THE SOUTH AFRICAN SUGAR TECHNOLOGISTS' ASSOCIATION

The South African Sugar Technologists' Association was founded in 1926. It is an independent, self-constituted organisation of technical workers and others directly interested in the technical aspect of the South African Sugar Industry. It operates under the aegis of the South African Sugar Association, but is governed under its own constitution by a Council elected by its own members.

The office of the Association is situated on premises kindly made available to it by the South African Sugar Association at the latter's Experiment Station at Mount Edgecombe.
PRINCIPAL CONTENTS

THE SOUTH AFRICAN SUGAR TECHNOLOGISTS' ASSOCIATION........................ iii
OFFICERS OF THE SOUTH AFRICAN SUGAR TECHNOLOGISTS' ASSOCIATION........... ix
LIST OF MEMBERS AND GUESTS .................................................................... x
OPENING ADDRESS by Mr. G. M. COATES, Secretary of the S.A. Cane Growers' Association ............................................................... 1
PRESIDENT'S ADDRESS .............................................................................. 4
FUNGUS INFECTIONS IN PEOPLE IN THE SUGARCANE BELT, by A. M. Beemer, M.R.C.S., L.R.C.P. ................................................................. 7
THIRTIETH ANNUAL SUMMARY OF CHEMICAL LABORATORY REPORTS, by Chs. G. M. Perk, ................................................................. 12
WEATHER REPORT FOR THE YEAR 1ST JUNE, 1954, TO 31ST MAY, 1955, by J. L. du Toit ................................................................. 28
THE NEW DARNALL MILLING PLANT, by J. H. Grant .................................. 33
METHODS FOR THE ANALYSIS OF BOILER WATER, by P. N. Boyes .......... 38
DECOMPOSITION OF SUCROSE IN THE MILLING PROCESS, by C. van der Pol and J. B. Alexander ................................................................. 46
SOME NOTES ON THE SIGNIFICANCE AND MEASUREMENT OF PH IN SUGAR FACTORIES, by K. Douwes Dekker ........................................ 54
THE KENT UNIVERSAL GLASS ELECTRODE, PH METER, by G. Toop ................................................................. 62
LEEDS AND NORTHURP PH MEASURING AND RECORDING INSTRUMENTS AS USED IN THE SUGAR INDUSTRY, by J. L. du Toit .... 68
BECKMAN PH METERS, by P. M. Harvey ..................................................... 74
CLARITY AND CLARIBILITY, by G. C. Dymond ....................................... 79
PAN CONTROL METHOD IN PRACTICE, by A. F. Ducasse ................................................................. 83
REPORT ON THE PERFORMANCE OF A CONTINUOUS SUGAR CENTRIFUGAL MANUFACTURED BY THE ESCHER WYSS CO. OF SWITZERLAND, by P. E. Bouvet ................................................................. 88
THE TOPPING OF SUGARCANE IN MAURITIUS, by S. Staub ...................... 104
SOME NOTES AND OBSERVATIONS ON THE FIELD TRANSPORT OF SUGARCANE, by E. Steward ................................................................. 109
A NEW PATTERN SOIL SAMPLER, by B. E. Beater ..................................... 113
PLANTING MEDIA FOR SUGARCANE FUZZ AND SEEDLINGS, by A. de Sornav and J. H. Julien ................................................................. 115
NITIDULID BEETLES IN SUGARCANE CUTTINGS, by J. Dick .................... 118
WEED CONTROL: HERBICIDES OR CULTIVATION? by N. C. King and F. L. Almond ................................................................. 122
A SURVEY OF CHEMICAL WEED CONTROL IN SUGARCANE, by M. J. Stewart ................................................................. 126
INSTRUCTIONS TO AUTHORS ................................................................... Cover

IV
WE RECORD WITH REGRET the death after a short illness of Mr. G. C. Dymond, well known in the South African Sugar Industry.

Mr. Dymond was born in Hampshire, England, in 1891, but spent most of his life in South Africa. He was educated at the Diocesan College, Cape Town, and at the South African College, later the University of Cape Town. He joined the Sugar Industry shortly after he qualified as a chemist and apart from a break during which he served with the South African forces in the First World War, he had served the Sugar Industry for thirty-seven years, for the greater part of which he was with Sir J. L. Hulett and Sons Limited.

On a number of occasions Mr. Dymond represented the Sugar Industry at Congresses of the International Society of Sugar Cane Technologists and he was well known throughout the sugar world. He played a big part in the development of the South African Sugar Technologists" Association and was elected to the presidency of this body on no fewer than six occasions. He was president in 1931-32 and 1932-33; he was again elected to the presidency in 1951-52 and occupied the chair for four successive years until after the Annual General Meeting in 1955. He was also on five occasions elected vice-president of the Association and his keenness and interest in its affairs contributed materially to the progress of the Association and the development of its strength.
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1955-1956

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B. GRANT

Vice-President
G. C. DYMOND (Dead)
W. G. GALBRAITH

Hon. Secretary
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1949-51 A. MCMARTIN
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1952-53 G. G DYMOND
1953-54 G. C. DYMOND
1954-55 G. C. DYMOND

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South African Sugar Technologists' Association,

Twenty-Ninth Annual Conference

The Twenty-ninth Annual Congress of the South African Sugar Technologists' Association was held at the M.O.T.H. Centre, Old Fort Road, Durban, on 28th, 29th and 30th March, and on the 1st April, 1955.

The following members and visitors were present:

G. C. DYMOND, President.

AGNES, G. E.
ALEXANDER, K. E. F.
ALMOND, F. L.
ANNETT, L. V.
ANTONOWITZ, J.
ATHERSTONE, W. E. C.
BARKER, A. N.
BARKER, N. F.
BARNES, Mrs. M. M.
BAKTHFIELD, C. C.
BAX, K.
BEATER, B. E.
BEEMER, A. M.
BEESLEY, E.
BOA, W.
BOOTH, C. E.
BONFA, N.
BOUIC, C.
BOUILLE, A. J.
BOUILLE, J. E.
BOUVET, P. E.
BOYD-SMITH, Mrs. N.
BOYES, P. N.
CAMDEN-SMITH, — —
CAMDEN-SMITH, E.
CARTE, R. A.
CHIAZZARI, L. F.
CHADWICK, D. W.
CHRISTIANSON, W. O.
CHRISTIE, J.
COATES, G. M.
COIGNET, I. J. P.
COX, R. B.
CROOKES, G. V.
CROOKES, L.
CUNNINGHAM, J. P.
DEDEKIND, E. T. J.
DE BROGLIO, A.
DICK, J.
DICK, J. McD.
DODDS, Mrs. E. A.
DODDS, H. H.
DOUWES DEKKER, K.
DUCASSE, A. F.
DU TOIT, J. L.
DUNN, G. A.
ELYSEE, A. D.
EWYNES, H. G.
FARQUHARSON, J. C.
FOSTER-BARHAM, C. B.
FREER, F. D.
FRENCH, G. B.
FURMOND, T.
GALBRAITH, W. G.
GRANT, J. B.
GRANTHAM, E. J. V.
GRAVETT, Miss I. M.
GILLATT, F.
GOLDING, C. D.
GRIFFITHS, W.
GUNN, J. R.
HARDY, R. L.
HARVEY, P. M.
HARRIS, Y. G.
HASTILLOW, D.
HAYES, F. W.
HEDCOCK, G. W.
HEDLEY, E. P.
HENDRY, D. W.
HILL, M.
HILLIARD, J. F.
HUNLEY, J. K.
JOHNSTON, F. S.
JOHNSTONE, P.
KEMSLEY, L. IT.
KING, N. C.
DE KOCK, G.
LARGE, S. M.
LAWES, S. A.
LAX, R.
LEK, G.
LENFERN, F. G.
LEWES, G.
LINCOLN, M. A.
LINDemann, W. C.
LINTNER, J.
LLOYD, A. A.
LUDORF, R.
MACBETH, F. B.
MACCORMICK, L. G.
MACLEAN, A.
MCIVER, N. F.
MCKENNA, H. G.
MCKINLAY, D.
MCMARTIN, A.
MCMARTIN, Mrs. S.
MAIN, J. W.
MATHIEU, J. E. A.
MAUD, R. R.
MAXWELL, W. J.
MORILLION, C.
MULDER, W. G.
MUNRO, D.
MURPHY, E. S.
MURRAY, P.
NADAULD, G. E.
NARBETH, C. A.
NICKSON, G.
NEL, G.
ODENDAAL, J. A.
OWEN, Mrs. M. H.
ORCHARD, G. R.
PALAIRET, H. E.
PARK, G. R.
PATTERSON, A.
PEARSON, C. H. O.
PERK, C. G. M.
PHIPSON, E. H.
PORTEOUS, J.
POYTON, Miss M.
PEGOTENHAUER, V. O.
RAMSAY, F. S.
RAPIT, J.
RENAUD, C. L.
RENNIE, L. L.
RISHWORTH, A. H.
ROSS, D. C.
ROSSOUW, G. S. H.
ROUTHLEDGE, D. A.
RUR, W.
SARGENT, N. Y.
SCHMELZ, G.
SEYMOUR, R. W.
SEXTON, Mrs. D.
SEXTON, T. A. F.
SIMPSON, J. R.
STARLING, C. R.
STEWARDE, E.
STEWART, Mrs. J.
STEWART, M. J.
THOMPSON, G. I.
TOOP, G. H.
TONNER, J.
TURNER, A.
TURNER, Q.
TWINCH, J. F.
VAN DER POL, C.
WALSH, Miss E. W.
WALSH, W. H.
WATERSON, H. D.
WATSON, R. G. T.
WAGNER, Y. A.
BUCKLEY WEBER, L.
WEBSTER, I. McC.
WIESE, C. R.
WILMOT, G. L.
WILSON, G. C.
Young, C. M.
YOUNG-THOMPSON, I. C.
TWENTY-NINTH ANNUAL CONGRESS

Proceedings of the Twenty-Ninth Annual Congress of the South African Sugar Technologists' Association, held at the M.O.T.H. Centre, Old Fort Road, Durban, on 28th 29th and 30th March, and 1st April, 1955.

G. C. DYMOND (President) was in the Chair.

OPENING CEREMONY

The President: Ladies and Gentlemen—I have much pleasure in asking Mr. Geo. M. Coates, the Secretary of the S.A. Cane Growers' Association, to open this Congress.

Mr. Coates: Ladies and Gentlemen -On thinking over a subject on which I could venture to address you, it occurred to me that it would be appropriate to make reference to the progress that has been made in the Industry's standards of efficiency since your Association came into being twenty-nine years ago.

It was at about that time (1926) that the first investigation into the affairs of the industry was undertaken by the Board of Trade and Industries and it was interesting to note some of the conclusions arrived at by the Board with reference to the industry's technical efficiency. In general terms the Board was not unduly critical of the standards that had then been attained, but it recommended, among other things, that a small bureau of pathology and entomology be established and that a larger number of qualified chemists should be appointed to carry out the work of the industry as a whole. The Board did not suggest that effort should be directed towards the introduction of new and better varieties of cane, the reason for this no doubt being, that the idea was so far from everybody's thoughts, that it simply did not occur to the Board as being a practical possibility. However, the positive recommendations that were made by the Board have borne fruit. Research into the technical aspects of sugar production in the field and in the mill has been carried on ever since that date and the industry's standards of production efficiency have improved out of all recognition.

Industrial Agreement

Soon after the publication of the Board's report—No. 66 of 1926—the first industrial conference took place in Durban for the purpose of determining the terms of an industrial agreement between millers and growers. The conference was presided over by the chairman of the Board of Trade, the late Mr. Frank Fahey, and it may be of interest to recall that the standard of overall recovery in mills used at that time, for the purpose of the evaluation of cane, was 73.5 per cent. This compares with the present-day figure of 85.5 per cent.

At a later stage I propose to comment upon the overall effect on the industrial economy of the high standards of efficiency now attained in the fields and in the mills, but it would be inappropriate to attempt to evaluate the contributions made respectively by the two sections of the industry. It is, however, evident that the effect of the increase in recovery to which I have referred has been most significant.

Referring now to the agricultural side of the industry, it will be recalled that in 1926 the only cane cultivated was the old Uba variety, and it was widely believed at the time that that was the only variety of cane that could be successfully grown under the semi-tropical conditions of Natal, even though Uba was a very inferior cane. Fortunately, however, some of our predecessors, among whom the late Mr. Owen Johnson and the late Mr. David Fowler were prominent, had the foresight to recognize that if the industry was to serve the needs of the country, the existing standards of field performance must be stepped up and the Sugar Association's Experiment Station was established a year or two before 1926.

In its early stages the Experiment Station was quite a small affair and I think, Mr. President, that your Association in those early days had quite a small membership. But from those small beginnings the progress made has been quite spectacular, and the present industry owes a great deal to those who pioneered the scientific developments that have since taken place.

New Cane Varieties

The knowledge gained in the agronomy of cane culture as a result of research at the Experiment Station has been of great advantage to the industry
in many directions, but the most outstanding has been the introduction of new varieties of cane which have now entirely replaced Uba. Of these the most successful up to date has been the variety N:Co:310 which provided 57 per cent. of the crop reaped last year.

These new canes have enabled the agricultural side of the industry to attain much higher yields than was thought possible years ago and this, coupled with the improvements in milling technique to which I have already referred, has influenced the economy of the industry in a manner which justifies the use of the word "spectacular," and in which we are entitled to take some satisfaction.

To illustrate my point, I must quote some figures.

In 1927, the first year of the Fahey Agreement, the area of cane cut for delivery to the mills was 136,000 acres. The crop reaped from this area was 2,631,000 tons of cane, from which 247,000 tons of sugar were manufactured.

The tonnage of cane reaped from each acre was 19 tons, the ratio of cane to sugar was 10.65 tons and the weight of sugar recovered from each acre was 1.82 tons.

In the year just closed the area of cane cut for delivery to the mills was 248,000 acres.

The crop reaped from this area was 7,374,000 tons of cane and the output of sugar from the mills was 828,000 tons.

The tonnage of cane reaped from each acre was nearly 30 tons; the ratio of cane to sugar was 8.9 tons and the weight of sugar recovered from each acre was 3.3 tons.

In other words the yield of sugar per acre was nearly double that of the year 1927.

These figures do not perhaps convey the significance of the increase in the standards of performance that has been achieved. I, therefore, express this more explicitly by saying that if our standards had remained at the same level as they were in 1927, the crop reaped from the 248,000 acres cut last year would have been no more than 452,000 tons of sugar. The difference is 376,000 tons, and I think that this illustrates the far-reaching effect of the advance made in milling and field technique since your Association was formed about thirty years ago.

This very brief review of technical developments within the industry would be incomplete if reference were not made to the effect that it has had on the economy of the country. This can best be expressed by comparing the price of sugar received by the industry in 1927 and in 1954.

In 1927 the price of first refined sugar, fixed by agreement with the Government, and considered to be requisite to the economy of the industry, was £25 per ton.

In the year just closed (1954) the comparative price was £33 6s. 8d., which represents an increase of 25 per cent.

But the currency in which these prices have been expressed has today a different and lower value, and in order to make true comparison it is necessary to relate our sugar prices to the value of gold.

In 1927 South Africa was still on the gold standard and the value of gold was approximately £4 per ounce. Commodity prices were in keeping with the value of gold.

But in 1954 the price of gold is approximately £12 per ounce, so that whereas in 1927 we could obtain 6½ ounces of gold, or its equivalent in commodities, for our one ton of sugar, in 1954 we can obtain only 2½ ounces.

In other words, the intrinsic value received by the industry under today's conditions is less than half the value received in 1927.

This contribution to the economy of the country is directly attributable to the technical advances that have been made during the last thirty years and, if the industry is prosperous today, it can fairly be said that it prosperity is due to its own progressive policy in which your Association, Mr. President, has played a notable part. I am happy to have this opportunity of making that acknowledgment.

**Future Requirements**

If I may now pass on to another subject, I would like to make some observations regarding the future. It is a most significant fact that during the last thirty years consumption of sugar in South Africa has increased from less than 200,000 tons annually to more than 600,000 tons. This compels consideration of the country's probable requirements in future. Reliable estimates have been made which indicate that consumption is likely to increase to approximately 800,000 tons by the year 1960, and to 900,000 tons by the year 1965. Thirty years hence consumption may well be a million and a half tons and this gives rise to the question—what will be the source of supply? In an attempt to answer it, I suggest that the industry's present standards of performance will be stepped up still further, particularly in the agricultural field, and an output of five tons of sugar per acre instead of the 3.3 attained last year would solve the country's sugar problems for many years to come. But the limitation on our productive capacity is water. During the past two years nature has been kind to us and the rainfall
industry during the past thirty years. I thank you again for inviting me to box in such a way as to insure that the conservation played its part in the technical development of the people would exercise their rights through the ballot passed on to the consumer, it may be that the its part in this, in just the same way that it has These ideas have to be pioneered by somebody, Mr. President, and perhaps your Association will take These dry cycles occasion heavy losses to producers and the higher the yield attained, the greater is the loss. In the meanwhile the water in the numerous rivers by which the sugar belt is intersected is allowed to run to waste.

Surely then, Mr. President, the time has come when the Government of the country should pay serious attention to the conservation of the water in the rivers of Natal? There are five major rivers traversing Natal from the Berg to the coast, and at least a dozen minor rivers that carry a considerable volume of water. But except for the provision of municipal water supplies, there are no conservation dams in any of these rivers and opportunity for irrigation is limited to the expensive process of pumping from the flow of the rivers during the driest periods of the year.

It is, of course, beyond the scope of the industry even to consider the construction of conservation dams on a major scale, but if the need for it is constantly kept in mind and if the legislature can be persuaded to take some interest in the enormous possibilities of the Natal rivers for the generation of hydro-electric power and for the growing of crops under irrigation, the time may come when the threat of drought will no longer be the bugbear of the life of a sugar planter, and the sugar requirements of the country will be assured for all time.

It may, of course, be asked how these things can be brought about and I am afraid I cannot answer that question except to say that Governments can be influenced by the weight of public opinion. If, therefore, it can be brought home to the people of Natal that the waste of water, which all can see, is something that affects their own lives in the sense that it leads to periodical shortages of foodstuffs and adds to production costs, which in the end must be passed on to the consumer, it may be that the people would exercise their rights through the ballot box in such a way as to insure that the conservation of the water in our Natal rivers becomes a live issue. These ideas have to be pioneered by somebody, Mr. President, and perhaps your Association will take its part in this, in just the same way that it has played its part in the technical development of the industry during the past thirty years.

With these thoughts in mind I conclude my observations. I thank you again for inviting me to open your Congress. I hope that your deliberations will in every way be successful and I now declare your Congress to be open.

Dr. McMartin: Mr. President, Ladies and Gentlemen—The main theme of the address to which we have just listened with so much pleasure is one in which a compliment has been paid to those scientific and technologist workers who are and have been associated with our industry over the past quarter of a century. A pleasing feature of the address is that so much emphasis has been laid upon what has been accomplished, without pointing a finger solely to what can be done.

In presenting a survey of achievements to a gathering such as this, no one is better suited to do so than Mr. Coates. Due to the position he has held, he has been able to watch the developments as they have taken place, and is in a position to assess them by means of the cash value they have meant to the industry.

Scientists and technologists, however, cannot just enter an industry and commence their work. In the first instance the demand for their assistance must be created, and the initiative must come from the industry itself. Scientific research itself requires some organisation and the money and means must be provided whereby the results can be translated into practice. This requires in any industry the presence of men of vision and courage.

Mr. Coates has referred to some early pioneers in this field, but Mr. President, Ladies and Gentlemen, Mr. Coates is himself one of those whose personal drive has been a factor in the development of research activities in the industry. In his capacity as Secretary of the Cane Growers' Association he has continually advocated the application of research for improvements in the industry, and has himself taken a leading part in the development of research as exampled by the Experiment Station.

Mr. Coates has referred to improvements in milling technique and agricultural operations, all of which are now taken very much for granted by the producers of sugar.

One neglected aspect of production, however, is that which Mr. Coates has very correctly now brought to the forefront—that of our water resources. In referring to the limiting effect of our rainfall on production he has emphasized once again the fact that the sugar crop here is grown under conditions of sub-optimum moisture, which is without doubt the greatest single limiting factor in production.

I have heard the remark repeatedly, that the sum total effect of all our diseases is not as great as that of one severe year of drought, and yet considerable
research is expended on the former, and very little on the latter.

It is incompatible with a progressive outlook that this should be so, and this is a feature of Mr. Coates' address which should be suitably taken notice of.

Reference has been made to the conservation of water as a national project rather than a parochial one, but it can still be pointed out by the industry by means of experimental evidence how limiting the effect of water is on sugar production.

Firstly, Mr. Coates' address is a tribute to science and technology; I would like now to reverse the procedure and pay a compliment for the scientists and technologists here to those organizers of the industry who have made our task possible. To Mr. Coates in particular I would like to pay tribute for the part he has played, and to wish him happiness in the easier time which I believe for him now lies not very far ahead. In confirmation of what I have said, I will ask you all now to show your appreciation of Mr. Coates' address in the usual manner.

THE PRESIDENT'S ADDRESS

Mr. G. C. Dymond (President): Mr. Coates, Ladies and Gentlemen—The democratic and accepted custom of delivering annual addresses usually affords the president of a society such as ours an opportunity to air his personal views on matters of general interest. By tradition, such surveys should pinpoint trends in technical development, summarize future possibilities, allow the speaker certain latitude in literary exercises and leave his listeners, if they are able to remain awake, a short time in which to meditate on the subject matter of the address. And there the matter ends—usually in the files.

Although the scope of any presidential address can be wide, its extent is wisely limited by time. "Let it be pithy, meaty and above all short." But whatever the field of generalities chosen, there is still the need to observe traditional periods of time—the past, in which one can play safe and be objectively historical; the present, where unpopular facts or personal opinions may prove injudicious, contentious and even dangerous; and the future. Here alone one can indulge one's fads and fancies, loosen the ties of one's imagination and if necessary conjure up the picture of an industry controlled by electronic brains, run by atomic power and working no more than one day in each week.

Past and Present

Because I feel that tradition demands that I should attempt to follow the stereotyped routine, I shall skip lightly among these periods. I leave myself free to touch where the spirit moves and in this mood I leave the past to others. It is enough just to say that it has added its share to the archives and to the store of knowledge available. If I should refer to the present, then it is only to generalise and to say that "sugar is a fertile field of enormous possibilities, firmly bound by economics and resulting in a maximum flow of words in a flood of sugar literature, with a minimum of application."

Yet the trends of research are indicative of how future problems can be tackled and how future development may be. inclined. All the accomplishments of science lay at one time in the unknown future. It is perhaps unnecessary to say that once the need arises, application in practice becomes economic development, for action is stimulated by depression and dulled in days of plenty.

Where can such need arise?

A large proportion of the basic raw materials on which our modern civilization depends are expendable. Coal, oil, metals and now uranium are capital commodities. Already the recovery of coal and oil economically is becoming difficult in some parts of the world, but amazing technological progress has been made in overcoming these difficulties.

These forms of carbon became fixed from the atmosphere by photosynthesis many millions of years ago. The same process is still going on today and at the head of the plant list comes sugar cane, which produces about eleven tons of carbohydrates or five tons of carbon per acre per annum. Is it too much to think that one day—and this in the not too distant future—this fact may be of supreme importance to industry in general and to the chemical industry in particular? Put in other words, the question is whether sugar may not become a source of alternative foods and also be used for industrial purposes. Surveys of these possibilities have been given recently by Professor L. F. Wiggins, head of the Tropical School of Agriculture in Trinidad, by Dr. H. B. Hass, President of the Sugar Research Foundation, U.S.A., Dr. Morton M. Rosenberg of the University of Hawaii, and others.

New Uses for Sugar

Exciting new uses for sugar as a raw material are opening up. Glucose or dextrose is becoming a competitor with sucrose in the U.S.A. Fructose, the sweetest sugar known, is of importance for medical purposes. Other sugars such as sorbitol and mannitol are now being manufactured and are used in foodstuffs, tobacco and leather processing and as a possible basis for plastics. It is estimated that plastic requirements in the U.S.A. in 1975 will be
eight million tons and sugar may be used as a part raw material.

The possibilities range from permanent wave lotions, an adhesive for powdery insecticides, detergents, dianines for rocket fuels, dyes and as fibres of the nylon types, glutanat, for food preserving to the most important of all, protein.

Nearly all vegetable proteins are deficient in three essential amino acids—methionine, iysine and tryptophan. Of these three Dr. H. B. Hass says: "Methionine can easily be made from petrochemicals, lysine can be made artifically, but so far not cheaply. No one is even close to a good synthesis of tryptophan. What we are doing is to look for an organism which can start with molasses and ammonia and produce a protein rich in iysine and tryptophan. This will probably be a long, tough job and we cannot guarantee it will ever be solved. If we do succeed, it will be possible to fowl the people of the world adequately for the first time in human history."

Turning from this brief picture of sucrose itself, there are its by-products. Cane tops and leaves, of which little use so far has been made, are; a potential source of cattle foods and paper; thirty million tons of dry bagasse, which, when atomic power runs industry, will become available for paper, fibre board and furfural; a billion gallons of molasses for cattle and possible human foods, together with numerous chemical products, alcohol, acetone, and butyl alcohol, citric and aconitic acids and dextran. Only the key chemical is missing—benzene, and, as Professor Wiggins says: "If it was possible easily to convert carbohydrates into this substance, then there would be little in modern chemical industry which could not be obtained from sugarcane."

Lastly, one and a half million tons of filter muds containing cane wax, fatty acids and sterols. The wax-free residue is a valuable filler for fertilizers.

So the legendary last gift of God to man, the sugar cane, may yet become His second greatest gift. It is sometimes forgotten that sugarcane belongs to the grass family, and grass itself is the very basis of human and animal life. It has been calculated that grassland farming in South Africa can yield up to £157,000,000 in a good year.

John Ingall in his beautiful prose poem was even more impressive when he wrote: "Grass is the forgiveness of Nature—her constant benefaction. Forests decay, harvests perish, flowers vanish but grass is immortal. It yields no fruit in earth or air and yet should its harvest fail for a single year, famine would depopulate the world."

I have endeavoured to paint a brief picture of the coming sugar age. One thing is clear. While we can keep our interest, our sense of adventure, our will to go on trying, the dull mental and physical inertia through the application of electronic brains and atomic power resulting in a one-day sugar week, will not eventuate.

Mr. J. B. Grant (Vice-President): Mr. Coates, Ladies and Gentlemen—We have just had the pleasure of listening to the last of a series of presidential addresses given by Mr. Dymond on the event of the opening of five Annual Congresses of the South African Sugar Technologists' Association.

It being my privilege to reply to the present address, I felt it my duty to re-read this respectable number of public speeches given by one man, and nobody who knows this man will be surprized when I say that whilst reading, this duty became a pleasure. There is not the slightest doubt that Mr. Dymond always had something interesting to say on these occasions, but what particularly roused in me a feeling of great admiration was the way in which he said it.

Our Chairman is an enviable master of the English language, he has a fine sense of humour, and he is not afraid to bring his opinion to the fore, an opinion which is usually original, and not just an impersonal reflection of the ideas and pronouncements of the leaders of this world. Is it then astonishing that his addresses are still a source of joy?

Mr. Dymond was president of our Association for the first time in 1932, but since he represented the Natal Sugar Industry at the San Juan Congress of the International Society of Sugar Cane Technologists in that year, his first presidential address was read in 1933. In this address he protested against the opinion of "the man in the street" that the activities of the Association are confined to the holding of our Annual Congress, whereby we bring about a pleasant renewal of old friendships, pass a few pious resolutions with a background of dreary papers which find their way eventually to some dusty corner earmarked "for further reference," and stated firmly that "the Annual Meetings represent the concrete results of work done and form the foundation of our Society, which in the words of our Constitution has for one of its main objectives the interchange of knowledge of sugar production."

Nineteen years later, in 1952, we find Mr. Dymond again in the Chair, and in his speech our attention is drawn to an extremely important subject: "populations, food and the value of organic wastes." We all know Mr. Dymond's concern for the maintenance of the fertility of the soil—I only have to remind you of his work on the water hyacinth—and as usual he gave us some very interesting data in this paper.
In 1953 the subject of his address was again a very important problem.

To illustrate this problem I repeat Mr. Dymond’s words dealing with the future of our Technologists’ Association, to wit: “The stalwarts of the past are going and it is sometimes with a feeling of dismay that we wonder who among the younger generation will take their places in the technical side of our industry.” Mr. Dymond then develops his ideas about organizing research in the sugar industry in which he stresses the importance of employing “individuals—individuals who have scorned red tape, musty methods and rusty bureaucracy,” and continues with some valuable advice to the young men "entering the Sugar Industry as routine technologists at the bottom of the ladder, or as qualified scientists in research organizations." To these he says: "Render to the organization the bits and piece-work of the organization, however dull it may be, but unto yourself stimulate your ideas, back your hunches, and carry out individual work outside the forty-eight hour week, even if that means Christmas Day."

I think everybody present will agree with me that it would be difficult to find words which represent better the man Dymond as we have all learned to know and respect him, even if we do not agree completely with his opinions.

In 1954 the value of research to our modern world is discussed. “We all know that Church and Nobility constituted the First and Second Estates, and that the People were termed the Third Estate.” To this the Press was added as the mighty Fourth Estate, and in 1925 the company of thinkers, workers, expounders and practitioners upon which the world is absolutely dependent for the preservation and advancement of that organized knowledge which we call Science was for the first time called the Fifth Estate.

Mr. Dymond, however, does not accept the Fifth Estate as that one which is solely responsible for industrial advancement, and speaking about the international meetings of sugar technologists he says: "From the Fifth Estate they are evolving into the final Sixth Estate, which is the logical and ultimate fusion of business and science into common sense planning, based on scientific knowledge.” And he continues by depicting the role of the Sixth Estate in the technical development of the Natal Sugar Industry.

However interesting this subject may be, the need for brevity forces me to leave it now in order to ask you to turn your minds again to the subject of the present presidential address. In this address Mr. Dymond has tried to visualise the significance of sugarcane for the future provision of the material wants of this world, and he has told us—supported by statements of men like Dr. Wiggins and Dr. Hass—that we not only shall have to look upon sugarcane as the source of one of our major foodstuffs, but that we may expect that the components of the cane will also be valuable raw materials for industrial purposes. He has enumerated the many possibilities of the utilization, of derivatives of sucrose and he has created in us the feeling that the importance of sugar will increase in the years to come.

However, nobody can say at the moment to what extent these possibilities will be transformed into industrial realities. We have to realize that in converting sucrose into doubtless useful chemicals there will be a strong economic competition from the oil industry. Is not even the production of ordinary alcohol, from molasses seriously threatened economically by the production of alcohol by oil refineries?

Dr. Wiggins had spoken very wise words when he said that a key chemical is missing on the lists of chemicals which can be made from sucrose, i.e. benzene.

For this reason—although we in the sugar industry have to be extremely grateful for the unflinching attempts of so many eminent chemists in exploring the possibilities—a certain caution about the economical value of the near-future results is advisable. Thirty-five million tons of sugar are produced annually for human consumption. It will be extremely difficult to find an industrial possibility which can absorb a quantity of sugar which is of any significance in comparison with this enormous tonnage.

We are however grateful to Mr. Dymond for bringing the subject of industrial utilization of sucrose to our attention.

I propose a hearty vote of thanks to our President for an address which, as you will have observed, will take an honourable place in the long series of addresses he has given us.
FUNGUS INFECTIONS IN PEOPLE IN THE SUGARCANE BELT

By A. M. BEEMER, M.R.C.S., L.R.C.P.
C.S.I.R. Tuberculosis Research Unit, King George V Hospital, Durban.

It is a pleasure and a privilege to me to tell you something about cases of fungus infection I came across in people from the sugarcane belt. Two of these people are, I think, members of your association. I am grateful to them for allowing me to describe their symptoms and my findings, and to Dr. Dormer, Medical Superintendent of King George V Hospital, for allowing me to investigate and treat them.

The first case is a European male who, in 1945, after tasting burnt sugarcane, developed sores on the tongue and patches of inflammation on his face. The condition became worse during the next ten years, and in August of last year I saw him at King George V Hospital for the first time. He then had very extensive lesions all over his face, with considerable reddening and thickening of the skin on the ears, chin, nose and forehead. From the lesions on the face a fungus called "Geotrichum" was grown. As the inflammatory lesion appeared first on the tongue fourteen years ago, I thought that this fungus might also have established itself in the intestines, so I examined the patient's faeces as well. A heavy growth of geotrichum (Fig. 1) was obtained from that source also. Dr. McMartin grew a fungus from lesions on the face of the same patient many years ago, and it was this interesting finding that really brought the patient to me ten years later.

The fungus that Dr. McMartin grew, however, was Monilia sitophila, and Dr. McMartin informed me that this fungus is found very frequently on burnt cane. Medical mycologists regard Monilia sitophila as a harmless laboratory contaminant. It grows very rapidly and can cover a petri dish four and a half inches in diameter in a few days. A further complication, though, is the fact that geotrichum also is, very often, pathogenic. Species of geotrichum are isolated frequently from sputum, skin, and faeces of people without clinical disease, and diagnosis of geotrichosis is justified only if the fungus can be demonstrated repeatedly, and all other possible etiological agents excluded. Geotrichum does not spread on culture as Monilia sitophila does; mid I think it is quite possible that the Monilia sitophila overgrew the geotrichum when Dr. McMartin first made his cultures from the skin lesions. Geotrichum was grown repeatedly from stool specimens from outpatient, but Monilia sitophila failed, to grow from that source. A very marked skin reaction was obtained by intradermal injection of a vaccine made from geotrichum. This reaction was much more pronounced than any resulting from vaccines made from other bacteria, and another skin fungus, (Epidermophyton floccosum). The geotrichum vaccine reaction remained prominent for a considerable time, and the skin condition flared up with the first administration. I think it is justifiable therefore, to conclude that this fungus was the cause of the skin lesions in this patient. Treatment which consisted mainly of desensitizing vaccinations, has produced a very gratifying improvement.

The second case was a field manager on a sugar estate, who developed sores on the tongue and lips, some three and a half years ago. These sores were extremely painful, and fresh ones appeared repeatedly until eight months ago, when the patient was given smallpox vaccinations every two weeks. The patient was referred to me in November, 1954. Culture from the tongue produced a mixed bacterial growth only (fungi were not grown). Culture of the stool, however, produced a growth of geotrichum. Treatment in this case also consisted mainly in desensitization, with a vaccine containing this fungus. Local therapy appeared to have no appreciable effect, and I think that the lesions must have been caused by an allergy due to the geotrichum. This patient's present condition is also satisfactory and he has been free from sores for about six weeks. This is very much longer than any previous period of freedom.
from these painful and distressing sores and I think it is fair to conclude that allergy to the fungus isolated caused the patient's symptoms.

The next three cases occurred in African males who were admitted to King George V Hospital with chest complaints.

Case 3. L.M. N3472. A Bantu male aged twenty-two years, whose home was in the Umzinto area, was admitted to King George V Hospital in 1951. He gave a history of persistent cough which began three months before admission to hospital. Within a week the cough became worse and the sputum was bloodstained. Numerous investigations gave no real clue as to the cause of the lung lesion. The X-ray showed that a lesion was present. It looked like a lung abscess, but culture from the aspirated material was always sterile. The patient was given antibiotics for bacteria in the sputum without good effect. Examination of the stool showed the presence of round worms, hook worms, tape worms and some flagellates. We thought that the previous failure to respond to treatment might have been due to these parasites. However, the lesion increased in size radiologically, despite all treatment, including that for the parasites. It was finally decided to operate and remove the affected lung. This was done on the 16th January, 1952. The excised lung showed that one lobe was almost completely destroyed and replaced by pale tissue surrounding a big ragged abscess (Fig. 2). The histology showed chronic inflammatory changes, with many giant cells and marked fibrosis. Special stains revealed the presence of fungal elements (Fig. 3). Unfortunately no fungus was grown from this lung because the tissue had been fixed in formalin immediately after operation. The patient died six months later, and areas of softening were found in the brain. A fungus, *Aspergillus fumigatus* (Fig. 4) was grown from these areas. I think there can be no doubt about the cause and pathogenicity of the organism in this case.

Case 4. M.P. N4612. An adult Pondo male, aged forty-two years, whose occupation was given as a sugar mill labourer, was admitted to King Edward VIII Hospital in January, 1953, complaining of cough for about a week and pain in the right chest. He was given various antibiotics and discharged in March, 1953. In September he was re-admitted to
King Edward VIII Hospital, complaining of abdominal pain and diarrhoea. He still had pleuritic pain and bloodstained sputum, but these were secondary symptoms. However, he was transferred to King George V Hospital because of the chest condition. There was no subjective improvement despite antibiotic treatment, good food and treatment for whip worms, tape worms and hook worms, ova of which were found on stool examination; so pneumonectomy was performed on 1st March, 1954. The excised lung looked firm and fibrous and unlike any form of lung disease I had ever seen (Fig. 5). However, I think it resembles the lungs described in pneumokoniosis due to inhalation of cane dust. Sections of the excised lung showed the presence of numerous fungal spores and a fragment of mycelium in a giant cell (Fig. 6).

The lungs where the main symptoms were cough, shortness of breath, and a thick sticky sputum occurring in a man who had been unloading bagasse in America. In the British Medical Journal, October 1942, four similar cases were reported by Castleden and Hamilton-Paterson, and in the same year, four cases were reported by Gilleson and Taylor.

I have found no record of any case of bagassosis in South Africa, but the three cases I spoke about...
which is protein and 5-7 per cent. is silica. Although the amount of silica is sufficient to produce silicosis, the actual acute pneumonic symptoms differ from any other known and described form of silicosis. Also the pneumonectomy specimens in the three cases at King George V Hospital did not look like silicosis. Jamison and Hopkins considered that a fungus which they had grown from two specimens of sputum from their case, was the cause of the disease. Castledon and Hamilton-Paterson failed to grow any fungus from the sputa of their cases. However, they made saline and other extracts from bagasse which they tested out intraderrmally in twenty individuals. It was interesting that only three gave positive reactions, and these were patients who had suffered from the disease bagassosis. As the investigators had failed to grow a fungus they concluded that the whole bagasse contains an antigen to which workers, who inhale the dust, can become sensitzed; and they hypothesized that the acute phase of bagassosis is an allergic response in the lungs to this antigen.

As soon as the disease was recognised as an occupational hazard, precautions were taken to avoid further exposure to bagasse dust, and none of their patients died.

The failure to grow the fungus, before operation, from any of the three lung cases at King George V Hospital may have been due to the fact that we were not sufficiently aware of the possibility of a fungus being the cause, so requests for fungal examinations were not made. Furthermore, Aspergillus fumigatus is ubiquitous. It grows on plants and grain and straw and bagasse and is often a most troublesome laboratory contaminant. This has led to much dispute about its pathogenicity. However, I think there can be no doubt that Aspergillus fumigatus was pathogenic in the patient who died from Aspergillus fumigatus abscesses in the brain. Although Aspergillus fumigatus was not grown from the other two cases I think that the histology is very similar to that in the proved case of Aspergillus fumigatus infection and that this fungus caused the disease in the lungs of these particular patients.

These cases have really a double interest and importance. I, myself, am of the opinion that they are a late stage of the disease called bagassosis, and as such may help to elucidate the cause of the disease and also may explain odd respiratory complaints that Dr. Labuschagne told me occur in cane workers. Furthermore, as bagassosis is a recognized occupational hazard, I think that all precautions should be taken to avoid inhalation of cane dust, with its associated fungi and foreign proteins. The precautions I would suggest are:

(1) Regular medical and radiological examinations, so that early lesions can be treated.

(2) Debilitating conditions, like worm infestations, should be treated. Round worms and hook worms spend part of their life cycle wandering through the lungs and this may produce a suitable nidus for growth of Aspergillus fumigatus.

(3) Long hours in a cane dust polluted atmosphere should be avoided, particularly in mills where there is a heavy concentration of the dust.

(4) Special extraction fans should be installed, as was done in England and America.

The part that fungi played in causing the pathological condition in the first two cases is, I think, fairly clear, and workers should avoid tasting burnt cane if possible. If this is not possible, rinsing the mouth and washing immediately after may be adequate safeguards.

Now I have given you my views on the part fungi have played in the cases described, but opinions do vary.

Perry, at the Proceedings of the Ninth International Congress of Industrial Medicine in London reported the presence of Aspergillus fumigatus in all specimens of bagasse dust he examined, but he considers that these organisms play no part in causing the disease. Gerstl et al, in Proceedings of the Society of Experimental Biology, vol. 70, 1949, however, reported pneumonic lesions in rabbits after administration of bagasse and from these lesions Aspergillus fumigatus was isolated. They also found that if bagasse was first autoclaved and then administered to rabbits, no pneumonic lesions occurred and they concluded that the pneumonic lesions were due to micro-organisms in the bagasse.

There is a huge field for research in Natal. If mass radiography of field workers could be organised at regular intervals—and sputa cultured for fungi and symptoms correlated at regular medical inspections, we should get much useful information.

It should also be possible to sterilize bagasse and then contaminate it with a pure culture of Aspergillus fumigatus only, and administer that to rabbits to see if pneumonic lesions can be produced without other mixed organisms. It is hoped that we shall be able to organise all this research.

The President said he was very much indebted to Dr. Beemer for diagnosing some obscure skin and lung troubles affecting workers in the sugarcane industry, and his work, he was sure, would be appreciated throughout the sugar world.

This was something new to the sugar industry, but it seemed a very important problem and he hoped that Dr. Beemer could continue his research. He
thought that the clanger from bagasse might be linked with those normally attributed to smog. It was noticeable that in Cuba very high chimneys were used in order to carry the smog and bagasse char dust far away from the factories. These conditions unfortunately did not apply in Natal. He was disappointed that more medical men were not present to hear this most interesting and important address.

Mr. Rault said it was obvious, any time when visiting a sugar factory, how much bagasse dust was flying about. He thought the irritation caused by such dust might contribute to the occurrence of throat and lung troubles. He asked whether the silica mentioned by Dr. Beemer as a constituent of bagasse could play a part.

Dr. Beemer replied that though there is enough silica in bagasse to cause silicosis, various investigators showed that silica was not the cause of bagassosis; clinically, too, bagassosis did not resemble silicosis. It was not known if the fibre caused the disease, but it might play a part, as by blocking small air passages, it might damage the lung and so produce a nidus for the fungus to grow. The question however was still unsolved and required further investigation.

Dr. McMartin thought we should be indebted to Dr. Beemer for putting down on paper something which might develop into an important field of medical investigation. Ten years ago he contracted a disease of the ear from which he isolated the fungus aspergillus and he had read that this type of fungus could also affect the lungs. He had mentioned this to Dr. Beemer, and also said that at that time when he had the ear infection, they were experiencing a minor epidemic of the infection amongst people working with sugarcane, and several fungi could be isolated from the ears of these people. He found that there was so much work involved in following this up that he passed it on to the Government Pathologist in Durban who thought that the climatic conditions were ideal for developing fungi which could affect human beings, more than, had been realized in South Africa. He considered this was something which should engage the attention of the sugar industry. He agreed with Dr. Beemer that research of this nature should be carried further and said that this research deserved the financial support of the industry.

Mr. Bax knew of a case in Mauritius where a factory worker contracted an eczema of the arm which was thought by some to be due to infection by bagasse. By changing his place of residence he became cured, but on return to his factory residence the eczema returned. He asked Dr. Beemer if it were possible that such a diseased condition might be caused by bagasse.

Dr. Beemer replied that he thought that this was possible. Many different foreign proteins cause eczema and the two cases of skin and mouth lesions described had produced enough evidence to make him consider that fungi from bagasse might well cause other allergic manifestations, like eczema.

Mr. Park asked if there were any antidotes to combat the effect of such fungi.

Dr. Beemer replied that there were various substances used in fungus infections and that he had made vaccines from the patient's own organisms which had helped, and he hoped to be able to pursue this work.

Mr. Bax asked Dr. Beemer if he considered that a mere change of climate, as in the case he had mentioned, would be enough to cure a patient of such a condition.

Dr. Beemer said such cures were known to occur.

Dr. Brett said he understood that worm infestations were very common in labourers in the sugar industry and he asked Dr. Beemer if, by eliminating these worm conditions, the fungoid attacks might also be eliminated.

Dr. Beemer thought that debilitating infestations with worms, particularly with worms that spend part of their life cycle in the lungs, could also play a part in predisposing to bagassosis, but they only play a part, and until further work was done he could not venture an opinion on how important that part was. He thought however that Dr. Labuschagne would agree with him that every person living in this coastal climate should have such parasitic possibilities investigated. If all labourers were examined and treated for such parasitic conditions the output from our local labour would improve tremendously.

Dr. Labuschagne was of the opinion that many respiratory conditions might be due to conditions other than those normally accepted. Many cases ascribed to normal causes might be due to something unknown to us, and while he was not in a position to state this opinion definitely, the matter would bear further investigation. He had wondered if bagasse particles for instance with their sharp edges, could produce similar conditions to silicosis. It might even lead to a tubercular condition. He said, as far as worms were concerned, they were extremely prevalent among sugarcane workers. He thought that some of the laziness of workers who complained of many symptoms was really attributable to parasitical worm conditions.

The President said Dr. Beemer was to be thanked for bringing this matter to the notice of the local sugar industry and he thought it should also engage the attention of the C.S.I.R. He concluded by saying that he hoped the paper would be published by the sugar journals of the world.
The 1954-55 sugar production of 828,555 short tons constitutes a new record for the South African Sugar Industry. This crop was manufactured from 7,374,241 tons of cane harvested, which figure establishes a new record for our cane growers. To facilitate comparison of sugar and cane productions in recent years, the productions attained during the last ten years are tabulated:

### TABLE A

<table>
<thead>
<tr>
<th>Year</th>
<th>Sugar Production</th>
<th>Cane Production</th>
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<tbody>
<tr>
<td>1945-46</td>
<td>355,974</td>
<td>4,967,953</td>
</tr>
<tr>
<td>1946-47</td>
<td>474,710</td>
<td>3,989,017</td>
</tr>
<tr>
<td>1947-48</td>
<td>513,905</td>
<td>4,543,253</td>
</tr>
<tr>
<td>1948-49</td>
<td>507,645</td>
<td>5,216,144</td>
</tr>
<tr>
<td>1949-50</td>
<td>561,122</td>
<td>4,929,089</td>
</tr>
</tbody>
</table>

In addition to the new records for cane and sugar productions, the fact that during the 1954-55 season two factories made more than 100,000 tons of sugar has to be put on record. Darnall produced during this season 102,165 tons and Tongaat 101,800 tons of raw sugar.

Regarding the quality of the cane as far as the quality can be indicated by the purity of mixed juice and sucrose and fibre content of the cane, we refer to Table VII (Comparative Data from 1925 to 1954 inclusive) at the end of this summary. We avoid mentioning in this connection cane to sugar ratios, because these ratios are affected by the Overall Recovery and to a lesser extent by the average pol of the sugar made. Particularly when comparing earlier results with present ratios, the differences in overall recovery make cane to sugar ratios unsuitable for comparison of cane qualities. The most suitable yardstick for cane quality would be recoverable crystal per cent. cane, a figure based on—let us say—30 per cent. Lost Absolute Juice and 100 per cent. Boiling House Performance. Such a figure would account for sucrose and fibre content of the cane, for the purity of the mixed juice and would not be affected by differences in factory performance, or sugar pol.

The discussions at the Congress on last year's Summary revealed that it would be appreciated when the comparison of results from cane harvested in the July-November period, compared with those of earlier and later months should again be included in the annual summaries. This review which is shown hereunder starts therefore by recapitulating the seven-year average of 1928-1934 and the ten year average of 1935-1944; from 1945 on, however annual data are recorded.

### TABLE B

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<tbody>
<tr>
<td>Mean 1928-1934</td>
<td>60.3</td>
<td>9.56</td>
<td>15.3</td>
<td>84.4</td>
<td>84.5</td>
</tr>
<tr>
<td>Mean 1935-1944</td>
<td>59.8</td>
<td>9.34</td>
<td>15.3</td>
<td>84.3</td>
<td>84.5</td>
</tr>
</tbody>
</table>

The survey shows that the purity of mixed juice during last season's optimum period is slightly higher than the ten years average figure. The sucrose content of the cane during last season's optimum period is, however, lower than the ten years average. The highest sucrose content of last season occurred during the September month (14.4%) and the highest purity during the October month (86.8%).

Since the figures of the balance of the crop were less favourable compared with the ten years averages, the averages of sucrose content cane and of purity mixed juice for the whole 1954-55 season are lower than the ten years averages. Average sucrose con-
tent of last season is 13.34 against 13.79 per cent. as ten years average and average purity of mixed juice 85.86 against 85.95.

