

SOME NOTES ON THE UTILISATION OF BAGASSE

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Amongst sugar technologists the subject of utilisation of the industry's normal by-products—bagasse, final molasses and filter cake—is always an attractive subject of discussion. Those of optimistic disposition stress the opportunity of making vast extra profits, and those of more pessimistic, or even realistic, temperament, usually point out the many unsuccessful attempts which have been made to achieve something spectacular.

It has to be admitted however that there is a group of hard-working men in the world who have succeeded in converting sugar cane waste products into useful goods and in making a profit too.

Studying the history of the cane sugar industry, one finds periods of increased interest in the subject, and also numbers of years in which nobody seems to have paid much serious attention to it.

At present we apparently live in a period of increased, and let us hope lasting activity, which also has its repercussions in Natal. Not only did Dr. Rapson bring the subject to the fore in his opening address to the Technologists' Congress at the beginning of last year, but at Darnall an extraction plant for the production of cane wax from filter cake has been erected, at Felixton a combined bagasse pulp and paper mill of twenty tons per day capacity has been completed, which produces unbleached semi-pulp for conversion on the spot into wrapping and corrugated papers and boards, and S.A. Board Mills have recently installed new plant which will be able to process bagasse. And of course most of Natal's final molasses is fermented and converted into alcohol, ether, dry ice, yeast and other products.

During my trip to the British West Indies and Louisiana in the first half of last year I had the opportunity to pay some attention to the problem, and I propose to put together here something of what I heard, of what I saw and of what I found in various publications on a subject which tends to be of increasing importance to South Africa. In this paper, however, I would like to confine myself to the utilisation of bagasse.

Natal produces annually about one million tons of dry fibre in bagasse which are almost completely burned under the boilers. If seriously attempted, a considerable portion of this vast quantity could be saved as surplus bagasse. Conservatively estimated, at least 150,000 tons of dry fibre could be saved, when we base our assessment on the amount of fuel required by cane sugar factories in other countries. Much more would be available, however, if mills would convert their bagasse-fired boilers into coal-

fired boilers, a procedure which might be recommendable if high transport costs made it desirable to have large amounts of bagasse available in one spot.

Thus, while it would not be necessary to worry at first about the available quantity, it would probably be imperative to pay some attention to the quality of our bagasse. Natal cane as delivered to the mills contains a considerable amount of trash, and although we have few reliable data, we know that the fibre percentage of trash is high. It would not be surprising if the percentage of the fibre which originates from trash rather than from clean stalks is at least 15 per cent. of the total, and we know that bagasse from trashy cane is inferior for some purposes to bagasse from clean stalks. However, this difficulty might be overcome and we can summarise by stating that in Natal there is plenty of bagasse available which is suitable for conversion into secondary products.

What can we do with it? When discussing this problem with overseas experts I was given the following advice which in my opinion seems quite sound. They said: do not try to use bagasse as a cheap substitute for the raw material of a product for which bagasse is not specifically suitable. Try to convert bagasse into a product which cannot so readily be obtained from some other source, or into a product of a quality which is superior to the quality of the similar product made from the usual raw material.

Considering the various possibilities it is obvious that following this advice, the production of a Celotex-type constructional board is one of the first projects to be regarded as a serious proposition. Cane fibre soft board is usually considered to have properties which in many respects are superior to those of soft boards made from some other raw material, for example, wood fibre. It has excellent insulating value, and does not move when mounted on walls. It can be used for ceilings and partitions and can be painted and distempered. Due to special treatment it withstands attacks from white ants and fungi.

Celotex is manufactured in the United States in one big factory in Louisiana, and part of the product is finished in another plant in Metuchen, New Jersey. Trinidad bagasse (Brechin Castle) is shipped to Stonebridge Park, Middlesex, England, and converted into Celotex. In Hawaii a similar product called Canec is manufactured at a rate of more than 550,000 sq. ft. per 24 hours, and in Australia Can-ite (160,000 sq. ft. per day) is produced.

The process applied to soften and separate the fibre bundles is partly chemical (cooking with water to which soda ash or lime may be added) and partly mechanical, and cannot be termed complicated or expensive. Board machines on the other hand are expensive units, and the costs of finishing should also not be underestimated.

In Louisiana I was allowed to visit the gigantic Celotex factory at Marrero near New Orleans which converts daily 700 tons of baled and dried bagasse, plus 200 tons of waste paper, into about 2,250,000 sq. ft. of board.

Louisiana produces annually 750,000 tons of fibre in final bagasse of which about 210,000 tons are used industrially. There is no other cane-growing country in the world which uses such a large portion of the bagasse produced for the manufacture of secondary products. This is, in my opinion, due to three factors:

- (a) the production of secondary products is becoming more and more essential to run the industry economically;
- (b) natural gas is abundantly and cheaply available as a substitute for bagasse as fuel;
- (c) the presence of big chemical and engineering industries in the same country stimulates attempts "to do something."

