulose of wood into glucose and that the product could be fermented in the usual way yielding ethyl alcohol. He patented this process all over the world, but the original methods as stated in the patent proved to be crude and unworkable. The claim is as follows:—

"The process of converting cellulose into sugar, which consists in heating the cellulose in a closed vessel at a temperature of 120°—145° C. with a solution of sulphurous and sulphuric acids substantially as described." (This J., 1900, 1028; 1901, 734, 1008.)

After successful experiments in a test plant erected by Classen in Aachen, a similar plant on a larger scale was erected at Highland Park near Chicago, to demonstrate to American capitalists its possibilities. The results were so satisfactory that a larger plant on a commercial scale was

erected at Hattiesburg, Miss. The plant included the following elements:—

1. An acid apparatus where the solution of sulphurous acid was prepared and where the excess of sulphur dioxide after use could be re-absorbed and saved for further utilisation.

2. A revolving cylinder, 30 feet long, and about 36 inches in diameter, which formed the converter or digester.

3. An exhausting battery consisting of a series of tanks in which the sugar was washed from the partly converted sawdust by hot water.

4. Neutralising vats in which the various acids remaining in the saccharine liquid were neutralised by calcium carbonate.

5. Fermentation vats, and a still, where the process was completed as in an ordinary distillery.

The wood waste was introduced into the digester (which it nearly, but not completely filled), made of iron lined with lead to prevent action of the sulphuric acid, and surrounded by a steam jacket by which it was heated. This revolving cylinder had a capacity of about two tons. To the charge of wood waste was added a weight of a nearly saturated solution of sulphur dioxide corresponding to about one-third of the raw material. The drum was closed air-tight and steam turned into the jacket while the whole slowly revolved. The temperature of the interior was thus slowly raised to 290°—300° F., and the pressure to about one hundred pounds. After from four to six hours the sulphurous acid and steam were blown off into the absorbing tanks and the sulphur dioxide thus partially recovered. The cover was removed and the contents emptied looking then very like finely ground coffee. This finely divided, treated wood was conveyed to the exhaustion batteries and the sugar extracted. The liquid obtained, contained from 350—400 lb. of sugar for each ton of raw material treated. The next steps were to neutralise the acid liquid, allow it to clear by subsidence, pump it into the fermentation vats, ferment it by yeast and distil the product in the usual way. It was claimed for the process that each ton of wood waste gave about 18—20 gallons of absolute alcohol.

The history of the original Classen process is an excellent example of how a process which will give very good results on a laboratory scale, and good results even on a larger experimental scale, will just fail to succeed when magnified to a size necessary for working on a commercial basis. Even the strongest supporters of the original Classen process do not now believe it to be a success as a money-making proposition.

The difficulties in the way to success for this process are explained to be: (1) The length of time necessary to convert 1½ to 2 tons of wood, this requiring from 4 to 6 hours; (2) the quantity of acid required; (3) the prolonged action of so much acid and water in the rotating converter reduced the wood to a very fine powder and formed much sulphuric acid which, acting on the sugar and other substances, produced gums and caramels, and so made the complete extraction of the sugar from the residue very tedious and expensive. (4) The buckling and breaking of the lead lining of the converter, which had to be repaired after every two or three operations, and proved a very great source of delay and expense.

The plant built in the United States, which is reported to have cost for building and working for a year about \$250,000, has not been used for some time. Two chemical engineers, Malcolm F. Ewen and G. H. Tomlinson, who were associated with the Classen process, both in Germany and the United States, finding the original process unlikely to prove a commercial success, obtained substantial financial aid from a Chicago engineer, Mr. J. M. Ewen, and in 1904 began experimenting along new lines to overcome the difficulties which prevented the old process from being a success. The result of their researches and experiments has been to shorten the time of the hydrolysis in the converter from six hours to 40 or 45 minutes, to obtain the treated wood waste in a form which could

* Tenders have been offered to deliver, 200 yards away, 200 tons of sawdust, etc., per day at 25 cts. per ton.

be quickly and efficiently extracted, to devise a converter which is not in the least degree affected by the process, to reduce the quantity of acid employed, and to obtain a very uniform and large yield of fermentable sugar from wood waste.