Cane Varieties

The cane variety Co.281 which reached in the 1945-46 season its maximum extension, i.e. 67.77 per cent., has been gradually replaced by other varieties. It was at first Co.301 which replaced Co.281, but after Co.301 had reached its peak of 41.89 per cent, in 1949-50, two other varieties, viz. Co.331 and N:Co.310, started to replaced not only Co.281, but also Co.301. The latter has been diminishing gradually from 41.89 percent, in 1949-50 to 20.97 per cent. in last season.

Compared with the quick rise of N:Co.310, Co.331, shows a slow progress.

### TABLE C

**Changes in Percentages of Varieties Crushed During Recent Years**

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Miscellaneous</td>
<td>1.10</td>
<td>0.26</td>
<td>1.86</td>
<td>2.28</td>
<td>2.02</td>
<td>1.74</td>
</tr>
<tr>
<td>Co.281</td>
<td>47.30</td>
<td>25.09</td>
<td>25.31</td>
<td>19.95</td>
<td>6.71</td>
<td>2.34</td>
</tr>
<tr>
<td>Co.301</td>
<td>41.90</td>
<td>37.38</td>
<td>36.30</td>
<td>37.80</td>
<td>28.21</td>
<td>29.07</td>
</tr>
<tr>
<td>Co.331</td>
<td>2.21</td>
<td>1.87</td>
<td>1.54</td>
<td>1.56</td>
<td>2.81</td>
<td>25.27</td>
</tr>
<tr>
<td>N:Co.310</td>
<td>2.60</td>
<td>15.07</td>
<td>21.12</td>
<td>37.86</td>
<td>41.25</td>
<td>49.41</td>
</tr>
<tr>
<td>P.O.J.'s</td>
<td>2.90</td>
<td>1.99</td>
<td>1.65</td>
<td>1.23</td>
<td>0.09</td>
<td>0.26</td>
</tr>
</tbody>
</table>

As a result of the steady increase in proportion of N:Co.310(), the harvesting of this variety is accelerated. For example, during the 1953-54 season we had to wait till the August period before 40 per cent. of the cane harvested consisted of N:Co.310; last season, however, during the June period, i.e. two months earlier, the 40 per cent. level was already reached. In this respect we draw attention to Umfolozi which, starting earlier than usual this season, crushed during the June period 77 per cent. N:Co.310.

### TABLE 1)

**Proportions of Cane Varieties Mills by Months for the Period Ended as Shown**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Miscellaneous</td>
<td>1.16</td>
<td>1.59</td>
<td>0.03</td>
<td>2.38</td>
<td>1.87</td>
</tr>
<tr>
<td>Co.281</td>
<td>8.16</td>
<td>4.66</td>
<td>3.37</td>
<td>1.38</td>
<td>1.75</td>
</tr>
<tr>
<td>Co.301</td>
<td>37.17</td>
<td>33.87</td>
<td>26.85</td>
<td>21.25</td>
<td>19.81</td>
</tr>
<tr>
<td>Co.331</td>
<td>21.23</td>
<td>19.36</td>
<td>21.76</td>
<td>25.72</td>
<td>27.87</td>
</tr>
<tr>
<td>N:Co.310</td>
<td>30.39</td>
<td>40.80</td>
<td>46.29</td>
<td>48.86</td>
<td>49.33</td>
</tr>
<tr>
<td>P.O.J.'s</td>
<td>1.89</td>
<td>0.32</td>
<td>1.29</td>
<td>0.31</td>
<td>0.39</td>
</tr>
</tbody>
</table>

When during the 1952-53 crushing season the proportion of Uba cane had dropped to a mere 0.13 per cent., the proportion of this cane has not been recorded separately any more. Since the proportion of P.O.J.'s crushed has dropped presently to 0.26 per cent., also this variety will not be mentioned any more separately, but will be included too in the group "Other Varieties." If it appears during the next season that one of the new varieties has reached an extension of more than 1 per cent., this variety will be mentioned separately in future.

Regarding the rainfall during the crushing season and as far as the rainfall interfered with crushing operations, we want to record that considerably more rain than the average has fallen during the following months:

<table>
<thead>
<tr>
<th>Month</th>
<th>1954-55</th>
<th>Sept.</th>
<th>October</th>
<th>January</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4.85</td>
<td>10.98</td>
<td>7.94</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>2.48</td>
<td>3.45</td>
<td>4.37</td>
</tr>
</tbody>
</table>

Note: The mean monthly rainfall data are derived from Weather Report 1953-54; the rainfall experienced during the 1954-55 season is quoted from Rainfall Statistics compiled by the Experiment Station.

December has been an exceptionally dry month; only 189 inches of rain has fallen; the mean for December being 4.93 inches.

### General Factory Performance

Nineteen instead of eighteen factories have been in operation during the 1954-55 season; Esperanza being transferred from the South Coast site to Pongola joined the crushing operations again. The tables and the discussions will refer to seventeen of the nineteen factories which have been in operation, viz. to those seventeen factories which regularly contribute data to our monthly and annual summaries. Since these seventeen factories crush 99 per cent. of all cane harvested and manufacture more than 99 per cent. of all sugar produced, the data shown and discussed in this summary are largely representative of the whole South African Sugar Industry.

To show how this "bigger crop than ever" was handled, we have collected a number of data which will facilitate comparison with the previous two crops.

### TABLE E

<table>
<thead>
<tr>
<th>Season</th>
<th>1952-53</th>
<th>1953-54</th>
<th>1954-55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Factories Crushing</td>
<td>17</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Total Cane Crushed</td>
<td>5,601,604</td>
<td>6,160,770</td>
<td>7,296,805</td>
</tr>
<tr>
<td>Total Hours Mills Open</td>
<td>74,491</td>
<td>75,324</td>
<td>89,488</td>
</tr>
<tr>
<td>Average Number of Weeks</td>
<td>125</td>
<td>125</td>
<td>368</td>
</tr>
<tr>
<td>Total Hours Actual Crushing</td>
<td>70,274</td>
<td>69,440</td>
<td>78,525</td>
</tr>
<tr>
<td>Average Days Actual Crushing</td>
<td>192</td>
<td>192</td>
<td>192</td>
</tr>
<tr>
<td>Mean Time Efficiency</td>
<td>84</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td>Mean Time Efficiency</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Hours of Stoppage per cent.</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Hours of Stoppage due to Cane Shortage per cent.</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
The MEAN CRUSHING RATE (average crushing rate in tons of cane per hour actual crushing per mill) of the 1953-54 season is affected by the falling out of Esperanza. When this factory would have crushed during that season the mean crushing rate would have been lower because Esperanza crushing rate was lower than the mean.

The collected data show that owing to the steadily increasing crop and notwithstanding the increased crushing rate the average duration of the crushing season has grown from $30\frac{1}{2}$ to $36\frac{1}{2}$ weeks, when comparing the two season that seventeen factories were crushing, viz. 1952-53 and 1954-55.

**TABLE F**

The next table shows the part each factory had in the increase of the joint crushing rate.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PG</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>UF</td>
<td>96</td>
<td>134</td>
<td>137</td>
<td>145</td>
<td>151</td>
</tr>
<tr>
<td>ZM</td>
<td>105</td>
<td>100 1/2</td>
<td>97</td>
<td>98</td>
<td>113</td>
</tr>
<tr>
<td>FX</td>
<td>90</td>
<td>90</td>
<td>87</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>EN</td>
<td>16</td>
<td>15</td>
<td>14</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>AK</td>
<td>90</td>
<td>87</td>
<td>88</td>
<td>94</td>
<td>103</td>
</tr>
<tr>
<td>D.K.</td>
<td>30 1/2</td>
<td>30</td>
<td>31</td>
<td>33</td>
<td>40</td>
</tr>
<tr>
<td>DL</td>
<td>124</td>
<td>119</td>
<td>121</td>
<td>150</td>
<td>171</td>
</tr>
<tr>
<td>GL</td>
<td>73</td>
<td>77</td>
<td>81</td>
<td>86</td>
<td>97</td>
</tr>
<tr>
<td>MV</td>
<td>33</td>
<td>33</td>
<td>36</td>
<td>36</td>
<td>40</td>
</tr>
<tr>
<td>CK</td>
<td>44</td>
<td>40</td>
<td>42 1/2</td>
<td>44</td>
<td>43</td>
</tr>
<tr>
<td>TS</td>
<td>179</td>
<td>169</td>
<td>170</td>
<td>171</td>
<td>174</td>
</tr>
<tr>
<td>NE</td>
<td>145</td>
<td>134</td>
<td>140</td>
<td>146</td>
<td>152</td>
</tr>
<tr>
<td>IL</td>
<td>53</td>
<td>49</td>
<td>62</td>
<td>59</td>
<td>64</td>
</tr>
<tr>
<td>RN</td>
<td>43</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>ES</td>
<td>48</td>
<td>44</td>
<td>48</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SZ</td>
<td>86</td>
<td>88</td>
<td>98</td>
<td>108</td>
<td>124</td>
</tr>
<tr>
<td>UK</td>
<td>28 1/2</td>
<td>28 1/2</td>
<td>28</td>
<td>28</td>
<td>31</td>
</tr>
</tbody>
</table>

**TABLE G**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons Cane per hour</td>
<td>76.57</td>
<td>78.96</td>
<td>80.56</td>
<td>88.70</td>
<td>82.92</td>
<td></td>
</tr>
<tr>
<td>Tons Fibre per hour</td>
<td>12.57</td>
<td>12.86</td>
<td>12.97</td>
<td>14.47</td>
<td>14.90</td>
<td></td>
</tr>
<tr>
<td>Tons Brix per hour</td>
<td>12.05</td>
<td>11.58</td>
<td>12.20</td>
<td>13.85</td>
<td>13.34</td>
<td></td>
</tr>
<tr>
<td>Tons Sugar per hour</td>
<td>9.56</td>
<td>8.79</td>
<td>8.47</td>
<td>10.57</td>
<td>10.47</td>
<td></td>
</tr>
<tr>
<td>Lost Juice per cent. Fibre</td>
<td>30.3</td>
<td>40.2</td>
<td>40.8</td>
<td>41.7</td>
<td>44.4</td>
<td></td>
</tr>
<tr>
<td>Imbibition per cent. Fibre</td>
<td>208</td>
<td>215</td>
<td>217</td>
<td>200</td>
<td>191</td>
<td></td>
</tr>
<tr>
<td>Boiling House Performance</td>
<td>96.9</td>
<td>96.7</td>
<td>97.2</td>
<td>96.0</td>
<td>97.4</td>
<td></td>
</tr>
<tr>
<td>Parity Final Maltose</td>
<td>40.5</td>
<td>40.3</td>
<td>39.3</td>
<td>39.5</td>
<td>39.3</td>
<td></td>
</tr>
<tr>
<td>Percentage Und. Losses</td>
<td>1.84</td>
<td>1.34</td>
<td>1.46</td>
<td>1.70</td>
<td>1.44</td>
<td></td>
</tr>
</tbody>
</table>

The fibre content of the cane varies from season to season, but these variations are completely outdone by variations in fibre content from mill to mill, even when occurring in the same season. For example, one of Pongola's Weekly Reports records a weekly average of 11.82 per cent. fibre, in cane, but on the other hand Weekly Reports of Natal Estates of the same season report 18.82 per cent. as weekly averages. It is obvious that when there is such a wide dispersion in fibre content, figures as "Extraction" and "Imbibition Water per cent. Cane" must be unsuitable for comparison purposes. In the case of 11.82 per cent. fibre an application of 30 per cent. water on cane corresponds with 254 parts of water per 100 parts of fibre, in the case of 18.82 per cent. fibre an application of 30 per cent. water on cane would mean that there are only 159 water available per 100 fibre. It is the same with "Extraction;" 2.50 per cent. sucrose in bagasse means in the first case an extraction of 95.3 and in the second case of only 92.5 per cent.; assumning that in both cases the sucrose content of the cane is 14.0 per cent. and the fibre content of the bagasse 45 per cent. Particularly for Natal with its big variations in fibre content it is to be recommended to use figures which are based on fibre ratios as "Imbibition Water per cent. fibre" and "Lost Absolute Juice per cent. fibre."

Table G reveals that since a minimum of 39.3 per cent. Lost Absolute Juice was attained during 1950-51, this ratio has been increasing steadily. We can mention two reasons for this increase of Lost Absolute Juice. Firstly the imbibition ratio is decreased and secondly the crushing rate has increased more than the capacity of the mill trains has been increased by extending of the trains.

To prove the latter statement the following data are tabulated:

(a) The capacity ratings of all milling trains as they were in 1950-51 and as they are at present (in tons of fibre per hour).

(b) The actual throughput of all milling trains in 1950-51 and in 1954-55 (in tons of fibre per hour).

_Note:_ The Capacity Ratings have been calculated with the aid of the formula derived by Reysom (Proc. 31st Ann. Conf. S.A.S.T.A. 1947; p. 37-51):

Capacity rating in tons of fibre per hour = $(D \times L \times N)/38.50 + D$ and $L$ in feet.
Table H shows that the average proportion between the calculated rating and the actual performance was in 1950-51 as 240.56 to 203.23, or in other words the trains were crushing 15 per cent. less than they could do according to their rating. In 1954-55, however, the actual performance amounted to 92 per cent. of the capacity rating. In addition the imbibition ratio had to be decreased as a result of the higher crushing rates, viz. from 206 per cent. in 1950-51 to 191 per cent. on fibre in 1954-55. These are two reasons why the figure of Lost Absolute Juice increased from 39.3 per cent. in 1950-51 to 44.1 per cent. on fibre in 1954-55.

Not only has the figure for Absolute Juice per cent. fibre gone up; the moisture content of the bagasse is also steadily increasing: 51.22 per cent. (1950); 51.71 per cent. (1951); 52.53 per cent. (1952); 52.47 per cent. (1953) and 52.92 per cent. (1954). Not only is the increase in moisture content of the bagasse one of the main reasons of the increase in Lost Absolute Juice, but the increase in moisture impairs also the calorific value of the bagasse: 3176 (1950); 3136 (1951); 3064 (1952); 3067 (1953) and 3028 Btu per lb. of bagasse (1954). We draw attention to the fact that the moisture content of the bagasse is increasing notwithstanding the imbibition ratio is decreasing (see Table G).

The extraction obtained by a milling train is the combined results of (a) the repeated pressings exerted by the consecutive units and of (b) the degree of mixing of the administered imbibition water with the juice present in the intermediate bagasse. If we did not apply water to the bagasse, or if the applied water did not mix at all with the juice, the units following the first two mills would not add to the extraction at all and the extraction of 18-roller train would be of the same magnitude as of a 6-roller train. Since the extraction which can be obtained by a milling train depends for such a great part on the degree of mixing of imbibition water and juice, a figure which indicates the attained degree of mixing is appreciated. One of the efforts to evaluate the efficiency of the imbibition water as applied is the so-called "Imbibition Efficiency" figure of which the meaning has been explained on page .19 of the Proceedings of the Twenty-Sixth Annual Congress of the S.A.S.T.A. Another figure is the ratio between "Tons of Imbibition Water present in Final Bagasse" and "Tons of Imbibition Water present in Mixed Juice." Since the part of the imbibition water which ends up in mixed juice does not serve a useful purpose at all and the part present in final bagasse did partake in the driving out of the juice, the higher the ratio the better. However, it does not mean that this ratio can be used as a yardstick for the degree of mixing, i.e. for the efficiency of the used imbibition water.

When we now, after this expatiation, study the following table (Table I) showing the imbibition efficiency figures and the imbibition ratios of recent years, then it strikes us: that the degree of mixing of Chaka's Kraal is steadily improving from 54 per cent. in 1951 up to 85 per cent. in 1954. Gledhow's figure, which jumped from 57 per cent. (1951) to 76 per cent. (1952) when a Searby shredder was installed in front of the milling train, made another jump this year, viz. from 76 per cent. to 92 per cent. Since no change has been made in the equipment, this raise must be due to the reduction of the imbibition, from 178 per cent. to 137 per cent. The figures of Renishaw are also striking; perhaps the change of intermediate carriers from slat type to dredge type is the cause of the higher level of the figures in 1953 and 1954 compared with 1951 and 1952.
TABLE I

Imbibition Efficiency

<table>
<thead>
<tr>
<th>Season</th>
<th>1952-53</th>
<th>1953-54</th>
<th>1954-55</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG</td>
<td>--------</td>
<td>--------</td>
<td>59 (159)</td>
</tr>
<tr>
<td>UF</td>
<td>46 (192)</td>
<td>43 (191)</td>
<td>49 (176)</td>
</tr>
<tr>
<td>ZM</td>
<td>39 (219)</td>
<td>44 (252)</td>
<td>54 (220)</td>
</tr>
<tr>
<td>FX</td>
<td>36 (225)</td>
<td>49 (224)</td>
<td>56 (189)</td>
</tr>
<tr>
<td>EN</td>
<td>27 (259)</td>
<td>27 (252)</td>
<td>29 (250)</td>
</tr>
<tr>
<td>AK</td>
<td>43 (219)</td>
<td>51 (219)</td>
<td>68 (191)</td>
</tr>
<tr>
<td>DK</td>
<td>65 (187)</td>
<td>80 (202)</td>
<td>63 (182)</td>
</tr>
<tr>
<td>DL</td>
<td>62 (225)</td>
<td>55 (229)</td>
<td>58 (183)</td>
</tr>
<tr>
<td>GL</td>
<td>57 (182)</td>
<td>76 (193)</td>
<td>76 (178)</td>
</tr>
<tr>
<td>MV</td>
<td>52 (192)</td>
<td>44 (228)</td>
<td>49 (228)</td>
</tr>
<tr>
<td>CK</td>
<td>54 (169)</td>
<td>64 (167)</td>
<td>66 (160)</td>
</tr>
<tr>
<td>TS</td>
<td>48 (185)</td>
<td>49 (193)</td>
<td>46 (194)</td>
</tr>
<tr>
<td>NE</td>
<td>39 (237)</td>
<td>42 (240)</td>
<td>47 (226)</td>
</tr>
<tr>
<td>IL</td>
<td>41 (246)</td>
<td>49 (193)</td>
<td>35 (203)</td>
</tr>
<tr>
<td>RN</td>
<td>43 (234)</td>
<td>59 (226)</td>
<td>78 (221)</td>
</tr>
<tr>
<td>ES</td>
<td>40 (240)</td>
<td>41 (226)</td>
<td></td>
</tr>
<tr>
<td>SZ</td>
<td>64 (237)</td>
<td>53 (226)</td>
<td>63 (219)</td>
</tr>
<tr>
<td>UK</td>
<td>41 (265)</td>
<td>47 (267)</td>
<td>47 (268)</td>
</tr>
</tbody>
</table>

Arithmetical Average:
- 47 (218) 51 (217) 55 (207) 56 (195)

Averages of those factories which apply more than 200 water per cent. fibre:
- 43 (237) 49 (223) 50 (229) 47 (221)

Averages of those factories which apply less than 200 water per cent. fibre:
- 54 (184) 56 (187) 60 (184) 63 (171)

Note: This division in factories using more and factories using less than 200 water per cent. fibre is required, because the higher the imbibition the less complete will be the mixing and consequently.

When considering the Boiling House Performance figures of recent years, we want to compare the Undetermined Losses percentages and the Purities of Final Molasses simultaneously, this is the reason why Table G shows these values too.

In the following Table J a review of all losses and of Overall Recoveries is given in order to enable us to trace why in one year the Overall Recovery was higher than in another year.

TABLE J

Sucrose Balance (Sucrose Per Cent. Sucrose in Cane)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Yr.</td>
<td>9.67</td>
<td>7.61</td>
<td>7.99</td>
<td>7.33</td>
<td>7.60</td>
</tr>
<tr>
<td>Filter Cake (q)</td>
<td>0.37</td>
<td>0.52</td>
<td>0.43</td>
<td>0.49</td>
<td>0.54</td>
</tr>
<tr>
<td>Final Molasses (c)</td>
<td>8.00</td>
<td>8.61</td>
<td>7.45</td>
<td>7.78</td>
<td>7.22</td>
</tr>
<tr>
<td>Undetermined (a)</td>
<td>1.34</td>
<td>1.36</td>
<td>1.46</td>
<td>1.59</td>
<td>1.44</td>
</tr>
</tbody>
</table>

Boiling House Losses:

Total of All Losses:
- 16.35 17.50 16.34 17.19 16.80

Overall Recovery:
- 85.05 82.50 82.66 82.31 83.20

Sucrose in Cane:
- 100.00 100.00 100.00 100.00 100.00

In Table K those factories are shown which obtained undetermined losses between 0.50 and 1.75 per cent. (on sucrose in cane). It shows that the number of these factories increased from six in 1950 to 11 in 1954.

TABLE K

Factories Showing Undetermined Losses of More Than 0.50 and Less Than 1.75 per Cent. of Sucrose in Cane

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>UF</td>
<td>0.88</td>
<td>0.97</td>
<td>1.00</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>ZM</td>
<td>1.15</td>
<td>0.97</td>
<td>1.24</td>
<td>0.69</td>
<td>0.95</td>
</tr>
<tr>
<td>FX</td>
<td>(x)</td>
<td>0.59</td>
<td>1.04</td>
<td>0.95</td>
<td>1.17</td>
</tr>
<tr>
<td>EN</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>1.56</td>
<td>1.54</td>
</tr>
<tr>
<td>AK</td>
<td>0.62</td>
<td>0.92</td>
<td>0.11</td>
<td>1.05</td>
<td>0.74</td>
</tr>
<tr>
<td>DK</td>
<td>(x)</td>
<td>(x)</td>
<td>H</td>
<td>H</td>
<td>1.54</td>
</tr>
<tr>
<td>DL</td>
<td>(x)</td>
<td>(x)</td>
<td>1.12</td>
<td>1.36</td>
<td>1.12</td>
</tr>
<tr>
<td>GL</td>
<td>1.26</td>
<td>1.26</td>
<td>1.40</td>
<td>1.38</td>
<td>1.54</td>
</tr>
<tr>
<td>MV</td>
<td>H</td>
<td>H</td>
<td>1.16</td>
<td>1.26</td>
<td>1.34</td>
</tr>
<tr>
<td>TS</td>
<td>(x)</td>
<td>(x)</td>
<td>H</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>IL</td>
<td>0.92</td>
<td>0.82</td>
<td>0.59</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>RN</td>
<td>(x)</td>
<td>(x)</td>
<td>(x)</td>
<td>1.41</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Number 6 6 10 11

Note: The letter H denotes that in that year the losses were more than 1.75 per cent. and L indicates that the losses were less than 0.50 per cent. (on sucrose in cane).

It has been explained in previous Summaries how the undetermined losses of those factories which do not weigh their molasses, has been estimated. In order to check the factor 0.83 which has been used for these calculations we computed for all factories the ratio:

\[
\frac{\text{Tons Nonsucrose in Final Molasses}}{\text{Tons Nonsucrose in Sugars}} = \frac{\text{Tons Nonsucrose in Mixed Juice}}{\text{Tons Nonsucrose in Cane}}
\]

The results of these computations have been tabulated.
Review of Nonsucrose Ratios for Recent Years

TABLE L

<table>
<thead>
<tr>
<th>Factory</th>
<th>1930-31</th>
<th>1931-32</th>
<th>1932-33</th>
<th>1933-34</th>
<th>1934-35</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG</td>
<td>0.82</td>
<td>0.89</td>
<td>0.83</td>
<td>0.85</td>
<td>0.82</td>
<td>0.82</td>
</tr>
<tr>
<td>UF</td>
<td>0.87</td>
<td>0.89</td>
<td>0.91</td>
<td>0.89</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>ZM</td>
<td>0.87</td>
<td>0.87</td>
<td>0.86</td>
<td>0.81</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>FK</td>
<td>0.87</td>
<td>0.82</td>
<td>0.82</td>
<td>0.83</td>
<td>0.86</td>
<td>0.83</td>
</tr>
<tr>
<td>EN</td>
<td>0.87</td>
<td>0.82</td>
<td>0.84</td>
<td>0.83</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>AK</td>
<td>0.85</td>
<td>0.86</td>
<td>0.79</td>
<td>0.80</td>
<td>0.85</td>
<td>0.80</td>
</tr>
<tr>
<td>GL</td>
<td>0.82</td>
<td>0.81</td>
<td>0.80</td>
<td>0.81</td>
<td>0.82</td>
<td>0.81</td>
</tr>
<tr>
<td>MV</td>
<td>0.85</td>
<td>0.88</td>
<td>0.85</td>
<td>0.80</td>
<td>0.86</td>
<td>0.84</td>
</tr>
<tr>
<td>TS</td>
<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
</tr>
<tr>
<td>NE</td>
<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
<td>0.81</td>
</tr>
<tr>
<td>IL</td>
<td>0.87</td>
<td>0.84</td>
<td>0.85</td>
<td>0.84</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>KN</td>
<td>0.87</td>
<td>0.87</td>
<td>0.87</td>
<td>0.87</td>
<td>0.87</td>
<td>0.87</td>
</tr>
</tbody>
</table>

*Average 0.82, 0.84, 0.82, 0.81, 0.80

The review shows us the so much higher nonsucrose removal by carbonation than by sulphitation juice clarification. As an average the nonsucrose present in final molasses and sugars is only 56 per cent. of the quantity present in mixed juice in the case of Natal Estates compared with 83 per cent. as an average for the other factories. Natal Estate's ratio of 56 per cent. compares favourably with Java's average of 72 per cent. for carbonatation factories (period 1938-1941).

Since we were met in a few cases with undetermined gains (negative losses) when assuming a ratio of 0.83 and calculating in this manner sucrose losses in final molasses and undetermined, we recommend checking as routine the undetermined sucrose losses in the manner shown hereunder:

TABLE M

<table>
<thead>
<tr>
<th>Factory</th>
<th>1930-31</th>
<th>1931-32</th>
<th>1932-33</th>
<th>1933-34</th>
<th>1934-35</th>
</tr>
</thead>
<tbody>
<tr>
<td>UF</td>
<td>38.9</td>
<td>37.1</td>
<td>38.5</td>
<td>38.5</td>
<td>39.9</td>
</tr>
<tr>
<td>ZM</td>
<td>39.1</td>
<td>37.3</td>
<td>38.7</td>
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<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
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<tr>
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<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>AK</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>DK</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>GL</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>CK</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>TS</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>RN</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
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<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>SZ</td>
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<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
<tr>
<td>UK</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
<td>38.6</td>
</tr>
</tbody>
</table>

No. of Factories 5 7 7 8 10

Since we were met in a few cases with undetermined gains (negative losses) when assuming a ratio of 0.83 and calculating in this manner sucrose losses in final molasses and undetermined, we recommend checking as routine the undetermined sucrose losses in the manner shown hereunder:

TABLE N

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Parts per 1000 Parts of Brix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime</td>
<td>19.10 17.44 4.20</td>
</tr>
<tr>
<td>Maximum</td>
<td>27.58 26.81 4.70</td>
</tr>
<tr>
<td>Minimum</td>
<td>11.61 13.24 4.07</td>
</tr>
<tr>
<td>Sulphur</td>
<td>7.60 7.16 6.68</td>
</tr>
<tr>
<td>Maximum</td>
<td>10.90 11.74 9.00</td>
</tr>
<tr>
<td>Minimum</td>
<td>4.19 5.68 9.90</td>
</tr>
<tr>
<td>Phosphoric</td>
<td>2.53 2.12 0.90</td>
</tr>
<tr>
<td>Maximum</td>
<td>6.81 4.43 0.99</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.19 0.87 0.87</td>
</tr>
</tbody>
</table>

Felixton, Darnall and Sezela constitute at present the backbone of this Table since they have not been absent once the last five years. A newcomer is Umfolozi, while Gledhow returned to the fold. The Table shows that molasses purities of 39.0 or lower are not limited to one special area of the sugar belt. The Table is steadily growing and we hope that this will be continued in the years to come.

Reducing the final molasses purity and reducing the undetermined losses is the only manner to improve the Boiling House Performance figure.

Chemicals

The consumption of lime, sulphur and phosphoric is indicated as usual in parts consumed per 1000 parts of brix in mixed juice.
Lime (Sulphitation). This year the maximum consumption was twice the minimum consumption against two and a half times during the 1950-53 period. The lowest line-consumption in 1954 is shown by Darnall, viz. 1.524 parts/1000 parts brix, while the lowest figure during the 1950-55 period was achieved by Doornkop in 1955, viz. 11.61 parts of lime per 1000 parts of brix.

Sulphur (Sulphitation). The maximum sulphur consumption has been twice the minimum consumption of 5.58 parts/1000 parts brix which was attained by Darnall. In the 1950-55 period Doornkop achieved the lowest consumption, viz. 4.19 in 1955.

Phosphoric (Sulphitation). The lowest phosphoric consumption in the 1950-53 period was 0.19 parts/1000 parts brix, attained in 1951 by Umfolozi. This year Umfolozi heads the list again; this time, however, with a consumption of 0.87 parts of phosphoric consumed per 1000 parts of brix in mixed juice.

Finally we tabulated separately the consumptions of chemicals of Illovo and Tongaat during the sulphitation and the defecation periods:

<table>
<thead>
<tr>
<th></th>
<th>Sulphitation</th>
<th>Defecation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Illovo</td>
<td>Tongaat</td>
</tr>
<tr>
<td></td>
<td>Illovo</td>
<td>Tongaat</td>
</tr>
<tr>
<td>Lime (parts/1000)</td>
<td>5.80</td>
<td>4.19</td>
</tr>
<tr>
<td>Sulphur (parts/1000)</td>
<td>31.62</td>
<td>37.74</td>
</tr>
<tr>
<td>Phosphoric (parts/1000)</td>
<td>20.60</td>
<td>15.92</td>
</tr>
</tbody>
</table>

We draw attention in particular to the drop in phosphoric consumption in the defecation periods of Illovo and Tongaat compared with the sulphitation period. When the chemistry of the clarification was scrutinized more closely than usual as a result of the defecation tests, it appeared that the phosphoric dose could be reduced considerably at these two factories. It is our opinion that in general too much phosphoric is used by the Natal raw sugar factories. The use of phosphoric and the adjustment of the quantity of phosphoric ought to be based on P₂O₅ determinations in mixed juice. Too high a dose of phosphoric leads to a bigger mud volume, which cannot be redressed by an increased lime and sulphur consumption.

Comparative Results from Other Countries for Recent Years

In previous years, Table VI contained more than thirty items. We have cut the number this year to twenty-three to facilitate comparison. A number of data which had limited value for comparison purposes have been dropped; however, two more useful figures have been added, viz. brix per cent. first expressed juice, and Boiling House Performance.

The figure; of brix per cent. first expressed juice has been added to the figure of purity of first expressed juice, because these two figures together give a better idea of the cane juice quality than purity alone does. The newly-added figure shows that brix of the first expressed juice of Natal cane is markedly higher than that of other reported countries. This implies that Natal's figure for sucrose per cent, bagasse cannot be used to compare milling efficiency of Natal with that of other countries. Since the fibre content of the cane of the reported countries differ, extraction cannot be used either; Lost Absolute Juice per cent. Fibre being the only remaining figure which can be used for comparison. The same applies to imbibition per cent. fibre compared with imbibition per cent. cane.

Boiling House Performance figures of all countries have been added, because Boiling House Recovery is not suitable since mixed juice purity varies from 79.7 to 85.6 and pol of sugar from 96.68° to 98.66°S. In addition to the factors affecting Boiling House Recovery, Overall Recovery is affected by the variations in fibre content of the cane (lowest figure 11.58 per cent. and highest figure 16.31 per cent.). The same applies to Tons of Cane per Ton of Sugar and to Tons of Cane per Ton of 96° Sugar.
<table>
<thead>
<tr>
<th>Table 1.—CANE CRUSHED, CANE QUALITY, VARIETIES, SUGARS PRODUCED, TIME ACCOUNT AND THROUGHPUT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACTORY...</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>Crushing period</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>CANE CRUSHED</td>
</tr>
<tr>
<td>Median hours</td>
</tr>
<tr>
<td>Cane Quality</td>
</tr>
<tr>
<td>Sucrose per cent.</td>
</tr>
<tr>
<td>Pure per cent.</td>
</tr>
<tr>
<td>Jar count</td>
</tr>
<tr>
<td>Total Cane per ton Sugar</td>
</tr>
<tr>
<td>Total Cane per ton Sugar of 0.1% Purification</td>
</tr>
<tr>
<td>VARIETIES CRUSHED</td>
</tr>
<tr>
<td>Moisture per cent.</td>
</tr>
<tr>
<td>Good per cent.</td>
</tr>
<tr>
<td>Mortality per cent.</td>
</tr>
<tr>
<td>Quality</td>
</tr>
<tr>
<td>TOTAL RAINFALL, Year 1944 (in.)</td>
</tr>
<tr>
<td>SUGARS</td>
</tr>
<tr>
<td>White Sugar</td>
</tr>
<tr>
<td>Governmental Grade</td>
</tr>
<tr>
<td>Re-Grind Sugar</td>
</tr>
<tr>
<td>Sugar in cane and chemicals</td>
</tr>
<tr>
<td>Total of 2,000 hrs.</td>
</tr>
<tr>
<td>Moisture</td>
</tr>
<tr>
<td>White Sugar per cent.</td>
</tr>
<tr>
<td>Sugar for White Sugar</td>
</tr>
<tr>
<td>Sugar in Sealed Paper</td>
</tr>
<tr>
<td>Sealed Paper</td>
</tr>
<tr>
<td>Total of Sealed Paper</td>
</tr>
<tr>
<td>Paper in Sealed</td>
</tr>
<tr>
<td>Paper bag</td>
</tr>
<tr>
<td>Paperine</td>
</tr>
<tr>
<td>Polishing of Raw Muscovado</td>
</tr>
<tr>
<td>Average Purification of All Sugars</td>
</tr>
<tr>
<td>OVERALL TIME EFFICIENCY</td>
</tr>
<tr>
<td>Hours Actual Crushing</td>
</tr>
<tr>
<td>Hours Mill Open</td>
</tr>
<tr>
<td>Hours of Seepage due to hours of Wax per cent. Hours</td>
</tr>
<tr>
<td>Mill Open</td>
</tr>
<tr>
<td>Total Hours of Stoppage</td>
</tr>
<tr>
<td>THROUGHPUT per hour crushing</td>
</tr>
<tr>
<td>Cane Crushed</td>
</tr>
<tr>
<td>Cane Fractured</td>
</tr>
<tr>
<td>Total of 2,000 hrs.</td>
</tr>
<tr>
<td>Moisture</td>
</tr>
<tr>
<td>White Sugar per cent.</td>
</tr>
<tr>
<td>Sugar for White Sugar</td>
</tr>
<tr>
<td>Sugar for Re-Grind Sugar</td>
</tr>
<tr>
<td>Sugar for Sealed Paper</td>
</tr>
<tr>
<td>Sugar in Sealed Paper</td>
</tr>
<tr>
<td>Sealed Paper</td>
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<tr>
<td>Polishing of Raw Muscovado</td>
</tr>
<tr>
<td>Average Purification of All Sugars</td>
</tr>
<tr>
<td>Hours Actual Crushing</td>
</tr>
<tr>
<td>Hours Mill Open</td>
</tr>
<tr>
<td>Hours of Seepage due to hours of Wax per cent. Hours</td>
</tr>
<tr>
<td>Mill Open</td>
</tr>
<tr>
<td>Total Hours of Stoppage</td>
</tr>
</tbody>
</table>
| *Hour's figures refer to various operations and are based on sugar of 96%. Most of the raw sugar has been refined and some 14,000 tons of refined sugar have been manufactured.
### Table II.—SUCROSE BALANCE, RECOVERIES, BAGASSE, JUICES, FILTER CAKE AND SYRUP.

<table>
<thead>
<tr>
<th>FACTORY</th>
<th>PC</th>
<th>UF</th>
<th>ZM</th>
<th>FX</th>
<th>EN</th>
<th>AK</th>
<th>DK</th>
<th>DL</th>
<th>GL</th>
<th>MV</th>
<th>CK</th>
<th>TS</th>
<th>NE</th>
<th>IL</th>
<th>RN</th>
<th>SZ</th>
<th>IK</th>
<th>Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUCROSE BALANCE (Sucrose percent, Sugars in each)</td>
<td>7.76</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar in Bagasse (% of Total)</td>
<td>6.70</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar in Filter Cake (S)</td>
<td>9.70</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar in Final Molasses (F)</td>
<td>6.70</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underemulsed Liquids (%)</td>
<td>7.60</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
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<tr>
<td>Sugar lost in Baling House (B)</td>
<td>11.47</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total of all losses (A)</td>
<td>19.25</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOSE ABSOLUTE JUICE PER CENT, HORE</td>
<td>60.2</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BORING HOUSE PERFORMANCE</td>
<td>38.00</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induction Water per cent, Total</td>
<td>50.00</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
<td>0.55</td>
<td>7.00</td>
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<td>Induction Water per cent, Colon</td>
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<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
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<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
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<td>0.61</td>
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<td>0.01</td>
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<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
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<td>70.00</td>
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<td>9.25</td>
<td>0.61</td>
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<td>0.01</td>
<td>0.24</td>
<td>0.01</td>
<td>4.75</td>
<td>3.08</td>
<td>0.75</td>
<td>0.05</td>
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**FINAL BAGASSE**

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<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
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<tr>
<td>Weight per cent. Bags</td>
<td>50.00</td>
<td>0.01</td>
<td>8.74</td>
<td>9.25</td>
<td>0.61</td>
<td>0.17</td>
<td>0.68</td>
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</tbody>
</table>

**FIRST EXPRESSED JUICE**

| Source | percent | | | | | |
|--------|---------|---|---|---|---|
| Purify (Equivalent) | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |

**LAST EXPRESSED JUICE**

| Source | percent | | | | | |
|--------|---------|---|---|---|---|
| Purify (Equivalent) | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |

**MIXED JUICE**

| Source | percent | | | | | |
|--------|---------|---|---|---|---|
| Purify Drumped from First Expessed Juice | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |

**CLASSIFIED JUICE**

| Source | percent | | | | | |
|--------|---------|---|---|---|---|
| Purify (Equivalent) | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |
| Reducing Sugar in Suction Boilers | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |

**FILTER CAKE**

| Source | percent | | | | | |
|--------|---------|---|---|---|---|
| Purify (Equivalent) | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |
| Reducing Sugar in Suction Boilers | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |

**SYRUP**

| Source | percent | | | | | |
|--------|---------|---|---|---|---|
| Purify (Equivalent) | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |
| Reducing Sugar in Suction Boilers | 50.00 | 0.01 | 8.74 | 9.25 | 0.61 | 0.17 |
### Table III.—MASSECUEITES AND MOLASSES, CHEMICALS.

| FACTORY | PG | UF | ZM | FX | EN | AK | DK | DL | GL | MY | CK | TS | NE | BN | SZ | UK | Averages
|---------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--------|

### A. MASSECUITE

| Cub. ft per ton of Briq | 15.50 | 24.38 | 18.07 | 16.24 | 28.12 | 24.51 | 25.41 |  - | 25.68 | 26.52 | 29.82 | 24.45 | 24.06 | 22.47 |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Briq of Massecuite | 9.25 | 94.55 | 51.7 | 122.8 | 91.0 | 98.5 | 90.9 | 88.6 | 91.4 | 93.8 | 90.4 | 92.4 | 90.8 | 91.4 | 90.8 | 92.4 | 90.8 |

### B. MASSECUITE

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<td>122.8</td>
<td>91.0</td>
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<td>90.9</td>
<td>88.6</td>
<td>91.4</td>
<td>93.8</td>
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<td>90.8</td>
<td>91.4</td>
<td>90.8</td>
<td>92.4</td>
<td>90.8</td>
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### C. MASSECUITE

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<td>51.7</td>
<td>122.8</td>
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<td>91.4</td>
<td>90.8</td>
<td>92.4</td>
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### TOTAL CUB. FT. OF ALL MASSECUITES

| Per ton of Sugar Made | 22.28 | 54.59 | 46.85 | 38.50 | 56.47 | 51.11 | 44.14 | 44.14 | 44.14 | 44.14 | 44.14 | 44.14 | 44.14 | 44.14 | 44.14 | 44.14 | 44.14 |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Per ton of Briq | 38.57 | 44.14 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 | 38.50 |

### FINAL MOLASSES

| Briq | 96.5 | 94.9 | 92.9 | 90.9 | 88.9 | 91.4 | 93.8 | 90.4 | 92.4 | 90.8 | 91.4 | 90.8 | 92.4 | 90.8 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Gravity Purity | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 | 49.8 |
| Reducing Sugars | 96.5 | 94.9 | 92.9 | 90.9 | 88.9 | 91.4 | 93.8 | 90.4 | 92.4 | 90.8 | 91.4 | 90.8 | 92.4 | 90.8 |
| Sulphated Ash | 96.5 | 94.9 | 92.9 | 90.9 | 88.9 | 91.4 | 93.8 | 90.4 | 92.4 | 90.8 | 91.4 | 90.8 | 92.4 | 90.8 |
| Ash, Sum | 96.5 | 94.9 | 92.9 | 90.9 | 88.9 | 91.4 | 93.8 | 90.4 | 92.4 | 90.8 | 91.4 | 90.8 | 92.4 | 90.8 |
| Weight of Molasses per 100 lbs of Briq | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 | 2.33 |
| Case | 96.5 | 94.9 | 92.9 | 90.9 | 88.9 | 91.4 | 93.8 | 90.4 | 92.4 | 90.8 | 91.4 | 90.8 | 92.4 | 90.8 |

### CONSUMPTION OF CHEMICALS

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<tr>
<td>Per 1,000,000 lbs of Briq</td>
<td>10.18</td>
<td>12.06</td>
<td>9.85</td>
<td>27.85</td>
<td>13.61</td>
<td>7.06</td>
<td>5.67</td>
<td>5.21</td>
<td>5.54</td>
<td>5.78</td>
<td>5.31</td>
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<td>5.93</td>
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<td>Sulphur—lbs. per ton of Case</td>
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<tr>
<td>Per 1,000,000 lbs of Briq</td>
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<td>Phosphoric Acid—lbs. per ton of Case</td>
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<tr>
<td>Per 1,000,000 lbs of Briq</td>
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<td>0.49</td>
<td>0.49</td>
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*Apparent Purity
$\%$ Present in Mixed Juice
$\%$ Melt—All averages are exclusive of Natal Estates' figures, with the exception of the averages referring to Final Molasses
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<th>Table IV.—COMPARATIVE RESULTS OF FINAL DATA FOR RECENT YEARS.</th>
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<td>Fibre per cent...</td>
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<td>JUICE QUALITIES</td>
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<tr>
<td>Purity of First Expressed Juice...</td>
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<td>Purity of Last Expressed Juice...</td>
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<tr>
<td>Purity of Mixed Juice...</td>
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<td>Purity of Syrups...</td>
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<td>Purity Drop First to Last Expressed Juice...</td>
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<tr>
<td>Purity Drop First to Mixed Juice...</td>
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<td>Purity Drop First to Syrup...</td>
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<td>Purity Increase Mixed Juice to Syrup...</td>
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<td>Reducing Sugar Sucrose Ratio of Mixed Juice...</td>
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<tr>
<td>Reducing Sugar Sucrose Ratio of Syrup...</td>
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</tbody>
</table>

**EXTRACTION AND RECOVERIES**

| | | | | | | | | | | |
| Sucre lost in manufacture % Cane... | 2.42 | 2.42 | 2.29 | 2.33 | 2.25 | 2.32 | 2.38 | 2.26 | 2.30 | 2.24 |
| Sucre in Sugar % a Sucre in Cane (Overall Rec.)... | 82.98 | 83.94 | 83.75 | 83.10 | 83.35 | 83.65 | 83.79 | 83.86 | 82.81 | 83.20 |
| Sucre in Mixed Juice % a Sucre in Cane (Extraction)... | 62.96 | 61.57 | 62.44 | 61.52 | 62.53 | 63.53 | 62.88 | 63.00 | 62.67 | 62.40 |
| SUCRE in Sugar % a SUCRE in Mixed Juice (B.H. Rec.)... | 80.99 | 80.12 | 80.00 | 80.56 | 80.00 | 80.90 | 80.96 | 80.36 | 80.46 | 80.44 |
| Imbibition % Fibre... | 2.20 | 2.27 | 2.21 | 2.24 | 2.24 | 2.20 | 2.28 | 2.24 | 2.24 | 2.26 |
| Imbibition % Cane... | 32.0 | 36.2 | 34.4 | 35.1 | 35.7 | 35.8 | 36.0 | 34.9 | 32.7 | 30.7 |
| Loss Absolute Juice % Fibre in Bagasse... | 21.3 | 26.0 | 21.8 | 23.8 | 25.8 | 25.9 | 27.3 | 28.3 | 29.8 | 30.3 |
| Boiling House Performance... | 96.4 | 96.7 | 96.8 | 96.5 | 96.6 | 96.8 | 96.6 | 96.2 | 96.1 | 97.43 |

**BAGASSE**

| | | | | | | | | | | |
| Sugar per cent... | 2.77 | 2.79 | 2.54 | 2.67 | 2.66 | 2.72 | 2.57 | 2.65 | 2.75 | 2.75 |
| Moisture per cent... | 69.39 | 69.32 | 59.46 | 59.53 | 59.64 | 51.22 | 51.71 | 52.33 | 52.47 | 53.92 |
| Lower Calorific Value... | 5251 | 5252 | 5244 | 5259 | 5269 | 5276 | 5292 | 5392 | 5392 |

**FILTER CANE**

| | | | | | | | | | | |
| Sugar per cent... | 1.13 | 1.06 | 1.00 | 1.29 | 1.12 | 1.20 | 1.28 | 0.84 | 1.05 | 1.16 |
| Weight % Cane... | 5.64 | 5.01 | 5.00 | 5.90 | 5.90 | 5.81 | 5.68 | 5.80 | 5.48 |

**GRAVITY PURITY OF FINAL MOLASSES**

| | | | | | | | | | | |
| Average Polarisation of All Sugars... | 41.08 | 41.73 | 41.70 | 40.33 | 40.50 | 40.26 | 39.33 | 39.33 | 39.33 | 39.33 |

**YIELD**

| | | | | | | | | | | |
| Tons Cane per Ton Sugar... | 8.28 | 8.36 | 8.84 | 8.75 | 8.76 | 8.32 | 8.68 | 8.26 | 8.53 | 8.87 |
| Tons Cane per Ton 56° Sugar... | 8.08 | 8.14 | 8.00 | 8.31 | 8.32 | 8.69 | 8.27 | 8.52 | 8.05 |

**SUCROSE BALANCE**

| | | | | | | | | | | |
| Sucre in Bagasse % a Sucre in Cane (a)... | 0.72 | 0.63 | 0.68 | 0.68 | 0.66 | 0.67 | 0.61 | 0.60 | 0.73 | 0.70 |
| Sucre in Filter Cake % a Sucre in Cane (b)... | 0.35 | 0.28 | 0.32 | 0.36 | 0.34 | 0.57 | 0.52 | 0.48 | 0.38 | 0.34 |
| Sucre in Molasses % a Sucre in Cane (c)... | - | - | - | - | - | - | - | - | - | - |
| Undetermined Sucre % a Sucre in Cane (d)... | 0.93 | 0.35 | 0.36 | 0.27 | 0.23 | 0.15 | 0.13 | 0.10 | 0.60 | 1.44 |
| Boiling House Loses % a Sucre in Cane (a) + (b) + (c) + (d)... | 9.98 | 10.11 | 9.71 | 10.13 | 9.60 | 9.68 | 10.25 | 9.84 | 9.66 | 9.26 |
| Total Losses % a Sucre in Cane (a) + (b) + (c) + (d)... | 10.70 | 10.94 | 9.99 | 10.69 | 10.85 | 10.90 | 10.90 | 10.90 | 10.90 | 10.90 |
Table V.—AVERAGE MANUFACTURING RESULTS BY MONTHLY PERIODS FOR S.A. SUGAR FACTORIES REPORTING TO THE SUGAR MILLING RESEARCH INSTITUTE, SEASON 1954-1955.

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<td>Tons of 2,000 lbs. Cane Crushed</td>
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<tr>
<td>To date</td>
<td>700,092</td>
<td>1,001,853</td>
<td>832,238</td>
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<td>755,410</td>
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<tr>
<td>To date</td>
<td>76,134</td>
<td>114,633</td>
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<td>124,815</td>
<td>88,882</td>
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*Arithmetical Average
Table VI—COMPARATIVE RESULTS FROM OTHER COUNTRIES FOR RECENT YEARS.

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*Apparent Purity
Table VII—COMPARATIVE DATA OF REPORTING S.A. FACTORIES FROM 1925 TO 1954 INCLUSIVE.