When comparing Natal with Louisiana conditions, one is easily tempted to attach considerable significance to the cheap natural gas factor in this latter country. It is true that burning natural gas allows Louisiana factories to sell their entire production of bagasse on the fuel value basis (plus a certain profit) at a rather low price to the Celotex factory, but the bagasse is first baled and stacked in the fields for some months before being railed to Marrero and when the bagasse arrives there the cost is about four times the purchase price paid to the sugar factory. Hence the purchase price is not the main factor in the cost structure. To illustrate the position in Louisiana, Dr. A. G. Keller has published the following data:

Price of natural gas at sugar factory, per 1,000,000 B.T.U.	\$0.145
Purchase price of bagasse in Louisiana, per ton of B.D. fibre	\$2.50
Baling, stacking and covering in field, per ton of B.D. fibre	\$6.00
Loading costs, storage to railroad cars, per ton of B.D. fibre	\$0.50
Total costs, f.o.b. cars at point of origin, per ton of B.D. fibre	\$9.00

To this must be added freight from the sugar factory to the point at which the bagasse is used, amounting to somewhat more than \$1 per 100 miles.

The purchase price of Louisiana bagasse (\$2.50 per long ton B.D. fibre) includes a profit on its fuel value (compared with natural gas) which Lathrop and Aronovsky have calculated to be \$0.50.¹ This profit is equivalent to approximately 3/3d. per ton of 2,000 lbs. of B.D. fibre.

Now considering the situation in Natal, it should be appreciated firstly that if Natal factories were required to operate on bought coal, increase of boiler efficiency and a more economical steam consumption would considerably reduce the amount of heat in fuel required to process one ton of cane. Assuming conservatively that 60 lbs. of steam would be required to convert 100 lbs. of cane into sugar and molasses, one pound of steam yielding 1,000 B.T.U., and a boiler efficiency of 70 per cent., it can be calculated that 1,714,000 B.T.U. in coal would be required. Heat available in bagasse as burned at present is 2,200,000 B.T.U. per ton of cane crushed, i.e. 28 per cent. more.

1,714,000 B.T.U. are liberated by burning 140 lbs. of coal (cal. value 12,200 B.T.U./lb.) which, at a price of 32/- per ton, would cost 26.88d. This is the fuel value equivalent price of the entire quantity of bagasse produced from one ton of cane.

If a Natal soft board factory would pay the sugar mill the price which is paid in Louisiana, i.e. \$2.50 per long ton of B.D. fibre, equivalent to 16/- per short ton of bone-dry fibre, the sugar factory would receive 1/11d. more than its fuel value for one short ton B.D. fibre, i.e. 3.68d. per ton of cane.

The Louisiana profit of \$0.50 per long ton of B.D. fibre corresponds to approximately 3/3d. per short ton of B.D. fibre, which is more than calculated for Natal, but if replacement fuel were available in Natal at the same price per B.T.U. as in Louisiana, the purchase price would be 5/2d. per short ton of B.D. fibre more than the fuel value. This would leave a greater profit than in Louisiana, partly due to the higher fibre content of Natal cane. The excess over the fuel value in Natal is actually very small, and attempts should be made in the first place to reduce the costs of baling, stacking and transport, for they largely determine what purchase price can be paid to the sugar factories.

This excess over the fuel value of 1/11d. per ton of B.D. fibre could not be considered to be a profit by the sugar factory, for the costs of converting the boilers to coal-firing would have to be paid from them, as well as alterations to the equipment necessary to reduce the steam consumption of the factory.

¹ Lathrop, Aronovsky and Naffziger, Increased Profits from Cane Sugar Byproducts, Sugar Journal 14 (1951) 10.

1/11d. per ton of B.D. fibre corresponds to £7,666 per 500,000 tons of cane crushed and would be the amount annually available for this purpose to a factory crushing 500,000 tons of cane.

The situation would be much more favourable if only excess bagasse were to be used for board manufacture. In this case the entire price of 16/- per ton of B.D. fibre could be used in the first place to improve conditions of steam production and consumption so that the factory could be run, for example, on 1,950,000 B.T.U. in fuel per ton of cane crushed.

A factory crushing 500,000 tons of cane annually would, under these conditions, save 11.5 per cent. of fibre in cane, i.e. 9,200 tons of B.D. fibre, for which a price of £7,350 would be paid. This is about the same amount as the difference in the purchase price of the entire bagasse production minus the costs of coal. And in the former case it would not be necessary to convert the boilers to coal-firing.