This process, by the courtesy of the patentees, I was enabled to study in June, 1909, at Chicago Heights, about 20 miles from the city of Chicago. The plant was erected by the Wood Waste Products Company, now called the Standard Alcohol Company, which has control of the Ewen-Tomlinson patents. This experimental plant was composed of units of commercial capacity, and was set up in workshops in the grounds of a large machinery manufactory. It consisted of the same elements as those required for the older process, *viz.*, the acid generating and recovery apparatus, a converter or digester, a battery of diffusion cells to extract the sugar, neutralising and storage tanks, fermentation vats, and a distillery.

The converter in use at Chicago was a revolving cylinder, 12 feet by 8, of steel, lined with fire-brick, and set in a cement of lead oxide and glycerin. It had a capacity of about two tons of shavings or three of sawdust. The wood waste, sawdust, shavings, or small chips, are dumped into the converter, which is completely filled, and is then closed air tight. Gaseous sulphur dioxide in measured quantity, only about 1 per cent. by weight of the dry wood, is introduced through a perforated tube passing through the trunnions of the cylinder and thus through the centre of the revolving mass of the sawdust. When the required quantity has been added the sulphur dioxide is turned off and live steam is introduced through the same tube till a pressure of about 100 lb. is reached. It takes from 10 to 15 minutes to get the contents of the digester heated up to the required temperature. The steam is then cut off and the digester revolves slowly for another 40 to 45 minutes, the temperature and pressure being kept constant, when the hydrolysis is complete. The steam, carrying with it the terpenes, the excess of sulphur dioxide, and some acetic acid, is then discharged into the absorption tank. The manhole is again opened and the coffee-coloured chips and sawdust discharged into a V-shaped bin which supplies the conveyors going to the diffusion cells.

In the plant now being built for the Du Pont Powder Company at Georgetown, S.C., it is probable there will be three or four converters, egg-shaped or spherical, and capable of taking four to five tons at one charge. These are to be so arranged that when the digestion in one is completed the steam and acid may be directly discharged into a second digester already filled with wood waste, thus saving time and expense in recovering the acid of each charge.

From the converter the treated wood is conveyed to the extraction battery where it is rapidly and effectively exhausted by hot water, the acid liquid neutralized with slaked lime and carbonate, allowed to settle in the settling tank, and then pumped to the distillery, fermented and distilled.

In the tests I made of the plant two charges of the converter were used. The first contained 3623 lb. of shavings from Chicago Mills, air dry and almost entirely pine. This carried 18.61 per cent. of moisture, making the dry wood equivalent 2948.8 lb. The second charge consisted of 2992 lb. of shavings and 2105 lb. of wet hardwood sawdust, consisting chiefly of oak but with some pine. The total weight of the second charge was 5097 lb. with a dry wood equivalent of 3058 lb. This second charge was made with a view of testing the effect of the process on sawdust carrying a very high percentage of moisture. The sawdust gave on analysis 70.4 per cent. moisture.

The product of the action of steam and sulphur dioxide on the first charge of shavings was a friable brown product resembling tan bark or coffee, with a fragrant aromatic odour and strongly acid. Analysis of this gave:

	per cent.
Moisture	32.23
Total reducing sugars	13.70
Calculated to dry basis	20.20
Total acidity (as sulphuric acid, SO ₃)	1.23
Sulphuric acid (SO ₃)	0.418
Reducing sugars, fermented	10.70
Unfermented sugars, xylose, etc.	3.00

The wood waste in the second charge after treatment resembled the heated shavings, but was finer and had a powerful aromatic odour and gave the following results:

	per cent.
Moisture	34.63
Total reducing sugars	14.28
Calculated to dry basis	21.18
Total acidity	1.12
Sulphuric acid	0.353
Reducing sugars, fermented	10.97
Non-fermented matter, xylose, etc.	3.21

The total weight of waste wood in the form of sawdust and shavings in these two charges was 8760 lb., or calculated to a dry basis, 6007.1 lb.