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<th>Year</th>
<th>Per cent. Case</th>
<th>Tons of Case per ton of Sugar</th>
<th>Extraction</th>
<th>Rolling</th>
<th>Overall</th>
<th>Indispensable</th>
<th>Absorbent</th>
<th>Mixed Juice</th>
<th>Purity</th>
<th>Baking Power</th>
<th>Number of factories reporting or touching</th>
<th>Percentage of cases covered</th>
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Average | 13.19 | 15.78 | 0.39 | 9.06 | 89.83 | 83.67 | 75.12 | 27.6 | 175 | 3.88 | 50.57 | 88.4 | 83.09 | 3.85 | 45.3 | 90.6 | 15 of 25 85.9 |

Average | 13.35 | 15.30 | 0.86 | 8.73 | 92.06 | 86.30 | 81.34 | 32.5 | 213 | 3.11 | 51.90 | 48.0 | 89.01 | 3.22 | 43.3 | 95.4 | 15 of 25 87.8 |

Average | 14.28 | 13.99 | 0.29 | 8.08 | 93.28 | 89.20 | 83.30 | 35.5 | 219 | 2.77 | 50.16 | 39.3 | 86.29 | 3.38 | 42.6 | 94.4 | 15 of 25 90.6 |

Average | 14.67 | 15.21 | 0.14 | 8.14 | 93.07 | 89.12 | 83.34 | 35.3 | 217 | 2.76 | 50.82 | 40.5 | 85.95 | 3.20 | 41.8 | 90.7 | 15 of 25 90.2 |

Average | 13.92 | 15.60 | 0.84 | 8.60 | 94.44 | 89.61 | 83.73 | 34.4 | 218 | 2.51 | 56.36 | 30.8 | 86.24 | 2.95 | 41.1 | 96.8 | 15 of 25 90.8 |

Average | 13.32 | 15.00 | 0.85 | 8.31 | 93.93 | 89.14 | 83.19 | 34.1 | 214 | 2.67 | 50.53 | 39.8 | 85.82 | 3.67 | 41.5 | 96.5 | 15 of 25 90.9 |

Average | 13.62 | 16.19 | 0.71 | 8.32 | 94.94 | 89.68 | 83.45 | 35.7 | 207 | 2.06 | 60.50 | 41.0 | 85.32 | 3.21 | 41.4 | 96.5 | 15 of 25 90.2 |

Average | 14.16 | 15.28 | 0.52 | 8.09 | 93.35 | 89.63 | 83.65 | 32.8 | 206 | 2.73 | 61.22 | 49.3 | 84.60 | 3.12 | 40.5 | 96.9 | 17 of 15 99.2 |

Average | 13.33 | 16.29 | 0.38 | 8.73 | 92.06 | 88.72 | 83.00 | 35.0 | 215 | 2.57 | 51.71 | 40.2 | 84.92 | 3.52 | 40.8 | 96.7 | 17 of 15 99.5 |

Average | 13.37 | 16.10 | 0.50 | 8.27 | 93.50 | 80.96 | 83.06 | 34.9 | 217 | 2.05 | 52.53 | 40.8 | 86.25 | 2.92 | 39.3 | 97.2 | 17 of 15 99.3 |

Average | 13.55 | 16.31 | 0.53 | 8.24 | 93.57 | 80.36 | 82.31 | 35.7 | 205 | 2.76 | 52.47 | 41.7 | 85.61 | 3.06 | 41.2 | 96.9 | 18 of 15 99.3 |

Average | 13.34 | 16.03 | 0.87 | 8.36 | 97.04 | 90.04 | 83.20 | 30.7 | 104 | 2.16 | 52.12 | 44.1 | 85.85 | 2.82 | 39.8 | 97.4 | 17 of 10 99.2 |

Average | 19.79 | 15.00 | 0.60 | 8.60 | 93.94 | 80.46 | 83.23 | 33.8 | 210 | 2.69 | 52.32 | 40.6 | 85.93 | 3.29 | 40.7 | 96.8 | 18 of 20 99.3 |
Mr. Perk: The time lapse between the last mill completing its crushing season and the beginning of the Annual Congress is becoming smaller and smaller each year. This year the last mill finished crushing on 13th March and within a fortnight the Annual Congress started. For this reason I want to thank all those Chief Chemists who sent us their final figures so promptly; in particular I want to again thank Mr. Odendaal of Darnall, which factory closed on Monday and whose final figures received on Wednesday morning, so that Wednesday afternoon the draft could be sent to the printers.

Note 1—Table B: When we compare the 1928-34 mean with the mean 1935-44 mean, we must appreciate that there is a difference of 81-75 or 8 over 75 equals 5 per cent. between the Overall Recoveries of those two periods. The difference between the first period and the present one is 83-75 or 6 over 75 or nearly 10 per cent. This implies that to compare cane qualities with the aid of cane/sugar ratios, 10 per cent. has to be subtracted from the first period ratios. For this reason I suggest dispensing with the showing of cane/sugar ratios in this Table, which is in the first place a Table showing agricultural results.

Mr. du Toit (Chairman), said that merely to congratulate an author did not necessarily add to the value of the discussion, but he could not help but compliment him in this case. The author stated that thanks to Mr. Odendaal's assistance he was able to complete the Summary in time for the Congress. Mr. du Toit felt that Mr. Perk was to be congratulated on completing the Summary in so short a time—two days after the last mill stopped crushing.

The way in which the Tables had been presented and explained was also a matter of which Mr. Perk could justly be proud. The introduction of the figures shown in Table B was a great advantage now that the milling season was being more and more extended. This Table shows markedly how the new-varieties indicate a rise in sucrose per cent. cane as well as purities when the optimum periods only are compared. Mr. Perk's Tables show that while the increase in fibre would account for the decrease in extraction, there were other reasons, such as reduction in imbibition per cent. fibre and the increase in crushing rate. The change in varieties was also to be considered. The effect of improved agricultural methods is also reflected. Mr. Perk had pointed out that most factories used too much phosphoric acid. In the past, sugarcane received too little phosphate fertilizers and the juice was then deficient in phosphoric acid. There has now been a change, however, and at least some areas now have sufficient phosphate which would in turn affect the phosphoric acid present in the juice. Mr. Perk had mentioned three factories in particular which had increased their imbibition efficiency in a remarkable way. Mr. du Toit would like to know from Mr. Perk the reason for the enormous increase in the level attained by Chaka's Kraal as far as this figure was concerned, he thought the Natal Estates figure for non-sucrose elimination compared excellently with the Javan figures.

Dr. Dodds said that he also thought the paper an admirable one and Mr. Perk was to be congratulated on the interesting way he had presented his Tables and the great pains he had taken to introduce new angles from which to judge the figures. The Annual Summary had steadily improved in scope over the years. He thought Table 7 the most interesting Table in the Summary for it showed a steady progress in practically every department, when compared over ten-year periods.

Mr. Bax asked if the reduced extraction had any value for South African conditions. In Mauritius this figure was found to be most valuable.

Mr. Perk said that some years ago he came to the conclusion that lost absolute juice per cent. fibre was the best possible figure to use as this made allowance for so many factors which the reduced extraction could not cover.

Mr. du Toit said that in the past we used to calculate both figures. Absolute juice lost per cent. fibre was the basic figure in calculating the reduced extraction, so to give the latter figure was really superfluous. Similarly with reduced boiling house recovery, virtual gravity purity of molasses was an integral part of the reduced figure. In this case, however, the purity of the mixed juice had a big effect on the purity of the molasses and virtual purity of molasses, making both virtual purity of molasses and reduced recovery unsuitable for assessing the relative efficiency of the boiling house operation.

Mr. Bax agreed with the information given by Mr. du Toit and said that in Mauritius both absolute juice per cent. fibre and reduced mill extraction were used.

Mr. Perk pointed out that the mills extracted juice and therefore to express a loss it was better to use a juice loss. It was bad policy to look at high extraction figures and to be satisfied with them; it is far better to examine the losses still remaining.

Mr. Walsh referred to Table H. He said that these figures did not show all the factors affecting the crushing rate and he thought it would be useful to set down the extraction figure's on this Table as well. It did appear from an examination of the figure's and the extraction obtained by the various factories that the Royston formula for capacity was not necessarily the best economic yardstick.
appreciate its repercussions on extraction of any individual mill.

For example, Natal Estates mill with a 115 per cent. performance above rated capacity, is showing but a very small drop in extraction, when compared with the highest extraction results mill, with only 75 per cent. rated capacity.

Mr. Perk though the reason for Natal Estates not suffering a loss in extraction because of this high actual crushing rate was due to the use of more imbition water.

Mr. Rault said that the larger elimination of non-sugars characteristic of the carbonatation process, as indicated by the reduction in weight of molasses, was strangely not confirmed by a superior recovery at that factory. He would volunteer some explanations. They were firstly the unduly high undetermined losses, through remelting and over-processing when turning out a very fine crystal and very white refined sugar, and secondly an incompletely exhausted final molasses through shortage of equipment and possibly the glucose to ash ratio.

It is interesting to note that in this case the 8 degrees higher purity of exhaust molasses represented only 1.7 per cent. as a fall on the recovery when compared with the better exhaustion of other factories.

Mr. Perk's Table also shows that low exhaustion is not necessarily connected with the highest density brix of the "C" massecuite.

Mr. Perk replied that it was better to increase the purity of the juice and decrease the purity of the final molasses as well. To decrease the purity of the final molasses might require more than merely three boilings.

Dr. Douwes Dekker thought that a reasonable explanation for the excellent results due to carbonatation was the high amount of magnesium salts present in Natal juice.

Mr. Rault, referring to Mr. du Toit's remarks that the use of larger amounts of superphosphate in the fields had increased the P2O5 content of cane juices, with beneficial effect on clarification, asked whether a more balanced dose of potash suggested by the fertilizer research, would not likewise increase the K2O content of juices, and be detrimental to molasses quantity and purity.

Mr. du Toit pointed out that a high magnesium intake is often a result of potash deficiency, so it would be possible that if more molasses were used in the fields, less magnesium would be present in the juice.

Mr. Hendry said, that with the high third massecuite purity at Natal Estates, high molasses purities were inevitable.

Mr. Main said that many years ago Noel Deerr investigated the formulae available for milling plant capacity calculations and he came to the conclusion that any formula which was effected by performance or extraction could not serve for pure capacity comparisons, owing to the fact that additional compressions in some mills, for instance, could be more offset in others by better milling technique.

At that time in India, certain mills were able to do enormous capacities and still complete the season with sucrose per cent, bagasse averages of 19 per cent, for twelve or fourteen-roller tandems and 1.5 per cent, for seventeen-roller tandems, while the moisture per cent, bagasse was usually below 48 per cent. This was accomplished in the same mills by the same personnel and with the same cane varieties which had previously rarely been able to give below 2.5 per cent, sucrose in bagasse.

The term "fibre per cent." was perhaps not sufficiently specific to serve as an accurate measure in capacity calculations as some canes have a very tough outer rind which can pull in a larger feed into a mill than another cane variety where a thinner or softer rind is balanced by a larger pith content to give the same fibre per cent.

This problem had been investigated in a series of tests carried out by himself at the Natal Technical College when the tensile strengths of certain canes were recorded. The cross sectional area and the age of the cane variety was taken into consideration. Cane varieties varied considerably in their tensile strengths and to bring them all to a common basis, the "fibre stress ratio" was adopted as a measure of the tensile strength, the fibre content and the cross sectional area. A significant result was that the cane which gave the highest fibre stress ratios in these tests in Durban were also the cane varieties which had given the best extraction and capacities in India.

He was convinced that the Noel Deerr formula for milling capacity, viz. "lfs. fibre per cubic foot roller/hour" was the best measure for milling plant capacities.

Mr. Perk pointed out that all such formulae were based upon the, same capacities, and the speed of the roller had also to be taken into consideration as well as the number of squeezes. He did not see that the Noel Deerr figure would be any improvement.

Mr. Bax stated that the relationship between non-sugars in mixed juice and the final molasses was not exact when one took into consideration the effect of non-sugars on the brix hydrometers when the latter were used for determining total solids. He thought that because of this the non-sugars eliminated were actually lower than shown, and that the factor of 83 must be low as compared with the real figure.

Mr. Perk pointed out that the ratio of 83 was only a mathematical form. Naturally these factors depended upon how they were calculated and in this case it was meant just as a means of calculating the amount of molasses.
WEATHER REPORT FOR YEAR 1ST JUNE 1954, TO 31ST MAY, 1955

By J. L. JU TOIT.

This is the fourth Annual Weather Report dealing with the period 1st June to 31st May the following year and using the monthly rainfall data from fifty-four representative centres within the sugar belt. It is believed that the weather conditions, and particularly the rainfall, of the twelve, eighteen or even twenty-four months preceding and including May will largely determine the crop then to be cut. This report will therefore deal with the weather conditions for the period June 1954 to May 1955, but the rainfall data for the twelve months before June 1954 will also be given as to get a fairly complete idea of the external influences that affected 1955-56 sugar cane crop which remains a predominantly two-year crop.

Rainfall Returns from Fifty-Four Centres

As stated in previous reports the fifty-four centres dealt with in this report are so chosen that with the exception of the four most northerly stations, each rainfall recording station is representative of about 2 per cent. of the annual total crop produced. The data are divided into the normal geographic divisions, i.e. South Coast, North Coast and Zululand and further sub-divided into magisterial districts which facilitate a possible con- elation later on between rainfall and yield data. The latter is also always divided into the abovementioned categories.

Table I gives the rainfall for the four past years for the fifty-four individual centres and also the total rainfall for the period June 1953 to May 1955. Table II gives the rainfall by districts and for the three main divisions for each month of the year from June 1954 to May 1955.

Table III gives the mean rainfall distribution for the past thirty-one years, the calculated mean rainfall for the same period and the actual rainfall for the year now under consideration. Evaporation data taken at the Experiment Station, Mount Edgecombe, are also given in the same Table.

Table IV gives the rainfall distribution according to growing periods for the past two years for all magisterial districts and main sub-divisions.

Table V gives the monthly rainfall for the fifty-four centres for the past four years, the evaporation from open water tank at the Experiment Station for the same period and the amount by which the evaporation exceeds the rainfall.
### TABLE II

Rainfall in Inches by Districts for the Months June, 1954 to May, 1955 inclusive

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<tr>
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<td>4.12</td>
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<td>8.13</td>
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### TABLE III

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<th>Mean percentage rainfall distribution 1924-1954</th>
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<th>Actual rainfall for 54 centres June, 1954 to May, 1955</th>
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<td>May, 1955</td>
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<td>2.12</td>
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| Total                                          | 100.00                                       | 37.78                                                 | 47.24                            | 46.75                            | 46.70                           |
### TABLE IV

Rainfall in inches by Districts for the Two year Period June 1953 to May, 1955 inclusive

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<td>5.92</td>
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<td>3.84</td>
<td>2.33</td>
<td>15.98</td>
<td>23.46</td>
<td>4.12</td>
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<tr>
<td>Lower Tugela</td>
<td>13</td>
<td>2.08</td>
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<td>17.78</td>
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<td>17.03</td>
<td>25.21</td>
<td>4.46</td>
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<td>6.70</td>
<td>27.22</td>
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<td>2.96</td>
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<td>4.83</td>
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<td>27.87</td>
<td>8.61</td>
<td>4.02</td>
<td>15.94</td>
<td>23.88</td>
<td>5.40</td>
<td>96.68</td>
</tr>
<tr>
<td>Hlantla</td>
<td>4</td>
<td>2.18</td>
<td>6.34</td>
<td>17.10</td>
<td>8.03</td>
<td>2.31</td>
<td>11.08</td>
<td>24.40</td>
<td>2.27</td>
<td>73.71</td>
</tr>
<tr>
<td>Uombobo</td>
<td>1</td>
<td>0.43</td>
<td>2.55</td>
<td>13.99</td>
<td>5.39</td>
<td>0.84</td>
<td>7.58</td>
<td>15.44</td>
<td>2.77</td>
<td>48.99</td>
</tr>
<tr>
<td>Piet Retief</td>
<td>1</td>
<td>0.22</td>
<td>3.46</td>
<td>17.29</td>
<td>4.22</td>
<td>0.53</td>
<td>7.30</td>
<td>18.96</td>
<td>3.97</td>
<td>55.95</td>
</tr>
<tr>
<td>Mean Zululand and Piet Retief</td>
<td>22</td>
<td>1.89</td>
<td>6.72</td>
<td>24.29</td>
<td>7.88</td>
<td>2.85</td>
<td>14.45</td>
<td>24.38</td>
<td>4.50</td>
<td>86.96</td>
</tr>
<tr>
<td>General Average</td>
<td>54</td>
<td>2.82</td>
<td>6.82</td>
<td>24.00</td>
<td>6.64</td>
<td>2.56</td>
<td>15.82</td>
<td>24.80</td>
<td>4.06</td>
<td>88.32</td>
</tr>
<tr>
<td>Computed mean for 31 Years</td>
<td>54</td>
<td>4.15</td>
<td>5.80</td>
<td>23.15</td>
<td>4.68</td>
<td>4.15</td>
<td>5.80</td>
<td>23.15</td>
<td>4.68</td>
<td>75.56</td>
</tr>
</tbody>
</table>

### TABLE V

Rainfall and Evaporation in Inches for the past 4 Years

<table>
<thead>
<tr>
<th>Month</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall</td>
<td>2.98</td>
<td>2.97</td>
<td>2.56</td>
<td>2.98</td>
<td>3.42</td>
<td>6.02</td>
<td>4.42</td>
<td>5.09</td>
<td>4.63</td>
<td>4.16</td>
<td>2.84</td>
<td>2.65</td>
</tr>
<tr>
<td>Evaporation</td>
<td>1.03</td>
<td>0.35</td>
<td>0.59</td>
<td>0.41</td>
<td>0.00</td>
<td>0.85</td>
<td>0.29</td>
<td>0.99</td>
<td>0.42</td>
<td>0.17</td>
<td>0.11</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>4.42</td>
<td>3.52</td>
<td>4.35</td>
<td>4.27</td>
<td>3.41</td>
<td>6.87</td>
<td>5.13</td>
<td>6.08</td>
<td>4.50</td>
<td>5.02</td>
<td>3.05</td>
<td>2.75</td>
</tr>
</tbody>
</table>

Total: 44.82 36.34 13.71 48.76 33.88 18.89 46.41 39.08 9.76 46.70 47.24 14.97
Comments on Rainfall

The mean computed annual rainfall over the last thirty-one years for the fifty-four rainfall reporting centres is 57.87 inches. The rainfall for these centres for the year ending 31st May 1954 was 39.08 inches and the average rainfall for the year ending 31st May 1955 was 17.24 inches. The sugarcane crop has therefore gone through two successive years with rainfalls above the average and this is the first time that this has happened in the last ten years. In fact the total rainfall recorded for the year ending May 1955 is one of the best ever recorded and was last exceeded for the year ending 31st May 1943 when the computed total was 48.94 inches and before that for the year 1935-36 with 49.97 inches and abnormally high rainfall in June, or again as early as 1924-25 with abnormally high rains in March 1925.

On the whole, the rainfall for the past year was well distributed although there were individual months when insufficient rain fell and the accumulated deficiency over the twelve months of monthly periods when the average rainfall was less than evaporation from an open water surface at the Experiment Station amounted to 14.07 inches. This is in contrast to the fact that the total rainfall for the year, 47.27 inches, was slightly in excess of the total evaporation of 46.79 inches, but in the above calculated total deficiency a rainfall above evaporation is in no way credited to any other month but simply recorded as no deficiency for that month. This may not be absolutely correct for a rainfall in excess of evaporation in one month is certain to benefit the crop the following month if the latter is deficient in rainfall, but it does give an idea of distribution of rainfall and it is better than comparing the totals of rainfall and evaporation for the whole year where excessive late rains may appear to make up the deficiencies suffered earlier on.

Although the rainfall for the winter months of June, July and August 1954 was fairly low with a total of 2.56 inches, the cane benefited considerably from the good May rains and the crop stood up fairly well to the deficient winter rains, but particularly the South Coast and the southern portion of the North Coast were getting dry. Towards the end of September excellent rains fell nearly everywhere in the sugar belt and broke the dry spell and provided good planting conditions. Exceptionally heavy rains fell during October averaging 10.6% for the whole industry and were far heavier than recorded for October in the last thirty-one years. There were a large number of wet days and in many cases heavy falls of over two inches in a single day were reported. There was surprisingly little soil erosion but a considerable number of working days were lost as a result of the wet conditions. The November rainfall was a little below normal but well distributed, and the crop made excellent progress. The rainfall during December was disappointingly low and averaged only 1.91 inches, which is the third lowest rainfall recorded for December during the past thirty-one years. The excellent spring rains, however, did much to minimise the adverse effects of this deficient rainfall. Excellent rains in January retrieved the effects of the dry spell during December and the crop was again making excellent progress. This rain also helped the crop on during February when the rainfall was below normal. Again excellent rains totalling 8.13 inches fell during March, to be followed by normal rains during April and a deficient fall during May when conditions on the South Coast were getting rather dry.

The crop is therefore somewhat vulnerable to a possible winter drought, but excellent conditions prevailed throughout the year and although a number of months with deficient rain were recorded, no serious droughts developed because these deficient falls were either preceded or immediately followed by excellent rains. The year before also was a good year although it started with a severe winter drought which was broken in August. Thereafter alternating dry and wet months were experienced but the condition never became serious again. The crop now to be harvested went through two excellent early growth periods, September and October 1953 and 1954, two good summers and reasonably good late growth periods during April and May 1954 and 1955. It can therefore be stated that since August 1953 the cane crop never went through a really critical stage as a whole, and although minor rainfall deficiencies were experienced since, on the whole the rainfall that affected this year’s crop was very good indeed and an excellent crop can be expected.

Temperatures

The mean screen temperature at the Experiment Station for the year ending 31st May 1955 was 68.3°F or 0.4°F lower than the 1928-54 average of 68.7°F. With the exception of September and December 1954 every month had a temperature below normal and during March the mean temperature was 1.0°F below normal. The highest temperature recorded was 95.5°F on 15th December and the lowest screen temperature 42.1°F on 18th July 1954. The lowest grass temperature recorded was 34.7°F on 28th July. This is now the second successive year with an average mean screen temperature below normal.

Soil temperatures, like last year, were again well below normal, averaging 70.4°F, 70.9°F and 71.1°F at 1 foot, 2 feet and 4 feet, compared with the 1935-54 averages at the same depths of 71.8°F, 72.9°F and 73.0°F. Soil temperatures at 2 feet depth are also given in
Table VII for Umzimkulu Sugar Co. Ltd. and Entumeni Wattle Co.

Summary and Conclusions

The industry experienced two successive years with rainfalls above normal for the first time in ten years. The average rainfall over the past two years was 86.32 inches and for the year ending 31st May 1955 it was 47.24 inches compared with a mean rainfall of 37.78 inches. There were alternating dry and wet spells but the last serious drought experienced was ended during August 1953 and since then good and on the whole well distributed rains fell with exceptionally heavy rains during October 1954.

During the past two years screen temperatures and particularly soil temperatures were below normal and somewhat higher temperatures would have benefited the crop.

On the whole, however, the weather conditions that affected this year’s crop were most favourable and an excellent crop can consequently be expected.

TABLE VI

The following are the Screen Temperatures by Months in Degrees Fahrenheit at the Experiment Station for the Period June, 1954 to May, 1955 Compared with the means for the period:

<table>
<thead>
<tr>
<th>Month</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Mean</th>
<th>Plus or minus Average</th>
<th>Daily Range</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Mean</th>
<th>Daily Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>72.3</td>
<td>52.7</td>
<td>62.5</td>
<td>-0.3</td>
<td>19.6</td>
<td>72.9</td>
<td>52.7</td>
<td>62.8</td>
<td>20.2</td>
</tr>
<tr>
<td>July</td>
<td>74.2</td>
<td>49.6</td>
<td>64.4</td>
<td>-0.3</td>
<td>23.6</td>
<td>72.3</td>
<td>51.6</td>
<td>61.9</td>
<td>20.7</td>
</tr>
<tr>
<td>August</td>
<td>73.6</td>
<td>52.7</td>
<td>63.1</td>
<td>-0.4</td>
<td>20.9</td>
<td>73.2</td>
<td>53.9</td>
<td>63.5</td>
<td>19.3</td>
</tr>
<tr>
<td>September</td>
<td>73.2</td>
<td>59.4</td>
<td>66.3</td>
<td>-0.5</td>
<td>13.8</td>
<td>74.4</td>
<td>57.2</td>
<td>65.8</td>
<td>17.2</td>
</tr>
<tr>
<td>October</td>
<td>75.6</td>
<td>61.9</td>
<td>67.7</td>
<td>-0.7</td>
<td>11.7</td>
<td>75.9</td>
<td>60.9</td>
<td>64.4</td>
<td>15.0</td>
</tr>
<tr>
<td>November</td>
<td>76.5</td>
<td>63.3</td>
<td>69.9</td>
<td>-0.8</td>
<td>13.2</td>
<td>78.0</td>
<td>63.3</td>
<td>70.7</td>
<td>14.7</td>
</tr>
<tr>
<td>December</td>
<td>80.2</td>
<td>66.2</td>
<td>73.2</td>
<td>+0.3</td>
<td>14.0</td>
<td>80.1</td>
<td>65.7</td>
<td>72.9</td>
<td>14.4</td>
</tr>
<tr>
<td>January</td>
<td>79.3</td>
<td>66.9</td>
<td>73.1</td>
<td>-0.9</td>
<td>12.4</td>
<td>81.0</td>
<td>67.1</td>
<td>74.0</td>
<td>13.9</td>
</tr>
<tr>
<td>February</td>
<td>80.2</td>
<td>67.8</td>
<td>74.0</td>
<td>-0.6</td>
<td>12.4</td>
<td>81.6</td>
<td>67.5</td>
<td>74.6</td>
<td>14.1</td>
</tr>
<tr>
<td>March</td>
<td>79.5</td>
<td>64.8</td>
<td>72.1</td>
<td>-1.0</td>
<td>14.7</td>
<td>80.3</td>
<td>65.9</td>
<td>73.1</td>
<td>14.4</td>
</tr>
<tr>
<td>April</td>
<td>77.2</td>
<td>62.1</td>
<td>69.6</td>
<td>-0.6</td>
<td>15.1</td>
<td>78.4</td>
<td>62.1</td>
<td>70.2</td>
<td>16.5</td>
</tr>
<tr>
<td>May</td>
<td>74.7</td>
<td>57.7</td>
<td>66.2</td>
<td>-0.3</td>
<td>17.0</td>
<td>76.0</td>
<td>56.9</td>
<td>66.3</td>
<td>19.1</td>
</tr>
</tbody>
</table>

Means... | 78.1  | 60.4  | 65.3  | -0.4                  | 15.7        | 77.0    | 60.4    | 68.7  | 16.8        |

TABLE VII

The following table gives the Mean Monthly Earth Temperatures:

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ft</td>
<td>2 ft</td>
<td>4 ft</td>
<td>1 ft</td>
</tr>
<tr>
<td>June</td>
<td>64.3</td>
<td>67.1</td>
<td>69.8</td>
</tr>
<tr>
<td>July</td>
<td>62.8</td>
<td>65.0</td>
<td>67.2</td>
</tr>
<tr>
<td>August</td>
<td>64.8</td>
<td>66.0</td>
<td>66.9</td>
</tr>
<tr>
<td>September</td>
<td>68.0</td>
<td>68.5</td>
<td>68.5</td>
</tr>
<tr>
<td>October</td>
<td>71.0</td>
<td>71.2</td>
<td>70.6</td>
</tr>
<tr>
<td>November</td>
<td>73.6</td>
<td>73.6</td>
<td>73.1</td>
</tr>
<tr>
<td>December</td>
<td>76.5</td>
<td>76.4</td>
<td>74.9</td>
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<tr>
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<td>78.7</td>
<td>79.2</td>
<td>77.1</td>
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<tr>
<td>February</td>
<td>79.6</td>
<td>79.8</td>
<td>78.4</td>
</tr>
<tr>
<td>March</td>
<td>76.3</td>
<td>79.1</td>
<td>78.5</td>
</tr>
<tr>
<td>April</td>
<td>74.9</td>
<td>76.5</td>
<td>77.0</td>
</tr>
<tr>
<td>May</td>
<td>69.5</td>
<td>72.0</td>
<td>73.8</td>
</tr>
</tbody>
</table>

Means... | 71.8  | 72.9  | 73.0  | 70.4  | 70.9  | 71.1  | 70.2  | 68.8 |

M Experiment Station.
South African Sugar Association,
Mount Edgecombe.
March, 1955.
THE NEW DARNALL MILLING PLANT

By J. B. GRANT

Historical

In 1950 the Darnall milling plant comprised two tandems of two roller crushers and four mills 32 ins. diameter by 60 ins. long, and the throughput of these totalled 120 tons per hour. However, the increase in cane production necessitated an increase in milling capacity and it was decided to instal one tandem to replace the existing units and to be capable of handling 160 tons per hour. This was subsequently increased to 180 tons.

It had been originally intended to instal two large mills behind the existing tandems as a nucleus of the new set-up and an order was placed for these two units. However, in order to improve the mill yard facilities to cope with the increased tonnage of cane, it was finally decided to instal the new tandem on a completely new site. At the same time it was decided to order three more mills and a Searby shredder, and provision was made for the installation of an additional mill at a later date. Owing to the inability of the machinery manufacturers to supply the complete, plant, only two mills were installed for the start of the 1951-52 crop and the cane was fed through them and then passed on to the two existing tandems. These two mills had 1 inch grooving throughout and were driven by two 400 h.p. high-speed engines which we had on hand. Three months later the shredder was installed and put into service. The shredder preceded the mills and the cane carrier fed directly into it. This was an innovation in milling in this country, and as there was a slight doubt that it might not be satisfactory, the shredder foundation was designed so that it could be replaced by a mill at a later stage. By the twenty-first week of the crushing season two further mills were ready and put into service, and the two old tandems were closed down. Four weeks later the fifth mill was complete and the new tandem was running as a complete unit. Finally for the start of the present season, a three-roller crusher was installed. The complete plant now comprises a three-roller crusher 44½ ins. by 84 ins., a Searby shredder and five mills 42½ ins by 84 ins.

Cane Offloading and Cane Carriers

Cane is supplied in 3-ton capacity basket trucks over our tramway system and in S.A. Railways trucks, approximately 50 per cent. of the total in each case. Cane is offloaded from the S.A. Railways trucks by two electrically-driven 7½ ton capacity cranes using "American Hoist and Derrick" type 8-tyne grabs. These were fitted with oil-cushioning cylinders so that they could be tripped in the air and these cylinders were attached to the framework of the grab head and the plunger rods to the grab main shaft. Although knuckle joints were provided where the rods were attached to the shaft to allow for any misalignment during operation, the rods were continually being bent at the bottom. However, turning the cylinder upside down, i.e. attaching the cylinder to the shaft and the plunger rod to the head, and of course correcting the valve mechanism, obviated this fault and they now operate with a minimum of trouble.

During the first year of operation an out-of-balance tipper was used for tipping the basket trucks directly on to the auxiliary carrier which is in line with the main cane carrier. With straight cane a means of dividing the load into two sections whilst being tipped, was devised and was (mite satisfactory.

However, with twisted cane, which interlocked during loading and transporting, no simple method was found whereby the loads could be halved and so ensure a satisfactory feed. Later a hydraulically-operated tipper was installed which tips two trucks at a time on to a subsidiary carrier which feeds at a right angle on to the auxiliary carrier, and this arrangement has been entirely satisfactory. The cane from the S.A. Railways trucks is also offloaded on to a subsidiary carrier which feeds at a right angle on to the auxiliary carrier.

The installation of the three-roller crusher necessitated the steepening of the main cane carrier and some doubt was expressed that the steep angle might cause slippage. The angle from the horizontal is 23°, but with the excellent preparation at the knives and with a blanket of prepared cane not exceeding 18 ins. when crushing at the rate of 180 short tons per hour, we have had no trouble whatsoever.

Cane Knives

As the intention in the first instance was to feed directly into the shredder it was necessary that any arrangement of knives should satisfactorily prepare the cane for this purpose. Only one set of high-speed knives was installed. This comprised a set of 48 knives, 5 ft. 6 ins. diameter over the tips, and driven by a 450 h.p. motor running at 550 r.p.m. The number of knives were specified to give the maximum coverage across the carrier and to avoid gaps between the blades. To keep the h.p. consumption of the motor at a minimum, to keep the tips of the knives as close as possible to the carrier and to ensure the best possible even feed to the shredder, the knives were set to cut on the end of the auxiliary carrier and the knives shaft was set about 45° in front of and above the carrier shaft. The tips of the knives
were set 1 inch from the carrier slats. Two difficulties arose from this arrangement. If separate bundles of cane on the auxiliary carrier were not tightly interlaced and so making virtually an unbroken mass of cane, and although while the greater part of the bundle was broken up into small chips, the end of the bundle was dragged through almost untouched and deposited on the main carrier in a heap, which, when it entered the shredder, caused overloading, tripping the driving motor and choking the shredder, with consequent loss of time. Secondly, hard straight cane such as Co.331 was dragged through in lengths up to six feet, and these fell on the main carrier and were covered over with chips from the next bundle. These long pieces bridged the shredder mouth and stopped the flow of cane into it, also causing further delays.

To overcome the first difficulty, a second set of knives (levelling) was put in on the slope of the carrier and was a big improvement, but was not completely successful as we still had choking which we wished to eliminate entirely. The second difficulty could possibly have been overcome by altering the mouth of the shredder, and probably both faults could have been overcome by installing the second set of knives at the point of the main carrier where the cane enters the shredder. However, as we had had considerable trouble with the installation as it was and there was a doubt that any new arrangement may have created further difficulties, it was decided to revert to the conventional arrangement in this country and instal a three-roller crusher before the shredder.

Whether this was the correct procedure to adopt is debatable, for although we have eliminated delays from the causes already mentioned, it is found that the best extraction that we can obtain from the cane is about 60 per cent., whereas the cane passed through the shredder first, the extraction by the first unit was a high as 63 per cent.

Mills

The mills are of the conventional king-boltless type with "Munson" air-oil hydraulic system. Having had bearing trouble at another of our factories with the type top brasses supplied originally with the "Munson" accumulators, i.e. brasses with one long and one short leg, we decided to revert to the conventional type brass with each side being similar lengths. Other large mills which had been put into commission just before Darnall, experienced bearing trouble.

With their misfortunes to guide us we were particularly careful on the positioning of the oil groove and oil feed inlets and have been fortunate in having no bearing troubles. The journal diameters are 21" X 30" long and the oil groove is 2" wide by 21" long.

The back edge of the groove on the top brass is 7 1/2" from the butts of the brass. The back edge of the oil groove of the side brasses is 7 1/2", 3 1/2" from the edge, and oil is fed into the groove through four holes equidistant along the groove. The first two mills were supplied with the side brasses water jackets between the brasses and the housings but we have latterly reverted to the water jacket being cast in the housing itself.

Trashplates are cast iron fastened to the dumb-turner bar with long studs, the studs projecting below the bar. The studs originally supplied were of muntz metal and we had innumerable breakages. After trying various mild and stainless steels we are now using a vibration-resisting steel, which is standing up very well, although we do have an occasional broken stud. The dumbturner bar has a specially long footing to reduce the tension on the draw bolt and we find that even with a loose draw bolt the trashplate remains snug against the feed roller. Independent self-discharging bed plates are fitted to each mill, discharging tangentially into a round tank 2 ft. 7 ins. deep and 4 ft. 9 ins. diameter. The velocity of the juice entering the tank causes a swirl, which prevents the cushion settling. The juice is drawn from the side of the tank by a centrifugal unchokable pump. This arrangement has been completely trouble free.

Roller grooving is 3 in. pitch on the crushers, 2 in. throughout on the first and second mills and 2 in. feed with 1 in. top and discharge on the third, fourth and fifth mills. We are this off-season putting 2 in. grooving throughout the third and fourth mills and hope that this will improve the efficiency of these two units. Messchaert grooving is used in all the feed rollers.

Owing to limitations of space it was only possible to install the mills at 21-ft. centres, and while it is a neat, compact arrangement, some may claim that it does not give sufficient time for the necessary penetration of the imbibition water and return juices.

Intermediate Carriers

With the exception of the intermediate carrier following the shredder, all of these are the scraper type. Here we had considerable trouble as the chains and slats were too light for the work. There were four chains arranged in pairs and each pair conveying slats at about 16 in. centres. The chain was 4 in. pitch and had a breaking strain of 5,500 lb. and the slats were made of muntz metal and we had innumerable breakages. After trying various muntz metals we are now using a galvanized serrated angles. Chain of 7,000 lb. breaking strain was obtainable locally and slats were made of heavy 3 in. angle with 1 in. square spikes welded on and projecting about 3 ins. below the slat. This was an improvement but not sufficiently so and we had to go on to a 6 in. pitch chain with a breaking strain of 8,500 lb. and...
the 3 in. angle slat before they were satisfactory. The carriers are driven by a 21/2 in. pitch Reynolds chain from the top roller of the preceding mill, and the speed of the carrier is slightly in excess of the peripheral speed of the rollers which is 37 ft. per minute when the engines are running at normal speed. There is a phenomenon to which we have not yet found the answer. From some mills the bagasse is discharged and flows away smoothly in a layer about six inches thick and the carrier slats convey it with the maximum of ease. In others the bagasse swells as it leaves the discharge roller and consequently the tail shaft of the carrier is rising and falling as the slats alternately slip and then bite into the bagasse. With the original chains and slats they would ride over the bagasse and give us endless trouble and several major breakdowns. However, the problem now is, why does the bagasse discharge differently from different mills? We can find no mechanical reason which could cause this, but mill efficiency results lead us to consider that it may be due to faulty mill or trashplate settings, and although we have made major alterations to these, it has not made any improvement.

We hope ultimately to find the answer to this peculiarity and a thorough investigations of the mills when they are opened up in the off-season may put us on the right track.

With the installation of scraper type intermediate carriers it was realized that some feeding apparatus was necessary and feeding rollers were fitted at each mill. These consisted of mild steel rollers 24 inches in diameter with longitudinal strips welded on, and facilities were provided that these could be adjusted so that the opening between the feeding roller and the top mill roller could be between 7 ins. and 14 ins. Experimentation showed that the closer setting was necessary, and as the adjusting gear was not sufficiently strong, these were made a permanent fixture at that setting for the five mills. As the crusher was handling unshredded cane, the opening here was set between nine and ten inches. In all cases this caused excessive strain on the driving chains and feeding roller shafts and these had to be increased in size to take the load. In the light of experience I consider that we could even have a closer setting, say four to five inches with equipment designed to take the heavier load. This would tend to bring us nearer to the "pressure feeder" idea which has been such a success in Australia. In stating this point, I take into consideration that the uncompressed blanket of bagasse on the intermediate carrier is only about six inches thick.

Prime Movers

All the milling units are to be driven by 600 h.p. compound engines, the steam pressure being 180 lb. per square inch and about 50°F superheat. Consideration was given initially to turbine drives but owing to the protracted deliveries of any type of driving unit and considering that we had on hand three 450 h.p. high-speed engines which we had to use to start up the plant, it was decided to accept the reciprocating engine drive. These drive through a double-reduction co-axial gearbox to a final enclosed spur gear on to the conventional box coupling and tail shaft. To allow for lift of the top roller the final gear shaft is set 1/4 in. above the top roller shaft. In conjunction with the other milling plants of similar design installed within the last few years, we have experienced a certain amount of engine bearing failures, but possible on account of our higher horse-power engines, not to the same extent as the other factories. These failures consisted of the white metal bearings of the big and small ends and main bearings cracking and coming loose from the shells. On investigation, these failures at the three factories by engineers of the suppliers, indicated that the faults were caused by excessive oil temperatures in the crankcase. It has been decided by this factory and I believe by the other factories, to install independent oil coolers on each engine, and while it is anticipated that this must be an improvement, it remains to be seen whether this is the complete answer to the trouble. Unfortunately, owing to a misunderstanding we will not be able to install the coolers for next crushing season but we hope that the other two factories will be so equipped, and as they experienced more trouble than we did at Darnall, it will be interesting to see the effects on their engines during the next crushing season.

Remote control for the speed of the engines has not yet been fitted and the intention is to have "push button" control placed on the mill platform independent for each engine, with a master control "stop" button which will immediately stop every engine preceding the switch operated.

Conclusion

The closing down of the old Darnall milling plant which has served us well since 1905 and in my personal experience since 1938, was like attending the funeral of an old and trusty friend. The starting up of the new plant was like the birth of a father's first offspring, full of hope, but tinged with a certain natural anxiety.

We doubt whether any young parent suffered the trials, the tribulations and the sleepless nights that our executive staff had in its first year of existence. Because of this I have been persuaded to describe some of our troubles and the means taken to overcome them, in the hope that it may be of assistance to our fellow technologists who may sometime be placed in similar circumstances. To complete the simile, we feel that we have a lusty young offspring.
which in the not-too-distant future will take an honourable place among the milling plants in Natal.

In conclusion I feel that it is meet that I express my grateful thanks to the staff of Darnall factory who worked so willingly and well during the construction and the difficult period in bringing the plant into full operation.

Mr. Bouvet asked what kind of feed rollers were used.

Mr. Grant replied that they were set on top of the feed roller and compressed the bagasse against the top roller.

Mr. Bouvet stated that after a lot of trouble in Mauritius they came to the conclusion that the best thing would be the removal of the trash-plate which some manufacturers place between the feed rollers and the front rollers of a mill.

Dr. Dodds said that the staff at Darnall were to be congratulated upon not only in installing the new plant but attaining such a tremendous crushing rate in the first season. Although the extraction now left something to be desired he thought that Darnall would one day be one of our most efficient factories.

Mr. Grant said that in endeavouring to find the reason for their low final extraction, he had taken some figures of individual mill extractions from three other Natal tandems of six milling units for comparison. In each of these cases, including Darnall, the extraction by the first three units equalled approximately 76.5 per cent. After that point Darnall fell away badly, and it was for this reason that they were now going to increase the grooving of the fourth and fifth mills to 2-inch pitch on the top and discharge rollers as well as the feed roller. He considered that this was necessary to obtain the maximum throughput of thirty tons of fibre per hour with a satisfactory extraction. He also considered that from the figures already quoted in the paper, from the point of view of extraction, it was advantageous to have the shredder preceding the first milling unit. He would, however, like an expression of views of engineers present, on these two points.

Mr. Hill stated that as they were considering installing a shredder at Renishaw he would also be pleased to learn other peoples' experiences and opinions on where the shredder should be placed. At the moment he was guided by Darnall’s experience and he felt that a mill or crusher should precede the shredder. He asked Mr. Grant what was the distance between the inter-carrier slats and how the carrier was driven. He found the settings at the bottom end of the carrier were most important.

Mr. Grant said that on the Darnall plant, the bottom plate of the intermediate carrier butted against the back edge of the scraper supporting plate and both of these were practically in line with each other.

The distance between the intermediate carrier slats was 18 inches.

Mr. Hill thought that more slats might be of value.

Mr. Gunn considered that the Darnall staff had done excellent work in accomplishing what they had to date. As far as grooving was concerned the feed roller grooving at Madistone had been increased.

He thought that by increasing to 2 inches far more throughput could be obtained. At Maidstone extractions at the first unit had been as high as 115 per cent. This last year when something happened to the trash-plate it had decreased to 62 per cent. He had a large labour staff chipping the back rollers, during the week-ends. If the bagasse did not expand on leaving the mill they then decided to chip the top rollers.

Mr. Rault stated that the reasonable moisture content of bagasse and sucrose extraction obtained at Natal Estates, in spite of a fibre throughout 115 per cent. over rated capacity, was in some measure the result of comparatively large groovings of the last mills, i.e. 1 1/2”; the innovation of multiple groovings in the top and back roller of the last unit meant, nevertheless, that every second groove was made smaller.

A peculiar feature of their milling plant was the drop in moisture content between the last unit and the penultimate one, which was over 15 per cent., whilst every successive unit after the crusher could drop the moisture by only 1 1/2 per cent.

This was tentatively explained by the nature of the imbibing liquid, which was dilute juice in every case except the last one, where water was used. Apparently this water could be more easily displaced than dilute juice.

Mr. Elysee said that at Amatikulu the moisture content often recorded figures which were not believed by the engineers. He had tried various new gadgets to check on moisture content. He thought that owing to the mills increasing their rate of crushing the moisture content increased. This high moisture content also led to steaming troubles. He wondered if using different settings and working their
mills slower, better results would be obtained. He was led to this conclusion by watching the figures over many years.

Mr. Me. D. Dick said that he understood that the setting of the cane knives on the new plant had been in different positions in relation to the nose of the preliminary carrier and asked if figures on the horse-power required per ton of cane per hour could be provided when the knives were in the various positions referred to.

Concerning the position of the shredder, Darnall had been the first factory to instal this before the first mill but we have been informed that the shredder now follows a three-roller crusher. An indication of the horse-power required by the shredder in the two different positions would be most useful information to have available.

Mr. Grant said that now the knives were set almost directly above the auxilliary carrier drive shaft and the h.p. used differed little from that used when the knives were in the original position. In each case the knives were set about 1 inch from the carrier slats and the average h.p. recorded was about 250. The depth of the cane on the carrier entering the knives varied between three and six feet.

The shredder was now driven by a 450 h.p. motor running at 1,000 r.p.m. and in its original position preceding the crusher, the h.p. varied over a very wide range, from 300 to 450 under normal working conditions, but as mentioned earlier, although the trips were set up to 700 h.p. this was frequently insufficient, and stoppages occurred. Since the crusher was installed in front of the shredder, the average h.p. consumed was about 230 and this was reasonably constant.

Mr. Wilmot, replying to Mr. Hill’s questions as to the situation of the shredder, said a lot depended upon the layout of the factory, and what room was available. At Sezela it was possible to place it only in front of the crusher. He agreed with Mr. Elysee that a larger setting and a slower crushing rate should give a lower moisture content of bagasse. Last year, running at a higher speed but with the same setting, the moisture content rose to 52 per cent.

Mr. Bax said in Mauritius, where intermeshing rollers in place of plain rollers had been used in the last mill of a tandem, the sucrose and moisture content went up, although all other conditions of crushing rate, hydraulic load, etc., had remained the same. He added that the conclusion arrived at, was that with plain rollers the crushing pressure per unit area was much higher, and also the drainage was much better with a plain Maeschaert grooved bagasse roller.

Mr. Walsh said that it should be remembered that this was a modern plant and could not be compared with older plants. At such high capacities in the milling plant the feeding of the carrier became of utmost importance. As far as high roller speeds were concerned, it must be remembered that the cost of milling plant was very high and one could not afford to run it at other than the maximum capacity. Plants are now designed for these high speeds and milling companies would obtain the figures desired of them. It would take a little time for the Darnall plant to settle down and for the necessary adjustments to be made.

Mr. Gunn affirmed that at Tongaat they were crushing at the rate which allowed them to get a good extraction.

Mr. Grant commented on the short centres between mills here, whereas in Australia designers endeavour to get the maximum distance, even up to seventy-five feet, and he had heard it stated that some operators would like the bagasse to take a quarter of an hour between leaving one mill and entering the following. In the Darnall plant, it was only a matter of thirty seconds.

Mr. Rault said that as a result of his trips overseas and after studying various milling plants he had come to the conclusion that sugar milling was largely a matter of compromise.

Mr. Phipson asked if the higher sucrose and moisture content was due to poor drainage and if using Maeschaert grooves in the discharge roller as well as the feed roller would not be of benefit.

Mr. Bouvet pointed out that in Mauritius very low moisture per cent. bagasse in the neighbourhood of 46 to 47 per cent. obtained by using plain rollers was increased when the rollers were grooved.

Mr. Phipson said that at Empangeni the last roller put in one year had Maeschaert grooving, and in spite of no scrapers being fitted, gave a performance which was much better than in recent years.
METHODS FOR THE ANALYSIS OF BOILER WATER

By P. X. BOYES

INTRODUCTION

At Tongaat we have become aware of the necessity of treating and conditioning our boiler waters, and during the coming 1955 season we are going to carry out a regular procedure for analysing them. This subject is of interest to the Sugar Industry and for that reason the Secretary has asked me to introduce this paper detailing the commonly accepted methods of analysis.

The detrimental effect of untreated boiler waters is only too well known to engineers. Dissolved gases, soluble and insoluble solids, extraneous liquids all have to be controlled to maintain peak boiler efficiency. Boiler control is designed to decrease to a minimum (1) scale formation in boilers and auxiliaries; (2) the possible formation of caustic embrittlement (intercrystalline cracking); (iii) corrosion throughout the water and steam side of the plant.

It is not my intention to discuss the various processes whereby this control is affected, but merely to give in detail methods of analysis which would be suitable for determining the more important chemical quantities. For a better understanding of the need for control I refer you to an excellent paper by Hillier. These quantities must be maintained within strict limits which will vary depending on boiler design and local conditions. As a guide to boiler control, I give the recommendations of four major concerns interested in boiler treatment for boilers up to 250 psig (Table 1).