Having looked somewhat deeper into the benefits of selling bagasse for soft board manufacture, it is also interesting to consider the other side of the story. There are of course quite a number of basic points which would have to be established before detailed plans for a soft board factory in this country could be considered. As such the planned capacity of the factory would be one of the most important.

I was told quite definitely that the minimum capacity of a building board factory to be operated economically would be at least 75,000 sq. ft. ($\frac{1}{2}$ " basis) per day. This is the daily output of one small board machine. It may be interesting to know that the new board machine at Marrero produces 500,000 sq. ft. per day! As to the maximum size, this would depend on the demand in the Union and neighbouring countries. Experience in America has taught that as builders get better acquainted with the excellent properties of cane fibre insulating board the demand grows at an accelerated rate, vide the following data for the sales of insulating boards in the United States for the years 1939, 1943 and 1948:

Year	Insulating Boards, $\frac{1}{2}$ " equivalent
1939	496,223,000 sq. ft.
1943	1,140,490,000 sq. ft.
1948	1,840,596,000 sq. ft.

The quantity of green bagasse required to produce soft board at a rate of 100,000 sq. ft. per day, i.e. 30,000,000 sq. ft. per annum, would be about 22,000 short tons per annum. 22,000 tons of bagasse is somewhat more than the quantity of surplus bagasse available from the factory crushing 500,000 tons of cane, which was discussed above.

The following can be said about the demand for cane fibre soft board in this country. It is understood that, with the exception of a small quantity of Celotex for accoustic purposes, no cane fibre soft board is nowadays imported into South Africa, owing to import restrictions. The demand for soft board is partly met by the manufacturers of wood fibre soft board, and partly by the manufacturerers of a product known as Rhino board. Wood fibre soft board is manufactured from both pine and wattle.

The consumption of these types of board in the Union is estimated to be about two to three million sq. ft. annually, which is not much more than the consumption of cane fibre soft board before import restriction was imposed. The price of wood fibre soft board is approximately £25/10/- per 1,000 sq. ft.; the price of imported cane fibre soft board when imported from England would be 20 to 25 per cent. more, but would include freight to the amount of £5/8/6 per shipping ton, i.e. £5/17/- per 1,000 sq. ft. Hence the f.o.b. price in London of cane fibre board is about the same as the price of wood fibre board in this country, and the question to be answered is: Is it possible to produce cane fibre soft board in the Union at the same price as in England? In view of the fact that the bagasse for the British factory has to be shipped from Trinidad, one would be inclined to answer this question in the affirmative, but other points have also to be considered—in the first place the effect on the production costs of the rather small capacity of the unit which we have discussed, i.e. a capacity of 100,000 sq. ft. per day.

And even this capacity is much more than is required for the present demand in the Union which probably would not take more than 10 per cent. of the produced quantity. The excess would have to be exported.

A second important point is the availability of suitable industrial water. Walter Scott, in his report to the Caribbean Commission, states that a board mill producing 150,000 sq. ft. of $\frac{1}{2}$ " boards per day requires 320 imp. gallons of water per minute, or twice this volume if it is required to wash out part of the pith to improve the appearance of the board. This last quantity, reduced to a 100,000 sq. ft. mill basis, is equivalent to 1.5 cusecs. It is understood that part of the water could be re-used after having been clarified.

Regarding the capital requirements to build a 100,000 sq. ft. of Celotex per day factory, we have little definite information. Some time ago the costs of such a plant were estimated at between 1.5 and 2.0 million dollars, i.e. between £500,000 and £700,000. As Celotex manufacture is now a well-established process, little advance research would be required to operate the factory. It is understood

that a complete Celotex factory can now be ordered in America.

A third question may be asked in connection with the fact that the Marrero factory uses bagasse and about 20 per cent. waste paper as raw material. Is it necessary to add waste paper (or old newsprint) to produce a satisfactory quality of Celotex? The answer is that waste paper supplies the hydrated fibres which act as a binder to the only slightly chemically attacked bagasse fibres. It is, however, quite possible to produce satisfactory hydrated fibres from bagasse itself. But waste paper may be available at a lower cost.

It is not the intention of this paper to go deeper into the problem. This simple survey should, however, suffice to warrant the preliminary conclusion that although soft constructional board of superior quality can be made from bagasse, the conditions for the actual production of this product in the Union are not very favourable. Main conditions for success would be an increased local demand for soft board and a favourable export potentiality.

Another product that can be made from whole bagasse is corrugated board as is used for box containers. In America and also in Europe it is true, corrugated board is made from straw, mainly wheat straw, but in Peru bagasse is used as the raw material. And of course much nearer home—at Felixton—bagasse is actually being converted into unbleached pulp for wrapping paper and boards. For this reason it does not seem necessary to digress further on this subject and I would rather turn to the production of fine white papers and newsprint from bagasse.