The treated wood was then exhausted with hot water in the extraction battery. The liquid containing the sugar from these two charges was collected in one storage tank and occupied a volume of 2984 gallons, or 26,150 lb. in weight. The mingled liquors contained 5.6 per cent. of reducing sugars calculated to dextrose.

The total acidity was 0.64 per cent. calculated to sulphuric acid; of this 0.21 per cent. was sulphuric acid and the balance was composed of acetic acid, a little sulphurous acid, and aromatic compounds of the type of pyrogallol. The presence of the polyphenols and tannin bodies was most obvious. On neutralizing this solution with lime and calcium carbonate it blackened rapidly and when ready for fermentation had an inky colour due to the oxidation of the aromatic salts. The liquid also contained a considerable amount of furfural. As there is little or no nitrogenous material suitable for yeast food in the liquor it does not ferment well alone, hence before adding the yeast about half a bushel of malt sprouts was added to a vat of 3000 gallons as food for the yeast.

In this experimental plant various forms of yeast have been tried. The problem as to which particular breed of yeast will give the best results was, in June last, still unsolved. The yeast used in my experiment was brewers' yeast from a neighbouring lager beer brewery which was found to give constant and regular fermentations, but not more than 75 to 80 per cent. of the theoretical yield of alcohol was obtained. The fermentation occupied about three days, when the liquid was handed over to the gauger and distiller who was an employee of the United States Government, and placed in charge of the distillery. From the 2984 gallons of fermented fluid, corresponding to 6007.1 lbs. of dry wood the gauger reported 115.92 gallons of proof spirit or 61.66 gallons of 94 per cent. alcohol.

This will be seen to be equivalent to 20.55 gallons per ton of wood waste calculated to a dry basis, or 14.14 gallons per ton of wood waste including the wet sawdust which contained over 70 per cent. of moisture. This alcohol when rectified to 94 per cent. is of a potable spirit, crystal white, and carries no trace of odour or flavour of wood. It contains no trace of methyl alcohol or of the higher alcohols such as fusel oil but, gives the reaction for traces of furfural and aldehyde.

At present there has been little or nothing done towards utilizing or indeed determining the quantity and value of the by-products resulting from the manufacture of ethyl alcohol by this process. The Standard Alcohol Company have contented themselves with manufacturing a very cheap and pure ethyl alcohol and have left the working out of the by-products to the future.

The wood waste left behind after complete extraction is a friable cellulose and represents about 65% of the original wood, of which only about one-third is rendered soluble and extracted by the process. This material, according to the present plan, is to be squeezed between rollers, dried partly by waste heat from the boilers and used as fuel. Turpentine and acetic acid are found in the absorption tanks after blowing in the steam from the converter and will no doubt be recovered.

In France there is in operation another process for the manufacture of ethyl alcohol from wood waste. I know nothing of this process beyond an account of it which appeared in the General Electric Review of September, 1909, by G. U. Bordo. The claims for this process are interesting and extraordinary. Finding the Claisen process

unworkable on a commercial scale the company who controlled those patents for France are reported to have so modified the process as to largely increase the value of the by-products, chiefly the acetic acid and the solid tailings, and can still produce about 20 gallons of alcohol per ton. The raw material is treated in a Classen converter with a solution of sulphurous acid at a pressure of 100 lb. Neither the time required—a most important item—nor the form of the converter nor yet the quantity of acid used are stated in the report. From the profound change effected in the character of the wood, however, the process must be greatly prolonged and the sulphuric acid formed given ample opportunity to attack the cellulose. The digested mass is allowed to partly cool in the digester when it is found to have shrunk about 25 per cent. The sulphurous acid is recovered and the material from the digester passed over to a separator in which the acetic acid is recovered by vaporizing it with steam. The whole mass, without any attempt at separating the sugar, is then neutralized, made into a mash, which is fermented and distilled in the same way as an ordinary grain mash is handled in a whisky distillery.