The modern practice is to express a number of quantities (including chlorides) in ppm CaCO₃. This may confuse those more accustomed to expressing quantities in different terms, in which case the conversion table may help (Table 11).

| TABLE I |
|------------------------|-----------------------|------------------------|-----------------------|
| Recommendations for Boilers up to 250 psig |                      |                        |                        |
| pH                     |                       |                        |                        |
| Total hardness ppm CaCO₃ | None (L.L.)          |                       |                        |
| Total alkalinity ppm CaCO₃ | 20% of TDS (g)      | Less than twice I'    |
| Caustic alkalinity ppm CaCO₃ | 15% of TDS (g)      |                       |                        |
| Phenolphthalein alkalinity ppm CaCO₃ | 15% of TDS (g)      |                       |                        |
| Chlorides ppm CaCO₃ | 430 max (g)          |                       |                        |
| Na₂SO₄    | > 2.5 (g)            |                        |                        |
| NaOH      | 2.0 (g)              |                        |                        |
| Total alkalinity as Na₂CO₃ | 2.0 (g)            |                        |                        |
| Phosphate as ppm Na₂PO₄ | 50-190 (g)         |                        |                        |
| TDS ppm   | 100-250 (g)          |                        |                        |
| Dissolved oxygen ppm | 0.05 (g)            |                        |                        |
| Oil       | None (L.L.)          |                        |                        |
| Suspended matter     | None (L.L.)          |                        |                        |
| Sucrose ppm          | < 10 (g)             |                        |                        |
| Silica ppm           | < 25 (g)             |                        |                        |
| Sulphate ppm          | < 10 (g)             |                        |                        |

METHODS OF ANALYSIS

In the Appendix appear details of some nineteen methods for analysing boiler and feed waters. Most of them are so well known that I will confine my remarks principally to three determinations, i.e. oil, hardness and phosphates.

1. The Determination of Oil

The elimination of oil in the boiler feed is of supreme importance. Oil separators, separating tanks and coke filter beds are used for this purpose. Major concerns recommend that the oil content of feed water should be zero, but where flocculating agents such as starch are used in the conditioning, up to 5 ppm can be tolerated. Where the oil is in the form of an emulsion the method using ammonia alum as a flocculating agent will give good results. For instance an oil emulsion containing 60 ppm oil, yielded 51 ppm on analysis. Where the oil is in the form of droplets floating on the sample, a. straight
2. The Determination of Hardness

Two methods are generally accepted: (a) the Wanklyn Soap method, and (b) the modified Schwarzenbach method.2

The Wanklyn soap method is inaccurate for TDS above 6000 ppm. It is difficult to determine the "ghost point" for reporting Ca++ and Mg++ hardness, and a latter correction amounting in some cases to more than the actual titration value has to be applied. Dissolved CO₂ gives high results and has to be removed. Hydroxides and carbonates also upset the reading.

I suggest that wherever possible the Schwarzenbach method is used. It is far quicker and simpler than the Wanklyn method. The titration is affected, however, by certain metallic ions. Heald, Coates and Edwards2 studied the effect of the more common ions and reported as follows: Cu²⁺ ions greater than 0.2 ppm gave no end-point in the total hardness titration and titrated as hardness in the calcium hardness determination. Fe³⁺ and Al³⁺ ions were studied up to 20 and 50 ppm respectively and did not affect the total hardness titration. However, Fe³⁺ greater than 5 ppm tended to give low Ca++ hardness figures. Mn²⁺ and MnO₂⁺ (hydroxylamine present in the indicator reduces this to Mn²⁺) titrate as total hardness. Small quantities greater than 2 ppm are able to mask the colour in the calcium hardness titration. Zinc, calcium and mercury also give colour changes to murexide.

It is usual to eliminate traces of hardness in the boiler feed by the addition of orthophosphates or polyphosphates. These remove calcium hardness as a precipitate of Ca₃(PO₄)₂. Sodium hexametaphosphate is used at Tongaat in a powder form containing 10 per cent. starch and 90 per cent. hexametaphosphate. In solution this compound contains polymetaphosphate ions thought to be in groups of 6, with their equivalent of Na⁺ ions. Up to two-thirds of the Na⁺ ions can be replaced by Ca⁺⁺ before precipitating and at high temperatures hydrolysis to insoluble Ca₃(PO₄)₂ takes place. The effect of this polyphosphate on known total hardnesses of 200 and 10 ppm respectively was studied (Table III). It was found that in the former case precipitation commenced after 40 ppm, giving lower readings for the soap method than the EDTA. On standing the titrating solution regained its red colour, probably due to an unbalanced state of dissociation. In the case of 10 ppm total hardness, up to 200 ppm polyphosphate powder did not affect the result and GO and 200 ppm orthophosphate gave readings which were only slightly low.

The Schwarzenbach method is based on the great affinity of disodium ethylene diamine tetra-acetate for Ca⁺⁺ and Mg⁺⁺ ions. Experiments have shown it to be a very useful descaling reagent in evaporators3 where the hard calcium scales are partially taken back into solution. It is possible that some of the hardness present in an unharmed form may be titrated as direct hardness when analysing boiler waters with this reagent.

The determination of hardness is divided into (a) methods applicable to hardness greater than 10 ppm, and (b) hardness less than 10 ppm. The methods in (a) can be used throughout if great accuracy is not required. Boiler waters are sometimes so discoloured that the end point of the titration is masked. For these cases a decolorisation method using activated charcoal is included.

TABLE III

<table>
<thead>
<tr>
<th>Effect of Polyphosphates and Orthophosphates on Total Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>ppm Ca₂⁺</td>
</tr>
<tr>
<td>0 ppm polyphosphate</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>200</td>
</tr>
</tbody>
</table>

The Determination of Phosphates

It is usual to determine phosphates colorimetrically. Molybdates are reduced by suitable reducing agents in the presence of orthophosphate ions as catalyst to a blue complex having molybdenuinum in 5 and 6 valence forms.4 The depth of blue colour depends on the PO₄³⁻ ion concentration.

A number of reducing agents have been found suitable including Sn, SnCl₂, hydroquinone and 1-2-4 aminonaphthol sulphonic acid. The Sugar Millers Research Institute adapted the use of SnCl₂ for the determination of phosphate in mixed juices and their procedure has been found suitable for boiler waters. The Hilger 81.0 Brochem Absorptiometer is used at Tongaat.5

For leaf analysis Cotton4 prefers the use of 1-2-4 aminonaphthol sulphonic acid as reducing agent. He maintains that compared with SnCl₂ interfering effects are reduced (of these only arsenites are specifically named). The reagent is stable for two weeks compared with the six to eight hours for dilute SnCl₂. Using SnCl₂, the blue molybdenium colour deepens rapidly and is stable from 4 to twenty
Fig. 1
EFFECT OF ACID STRENGTH ON PHOSPHATE COLOUR DETERMINATIONS
minutes. The colour deepens slowly with sulphonic acid and is stable after twenty-five minutes.

The hydrogen ion concentration of the solution under observation is most important. Cotton made up his molybdate reagent with H$_2$SO$_4$ and showed that using 1-2-4 aminosulphonic acid as reducing agent steady colorimetric readings could be obtained within the fairly broad limits of 0.8 to 1.65N. Outside these limits the blue colour decreased progressively and gave very low readings. Lindner, using SnCl$_2$, made his solution 0.6N wrt H$_2$SO$_4$. In the SMRI method it will be seen that the molybdate is made up with HCl, giving a test solution of 0.7N. Fig. 1 gives colorimetric readings vs. acid concentrations for different phosphate compositions. It will be seen that steady readings are obtained from 0.5 to 0.8N.

Lindner found that Beers law was followed for P$_2$O$_5$ contents lying between 0.004 to 0.4 per cent. on a 100 mgm sample. Obviously this can only be true for solutions having the same hydrogen ion concentrations. It is best to plot a standard curve of known P$_2$O$_5$ contents for comparison with the unknown solutions.

By means of the method outlined, no difficulty was experienced in determining orthophosphate ions. Polyphosphates would be hydrolyzed to orthophosphates in the boiler and determined as such. Polyphosphates in boiler feed are a somewhat different problem. Samples containing sodium hexametaphosphate did not appear to be hydrolyzed even after fifty minutes boiling. When excess Ca$^{++}$ ions were added to the solution hydrolysis appeared to be rapid on heating and a precipitate of Ca$_3$(PO$_4$)$_2$ appeared. There were then sufficient PO$_4^{3-}$ ions present to produce a blue colour.

The hexametaphosphate hydrolyses rapidly in acid solutions and this forms the basis of an indirect determination of this substance in boiler feed water. The difference in P$_2$O$_5$ content before and after reversion of the metaphosphate to orthophosphate, indirectly determines the metaphosphate present. The acid strength used for the hydrolysis is 0.4N H$_2$SO$_4$ and two hours boiling is required before completion.

Turbid boiler water samples containing precipitates, e.g. Ca$_3$(PO$_4$)$_2$, must be filtered before analysing.

**GENERAL**

Difficulty may be experienced determining the end point of the methyl orange indicator in the total alkalinity test. This may be overcome by preparing a standard colour for comparison by titrating N/50 H$_2$SO$_4$ against N/50 NaOH to pH 4 as determined by a pH meter. M.O., however, is unsatisfactory in the presence of organic substances.

Precipitation of sulphates by benzidine mono- or di-hydrochloride is much quicker than the longer gravimetric procedure of precipitating as BaSO$_4$. This method gives satisfactory results in the laboratory.

Winkler’s method is given for dissolved oxygen. It is based on the oxidation of the manganous ion to a manganic form and subsequent reduction of the iodide to liberate free iodine. The chief difficulty in this determination lies in the precautions taken during sampling and testing (see Appendix) thereby preventing entrainment of atmospheric oxygen. For the determination of Large quantities of oxygen (greater than 0.5 ccs/litre) a method using FeSO$_4$ has been advocated.

The method for determining silica and soluble solicates is a colorimetric one adapting the Hilger Absorptiometer. Calibrated colour standards of picric acid or potassium chromate are used. No precautions are taken for interfering substances except phosphates (see Appendix). Nevertheless fair results are obtained for quantities up to 50 ppm SiO$_2$. A study has been made by Alexander and Parrish of the existence of silica in soluble and insoluble forms in raw juices. Much of their paper is applicable to boiler water analysis, particularly their colorimetric determination of soluble silica adapted from the method of Cerny. They affect a reduction of ammonium molybdate to the blue complex using 1-2-4 aminonaphthol sulphonic acid in the presence of silicate ions.

**REFERENCES**

3 Schmidt and Wagener J.S., 1, 669, 252, (1954)
4 Cotton: Ind. Eng. Chem. (Anal.), 17, 11, 785. (1945)
5 Lindner: Plant Physiology, 19, 1, 79, (1944)

**APPENDIX**

**DETERMINE TDS (TOTAL DISSOLVED SOLIDS) BY HYDROMETER OR DIONIC TESTER AND pH BY METER**

**OIL IN FEED AND BOILER WATER**

Reagents (i) Saturated lime water.
(ii) Ammonia alum (5 per cent. w/v).
(iii) CC1$_4$.
(iv) HCl (A.R.) N/2.
Method—Measure out 1000 ml of well shaken sample into a glass cylinder. Add 100 ml of clear saturated lime water solution and 10 ml of 5 per cent. ammonia alum solution. Shake and allow to stand for 10 minutes for froth to appear.

Filter sample through No. 4 Whatman paper (15 cms). Place filter paper and precipitate in a clean beaker, dilute with 100 ml of distilled water and add 5 ml of N/2 HCl. Add 50 ml CCl₄, and agitate well with a rubber policeman. Pour off the supernatant liquid. Add further portions of distilled water 50 ml at a time until most of the filter paper has been removed. Finally pour into a 250 ml separating funnel and collect the lower tetra-chloride layer in an open tared dish. Evaporate to dryness over a water bath and determine increase in weight.

Weight of oil in milligrams = ppm oil present in sample.

TOTAL HARDNESS

(i) Wanklyn Soap Method

Reagents
(i) Standard soap solution (1 ml = 10 ppm CaCO₃).
(ii) Standard CaCl₂ solution (1 ml = 1 mgm CaCO₃) used for standardising soap solution.

Method—Measure out 100 ml of sample. Add a few drops of phenolphthalein (1 per cent. solution) to boiler feed samples, making alkaline with NaOH if necessary. Add the soap solution 0.2 ml at a time until a lather begins to form. Then add more carefully 0.1 ml at a time, shaking vigorously after each addition. A persistent hither which disappears on further addition of soap is known as the false end point or ghost point. Its value is determined by subtracting the lather correction from the total ml soap added and it represents very approximately the magnesium hardness present in the solution. The lather correction is the number of ml soap required to produce a permanent lather on 100 ml of distilled water and is usually 0.5 ml.

Continue adding soap solution until a stable lather, persisting for five minutes, is produced. If the TDS is above 000 it will be necessary to dilute the sample down. Smaller samples may be used depending on the total hardness value.

Total Hardness =

\[
1000 \times \frac{(\text{No. of ml sample} - \text{lather correction}) \times \text{ppm CaCO}_3}{\text{Volume of sample in ml}}
\]

(b) Modified Schwarzenbach Method for Hardness

Greater than 10 ppm CaCO₃

Reagents
(i) N/50 disodium ethylene diamine tetra-acetate. Dissolve 3.72 gms per litre. Check against the standard CaCl₂ solution.
(ii) Ammonia buffer solution. Weigh out 0.7 gms NH₄Cl. Dissolve in 570 ml of NH₄OH solution (25 per cent. solution). Dilute to 950 ml with distilled water. In 50 ml distilled water dissolve 0.300 gms MgSO₄ anhydrous and 0.93 gms EDTA reagent. Add this solution to the former.
(iii) Total hardness indicator. Weigh out 0.05 gms solochrome black WDFA and 4.5 gms hydroxalmine hydrochloride. Dissolve in 100 ml of commercial alcohol or 90 ml absolute alcohol diluted with 10 ml distilled water.

Method—Transfer 100 ml of sample to a clean 250 ml porcelain casserole. Add 2 ml of the buffer solution and 6 drops of indicator solution. This will impart a purplish-pink colour to the solution. Titrate directly against the standardised EDTA solution until a sharp colour change varying from blue to grey is observed.

Total hardness =

\[
\frac{\text{Titrations in ml}}{\text{Volume of sample in ml}} \times 1000 \text{ ppm CaCO}_3
\]

(c) Modified Schwarzenbach Method for Hardness

Less than 10 ppm CaCO₃

Method—Five ml of standard hard water (or about 50 ml of natural water) is added to 50 ml distilled water contained in a large porcelain dish. 10 ml ammonia buffer solution and (i drops indicator are added and solution titrated to end point. 500 ml of the low hardness water are then added and a further 1 ml of indicator added and titration continued until the end point. The difference in titration is a measure of the hardness of the water.

Total hardness =

\[
\frac{\text{Titrations difference in ml}}{\text{Volume of sample in ml}} \times 1000 \text{ ppm CaCO}_3
\]

CALCIUM HARDNESS

(a) Modified Schwarzenbach Method for Calcium Hardness

Greater than 10 ppm CaCO₃

Reagents
(i) EDTA standard as above.
(ii) 4N NaOH. Dissolve 16 gms of sodium pellets in 100 ml distilled water.
(iii) Calcium hardness indicator. Weigh out 0.20 gms murexide ( ammonium purpureate) and grind to a fine powder with 100 gms of NaCl.

Method—Transfer 100 ml sample to a clean 250 ml porcelain casserole. Add 1 ml of 4N NaOH and 0.2 gms of calcium indicator. The latter is weighed out roughly on a tared scoop. The indicator imparts a red colour to the solution. Titration against KOH is carried out until no further deepening of the violet colour is observed. The end point is approximately 0.1 ml after the initial pale violet colour.

Calcium hardness =

\[
\frac{\text{Titrations in ml} \times 1000 \text{ ppm CaCO}_3}{\text{Volume of sample in ml}}
\]

(b) Modified Schwarzenbach Method for Calcium Hardness

Less than 10 ppm CaCO₃

Method—To 500 ml of the low hardness water contained in a large porcelain dish add 5 TlBs of 4N NaOH and 0.6 gms indicator. The titration is carried out as above.

Calcium hardness =

\[
\frac{\text{Titrations in ml} \times 1000 \text{ ppm CaCO}_3}{\text{Volume of sample in ml}}
\]

(c) Decolourisation of Boiler Samples using Activated Carbon

Reagents
(i) Activated carbon. Activated charcoal powder for decolourising purposes (1511).
(ii) Brom phenol blue indicator.
(iii) HCl 25 per cent. w/w.

Method—To 1 gm of activated carbon add 100 ml distilled water containing 1 ml 25 per cent. w/w HCl. Mix thoroughly and filter on a pad of paper pulp and wash with 100 ml distilled water.

500 ml of coloured boiler water is first filtered and acidified using 25 per cent. HCl to adjust the pH to 2.5 using brom phenol blue indicator. The treated water is then filtered through the bed of activated carbon, refiltering if necessary. Total and calcium hardness are then determined as above.

MAGNESIUM HARDNESS

This is determined indirectly from the relationship

MAGNESIUM hardness + Ca HARDNESS = TOTAL hardness.

FREE CARBON DIOXIDE

Reagents
(i) N/50 Na₂C₂O₄. Dissolve 1.06 gms in 1000 ml of standardise this solution against HCl using M.O. indicator.
(ii) Phenolphthalein indicator (1 per cent. w/v). Weigh out 1 gm phenolphthalein in a mixture of 55 mls commercial alcohol and 45 mls distilled water.

Method—Measure out 100 ml of sample and pour into a casserole. Add 10 drops of phenolphthalein indicator and titrate against standardised N/50 sodium carbonate solution until a faint pink colour forms and persists for thirty seconds.

Free Carbon Dioxide =

\[
\frac{\text{Titrations in ml} \times 1000 \text{ ppm CaCO}_3}{\text{Vol. of sample in ml}}
\]

ALKALINITY

Determination of the P, M and P(BaCl₂) readings where –

\[ P = \text{alkalinity up to the end point of phenolphthalein indicator and represents in ppm CaCO₃ the hydroxides and half the carbonates present.} \]

\[ M = \text{Total alkalinity as determined by the end point of methyl orange indicator. It represents in ppm CaCO₃ the carbonates and hydroxides or bicarbonates.} \]
The method is a colorimetric one using the Hilger 810 Biochem Absorptiometer. A No. 7 filter with a peak wavelength of 610 mu was used.

Reagents
(i) Ammonium molybdate. 15 gms ammonium molybdate dissolved in 300 mls distilled water at 50°C. Filter cool then add 350 mls RN HCl slowly with shaking. Cool and dilute to 1000 mls with distilled water. Store in a dark place and replace every 2 months.

(ii) SnCl2.H2O solution. 10 gms of dihydrate are dissolved in 25 mis distilled water. Lasts for 8 hours.

(iv) Standard phosphate solution. Dissolve 0.7668 gms of pure mono potassium phosphate in distilled water and transfer to a litre flask. Add 10 mls of RN. H2SO4 and make up to the mark. 1 ml = 400 ppm P2O5.

Method - Pipette 100 mls sample into a 200 ml flask and make up to the mark with distilled water. Pipette an aliquot (usually 10 mis) into a 100 ml flask, make up to approximately 70 mls and then pipette 5 mls of the dilute stannous chloride reagent. Make up to 100 mls and mix well. Measure the optical density reading on the absorptiometer. Standards containing 0-200 ppm P2O5 are prepared and a graph of the optical density vs. P2O5 content drawn up. In this way the original sample can be calculated by multiplying by the appropriate factor.

DISSOLVED OXYGEN

Winkler’s Method

Reagents
(i) MnCl2 anhydrous. 400 gms in 1 litre distilled water (or 480 gms MnO2 in 1 litre).

(ii) Alkaline iodide solution. 700 gms KOH and 150 gms KI in 1 litre of distilled water.

(iii) 50 per cent. v/v H2SO4 (SG. 1.83).

(iv) N/50 Na2SO3.3H2O. Weigh out 5 gms and make up to a litre. Standardise against KIO3 using starch indicator.

(v) N/50 standard KIO3. Weigh out accurately 0.713 gms and dissolve in 1 litre. For standardisation against Na2SO3 taken an aliquot of 25 ccs add 0.2 gms iodate-free KI and 3 mis N. H2SO4 and titrate using starch indicator.

(vi) Starch indicator. Make a paste of 1 gm soluble starch with a little water. Pour the paste with stirring into 100 mls boiling water and boil for 1 minute. Allow to cool and add 3 gms of KI. Preserve under a layer of toluene.

Method - It is necessary to test for oxygen as soon as possible after sampling. This is done by adding 1 ml MnCl2 to the 600 ml sample and shaking the stopped bottle vigorously. 2 mls of alkaline iodide reagent are next added and the bottle again shaken, followed by 3 mis of 50 per cent. H2SO4 with shaking. The addition of the various reagents must be made quickly using pipettes with their lower stems immersed in the liquid.

DETERMINATION OF PHOSPHATES

The method is a colorimetric one using the Hilger 810 Biochem Absorptiometer. A No. 7 filter with a peak wavelength of 610 mu was used.

Reagents
(i) Benzidine di-hydrochloride (1.6 w/v solution).

(ii) Alkaline iodide solution. 700 gms KOH and 150 gms KI in 1 litre of distilled water.

Method — It is necessary to test for oxygen as soon as possible after sampling. This is done by adding 1 ml MnCl2 to the 600 ml sample and shaking the stopped bottle vigorously. 2 mls of alkaline iodide reagent are next added and the bottle again shaken, followed by 3 mis of 50 per cent. H2SO4 with shaking. The addition of the various reagents must be made quickly using pipettes with their lower stems immersed in the liquid.

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DETERMINATION OF SOLUBLE SILICATES

Reagents
(i) A.R. ammonium molybdate. 30 gms dissolved in 200 mls distilled water.
(ii) Standard comparison solution. 0.530 gms A.R. potassium chromate in 100 mls distilled water.
(iii) Concentrated H2SO4 (Sg. 1.83).

Procedure
To 50 mls of sample add 2 mls molybdate solution and 2 mls 2N HCl.

Comparison
The method is a colorimetric one using the Hilger Absorptiometer. The yellow colour produced by the action of thio­glycollic acid on iron, both ferrous and ferric, in the presence of ammonia is more popular.

DETECTION OF TRACES OF SUGAR

Reagents
(i) Alpha-naphthol (20 per cent, alcoholic solution),
(ii) Concentrated H2SO4 (Sg. 1.83).

Method
To 2 mls of sample add 5 drops of alpha-naphthol solution. By means of a pipette slowly pour down the side of the test-tube 5 mls of concentrated H2SO4. In the presence of sucrose a violet zone or ring appears at the junction of the two liquids. The depth of colour depends on the sucrose present and forms the basis of a colorimetric determination for traces of sucrose.

The reaction described above can be carried out by other phenols, e.g. thymol, menthol, resorcinol, lysol or cresol. Cresol can detect 1 ppm sucrose, produces stable colours varying from pale pink to reddish black depending on sucrose content, and unlike alpha-naphthol is unaffected by impurities such as iron and lime salts. Alpha-naphthol due to its great colour sensitivity is more popular.

Dr. Douwes Dekker recalled that the Sugar Milling Research Institute had been asked to undertake investigations in boiler feed difficulties, and said that Mr. Boyes had put forward a paper which would initiate considerable discussion.

Mr. Bouvet asked if the high pH over 10 recommended for boiler water would not be conducive to priming.

Mr. Boys said that that figure was recommended by both the LCI. and Babcock & Wilcox. He did not think that this would be conducive to priming provided the total solids were kept to a low figure.

Dr. Douwes Dekker pointed out that priming would occur at such high pH if the organic matter
in the boiler water were high. He pointed out that it was necessary to keep a close watch on the organic matter in the boiler water. In this connection sugar was particularly important. He did not think it necessary to work at a higher pH with our present medium pressure boilers.

Mr. Phipson asked if the corrosion was due to the dissociation of magnesium chloride.

Mr. Boyes replied saying that he was not thinking of corrosion due to chlorides but rather to the dissociation of water itself.

Mr. Lindemann considered that caustic embrittlement could not be prevented by any chemical treatment because it was due merely to bad workmanship in the boiler construction. It was found only in seams below the water level of the cross-drum type of water tube boiler. He said in America, it was shown that this so-called "caustic embrittlement" was not found in boilers up to 200 lbs. per square inch pressure. The Germans called this embrittlement "hydrogen disease." In the latest treatment of boiler plates, there was no trace of hydrogen present. In his experience a pH of 7.5 to 8.5 was best. He did not consider scaling of vertical boiler shells a serious matter. It helped in insulation. He thought that the methods of boiler water control suggested could not be universally applied to all boilers.

Mr. Boyes agreed with Mr. Lindemann's ideas on caustic embrittlement. He had inquired of the I.C.I. if it were worthwhile taking caustic embrittlement into account, and they expressed the view that until the theory and effects of caustic embrittlement were clarified a definite sodium sulphite/sodium hydroxide ratio should be adhered to.

Mr. Phipson considered that if the scaling of boiler drums could be considered as insulation, what about sealing of tubes? Would that not interfere with the transference of heat?

Mr. Gunn related that as a consequence of a flood the pH of the boiler water dropped because of the extra organic matter present. This led to a large number of boiler tubes being seriously affected.

Mr. Phipson said that high pH was found to be useful but in recent years when the pH had been allowed to drop at Empangeni, corrosion was becoming a serious factor. Some of their trouble might of course be due to dissolved oxygen as well as to the presence of oil. They were now considering using sodium sulphite; to reduce the oxygen.

Dr. Douwes Dekker pointed out that the high pH of itself would lower the activity of the oxygen present. We had now been given the methods of analysis of boiler feed water. He hoped that at some future date the results of boiler feed water treatment at Tongaat would be recorded.
DECOMPOSITION OF SUCROSE IN THE MILLING PROCESS

By C. VAN DER POL and J. B. ALEXANDER

Origin of Sucrose Loss

The decomposition of sucrose in the milling process can be due to two factors.

Firstly, the inversion of sucrose due to the combined effect of temperature and pH, and secondly, the destruction of sucrose by enzymes. Possible sucrose losses due to the temperature and pH effect are small under normal operating conditions and can be neglected. Sucrose-destroying enzymes are present in cane juices, the main source of these enzymes being micro-organisms which enter the mill on the cane and are also present as slimes in the milling tandem.

Owing to the lack of accurate knowledge on the quantity of sucrose entering the mill in the cane, an accurate sucrose balance cannot be drawn up over the milling process and sucrose lost by destruction can only be assessed by indirect methods. The method adopted in this investigation can be briefly outlined as follows:

The micro-organisms producing the enzymes responsible for the sucrose destruction are considered to be active in three different localities—

1) those adhering to the bagasse, as it moves from mill to mill;
2) those suspended in the juice as it flows through the tandem;
3) those adhering to the milling plant in the form of slimes.

A summation of the sucrose losses in each of these three localities represents the total sucrose loss.

The quantity of sucrose lost in, e.g., the juice stream in a given time T can be expressed as

\[ Q = Y \times T \times W \]

where Q is the quantity of sucrose lost, Y is the deterioration rate of the juice, T is the residence time in the mill and W is the weight of juice in the mill.

If, hence, the deterioration rate of the juice due to micro-organisms in the three localities can be measured, Q can be calculated.

Determination of Deterioration Rate

The determination of the deterioration rate of a juice as it exists at the time of sampling is a complicated matter due to the increase in population of micro-organisms (and hence of enzymes) with time, which results in a continuously increasing deterioration rate. The shape of the theoretical deterioration curve is shown as the curve ab in Fig. 1, and the deterioration rate of the juice at sampling time can be represented by the tangent drawn to the curve at time t — o.

The shape of the curve and also the slope of the tangent depends on the concentration of enzymes, the rate of multiplication of organisms and the concentration of sucrose in the juices. Since these factors vary through the milling train, a determination of the absolute sucrose loss involves the analysis of a large number of samples of all the individual mill juices and intermediate bagasses. This would involve an enormous amount of analytical work for which no mill is properly equipped or staffed.

Since the purpose of this work was to find the order of the quantity of sucrose lost rather than the exact value of the sucrose loss, certain assumptions were made which enabled us to determine the maximum sucrose loss which could have occurred if conditions in the whole milling train had been as at the worst point.

Owing to the natural increase in the population of organisms with time it is obvious that the deterioration rate of juices at the end of the milling tandem is the highest in the tandem. (This was confirmed by experiment.) Hence if the deterioration rate as existing at that mill is applied to the whole tandem, the highest overall sucrose loss possible would be obtained.

Since the slope of the tangent to the theoretical curve, i.e. the deterioration rate at sampling time, is also a function of the sucrose concentration, the deterioration rate of last mill juice has to be corrected to the average sucrose concentration of the juice in the whole mill.
The rate of decomposition of sucrose by a constant concentration of enzymes, and hence the equation of the tangent to the deterioration curve, has the form:

$$\frac{x}{t_1 - t_0} = kC \quad \ldots \quad (1)$$

where \( x \) is the quantity of sucrose destroyed in the small time interval \( t_1 - t_0 \), \( C \) is the average concentration of sucrose between the times \( t_1 \) and \( t_0 \) and \( k \) is the velocity constant of the reaction which depends on the temperature, \( pH \) and concentration of enzymes, but is independent of the sucrose concentration. Rewriting the above equation in the differential form one obtains:

$$\frac{dx}{dt} = k \dot{x}, \quad \text{which, on integration, produces the expression}$$

$$k = \frac{2.303}{t} \log \frac{a}{a - x} \quad \ldots \quad (2)$$

where \( t \) is the time interval \( (t_0 - t_1) \), \( a \) = concentration of sucrose at time \( t_0 \) and \( x \) = the quantity of sucrose destroyed in the time interval \( t \).

\( k \) can hence be calculated for the last mill, and can be applied to the whole milling tandem for the estimation of maximum losses.

**Conditions in the Mills at the Time the Tests were Conducted**

The milling tandem at Umfolozi consists of a three-roller crusher followed by five mills. Sanitary conditions in the tandem at the time the tests were conducted were not worse than observed at any other factory in Natal and no special efforts were made to clean the mills or cushion screens by mechanical means. All the intermediate mill juices are screened prior to pumping and slimes were present on the cushion screens and conveyor slats.

The tests were conducted over a period of three consecutive weeks, during the first and last week of which the normal procedure of chlorination was applied. During the second week chlorination was stopped. The normal chlorination procedure at Umfolozi consists in bleeding a stream of saturated chlorine water into fourth mill juice just before the juice pump at the rate of about 2 lb. chlorine per 100 tons cane crushed.

**Experimental Procedure and Results Obtained**

**Bagasse Loss.** 400 g of final bagasse were agitated with 1,500 ml of sterilized last expressed juice. Samples of juice were periodically withdrawn and analysed for reducing sugars and sucrose by the Luff Schoorl method. Typical results obtained are as in Table I and Fig. 2.

<table>
<thead>
<tr>
<th>Time</th>
<th>Red. Sugars mg/l juice</th>
<th>Sucrose mg/l juice</th>
<th>pH</th>
<th>Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min.</td>
<td>1810</td>
<td>27920</td>
<td>5.9</td>
<td>27°C</td>
</tr>
<tr>
<td>05 min.</td>
<td>2220</td>
<td>28520</td>
<td>5.8</td>
<td>27°C</td>
</tr>
<tr>
<td>110 min.</td>
<td>2490</td>
<td>28280</td>
<td>5.7</td>
<td>27°C</td>
</tr>
<tr>
<td>155 min.</td>
<td>2800</td>
<td>28020</td>
<td>5.6</td>
<td>27°C</td>
</tr>
</tbody>
</table>

The shape of the sucrose vs. time curve does not conform to the theoretical, due to sucrose being leached from the juice associated with the bagasse. This renders this curve useless for the determination of \( k \). For the same reason the reducing sugars increased more rapidly than can be attributed to enzymatic decomposition of sucrose only. However, acid formation, which takes place to a slight extent (as will be mentioned later) can be assumed to compensate for the higher rate of reducing sugar formation and for the purpose of this investigation it is assumed that the quantity of reducing sugars formed is equivalent to the quantity of sucrose destroyed.

Also, since the change in sucrose concentration is small, it is preferable to use equation (1), whence

$$k = \frac{x}{t} \times C$$

$$\therefore k = \frac{400 \times 0.95}{60 \times 28000} = 2.26 \times 10^{-4}$$
Similarly the arithmetical mean of 10 determinations gave a value of $k = 1.25 \times 10^{-4}$ between the limits $0.7 \times 10^{-4}$ and $2.26 \times 10^{-4}$.

Applying this average value to the average mill juice associated with the bagasse, assuming the average sucrose concentration of juice in bagasse to be 50 gram per litre, the deterioration rate of the juice in the bagasse per hour $= 1.25 \times 10^{-4} \times 60 \times 50000 = 375$ mg sucrose per litre juice per hour.

Since 400 g bagasse were treated with 1500 ml of sterilized juice, the deterioration rate per unit weight of bagasse = $\frac{375 \times 1.5 \times 1000}{400} = 1406$ mg sucrose per kilogram bagasse per hour. At 50 per cent moisture the deterioration rate per kilogram dry fibre = 2.81 gram per hour.

At Umfolozi, it required 4 minutes and 10 seconds for the bagasse to pass from No. 1 mill to the end of the tandem, at an average crushing rate of 100 tons cane per hour at 13 per cent, fibre.

Therefore on its way through the mill the weight of sucrose lost per kg dry fibre $= \frac{2.81 \times 4.1}{60} = 0.192 \ g$ sucrose.

The fibre rate at the above crushing rate amounted to 20.8 tons per hour and hence the total quantity of sucrose lost per hour equals

$\frac{0.192 \times 20.8}{1000} = 0.004 \ tons \ per \ hour$

**Juice Loss.** Samples of the various mill juices were collected, kept agitated on a magnetic stirrer and analysed for reducing sugars and sucrose at predetermined intervals.

In these tests most of the sucrose curves obtained conformed to the theoretical type mentioned. A typical curve is given in Fig. 3.

From the shape of this curve it is evident that a great deal of imagination would be required to draw a tangent to the curve at time $t = 0$.

It was found in these tests that in the initial stages of decomposition the quantity of reducing sugars formed was very nearly equivalent to the quantity of sucrose destroyed. On the average 100 minutes were required before the reducing sugars formed could account for only 80 per cent. of the sucrose destroyed, which dropped to 04 per cent. after 140 minutes. That, acid formation was slow was borne out by a very small drop in pH of the juices over the first 100 minutes of deterioration. Hence for the purpose of this investigation no serious inaccuracy can result from the assumption that at time $t = 0$, the rate of sucrose destruction equals the rate of reducing sugar formation. This assumption enhances accuracy since reducing sugar concentrations can be measured with a greater degree of accuracy than sucrose.

$k$, as determined for last mill juice, averaged at a value of $1.92 \times 10^{-4}$ between the limits $1.30 \times 10^{-4}$ and $2.35 \times 10^{-4}$. This average value is higher than the average value for the other mills, i.e. $1.08 \times 10^{-4}$.

Again assuming the average sucrose content of the juices in the tandem after the first two units to be 50 g per litre the average deterioration rate of the juices amounts to 0.760 gram sucrose per litre juice per hour.

The average weight of juice in the tandem and its average residence time cannot be determined directly but the assumption that all the juice not extracted in the first two units of the tandem remains in the mill for an average time interval of 10 minutes (2½ times the fibre hold up time) is no under-estimation of fact. On this assumption the ratio of juice to fibre in the last 4 mills is as 7 is to 1, and the quantity of sucrose lost in the juice streams amounts to 0.0070 tons per hour.

**Slime Loss.** Quantities of slime were collected around the mill, weighed and mixed with known volumes of sterilized juice, stirred continuously and analysed at intervals as before.

The curves produced again conformed to the theoretical shape as is seen in the typical example in Fig. 4.
At a crushing rate of 160 tons cane per hour at 13 per cent. sucrose this amounts to a loss of
\[ \frac{0.0485 \times 100}{20.8} = 0.23 \text{ per cent. of sucrose in cane.} \]

**Discussion**

There is little doubt that the actual sucrose losses which occurred at Umfolozi during the period the tests were conducted, were smaller than 0.23 per cent, on sucrose in cane. The slime loss was calculated to be proportional to the weight of slime present in the mill. In actual fact the surface area of slime exposed to the juice stream determines the sucrose losses and not the weight of slime.

The assumption that conditions in the last mill can be applied to the whole tandem also tends to yield an exaggerated estimation of the loss, as does the exaggerated slopes to the curves from which the values of \( k \) were calculated.

From the results obtained it is concluded that the main possible source of sucrose destruction is that due to slimes with which the juices come in contact. This conclusion is supported by numerous other investigators who are almost unanimous in reporting that the removal of slimes and stale bagasse from the mill, resulted in a diminishing of phenomena usually associated with deterioration losses.

The results obtained also indicated that the method of chlorination as applied at Umfolozi is not effective. No tendency towards higher sucrose losses was observed during the week chlorination was stopped. This is not really surprising since the method of chlorination cannot be effective in reducing the concentration of slimes in the mill. In a recent report on chlorination as applied in the Beet Sugar Industry\(^1\) and in other literature published by the manufacturers of chlorine-containing disinfectants\(^2,3\), the necessity of mechanical cleaning in conjunction with chlorination is pointed out very clearly. Chlorination should also be directed at localities where regular mechanical cleaning is not possible, to prevent the formation of slime deposits. Adding chlorine or chlorine-containing disinfectants directly to the juice stream cannot be effective, since organic matter in the juice reacts with the chlorine and renders it inactive before it has a chance to do any effective sterilization of the path along which the juice flows.

Although we can as yet not produce any experimental evidence to support our statement, it is our opinion that the scrubbing brush and a high pressure steam jet applied regularly at the most effective points in the milling tandem will be more economical and as efficient in curbing sucrose losses in the milling process as is the application of chlorine in

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The straight lines, from which the constant \( k \) was calculated, were in every case slopes to a curve at points well beyond time \( t = 0 \), indicating a much exaggerated rate of decomposition.

Under such circumstances the average value for \( k \) per unit weight of slime was found to be \( 5.08 \times 10^{-3} \) between the limits \( 3.78 \times 10^{-3} \) and \( 6.91 \times 10^{-3} \) (using equation (2) since \( C \) can no longer be assumed constant). The lower values of \( k \) observed, corresponded to samples of slime on the cushion-slats and the higher values to samples taken from under the cushion screens.

The average value of \( k \) corresponds to a destruction of 1.5 g sucrose per gram of slime per hour, for an average juice containing 50 g sucrose per litre.

The weight of slime in constant contact with the juice stream in the milling train at Umfolozi is estimated not to exceed 50 lb., whence a loss of sucrose amounting to 0.0375 ton sucrose per hour is calculated.

The **total loss can now be summarized as follows:**

- Loss due to organisms in bagasse \( 0.004 \) ton sucrose per hour
- Loss due to organisms in juice \( 0.007 \) ton sucrose per hour
- Loss due to organisms in slime \( 0.0075 \) ton sucrose per hour
- Total \( 0.019 \) ton sucrose per hour

---

**Fig. 4**
any form. Chlorination can never be a substitute for cleanliness.

It is hoped to confirm the results obtained at Umfolozi at some other mill in the near future and also to carry out some work on the effectiveness of mechanical cleaning in preventing sucrose losses during the milling process.

Acknowledgments

The authors wish to express their grateful appreciation to the Manager and Staff of the Umfolozi Factory for provision of laboratory and other facilities.

REFERENCES


2. Wyandotte Chemical Corp., Pamphlet on Chlorination in the Cane Sugar Industry (No. 10).


Mr. du Toit (Chairman) said that this would naturally be a rather controversial subject, particularly after Mr. Antonowitz' paper last year which indicated severe losses in the milling train and the results of combating these losses by the use of chlorine. It was very difficult to measure, and indeed is not usually attempted, to measure losses which result during the interval from the time the cane entered the crusher to when the juice was weighed. One method of estimating this loss was to sample cane and compare it with the milling results. A second method was to measure the Java Ratio as Mr. Antonowitz had shown us last year. This paper indicated a third method. The first method mentioned by him was dependent upon the difficulty of obtaining an adequate sample. The second method depended upon the Java Ratio which was affected by other factors. In this third method the endeavour was made to measure the maximum amount of sucrose which might be destroyed. They arrived at a figure of only 0.23 per cent of the sucrose, which was very low as compared with determinations carried out elsewhere by the first two methods. It was necessary in this method to assume many things which could not be measured and it was necessary to take these micro-organisms out of their environment so that they could be dealt with in glass flasks in the laboratory. These are decided disadvantages. The biggest factor in deterioration was found by the authors to be the slime, but as pointed out by the authors, it was not the amount, but rather the area, of slime exposed to the juice. According to the authors a certain amount of slime was added to juice, but could the authors be sure that an area of slime was exposed in this case which would compare with the actual milling process?

Mr. Antonowitz mentioned that it was not possible to measure the activity of organisms by measuring the action of the enzymes. In this paper the estimation of the decomposition of sucrose in the milling train was based upon the assumption that the measurement of enzymatic activity was proportional to the metabolic activity of the micro-organisms secreting the enzyme. He referred to his paper on fermentation in the milling train, read to this Congress last year, in which he shewed that continuations drawn from the deterioration rate of heavily contaminated juices placed in buckets could be most misleading. The activity, density and heterogeneity of a mixed microbial population was conditioned by its environment. When the environment was changed the various characteristics of this population changed also. The only circumstances under which he felt a measure of enzymatic activity would give an estimate of sucrose destruction in juices were those applying to juices entering the subsiders.

Referring to "Alcoholic Fermentation," by Arthur Harden, 1932, page 30, he noted that the activity of live yeast was forty times greater than that of its principal enzyme, zymase. This applied of course to a specific yeast and a specific enzyme. When it was appreciated that the fibre of the cane carried most of the naturally-occurring enzymes present, it was obvious that the destruction of sucrose by micro-organisms was much more rapid in the presence of bagasse. A relative observation in this connection was that in the brewing of beer great care was taken in the malting of barley to secure the maximum amount of diastase so that subsequent fermentation, after inoculation with yeasts, would proceed at optimum rate. Thus a high concentration of enzymes would stimulate the metabolic activity of the micro-organisms, the function of the enzyme being simply inversion, while that of the micro-organism was principally functional metabolism.

In the experimental procedure outlined in the paper under discussion, the principal factor was the deterioration per unit of time. All contentions made by the authors hinged upon this factor, so that if it were unreliable, all conclusions drawn would be worthless. He had already pointed out that this deterioration factor could apply specifically to the activity of the enzyme in the sample of juice in the container in which it was placed. Measurement, of enzymatic activity in an environment wherein the activity of the micro-organisms which secreted it was suppressed, could have no relation to the activity which the enzyme could display when
operating within or in conjunction with the live organism. Microbial populations in all their ramifications maintain a dynamic equilibrium with the environments in which they occurred.

One reason for his writing his own paper was to draw attention to an aspect of microbial activity which was not readily apparent unless one had practical and comprehensive knowledge of continuous fermentation processes. It was not readily appreciated that an enormous consumption of nutrients and multiplication of microbial populations could take place in an environment favourable to a variegated microflora, such as would be the case under certain favourable conditions in a continuous fermentation process—and conditions in a milling train using compound imbibition paralleled to a remarkable degree the environmental characteristics of such a process.

Dr. van der Pol said that Mr. du Toit had correctly pointed out that the nature of the experiment forced them to make certain assumptions. That being so they had endeavoured to make that type of assumption which would throw light on the maximum deterioration which could possibly have occurred at the time of the investigation. That was why the last mill juices and bagasses were studied. The assumption that the total weight of slimes in the milling train amounted to 50 lb. was perhaps open to question. However, the weight of slime was unimportant, since it was the area of slime exposed to the juice stream which was the deciding factor.

The objection raised by Mr. du Toit and Mr. Antonowitz, on the grounds that the environment of the organisms was changed in the studies were, in his opinion, unfounded. The physical and chemical conditions of the juices in contact with the organisms in the laboratory were identical to the mill juices and he did not think that the container could have a major effect. He agreed that sucrose concentration was an important factor, but since it was an established fact that organisms were most active in dilute solutions, the use of last mill juice could only have had a positive effect on the results obtained.

He said that he thought that Mr. Antonowitz spoke as though the experiments had determined the activity of the enzymes in the juices and not the activity of the micro-organisms. He explained that the activity of organisms was solely due to the enzymes which were secreted by the organisms or which were contained within the cells of the organisms. He mentioned that a similar type of experiment had been carried out in Java many years ago, in which the organisms were killed by preservatives, which did not effect the enzymes. He had considered working along the same lines, but after contacting the Council for Scientific and Industrial Research, some serious objections to this method were brought forward and so he preferred to study the effect of the organisms themselves and not the effect of their enzymes separately, as Mr. Antonowitz seemed to think was the case.

As far as the time factor was considered, he said the the only time interval to be considered was the time the juices and the bagasses spent in the mill.

Mr. Antonowitz observed that inversion of sucrose by enzymes could occur whether antiseptics were present in the juice or not, for enzymes were preserved by antiseptics; and hence when determining the rate of enzymatic activity in juices, the presence or absence of chlorine was irrelevant. He considered it pointless to try to estimate the effectiveness of chlorine by estimating the activity of the enzymes when chlorine was applied to the milling train, and then comparing this activity when it was not applied. It seemed to him that the statement made in the paper to the effect that no tendency towards higher sucrose losses was observed during the week chlorination was stopped would have been more precise if the words "enzymatic activity" were substituted for "sucrose losses."

Dr. van der Pol agreed with Mr. Antonowitz on the unimportant effect of chlorine on enzymes and saw in that an objection to the addition of chlorine to mill juices.

Mr. Antonowitz, to illustrate the chlorination (although applied in an unsatisfactory manner) did have some effect on reducing sucrose loss, submitted the following table:

<table>
<thead>
<tr>
<th>Year</th>
<th>1954</th>
<th>1955</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S.M.R.F. Test Period</td>
<td></td>
</tr>
<tr>
<td>Week ending</td>
<td>22/11</td>
<td>28/11</td>
</tr>
<tr>
<td>Pounds Cl2 used</td>
<td>450</td>
<td>550</td>
</tr>
<tr>
<td>Java Ratio</td>
<td>89.96</td>
<td>89.96</td>
</tr>
<tr>
<td>Sugar percent</td>
<td>12.90</td>
<td>13.21</td>
</tr>
<tr>
<td>Java Ratio</td>
<td>92.01</td>
<td>90.61</td>
</tr>
<tr>
<td>Purity</td>
<td>85.80</td>
<td>86.74</td>
</tr>
<tr>
<td>shaker juice</td>
<td>84.44</td>
<td>84.42</td>
</tr>
<tr>
<td>Purity</td>
<td>1.62</td>
<td>2.32</td>
</tr>
<tr>
<td>Sugar percent</td>
<td>15.70</td>
<td>16.64</td>
</tr>
<tr>
<td>Purity</td>
<td>85.80</td>
<td>86.74</td>
</tr>
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<td>2.32</td>
</tr>
</tbody>
</table>
He then stated that it would be noted from the table that the Java ratio decreased materially when no chlorine was used, and on calculating the absolute juice sucrose ratio (Java ratio divided by 100 — fibre per cent cane), to eliminate the influence of fibre on Java ratio, a very marked difference in favour of the use of chlorine was apparent. It was also to be noted that the theoretical sucrose per cent bagasse, calculated as indicated by the method of S. G. Smart (I.S.J., Dec, 1954), shewed a larger quantity of sucrose was lost in bagasse when no chlorine was used.

Mr. Christianson reminded the authors that it was stated at the last annual congress that to check on the value or otherwise of chlorine, a large number of tests would have to be done and these properly examined by statistical method, before any conclusion could be arrived at. He pointed out also that there was a serious discrepancy between the sucrose loss estimated by the authors and that found by Mr. Antonowitz when comparing the use of chlorine as against no chlorine and also the loss found at Gledhow in 1935. Mr. Antonowitz last year showed a loss of ten times as much as that recorded in the paper, while at Gledhow, where some 700-800 cane samples were tested against four week's crushing by the mill, the loss shown was twenty times as much. This was a very serious discrepancy, indeed, there was something wrong somewhere and he asked Dr. van der Pol, when he tested out the effect of manual cleaning of a milling plant, to attack it from the practical angle and not try to simulate milling conditions.

Dr. van der Pol, in reply to Mr. Antonowitz, said that as far as the drop in Java ratio was concerned, he thought that this was just a coincidence. He then read a letter previously sent to the Umfolozi Sugar Planters Ltd., in which he had pointed out that sudden drops in Java ratio, even with the application of chlorine, were by no means uncommon. Such drops were never associated with an increase in the purity drop between first expressed and last expressed juice, which would surely have been the case if 6 per cent of the sucrose in bagasse after the first mill had been destroyed during the milling process. He then said that another paper had been mentioned, one published in the I.S.J. This paper contained, as a fundamental argument, the assumption that brix extraction was equal to sucrose extraction. This was a serious error and any conclusions based on such an assumption must be erroneous. If the application of chlorine, as done at Umfolozi, prevented a fall in the Java ratio of two units, then some out-of-the-ordinary rise in Java ratio should result when chlorination was applied correctly. He quoted from the Swedish Journal, Sucker, on experience in the beet sugar industry with the application of chlorine to the diffusion battery, where it was found that the primary aid to all disinfection was mechanical cleaning.