One of the first things I learned in the U.S. is that it is wrong to conclude from the first that newsprint is one of the lower grades of printing paper and that it can satisfactorily be made from any cheap raw material, as for example bagasse. In fact newsprint is really a highly specialised product. It is manufactured on the largest paper machines and at the highest production speeds of any of the printing papers (1,750 ft. per minute).

I discussed the subject of utilising bagasse for board and paper manufacture extensively with Drs. Lathrop and Aronovsky. Dr. Lathrop is head of the Agricultural Residues Division of the Northern Regional Research Laboratory, one of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U.S. Department of Agriculture. Dr. Aronovsky, who also has a vast experience in paper making, is on the staff of the N.R.R.L. When I visited this laboratory, Dr. Lathrop and Dr. Aronovsky were kind enough to give me a whole day of their time and they also arranged for some demonstrations,

using the Hydrapulper, an apparatus about which I shall speak later on.

As Dr. Lathrop says in one of his publications: "Consideration must be given particularly to the qualities of the pulp required for newsprint. In use, newsprint must run on the modern high-speed printing presses with relatively few breaks. It must be capable of absorbing the cheap new inks rapidly and yet receive sharp impressions of types, cuts and printing plates without blurring." And more requirements have been enumerated. "Although it is possible to produce from bagasse a pulp which can be made into paper of newsprint weight and which would run fairly satisfactorily over the present newsprint presses, such paper would not look like or behave like present standard newsprint and changes would have to be made in the types of ink used for printing. In addition the cost of such paper would be at least as high as of ordinary newsprint which is now all but exclusively made from ground soft wood." This is what is usually called mechanical pulp, and what is called standard newsprint has to be made from mechanical pulp and cannot be made from 100 per cent. chemical pulp from any material, either softwoods, hardwoods, straw, bagasse, or other wastes since the chief properties of newsprint are dependent on the presence of the mechanical pulp.

Mechanical pulp which is the cheapest type of pulp on the market is, however, not the only raw material for newsprint pulp. It is always mixed with 12 to 20 per cent. spruce sulphite pulp. In extensive tests carried out in America it was found that the latter chemical pulp can be replaced by straw and bagasse pulp, the new mixture making a newsprint of completely satisfactory quality. It was also shown that a good quality newsprint can be made from waste—de-inked newsprint being mixed with a lightly-bleached pulp from straw or bagasse.

These possibilities, however, seem to be mainly important in cases of emergency when normal spruce sulphited pulp is not available. As a whole I think we have to accept for the time being that mechanical pulp is the cheapest and most suitable material available to produce newsprint. This opinion is also shared by Mr. Underlay who discussed the subject in Australia and is quoted in the Producers' Review, and by Dr. Atchison. Speaking about proposals to produce newsprint from bagasse and about tests which have been made all over the world, Dr. Atchison says: "In every case, after a thorough economic and technical appraisal has been made of these proposals, it has been concluded that bagasse newsprint could never be produced economically in competition with newsprint made from the standard furnish consisting of 85 per cent. low cost mechanical wood pulp and 15 per cent. chemical pulp."

Much more promising are the views held by Dr. Lathrop c.s. about the use of bagasse for the manufacture of fine white papers. But before going somewhat further into this matter we have to pay some attention to the anatomical details of our raw material, bagasse, or rather sugarcane.

A cross-section of an internode shows in consecutive order, from the outside to the centre, the following tissues:

- epidermis;
- a narrow cortex or rind;
- vascular bundles embedded in ground tissue.

For the manufacture of any fibrous material, fibres, the length of which is several times the diameter, are most suitable. In sugarcane such fibres are found in the rind and in the vascular bundles. The cells constituting the ground tissue are much less elongated and non-fibrous. They are the storing cells containing the juice; they are thin-walled and easily ruptured when put under pressure.

In bagasse we discern "fibre" and "pith." Fibre consists generally of the vascular bundles and the rind, pith consists of the ruptured ground tissue cells. Generally speaking the presence of pith is undesirable when bagasse has to be converted into a high grade, easily bleachable, pulp.