The tailings from the still are compressed and dried as in the previous process by waste gases from the boilers. This material is claimed to be useful as a stock food, or can be briquetted or mixed with magnesia to form artificial stone of value. In an experiment conducted by the writer I am quoting, he obtained from 3200 lb. of refuse wood 21½ gallons of 94 per cent. alcohol, 76 lb. of acetic acid and 1800 lb. of stock food. The value of this he estimates as follows:

Alcohol at 40 c. per gall.	\$ 8.60
Acetic acid at 6 c. per lb.	4.58
Stock food at \$23 per ton	17.25
	<hr/> \$30.41
	\$
Estimated cost of production	7.00
Net profit	25.41
	<hr/> \$30.41

If this be a true estimate of the value of the products obtained from a ton and a half of sawdust it is much more profitable than the process I have reported upon. The ethyl alcohol produced according to the above is of secondary importance both commercially and economically to the manufacture from sawdust of a foodstuff for stock of greater value than Indian corn. The description of the process does not convince one that the inherent difficulties of the Classen process have been removed. The exaggerated value placed upon the stock food is obvious. There is no reason, however, why a prolonged digestion of wood at a high temperature should not greatly increase the yield of acetic acid and might produce a substance from cellulose by the hydrolysing effect of sulphuric acid which might have a food value, but necessarily a very low one after the extraction of the sugar. It is known that the partial hydrolysis of keratin (horn, hoof, hair, etc.), renders such substances digestible. If the process be carried so far as this, however, it seems very probable that the sulphuric acid formed would destroy much of the sugar and thus lower greatly the yield of alcohol. In the Ewen-Tomlinson process which I have studied, it was found that the more rapidly the contents of the digester could be raised to the required temperature the shorter was the time required to produce the maximum yield of sugar; a gradual elevation of temperature, as occurs in the Classen process, induces secondary reactions and a lower yield of fermentable sugar. This rapid heating of the contents of the converter is only possible by the Ewen-Tomlinson method of introducing live steam into the interior of the mass by the perforated tube in the axis of the converter.

All will watch with interest the development of these two offsprings of the Classen process in America. A plant is being erected to use this French process at Hadlock, Wash., and another is proposed for some place in Ontario.

As to the cost of production of ethyl alcohol by the Ewen-Tomlinson process, a very close estimate has been made, based upon tenders and the experience of the

patentees in the Classen plant. Broadly speaking, the cost is about the same as that required to produce alcohol from grain or any other starchy material. Outside the converter itself there is nothing used in the plant which is not quoted on the market and made for other purposes. Without going into details, a plant capable of handling 100 tons of dry sawdust in a ten hour day, or working continuously, 200 tons per day, including buildings of a simple character and of cheap substantial construction, was estimated at \$99,500. The daily cost of maintenance, including interest, depreciation, labour, and material, allowing 50 cents per ton for the sawdust or other wood waste, would amount to \$217, i.e., \$217 for 100 tons, or \$2.17 for 20 gallons of alcohol, 90 per cent., or a nett cost of 10.8 cents per gallon. No allowance is here made for fuel, save the cost of drying the unused portion of the sawdust. This estimate further is made on a plant not smaller than 100 tons.

When one considers the possible value of the by-products from a large plant, and the fact that quite 20 per cent. of the available sugar was not fermented in the experiments made last June, it would appear that cheap industrial alcohol has at last arrived.* Ethyl alcohol from grain, 94 per cent., averages about 52 cents to the consumer without the Government tax, and denatured alcohol from 45 to 60 cents. Alcohol made from refuse wood should not cost the consumer more than 20 to 25 cents.

Quite apart from its economic aspect, the manufacture of fermentable sugar from wood by this process is intensely interesting to the chemist. The process is essentially one of hydrolysis analogous to the conversion of starch to sugar by the amylolytic ferments. The celluloses are, like starch, polysaccharides of unknown constitution. They are generally represented as having the same percentage composition and empirical formulae, and just as we can represent the hydrolysis of starch to maltose and dextrose, so we can show how by the assimilation of water the cellulose can give rise to maltose and dextrose. It is assumed that it is the cellulose element in the wood which gives rise to the sugar.