Mr. Christianson said that there were several factors which affected the Java Ratio. As shown by himself in 1952, the pressure at the crusher was not one of these. One important factor was fibre. A shredder in front of the crusher might be another, but the two most important were fibre percentage of cane and the deterioration of sucrose in the milling train.

Mr. du Toit said that Mr. Antonowitz had attempted to eliminate the effect of fibre by calculating the absolute juice sucrose ratio.

Mr. Antonowitz said that he could not see that after two years' experiment and finding that the Java Ratio was always lower when chlorine was not used, as compared with the comparable period when it was used, that this could be due to coincidence alone.

Dr. Douwes Dekker averred that it was not possible to measure the Java Ratio correctly over a period of one day.

Mr. Antonowitz replied that increase in Java Ratio when chlorine was used, was something that happened not only over one day, but it happened time and time again.

Mr. Rault said that the variations between daily Java Ratios were known to exist, but if these variations were continually one-sided under certain experimental conditions, one had to accept the fact that those conditions were the cause of the variation.

Dr. McMartin said that the Experiment Station, many years ago, realised that they should try out various disinfectants to prevent rotting of setts and a number were tried. One of the groups discarded first were those which contained chlorine in any shape at all. He was therefore not surprised that chlorine was of no value in disinfecting cane juices.

Mr. Phipson said he had found that it was possible to prevent the growth of slime by sprinkling chloride of lime on mill bed-plates and the, like, or using it in
the form of a 1 per cent. solution of chloride of lime, particularly on the cush-cush chain slats and the plates underneath. He preferred to use mechanical means as far as possible, using hot water rather than steam, and a scrubbing brush and thereafter using chlorine in the form of chloride of lime.

Mr. Bax had tried using hypochlorite of lime in conjunction with hot water every three hours. He had found no improvement from the use of chlorine. On the other hand he noted that in Hawaii and in Cuba, however, there had been different results. The purity drop between crusher and mixed juice had been reduced to 0.3 degrees with the use of chlorine in those countries.

Dr. Douwes Dekker said there were two problems to be kept separate. Firstly, was there any appreciable deterioration and furthermore, what could be done to stop it? He agreed with the general opinion that there was deterioration in the milling train, although there was controversy about the extent of it. Secondly we have to be very careful in the application of chlorine. It is better to keep our mills clean and to rely on that, rather than on the application of chlorine.

Mr. Main said that chlorination of the milling train was tried many years ago in India, and the use of chlorine in large quantities had to be discarded, because of complaints from sweet manufacturers and also from users of molasses. He could not agree with Mr. Phipson that chloride of lime was at all effective in the milling train.

Dr. Douwes Dekker pointed out one disadvantage of chlorine, which was the corrosion factor.

Mr. Phipson replied to Mr. Main and said that by sprinkling chloride of lime, and thus getting a high concentration, the breeding of micro-organisms could be prevented completely.

Mr. Hayes said that it would appear that people did not realise the magnitude of the problem, for all kinds of bacteria are involved. To ensure that one had a sterile, clean surface and to make sure that a clean surface could be kept sterile, it was necessary to change the form of disinfection from time to time. This was a very complicated problem and he thought that to use chlorine by itself in the juice was probably useless and liable to cause trouble in other directions.
Introduction

The general relationship between pH and the rate of inversion of sucrose is well known; the more acid the solution the faster sucrose decomposes.

Even if it was for this reason only, it would be one of the most important duties of every chief of fabrication to keep a close watch on the pH values of all the liquors in his factory. The pH, however, does not only affect the rate of sucrose inversion, it is also of primary importance in all chemical reactions which together are known as the clarification of our juices, and finally it has an important bearing on the rate of decomposition of the reducing sugars.

It is only by giving the fullest attention to the pH values in his factory (and incidentally also to temperatures) that a chief of fabrication can hope, to attain maximum clarification effect and a minimum loss of sucrose.

pH measurement, or better pH recording, at a few strategically selected points in the factory is therefore a must wherever the highest efficiency is strived for. Yet, we have to admit that pH recording is not general practice in all factories, and that the factories endeavouring to operate pH recorders frequently run into difficulties. Electrical pH meters and recorders have not a very good name in our factories; the owners of the factories think that they are expensive gadgets, and the operating staff are often extremely doubtful about the practicability of operating them satisfactorily, i.e. with little interruption and with reliability.

As to the price, one has to realise that a pH recorder of say £350 pays for itself in one season if it succeeds in a factory of average size in reducing the loss of sucrose, either undetermined or in final molasses, by a few hundredths of one per cent.

As to the satisfactory operation of pH recorders the situation is more complicated and quite a number of factors could be indicated which may have contributed to the bad reputation of these instruments.

It is of course possible that the instruments used so far in our factories have not been, built by their manufacturers to withstand adequately the rugged conditions of sugar factories. On the other hand manufacturers have the right to ask: Have our instruments always been operated as they should be? and finally there is the question of proper maintenance and repair when the instrument breaks down.

Obviously a solution to this problem can only be found by a close co-operation of pH meter manufacturers, who must have a well-founded knowledge of conditions in sugar factories and of reasonable requirements in regard to sugar pH meters, and of the sugar factory executives, who must at least have a working knowledge of the principles of pH meters, of the correct way to operate them and of minor repairs.

To stimulate such co-operation the S.A.S.T.A. Council has made arrangements for a full discussion of the subject at this Congress and I am happy to say that representatives of three pH meter manufacturing firms have agreed to give us their full co-operation. They will discuss the principal properties of their instruments, will tell us about correct maintenance, and finally, this afternoon, will demonstrate the instruments at the S.M.R.I. But before proceeding to the discussion of these industrial instruments, I thought it might be desirable to discuss pH and pH measurement: in general terms.

The Definition of pH

We all know that positively-charged hydrogen ions are always present in aqueous solutions. They are formed either by the electrolytic dissociation of water molecules, or by the dissociations of acids.

$$H_2O \rightleftharpoons H^+ + OH^-$$
$$HA \rightleftharpoons H^+ + A^-$$

Their concentration is one of the most important properties of the aqueous solution. In physical chemistry this concentration is usually expressed in gram ions per litre, and it was Sorensen who, in 1907, introduced a simple way of expressing the concentration by defining the pH of an aqueous solution as the negative logarithm of its concentration of hydrogen ions. $pH = - \log [H^+]$.

In some simple cases it is possible to find the pH of a solution by calculation. Such a simple solution is, for example, N/100 HCl solution. Being a strong acid the HCl molecules are completely dissociated, which means that the concentration of the solution in respect of hydrogen ions is 0.01 gram ion per litre. Hence $[H^+] = 1/100$ and the pH of the solution is $pH = - \log (1/100) = 2$.

The pH of more complicated solutions cannot be found by calculation. We then have to measure the pH.

As said above, even pure water is slightly dissociated, the concentration of hydrogen ions at room
temperature being $10^{-7}$ gram ions per litre. The pH of pure water is 7, and as the number of negatively-charged hydroxyl ions is equal to the number of positively charged hydrogen ions, one may also say that $pOH = 7$. It is a property of all aqueous solutions at room temperature that the sum of $pH$ and $pOH$ is 14, independent of the acidity or alkalinity of the solution.

It is easy to see that the concentration of hydrogen ions in an aqueous solution has to be increased ten-fold to reduce the pH by one unit. Also, to bring the pH of a solution from 3 to 2 requires 10,000 times the number of hydrogen ions required to bring the pH from 7 to 6. Generally, when acid is added to an aqueous solution the hydrogen ion concentration increases and the pH drops. How much depends on the nature of the acid and on the original composition of the solution. In some cases, for example, when an organic acid is added to a solution of its salts, the drop is slight. In that case we speak of a strongly buffered solution.

This is all rather elementary, and can be illustrated by equations and figures for the so-called dissociation constants, but this does not seem necessary for our purpose at this stage.

For the moment we have to remember that the acidity of a solution as given by its hydrogen ion concentration, is commonly expressed by the term pH, and that since calculation is usually impracticable, measurement of the pH is our only recourse.

**The Principles of pH Measurement**

There are two methods of measuring the pH of a solution, viz. with so-called indicators and electrically. Indicators, i.e. organic compounds which change their colour according to the pH of the solution in which they are dissolved, have been used to a large extent in the sugar industry, and mainly as indicator papers, are still used. The main disadvantages of the use of indicators is the amount of labour required and the fact that it is impracticable to use them for pH registration. Otherwise indicators are quite satisfactory, particularly when their application has been properly standardised.

The electrometric method of determining the pH of a solution is based on the following phenomenon.

When an element, say a cylindrical rod of silver, 5" long and $\frac{3}{4}$" in diameter, is placed in a solution containing ions of this element—in this case a diluted silver nitrate solution—there is a tendency for the silver to push positive Ag-ions into solution. By doing so the silver tends to become negatively charged in respect of the solution. On the other hand the silver ions in the solution, tend to give up their positive charge to the negative silver electrode and, having become atoms, to precipitate on the electrode. These opposing tendencies result when equilibrium has been attained in an electrical potential being set up between the element and the solution.

The pressure exerted by the electrode is independent of the concentration of the solution, but the pressure exerted by the ions depends on their concentration. Hence the potential difference between the electrode and the solution depends on the concentration of the ions.

The pressure exerted by the solution is not exactly proportional to the concentration of the ions. The solution pressure of the ions is usually defined as the "active concentration" of the ions, or their activity. Only in a few simple cases is the active concentration equal to the true concentration.

The relation between the active concentration of the ions and the potential at the surface of the electrode is given by the following equation:

$$E = \frac{RT}{nF} \ln \frac{a_o}{a_1}$$  \hspace{1cm} (1)

where $E$ is the potential in volts

$R$ is the gas constant = 8.313 watt seconds $\cdot$ moles$^{-1}$ $\cdot$ $\circ$C$^{-1}$

$T$ is the absolute temperature

$n$ is the valency of the ions

$F$ is 96494 coulombs

$a_o$ is a constant indicating the pressure exerted by the element

$a_1$ is the molar activity of the solution.

By substituting and converting to Napier’s logarithms:

$$E = \frac{RT}{nF} \ln a_o - 0.0001984 \frac{T}{n} \log a_1 \text{ volts}$$  \hspace{1cm} (2)

Formula (2) gives us the relationship between the electrical potential difference at the electrode and the active concentration of the ions concerned. It clearly shows that this relationship if affected by temperature, i.e. even if the concentration of the ions at a higher temperature is equal to that at a lower temperature there will be a difference between the potentials measured. Later on we will come back to this point.

Since $a_o$, at least at constant temperature, is a constant, the first term of the right hand side of equation (2) is constant, and the equation can be written as:

$$E = E_{o1} - 0.0001984 \frac{T}{n} \log a_1 \text{ volts}$$  \hspace{1cm} (3)

Formula (3), although explained here for a silver electrode in a solution of a silver salt, is also valid for the potential difference between a hydrogen electrode and a solution containing hydrogen ions. How a hydrogen electrode can be made will be explained later on, the main point at the moment is that it is possible to measure the concentration of hydrogen ions, i.e. the pH, electrometrically using equation (3).
Now in actual practice it is not feasible to measure the potential set up at a single electrode. A second electrode has always to be used to complete the circuit to the measuring instrument. This second electrode, usually called the reference electrode, is also placed in the solution to be tested, and normally also shows a potential difference against the solution. This potential difference is a function of temperature, but is independent of the pH of the test solution. Hence at constant temperature this potential difference is constant, and can be termed \( E_1 \).

Therefore the overall potential of a cell consisting of a hydrogen electrode and a reference electrode—now termed \( E \)—is given by the following formula:

\[
E = E_0 + E_1 - 0.0001984 \cdot T \log a_1 \tag{4}
\]

In this equation \( n \) has been left out since hydrogen ions are monovalent. If \( E \) as measured on a solution for which \( a_1 = 1 \), e.g. \( \log a_1 = 0 \), is termed \( E_N \), then \( E_N = E_0 + E_1 \), and for any other solution the measured overall potential of the cell is

\[
E = E_N - 0.0001984 \cdot T \log a_1 \tag{5}
\]

or in terms of pH, since \( pH = - \log a_1 \),

\[
pH = \frac{E - E_N}{0.0001984 \cdot T} \tag{6}
\]

Unfortunately \( E_N \) is dependent on the temperature of the solution in a way which cannot be predicted or calculated and has to be found by experimental determination for each cell. This, however, is not too difficult—and once the temperature dependency of \( E_N \) is known, equation (6) can be used to convert millivolts into pH at all temperatures.

Many pH meters, however, are provided with a scale divided in terms of pH, instead of in millivolts. Obviously such a scale can only be correct for measurements carried out at one temperature, for example at 20°C. At all other temperatures a correction has to be applied. This is sometimes done automatically. The Speedomax instrument, for example, is provided with a "Thermohm temperature compensator which automatically changes its resistance with changes in solution temperature to compensate for the effect of the latter on the electrodes." A similar resistance thermometer automatic compensation is also found in electrodes made by other firms.

Some other pH meters are provided with a knob which has to be adjusted according to the temperature of the solution tested. This system is correct for ordinary laboratory determinations, but would be less suitable for pH recording purposes owing to the varying temperatures experienced in the factory.

Returning to equation (6) it will have been observed that although originally \( pH \) was defined in terms of the true concentration of the hydrogen ions, the new definition relates the \( pH \) to the active concentration of the ions. This is all to the good since the rate of inversion (and other chemical, reactions) are more closely related to the active than to the true concentration of the hydrogen ions.

### Hydrogen Electrodes

Obviously we cannot make an electrode of solid hydrogen to be used for \( pH \) determination, but fortunately means have been found to overcome this difficulty. A true hydrogen electrode, for example, is a platinised platinum wire on which hydrogen is continuously absorbed during measurements. Such a hydrogen electrode is not suitable for industrial purposes but is still being used for accurate laboratory determinations.

The quinhydrone electrode is not of practical significance for the sugar industry, but the antimony electrode has been used in the cane and beet sugar industries with considerable success. However, it is the glass electrode which now, almost universally, has captured the field of industrial, \( pH \) measurement and which is the only one used in the Natal sugar industry.

### Glass Electrodes

Theoretically the glass electrode is still imperfectly understood. It is sufficient to say that certain types of glass behave as though they were permeable to hydrogen ions, and if a thin membrane of such glass separates two solutions of different \( pH \) a potential difference is established between the two solutions which is a function of their difference in \( pH \) value. A glass electrode in its most primitive form is a thin glass tube closed at one end by a very thin membrane in the shape of a bulb and open at the other end. The bulb and part of the tube are filled with a solution of a known \( pH \), for example a \( N/10 \) HCl solution. The problem now is to establish the potential difference across the glass when the electrode is placed in a solution of unknown \( pH \).

A suitable reference electrode has to be used, but to complete the circuit to the measuring instrument the \( N/10 \) HCl solution has also to be connected to this instrument. For this purpose a \( Ag/AgCl \) electrode is used and the complete cell may be represented as follows:

\[
H_2 \quad H_2SO_4 \quad KCl \quad \text{Sample} \quad \text{Glass} \quad \text{N/10 HCl, AgCl} \quad Ag \]

At the interfaces a, b, c and d, potential differences may be expected, which, added up, constitute the overall potential difference \( E \) which is measured. Since the potential differences at the interfaces a, b and d are constants at constant temperature, their sum is equal to \( E_N \) in equation (6). Theoretically \( E_N \) can be found by measuring the overall potential obtained when the active hydrogen ion concentration of the solution equals 1, but in actual practice the relationship between \( E \) and \( pH \) is always found by measuring the potential of so-called buffer solutions of which the \( pH \) is accurately known at various temperatures.

Glass electrodes originally had one enormous drawback: the resistance of the glass membrane was...
so high that it was not possible to measure the overall potential difference on a normal potentiometer, and the glass membranes had to be made very thin. This made them extremely fragile which seriously reduced their usefulness.

At present more suitable types of glass are being used which allow the construction of robust glass electrodes. Moreover, although the cell potential is still balanced in the potentiometer against the potential of a battery which can be calibrated against a standard cell, suitable electronic amplifiers are now used in order to get adequate readings.

I will not go deeper into the problem of how exactly the overall potential difference is measured in the various commercial pH meters and recorders. I hope that the representatives of the manufacturing firms will spread some light on this subject, which in my opinion has now been solved satisfactorily in more ways than one.

In addition to fragility the glass electrode has also some minor drawbacks. The normal type of electrode which is most commonly used, is not suitable for high temperatures, i.e. temperatures above 50°C and not for high alkalinities, especially if the concentration of sodium is high. Fortunately special electrodes have been constructed which allow accurate measurements at extreme conditions.

The pH of Sugar Liquors at Elevated Temperatures

In many cases if it is desired to measure the pH of a juice, say clarified juice as it leaves the clariners, a sample of the juice is taken to the laboratory, and the pH is measured using a laboratory type pH meter. During the transport of the sample its temperature drops, and sometimes the sample is intentionally cooled down to room temperature before measurement. The interesting question now is: has the hydrogen ion concentration of the juice changed by reducing its temperature?

For quite a number of years we have tacitly assumed that the effect of temperature on the hydrogen ion concentration of sugar liquors was negligible, but more recently, particularly in connection with pH recording and the introduction of automatic pH control, more attention has been paid to this subject.

In the first place we know that when pure water is heated the concentration of hydrogen ions increases due to an increased dissociation of water molecules. The concentration of hydroxylions of course also increases at the same rate and hot water is still neutral, but its pH is lower than at room temperature.

The sum of pH and pOH which as we have seen is 14 at room temperature, drops to 12.32 at 100°C, i.e. the pH of pure boiling water is 6.16. If such a drop were also to occur in our juices, the determination of the pH at room temperature would give a completely wrong impression about the possibility of inversion at higher temperatures, since the rate of inversion is governed by the hydrogen ion concentration.

However, up till 1949 so little was known about the effect of temperature on sugar liquors that the referee for Subject 16—Determination of the Hydrogen-Ion Concentration of Sugar Factory Products, of the International Commission for Uniform Methods of Sugar Analysis, recommended that "for official reports, pH in sugar products shall be accepted as that obtained when using a set equipped with a suitable glass electrode at 20°C (or 28°C) standardised with N.B.S. buffers 4.005 and 9.20 pH, all products being tested at existing degrees Brix."

But at the same meeting a report was submitted by D. Gross containing the results of pH determinations of sugar liquids at normal and elevated temperatures. In this report he discussed some previously published studies on the same subject and gave the results of his own determinations.

At the meeting of the Xth International Congress of Agricultural Industries in Madrid in 1954, Gross submitted new data over the range of 20-100°C. Although it had been known for some time that the pH of beet sugar products drops at higher temperatures, he found a positive temperature coefficient for 60° brix solutions of raw cane sugars of different origin. For example a B.W.I, raw sugar showed in a 60° brix solution at 20°C a pH of 5.77, and at 100°C a pH of 6.10. On the other hand, for various refinery products he found both positive and negative temperature coefficients. Carbonated and filtered brown liquor, for example, had at 20°C a pH of 9.10, and at 100°C at pH of 7.95.

The important conclusion for us to remember is that the determination of the pH in samples cooled down to laboratory temperature may give results which are different from the pH values actually existing at processing temperatures. The difference may be negative or positive. To determine the pH at elevated temperatures the pH meter has to be checked at the same temperatures with buffer solutions of which the pH is known at those temperatures.

This seems to be of importance firstly for the carbonation process. At Tate & Lyle's Plaistow refinery 0.6 is deducted as an "average correction" from the pH as determined at room temperature to calculate the pH value existing at the temperature of carbonatation (80°C), which factor, according to Gross, may even be somewhat too low.

It hardly needs stressing that the effect of the temperature on the hydrogen ion concentration of a solution is something quite different from the effect of temperature on the ratio between hydrogen ion concentration and the number of millivolts measured.
The latter effect is either automatically compensated for, or can be compensated for by turning a temperature regulator knob on the meter. Compensation is not feasible for the former effect since the temperature coefficient varies from liquid to liquid, may be positive, or may be negative.

The effect of temperature on the hydrogen ion concentration has also to be kept in mind when the pH of the boiler water is discussed. If a pH of say 7.5 is found when a sample of boiler water is tested in the laboratory at room temperature, it is a near certainty that the pH at the boiler temperature is under 7. The higher the temperature the larger the difference. That is why the pH of the contents of high-pressure boilers when tested—as usual—in the laboratory has to be higher than the pH of medium-pressure boilers. For sugar factories the measured pH should be between 9 and 10, but for high-pressure boilers a pH of 11 is recommended. At lower alkalinities corrosion of the construction material is likely to occur.

The Application of pH Measurement in Sugar Factories

In sulphitation factories the pH of the juice is intentionally altered in three places, i.e. in the pre-liming tanks, in the sulphur tower and in the tempering tanks. Further changes take place in the clarifiers and during evaporation, but they are largely independent of human interference and have to be regarded as "natural" properties of the juice. Hence the key position in respect of good work in the clarification department is the tempering tank and it is a primary requirement for the chief of fabrication to be continuously informed of the pH of the juice pumped to the heaters.

It is here that pH registration is required first. The objective of this registration is to inform him to what extent the pH of the tempered juice is equal to the pH value prescribed by him. The registration of the pH will not only inform him of the average difference between the expected and actual pH, but also—and this is very important—of the fluctuations occurring from tank to tank. A generous sample should continuously be taken from the pressure side of the pump to the heaters and run into the vessel into which the electrodes are placed, the excess of juice to be returned to the tempering tanks.

The exact pH to which the juice has to be tempered depends on two kinds of factors. In the first place this pH should be such that a maximum clarification effect is achieved, but on the other hand we should not forget that the loss of sucrose through decomposition during boiling, crystallization, etc., depends to a great extent on the pH of the syrup. It is true that normally little sucrose is lost through inversion, but we have to admit that it is not unlikely at all that if we had the means of adjusting the pH of syrup to exactly the correct value, our Undetermined Loss data would be reduced by a few hundredths of a per cent., which over a whole season is quite a lot of sugar.

Now, since it is at present not customary to adjust the pH of syrup, for example, by adding soda, the pH of the syrup is directly related to the pH of the tempered juice. Hence in fixing the pH of the tempered juice at say 7.4, the pH of the syrup is fixed, too, as long as the pH drop across clarifier and quad are normal, and the chief of fabrication when fixing the desired pH of tempered juice will in addition to the clarification effect, have to keep in mind what pH he desires in syrup.

This may seem to practical men rather academic, because normal factory data usually do not show any connection between pH of syrup and the Undetermined Loss figure, but one should not forget that so many factors influence the Undetermined Loss data that a reduction of the loss of sucrose through inversion at the pan stage by say 0.03 per cent, will hardly be discernible in them.

Yet, as apparent from the data, published by Stadler, a loss of 0.03 per cent, or even more of sucrose due to syrup having a too low pH value, is a definite possibility. For maximum efficiency the pH of syrup is a factor which should not be neglected and has to be known in every factory with some accuracy. The same applies to clarified juice as it leaves the clarifiers. It would be a valuable contribution to a better understanding of the drops in pH occurring in clarifiers and evaporators if a couple of factories would register simultaneously the pH values of tempered juice, clarified juice and syrup.

For ordinary routine control purposes, however, it seems doubtful if the costs of pH recorders on clarified juice and syrup are justifiable. However much we are in favour of a pH recorder on tempered juice, it seems that a regular determination of the pH of catch samples of clarified juice and syrup in the laboratory will also serve our purpose.

In respect of the desirability of continuously recording the pH of pre-limed and of sulphured juice, I should like to make the following remarks. The general feeling amongst technologists about sulphitation clarification seems to be that the main purpose of pre-liming is to make the juice so alkaline that a sufficient quantity of SO₂ will be absorbed in the tower, this quantity, particularly in mill white factories, being of primary importance for the success of subsequent manufacturing operations. General experience, so far, has not indicated that the exact pH of the pre-limed and of the sulphured juice are of primary importance, provided sufficient SO₂ is absorbed in the available time in the tower.

One will have to admit that this opinion is at the best a very crude description of the effect of external conditions on the result of the clarification operation.
There is, however, sufficient evidence to presume that if it had been routine in Natal to register continuously the pH of pre-limed and of sulphured juice, general experience would have provided us with information about the correlation between these pH values and let us say factors like the destruction of reducing sugars, the calcium content of clarified juice, and even, maybe the purity of final molasses. If we want to improve the effect of the clarification operation it is necessary to be informed, of the pH values of pre-limed and of sulphured juice.

Therefore I should like to recommend sulphitation factories to instal in addition to a pH recorder on tempered juice, arrangements for registration of the pH of pre-limed and of sulphured juice. Apparatus are available capable of recording simultaneously the pH as measured by separate cells at more than one place. Such an apparatus would admirably suit our needs.

Summarizing, if a sulphitation factory considers introducing or extending pH registration., the correct places, in order of urgency, are:

1. the tempered juice as pumped to the heaters;
2. pre-limed juice as pumped into the sulphur tower;
3. sulphured juice as emerging from the sulphur tower;
4. syrup as pumped to the pan stage;
5. clarified juice as pumped into the evaporator.

In a carbonatation factory the situation is different. It is still doubtful if pH is the correct criterion for the first carbonatation. But there is not the slightest doubt that it is the final pH of the second carbonatation which governs the soluble lime salts content of the second carbonatation filtrate. If the pH is either over or under the correct value the result is an unnecessarily high lime salts content, which means increased scaling, a higher viscosity and an unsatisfactory exhaustion of the final molasses. Here, I think, pH registration is a must in a modern carbonatation factory.

As to thin juice sulphitation, this of course is also important, since here is the last possibility for the factory operator to adjust the pH so that loss of sucrose through inversion further on in the factory will be at a minimum, and although I would like to see a pH recorder on thin juice as pumped into the quad in every carbonatation factory, if only one instrument is available, its correct place is at the second carbonatation.

In defecation factories registration of the pH of the limed juice, particularly if timing is carried out as a continuous operation, is highly desirable. In respect of registration of the pH of the juice from the clarifiers, and of syrup, the same reasoning applies as set out for sulphitation factories.

### Final Remarks

A pH meter, indicating or recording, is a delicate instrument and we have to realise, although manufacturers try to make them as rugged as possible, that satisfactory results can only be expected if proper care is given to electrodes and measuring units.

Glass electrodes do not last for ever. On prolonged use there is a certain deterioration of the sensitive glass surface which may be aggravated by the need to clean the electrodes regularly. Glass electrodes have the unfortunate property that they are coated by a deposit when placed in our factory liquors. This makes it necessary to take them to the laboratory for cleaning, since tin deposit affects the readings. It is difficult to give a general rule, but it certainly is recommendable to replace each glass electrode once every shift by a freshly-cleaned one. It is the task of the laboratory staff to change the electrodes at least once every eight hours, to take the coated electrodes to the laboratory, to clean them, for example, with diluted HCl, and to place them alter washing in distilled water until the moment arrives that they will be commissioned again. Moreover, each glass electrode has to be tested in the laboratory once a week to check that the recordings are still correct. For every measuring cell in the factory three glass electrodes should be available for regular interchange. The calomel electrodes are more stable than the glass electrodes and it is not necessary to clean them as frequently as the glass electrodes. The care of the glass electrodes should be in the hands of the laboratory and the chief chemist will do well to see that proper care is always given.

If properly looked after glass electrodes can be expected to give satisfactory results for at least three to four months under normal factory conditions. The durability of glass electrodes of various makes is not necessarily the same. Gross, who in his investigation mentioned before, has used various makes of commercially available glass electrodes in his pH measurements at high temperatures, as well as home-made electrodes of "Corning 015" glass, reports that of these "the glass electrodes by G. Kent Ltd. proved to be superior with regard to pH response, durability and reproducibility."

The recording unit is a rather complicated electrical device. I had hoped that time would have been available to discuss this morning the wiring diagrams of the older pH meters which have been developed by the Java Experiment Station and. the Queensland Bureau of Experiment Stations, for this would have demonstrated the principles underlying the measurement of the minute voltages set up at the electrodes. Unfortunately this would have taken too much time. I hope, however, that we will be informed
later on in the morning of the principles of present commercial instruments. As said, they are delicate instruments, and in the first place attention should be given to the place where they are to be installed. Once installed they should be free from vibration and maybe more important, they should be protected from dust. But even then there is always a possibility of a breakdown. If this happens my advice is, unless there is somebody in the factory fully conversant with the wiring diagram, and interested in the subject, do not try to repair them. The Natal Sugar Millers' Association has appointed an instrument-maker at the S.M.R.I., who will gladly come to your assistance in such cases, and of course the firm who has provided the instrument should also be available for repairs.

The last point I should like to discuss is: should we have indicating or recording instruments? From what I have said before, it should be plain that the advantage of having records of the pH at some of the strategic points in the factory is difficult to underestimate. Hence recording instruments should be installed. But of course for proper adjustment of the desired pH values and for convenient supervision of processing, it is necessary to have indicating instruments of appropriate size. A combination of recording and indicating meters is thus the ideal.

Mr. Rault said that Dr. Douwes Dekker had not mentioned whether a high pH reaction favoured the absorption of SO$_2$ in the sulphitation tower.

At Natal Estates, where a very large quantity of lime was used for safe filtration at the vacuum filter station, the efficiency of CO$_2$ gas absorption was a constant problem, in order to deal with large juice capacities carbonated in a minimum period of time.

The easiest way out of the difficulty was to maintain a fairly high pH reaction during simultaneous liming and gassing, namely 10.8 to 11.0 pH. This high pH reaction in combination with a temperature of 70°C was a cause of severe reducing sugar destruction and formation of soluble lime salts.

A pH control at this stage was extremely useful, but so far has not materialised, through the unreliability of control instruments and the non-existent servicing organisation.

pH control at the second stage was a much easier operation and could be made automatic.

He had found that the variation of lime salts content of second carbonatation juice was not so much a result of end point reaction, which was fairly stable at his factory, but was more of a legacy from the nature of the raw juice and the bad work done at the first carbonatation stage.

Dr. Douwes Dekker replied that he had not mentioned the rate of absorption of SO$_2$ gas in the sulphur tower in sulphitation factories. He had said that the total quantity of gas absorbed could be increased by adding more lime to the juice in the pre-liming tanks. The problem at Natal Estates on the other hand, owing to the limited capacity of the carbonatation tanks, was to achieve a faster absorption of CO$_2$ gas. The problems were different.

He was glad that Mr. Rault agreed that a pH recorder could be installed more usefully at the second than at the first carbonatation. It should be appreciated, however, that the correct final pH of the second carbonatation depended on certain properties of the juice and might fluctuate between, for example, 8.5 and 8.9. The pH of minimum lime salts content could, however, readily be established experimentally. The minimum lime salts content also depended on certain juice qualities.

Mr. de Kok enquired if there was any definite rule as to what the pH should be after the sulphur tower.

Dr. Douwes Dekker replied that there was no such fixed point, but no serious inversion would occur at a pH of six or more.

Mr. de Kok said that as far as measurement of the pH of the juice going to the evaporator was concerned, if one found the pH to be too high or too low, what could be done to correct his?

Dr. Douwes Dekker said that the pH of the clarified juice was governed by the tempering of the juice.

Mr. Antonowitz said that he agreed that the pH at the tempering tanks was of vital importance, but to use a recorder here was difficult, because the electrodes kept on scaling up within a few hours.

Dr. Douwes Dekker said there was no method of keeping the electrodes clean, the only way was to change them. There was a possibility when antimony electrodes were used to brush them repeatedly during operations, but this could not be done with glass electrodes.

Mr. Phipson enquired if it were not possible to install electrodes in duplicate and keep them clean alternately by condensed water from the evaporator?
Dr. Douwes Dekker said he could not say if this would be effective; it would have to be tried out.

Mr. Harvey said that in his paper he would show that it is possible by using mechanical means to keep the electrodes clean.

Mr. Coignct enquired if the absorption of $S\text{O}_2$ and $C\text{O}_2$ would not be affected by differences in atmospheric pressure.

Dr. Douwes Dekker said he thought that although the rate of absorption was a function of pressure, the effect under actual working conditions could be slight.

Mr. Bax said, he had done much work on after-products, especially molasses, but he had been informed that pH figures after dilution of these products were not reliable. He was referring to colorimetric methods. He wanted to know the extent of the error.

Dr. Douwes Dekker replied that it was almost impossible to measure the pH of coloured solutions colorimetrically, and measuring pH electrically was probably the only way for such products.

Mr. Bax said, that in most cases colorimetric methods were used in Mauritius. Some electrical instruments were used, but generally gave so much trouble that they were not general.

Mr. Phipson enquired if the pH of syrup should be determined, in its concentrated form, or after diluting down.

Dr. Douwes Dekker replied that diluting down was inadvisable.

Mr. Hardy enquired what would be the optimum pH which could be used without endangering the colour of the sugar in the case of a white sugar factory.

Dr. Douwes Dekker replied that a pH of 6.5 or thereabouts in syrup would not lead to large inversion or cause any poor coloration of sugar.
THE KENT UNIVERSAL GLASS ELECTRODE pH METER

By G. TOOP

General Principles of the Apparatus

General

The pH of the solution under test is a function of the concentration of dissociated hydrogen ions. It is possible therefore to measure the pH by measuring the potential produced by the hydrogen ion activity and the most convenient means of doing this is by the glass electrode and a suitable reference cell.

Since the potential produced across a glass membrane having a solution of constant pH on one face, is a function of the pH of the solution on the other face, the determination of the unknown pH is reduced to the measurement of this potential. In order to complete the circuit via the measuring instrument and back to the solution, it is necessary to introduce a reference cell in the solution, which will do so without itself introducing varying potentials at the various interfaces. The calomel electrode has this property of producing a constant E.M.F. independent of the pH of the solution.

In order to make it possible to prevent polarization of the electrodes, and in order to prevent excessive voltage drop, due to the high resistance of the electrodes, it is essential to utilize circuits which virtually demand no current from the electrodes, and the Kent system is designed to do this without the use of specially-selected electrometer valves and similar devices.

Principle of Operation

Referring to the simplified circuit diagram (Fig. 1), a condenser, C.1, is arranged so that it is alternatively connected across the electrodes and then across the instrument potentiometer. The switching is done by a special, relay operated every two seconds by a cam-operated switch in the instrument drive system. If the slidewire of the potentiometer is correctly positioned and the meter is therefore registering the true pH of the solution, the E.M.F. charge on the condenser will equal that developed by the potentiometer and no current will flow, but if the E.M.F.'s are unequal, the condenser will either charge from or discharge to the amplifier circuit via the condenser C2. The pulse is applied to the grid of the amplifier and the resultant pulse in the anode circuit is passed via C3 to the galvanometer, which deflects accordingly. The cam-
operated switch is synchronised with the clamping mechanism of the galvanometer, so that it is clamped while deflected. The deflection of the galvanometer is detected by the self-balancing potentiometer mechanism which automatically moves the slide-wire in such a direction as to move the deflection at the next cycle, and thus at the same time moves the indicator towards the true pH reading.

Two users adjustments are provided - one for adjusting the sensitivity of the instrument—and one for asymmetry adjustment, due to slight variations between glass electrodes and variations which may occur with ageing of electrodes.

**Temperature Compensation**

The E.M.F. of the electrodes varies not only with the pH of the solution, but also with their temperature, and therefore it is necessary to employ an automatic correction, so that the meter reads the true pH of the solution at that temperature. It will be appreciated that the pH of a solution can also vary with temperature and that this cannot be compensated, since no two solutions have the same characteristic. However the user only requires to know the pH at the working temperature, which is always correctly indicated and the solution characteristic need only be taken into account when checking a sample, since the sample temperature must be kept at the working temperature if serious errors are to be avoided.

The law connecting the E.M.F. developed by the electrodes with the temperature is of the form: 

\[ E = E_0 + bT + c \cdot \text{pH} \]

where \( T \) is absolute temperature.

The Kent system employs a resistance thermometer in the solution, which forms one arm of a Wheatstone bridge, which is balanced at 25°C. If the temperature varies from 25°C, the resistance alters, the bridge is unbalanced and a correcting potential is applied to the potentiometer circuit via a second slidewire which is positioned by the meter according to the pH. The correcting potential is thus made a function of temperature and also of pH and perfect compensation for temperature changes at the electrodes is achieved.

**The Salient Points Ensuring Accuracy and Reliability**

These can perhaps best be covered by mention of a description of the equipment, itself. The installation consists of three units (see Fig. 2).

(i) The primary unit which incorporates the electrodes.

(ii) The electrometer unit which holds the amplifier, relay and switching condenser, as well as the power pack.

(iii) The pH meter which incorporates the potentiometer slidewire galvanometer and self-balancing mechanism.

![Indicating & Recording Instrument](image)

![Electrometer](image)

![Primary Units](image)

![Tank Type](image)

![Flow Type](image)

*Fig 2*
Primary Unit

There are two types of primary unit—the tank type for direct insertion into tanks and troughs, and the flow channel type, in which a sample is piped to a chamber surrounding the electrodes. The two types are basically similar, and in fact the main portion is interchangeable. Referring specifically to the flow channel type, Fig. 3 (a), the head is designed to prevent ingress of moisture, and is constructed so that only non-corrodable materials are in contact with the solution.

The sample pipes are directly inserted into the rubber lining of the chamber, which acts as a gland at the connections, so that glass, metal or plastic pipes of the correct O.D. can be used. The rubber lining also acts as the sealing gasket between the pressure chamber and the head, which is machined from silvanite. The connecting cable enters the head via a rubber seal and the entry chamber contains a silica-gel drier. The electrodes enter the head via rubber-sealed joints and again a drier unit is incorporated in the space. In order to seal the chamber when an electrode is withdrawn, spring-loaded plungers press down upon a rubber sealing ring when either of the electrodes is removed from the head. A copper screen surrounds the inside of the chamber and is connected to the earth lead of the cable, so that static charges on the insulating material of the head are earthed.

Reference Cell (Fig. 3 (b))

The reference electrode is of patented design, consisting of a rubber sheath into which a porous ceramic ball is fitted to act as the salt bridge. The calomel electrode is a ready-made-up unit in a plastic housing which fits into the top of the rubber sheath, the latter being half filled with KCl crystals and topped with KCl solution. It will be appreciated that with this design the risk of contamination of the electrode is very small and in most cases the electrode has a life of many months without requiring renewal of the KCl. By using a rubber sheath which can deform to equalise pressure inside and out the passage of solution in or out of KCl, is practically prevented altogether. The sheath also acts as its own seal when the locking nut is tightened into the head.

Glass Electrode (Fig. 3(c))

This is a relatively robust item and can stand any reasonable handling. The ballistic circuit makes it possible to use electrodes of high resistance (80 megohms) and advantage is taken of this to use a relatively thick membrane. It is a self-contained.
electrode and can be removed from the head by loosening its lock-nut, all glass electrodes being quite interchangeable. It is protected from erosion and physical damage by a perforated silvanite guard, and the whole electrode system and resistance thermometer are further protected by another guard in the case of tank type units.

Resistance Thermometer
This is completely enclosed in a rubber sheath which is sealed into the head by a locking nut and skid ring.

Generally then it can be said that the whole primary unit is designed for industrial conditions and is adequately protected against both damp and physical damage when in use.

5-Core Cable
The cable connecting the primary unit to the electrometer is a special 5-core cable with the two electrode leads insulated by a plastic and shielded by a braided copper screen, which acts as an earth lead.

Electrometer Unit
The electrometer is completely sealed and once installed should rarely, if ever, need attention. All the cables enter via "O" ring rubber glands, the joint in the case is sealed by a rubber gasket and two silica gel driers are fitted inside to remove all moisture from the air in the case. The terminal block for the electrodes is of polystyrene for high insulation. The relay unit which operates the switching of the condenser from the electrodes to the potentiometer is of special design using gold wire contacts and with all leads passing through a polystyrene block. The single valve is a double triode 12Ax7 or similar type obtainable from most suppliers and not requiring any selection, since the ballistic circuit makes the amplification characteristic relatively unimportant. The supply for the circuit is passed via a constant voltage transformer, so that normal voltage and also frequency variations do not affect the instrument.

Multelec
The receiving instrument is a self-balancing potentiometer of proved design and is in most respects identical with the standard Kent temperature and millivolt recorders, except for the cam switch and additional temperature compensating slidewire. Since the ballistic circuit is used, there is no drift, due to change of valve characteristics, and the only adjustment required is to the asymmetry adjustment when checking on buffer after changing electrodes. In most cases electrodes agree within about 0.1 pH without any adjustment. Since the electrode system is quite separate from the amplifier and metering circuits it is possible to earth the whole installation and the reference electrode is not used for this purpose as in some systems.

Important Points to be Watched When Installing and Operating

Primary Unit
Before installing the equipment it is essential to choose the correct equipment for the particular installation.

The choice of primary unit lies between the tank type and the flow channel, and the limitations of the two types can be seen, from the graph 4A. The flow channel can be used up to 100°C, and 80 p.s.i. pressure as the extremes, the black line indicating the limiting values between these extremes. The tank type can be used up to 80°C, providing only the electrodes are immersed, but below 60°C the whole unit can be immersed if desired, the length of extension tube being up to a maximum of five feet.

Electrodes
Three types of glass electrode cover the whole field of operation, the approximate limits of the types being shown by the latched line on the graph 4 B. All are identical in size and can be freely interchanged without any change in the rest of the installation. The general purpose electrode can be used above 50°C and 10 pH, but in both cases its life will be shortened and it is prone to sodium errors above 10 pH. The high alkaline electrode is of lithium glass and reduces the error very considerably. The high temperature electrode cannot be used below 50°C, since its resistance becomes excessive, and in fact when buffer checking it, the buffer solution must always be heated up above 50°C.

Change-Over
If the operating conditions are severe, due to high temperatures, or heavy build-up of deposits on the electrodes, it is advisable to have stand-by primary units which are plugged in while the normal unit is being cleaned or having its driers renewed. The spare units should always stand in water ready for use, so that the electrodes are soaked. When in store the reference electrode should be fitted with the sealing cap supplied, so that it does not deteriorate.

Positioning
The electrometer unit should be put in an accessible and relatively dry spot, so that if it is opened up at any time it does not become excessively damp.
or dirty. It is possible to have the electrometer up to 300 feet from the primary unit, so that it should always be possible to find a suitable spot. The meter itself is a robust mechanism, but in view of the quantities of bagasse and similar dust flying in most mills, it is best to protect the whole instrument if possible by placing it in an outer case with a glass front. The instrument can be up to 600 feet from the electrometer if required.

**Maintenance**

This is undoubtedly a vexed question, because pH meters are no doubt relatively complex affairs and on the other hand sugar mills in this country do not employ instrument mechanics. This is, of course, not the case in the U.K. and U.S.A., where instruments and automation are making their mark in sugar as much as they are in other process industries. The fact that this Association is discussing pH and that manufacturers are here in on the discussion indicates that the industry is alive to the possibilities, but the opinion I formed when visiting many mills last year was that instruments are not really considered essential to the running of the plant and therefore do not get the same consideration as for example the pumps and motors. I feel therefore that if the industry is going to take instrumentation and later automation seriously and get the full benefits from it, there is a need to give the whole question much more consideration.

For example one steel-works in Pretoria where conditions are nowhere near as bad as the average mill not only builds its instrument panels behind glass faces as is done in the U.K. and U.S.A., but also air conditions the cubicle. While I do not for a moment say this is essential, I do say it indicates that that factory does appreciate that working instruments make money by more accurate control of processes and greater efficiency, and they are prepared to spend time and money in order to get the return. Instruments which are not maintained and which are not kept working, are a waste of money. I would suggest therefore that there should be some person in every factory who is made responsible for the instruments as a whole and who is given the opportunity to learn enough to maintain them properly in between normal service visits by the suppliers. If meters need complete overhaul, then as far as my own firm goes, we are prepared to carry it out and no doubt if men are available to be trained, this could also be arranged.

While it is probably not necessary to have an instrument engineer in each factory, in my opinion it is essential that each factory or group should aim at getting a reasonably intelligent mechanic to take on the maintenance.

The trend in all process industries is towards continuous processes in which the automatic control of all variables is normal and it seems inevitable that this must sooner or later come to the cane sugar industry. Thus in view of the world-wide shortage of trained instrument men, due to the unprecedented growth of instrumentation, it is suggested that now is the time to earmark suitable men for
training on instruments, so that as the inevitable developments take place, these men grow in experience to meet the need of the times.

Returning now to the specific details of maintenance on Kent pH equipment, it can be said that the electrometer itself should not need any maintenance, except that the driers should be regenerated, between campaigns. To regenerate the silica-gel driers they are heated for about eight hours at 100°C. In the case of the receiving instrument, the maintenance consists of straightforward oiling of bearings as indicated in the instructions, and of minor adjustments, which are quite within the scope of a normally intelligent fitter—providing that man is properly detailed to look after the meters, is given the time to carry out the work and is disciplined when they are neglected.

The primary units are however a different matter and they will definitely need periodical attention, the frequency depending upon, the nature of the duty. For example, when dealing with liquids in the range above 60° C. it will probably be necessary to renew the drier in the head about every month, and in this case we would recommend that the complete primary unit be unplugged and taken to some dry spot in the laboratory or instrument shop where it can be opened up and a spare drier fitted. Since it is so easy to plug in a spare primary unit, this does not involve any particular trouble.

The reference cell can be recharged with KCl at the same time, although this is more a precaution than a necessity. In applications where build-up of sulphates and other salts is experienced, the best solution is to use a spare primary unit, which is plugged in as soon as incrustation begins to affect the operation, the built up unit then, being cleaned.

In many cases it is possible by careful choice of sampling position to avoid or reduce the build-up of deposits. For example in one application in a uranium plant it was found that up to 1/32" of hard deposit formed in an hour or two, so that after six to eight hours the electrodes ceased to function. On investigation this was found to be due to the fact that the liming process, which was carried out in a large mixing tank, was not being carried to completion in the tank, due to by-passing of the lime to the exit pipe and consequently the major part of the deposition of solids occurred in the exit pipe itself. By ensuring adequate mixing in the tank, not only was it found possible to run the electrodes for a month or so without cleaning, but the frequency at which the plant was forced to shut down to clean the pipes was reduced considerably.

In passing it is fair to mention that this particular application was given us as a particularly difficult one to run a test of our equipment, since the meters supplied with the plant had been given up as useless, the electrodes lasting only a day or less in the highly erosive slimes, and the glass R.T. and reference cells getting broken while being cleaned. The Kent electrode system was still functioning after one month when the trial ended, and in fact the tank type unit which was used and has been in use since on many other tests, is in use today.

While on the subject of electrode durability, perhaps you will forgive me if I quote an extract from a paper presented by Doctor D. Gross of Tate & Lyle, Research Laboratory, Keston, England, to the International Congress of Agricultural Industries, Madrid, 1954. Entitled "Recent Studies of pH Measurement and Control in the Sugar Industries," 'The author has used various makes of commercially available glass electrodes in his pH measurements at high temperatures, such as made by Beckman Cambridge, Electrofact, Kent, as well as home-made electrodes of Corning 015 glass with great variations of membrane thickness, shape, inner reference electrode and electrolyte. Of these the glass electrodes by George Kent Ltd. proved to be superior with regard to pH response, durability and reproducibility.'

We are of the opinion that success of pH measurement in the sugar industry will depend not only upon choosing the best equipment, but also upon applying that equipment to the best advantage in conditions peculiar to the cane sugar industry. In fact we feel that however good the equipment may be it will fail unless (a) it is installed after due experimentation on each type of application to ensure that it is applied to the best advantage; and (b) there is an adequate spares and service organisation to back up the factory staff as necessary.

At the present time Kents are conducting tests on the sulphitation process at a factory in India and we hope to carry out trials at a local factory in a few weeks. We understand that so far no pH instruments have been successful on the sulphitation process in India, although quite a number of various makes have been bought and installed. Preliminary reports from our engineers indicate that the problems are by no means easy to solve and that control will also present difficulties, unless advanced techniques are employed, involving control of other variables affecting pH, presumably therefore the same or similar problems will arise; here which can only be overcome by close co-operation between the suppliers and users of the instruments concerned.

May I say again that I am grateful for the opportunity of addressing you today and grateful to those of you who gave up so much of your valuable time to discussing your problems, when we visited you last year.
In our modern industrial age most products pass through some process which demands accurate control, whether it be temperature, pressure level, pH or any other process variable. Some people refer to these process environments as “industrial weather.” How very fortunate for our industrial weather bureau, because we can predict and control “industrial weather” with ultra precision by the aid of high fidelity instrumentation.

Before we can attempt to control any process variable, either manually or automatically, the first essential is to measure our variable with reliability and precision.