Since little information was available on the proportion of pith and fibre in commercial bagasse, Lathrop c.s.¹ have determined the percentages of these constituents in dirt-free bagasse from different origin and found the following data:

	Dirt (%)	Dirt-free Pith (%)	Basis Fibre (%)
Stored Louisiana bagasse	10.9	33	67
Fresh Louisiana bagasse	11.8	27	73
Fresh Florida bagasse ...	16.6	33	67
Stored Louisiana bagasse	14.2	25	75
Fresh Louisiana bagasse	13.7	20	80

A one hundred per cent. complete separation of pith and fibre by technical means, however, is impracticable and one should be satisfied when the pith content of the fibre is reduced to a certain maximum value by the technical separation process. Processes are nowadays available by which this result can be achieved. A substantial reduction in pith content has also been attained by mixing whole bagasse with some other fibrous raw material, for example bamboo, as I have seen practised in a Formosa paper factory.

One of the processes to separate pith and fibre has been developed by Drs. Lathrop and Aronovsky and

¹ *Loc. cit.*

was demonstrated to me when I visited the Agricultural Residues Division of the N.R.R.L. The apparatus used to effectuate the separation is the Hydrapulper. A hydrapulper is a cylindrical apparatus with a fast rotating rotor at the bottom. The rotor is divided with fins and causes a swirling vortex of the bagasse-water-mixture placed in the pulper.

By the violent agitation of the suspension caused by the rotor the pith is loosened from the fibre. This loosening action is strengthened by baffles placed on the inner wall of the tub. However, since the pulp is not subjected to treatment between two metal surfaces, the fibres are not cut. Cold water is applied and the treatment of the bagasse is completed in about thirty minutes. The actual separation of pith and fibre is done by washing the mixture over a rotary screen having $\frac{1}{2}$ " round holds. Previous to fractionation, dirt is washed from the mixture over a flat screen having 0.04" holes.

The length distribution of the fibre bundles from which the pith had been removed is given by Lathrop c.s. for stored Louisiana bagasse:

$\frac{1}{4}$"	$\frac{1}{4}$ " - $\frac{1}{2}$ "	$\frac{1}{2}$ " - $\frac{3}{4}$ "	> $\frac{3}{4}$ "
4.0	4.6	7.4	84 %

For Florida bagasse the distribution was, however, less satisfactory.

The separation of pith and fibre of Hawaii bagasse has been the subject of a joint investigation of the Hawaiian Experiment Station and the N.R.R.L. and Dr. Baver in a paper read before the Barbados Congress reported that it has been ascertained that "economical and satisfactory methods of separation, either in a wet or a dry condition, can be obtained."

A different process for the wet separation of pith and fibre has been developed by Dr. Keller c.s. at the Louisiana University. Few details about the efficiency of the separation have been published.

Dry separation is carried out in Louisiana at Reserve factory. When visiting this factory we were not allowed to see the process. It is understood that the separated pith is mainly sold as chicken litter and mixed with final molasses as poultry or stock feed.

Various experts agree that bagasse fibre freed from pith is a suitable raw material for high grade paper. The following data show the fibre dimensions and relative ease of pulping of bagasse and some other agricultural fibres and pulpwoods.

The agricultural fibres are classified into five groups, t.w.: (1) straws and esparto; (2) canes and reeds; (3) woody stalks with bast fibres (flax, hemp, cotton); (4) leaf fibres (manilla, sisal, pineapple); (5) bamboos.

Group	Fibre	Average length (mmu)	Average diameter (mmu)	Ratio length to diameter	Relative density	Relative ease of pulping
1	Straws and esparto ...	1,100-1,500	9-13	110-120:1	open	1
	Rice straw	1,450	8.25	170:1	open	1
2	Stalks and reeds	1,000-1,800	8-20	80-120:1	open	2
	Sugar cane fibre	1,700	20	85:1	open	2
3	Woody stalks with bast fibres					
	A. Woody stems ...	200-300	10-11	<30:1	dense	4
	B. Bast fibres	20,000-25,000	16-22	>500:1	open	3
4	Leaf fibres	6,000-9,000	16-18	250-300:1	open	3
5	Bamboos	2,700	14	200:1	dense	4
6	Coniferous woods... ..	2,700-3,600	32-43	57-90:1	dense	4
7	Deciduous woods... ..	1,000-1,600	38-50	<50:1	dense	4

Comparative data have also been given for the chemical composition of the same materials:

Group	Fibre	Ash %	Lignin %	Pentosans %	Cr. and B. cellulose	Alpha-cellulose
1	Straws and esparto ...	6-8	17-19	27-32	50-54	33-38
	Rice straw	14-20	12-14	23-25	46-49	28-36
2	Stalks and reeds	3-6	18-22	28-32	52-58	33-43
	Sugar cane fibre	2	19-22	30-32	59-62	40-43
3	Woody stalks with bast fibres					
	A. Woody stems ...	2-3	23-27	15-22	40-48	31-33
	B. Bast fibres	1-2	1-6	2-6	70-80	60+
4	Leaf fibres	0.6-1.2	7-10	17-24	70-80	53-64
5	Bamboos... ..	1-2	24-29	16-18	60-63	50+
6	Coniferous woods	<1	26-34	7-14	53-62	40-45
7	Deciduous woods	<1	23-30	19-26	54-61	38-49