I was much struck by the regular action of sulphurous acid upon the sawdust, a constant quantity, about 35 to 40 per cent. of the wood, only being attacked. We know from the studies of numerous chemists, such as Hugo Müller, Sachs, Cross and Bovan, and others, that wood freed from adventitious constituents such as the tannins, colouring matters, resins, &c., is strikingly uniform in the composition of its fundamental tissues, notwithstanding the great variety in structural complexity, and this uniformity in composition is not confined to species, but is found to embrace all sorts and varieties of woody tissue. The average composition of wood from all sources may be said to be, water 11 per cent., cellulose 50 per cent., soluble in water 3.5 per cent., non-cellulose 35.5 per cent. Lignum vite and ebony are exceptions, being very low in cellulose and high in non-cellulose.

In the Classen patents and in one of the Ewen-Tomlinson patents it is the cellulose which is claimed to be converted into fermentable sugars. It seems more than a coincidence that the quantity of material hydrolysed in the Ewen-Tomlinson process should be so constant and should correspond so closely to the proportion of non-cellulose found in woods. In all processes of hydrolysis the non-cellulose or lignone complex is the first to break down whether the hydrolysis occurs in an acid or an alkaline medium. There is every evidence that here the lignone complex is broken down. The presence of hydroxy-derivatives of benzene, of pentoses, acetic acid, and furfural in quantity is obvious in the liquid extract of the treated wood. It seems probable that the lignone complex in woods is attached to a certain proportion of cell cellulose (hemi-cellulose) as well as to the oxy-cellulose and perhaps to the true fibre cellulose.

The material left after treatment consists of cellulose which is found on being again submitted to steam and sulphur dioxide to yield but a trace of sugar. True fibrous

*The Standard Alcohol Company claim to be able to produce this alcohol at a cost of 7 cents per gallon in a large plant.

cellulose (absorbent cotton) in another experiment remained unattacked. Its physical as well as its chemical properties were practically unchanged.

Under the conditions of the process a small quantity of sulphurous acid is employed for a short time only and very little sulphuric acid is formed. It would seem that the acid acts here as a catalyser inducing a rapid hydrolysis of the lignone complex and of a proportion of easily attacked cellulose. The oxy-cellulose for the most part and the true cellulose present are not seriously altered chemically. It would seem possible that, authorities to the contrary notwithstanding, the lignone complex is capable of yielding a certain amount of fermentable sugar. Should this, on further study, prove to be the case, it might be possible to treat pulp wood by this process as a preliminary to its conversion into pulp, and then by a second treatment to produce pulp fibre from the unattacked residue.

There is little doubt that in the original Classen process there was, owing to the larger proportion of acid and the prolonged action, a more profound action on the cellulose and the lignone complex, as well as probably a secondary action on the carbohydrates produced.

In a lumber producing country like Canada, any industry that can utilise waste wood and give it commercial value should receive encouragement. If this be the "revolutionary discovery," which the Department of Agriculture at Washington has pronounced it to be, it will add much to the wealth of nations. It will not only open up new fields for the use of industrial alcohol, but will liberate for use as food the million of bushels of grain now used up in the manufacture of ethyl alcohol, 90 per cent. of which is used as a luxury in life and regarded by many as a distinct evil in the community.

Liverpool Section.

Meeting held at the University on Wednesday, November 10th, 1909.

MR. MAX MUSPRATT IN THE CHAIR.

A RAPID METHOD FOR THE DETERMINATION OF ZINC IN THE PRESENCE OF IRON.

BY JAMES M. TAYLOR.

The published volumetric methods for the determination of zinc in the presence of iron require a preliminary treatment to obtain a pure zinc solution. This usually means the separation of copper, lead, and bismuth by hydrogen sulphide. The excess of hydrogen sulphide is boiled off, and iron oxidised. Precipitation by ammonia or ammonium acetate, in the presence of ammonium chloride, throws down ferric hydroxide with varying amounts of zinc; this is dissolved in acid, and reprecipitated by ammonia, the process being repeated till the filtrate is free from zinc. In most methods it is also necessary to remove manganese before estimation of zinc. The precipitation of zinc sulphide in the presence of chloroacetic acid is not complete if chlorides are present. These separations require too much time, and methods involving them were not useful on that account. A method of titrating zinc in the presence of iron seemed, therefore, a necessity.