For many years the galvanometer was the best secondary measuring element known for determining electrical variables. Instrument development engineers realised that the refinement of primary measuring elements such as thermocouples, resistance thermometers, thermopiles, pH glass electrodes, etc., was useless until an instrument more reliable than the galvanometer type millivolt meter was developed.

Leeds & Northrup did their contribution by developing their potentiometer, which was marketed in 1906 and was followed six years later by their potentiometric recorder. We actually have one of these Leeds & Northrup potentiometer recorders in Johannesburg, which was brought into commission in this country in 1923. Although this was a new era in instrumentation the accuracy of measurement was still dependant on the null balance galvanometer.

After many years of continued research the bottleneck of measurement by utilising a galvanometer was removed when Leeds & Northrup fortunately for us, brought their Model "A" Speedomax into the field in approximately 1938 or 1959. This model "A" Speedomax operated entirely without a galvanometer. It was a pure electronic circuit with a direct electric motor drive for the potentiometric null balancing. The degree of accuracy of this instrument as well as its reliability was phenomenal. Our principals were then fully occupied in manufacturing instruments for war work, but in spite of this, shortly after the war they produced a still simpler and more modern electronic recorder, which was the famous Model "G."

As we are concentrating on pH measurement today, I will briefly show the development of the Leeds & Northrup Industrial pH Indicator and Recorder.

The first instrument they developed was known as the ballistic recorder. Fig. 1 is a simplified representation of the measuring circuit.
Since the internal resistance of the glass electrode is very great, the cell voltage must be measured without drawing much current from the cell. An electronic circuit is used to transform the cell voltage into galvanometer current. In the electron tube circuit, the current flowing from plate to cathode, or also known as electron flow from cathode to plate (plate current) is a function of the difference in potential between the cathode and the grid.

The plate current through the resistor P will cause a potential drop across the resistor, and current will flow through the galvanometer and capacitor C until the capacitor has charged up to the potential across P. This potential will change if there is any change in the potential between the cathode and the grid of either tube.

The glass electrode recorder circuit is so arranged that the output of the cell is periodically connected in series opposition to the potential of the potentiometer slidewire between the grid and cathode of the first electron tube, through a motor-driven cam switch. If the slidewire potential exactly balances the potential of the electrodes, the grid potential will remain the same regardless of whether the cam switch is in the upper or lower position, but if any unbalance exists between electrodes and slidewire, the grid potential will change as the cam closes one contact and then the other once during every camshaft revolution.

If the pH of the test solution changes, the cell output will increase or decrease. The consequent change in grid potential will correspondingly increase or decrease the potential across the resistor P. While the capacitor C is charging or discharging to match the new potential existing across P, a flow of current will cause the galvonometer to deflect. This deflection is picked up mechanically by the micromax mechanism which operates to position the recording mechanism, and to turn the slidewire of the recorder until electrode voltage and potentiometer voltage are exactly balanced.

The battery B supplies current to slidewire S, so that there is a precise known voltage across the slidewire. The slidewire output voltage (i.e. voltage between the slidewire contact and the zero rheostat contact) is connected in series opposition to the unknown voltage X, so that any difference (error) between the two voltages causes a potential to appear across the outside contacts of the vibrator converter. The converter reed V is driven between the outside contacts at line frequency, causing an alternating voltage at very low current, to be applied to the control grid of the cathode follower input. The resultant cathode follower output is amplified through three voltage stages, and a power stage and is finally impressed on the control winding of the balancing motor in the proper phase to drive the slidewire until the voltages are balanced and there is zero signal voltage at the cathode follower grid. The indicating device is mechanically linked to the slidewire and thus indicates the measure voltage. Since this voltage (X) is the output of an electrode assembly or other primary element, the instrument scale may be calibrated in pH or other appropriate terms.

The basic principal of null measurement is also applied in our latest instrument, the panel mounted indicator.

Incidentally, the Leeds & Northrup Laboratory pH Instrument, operates on the same principal as the panel indicator, which I will describe to you now.
Fig. 3 is a block diagram of the circuit of the panel mounted indicator.

A high gain, low-level, a-c amplifier is the heart of the instrument. Conversion from direct to alternating current by means of a contact type synchronous converter avoids the conventional d-c amplifier, and its inherent zero drift. Electronic reconversion to direct current permits the use of overall d-c feedback to stabilise the gain. Sufficient amplification is provided in the a-c amplifier so that the difference between the input voltage and feedback voltage is very small and normal changes in amplification will produce only small changes in this difference and hence, negligible errors. Since this difference voltage is a small fraction of the electrode voltage, the current flowing in the input circuit is correspondingly small. Hence, the measurement is made under practically open-circuit conditions (null measurement).

The standardisation circuit injects a voltage into the input circuit to adjust the meter pointer position to zero when there is no voltage input from the electrode system. Sufficient adjustment is provided so that the zero position of the pointer can be shifted from one end of the scale to the other. A vernier is provided so that, even with the wide range of adjustment, very fine adjustments are possible. The standardisation circuit also provides the voltage necessary to correct for the asymmetry potential of glass electrode systems.

Fig. 4 is a schematic representation of the input and feedback circuit of the instrument which we have just described. If you compare this with Fig. 2 you will find them very similar.

Some of this circuitry is provided in the form of printed circuits, while the input filter portion is moulded in plastic.

This circuitry and the features combined with it provide an instrument which has specific features well worth mentioning.

1. The warm-up time after placing the instrument on the line is short. After about one minute you are in business with this instrument.

2. The sealing of the component parts and the insulation, characteristics are such that the device can be operated under conditions of humidity which can well cause failure in other instruments.

3. These indicators are particularly unaffected by line voltage surges and electrical pick-up and exhibit essentially no zero drift.

4. The accuracy of the meter used in this instrument is relatively high. It is a half per cent, meter. This is, of course, reflected in accuracy of measurement. With less accurate meters accuracy of measurement can only be obtained by the use of an accurate external meter.

5. These instruments are provided for both manual and automatic temperature compensation. The manual compensation is built into the instrument. Automatic temperature compensation is affected by the use of an external connecting compensating thermohm subjected to the temperature of measurement.

6. Special, cables are not required to connect the indicator to electrode assembly or recorder. That is to say, the connecting cables necessary can normally be obtained in any radio supply store.

7. These indicators are designed so that they can be used with grounded or ungrounded solutions with no modification in the grounding system.

8. These instruments make use of printed components with conventional wiring and plug-in type electrolytic capacitors. Replacement items are,
therefore, in "unit items," rather than "assembly items."

Both the laboratory model as well as the panel indicator model are designed for and provided with scales for some measurements other than pH. Any potential measurement falling within the range of 1,400 millivolts can be measured with the standard instrument and under conditions of high input impedance (up to 2,000 megohms).

Fig. 5 shows the terminal connections in the panel mounted indicator and indicates some of the versatility of this device. It will be noted that the indicator can be used as a preamplifier to an ordinary millivolt recorder or that a number of remotely mounted auxiliary meters may be operated from the instrument.

Perhaps the best liked feature of these instruments is its high degree of stability and lack of drift. Where measurements are made over a period of time or where the indicator is used directly such as a continuous indicator on continuous process material, it is distinctly advantageous to know that the only standardisation normally required is that of the electrodes. The stability of the meter itself can be depended upon.

Meters of this type have been operating where they are subjected to splashing of water and wash-down of processing equipment. Although the instrument is designed to operate under these conditions, it is necessary that the rear connections of the instrument be tight and it is suggested that a thin layer of silicon grease be applied to the gaskets behind the terminal box and the door.

The instrument has operated under conditions where water collected on the bottom of the case. Such procedure is not, of course, recommended, but it simply points up the degree of insulation and shielding that has gone into the manufacture of this device.

Under normal conditions, it is advantageous to leave the power supply on the instrument. The switch should be turned off only for long shut-downs or to de-energise the instrument for servicing.

The instruments are supplied with comprehensive directions with a complete listing of component parts with values. This is an aid in making emergency replacements when or where the manufacturer's component parts are not immediately available.

If the operation in the sugar mills is seasonal, it is suggested that in the off-season the equipment be stored in a relatively dry place. It is also suggested that it would be advantageous to have the instrument on the line for a few hours at the beginning of a campaign in order that it might be thoroughly warmed up and dry.

We want to spend a few minutes on discussing glass electrodes and calomel reference electrodes.
We have three specific types of electrodes:

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Marked</th>
<th>Range °C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. 1199-22</td>
<td>2 white dots</td>
<td>50—90</td>
</tr>
<tr>
<td>Std. 1199-32</td>
<td>1 black dot</td>
<td>10—60</td>
</tr>
<tr>
<td>Std. 1199-33</td>
<td>1 blue dot</td>
<td>0—20</td>
</tr>
</tbody>
</table>

It is wise to use the electrodes for recommended temperatures, the temperature range may be exceeded under some circumstances, but the following should be considered:

1. The electrical resistance of the glass bulb increases logarithmically as the temperature decreases. Very high resistances (2,000 megohms or more) for which the electrical circuits may not be suited may be encountered at temperatures much below the recommended minimum.

2. At temperatures above the recommended maximum, excessive sodium ion corrections may be encountered with alkaline solutions. Also the glass bulbs are more soluble at high temperatures which results in shortened life. When the temperature exceeds 90°C., the calomel may slowly be reduced to metallic mercury with eventual complete failure of the electrode.

Before the electrodes are put into commission it is advisable that they are conditioned by soaking the bulbs in distilled water or a seven-eighths buffer solution for a few hours at approximately room temperature. This procedure should also be followed with electrodes which have become dry during periods of use.

When an electrode becomes sluggish, it is possible to correct this by immersing the electrode in a 20 per cent, solution of ammonium bifluoride (in a rubber or waxed beaker) for about one minute at about 250°. The amount of glass removed by such a treatment should be small and there is very little change in resistance. Only a very slight; surface etching ever results. The electrode, after the bifluoride treatment, should be thoroughly washed and stored in the borax buffer prior to use.

Electrodes not in use can be stored in a vertical position with the bulb immersed in distilled water or pH 7 buffer solution again. Caution should be exercised when cleaning the terminals with alcohol, that some of the alcohol does not drop into the solution in which the bulbs are soaking or immersed for measuring, or even touch the bulbs with the alcohol-soaked cloth. I refer to cleaning the terminals with alcohol.

I would like to stress this point, whenever you are fitting new electrodes or making an adjustment or alteration of any kind, be perfectly sure that no moisture from the hand is deposited on any terminal connection. This is of course rather difficult, and after such work has been completed, take pure...
alcohol with a small brush and clean off the terminals to ascertain that no moisture remains behind.

This applies to terminals in junction boxes at the measuring points along the line, or in the instrument. I would like you to take special note of the fact that, on numerous occasions difficulties are experienced with pH instruments due to this factor, which appears an insignificant point.

As regards calomel reference in electrodes, the most important point to watch is that sufficient K.Cl. solution is in the reservoir. It is advisable to have undissolved crystals in the reservoir as well. Here again keep the connecting post of the internal element clean and free from moisture from the hands, or any moisture for that matter.

Caution should be exercised that no precipitate forms in the K.Cl. at high temperature. Excess of this precipitate may raise the resistance of the electrode, and give erratic records. It is better to clean out the reservoir immediately and replace with fresh KG, as KG crystallizes in the liquid junction. After a period of dry storage this condition can be corrected by filling the salt bridge with KCl solution and allowing it to stand overnight in air. If this method fails, you can actually boil the bridge in water for approximately two hours, which will dissolve the crystalised KCl.

As regards the installation of electrodes, I feel it advisable to use a good type of flow unit, as this flow unit provides a water-tight compartment above the electrodes with the leads leading into a water-tight junction box.

As you know, moisture is our greatest enemy on the electrode connections in pH measurement. From the flow unit to the instrument conduit should be used, preferably overhead and not under floors and platforms, as moisture can easily collect in the loops.

Another important point is that the conduit should be installed with a slight slope, and at both ends compound sealing boxes would be desirable. Although shielded cable can conduits are used, it does not shield the leads from all electrical interferences, it only shields for electro-static waves, but cannot shield against electro-magnetic waves, in other words try to avoid installing electrodes close to switchgear, motors, welding plants and other electric machinery.
pH is no longer just a laboratory term; its study has assumed much more than mere academic interest. It can be readily demonstrated today that in many process industries the proper control of the pH of liquids so far regarded as unimportant can have a direct and pronounced effect upon plant efficiency.

Chemical engineers and plant executives have long known about the effects of pH upon production costs and product quality, and the relation of pH to such factors as the consumption of raw chemicals and the cost of maintaining equipment. Only in recent years, however, have production men had the necessary tools to apply this laboratory knowledge and to turn it into practical, successful systems for industrial pH measurement and control. The use of pH equipment has pointed the way in numerous industries to reduced costs and a better product. The Beckman-Foxboro pH combination consists of a measuring element, called the electrode assembly, indicating amplifier and the recorder.

Electrodes assemblies and indicating amplifiers are manufactured by Beckman and the recorder by Foxboro. The amplifier discussed here is the new-Model W, released approximately one year ago by Beckman. Ever since 1938, when Beckman made the first industrial pH instrument, their research and design engineers have been gathering ideas for a completely new industrial pH meter. These ideas are all in the Model W. It is completely new from start to finish, and has packed into it eighteen years of experience by Beckman engineers. Let us see some of the features of the new Model W.

1. It is small and compact. It is an indicating amplifier which can be placed next to the point of measurement and can give the operator a true indication of what is going on in the process.

2. The Model W is designed to keep right on running without electronic specialists. Beckman has made it easy to service it right on the job by the operators themselves.

The circuits are all contained in three separate plug-in units. Each of these can be replaced with spares kept on hand without soldering irons—and in a matter of minutes—and by anyone, even though unfamiliar with the instrument.

Field replacement of these three units, namely, amplifier unit, preamplifier unit, and power supply unit, will put the Model W back into immediate operation. Then, the faulty component can be serviced in a shop at a more convenient time.

3. The Model W is designed for industrial use—it has rubber gaskets, which seal the door to the case, so that no corrosive gasses and dust can enter the instrument.

A. The Model W puts out zero millivolts to the recorder when the Model W needle is at mid-scale. In other words, when the recorder and Model W cover exactly the same range, the recorder will have zero input when it is in mid-scale.

5. The Model W allows the recorder to record full scale virtually for any pH range. The recorder can have the same range as the Model W amplifier, say 2 to 12. Or with a 2-12 Model W, the recorder range can be expanded to record a greater number of pH units, or compressed to record a lesser number of pH units, or shifted to record anywhere up or down the scale.

Let us brieﬂy discuss pH and the Model W, to see just how this instrument works.

(The author then exhibited slides to illustrate his lecture)

pH Scale

In its simplest form, pH is the measure of acidity or alkalinity of a solution, just as the Fahrenheit scale is a measure of temperature, the pH scale is a measure of acid or alkaline strength. The pH scale ranges from 0 to 14, with 7 being the neutral point. Numbers below 7 indicate increasing acidity, while numbers above 7 indicate increasing alkalinity.

Voltage from Electrodes

If we put a pair of electrodes in a beaker of a sample solution, and if the solution is acid, a positive voltage will be developed between the electrodes, which is proportional to the pH of the solution. If the solution is alkaline, a negative voltage will be developed. This voltage is measured and amplified by the Model W and translated into pH units right on the meter dial. The exact acidity or alkalinity of any solution can thus be determined by simply inserting this pair of electrodes and reading the meter.

Voltage versus pH Graph

The relationship of voltage and pH is better explained graphically when it can be seen that there is no voltage produced between the electrodes in a pH 7 or neutral solution. At pH 6, however, there are a little less than 60 millivolts produced.
pH numbers decrease, indicating stronger acids, the voltage increases. On the other side of the scale, alkaline solutions produce negative voltages between the electrodes.

**Model W Amplifier**

The voltage between the electrodes is applied to the Model W amplifier. The following points are of special interest. The power supply provides D.C. voltages for the instrument operation. The built-in electronic regulator provides constant D.C. voltages, even with line variations of plus or minus 15 per cent.

The relationship of the components of the pH measuring system was shewn diagrammatically. The amplifier produces a current between the amplifier and the ground terminal. This current is a measure of the voltage at the electrodes. The current is used to drive a direct pH reading meter on the amplifier. Also, through a resistor, the current develops the voltage necessary to drive the recorder.

Let us now see what the controls on the Model W are and what they do. First are the two controls dealing with "zero check." When the Model W is switched on, and there is no voltage input to the amplifier, the Model W meter should read pH 7. This is the "zero check" point. To make this check, we get zero voltage input by pressing the zero check button. The zero adjust control is then turned until the needle reads pH 7.

Firstly, press the button called "zero check" and observe the meter reading. Second, turn the zero adjust control until the meter reads pH 7. This sets up the amplifier and meter reference.

**Adjustment for Asymmetry Potential**

The second knob adjusts for asymmetry potential. To see what this means let us first consider the voltage between the electrodes. When the electrodes are immersed in a solution of pH 7, there should be no voltage between the electrodes, and the meter should read 7. If a voltage does exist between the electrodes, it is compensated by adjusting the asymmetry control. This is the process of standardisation.

This is how the asymmetry control works. With the electrodes in a buffer solution of pH 7, we should read 7 on the meter. If not, turn the asymmetry control until the current passing through the meter alters the reading to indicate the correct pH values. The feedback action of the amplifier prevents significant voltage alteration across RT.

Here is the simple set-up for standardisation. With the electrodes in a buffer of pH 7, first turn the asymmetry control to make the needle read 7. This adjustment may also be made with other buffer solution values. For example, if buffer of pH 4 is used, adjust the asymmetry control until the needle on the meter reads 4. This is a simple and fast operation.

**Thermo - Compensation**

One important feature of the Model W pH Meter is the thermo-compensating resistance element which is immersed in the solution along with the electrodes. The resistance of the thermo-compensator varies with the solution temperature, so that the amplifier is always giving the correct pH reading for the solution at the temperature at which it is measured.

This will serve to illustrate the necessity for the thermo-compensator. The same pH at different solution temperatures will give voltages at the electrodes which vary with the temperature. Note that for a pH of 3 at zero degrees, 200 millivolts are produced between the electrodes; but for a pH of 3 at 100 degrees, 300 millivolts are produced. Regardless of the temperature, the thermo-compensator corrects this effect of temperature on the electrodes.

**Electrodes**

It is well to be reminded that the key to pH measurements is the electrode pair, the glass electrode and the reference electrode. Of the two, the glass electrode, which senses the pH change, is the more important. The performance of the glass electrode depends largely on the type of glass used in the pH sensitive immersion end. Early electrodes had thin, fragile bulbs. But Beckman research engineers developed special low-resistance glass compositions for glass electrodes.

The best known electrode is the Beckman General Purpose Glass Electrode. These electrodes using this special glass can cover a temperature range from freezing to boiling, as well as almost the entire pH range. The pH sensitive glass tip is so rugged that it can withstand abrasion and even accidental impact by hard objects. It is almost universal and practically indestructable. However, for special applications such as extremely abrasive fluids encountered in the mining and particularly in the uranium industry, a special abrasion resistant glass electrode is built by Beckman, which has proved its value overseas, as well as on many uranium mines on the Rand and in the Free State.

**Sodium-ion Errors**

The only area, not accurately covered by the General Purpose Glass Electrode, is the extreme alkaline range. As noted on this graph, all electrode glasses show some error, due to strong concentrations of sodium-ions. For accurate results even at
the top of the alkaline range, Beckman research has developed special electrode glasses which are practically unaffected by these sodium-ions. Most accurate at high pH is the amber glass shown. The most deviation from the correct pH in highly-alkaline solutions is shewn by Corning 015 glass—the former standard glass electrode.

Reference Electrode

Now let us look at the reference electrode. This electrode gives a stable voltage, a voltage which does not change with changes in the pH of the solution. To illustrate the necessity for a reference, consider yourself in a stationary motor-car, watching a train go by. The train would be passing you at, say, 20 miles per hour. If you were riding alongside this same train in a motor-car travelling at 20 miles per hour, the train would not be passing you at all.

Just as the speed of the train depends on your reference point, so does a pH measurement depend on the reference electrode. This electrode is like the stationary motor-car—it provides a voltage which is constant and which does not depend on the pH of the solution.

Sleeve Electrode

Most common for industrial measurement is the sleeve type reference electrode. It has a moderately rapid KC1 flow rate and large liquid surface contact. In cases where samples have high viscosity, the sleeve type reference electrode is especially advantageous. It is also preferred for slurries, turbid solution, oil emulsions and soap solutions.

Fibre Electrode

For some industrial installations, the fibre type reference electrode is preferred. In this electrode, electrical contact with the process solution is established by KC1 solution flowing slowly through a porous fibre sealed into the immersion end of the reference electrode. The fibre electrode has a slower flow rate than the sleeve type electrode, and has no breakable glass sleeve.

Necessity for pH Scale Accuracy

Very few people realise the important fact that a small error in a pH measurement means a large error in measuring the acidity. When you change the pH reading by 1 unit, you change the acidity 10 times. And when you change the pH of a solution by 2 pH units, the acidity changes 100 times. This comes about from the logarithmic nature of the pH scale. As the pH drops from 6 to 5, the acidity increases 100 fold. This means that the electrical components in the pH meter must be designed for accuracy if you are going to know the acid strength precisely.

On the Model W the output to the recorder is accurate to 0.02 pH, in other words, less than the thickness of the indicating needle.

Beckman manufactures two types of electrode assemblies, namely, a flow type and an immersion type assembly. These will be shown to you during the course of the afternoon. The flow type electrode assembly is porcelain enamelled in order to resist the corrosive action of the fluid to be measured.

The immersion electrodes are made in, two versions, namely, one manufactured from Type .510 stainless steel and the other one in a hard rubber construction.

The Foxboro Recorder, which works in conjunction with the Beckman equipment described, is also a most modern instrument. It is the well-known Dynalog, which stands for a new conception of the electrical bridge, self-balancing type of instrument. In a sweeping departure from the conventional design, Foxboro has produced an industrial instrument that offers performance and previously unknown freedom from maintenance.

The conventionally used resistance balancing slidewire has moving, electrical contacts, which wear and limit the instrument performance unless regularly maintained. This slide wire also limits instrument accuracy and sensitivity, because it can measure resistance only step by step—from turn to turn of the coiled wire.

Foxboro dynalog instruments employ instead a very simple variable air capacitor, completely eliminating moving and rubbing contacts. The electrical capacitor varies directly with the degree of intermesh between its rotor and stator plates. It provides continuous stepless balancing and gives a precise measure of the most minute change in the measured variable. The result is extreme sensitivity of one-hundredth of 1 per cent, and high sensitivity sustained accuracy of a quarter of 1 per cent, of the scale span.

Conventionally used dry cell batteries need frequent replacement and their use generally necessitates daily manual circuit standardisation or periodic complicated automatic standardisation.

Dynalog instruments require no dry cell. They empty an electronic system with continuous and direct standardisation against a standard cell. This eliminates manual standardisation, errors which develop between standardisations and interruptions.
to the instrument operation for manual or automatic standardisation, especially important when on automatic control.

The conventionally used high-speed, continuously rotating, circuit balancing motor, with its associated drive gears, requires periodic lubrication and maintenance. Such drives can produce high pen speed, but with the disadvantage that the higher the speed, the greater the wear. Dynalog instruments employ a powerful "dynapoise drive," which produces high pen speed, yet has only four slow moving parts, which operate practically without wear. This drive, mounted integrally with the air capacitor, balances the pull of one solenoid against that of another and moves only when the circuit is re-balancing. It can drive the pen full scale across the chart to complete balance at the new reading in normally five seconds or on high-speed instruments in one second.

The accuracy of the conventionally used mechanical balance galvanometer is limited, because it is delicate and vibration-sensitive and its movement is often hindered by dust accumulations. Galvanometers also require periodic maintenance.

Dynalog instruments employ a simple, stable, vacuum tube circuit, which is unaffected by dust and vibration, and requires no mechanical adjustment. The result is, again, greater, more dependable accuracy.

The Foxboro dynalog instrument is easy to install. It will operate without loss of accuracy even if tilted 75 degrees from the normal vertical position, as will be shown during the demonstration. The dynalog measuring system consists of three major unit assemblies, namely, first the dynapoise drive, second the range unit, third, the amplifier.

The dynapoise drive requires no lubrication or adjustment and has no backlash. It consists of a balancing capacitor with a cross arm, each end of which is connected to the core of a powerful solenoid. A change in the measured variable electrically imbalances the measuring circuit and causes the solenoid cores to exert an unbalanced pull on the cross arm. The range unit makes it possible to change the range of a dynalog instrument in the field by simply replacing one range unit with another one without soldering joints, without making adjustments, and without affecting instrument accuracy in any way. These dynalog range units are enclosed in compact containers which provide full protection against moisture, corrosion and mechanical damage, and a range unit for a pH recorder is simply plugged into the instrument like a vacuum tube. The amplifier units are designed and built to stand up under the strain of vibration, pulsation, dust and corrosion—conditions usually encountered in industrial service. The vacuum tubes used in dynalog amplifiers are standard—obtainable wherever tubes are sold. They are not specially selected, and normal variations in tube characteristics have no effect on instrument operation. These units are completely interchangeable and a new unit can be quickly and easily installed in case of accidental mechanical damage.

Foxboro pH dynalog instruments employ a vibrator to compare input voltage with standard cell voltage and produce a pulsating D.C. unbalance voltage for amplification.

The dynalog vibrator operates in a very high impedance circuit—a distinct advantage in that changes of as much as several thousand ohms in contact resistance can have no effect on the accuracy, speed, or sensitivity of the instrument. The vibrator unit has highly polished precious metal contacts and is oil-filled and hermetically sealed in a compact metal housing. It plugs in like a vacuum tube.

Seeing that the Beckman amplifier is of the indicating type, it is possible to mount the amplifier next to the point of measurement, thus providing the operator with an indication of the pH. The Foxboro recorder or controller can then be mounted any distance away from the amplifier, as the only connection between these two parts is standard two-core cable. All Beckman industrial electrodes have 10-feet leads and in many cases it is possible to plug these electrodes directly into the amplifier. Where it is not possible to mount the amplifier next to the point of measurement, a connector box and cable assembly should be used which is provided with four conductor shielded cable. These connector boxes and shielded cable assemblies are available in any length up to a maximum of two hundred feet.

For recording pH at several locations throughout the plant, it is possible to use a number of electrode assemblies and one amplifier only to work in conjunction with a multiple point dynalog recorder. The switch inside the multiple recorder will operate a Beckman automatic six point selector switch, which will bring into the circuit the six electrode assemblies in rotation. This Beckman automatic selector switch is equipped with an asymmetric potential adjustment for each electrode assembly.

If on the other hand, the six measuring points are too far apart, with the result that the Beckman automatic switch cannot be conveniently used, it is possible to make use of one amplifier for each
electrode assembly. There is, of course, the advantage on this set-up that an indication of the pH is available at each place of measurement and can still be recorded on a common chart.

In conclusion, on behalf of my firm, I would like to express my thanks to the South African Sugar Technologists Association, for the opportunity offered me in presenting you with details of the Foxboro-Beckman pH equipment.

Dr. Douwes Dekker, the Chairman, thanked the three speakers for their most interesting papers to the Congress on the subject of pH measurement. We should be grateful for the trouble they had gone to to present descriptions of their instruments in such an interesting way. Each instrument described had some good features of its own. He hoped that the firms whose representatives had attended today now realised the necessity of obtaining spares readily.

Mr. Rault asked Mr. Toop if he had had any experience of attaching the electrodes into the inside of a tank, where juice was circulating rapidly under a pressure of 10-12 lb.

Mr. Toop replied that while he had not done this with regard to sugar juice, similar conditions in treating slimes were also measured by immersing an electrode in the tanks. Under these conditions a resistance thermometer, being in a rubber sheath, finally failed. This was overcome by fitting a metal supporting liner in the rubber sheath. He thought that trying to record pH readings under conditions where the liquid was not properly mixed, did not give correct results. In the case of a continuous process the best position for an electrode would be in the external flow.

Mr. Rault asked if there would not be a time lag with such a procedure. Certain reactions were instantaneous and a high pH had to be avoided in some cases.

Mr. Toop said that the time lag was one of the greatest importance. It was no use measuring pH at one point, which might be quite different from that further down the pipe-line.

Mr. Hardy said that by using duplicate electrodes one might easily get an error of 0.1 pH. He asked if it were possible for manufacturers to standardise their electrodes, in the same way as brix hydrometers are now standardised.

Mr. Toop pointed out that the thickness of the glass was so small that it would be impossible to standardise electrodes. If 0.1 pH was important, it was always possible to apply a buffer check and then to adjust the instrument to allow for these varying standardisations would be a simple matter.

Mr. de Kok related that during the war, when he was working for African Explosives, it was necessary for them to manufacture their own electrodes. There was quite a difference in the characteristics of one piece of glass-tubing tested at various points. So he did not think that the thickness of the glass was the chief cause in variation between two electrodes. He pointed out that it was always possible to adjust for variation between electrodes. This view was supported by Mr. Harvey.

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Mr. Toop replied that while he had not done this with regard to sugar juice, similar conditions in treating slimes were also measured by immersing an electrode in the tanks. Under these conditions a resistance thermometer, being in a rubber sheath, finally failed. This was overcome by fitting a metal supporting liner in the rubber sheath. He thought that trying to record pH readings under conditions where the liquid was not properly mixed, did not give correct results. In the case of a continuous process the best position for an electrode would be in the external flow.

Mr. Rault asked if there would not be a time lag with such a procedure. Certain reactions were instantaneous and a high pH had to be avoided in some cases.

Mr. Toop said that the time lag was one of the greatest importance. It was no use measuring pH at one point, which might be quite different from that further down the pipe-line.

Mr. Hardy said that by using duplicate electrodes one might easily get an error of 0.1 pH. He asked if it were possible for manufacturers to standardise their electrodes, in the same way as brix hydrometers are now standardised.

Mr. Toop pointed out that the thickness of the glass was so small that it would be impossible to standardise electrodes. If 0.1 pH was important, it was always possible to apply a buffer check and then to adjust the instrument to allow for these varying standardisations would be a simple matter.

Mr. de Kok related that during the war, when he was working for African Explosives, it was necessary for them to manufacture their own electrodes. There was quite a difference in the characteristics of one piece of glass-tubing tested at various points. So he did not think that the thickness of the glass was the chief cause in variation between two electrodes. He pointed out that it was always possible to adjust for variation between electrodes. This view was supported by Mr. Harvey.

Mr. Elysee complained that after buying pH instruments, and they went wrong, the agents were no longer interested. He hoped that the instruments to be demonstrated today would not suffer in the same way.

Mr. Bouvet said that he had a lot of trouble in Mauritius with pH controllers. He was happy to see that the makers had now gone to a lot of trouble to try to eliminate the difficulties he had experienced. He asked if frequency variations in current would not render the application of these instruments almost impossible.

Mr. de Kok replied that with his new amplification circuit such variations as normally occurred could be taken care of.

Mr. Toop pointed out that the speed at which these frequency variations occurred was of great importance. A slow change would not have any appreciable effect. He thought that any dangerous variation would be more likely to occur when current was generated by a factory itself and not when the current came from a big supply concern.

Mr. Costello asked if in removing a coating from an electrode it was not possible to severely damage it.

Mr. Harvey replied that the removal of a scale was not a difficult process.

Dr. Douwes Dekker said that in the past the sugar industry had not been very instrument-minded, but he thought that in future it would become so, and when processes were automatically controlled better results would ensue. He thought that recording instruments for temperature were increasingly used, but as far as pH recording was concerned, the situation was not satisfactory at all. He felt, however, that today had marked a great step forward.
The clarity of a juice is measured by the Kopke or Luximeter methods. Both are simple and comparative.

The evaluation of clarity in cane sugar manufacture and the factors which influence it, are both complex and varied.

P. Honig discusses some of these factors and the wax complex, which he calls "lipids" in a paper presented at the 1953 I.S.S.CT. Congress. Axtell and Keller at the same Congress, showed that, "the removal of the wax complex by solvent treatment of the raw juice substantially improves the clarity of the juice by increasing the purity, the settling rate and decreasing the mud volume."

In the past clarity was considered important in Natal in the making of plantation white sugars and to assist in filtration of the muds in plate and frame presses. To achieve this up to 3 gms. of sulphur dioxide were used per litre of juice, but with the advent of the Oliver Campbell filter and diminution of the quantity of mill whites produced, the tendency has been to make what appears an obvious monetary saving by reducing chemicals and leaving the refinery to deal with the raw sugars so produced.

As a result the clarity of the juice has generally deteriorated wherever chemicals have been cut.

In order to throw some light on this complicated problem a series of experiments was carried out, with the following results:

1. The Effect of Pre-Heating Raw Juice in Simple Defecation

A composite sample of cold mixed juice was treated with 0.3 gms. of phosphoric paste, a standard procedure in all these experiments. One 2 litre sample was limed to 8 pH at atmospheric temperature, boiled and settled. The rest were pre-heated at temperatures ranging from 40°C to 90°C before treatment. The results were positive and illuminating.

<table>
<thead>
<tr>
<th>Mixed Juice Temperature</th>
<th>Atmospheric Temperature</th>
<th>40°C</th>
<th>50°C</th>
<th>60°C</th>
<th>70°C</th>
<th>80°C</th>
<th>90°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luximeter reading:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarified juice</td>
<td>... 62</td>
<td>58</td>
<td>56</td>
<td>54</td>
<td>52</td>
<td>46</td>
<td>42</td>
</tr>
<tr>
<td>pH Clarified juice</td>
<td>... 6.7</td>
<td>7.1</td>
<td>7.0</td>
<td>7.4</td>
<td>7.5</td>
<td>7.6</td>
<td>7.6</td>
</tr>
<tr>
<td>Repeat different sample</td>
<td>... 7.3</td>
<td>7.45</td>
<td>7.45</td>
<td>7.55</td>
<td>7.7</td>
<td>7.75</td>
<td>7.85</td>
</tr>
</tbody>
</table>

A repeat experiment using acid sulphitation gave the same decrease in clarity through pre-heating. The raw juice was sulphited to 2.8 pH and then limed to 8 pH before boiling and settling.

<table>
<thead>
<tr>
<th>Atmospheric Temperature</th>
<th>Pre-Heating Temperature</th>
<th>40°C</th>
<th>60°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luximeter reading:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarified juice</td>
<td>... 80</td>
<td>74</td>
<td>74</td>
</tr>
</tbody>
</table>

2. Chemicals

The quantity of lime required to bring a juice to a given pH varies considerably with the nature of the juice. Thus in simple defecation the amount of lime used to bring a juice to 8 pH was found to vary from 1.13 to 2.17 lbs. CaO per ton of cane and in acid sulphitation comparative tests varied from 3.35 to 5.65 lbs. CaO per ton of cane. In each case the lower purity juices 82.1—84.6° required less lime than juices at 87.0°.

This may be accounted for by the fact that the lower purity juices contained approximately 200 mgs. per litre more magnesia than the high purity juices. In sulpho-defecation the amount of lime required varies with the quantity of the lime first added. Thus at 9.5 pH the quantity in one sample was 1.56 lbs. CaO per ton of cane and at 11.0 pH it was 4.45 lbs. per ton of cane.

3. Lime Salts

Natural lime salts in mixed juice at Darnall range from 250 to 400 mgs. per litre. A much wider range exists with magnesium salts. The minimum found was 46 mgs. in juice from flat cane at Felixton and the maximum was 844 mgs. at Darnall.

Pre-heating has the following effect on the lime and magnesia salts in clarified juice. Thus:

<table>
<thead>
<tr>
<th>Mixed Juice</th>
<th>Atmospheric Temperature</th>
<th>Acid Sulphitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO &amp; MgO mgs. per litre</td>
<td>... 1,130</td>
<td>1,210</td>
</tr>
<tr>
<td>CaO mgs. per litre</td>
<td>... 504</td>
<td>616</td>
</tr>
<tr>
<td>MgO mgs. per litre</td>
<td>... 629</td>
<td>694</td>
</tr>
</tbody>
</table>
These experiments show that pre-heating raw juices prior to simple defecation or acid sulphitation, causes a progressive decrease in clarity, increasing lime salts and decreasing magnesia.

The effect of increasing the final pH from 7.5, to 8.0, 8.5 and 9.0 also caused a progressive increase in lime salts and a reduction in magnesia.

In general, cold simple defecation gave lower lime salts than any other method. An average, of 5 runs gave the following comparison with acid sulphitation:

<table>
<thead>
<tr>
<th></th>
<th>Lime Salts</th>
<th>Magnesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed juice</td>
<td>287</td>
<td>765</td>
</tr>
<tr>
<td>Simple defecation</td>
<td>470</td>
<td>624</td>
</tr>
<tr>
<td>Acid sulphitation</td>
<td>624</td>
<td>594</td>
</tr>
</tbody>
</table>

The following series were carried out before renewed interest in simple defecation arose:

<table>
<thead>
<tr>
<th></th>
<th>Mgs. per Litre</th>
<th>MgO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed juice</td>
<td>385</td>
<td>718</td>
</tr>
<tr>
<td>Acid sulphitation</td>
<td>662</td>
<td>531</td>
</tr>
<tr>
<td>APC process</td>
<td>663</td>
<td>577</td>
</tr>
<tr>
<td>General factory average</td>
<td>700</td>
<td>566</td>
</tr>
<tr>
<td>Sulpho-defecation</td>
<td>812</td>
<td>466</td>
</tr>
</tbody>
</table>

The following series were carried out before renewed interest in simple defecation arose:

The maximum mgs. CaO found was 938 in a sulpho-defecated juice pre-heated to 65°C and pre-limed to 10 pH, and the lowest was 320 mg. in a simple defecation different sample. In the factory the maximum CaO found was 882 mgs. per litre, and the maximum 588 mgs. magnesia was 486 maximum and 186 minimum.

In all cases simple defecation gave the lowest clarity, the lowest Luximeter reading being 30 and the highest 58. Other processes ranged from 60 to 80.

Wax Complex or Lipids

The wax complex content of mixed juice ranged from 1.5 to 2.5 gms. per litre at Darnall. Honig states that "the percentage of hard wax recovered in the milling process via the extracted juice, decreases when the pre-treatment of cane in the milling process by knives and shredders is intensified." 2

A sample containing 2.03 gms. of wax per litre was boiled, filtered and washed with cold water over Kieselguhr under vacuum. No wax was lost. Another sample containing 1.33 gms. wax per litre was treated in the same way but washed with hot water. No wax was lost. This shows that an efficient absorbent medium such as Kieselguhr will retain the wax complex whether partly emulsified or not.

On applying simple defecation to the first sample, with no pre-heating, 37.6 per cent, of the total wax was lost. The top scum after boiling, which is voluminous in this process, contained 0.39 gms. of wax per litre and the mud 0.89 gms., a total of 1.28 gms.; 0.75 gms. were therefore lost. In other words, the mud only absorbed 43.4 per cent, of the total wax originally present in the mixed juice.

Wax retention varies with the raw material, time of heating, agitation, reaction, the absorbing medium or the method of clarification used.

The effect of the clarification process used is shown in the following series:

<table>
<thead>
<tr>
<th></th>
<th>Mixed Juice</th>
<th>A.P.C. Process</th>
<th>Acid Sulphitation</th>
<th>Sulpho-defecation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1st ppt.</td>
<td>2nd ppt.</td>
<td>Atmos. Temp. (°C)</td>
</tr>
<tr>
<td>Gms. dry cake per litre</td>
<td>3.98</td>
<td>10.88</td>
<td>10.78</td>
<td>10.22</td>
</tr>
<tr>
<td>Wax percentage dry cake</td>
<td>38.04</td>
<td>27.5</td>
<td>1.2</td>
<td>10.4</td>
</tr>
<tr>
<td>Gms. wax per litre</td>
<td>1.52</td>
<td>1.50</td>
<td>0.07</td>
<td>1.12</td>
</tr>
</tbody>
</table>

1.57
In the foregoing series the A.P.C. process retained all the wax with cold washing. In practice hot washing and mixing of the two cakes might cause some loss. This point was not determined. Cold acid sulphitation came second with 73.6 per cent, retention and the others ranged from 34 to 54 per cent.

In simple defecation nearly all the wax may be recovered by raising to the boil quickly, removing the top by skimming and incorporating it with mud at a low temperature. In the A.P.C. process there is no scum as most of the wax is precipitated in the cold first precipitate.

**General**

The foregoing observations were made from a large number of experiments carried out during the 1954 crop.

Dr. Honig says, "A better understanding of the behaviour of waxy material in sugar manufacture can only be obtained, if we differentiate between the various types of lipids and not classify them as one group. This system of classifying lipids as a uniform single group leads to more confusion than real understanding, just as is the case when explaining differences in the behaviour of juices by a general term such as "non-sugars" without a proper analysis of what is actually to be understood and what kind of reaction we are specifically considering."

In theory this is undoubtedly true but in practice the variations are so great and unpredictable that no practical application would be possible, were this knowledge available.

It remains therefore to use a process of clarification which will cover all known extremes and not revert to primitive methods which are subject to all the variables common to raw material in this country.

**REFERENCES**


**Mr. Dymond**, in reply to Mr. Rault, said that the higher figures obtained with the luximeter indicated the better clarity. Water gave a reading of 100.

**Dr. Douwes Dekker** said, he did not want the audience to gain the impression that the clarity of a clarified juice was connected with the claribility of the mixed juice (from which the clarified juice was prepared) as defined by Axtel and Keller. In their paper dealing with the removal of wax by solvent extraction on the claribility of mixed juice it is said: "Claribility of the juice is a concept developed to permit expression of clarification efficiency in mathematical rather than descriptive terms. It can be considered as being a function of the available sucrose, the settling rate and the mud volume."

Hence the claribility is closely connected with plant capacity. In the paper by Axtel and Keller, the following data for claribility of the mixed juice and clarity of the clarified juice are given in respect of a series of tests in which the proportion of solvent to juice were increased.

<table>
<thead>
<tr>
<th>Raw juice</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarity, clarified juice</td>
<td>56</td>
<td>43.7</td>
<td>35.5</td>
<td>36.2</td>
</tr>
<tr>
<td>Claribility, raw juice</td>
<td>103.2</td>
<td>128.8</td>
<td>116.9</td>
<td>337</td>
</tr>
</tbody>
</table>

Underneath raw juice we find the data for clarity and claribility obtained in the tests of the untreated raw juice, under 1, 2, 3, and 4. The data pertaining to juice treated with trichloroethylene in increasing quantities. It appears that solvent extraction did not improve the clarity of the clarified juice (on the contrary, the clarity was worse), but the claribility increased considerably, in particular when larger quantities of solvent were used.

He referred Mr. du Toit and Mr. Rault to the I.S.S.C.T. Proceedings for the details of the paper on claribility. He said further, that the explanation given by Mr. Dymond to account for the smaller quantity of lime required to clarify juices of lower purity, i.e. the higher magnesium content, was interesting, but would have to be confirmed by further tests.

He also said that the better removal of magnesium salts by the A.P.C. process, as found by Mr. Dymond, was contrary to results obtained by the S.M.R.I. Moreover the superiority of the A.P.C. process in this respect was difficult to explain theoretically. To remove magnesium, a high alkalinity was required, as in the first carbonation. He also objected to Kieselguhr being termed "an efficient absorbent medium." Kieselguhr was an excellent filter aid, but its absorbitive capacity was insignificant.

**Mr. Rault** said that the February issue of Sugar had an interesting article on the effects of cold versus hot liming at a Puerto Rican central.

The authors claimed that when dealing with juices of high P₀₀₅ content (600 to 1,000 p.p.m.), hot liming gave superior clarity and rise in purity. The conclusion was also that a high pH after clarification was easier reached by hot liming and this method was a means of saving chemicals.
Farnell working on West Indian juices had found hot liming eliminated a larger proportion of nitrogenous impurities than cold liming.

With carbonatation in South Africa it was found that juices carbonated hot at 70°C., in spite of the clanger of glucose destruction, gave a better filtration rate than if carbonated at 55°C., and subsequently heated to 70°C. before filtration.

The composition of the ash before and after carbonatation, although showing a practically total elimination of magnesia, could not explain the enormous rise in purity experienced at Mt. Edgecombe. Organic impurities removal was of a greater magnitude than the demineralisation effect, made somewhat ineffective by the substitution and increase of lime salts.

Dr. Douwes Dekker agreed that the removal of the organic non-sugars was most important and this led to a higher purity being obtained, but the very-good removal of magnesia was also a factor. He said that the higher pH attained with hot liming was explained by coagulation of proteins by heating and before liming.

Mr. W. H. Walsh asked for Mr. Dymond’s definition of claribility.

Mr. Dymond said that he had understood that claribility meant the ease with which a juice could be clarified, together with the factors which caused bad clarification. However he now accepted Dr. Douwes Dekker’s more precise definition.

Dr. van der Pol said that he had done a considerable amount of laboratory work on clarification and his experience was that laboratory results alone were not a true indication of what would happen in the factory. Exact duplication of a factory process in the laboratory was impossible and the effect of the return of filtrates as well as the effect of the hold-up time in the subsider cannot be assessed accurately in the laboratory. He said that laboratory tests, while being a useful adjunct, could not completely cover what was required under practical working conditions. In Australia, for example, prediction on the method of liming to be used for optimum clarification results was considered impossible. Often a season was started with cold liming and as the season progressed it was found necessary to change to the hot liming process for better results. The next season might show the reverse. He remarked that such experiences were really not surprising, in view of the great variability of juice properties which were encountered throughout the season and even from hour to hour. He was of the opinion that clarity of the clarified juice was no criterion of a well clarified juice and related the experience of one factory manager in Natal who had obtained a record recovery during a season when clarity was at its worst.

Mr. Dymond said that he was limited to laboratory tests because he had no plant. As far as simple defecation was concerned, he thought that difficulties might occur later on, especially in the refinery.

Mr. Antonowitz said that experience at Umfolosi had shown that pre-heating of the juice before liming paid dividends as far as clarification was concerned. He said that the sugars obtained from hot liming were superior to those obtained during the period they used cold liming.

Mr. Dymond pointed out that there were a number of factors involved in clarification. Hot and cold liming were not the only ones to be considered. In the same way sulpho-defecation was a loose term for a process in which the clarification varied considerably with the amounts of lime and sulphur used.
It may be recalled that a paper "An Aid to Pan Boiling" was read at the Twenty-eighth Annual Congress of the South African Sugar Technologists' Association in 1954.

Since then, great interest in the new method of pan control has encouraged the author to elaborate on the system from a practical angle.

In practice, it must be admitted that as an aid to pan boilers, any instrument used must be a simple device, of robust construction and more or less foolproof.

As the method is based on galvanic action and can produce, with suitable electrodes, a measurable current which can be of .5 m.a. or less to an unlimited maximum (according to the electrodes used) it can be understood that a milliammeter with a range of 0—100 m.a. will be difficult to read with the desired accuracy, but when the instrument is of a range of 0—1 m.a., with resistances incorporated and switching arrangement giving ranges—

0—2 m.a. 0—10 m.a. 0—100 m.a.

we can attain our purpose and find the sensitivity and accuracy which is required for pan work.

Although the voltage obtained is low, being below .2 volts DC to .8 volts DC, the construction of a recording device should offer no difficulty.

The electrodes, although showing signs of scaling-up when on test in the laboratory, show no appreciable deterioration when used in practical pan boiling. This was proved when one electrode was used at Renishaw throughout the 1954 season and the meter readings were graphically correlated against the densities of "C" or third massecuites boiled during the season.

While on the subject of electrodes, the following may be mentioned:

1. measurement of capacity in Mfd between electrodes is not essential to practical pan boiling;

2. surface area does not play the part one would expect. At Renishaw, a machined electrode of solid zinc with apparently more surface area than a zinc disc electrode proved unreliable;

3. to step up current, one electrode with two or more banks of zinc discs which must be so separated as to produce the same effect as electrodes in parallel;

4. sufficient clearance must be allowed between the pan wall and the electrode or electrodes, so that after discharging the heavy massecuite and subsequent steaming out of the pan, no accumulation of massecuite is left to give a false reading.

Experiments made in other factories gave practically the same readings as those obtained with the meter used at Renishaw.

Unfortunately different types of electrodes were used, but results tend to prove that whether the slurry method or shock seeding was in operation, even at varying purities and temperatures, the saturation point for the introduction of slurry or shock seed showed little variation.

It must be borne in mind that individual pan boilers have a different "touch" to determine the density prior to introduction of slurry or shock seed.

It can also be assumed that there is a definite relation between the density of the liquor at the time of introduction of seed and appearance of the required number of crystals.

It is thus possible that were the electrodes standardised and pans calibrated, more uniform graining could be obtained when using the new method of pan control.

There have been queries as to whether the method could be used successfully with steel pans. Should there not be sufficient measurable current when using the steel wall of the pan as one electrode, then two electrodes should be introduced, one of cast iron or of similar metal and the other of zinc discs, as used in the cast iron pan.

In the laboratory, the instrument has been found to be sensitive to change in pH, yet in practical work the introduction of hydrosulphite of soda ("blankit") into the pan while graining made no difference to the reading.