As can be seen from the first table the bast and leaf fibres are much longer than those of other groups. Coniferous woods and bamboos possess fibres of substantially the same lengths. According to Dr. Lathrop, such fibres produce high tear resistance in papers, and, in fact, possess near the maximum length practical for good paper making. The deciduous woods, straws, esparto, stalks and reeds have somewhat shorter fibres. They vary about the same in length among the various groups as do the individual fibres within the groups. The tearing strength of papers made from them alone is low and such papers are not suitable for wrapping and bags, when papers made of longer fibres are available.

The ratio fibre length to fibre diameter is one of the most important criteria for evaluating paper-making fibres. This ratio is generally higher for agricultural fibres than for those of the pulpwoods. Sugarcane bagasse fibres compare very favourably with the conifers in respect of this ratio.

As to the chemical composition, sugarcane fibres contain less ash than the other annuals. The lignin content is somewhat higher than that of the straws, but lower than that of the pulpwoods. Twenty-two months Hawaiian fibres contained more lignin (22 to 23 per cent.) than the fibre of Louisiana sugarcane which was harvested 9 to 11 months after planting. Naturally more chemicals are required to pulp this particular Hawaiian bagasse. The lignin content of the newer Natal varieties is not known, and may be high since Cornelison and Cooper have found that with increase in age a greater and greater deposit of lignin-like compounds occurs in and around fibrovascular tissue.

The chemical reactions involved in pulping are undoubtedly surface reactions. Fibres in group 1 are easiest to pulp because of the very open plant structure. The thin walls of the straws and esparto present a large initial surface for chemical attack and minimise the problem of diffusion encountered

with all of the pulpwoods. The canes and reeds require somewhat more chemicals and somewhat more vigorous pulping conditions. This is due to the fact that the rind fibres of these plants are generally denser and the fibre walls thicker than those en-

countered in group 1.

Dr. Lathrop c.s. have also determined the chemical composition of pith and fibre separately.

The following data are given for stored Louisiana and freshly dried Florida bagasse:

	Whole bagasse %	Louisiana (stored)		Florida (freshly dried)		
		Pith %	Fibre %	Whole bagasse %	Pith %	Fibre %
Moisture... ..	4.1	12.2	6.8	7.3	8.9	7.2
Ash	2.9	4.6	2.0	2.2	3.4	2.0
Extractives						
Alcohol/benzene	1.7	1.7	1.6	3.5	3.5	2.6
Hot water	4.0	3.1	2.4	11.2	4.6	4.5
1 per cent. NaOH	32.9	36.1	28.4	39.9	35.0	31.2
Lignin	21.3	21.3	20.7	10.1	18.2	19.1
Pentosans	29.4	31.3	30.6	28.5	32.5	31.7
Cr. and B. cellulose	58.4	54.6	61.4	52.0	58.2	61.4
Pentosans in Cr. and B. cellulose ...	29.3	30.3	31.7	26.9	29.1	29.8
Alpha in Cr. and B. cellulose	67.1	62.8	70.0	68.1	61.3	64.4
Alpha basis original	39.2	34.3	43.0	35.4	35.7	40.1
Pentosans in alpha	6.1	5.7	10.0	4.7	5.0	4.6

The above data show—particularly for stored Louisiana bagasse—that the fibre is a purer cellulose product than pith and should be more easily converted into fine paper pulp. Hence fibre is superior to pith not only because the dimensions of the unit particles are more suitable, but also because of its chemical composition.

As said above, the presence of pith is undesirable when bagasse has to be converted into a high grade, easily bleachable, pulp. Numerous attempts have been made, however, to produce such pulp from whole bagasse. Most experts will maintain that such attempts were doomed to failure. Nevertheless it has recently been reported that a factory will be erected in Louisiana which will manufacture paper from whole bagasse. It is also claimed, but details are not yet available, that a new German process is capable of producing good paper from whole bagasse.

The first step is always to convert the raw material into a pulp, and various processes are available for this purpose. They mainly consist of cooking the raw material with a chemical agent. The result depends on the length of the cooking period, the temperature, the nature and the concentration of the chemical agent. Drs. Lathrop and Aronovsky, who succeeded in developing a practicable process for the separation of pith from fibre, using the Hydrapulper, have also worked out a simple process for pulping fibre, using the same machine. The

new mechano-chemical process was originally developed for straw, the first agricultural residue which was studied. It was found to be particularly suitable for the production of strong and easily-bleaching pulp from straw and depithed bagasse. In this process, which was also demonstrated when I visited the N.R.R.L., the bagasse is cooked at atmospheric pressure for 45-75 minutes with 15% caustic soda (basis oven-dry fibre) at 9% consistency. The yield and the quality of the pulp was quite satisfactory. Dr. Lathrop and Dr. Aronovsky were particularly hopeful about the results of the industrial application of this process.