Zinc sulphide is precipitated when hydrogen sulphide is passed into a dilute neutral solution of a zinc salt, with the liberation of an equivalent of acid. Ferrous salts,

under similar conditions, are unaffected. An endeavour was made to utilise these facts, by titrating the free acid liberated with caustic soda, using methyl orange as indicator.

Hydrogen sulphide was added to a mixture of zinc and iron sulphates, and normal caustic soda run in from a burette; towards the end of the titration "clots" of ferrous hydroxide were formed where the caustic soda dropped into the liquor, which did not readily dissolve. The white zinc sulphide first obtained darkened when the neutral point was reached. The further addition of about 0.2–0.3 c.c. of caustic soda gave an almost black coating of ferrous sulphide. The results were not satisfactory.

Sodium carbonate was tried instead of caustic soda, with some success, and pointed to the possible additional advantage of using bicarbonate. The latter was adopted with immediate success, and concordant results were obtained.

The use of methyl orange as indicator was abandoned, and the point when all zinc was precipitated and ferrous sulphide commenced to be thrown down, giving a greyish chocolate colour to the precipitate, was taken as the end point.

The following is the method employed for the determination of zinc in solutions containing ferrous salts, supposing them to be free from lead and copper—5 or 10 c.c. of the liquor are measured into a 600 c.c. flask 20 c.c. of a saturated solution of ammonium chloride, and a drop of methyl orange solution are added, and the solution neutralised with $N/2$ sodium bicarbonate. About 100 c.c. of water saturated with hydrogen sulphide are added, and then $N/2$ sodium bicarbonate is run from a burette, at first at the rate of about 2 or 3 drops per second. The contents of the flask must be well shaken throughout the titration. Each drop of sodium bicarbonate as it touches the liquor gives a black precipitate which *instantly* dissolves. Should the black precipitate of ferrous sulphide not form, it is a sign that insufficient hydrogen sulphide is present. When the zinc sulphide commences to turn grey, the sodium bicarbonate is added more slowly, shaking for four or five seconds after the addition of every 0.1 c.c. Finally, one drop will change the colour to a decided chocolate, when the titration is finished. 1 c.c. of $N/2$ sodium bicarbonate solution is equivalent to 0.016 gm. of zinc. The sodium bicarbonate solution is made by dissolving 42 grms. of bicarbonate in water and diluting to one litre. The solution is stable, but it is advisable to titrate a known amount of zinc alongside the sample till the operator becomes accustomed to the end point, taking the sample to the same depth of colour. The bicarbonate solution is standardised as follows:—0.15–0.25 gm. of zinc is measured into a 600 c.c. flask, and 20 c.c. of saturated ammonium chloride solution and about 0.1 gm. of ferrous sulphate are added. The solution is neutralised, treated with hydrogen sulphide, and titrated as described above for the actual determination of zinc. The end point is more distinct if the ferrous sulphate is added about 0.5 c.c. before the finish.

One, or at the most two drops of sodium bicarbonate solution cause a distinct darkening that is not materially increased by the addition of a further cubic centimetre.

In carrying out the determination of zinc by this method, the following points must be noted:—

(A) Copper, lead, and bismuth, unless present only in traces, must be removed by means of iron gauze or hydrogen sulphide in acid solution.

(B) Iron should be present in the ferrous state, otherwise the neutral point is obscured. Heating with iron wire or sulphurous acid speedily accomplishes this.

(C) The volume of solution should be about 150 c.c. after adding hydrogen sulphide water, when the zinc is 0.1–0.3 gm. If the zinc is present in small quantity say 0.1 gm., a sharper end reaction is given if the volume does not exceed 70 or 80 c.c.

(D) As in the case of most zinc titrations, the conditions should be as near alike as possible in sample and check test.