However, when boiling weekend syrups, it was found that there was an appreciable change in the readings of the meter and consequently it is suggested that a different graph for such conditions be prepared.

Any instability or flickering of the needle would show that the pan is not boiling normally, i.e. drawing air, defect in vacuum system or abnormal changes of temperature.
COMPARATIVE READINGS OF CUITOMETER at 4 & DUCASSE INSTRUMENT
set on 2", TAKEN AT INTERVALS OF
THREE MINUTES
MONDAY, 20th DECEMBER, 1954
Concentrating a blend of 1st and 2nd
green molasses (purity 73) up to shock-
seeding and allowing the grain to grow by
balancing water until a massecuite footing
is formed previous to feeding with 2nd
green molasses
PAN No. 6 — LAST BOILING
NATAL ESTATES, MOUNT EDGEcombe
WEDNESDAY, 2nd DECEMBER, 1954
COMPARATIVE READINGS OF CUITOMETER AND DUCASSE INSTRUMENT
AFTER CLOSING MOLASSES FEED, AND TIGHTENING THE MASSECUITE
FOR ONE HOUR AND TWENTY MINUTES TO 99.5° BRIX BEFORE STRIKING.
An interesting comparison between the pan aid instrument and one of the conventional recording types was made by Mr. J. Rault and a graph shewing the readings of the two instruments during the boiling of a "C" massecuite at Natal Estates, Ltd. factory is appended.

In conclusion I would like to thank the President, members of the Council and of the Association for the kind interest they have shown and the valuable assistance extended by various technologists.

I also would like to convey special thanks to Messrs. Crookes Bros., Renishaw.

Mr. Rault, the Chairman, said that it was rather rare to obtain a valuable contribution of this nature, from a practical pan boiler. He said that this paper was a continuation of the one written by Mr. Ducasse last year. Mr. Rault remarked that a deputation invited by the Council went to Renishaw to see the pan control instrument under actual working conditions. A pan boiler from another factory, who had no experience of the instrument, was quite successful in boiling a pan with the instrument alone. After this there was a discussion, when various questions were asked and satisfactorily answered. He was so satisfied with the instrument that he took it to Mount Edgecombe, where it was placed side by side with the cuitometer, as shown on the graph for the 3rd massecuite. He was quite satisfied with its working.

Mr. Elysee said he had tried the machine out in the laboratory with varying densities and varying temperatures. (He demonstrated his findings on the blackboard.) He said that he found that an increase in temperature gave a regular increase in reading on the instrument. This he found was due to the evaporation of the syrup sample under tests. He then tried out another test where the temperature was kept constant and water was added drop by drop to lower the density. Again the machine faithfully recorded differences in density. He found in the laboratory, by introducing $SO_2$, that this had a great effect on the readings. These tests were made parallel with the cuitometer. The cuitometer, however, did not show any differences with decrease of $pH$. This would account for the difficulty experienced by Mr. Ducasse when boiling week-end syrups. He found that air occluded in the syrup sample through speeding up the stirrer used also to affect the readings. He duplicated these tests on first and third molasses with very different results from those obtained on syrups. When the machine was fitted to the vacuum pans, he found that scaling occurred. There was a difference between the first day's readings and subsequent ones. He had to alter Mr. Ducasse's electrode to get it into the pan, which meant that the electrode had to be ground down, so that it became almost a solid core. He found on dismantling the electrode, a black deposit on the discs, which he thought was due to sulphur.

Mr. Tonner asked what, was the difference between this machine and the ordinary cuitometer.

Mr. Ducasse replied that in the case of most sugar factories there were tremendous variations in current, which affected the cuitometer, but of course this did not affect his instrument. Variations in current led readings to be unrealiable. In his case he said his machine was not dependent on outside fluctuations in current.

Mr. Elysee said that he found enormous variations in the cuitometer at Amatikulu.

Mr. Calbraith supported this, saying that he had similar difficulties with the cuitometer at Sezela, so when he heard of Mr. Ducasse's instrument he installed them especially for C massecuite and he found that he got much better results from Mr. Ducasse's instrument. The pan boilers took to the instrument immediately, and were quite upset when the instruments had to be taken away and returned to Renishaw.

Mr. Phipson enquired what massecuites the machine had been tried out upon. He also considered an important advantage of the machine was the low cost.

Mr. Ducasse said that in its present form, without a recorder, the price was £35, but even with a recorder added, it would be much under £100.

Mr. Rault enquired if the machine would work satisfactorily on very pure massecuites.

Mr. Ducasse replied that he thought that it would be successful, but it would probably be necessary to increase the size of electrode.

Mr. Rault said that one of his pan boilers had said that he could notice differences in concentration rather more quickly than the machine recorded them.

Mr. Hardy bore out this contention.

Mr. Elysee pointed out that the cuitometer also showed a time lag, and this instrument would also do so for the same reason, which was in his opinion solely to the poor circulation in the pan.

Mr. Bax said that cuitometers were used in Mauritius for all massecuites and that he found that they were more accurate for C massecuites, but in general the strikes using the cuitometers were very, very satisfactory.
Mr. Elysee said that the machines were tried out at Amatikulu, specially because of the introduction of slurry graining, as in this case it was necessary to know exactly at what point to introduce the slurry. He found the refractometer gave the most reliable results, but this did not apply to B and C massecuites, for which products the catapult or Mr. Ducasse's instrument gave reliable results.

Mr. Tonner said that when using pre-cured syrups such as the liquor from the char in the refinery, the ash content was very low, and he wondered if any electrical, instrument could give reliable results, because of the small amount of current passed. He said he was particularly interested in the use of such instruments for his lower grade massecuites and he wondered if the charts prepared for syrups of say 80° purity would be reliable, when later on the syrup purity changed to 85.

Mr. Ducasse replied suitably. In reply to Mr. Hardy, Mr. Ducasse said the machine had proved quite reliable on A massecuites, which were compiled from syrup alone.

Mr. Sergeant asked if anybody had used, such an instrument on the crystalliser to keep a check on dilution.

Mr. Ducasse said the instrument could probably be used, but he would not like to say how accurate it would be.

Mr. Elysee said that although he had not much experience with this, he thought Mr. Ducasse's instrument was so sensitive that it could be used with success on the crystalliser. He said to get the utmost success from the instrument the electrodes should be changed with every graining.

Mr. Rault pointed out that as Mr. Elysee had shown, the temperature made a big difference, apart from density, so if one wanted to control dilution alone there would be another factor interfering, namely, the drop in temperature during cooling in motion.

Mr. Galbraith said an important point in factory management was the tightening up of the 3rd massecuite and he had found that for this purpose the machine was extremely reliable.

Mr. Hardy asked if the instrument could be used as a density indicator for the syrups leaving the evaporator?

Mr. Ducasse considered that for this process there might be too much scaling up of electrodes.

Mr. Elysee thought the instrument could be used with success for measuring densities of syrup, provided this density was kept within certain limits.
REPORT ON THE PERFORMANCE OF A CONTINUOUS SUGAR CENTRIFUGAL MANUFACTURED BY THE ESCHER WYSS CO. OF SWITZERLAND

By P. E. BOUVET

Introduction

The machine belongs to a type of continuous centrifuge that has been in operation in the chemicals industry for a number of years already, where it has given full satisfaction for the separation of crystals from mother liquor, high viscosities being seldom encountered in this type of operation. In the sugar industry, however, especially in the raw sugar mills, the high viscosity of the mother liquor renders this separation much more difficult.

In order to cope with these high viscosities the Escher Wyss Company have modified their original design and have produced two types of machine: the C4/2 and subsequently the C4/4, which is an improvement of the C4/2. The C4/2 was in operation in 1953 at Saint-Antoine and though the results achieved proved that a great step had been accomplished in the direction of a continuous operation, they were not convincing to the sugar technologists of the raw sugar mills.

The performance of the C4/4, however, which is the object of this report, has proved to be superior to the previous type and the author has no hesitation in stating that it can be operated commercially with success. At a later stage in this report we shall deal with its advantages and disadvantages as compared with the standard type of centrifugals.

Brief Description and Operating Principles of the C4/4

Briefly, the machine consists of a series of four consecutive horizontal, perforated baskets which rotate continuously at constant speed during all the time the machine remains in operation.

The Massecuite is fed into a funnel which is set concentric to the baskets and is accelerated gradually to drum speed as it flows out of the feed funnel. A cake of crystals is deposited on the screen of the first drum or basket, filling the space between the basket and the rim of the funnel. To remove the cake an hydraulically-actuated pusher moves a short distance, shoving the cake along the basket the length of one stroke. Dry cake flies off the end of the first basket on to the second and so on until finally it is discharged through the discharge opening on the sugar conveyor underneath. The pusher then returns, and additional cake is deposited before the next stroke. The frequency of the strokes may be adjusted and is generally set to handle slightly more than the anticipated maximum production of solids.

As the cake moves along the haskets the mother liquor is spun oil and is led from the casing through a manifold, where the undiluted molasses is discharged separately from the diluted molasses. (By undiluted molasses is meant the green molasses to which neither steam nor wash water has been added.)

The pusher is activated by oil pressure and operates very smoothly. The thickness of the cake is limited by the annular space between the inside of the first, perforated basket and the outer circumference of the removable ring of the feed funnel. The diameter of this ring and the frequency of the pusher control the capacity of the machine. The low acceleration of the massecuite as it is brought up to basket speed and the smooth action of the hydraulic pusher, relatively free from any cutting action on the crystal, make this machine suitable for sugar crystals.

Power Consumption

One of the major advantages of the Escher Wyss centrifugal over the standard types of modern high-speed centrifugals lies in its very low power consumption. Moreover there is a complete absence of peaks in the load characteristics (except on starting, of course). The maximum amperage recorded during the test runs at Saint-Antoine was about 45 amperes for a sugar output of 7 tons per hour and a grid voltage of 400 volts.

Aims of Tests and Methods of Testing

The aims of the tests were to find out:

1. The output of the machine.
2. The quality of the sugar produced, compared with that from standard centrifugals.
3. The quality of molasses compared with those from standard centrifugals.
4. The general behaviour of the machine under actual working conditions.

Though the machine was intended to operate on "A" massecuite, several trials were conducted on "B" massecuite as well. The standard of comparison
at the Saint-Antoine mill was a battery of belt-driven 36 in. d.a., 1,000 r.p.m. machines and at F.U.E.L. a battery of high-speed electric centrifugals of a modern design.

All the tests results have been set out in tabular form. Curves have been drawn to bring out more clearly the relationship existing between temperature and viscosity of mother liquor and also to show the influence of speed of rotation on the crushing action of the pusher mechanism.

Table I shows the result of all the tests carried out by the author and the Escher Wyss engineer, while Table II shows the results of 105 routine analyses carried out by the mill laboratory staff.

Influence of Viscosity

One of the most important factors concerning the separation of crystals from their mother liquor is viscosity.

This is specially true with a continuous centrifugal of the type under consideration due to the facts that:

(a) The "gravity factor" of the machine is comparatively low.

(b) The length of time available for the purging of the molasses is short.

It is obvious that the viscosity of the mother liquor may reach a point such that the resistance to its outward flow (under the impulsion of centrifugal force) may become so high that there may not be enough time for all the molasses to permeate through the cake of crystals during the time taken by the cake to move along the baskets, and consequently some of the mother liquor is discharged with the sugar. When this happens it means that the rate of admission of massecuite to the machine is greater than the rate of discharge of the corresponding quantity of molasses, and the only remedy then is to reduce the number of strokes (so as to increase the time of travel of the travel of the cake) which results in a decrease of output. Thus we are led to the conclusion that there exists a critical number of strokes for a massecuite of given characteristics beyond which complete separation of crystals from mother liquor is impossible.

This is exemplified by comparing tests 20 and 22 of Table I. Both tests were carried out on B massecuite. Test No. 20 shows that the number of strokes was 21, with a molasses viscosity of 2,200 cp. at 55°C, which is unusually high, whereas in Test No. 22 the number of strokes could be increased to 34 with a molasses viscosity of 760 cp., which is abnormally low.

It is true that in the case No. 20 the r.p.m. was 800, whereas in the case of Test No. 22 the r.p.m. was 900. The difference in output however cannot be attributed to the increase of r.p.m. and it will be shown further on that an increase of 100 revolutions per minute has little effect on the output of the machine, all other conditions remaining the same.

This critical number of strokes for A massecuite was never reached. It will be noted by referring to Table I that up to the 9th September, the number of strokes was set at 33, which was the maximum possible. After this date a new oil pump was fitted, which permitted a maximum number of strokes of 48.

It will be observed that again the machine was operated at the maximum rate and it would seem that the critical number of strokes for the type of "A" massecuite, as was found at Saint-Antoine during the second half of the campaign, lies above 48.

Table III and the related curves illustrate the following facts:

1. The marked influence of temperature on the viscosity of molasses and hence the importance of curing at as high a temperature as practically permissible. This is true for all types of centrifugals.

2. The wide difference observed in viscosities of different massecuites of about same Brix and purity from the same and different mills.

3. The marked influence of repeated boilings on the viscosity of boiling house products.

Moreover there seems to exist no relation between Brix and viscosity in the case of molasses. Thus referring to the temperature-viscosity curves for molasses it will be seen that curve No. VIII refers to a massecuite having a Brix of 93.6, whereas No. VI refers to one of 94.6 Brix.

One more important fact is borne out of these viscosity determinations: repeated boiling increases viscosity of mother liquors, as was proved by shifting from the "Old" three boiling systems, where a certain proportion of "A" molasses is recirculated on the A massecuite, to the "New" three boiling system where no molasses is used for boiling A massecuite. This point is illustrated by curves No. II and III—No. II refers to the average of live molasses obtained whilst using the "Old" system (Tests Nos. 11, 13, 17), Brix 86.8 and purity 63.3, whilst No. III refers to the average of two molasses obtained (Tests Nos. 14 and 16) whilst using the "New" system, Brix 80.8, purity 59.1. The difference is significant.
Influence of the Crystal Content of Massecuite on Output of Sugar

The capacity of the machine can be assessed in two ways:

1. By measuring the volume of massecuite going through the machine over a known period of time (i.e. the throughput).

2. By measuring the quantity of sugar produced over a known period of time (i.e. the output).

It would be more fair to the machine to measure the capacity in terms of volume of massecuite handled per hour. However since the specifications laid out involved an output rather than a throughput, the capacity tests were carried out in terms of weight of sugar produced per hour.

It is hardly necessary to stress the fact that a continuous machine of this type can only handle a definite volume of massecuite per unit under a given set of conditions. The output of sugar on the other hand for the same set of working conditions will depend largely on the quantity of crystals contained per unit volume of massecuite.

The information gathered by the author during the last campaign indicates that the crystal content of "A" massecuites (average purity about 75) for Mauritius mills averages 50 per cent. There are a few mills, however, where the practice is to boil high purity "A" massecuites (80° to 85° purity) with crystal quotient as high as 60 per cent.

Influence of Speed of Rotation on Performance

The machine at Saint-Antoine was run at: 800, 850 and 900 r.p.m., whilst that at F.U.E.L. was run at 750 and 850 r.p.m. The ratio of centrifugal force developed at 750, 800, 850 and 900 r.p.m. is 0.88; 1.00; 1.13 and 1.27 referred to a standard speed of 800.

Whereas no appreciable gain in output was observed by increasing the speed above 800 r.p.m. (see Table I), a definite increase in the crushing action of the reciprocating movement resulted, as is clearly indicated by Table V and the related curve.

Apart from the fact that the presence of very fine grains is detrimental to the refining qualities of raw sugar, these line grains bring about a decrease in the purity drop between massecuite and runnings, which is detrimental to the processor himself, and thus the optimum speed, according to the author is 800 r.p.m.

Influence of Wash Water and Steam on Purity Drop between Massecuite and Runnings Compared with Standard Machines

Tests were carried out with steam and water and water only, though most tests were performed using both steam and water. The rate of water added was measured by means of a rotameter incorporated in the machine.

The average rate of wash water added was about two litres per minute, which corresponds to ten litres per ton of massecuite for an output of six tons of sugar from twelve tons of massecuite.

The average Brix of undiluted and diluted runnings according to Table I are 87.0 to 86.5 and the average purities 61.6 and 62.3 respectively. Seeing that in any case a certain amount of dilution and dissolution is to be expected (as is the case for all types of centrifugals), due to the effect of steam, the amount of dilution and dissolution, that can be attributed to water alone in this case is small indeed, as testified by an increase of purity of only 0.7 degrees. On the other hand, a few tests were carried out with water only, with no adverse effects as testified by tests Nos. 14 and 17. As a matter of fact in the case of test No. 14 the purity drop was the greatest recorded, while the increase in purity...
of the runnings was only 0.2. On the other hand in the case of test No. 17 the purity drop was only 14.1 and the increase in purity 1.0, which seems to indicate that purity drop is more influenced by other factors than by wash-water when used at the rate of about two litres per minute.

It is unfortunate that there was no means of measuring the rate of flow of steam as the only control was a hand-operated globe valve with which it was very difficult to regulate the steam flow. A needle valve in combination with a pair of steam pressure gauges would have provided a far better means of control. As it was, it is to be feared that at times when the machine was running at high capacity the amount of steam may have been insufficient, whereas at other times when the supply of massecuite failed a little for example, the amount of steam may have been far in excess. This might explain why in a few isolated cases recorded in Table II differences in purity drops (as compared with standard machines) ranging from 4° to 8° were recorded.

Comments on Table II

In Table II are recorded the results of 105 comparative analyses on samples taken during actual working conditions, during day-time as well as at night, when the machine was under the control of the shift operators.

The average of all the results show that:

1. The average purity drops between massecuites and runnings were: 18.4 in the case of the standard type machine and 17.8 in the case of the Escher Wyss centrifugal, in spite of the fact that in ten cases the difference in purity drop between the two runnings ranged from 4.1° to 8.7°, which, as has been explained in the previous section, was probably due to the use of excessive amounts of steam. In any case the average difference is only 0.6° and cannot be considered as being a serious setback for the continuous machine.

2. The average polarization of sugar from the standard type of machines was 97.5° and for the Escher Wyss 97.4°, which indicates no significant difference.

3. The average humidity of the sugar from the standard type of machine was 0.79 per cent., whereas that from the Escher Wyss was 0.81 per cent., again showing no significant difference.

It must be emphasized, however, that the humidity of the sugar from the standard machines in this case is unusually high and certainly above average.

With standard machines the humidity can be decreased to a certain extent at will by increasing the time of spinning after the steam jet has been removed, whereas it is doubtful, in the light of the experience gathered over the period of testing, that the moisture content of the sugar can be decreased below the average obtained with the Escher Wyss centrifugal as there seems to exist no definite relation between capacity and moisture content (see Table I).

Output

From what has been said in the previous sections of this report one has certainly gained the impression that the output of the machine is dependent on a variety of factors, the most important being:

1. Viscosity of mother liquor.
2. Crystal content of massecuite.
3. Size and regularity of crystals.
4. Number of strokes per minute of pushing mechanism.

With the three first conditions constant, uncapacity will be dependent on the number of strokes, and provided the machine is equipped with, the new-oil pump (which is capable of imparting 48 strokes per minute), it can safely be stated that for an "A" massecuite of average quality (50 per cent, crystal; S.G.S....0.7 mm. or more, purity 77°) an output of 6 tons of sugar per hour can be expected.

Summary and Conclusion

1. Mechanical behaviour: during testing period of three months was excellent, apart from a slight defect in the deflector at the end of the fourth basket. The cause of this defect has been located and no trouble is expected there in the future.

2. Output: 6 to 7 tons of "A" sugar per hour to be expected with an average quality massecuite.

3. Energy Consumption: 40 to 50 amperes at 400 volts.

4. Operating Speed: 800 is considered the optimum speed in the light of the results obtained, with 48 strokes per minute of the pushing mechanism.

5. Cutting Action of Pushing Mechanism on Crystals: This can be considered negligible when operating at 800 r.p.m.

6. Action of Wash-Water: This is very small indeed when water is applied at the rate of not more than two litres per minute,
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TABLE II (continued)

RESULTS OF ROUTINE ANALYSIS BY THE SAINT-ANTOINE LABORATORY STAFF

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### Table III

**VISCOSITY DETERMINATION ON "A" RUNNINGS**

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<tr>
<th>No.</th>
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<th>13</th>
<th>14</th>
<th>16</th>
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<td></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Fuel</td>
<td>Saint-Ullix</td>
<td>Bennebois</td>
<td>St. Arnaud</td>
<td>Medine+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Residue</td>
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<td>80.3</td>
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<td>104.3</td>
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<td>78.8</td>
<td>74.9</td>
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**Legend**

- M.C. (end of campaign) treated in Werkspeur
- No. 1: Old "Three-Boiling-System"
- No. 2: New "Three-Boiling-System"
- R = Running
### TABLE IV

**COMPARATIVE DATA ON PURITY DROPS AT F.U.E.L.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Running</th>
<th>PURITY DROP</th>
<th>SPEED</th>
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<tr>
<td></td>
<td>Bux</td>
<td>Dirty Bux</td>
<td></td>
</tr>
<tr>
<td>8.XI</td>
<td>91.4</td>
<td>67.9</td>
<td>86.2</td>
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<td>22.XI</td>
<td>91.4</td>
<td>67.6</td>
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</tr>
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<td>27.XI</td>
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<td>86.8</td>
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<tr>
<td>AVERAGE</td>
<td>91.4</td>
<td>67.1</td>
<td>86.6</td>
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</table>

N.B. Data for each day represents the average of four tests.

### TABLE V

**SIEVE ANALYSES**

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<th>Test No.</th>
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<td>D.M. N.</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Openings (mm)</td>
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<td>33</td>
<td>33</td>
<td>53</td>
<td>46</td>
<td>48</td>
</tr>
<tr>
<td>Ress. per Ml.</td>
<td>750</td>
<td>1,500</td>
<td>100%</td>
<td>1,000</td>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>Above 5</td>
<td>1.2%</td>
<td>1.0%</td>
<td>5.3%</td>
<td>4.7%</td>
<td>17.4%</td>
<td>19.6%</td>
</tr>
<tr>
<td>5-6</td>
<td>12-1.02</td>
<td>6.8</td>
<td>7.3</td>
<td>13.25</td>
<td>17.05</td>
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<td>6-8</td>
<td>1.02-0.75</td>
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<td>23.3</td>
<td>25.23</td>
<td>23.86</td>
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<td>8-12</td>
<td>0.75-0.49</td>
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<td>32.3</td>
<td>46.86</td>
<td>42.9</td>
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<td>Under 12-16</td>
<td>10.3-6.386</td>
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<td>11.7</td>
<td>6.4</td>
<td>5.85</td>
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<td>16-6.386</td>
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<td>4.3</td>
<td>3.8</td>
<td>3.85</td>
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<tr>
<td>Specific Grain Size</td>
<td>0.60</td>
<td>0.61</td>
<td>0.67</td>
<td>0.79</td>
<td>0.82</td>
<td>0.85</td>
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<tr>
<td>DECREASE IN SPECIFIC GRAIN SIZE</td>
<td>1.64%</td>
<td>4.28%</td>
<td>3.53%</td>
<td>8.23%</td>
<td>8.46%</td>
<td>11.27%</td>
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<td>Temperature (°C)</td>
<td>40</td>
<td>45</td>
<td>50</td>
<td>55</td>
<td>60</td>
<td>65</td>
</tr>
<tr>
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<tr>
<td>23-Nov.</td>
<td>4.100</td>
<td>4.000</td>
<td>3.350</td>
<td>2.200</td>
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<td>-</td>
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<tr>
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<td>1.150</td>
<td>1.650</td>
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<td>3-Dec.</td>
<td>3.500</td>
<td>2.000</td>
<td>1.100</td>
<td>1.650</td>
<td>-</td>
<td>-</td>
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<tr>
<td>19-Nov.</td>
<td>3.100</td>
<td>1.750</td>
<td>1.600</td>
<td>0.50</td>
<td>700</td>
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<tr>
<td>19-Nov.</td>
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<td>1.400</td>
<td>700</td>
<td>400</td>
<td>-</td>
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</tr>
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<td>1.020</td>
<td>500</td>
<td>600</td>
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Temperature Viscosity Curves
50\% pure sucrose solution
Data from international critical tables

GRAPH 1
Viscosity Concentration Curve of Pure sucrose solutions
I. SAINT-ANTOINE. Average of tests 4, 6, 7, 10. Brix 88.1; Purity 60.9 (old 3-boiling)
II. SAINT-ANTOINE. Average of tests 11, 13, 17. Brix 86.8; Purity 63.3 (old boiling)
III. SAINT-ANTOINE. Average of tests 14, 16 (new boiling system). Brix 85.8; Purity 59.1
IV. FUEL. Brix 83.6; Purity 54.8
V. FUEL. Brix 87.3; Purity 54.2
VI. MEDINE (new boiling system). Brix 94.6; Purity 85.2
VII. SAINT-FELIX. Brix 89.8; Purity 56.9
VIII. UNION SAINT-AUBIN Brix 93.3; Purity 49.4
7. **Effect of Viscosity:** It is important to keep the viscosity of the products to be treated to a minimum. In this connection the makers were justified in specifying a curing temperature of 55°C.

8. **Effect of Grain Size:** This is important and is the principal factor influencing the purity drop, as some of the sugar crystals that are smaller than the basket perforations find their way out with the runnings.

9. **Polarization and Humidity of Sugar:** The aim in Mauritius is to produce a raw sugar of 98.5 Pol. The average of 0.105 analysis of the Escher Wyss sugar is 97.4 (against 97.5 for the standard type of centrifugals) and the average moisture content 0.81 per cent. By drying, the same; sugar could be made to polarize 98°, whilst a more careful use of steam, provided means of control for that purpose are incorporated in the machine, would enable the user to produce a higher purity sugar.

**Conclusion**

The Escher Wyss continuous centrifugal type C4/4 is very suitable for the curing of high-grade massecuite, provided the massecuite temperature be not less than 50°C at the time of curing. Moreover since the sugar cured in this machine has a high moisture content it is essential, from the point of view of quality of final product, that the sugar be further dried in an efficient dryer.

It is to be expected that this machine will be rendered suitable for curing of "B" massecuite as well, after a few minor alterations have been made to the present design.

In its present form, however, it is not to be recommended for the curing of lower-grade massecuite.

A new type is being designed, however, which will be capable of handling low purity products.

Mr. Walsh, at the conclusion of the reading of the paper, mentioned it appeared from the description of the operation of the machine it was really a batch centrifugal, only the speed being constant. Prior to the centrifugals, the process of sugar manufacture was continuous. At the vacuum pans it became a batch process and a much more variable produce. On the latest high-speed standard centrifugals adjustments could be made at various stages in the cycle to deal with the variable nature of the massecuite. A continuous machine suffered from the disability that it was not easy to make provision for varying adjustments. One of the points claimed for a continuous centrifugal was the low power required and this was an important consideration. While the high output was also reported to be an advantage, the capacity given, in the paper for this machine was not even as high as could be obtained on some of the high-speed standard machines on the market at present.

Mr. Bouvet contended that it was a continuous machine for the massecuite was continually flowing into it and sugar crystals discharged continually. He likened it to a reciprocating pump or steam engine. The quality of different massecuites certainly varied from batch to batch. Adjustments could be made to allow for this by reducing the feed to the machine and varying the quantity of water required. The machine was operated on varying types of massecuite. Towards the end of the season some very bad cane had been received, yielding a molasses content of 6 per cent, on cane. He said that he had quoted a low figure for output, actually he had obtained up to eight tons sugar per hour with suitable massecuites.

Dr. Douwes Dekker said that people in countries where new machines had not yet been tried out had to rely on notices and reports in the sugar literature, some of which might be too optimistic. He was therefore glad that somebody with practical experience of these machines had given us his experiences to be published in our Proceedings as an objective report. He thought that having to heat the massecuite meant there would be a chance of remelting some crystals and care therefore must be used to obviate this. He commented on the grain size of 0.7mm. In Natal the average size was smaller and we could not expect as good a performance on our sugars.

Mr. Bouvet pointed out that the size given referred to A massecuite only. In the new three boiling system the A massecuite was boiled from syrup only. This had lowered the viscosity as compared with the old method and the crystal size increased enormously.
Mr. Perk asked if the perforations of the basket in the continuous machine were bigger or smaller than of standard machines. He also wanted to know the diameters of the baskets and the speed of the continuous machines, so that he could calculate "g" for them.

Mr. Bouvet gave the speeds of the standard machines used and said that the basket perforations so far were larger in the continuous one.

Mr. Farquharson said that he was most interested to hear this paper by an actual user of a continuous centrifugal; like Dr. Douwes Dekker, he had only reports in various journals and makers' claims on which to form an opinion. He had always been led to believe that Natal sugars were more "difficult" than elsewhere in the world and, for this reason, he wondered if the performance of such a machine could be repeated with our sugars here.

He said that the management of every sugar factory was concerned with the labour problem and he asked what labour force was required to operate this machine as against the standard type of centrifugal.

He was very glad to note the emphasis which Mr. Bouvet placed on reducing the viscosity of the massecuite by heat. This was a most important condition for good work with any type of centrifugal, but unfortunately, few factories went very far with this. There seemed to be a general fear, as expressed by Dr. Douwes Dekker, of remelting some of the crystals.

In his opinion, one of the greatest advantages of the continuous centrifugal lay in the steady, continuous load on the motor, which could be operated at full load, and therefore high power-factor all the time, and if, as seemed to be indicated in this case, power was taken from the grid, this was a most desirable feature from the power-cost point of view. It was also an important point where a factory's own power station had no great overload capacity.

Mr. Bouvet replied that as far as labour was concerned, a mill, crushing 100 t.c.h. would require only two machines for A massecuite and this would demand the attention of only one operator.

Mr. Rault enquired how long a massecuite took to go through the machine, or rather from the time the massecuite entered until the sugar was discharged.

Mr. Bouvet said that the length of the machine was only about three feet and the whole time involved would be about one-and-a-half minutes. He said that the machine had to be thoroughly cleaned once per shift.

Mr. Galbraith enquired if these machines had been tried out on white sugar.

Mr. Bouvet said that he had heard that in Java a similar type of centrifugal, a two-stage machine, was operated on white sugar.

Mr. Grant said that this most interesting paper was the result of our inviting delegates from overseas. One point he would like to comment on was the high moisture content of the sugar. This would probably entail the use of a dryer, which would have to be added to the costs in assessing the total capital expenditure necessary for the installation of these machines.

Mr. Bouvet replied that the cost of one of these machines was less than that of one high-speed centrifugal of the same capacity.

Mr. Beesley, referring to the application of continuous centrifugals in Java, quoted the following dimensions of a two-stage machine he had seen employed there as a fore-worker for mill white sugar.

Basket r.p.m...725 r.p.m.
33 h.p. drive motor, 3-phase, 225 volts...28 amp.
Machine handles 4 tons/hr. sugar as a fore-worker on A's and could be employed on B's.
A's use 2.3/4 litres/min. 70°C. wash water
B's " 3.1/2 " 70°C. "
Massecuite temperature...70°C.

Mr. Walsh referred to the crushing action of the pusher and the conclusion drawn that no crushing action took place if the speed were kept down to 800 r.p.m. He wanted to know if this was determined by microscopical examination.

Mr. Bouvet said that he did not want to go into a long description of the method used to determine the crystal size, which was that of the Java Sugar Experiment Station, but he assured Mr. Walsh that the tests were done very carefully, using standard equipment.

Mr. Rault stated that he had found it difficult to sift raw sugar in determining the crystal size, as it tended to stick to the sieve.

Mr. Bouvet replied, that the difficulty was completely overcome when the method he had indicated was vised. Mr. Rault could find all the necessary information in a paper published by Dr. Douwes Dekker in the South African Sugar Journal of February, 1952.
THE TOPPING OF SUGARCANE IN MAURITIUS

By S. STAUB

During the 1954 crop a study was made on the composition of the different parts of the sugarcane with a view to determining the point at which it would be most economical to top the cane. The study was made at Reunion Sugar Estate as this estate covers regions having varying rainfalls and soils.

Nine experiments were made on the variety M134/32. Individual experiments consisted in harvesting a number of complete stools of cane in order to have about sixty canes. A smaller number of canes does not produce an adequate weight of some samples. The number of complete stools so harvested varied from six to nine. It was preferred to harvest every cane in a stool rather than to sample canes at random in a field because it was believed that this method would be more representative of practical conditions. Indeed under the conditions prevailing in Mauritius there is a great variation in sucrose content and juice purity between individual canes in the same stool; this variation is much greater than that between individual complete stools. Each cane was cut into seven parts as indicated in Fig. 1.

The reference point was the point of attachment of the first partially green leaf to the cane stalk. The two nodes above that point were numbered 1 and 2 and the three nodes below a, b and c. Part No. 3 is the white top above node No. 2 and part d is the remainder of the cane below node c, these parts were composited for all the canes in one experiment, the weights of the composite samples were determined and the samples were then crushed separately. On the various juices obtained the degree Brix, sucrose per cent, and purity were determined. These results together with the percentage weights of each part are given in Table I.

The available sucrose in each part was then calculated on the assumption that the percentage of fibre in all the parts was constant and equal to 12.5 per cent. This is of course not strictly correct but is sufficiently accurate for the purpose in view. The method of calculation is given hereunder by way of illustration.

Figure 1. Method of sampling used in the experiments.

![Diagram showing method of sampling](image)

Available sucrose in part per cent, total cane
\[ \frac{w}{100} \times \frac{100 - 12.5}{100} \times 0.9 \times 0.95 \times 0.99 \left( \frac{p - 40}{99 - 40} \right) \times 0.99 \]

where:
- Percentage weight of part \( W \)
- Fibre per cent, \( = 12.5 \)
- Factor for converting sucrose per cent, juice extracted into sucrose per cent, absolute juice, \( = 0.9 \)
- Sucrose per cent, juice extracted \( S \)
- Mill extraction, \( = 0.95 \)
- Purity of sugar manufactured, \( = 99^o \)
- Purity of juice extracted, \( = p \)
- Purity of final molasses, \( = 40^o \)
- Boiling house efficiency, \( = 0.99 \)

The results obtained are given in Table II.
### TABLE I—SHOWING THE COMPOSITION OF VARIOUS PARTS OF THE SUGAR CANE

<table>
<thead>
<tr>
<th>B R I X</th>
<th>SUCROSE PER CENT. GRAM</th>
<th>P U R I T Y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 2 1  a  b  c  d</td>
<td>3 2 1  a  b  c  d</td>
</tr>
<tr>
<td>Expt. I</td>
<td>7.90 11.00 13.65 15.30 16.04 17.99 20.51 2.31 6.00 9.87 12.37 14.41 15.87 19.35 41.0 63.3 72.3 80.9 85.1 87.1 94.3</td>
<td></td>
</tr>
<tr>
<td>Expt. II</td>
<td>7.74 10.26 11.46 13.32 15.71 18.02 20.73 1.82 4.63 6.57 9.29 12.48 15.26 19.44 25.1 44.8 57.3 69.8 79.4 84.8 93.8</td>
<td></td>
</tr>
<tr>
<td>Expt. III</td>
<td>7.54 9.67 11.03 13.50 15.76 19.31 20.87 1.98 4.39 7.50 11.34 15.26 17.46 19.86 26.3 45.4 61.4 78.5 86.0 90.4 95.2</td>
<td></td>
</tr>
<tr>
<td>Expt. IV</td>
<td>7.46 9.12 10.69 13.34 16.30 18.10 20.37 2.31 5.98 8.93 12.97 17.17 20.25 23.2 40.7 55.5 71.0 80.5 89.5 92.3</td>
<td></td>
</tr>
<tr>
<td>Expt. V</td>
<td>7.64 10.93 14.12 15.06 17.51 21.05 21.26 2.66 5.09 8.06 12.03 14.84 16.82 20.00 34.8 60.3 84.2 97.8 84.8 86.8 94.1</td>
<td></td>
</tr>
<tr>
<td>Expt. VI</td>
<td>7.78 10.64 12.47 14.42 16.29 18.13 21.31 2.32 5.15 8.08 10.60 13.48 15.02 20.22 29.8 57.8 64.8 79.4 82.8 85.8 94.9</td>
<td></td>
</tr>
<tr>
<td>Expt. VII</td>
<td>7.68 10.67 11.75 13.65 15.24 17.24 20.93 2.36 5.82 7.47 9.93 12.82 15.36 19.55 30.7 62.7 63.6 72.8 84.1 89.1 93.4</td>
<td></td>
</tr>
<tr>
<td>Expt. VIII</td>
<td>7.19 9.00 10.21 12.37 14.94 17.65 20.39 1.65 3.07 5.45 8.50 12.08 15.54 19.12 23.0 44.1 53.4 68.7 80.9 88.1 93.8</td>
<td></td>
</tr>
<tr>
<td>Expt. IX</td>
<td>7.41 8.64 9.24 10.19 12.11 14.40 20.87 1.72 2.62 3.81 5.24 7.82 11.18 19.16 23.2 33.8 41.2 51.4 64.8 77.4 94.4</td>
<td></td>
</tr>
</tbody>
</table>

| Arithmetic Mean | 7.54 10.00 11.69 13.64 15.87 17.77 20.75 2.24 3.02 7.06 9.04 12.98 15.50 19.50 29.53 40.54 50.64 71.98 80.91 87.09 93.99 |
| True Mean | 7.54 10.00 11.69 13.64 15.87 17.77 20.75 2.24 3.02 7.06 9.04 12.98 15.50 19.50 29.53 40.54 50.64 71.98 80.91 87.09 93.99 |

### WEIGHT — Kgs.

<table>
<thead>
<tr>
<th>3 2 1  a  b  c  d</th>
<th>Total c  d</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expt. I ...</td>
<td>7.940 8.018 8.090 1.001 1.138 1.307 82.860 95.683</td>
<td>7.9 0.9 0.9 1.0 1.2 1.4 86.7</td>
</tr>
<tr>
<td>Expt. II ...</td>
<td>6.933 6.972 6.941 6.913 6.934 6.952 48.300 58.276</td>
<td>10.4 0.9 0.9 1.1 1.4 1.6 1.8 82.8</td>
</tr>
<tr>
<td>Expt. III ...</td>
<td>7.187 8.998 1.154 1.415 1.576 1.640 40.168 54.078</td>
<td>13.3 1.8 2.1 1.7 2.6 2.9 3.0 74.3</td>
</tr>
<tr>
<td>Expt. IV ...</td>
<td>8.741 9.001 1.229 1.440 1.733 1.888 59.100 65.178</td>
<td>15.8 1.8 2.2 2.7 3.1 3.5 70.9</td>
</tr>
<tr>
<td>Expt. V ...</td>
<td>9.275 8.268 9.000 1.082 1.202 1.340 54.800 59.478</td>
<td>13.1 1.2 1.4 1.3 1.7 1.9 78.9</td>
</tr>
<tr>
<td>Expt. VI ...</td>
<td>9.069 8.881 9.997 1.156 1.201 1.342 55.000 70.980</td>
<td>13.3 1.2 1.4 1.6 1.8 2.0 78.4</td>
</tr>
<tr>
<td>Expt. VII ...</td>
<td>8.424 8.331 8.595 8.686 8.774 8.879 54.000 44.470</td>
<td>14.4 1.2 1.3 1.5 1.8 2.0 77.8</td>
</tr>
<tr>
<td>Expt. VIII ...</td>
<td>11.367 1.248 1.473 1.645 1.987 2.277 59.000 70.897</td>
<td>16.0 1.7 2.1 2.3 2.0 3.2 71.8</td>
</tr>
<tr>
<td>Expt. IX ...</td>
<td>11.344 1.088 1.188 1.410 1.580 1.650 77.000 94.650</td>
<td>22.3 1.1 1.2 1.5 1.7 2.0 80.2</td>
</tr>
<tr>
<td>Arithmetic Mean</td>
<td>8.674 8.709 9.013 1.187 1.357 1.460 53.840 58.330</td>
<td>13.00 1.31 1.92 1.79 2.09 2.31 77.08</td>
</tr>
<tr>
<td>True Mean</td>
<td>8.674 8.709 9.013 1.187 1.357 1.460 53.840 58.330</td>
<td>13.00 1.31 1.92 1.79 2.09 2.31 77.08</td>
</tr>
</tbody>
</table>
TABLE II

Available Sucrose in various parts of the Sugarcane

<table>
<thead>
<tr>
<th>No. of Part</th>
<th>Per Cent. of total Part</th>
<th>Available sucrose in Part per cent. total cane</th>
<th>Cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>12.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.3</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.5</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>1.7</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>2.0</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>2.2</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>78.6</td>
<td>10.90</td>
<td></td>
</tr>
</tbody>
</table>

Total: 11.47

Table III gives the effect of various points of topping for 100 tons of total cane.

<table>
<thead>
<tr>
<th>Point of Topping</th>
<th>Weight of Cane Harvested (tons)</th>
<th>Sucrose Extraction</th>
<th>Weight of Sugar Extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>between 3 &amp; 2</td>
<td>87.3</td>
<td>13.14</td>
<td>11.47</td>
</tr>
<tr>
<td>between 2 &amp; 1</td>
<td>86.0</td>
<td>13.31</td>
<td>11.450</td>
</tr>
<tr>
<td>between 1 &amp; a</td>
<td>84.5</td>
<td>13.50</td>
<td>11.490</td>
</tr>
</tbody>
</table>

We must now calculate how much it costs to cut, load, transport and manufacture in relation with the point of topping. The cost of cutting, loading and transport will be proportional to weight of cane and we can reckon that the cost of manufacture will be proportional to the weight of impurities. If we assume that the value of the sucrose in the factory bins is Rs 440/ton and that cutting, loading and transport costs Rs 8 per ton of cane and that the cost of manufacture (bagging and transport excluded) is Rs 6.50 per ton of cane topped between 1 and a, i.e. just above the point of attachment of the first partially green leaf, we have, then, for 100 tons of total cane, to the nearest rupee as shewn in Table IV.

This is a simplification of the problem as the value of the residues is not taken into consideration nor is it reckoned that the cost of manufacture decreases whilst the tonnage of canes manipulated increases. Also, cane will vary in composition and finally, in special cases where factories are frequently idle due to shortage of canes, the cost of manufacture of an extra two or three per cent, of canes can only be a matter of conjecture. On the other hand factories with a regular supply of canes and no capacity to spare will find it very expensive to crush an additional two to three per cent, of inferior cane.

However, if we consider the problem of topping isolated from related considerations, we see that in principle the cutting blow should be aimed just above the point of attachment of the first partially green leaf. In special circumstances it might be advantageous to cut slightly higher, one or two nodes above the point of attachment of the first partially green leaf; but it is quite certain that in no case should the topping be higher. The top 12½ per cent. of the total cane (leaves excluded) has a purity of less than 30°, and thus its introduction in the mill can only be a very grave disadvantage. I should like to thank Messrs. R. Leclezio and R. Thelemaque for their valuable help in carrying out these experiments, and Mr. E. Julienne, Manager of Reunion Sugar Estates for the interest he has shown in the work.

The President, Mr. Dymond said that this was the second paper we had had from our friends in Mauritius. This particular paper would prove of much interest to sugar people all over the world.

The paper was ready by Mr. Bax of Mauritius, as Mr. Staub was not able to attend the Congress.

Dr. Douwes Dekker said he agreed the subject was of great importance. Work had been done on similar lines in this country, some work at the S.M.R.I, and also some at the Experiment Station. Mr. du Toit had shown that the maturity of the cane was an important consideration.

Mr. du Toit asked whether there was any penalisation for planters sending in dirty canes.

Mr. Bax stated that there was no direct penalisation, but the estate authorities could refuse to take cane which they did not consider suitable for milling.

Mr. Bouvet pointed out that in Mauritius, cane was paid for on a purity basis, as well as on sucrose percentage and the presence of tops did affect the purity of the juice and planters were penalised if they sent in an abnormal quantity of tops.
reply to Mr. du Toit, he said there was no direct penalisation if planters sent in excessive tops.

Mr. Bax added that he agreed with Mr. Bouvet up to a point, but in general, planters were more interested in their weight of cane, than in the analysis, all the more so in the case of small planters, whose canes were mixed together for analysis.

Mr. du Toit asked what was the basis of payment for cane in Mauritius. Was it the C.C.S., or some other system?

Mr. Bax said that planters were paid a maximum of two-thirds of their extraction as analysed by chemists from the Central Board.

During the whole crop period, chemists from the Central Board visited all the factories and carried out regular analyses of all planters' canes, which were paid for on an extraction basis. The minimum weight of cane from which the cane samples were taken was about fifteen tons, which represented ten to twenty minutes' grinding, according to the tonnage crushed per hour. During that period the first expressed juice of the same cane was sampled at the mills. The sample of cane was sub-sampled and sent to the Central Board laboratory for fibre determination, from which the absolute juice per cent, cane was calculated. The sample of first expressed juice was analysed in the factory laboratory for brix and purity, from which those of the absolute juice were obtained and the "richness" thus calculated.

For the extraction, the average figures for the whole island were taken for mill extraction and molasses purity, while the recovery was calculated from the purity of the first expressed juice of the planter's cane, minus the purity drop between the average first expressed and the mixed juice, as found for both weekly in the laboratory figures.

Mr. du Toit inquired how the absolute juice purity was obtained.

Mr. Bax replied that the purity of the absolute juice was calculated for each planter's cane by deducting from the purity of the first expressed juice found, the purity drop between first expressed juice and absolute juice, as indicated weekly by the factory laboratory figures. He added that it was sometimes argued that the sampling of the cane could not be representative, but he considered that on the whole crop, errors would be compensating and he thought this system for assessing planters' cane was good, as any method had some drawback.

Dr. McMartin inquired what was meant by the reference point. Was it the first leaf turning green, or what?

Mr. Bax said that he understood that it was the first leaf that was yellowing.

Mr. Park said it was the third partially open leaf which was meant.

Mr. Dymond asked if any use was made of tops for planting purposes in Mauritius. This was particularly the case in Cuba. In this country, growers were used, to being paid in the past on the weight basis, and did not realise the losses that occured in factories through sending in immature tops.

Mr. Bax replied that over a limited period of time and over limited areas, tops were used for planting, although most planting was done with young canes from eighteen months to one year old.

Mr. Park said that in Mauritius, 75 per cent, of the; cane was planted after the crop was over. Some 25 per cent, was planted during the season. In high rainfall areas ratoons from the latter were superior to those from the former. Actually the amount of tops utilised was only about 10 per cent, of the total required for planting.

Mr. Steward said that it was obvious from Mr. Staub's paper and from the present discussion that cane generally was topped too high.

It was however difficult for planters to top the cane low and thus see tons of apparently good cane being left on the ground with the tops. If planters got into the habit of talking of their yields in tons of sucrose per acre instead of in tons of cane per acre they would come to realise that the extra cane left attached to the top was not as valuable as the rest of the stick and that the loss to them by correct topping was very small.

Dr. McMartin pointed out that the planting of cane tops was a very old Natal practice. Experiments made by the Experiment Station showed that tops were excellent material for planting, but this had long been realised. The Experiment Station had further recommended that for planting purposes cutting a longer top was useful.

Mr. Elysee pointed to the enormous amount of non-sugars introduced into the factory by poor topping. He therefore welcomed data affecting the £ s.d. aspect being introduced into this paper. He found some difficulty in appreciating the value in rupees rather than in £ s.d.

Mr. Bax pointed out that a rupee was worth about 1s. 6d.

Mr. Christiansen said that a bigger loss to planters who sent in immature tops, was the loss of plant
Mr. Rault pointed out that with the present system of using an average weekly Java Ratio for sucrose distribution, there was no inducement for a cane supplier to send a clean material, as the other man who sent extremely trashy canes scored materially by being allotted a sucrose content in excess of his true one through using a common juice factor. This free gift was at the expense of the clean cane supplier, as no penalty can be imposed on dirty canes.

Mr. Bouvet said that as long as we did not use a purity factor in South Africa the advantage would always be in favour of the growers who send in poor low sucrose and badly-topped cane.

Mr. Dymond pointed out that much of the cane used for planting should go into the mill and that if tops alone were used the good cane would go into the mill. Another very important point was the amount of trash which was sent in with the cane. By trash in this country was meant only the dry-leaves. He had carried out experiments which showed a maximum of 17 per cent, of dried trash in some cane as against less than 2 per cent, on well cleaned cane. If cane was properly cleaned the crushing period at Darnall would be reduced by a matter of about sixty-sixty days. He asked Mr. Bax if there was any penalty in Mauritius for trash.

Mr. Bax said that in the case of any unsatisfactory cane being sent into the factory, officials of the Central Board were called in to adjudicate, and they had the power of completely rejecting cane which did not conform to their accepted standard.

Mr. Dymond referred to pre-trashing practice carried out at Illovo, which he had noted was a common practice in Mauritius. He asked if this was still the case.

Mr. Bax said that owing to labour shortages this practice had rather fallen into disuse, except at the beginning of the season.