However, although the yield in respect of depithed bagasse is satisfactory, the yield in respect of the original whole bagasse is low due to the removal of the pith. The economics of the process are thus endangered unless some suitable outlet is found for the pith.

Dried pith is an excellent absorbent and pith is used to a certain extent in the manufacture of explosives, but it is obvious that it would be of advantage to find an outlet which can absorb great quantities of this material. As such the production of stock feed by mixing pith with final molasses and eventually other materials has been suggested and deserves serious consideration.

The value of final molasses for fermentation purposes is decreasing continuously now alcohol

is being cheaply produced by the oil industry and it has been suggested that the only satisfactory method to utilise final molasses is to use it for feeding purposes.

It has been known for more than half a century that molasses is an excellent stock feed, and it has been used for this purpose in relatively small quantities in all cane producing countries of the world. However it apparently never came to a really significant use probably partly due to the fact that the merits and demerits had never properly been studied. A disadvantage was that owing to its sticky nature molasses was somewhat difficult to distribute. It is true that mixing with bagasse in order to produce a dry feed was practised in the early days, but the sugar industries of the various countries never took a great interest in the matter.

The situation is now changing rapidly. The Hawaiian sugar industry has started a thorough investigation into the value of molasses as stock and poultry feed, the Sugar Research Foundation has published a survey of the available literature, the Louisiana Sugar Journal has published a special number dealing with this subject alone, and increasing amounts of final molasses, a.o. the complete Hawaiian production, are now sold for feeding purposes.

It is estimated that in South Africa, out of the 163,500 tons of final molasses produced in 1952, about 17,500 tons were used for feeding purposes, and in 1953 one of the sugar factories produced 1,800 tons of a mixture of molasses and bagasse which is being sold as Molameal at a price of £4/15/0 per ton.

Due to its great absorptive power, pith can absorb more molasses than bagasse and still be converted into practically dry cakes, which are easily distributed. I will not go deeper into this matter since I do not want to take too much of your time, but I hope that I have made clear that the potential use of pith in stock feed has opened a way for the utilisation of bagasse for the production of fine papers, using fibre only.

It will be necessary to study properly the best way to use pith in stock feed and also the improvement of the quality of the feed by adding other substances, for example nitrogen containing matter. As such urea is used in the U.S.A. and more recently even ammonia. The essential fact about urea-molasses and ammoniated molasses seems to be that these materials in the rumens of ruminants are converted by bacteria into proteins which can be absorbed by the animals. Rubenstone¹ gives a few extremely interesting data on the potential consumption of molasses for feeding purposes in America, which

may be of interest to South Africa too. He has calculated the potential consumption of molasses by the entire animal population of the U.S.A. by multiplying their number by what can be considered to be the optimum amount of molasses which can be fed to each type of animal, and has published the following figures:

	Average consumption Per head, per day, lbs.	Average Population, Million Head	Annual consumption, Millions of gallons
Beef cattle... ..	5	60	9,359
Dairy cattle	3	25	2,340
Hogs	1.5	60	2,808
Sheep	1	30	936
Horses and Mules	4	6	749
Poultry	0.01	450	144
			16,335

The total quantity of molasses available in U.S.A. is 588 millions of gallons. This volume includes molasses from Cuba, Puerto Rico, Hawaii, and other countries and is less than four per cent. of the potential consumption.

It would be interesting to have similar figures for South African conditions.

Returning to bagasse, we shall now continue our survey of potential ways of utilisation. As such the production of pure cellulose to be used for the manufacture of rayon has to be mentioned. Not much information on this subject is, however, available in technical literature. Probably one of the most extensive investigations was carried out in Java about 1930. The results of this investigation, which were satisfactory from a technical point of view, have, however, never been published. The cellulose produced in Java was sent to one of the big rayon factories and converted into a good quality rayon. It never came to the erection of a cellulose factory. One difficulty was that the rayon industry wanted a guaranteed supply of cellulose over a considerable period of years. Such a guarantee was difficult to give in view of the possibility of the introduction of new cane varieties of a low fibre content.

The suitability of bagasse for the production of the secondary products so far discussed is mainly based on its high cellulose content. There are, however, other constituents which make bagasse suitable for industrial utilisation.

Firstly there are the pentosans which can easily be converted into furfural. Furfural is an organic liquid which is being produced in fast increasing quantities, mainly from corn cobs and oat hulls. It is a selecting solvent for refining lubricating oil, is used in the plastic industry and is one of the potential

¹ Sugar Journal, September, 1953, p. 18.

raw materials for an intermediate product in nylon manufacture. By distillation with sulphuric acid, pentosans are easily converted into furfural which can be separated and purified by distillation. One ton of B.D. bagasse can be converted into 155 lbs. of furfural. This is less than produced from other agricultural residues (corn cobs, for example, yield 214 lbs., oat hulls, 224 lbs.), but one of the advantages of bagasse is that it is available in a large quantity at one place. The production of furfural from bagasse has frequently been discussed in sugar literature, and I think that some time ago an offer was made to the South African sugar industry for bagasse to be used for furfural production. This offer, however, was not accepted: neither did furfural factories using bagasse materialise in other countries.

Quite recently however it was announced that furfural will be manufactured from Dominican Republic bagasse¹. It is interesting to note that the total bagasse production of Central Romana will be converted and that the furnaces will be fired on oil. Although the Central Romana By-products Company has been exempted from paying taxes on oil for a 20 year period, oil will in all probability prove more expensive as a substitute fuel than natural gas in Louisiana. This would indicate that the purchase price paid for bagasse in the Dominican Republic is higher than the Louisiana price of \$2.50 per ton of B.D. fibre, a fact which should be remembered if manufacturing furfural from bagasse is ever considered again in South Africa.

The last outlet for bagasse which will be discussed is the manufacture of briquets, which can be made available cheaply as a household fuel to people living near a sugar factory. Using bagasse for this purpose will obviously deserve consideration only when surplus bagasse is available and industrial utilisation on a larger scale is not feasible.

Technically the problem has been solved satisfactorily and bagasse briquets were produced before the war in Java by more than one factory. The subject was discussed at one of the meetings of the Barbados Congress and general opinion indicated that under certain conditions manufacturing briquets from bagasse with molasses acting as a binder would be the best method to dispose of surplus bagasse. A briquet produced without binder, by applying a high pressure, was also demonstrated.

This brings our discussion to a conclusion. Those who visited Jamaica and Trinidad will have seen bagasse returned to the fields for use as a soil conditioner. Whether agricultural utilisation of bagasse of this kind deserves further study in South Africa is a subject which I must leave to my agricultural friends.

The President said that he was very interested to hear of what had been done in other countries in the

utilisation of bagasse. A paper by Deenek on the use of screened bagasse and molasses for stock-feed could be found in one of our past Proceedings.

Dr. Dodds said that he confirmed Dr. Douwes Dekker's remarks upon the economies of producing building board from bagasse. He had been appointed by a sugar manufacturing company in Natal to study this question while in the U.S.A. for the Louisiana Congress in 1938. It was found to be impossible to establish economically a Celotex factory in South Africa, as the minimum quantity which the factory would be required to produce would have been much beyond the capacity of the country to absorb at that time. At the Experiment Station, experiments were made to produce cellulose from bagasse by using various chemicals to remove lignins, etc. A very high-grade of cellulose could be produced, suitable for the manufacture of rayon. When samples were sent overseas it was found that it was a matter of great doubt that the material could be produced economically, without first establishing a pilot plant to study the economics of manufacture on a semi-commercial scale.

Mr. Du Toit said that he had always been impressed by the possibilities of bagasse for making soft-board, and he had visited a factory in Hawaii, but there they had found, as mentioned by Dr. Dodds and Dr. Douwes Dekker, that the project was not economic. As far as the production of furfural was concerned, arrangements were made to send a considerable quantity of bagasse overseas for test. It was thought that the bagasse could then be used as fuel, but although the moisture content of the residue would not be much higher there seemed to be some danger from the acid content of the residue as far as the utilisation in furnaces was concerned. Experiments conducted at the Experiment Station, many years ago on producing cellulose from bagasse gave figures very similar to the figures quoted by Dr. Douwes Dekker, but so far as he could recollect the lignin figures did not agree.

That depended upon the method used to extract the cellulose. In connection with molasses, he was surprised to find in Hawaii that all the molasses was now used as stock feed and he thought that the possibility mentioned by Dr. Douwes Dekker of adding nitrogen in the form of urea or ammonia to the molasses might have considerable advantage in producing more cattle in South Africa.

Mr. Baars thought that the figures shown for B.T.U. value of bagasse were really actually lower. He had seen newsprint made entirely from bagasse which approached very nearly that from wood pulp and the possibility of producing it should not be completely lost sight of in spite of the statement by Mr. Atcheson. He thought that other processes might be used to produce bleached pulp from bagasse other than those now being utilised.

¹ Sugar Journal, January, 1954, p. 29.