Mr. Boulle said that using tops alone for planting cost twice as much as using cane for planting. That was another reason why tops were not used for planting in this country, to the same extent as elsewhere.

Mr. Pearson said that although the mills might gain sixty-sixty days through the careful removal of trash, the growers might lose considerably more, as labour costs where pre-trashing was concerned were high. Something might be said for this practice where there were low yields, but not in the case of heavy yields, where the cane would begin to fall down, for it then was not economical. The only advantage to growers in pre-trashing was the extra cutting and loading he could get out of his labour.

Mr. Dymond pointed out that there were however planters in this country whose cleaning of cane compared with that carried out anywhere in the world, and he did not think those growers showed a loss from their planting activities. He would like to know from Mr. Pearson why the cane crop was allowed to grow for such a long period.

Mr. Pearson said that as far as he was concerned he would prefer to see the crops reaped whilst the cane was still upright and before the yields got to fifty tons per acre, when it fell down and was very difficult to harvest.

Mr. Elysee said that sending in the extraneous matter such as tops lowered the efficiency of factories and if this stuff were removed from the cane, the mills would be in a position to pay them more for their crop.

Mr. Palairet said that the figures given implied that there was one ideal break-point; if he cut below this the grower would lose more than the miller gained; whereas, if he cut above this, he gained little, if anything, and the miller lost much. A bonus-penalty scale would not meet this and would never be accepted by the Growers’ Association. The purity seems to be so closely associated with the point of topping that it should be possible to determine a purity figure which, on the average, corresponds to correct topping. If the miller were to make a small ex-gratia payment on all cane of purity above this figure (such as 6d. a ton of all cane of purity 88 or above) this would compensate the grower for the extra supervision involved, and the extra throughput and better quality juice would more than pay for this.

Mr. Steward said he would like to explain why some planters could top their cane well and others found it impossible to do so. The planter with a small crop could watch and train his boys, but on a large estate, where there might be upwards of 200 labourers to watch, this could not be done to the same extent.

Mr. Dymond pointed out that in the case of one planter, the cleanliness of whose cane should be visible to anybody travelling in Zululand, this grower cut a big crop of 12,000 tons.
SOME NOTES AND OBSERVATIONS ON
THE FIELD TRANSPORT OF SUGAR CANE

By EXLEY STEWARD

One of the major operations on every sugar farm or estate is the transport of the crop from the field where it is grown to the point where any further transport is no longer the responsibility of the planter. This point is either the locomotive line, a South African Railways siding or the mill yard. Being one of the important features of sugar planting, transport has a big influence on the cost of production and the object of this paper is to discuss briefly, various methods of transport with their relative advantages and disadvantages.

In a large section of the farming industry field transport has, during the last quarter of a century, evolved from the ox wagon stage through the portable tramline stage to the present ever-increasing use of road transport, either by means of lorries or by road tractors and trailers. The ox wagon method is not worthy of discussion as it has now, with a few exceptions, been discarded. It remains, therefore, to present only the portable field line and road transport methods, and in doing so it may be as well first to list the obvious advantages, or disadvantages, of the one method over the other. Let us then consider the advantages of road transport over field line transport. These are set out below, not necessarily in the order of importance, as no doubt mill managers, transport managers, field overseers or the planter will differ as to the importance of one advantage over the other depending on how it particularly affects himself.

Advantages of Road Transport over Field Tramline

1. A greater output per loader owing to the shorter distances the cane has to be carried.

2. Better supervision of loading as only a few lorries are loaded simultaneously, while, on tramline, a long string of trucks are all loaded at the same time.

3. Heavier truck weights, if load is transferred to truck by gantry crane. This increase is as much as 25 per cent., from an average of 3 tons to 3.75 tons per truck.

4. Less skill required to load a lorry or trailer, resulting in better use of any inferior type of labour that may have to be employed.

5. Larger number of units per gang allows of one or two duds, or smaller boys, to be absorbed in the gang.

6. Labour is not kept idle waiting for trucks that may arrive late.

7. No night work taking trucks from field to main line.

8. No labour expended on laying rails daily.

9. No tramline maintenance, such as the replacement of worn rails, sleepers, fishplates and bolts.

10. No animal drivers, brake boys, sand boys, etc., required.

11. Less draught animals required on the farm with consequent saving of stabling and grazing.

12. Grades for roads do not require such uniformity and can also be heavier than for tramline.

13. Greater mobility to reap any particular area at short notice, as may be required after an accidental fire or during periods of drought.

14. Elimination of possible damage to cane trucks due to capsizes or runaways in the field.

15. Quicker turn-over of cane trucks with consequent reduction of number required by the mill transport department.

16. Ability to take cane right up to the mill cane carrier, thus releasing basket trucks and S.A.R. trucks for use in areas at greater distances from the mill.

17. Use of lorry or tractor for other work in the off-season.

Disadvantages of Road Transport

1. Immobility during wet weather.

2. Highly-paid labour required as drivers. This, however, is more than compensated for by advantages (8) and (10) above.

3. Higher standard of housing required for drivers.

4. Provision of suitable off-crop work for drivers.

5. Maintenance expenditure on lorries, tractors and trailers. This is offset to a considerable extent by advantage (9) above.

It appears, then, that the advantages of road transport over field tramline outnumber the disadvantages in no uncertain manner. In fact the only
serious disadvantage is that of immobility in wet weather and this varies tremendously according to the type of soil or road surface in any particular area. On a very sandy farm, for instance, road transport may be even easier under wet, than under dry conditions, while, on the other hand, over black or reel soil farm roads lorries cannot operate at all until the roads dry out.

As to a comparison of costs between the two methods no definite statement can be made. Either method may prove the more economical depending on the conditions prevailing under which the transport is being carried out, which vary so considerably from place to place. Under general average conditions there is probably very little difference between the two methods in the final cost per ton. The decision to use field tramline or road transport must be made according to the conditions under which it is intended to operate. For instance if a farm already has adequate field tramline on hand, and permanent earthworks constructed over easy grades, it is more than likely that no change could be made for the better. On the other hand should new territory be opened up with no existing transport facilities it seems that road transport would be the more attractive proposition especially when it is borne in mind that the present cost of only one mile of 16 lb. track, complete with sleepers, etc., is £1,850.

The road transport method is itself divided into two systems, by use of lorries or by use of tractors and trailers, each system having advantages of its own. It is assumed that only Diesel driven lorries and tractors are under consideration owing to the very much higher running costs of petrol-driven vehicles, and further, that the load of cane from either lorry or trailer is transferred to the truck by a gantry or crane.

In order to compare the two systems of road transport the different advantages and disadvantages are set out below.

Advantages of Diesel Lorry over Tractor and Trailer

(1) Able to operate over longer distances owing to greater speed. Under normal working conditions a lorry carrying a double load, i.e. two truck loads can do eight trips of 10 miles, and deliver 16 truck loads per day. In an emergency over 100 miles per day has been achieved.

(2) Greater power. A diesel lorry of 120 b.h.p. will carry a load of 9 tons up a gradient where a tractor and trailer will fail with 4 tons.

(3) Over double the amount of working hours can be expected from a lorry during its lifetime.

(4) It is far easier to transport a dual load, i.e. two truck loads at a time, on a lorry. Although dual load trailers are in use they operate satisfactorily only under comparatively favourable conditions.

(5) Half the number of drivers will, be required, it being assumed that dual load lorries are being used, whereas in the majority of cases tractors haul a single load.

Disadvantages of Lorries

(1) Capital outlay for a unit, far greater. Although it may be noted that the outlay for one dual load capacity lorry is practically the same as for two tractors and four trailers, which would be required to do the same amount of tonnage.

(2) A lorry cannot be taken right up to the cutters in the field for loading to the same, extent as a tractor and trailer.

(3) Time taken for loading as against a tractor having a loaded trailer waiting. This is not considered a serious disadvantage as it is more than compensated for, except under very short haulages, by the extra speed of the lorry and by the saving of time in attaching a trailer.

(4) Lorries cannot be used for cultivation when not required for transport.

The decision whether to use lorries or tractors and trailers depends, once again, on the particular conditions on which the transport is to operate. It appears that for the smaller planter whose crop can be handled by one tractor and two trailers, over short distances and easy grades, that this method would prove to be the better. On the other hand for the large crop over long distances and steep grades the Diesel lorry should be more satisfactory. For the bigger planters, whose crops warrant it, or for the miller-cum-planter estates, a combination of the two systems is to be recommended, when, according to prevailing conditions, either can be used to its best advantage.

The costing of the various methods has been deliberately omitted as it is felt that it is too much of a controversial nature to introduce into the few observations that have been made in this paper, the object of which is only to open up a discussion on field transport, which, it is hoped, will prove interesting and informative.
Mr. Grant said that he was glad to have the opportunity of being in the chair for the reading of this paper, as some growers had mentioned to him during Congress that they felt that most papers would be of too high a standard technically for them to fully understand or to take part in the discussion. This was probably one reason why attendance by growers has at times been poor. However this paper was on a subject to which many growers were giving thought at the present. It was such that any grower or person with no technical training could enter into the discussion, and was an example of many papers which have been presented at our Congresses. He thought that the knowledge that such papers were presented, might encourage more growers to attend.

Mr. Boa then made the following contribution to the discussion: In 1948, 1950 and this year, the Sugar Association has made surveys of cane production methods. From the results of these surveys it can be seen that tractors and trailers are replacing motor lorries and portable tramline for transporting cane. In 1948 40 per cent, of growers used motor lorries, 17 per cent, used tractors and trailers and 21 per cent, used portable tramline. Now, motor lorries have been reduced to about 30 per cent., tramline to 14 per cent., while tractors and trailers have increased to 44 per cent., and although a few growers intend to buy heavy motor lorries, many are changing to tractor and trailer, so that by 1956 it is likely that 50 per cent, of growers will use tractors and trailers and only 25 per cent, motor lorries.

This change of method tends to show that the advantages which Mr. Steward has set out in his paper for Diesel lorries can only operate in very limited circumstances. These circumstances may be a distance of over ten miles; only about 2½ per cent, of growers carry their cane this distance.

Also, now that larger-wheel tractors are becoming more common, it is probably that trains of two or three trailers will become usual for longer road hauls of under ten miles. A 45 b.h.p. tractor should manage to transport ten to fifteen tons of cane on farm and main roads and about five to seven tons in field conditions, where the gradient does not exceed 1 in 3½. If the trailer brakes are adequate, this type of outfit travelling at twelve to fifteen miles per hour, should be safe on the road and that alone does much to commend it.

Mr. Steward in reply to Mr. Boa’s statement that one advantage which he gave in favour of the use of Diesel lorries was that they could operate only in very limited circumstances, he would point out that Mr. Boa’s deductions had been arrived at from figures submitted by planters in a general survey of transport methods. Now it may well be the case that the initial cost of a large Diesel lorry was the reason for the use of tractors and trailers figuring more prominently in the percentages quoted by him. He was of the opinion, however, that given the conditions as outlined in his paper, Diesel lorries could not be omitted from consideration when efficient, fast and economic road transport was required.

Mr. Boa mentioned, also, that with larger wheel tractors becoming more common, it was probable that trains of two or three trailers would become more usual. While appreciating the fact that a train of trailers may be the ideal at which to aim, he felt that the roads on practically all farms and estates are not of the standard required to allow of the operation of a train of trailers. He was sure that it had been the experience of most planters that operating only one trailer had often given them enough to worry about when, contending with sand, mud, sharp corners, steep gradients and the like.

It was axiomatic that good roads are the complement of successful road transport, and that meant more attention would have to be given to them, and more money spent on them, than had been done in the past, until the time was reached when it would be a practicable proposition to operate a tractor with a train of trailers.

In reply to Mr. Park, Mr. Steward said that cane was loaded on to the lorry by hand, but usually unloaded by crane. The loading of lorries divided into compartments was much easier than the loading of cane trucks, for a boy could just dump his load into a box on the lorry, whereas in loading cane trucks, the cane had to be properly placed—a matter of some skill.

Mr. Park enquired about the matter of loading cane mechanically. He thought that mechanical loading would be cheaper.

Mr. Steward pointed out the difficulties of terrain in a large portion of the sugar lands in South Africa which did not lend itself to mechanical loading.

Mr. Palairet said that for a large crop, tractors and trailers would pay best. With a smaller crop and a long haul, Diesel lorries should be used, whereas on a small crop and short haul, a petrol lorry would be best. Until a considerable number of cost accounts were available, dividing lines could not be drawn and individual growers must still use their own judgement.

Mr. Renaud said he thought that it would be agreed that a bonus system for loading could be more easily applied on a tramline than where lorries or tractor and trailers were used.
Mr. Steward said that in all cases the method of calculating the bonus was the same, although in the case of loading lorries, the bonus had to be divided among a larger number of labourers, so it was possible that a boy not pulling his weight in a lorry-gang would be paid more than he was entitled to as his share of the total bonus.

Mr. Renaud said that all our troubles revolved around labour and the smaller the number of boys the bonus had to be split amongst the more inducement there was for a boy to work harder.

Mr. Steward said that on a general average boys loading lorries could accomplish more and therefore earn more bonus than those loading trucks. Labourers preferred loading lorries or trailers to loading trucks, because of the short carry involved and also because they were not kept waiting for trucks.

Mr. Machin wanted further explanation as to why Mr. Steward considered the operation of lorries was cheaper than a tractor and trailers.

Mr. Steward replied that this was based on his own observation which showed that a lorry had a much longer life than a road-type tractor, so that depreciation on a lorry was less.

Mr. Machin said a lot of factors entered into it, but he thought that frequently too light a tractor was used for hauling, with the consequence of rapid wear. If a tractor of adequate size were used, there was no reason why the life of the tractor should not be just as long as that of a truck.

Mr. Turner enquired, when carrying heavy lorry or trailer loads, say nine tons, was any trouble caused to ratooning through compaction of the soil?

Mr. Steward replied that when running over the field a certain amount of damage was done to the roots and when using heavy Diesels it was inadvisable to take them right up to the cutters. The ideal method was to have roads laid out, so that all lorries or trailers could be loaded without leaving a road.
A NEW PATTERN SOIL SAMPLER

By B. E. BEATER

The soil sampler described in this paper was selected from a variety of makes which were experimented with. Once the writer had satisfied himself that the two-handled principle, incorporating two foot-pressure brackets as well, gave the maximum possible thrust, careful attention was devoted to the design of the cutting edge. About a score of differently designed cutting edges were manufactured and each design was tried out in turn, the object being to select one which would adapt itself to most known soil variations. It would be comparatively simple to design a sampler for a single class of soils, but when all factors had to be considered, a considerably more versatile product would be required. This increased demand for general serviceability must undoubtedly result in certain limitations being imposed upon the sampler.

A primary difficulty throughout has been the non-existence in this country of a supply of high quality steel tubing of 14-gauge and of uniform internal diameter of 1 inch. Such a material could be manufactured, but only to meet a large order. The writer, therefore, had to take what was available, but latterly was fortunate in securing an odd supply of Black Vereeniging special bending 12-gauge tube of uniform 1 inch internal diameter. As this material was still too thick it was machined down in the process of manufacture.

The actual procedure for manufacture of the sampler is as follows: Select an 11" length of the steel tubing and after facing the end, set to $\frac{1}{4}$ to $\frac{11}{2}$ taper and machine back to 9". Draw the cutting head down to an internal diameter of $\frac{11}{2}$ (2 cms), and mill four teeth to a squared-off depth of $\frac{3}{4}$ (11/2 cms) into the head. The four squared-off sections between the teeth are now ground back, resulting in four 3/8" flattened faces tapering back about 11/2" from the tip. This uneven outer shape of the tube appears to assist penetration in hard dry soils. The point should finally be correctly hardened.

In order to attach the tube to the handles, which consist of $\frac{3}{4}$ heavy duty seamless conduit tubing, two 4" lengths of $\frac{3}{4}$ wide by $\frac{3}{4}$ thick shaped steel supports are first brazed onto the tube 9" from the tip. A connecting arm and ring of $\frac{3}{4}$ steel rod flattened at both ends is now brazed onto the arms $\frac{3}{4}$ up from the foot pressure brackets. This device not only gives strength to the arms but acts as a support for the sampling bag.

The actual sampling operation comprises a two-handed-and-right-foot thrust, using the weight of the body and accompanying the action with sharp twisting of the sampler from side to side. In the case of very hard soils, the sampler is aided by a "shuffling twist," as this opens up the ground around the cutting tip.

In all cases, to remove the core, invert the sampler and thump the tube with the palm of the hand, or give it a sharp stroke with a piece of wood. If the core fails to fall into the attached sample bag, support the bag with the left hand and thump the handles sharply on the ground. A gentle pressure may be applied with the finger to an obstinate core,
but under no circumstances—we repeat, under no circumstances—should the core be initially thrust in with the finger. Such a procedure may firmly lock the core in the tube, which incidentally must always be kept very clean inside.

To withdraw the sampler from the soil without difficulty it should be levered about in four directions, and the procedure of emptying the core into the bag can be carried out while proceeding to the next sampling site. If it is desired to incorporate surface litter, the sampler is hurled into the ground before twisting in. In the case of a heavy blanket of trash not required in the sample, a small patch of ground will of course have to be cleared. As the weight of each soil core is about 4 1/4 ozs., up to twenty-five samples can be taken with comfort before the attached bag need be replaced.

Experiment Station,
South African Sugar Association,
Mount Edgecombe.
March, 1955.

Mr. Dymond said that anyone who had had experience of taking soil samples should welcome this new type of soil sampler, which was a big improvement over the old type of soil auger.

Mr. Lintner said in these days of complicated lay-outs of plots in field experiments, it was necessary to take a large number of samples and using the usual type of soil auger presented a lot of problems, but this particular piece of apparatus allowed one to take a large number of samples in a short time. Mr. Lintner thought an improvement would be effected if the bottom bar to which the centre piece was attached, was made rather wider, that the handle-bars might be longer to suit a tall individual, and also that the handles themselves might be bigger. These minor modifications would not improve or detract from the efficiency of the instrument, but merely add to the comfort of those using it.

Mr. Boulle enquired of Dr. Beater if he did not find this new type an encumbrance in big cane as compared with the other type of soil sampler.

Mr. Schmelz said that he had taken over 3,000 samples with this sampler and in cane up to about ten months old and in all types of soil, and although at times it was difficult to push the sampler into the soil, it was still easier than the older type, which required hammering. A large number of samples could be taken in a short time. It was essential, however, to make sure that the sampling tube was perfectly clean.

Mr. Lintner said there was no difficulty in getting through large cane, one had only to turn the handles sideways and the handle then went through tall cane quite easily; even the bag proved to be no encumbrance.
The experiments with modified John Innes’ composites which are described in this paper were carried out on sugarcane fuzz and seedlings at the Mauritius Sugar Industry Research Institute following promising results obtained by the first writer with vegetables, flowering plants and tobacco at the Barkly Experiment Station of the Department of Agriculture.

(A) COMPOSTS

Both the original John Innes’ seed and potting composites have been modified to suit local conditions as follows:

<table>
<thead>
<tr>
<th>Original John Innes’ Seed Compost</th>
<th>Modified Seed Compost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 turfy loam</td>
<td>2 top soil</td>
</tr>
<tr>
<td>1 granular peat</td>
<td>1 granular material obtained by shaking decaying wood through 1/2” sieve</td>
</tr>
<tr>
<td>1 sand</td>
<td>1 top soil</td>
</tr>
<tr>
<td>2 lb. superphosphate</td>
<td>2 lb. superphosphate per cubic yard</td>
</tr>
<tr>
<td>1 lb. chalk</td>
<td>1 lb. chalk</td>
</tr>
</tbody>
</table>

The top soil for both the seed and potting composites was steam sterilized at 93°C for 5 minutes at low pressure.

The ordinary mixture used as control consisted of:

- Top soil ... ... ... 2 parts
- Farm-yard manure ... 1 part

The mixture used for planting fuzz was steam sterilized at 93°C at low pressure for about four hours. That used for potting seedlings was not sterilized. Some phosphatic guano was added to the mixture as usual.

Equal parts by weight of fuzz were sown in:

1. Common seedling flats 193/4”x131/2”x42/3” containing soil-manure mixture.
2. Common seedling flats containing modified J.I. seed compost.
4. Standard British seed boxes 14”x81/2”x2” containing modified J.I. seed compost.
5. Standard British seed boxes containing modified J.I. P₂ potting compost.

The object of the experiment was to compare:

- 1 and 3
- 1 and 5
- 3 and 5

1 and 2 and 4, the seedlings in 2 and 4 being pricked.

Fuzz from 14 different crosses has been used in the experiments, but that from five crosses only gave good germinations, the number of seedlings obtained being as follows:

<table>
<thead>
<tr>
<th>Cross No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1745</td>
<td>88</td>
<td>72</td>
<td>95</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>1747</td>
<td>591</td>
<td>560</td>
<td>600</td>
<td>840</td>
<td>752</td>
</tr>
<tr>
<td>1751</td>
<td>44</td>
<td>50</td>
<td>50</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>1752</td>
<td>162</td>
<td>168</td>
<td>120</td>
<td>120</td>
<td>124</td>
</tr>
<tr>
<td>1753</td>
<td>413</td>
<td>456</td>
<td>497</td>
<td>390</td>
<td>384</td>
</tr>
<tr>
<td>Total</td>
<td>1,298</td>
<td>1,362</td>
<td>1,470</td>
<td>1,346</td>
<td></td>
</tr>
</tbody>
</table>

There was, in all probability, no difference in the times taken for the fuzz to germinate, in the number of seedlings obtained and in the rate of seedling growth between the experimental and control flats.

A few cases of damping-off were noticed in the plots containing soil-manure mixture, but none in those containing the modified John Innes’ composites. The disease did not make much headway in the affected flats, except in one case, where it was acute.

Pricking

Experiments were made to determine the best stage of growth for pricking seedlings, and conclusively showed that this operation should be performed as soon as the seedling can be handled, that is, about five days after germination. There is then apparently no set-back.

Seedlings from experiments 2 and 4 were pricked in standard British cases containing modified John Innes’ potting compost at the rate of sixty seedlings per case. A loss of 5 per cent, only was recorded. The seedlings which had been pricked were the best.
Transplanting to Pots

One hundred seedlings from pricking boxes were transplanted to ordinary straw pots containing modified John Innes' potting compost, and one hundred seedlings from the same boxes were transplanted to control straw pots containing unsterilized soil-manure mixture.

The seedlings transplanted to pots containing compost seemed to perform better than those in the control pots up to about two weeks after transplanting, the best seedlings in the soil-manure mixture not being sturdier than those in the compost. There was, thereafter, distinct nitrogen deficiency symptoms in the experimental pots as a result of hoof and horn not having been added to the potting compost. The addition of a few grammes of sulphate of ammonia soon corrected the deficiency, the seedlings resuming normal growth five to six days after application of the nitrogen fertilizer.

(B) BASALT

Basalt dust was added to the ordinary soil-manure mixture at the rate of one part by volume of basalt to two parts of mixture, with a view to improving the physical structure of the ordinary planting medium used for sowing the seed-bearing fuzz. Flats containing the soil-manure mixture alone were used as control. Fuzz from thirteen crosses was used for the experiment. The mean number of seedlings obtained was:

<table>
<thead>
<tr>
<th>Soil-manure–basalt</th>
<th>277</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil-manure (Control)</td>
<td>246</td>
</tr>
<tr>
<td>Significant difference (20:1)</td>
<td>±61</td>
</tr>
</tbody>
</table>

Crushed basalt had, therefore, no effect on fuzz germination. A depressing effect on growth of seedlings was noticed in 50 per cent. of the seedling flats, there being not a single case of positive response to the basalt. In view of these poor results, no pot experiments have been made, and crushed basalt cannot be recommended as a soil conditioner in seedling flats.

CONCLUSIONS

The modified John Innes' seed compost has not proved better as a planting medium for fuzz than the ordinary soil-manure mixture, except in so far as the compost is less conducive to damping-off disease incidence. The volume of compost in the standard British seed-boxes being about a quarter that in the common seedling flats used by the Sugar Research Institute, the total amount of compost to sterilize is accordingly much less, a factor of economic importance when large quantities of fuzz have to be dealt with.

Pricking is definitely advantageous, particularly when competition for growth in dense seedling populations results in thin seedlings more likely to die off after potting. This operation is naturally labour-consuming, but the benefits derived therefrom will largely offset extra costs. It was found that a trained labourer can prick 60 seedlings in 12 minutes, or about 2,500 per day.

Regarding the ingredients in the modified John Innes' formulae, coral sand and top soil can easily be obtained. Large deposits of partially decomposed stems and roots of the traveller's tree (Ravenala
Madagascarensi) are readily available. About forty-eight cubic feet of this decayed material will be required for raising 60,000 seedlings. Leaf-mould prepared with appropriate activators could be used as a substitute if need be.

It is intended to import hoof and horn, which is a source of slow-acting nitrogen. The absence of this nitrogenous fertilizer from the potting compost resulted in a nitrogen deficiency which was rapidly corrected by the application of a little sulphate of ammonia.

Lack of response to crushed basalt is surprising in view of the good results of field experiments conducted by the Chemistry Division of the Research Institute. Yield increases of the order of five to six tons of cane per acre have been obtained, under super-humid conditions, following single applications of 182 tons of basalt dust at planting. The depressed growth in the flats to which crushed basalt had been incorporated may be due to lack of adequate nutrients, particularly nitrogen, the volume of soil-manure being reduced, due to addition of basalt. It must be remarked, however, that the addition of nitrogen to the seedling flats would have produced soft growth, and is, therefore, not desirable.

**Department of Agriculture, Mauritius.**

**Mauritius Sugar Industry Research Institute,**

**March, 1955.**

Dr. McMartin, the Chairman, said that many people would remember Mr. Julien and Dr. de Sornay, who had attended the Congress some years ago from Mauritius. As these gentlemen were not present today, he called upon Dr. Brett to read the paper on their behalf.

At the conclusion of the reading Dr. McMartin said although the method of raising seedlings was of interest to people who were raising cane seedlings, it applied to people who were interested in raising seedlings of any description. He related that many years ago it was necessary to study a large number of formulae for potting composites. The John Innes' Institute, therefore, made a study of all the varying formulae and had now reduced them to one or two. Slight modifications to the John Innes' recipe has been used at the Experiment Station. Using these scientifically composited, sterilised composites made a big difference to seedling raising at the Experiment Station. It was therefore interesting to see that Mauritius had worked along the same lines and while the authors showed no appreciable difference between the John Innes' formula and the ordinary old-fashioned soil manure mixtures as far as germination was concerned, the incidence of disease was remarkable in the case of the old soil manure mixture.

Mr. du Toit said that in high rainfall areas it was claimed that a great response was obtained by the use of crushed basalt. It was used in enormous quantities and he asked Mr. Park how this enormous quantity was handled.

Mr. Park said that the amount which was used was over 100 tons per acre and this did not prove to be a practical proposition.

Dr. Brett, in connection with a question asked by Mr. Rault, said that they had recently resorted to merely trimming the seedlings, to prevent undue competition between them when the flats were crowded.

Mr. Lintner asked the relative importance of soil mixtures as against sterilisation as far as damping off of seedlings was concerned.

Dr. Brett said that sterilising the soil greatly reduced, though it did not completely eliminate, the possibility of infection.

Mr. Twinch said that damping off could be prevented by the use of various fungicides.

Dr. Brett said that they had tried out various fungicides, but had not found any that were completely satisfactory.

The Chairman said that as far as damping off was concerned steam sterilisation had still proved to be the best.

Mr. Coignet asked if it was necessary when large numbers of seedlings were planted out to sterilise the whole tin of soil or just the top two inches.

Dr. Brett said it was advisable to sterilise all of the soil used in the flats.
When cane cuttings that have failed to germinate are dug up and examined, they are frequently found to be infested with the larvae and adults of Nitidulid beetles which, consequently, are often accused of responsibility for such failure. As additional evidence against them is adduced the rapidity with which replants may become infested in fields in which a high population of the beetles has been built up in the soil as a result of poor germination in the original planting. The investigations described here were carried out to determine to what extent this accusation is justified and to test methods of control in case these should prove necessary.

Although several different species are encountered, the commonest has been identified as *Carophilus humeralis*, F. The adults are shiny black or dark brown beetles, three to four millimeters in length, which can be recognized by their distinctly clubbed antennae and by their truncated elytra (wing-covers) which leave the hind end of the abdomen uncovered. The larvae are whitish grubs, rather slender in build, and about six millimeters long when fully grown.

Although *Carophilus humeralis* has been recorded from fermenting bananas and oranges in this country, and is one of the species listed as occurring in damaged sugarcane in Hawaii. Closely related species occur in many other kinds of fermenting vegetable matter, and a few are known as pests of dried fruit.

Since, in many of the instances investigated, it was possible to discover other causes of bad germination, such as drought, poor seed-cane and infection with pineapple disease, it was considered unlikely that the beetles would prove to be a primary cause of failure to germinate. However, the possibility was suggested that the presence of these insects might enable fermentation to spread more rapidly through the stick. Fermentation may commence at the ends of a cane sett almost immediately after it has been cut, but is considerably retarded on reaching the first node. It was thought possible that the feeding of the beetles might open a way through the node and enable the rest of the stick to be attacked by the organisms causing fermentation.

In a preliminary experiment, cane setts of the variety N:Co.31-0 were planted in tins, untreated or after dipping in Aretan (an organo-mercurial fungicide) at 1 ounce per gallon water, DDT suspension at \ ounce per gallon, or a mixture of Aretan and DDT. Four tins were planted for each treatment, each tin receiving three three-budded setts. Fifty adult insects were introduced into each tin, which was then covered with a cloth cage. The tins were kept in a greenhouse and watered when necessary. After a month, the shoots which had developed were counted; the figures obtained are shown in Table I.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control</th>
<th>Aretan</th>
<th>DDT</th>
<th>Aretan and DDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoots One Month</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>8</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>30</td>
<td>25</td>
<td>29</td>
</tr>
</tbody>
</table>

Although these figures suggest slightly better germination in the setts treated with Aretan, statistical analysis shows that the differences are not significant. Here, conditions favourable for germination had been provided artificially, and the shoots were well established before the setts could be damaged.
Subsequently, a similar experiment was planted in the field, in which sixteen setts of N:Co.310, with an average of four buds, were planted for each of the following treatments: C.—Control, untreated; A.—Dipped in Aretan; B.—Buds removed to prevent germination; AB.—Buds removed and setts dipped in Aretan. The soil was known to harbour beetles, since populations had previously been built up by burying cane with the buds removed.

Examination, one month after planting, showed that germination of the cane with undamaged buds had been good, 39 shoots having developed in the control line and 41 in that planted with setts treated with Aretan. In the cane with buds removed, the root-buds had sprouted. Examination of samples showed the presence of a few larvae: in sticks from each treatment, in those treated with Aretan, none had penetrated beyond the first node from each end, even when the buds had been removed, while in the rest a few larvae had penetrated beyond the first node.

After four months, all the cane was dug up and examined, larvae and adults being found in all sticks. In the series treated with Aretan, infestation was practically confined to the first joint at each end, but in the untreated cane practically all sticks were completely infested. By this time the shoots from both untreated and Aretan-dipped setts in the series with undamaged buds were healthy and well established. Many of the original setts in the untreated series were completely hollowed out by various factors including the feeding of the beetles. Once the young cane is established, however, the destruction of the original sett is of no importance.

In order to determine what effect chemical treatment would have on infestation, a small field experiment was started in January, 1954. Setts of N:Co.310, with an average of five joints, were planted in short rows, with two replications for each treatment. Half of the rows were planted with cane from which the buds had been removed, in order to study the progress of infestation in setts which would not germinate. The other half were planted with undamaged cane, to determine whether any of the treatments would affect germination.

The treatments consisted of dipping the cuttings in the following:

- Control, tap water.
- BHC, a suspension of benzene hexachloride containing 5.7 gms. of 4 per cent, gamma isomer per gallon water.
- DDT, a suspension of 9.5 gms. of 50 per cent, per gallon.
- Parathion, an emulsion of 3.3 ml. per gallon.
- Systox, an emulsion of 3.3 ml. per gallon.
- Toxaphene, a suspension of 18.9 gms. of 20 per cent, per gallon.
- Aldrin, a suspension of 47.3 gms. of 25 per cent, per gallon.
- Dieldrin, a suspension of 47.3 gms. of 25 per cent, per gallon.
- Aretan, a solution of 23.6 gms. per gallon.
- Lead Arsenate, a suspension of 14.2 gms. per gallon.
- Lime Sulphur, containing 170 gms. dry mixture per gallon.
- Hot water, immersion for two hours at 50°C.

The hot water treatment was included as it was considered desirable to obtain information on possible effects on fermentation or beetle infestation which might be brought about by the treatment recommended as a means of controlling ratoon stunting disease.

As it is difficult to distinguish between primary and secondary shoots in the field, all shoots which developed in the undamaged series were counted at monthly intervals. The figures obtained one month after planting, which approximate fairly closely to primary germination, and four months after planting, when counting was discontinued, are shown in Table II.

### Table II

<table>
<thead>
<tr>
<th>Numbers of Shoots Developed</th>
<th>After One Month</th>
<th>After Four Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>...</td>
<td>32</td>
</tr>
<tr>
<td>BHC</td>
<td>...</td>
<td>34</td>
</tr>
<tr>
<td>DDT</td>
<td>...</td>
<td>92</td>
</tr>
<tr>
<td>Parathion</td>
<td>...</td>
<td>30</td>
</tr>
<tr>
<td>Systox</td>
<td>...</td>
<td>32</td>
</tr>
<tr>
<td>Toxaphene</td>
<td>...</td>
<td>27</td>
</tr>
<tr>
<td>Aldrin</td>
<td>...</td>
<td>17</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>...</td>
<td>17</td>
</tr>
<tr>
<td>Aretan</td>
<td>...</td>
<td>39</td>
</tr>
<tr>
<td>Lead Arsenate</td>
<td>...</td>
<td>32</td>
</tr>
<tr>
<td>Lime Sulphur</td>
<td>...</td>
<td>31</td>
</tr>
<tr>
<td>Hot water</td>
<td>...</td>
<td>13</td>
</tr>
</tbody>
</table>

Significant differences:

- 11.7 at 19:1
- 16.6 at 99:1

Germination was thus slightly better, though not significantly so, in cuttings treated with Aretan...
than in the control. On the other hand, Aldrin, Dieldrin and the hot water treatment significantly depressed germination. Examination of the figures obtained four months after planting showed that the Dieldrin lines had overtaken the control, while the difference between the Aldrin lines and the control was no longer significant. There was still a significant depression in the hot water lines. On the other hand, the BHC and Aretan lines were now significantly better than the control, while DDT, Systox, Parathion and Toxaphene were suggestively, though not significantly, better.

The disbudded cane was dug up at intervals and examined, counts being kept of the numbers of joints infected with organisms causing fermentation as well as those infested by the beetles. Figures for the final count for both factors are given in Table III.

**Table III**

<table>
<thead>
<tr>
<th>Numbers of Internodes Penetrated by</th>
<th>Fermentation</th>
<th>Beetles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>59</td>
<td>46</td>
</tr>
<tr>
<td>BHC</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>DDT</td>
<td>38</td>
<td>14</td>
</tr>
<tr>
<td>Parathion</td>
<td>46</td>
<td>31</td>
</tr>
<tr>
<td>Systox</td>
<td>54</td>
<td>41</td>
</tr>
<tr>
<td>Texaphene</td>
<td>58</td>
<td>52</td>
</tr>
<tr>
<td>Aldrin</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>40</td>
<td>22</td>
</tr>
<tr>
<td>Aretan</td>
<td>46</td>
<td>34</td>
</tr>
<tr>
<td>Lead Arsenate</td>
<td>51</td>
<td>30</td>
</tr>
<tr>
<td>Lime Sulphur</td>
<td>61</td>
<td>56</td>
</tr>
<tr>
<td>Hot water</td>
<td>55</td>
<td>46</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>597</td>
<td>427</td>
</tr>
</tbody>
</table>

Significant differences between treatments:
- 11.9 at 19:1
- 15.8 at 99:1

Significant differences between totals:
- 44 at 19:1
- 63 at 99:1

These figures indicate that both fermentation and attack by the beetles have been significantly delayed in sets treated with DDT, Dieldrin, Aldrin, BHC, Parathion and Aretan, effectiveness against the beetles being in the order in which these materials are listed here. Lead arsenate has had no effect on fermentation but has significantly reduced attack by the beetles. The other treatments have been ineffective.

This experiment also gave a certain amount of information on the relationship between Nitidulids and fermentation. It was observed that, in practically every case, fermentation had penetrated further into the sets than had beetle infestation, as can be seen by comparing the totals for fermentation and beetles in Table III. It appears unlikely that the insects normally play an active part in facilitating the spread of fermentation through the stick, since they occur only in joints which have already fermented. Probably, therefore, their attack is not a primary cause of failure to germinate.

It should be noted that the major portion of this cane was left in the ground considerably longer than would normally be required for germination so that, even for the best treatments, a considerable proportion of the joints were attacked. The most that would be required in practice would be protection for one or two months. If conditions at the time of planting are suitable for rapid germination, the young shoots are able to develop and become independent before fermentation and beetles can spread through the stick. If, on the other hand, germination is delayed, both fermentation and beetles may have time to progress through the stick before the young shoots can become established. Once the new shoots are independent, the destruction of the original sett, which eventually takes place under normal conditions, is of no importance.

**Acknowledgement**

Thanks are due to Miss H. A. van Schalkwyk of the Union Division of Entomology for identification of the species.

**Summary**

Nitidulid beetles are frequently found in sugar-cane cuttings which have failed to germinate. Investigations on their status have given results suggesting that these beetles are not a primary cause of failure to germinate, since they occur practically exclusively in internodes which have already started to ferment. Tests involving the dipping of sets in insecticides and a fungicide are described. Best results were obtained with a DDT suspension.

Mr. King, the Chairman, said that this paper was of particular value to those who had to explain to planters why cane failed to germinate. It was particularly interesting to know that beetle attack...
was not of primary importance. An interesting point was that Aretan did not only prevent disease attack and fermentation of the sett, but also helped prevent attack by the beetle.

**Dr. Dick** pointed out that Aretan itself was not an insecticide, but by preventing fermentation, it did limit the activity of the beetle.

**Dr. McMartin**, commenting on Dr. Dick's conclusion that fermentation was the reason for beetle attack, asked if varying organisms could have varying effects as far as this was concerned, or if other types of organisms were present, if this would not result in other types of insect attack.

**Dr. Dick** replied that the odour particularly attractive to these Nitidulid beetles was probably that of a dilute mixture of alcohol and acetic acid, which would be present in almost any kind of fermentation. Although other species of insects were sometimes found in fermenting setts, he did not know if this was due to the odours of different types of fermentation.

**Mr. Brassey** enquired if there were not some natural predators existing in the cane fields and if such predators could not be encouraged.

**Dr. Dick** stated that no parasites or predators had been found. The utilisation of natural enemies in control programmes had, in general, only proved successful where a pest introduced without its natural enemies could be attacked by introduced parasites and predators. In other cases, the pest and its enemies had usually established a form of equilibrium.

**Mr. Coignet** asked if there was any difference in virulence of attack by using setts from young cane, as compared with using setts from old cane.

**Dr. Dick** replied that setts from young cane often germinated more readily and therefore might not be so subject to beetle attack.

**Mr. Park** asked about the effect of hot water treatment used for ratoon stunting disease and whether this had a marked effect on germination and fermentation.

**Dr. Dick** replied that the germination of some varieties, for example, Co.301, might be adversely affected by hot water treatment. He had noted, however, found treated cane more adversely attacked by beetles.

**Mr. Bax** enquired if the cane was more readily attacked by such insects under wet conditions.

**Dr. Dick** said that he had found severe attack in instances where germination had been poor, on account of waterlogging.

**Mr. Rault** enquired of the progress made in the experiments carried out with the hot water treatment as far as ratoon stunting was concerned.

**Mr. King** replied that the experiments had not yet been harvested, so no definite reply could be given. There did not appear in some varieties to be any advantages in the hot water treatment.

**Mr. Pearson** said he had noticed on flats such as Umfolozi and Umhlutuzi, where supplying was necessary, that the setts supplied did not strike very well and he wondered if this was due to the attack of the beetle, which had been built up on the original planted cane. He would therefore like to know what the life cycle of the beetle was and if it were possible to build up an infestation on the lines he had indicated.

**Dr. Dick** said he had not yet worked out the life history of the beetle in its various stages, but he considered that the whole life cycle would be short, probably two months if conditions were suitable.

**Mr. Twinch** said that Aretan, being a mercury compound, might well prove to be of value as an insecticide.

**Dr. Dick** replied that such a possibility did exist, but it had not been completely studied by itself, but he thought that the primary effect of Aretan was its effect on preventing fermentation rather than as an insecticide.

**Dr. McMartin** asked Dr. Dick if it were not the case that the small amounts used as a fungicide dip would be insufficient to act as an insecticide.

**Dr. Dick** replied in the affirmative. He pointed out that a real study of the value of Aretan as an insecticide had not yet been made.
The recent introduction of herbicides as a supplementary method to cultivation for controlling weed growth has, from time to time, brought forth various questions concerning the relative merits of herbicides and the normal methods of hand weeding and cultivation. In order to obtain experimental evidence on some of these questions an experiment was planted in which normal weeding and cultivation methods were compared with herbicides. The opportunity was also taken to find out at which period of growth the cane crop was likely to suffer most damage from neglected weed control.

The experiment was planted, using the variety N:Co.339, on 11th December, 1952. The soil type was a heavy clay loam of doleritic origin which was comparatively free of watergrass. The fertilizer applied was 500 lbs. per acre Super-Rock A mixture. No top dressings were given. The statistical layout was a random block of four replications.

Table I shows the pre- and post-emergent treatments used, the date when any weed control measure was carried out and the rainfall.

Factors Influencing Weed Growth and Control

Prior to the application of herbicides the normal steep sides of the furrow, except in Treatment 1, were broken down, as it was thought that the gradual crumbling of the sides would rapidly offset the effect of the herbicide.

The weather conditions play an important part in the growth of weeds. Although the annual rainfall (44.58") for 1953 was above average (36.29") it must be realised that over 10" of this rainfall fell overnight and after the experiment had been given the pre-emergent hericidal spray. This heavy rainfall resulted in a lot of soil movement and the efficiency of the spray must have been greatly reduced. After the good rains in January and February a period of severe drought was experienced which continued until the end of August, thereafter the rainfall appears to have been fairly normal. This period of drought was sufficient to inhibit the germination and growth of the weeds. Hence, it is felt that under normal rainfall conditions more weed control measures would have had to be adopted.

Weed Populations

A survey of the weeds growing in the experiment was carried out on 4th February, 1953. Thirty-three different species of weeds were identified, only six belonging to the grass family, the remainder being broad leaf species. A density scale was adopted, and the relative density of each weed species recorded.

Table II shows the number of weed species and the relative density for each treatment.

In the "cultivation only" plots it was found that a number of weeds developed in the cane line, probably as a result of no hand weeding. The 2, 4-D pre-emergent application kept the weeds down for about a month but when growth took place the cultivators were unable to kill the weeds in the line which were protected by the young cane.

The plots which had no 2, 4-D pre-emergent spray and were due to be kept clean by cultivation were cultivated two weeks after planting. This destroyed all the young weeds and it remained clean for a further period of five weeks by which time the cane was well developed.
<table>
<thead>
<tr>
<th>Planting No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>re-emergent</td>
<td>2.0 lbs. Sodium salt 2, 4-D</td>
<td>2.0 lbs. Sodium salt 2, 4-D</td>
<td>1.45 lbs. Sodium salt 2, 4-D</td>
<td>1.45 lbs. Sodium salt 2, 4-D</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td></td>
</tr>
<tr>
<td>post-emergent</td>
<td>Cultivation and weeding</td>
<td>Cultivation only</td>
<td>Herbicides</td>
<td>Cultivation only</td>
<td>Herbicides</td>
<td>Cultivation</td>
<td>Herbicides</td>
<td>Cultivation and weeding started</td>
<td>NIL</td>
<td>weeks only</td>
</tr>
<tr>
<td>12/32</td>
<td>Planted Experiment</td>
<td>11th to 12th December</td>
<td>2.00&quot; spread over</td>
<td>over 5 days</td>
<td>1.45 lbs., 2, 4-D</td>
<td>ac</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>12/32</td>
<td>2.0 lbs. 2, 4-D</td>
<td>2.0 lbs. 2, 4-D</td>
<td>1.45 lbs., 2, 4-D</td>
<td>ac</td>
<td>1.45 lbs., 2, 4-D</td>
<td>ac</td>
<td>8 days</td>
<td>9 days</td>
<td>Heavy rain of 10.15&quot; in one day</td>
<td>--</td>
</tr>
<tr>
<td>12/32</td>
<td>Rainfall 1st</td>
<td>January to 12th</td>
<td>January, 1953</td>
<td>1.11&quot; spread over</td>
<td>1.0 lb. 2, 4-D Iso Propyl Ester + 4 gals. C.A.D.E. per acre</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1/3</td>
<td>Rainfall 2nd</td>
<td>January to 6th</td>
<td>February, 1.22&quot; spread over</td>
<td>7 days</td>
<td>1.0 lb. 2, 4-D Iso Propyl Ester + 4 gals. C.A.D.E. per acre</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2/3</td>
<td>Weeded</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
</tr>
<tr>
<td>3/2</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
</tr>
<tr>
<td>3/1</td>
<td>Cultivated</td>
<td>April, 1953</td>
<td>to 13th January, 1954</td>
<td>20.82&quot;</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
</tr>
<tr>
<td>3/1</td>
<td>Wooded</td>
<td>Rainfall 13th</td>
<td>January to 24th</td>
<td>July, 1954</td>
<td>14.86&quot;</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
<td>Cultivated</td>
</tr>
<tr>
<td>7/54</td>
<td>Harvested at 10 months old cane</td>
<td>Total Rainfall: 84.69&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table I**

**TREATMENTS:**
- Herbicides
- Cultivations
- Weeding

The weight of 2, 4-D used is the acid equivalent weight. All spray was applied at the rate of 35 gallons per acre.
Table IV gives the sucrose percentage cane for the various treatments.

Significance at 19 : 1 = 0.52 sucrose % cane
99 : 1 = 0.70 sucrose % cane

From these results it may be deduced that it does not matter whether the weeds are brought under control by herbicides or cultivation methods, provided they are controlled early. There appear to be indications that after a pre-emergent spray is applied it is better to cultivate than to apply a post-emergent herbicide. The extra depth of soil over the setts apparently has the effect of encouraging tillering and keeping the setts in a moister condition.

Table III gives the tons cane per acre harvested from each treatment.

Significance at 19 : 1 = 12.36 tons per acre
99 : 1 = 16.56 tons per acre

Here it is seen that where the weed control has been bad the sucrose has decreased. This experiment shows then that with bad weed control there is a loss not only in yield but also in sucrose.

Table V shows the number of sticks produced three months after planting and at harvest time.

Table IV gives the sucrose percentage cane for the various treatments.

Significant difference at 19 : 1 = 0.52 sucrose % cane
99 : 1 = 0.70 sucrose % cane

Here it is seen that where the weed control has been bad the sucrose has decreased. This experiment shows then that with bad weed control there is a loss not only in yield but also in sucrose.

Time of Weed Control

In considering the two treatments, "Control for 11 weeks after planting (Treatment 9)" and "Control beginning II weeks after planting (Treatment 8)," the following observations were made: according to Table III the yields were 48.00 tons cane; per acre and 43.16 tons cane per acre respectively which shows no significant difference; but, when the number of sticks produced is taken in consideration, it will be seen that three months after planting there were twice as many shoots in the weeded plots (Treatment 9) as in the neglected ones (Treatment 8) as is shown in Table V.

Table V shows the number of sticks produced three months after planting and at harvest time.

In Treatment 8 there must have been a large number of bull shoots and year-old canes produced, probably caused by more light and better growing conditions prevailing when the weeds were removed. If the cane had been harvested earlier a loss in yield could have resulted from the early neglect of weed control.

Some Observations on Weed Control

When controlling weeds either by cultivation or herbicides it is essential that the control measures should be carried out when the weeds are young, preferably soon after germination. The drag-harrow used a few weeks after planting can save a tremendous amount of weeding later. The correct time to use the drag-harrow is when the weeds have just germinated and the cane shoots by then will probably be just below ground level so that the extra covering of soil will not prevent the shoots from coming through the ground.

The herbicides should be applied as a pre-emergent spray, i.e. after the cane is planted but before the weeds have germinated. This pre-emergent spray will control grasses as well as broad leaf weeds. If a post-emergent spray is necessary it must be used when the weeds are small.
If fields which are intended to be planted, are left fallow for any period, they should be harrowed periodically to kill any weeds before they have had time to seed. The old saying "one year's seeding, seven years weeding," should be borne in mind although not strictly applicable to the sugar industry it nevertheless makes one realise the dangers of allowing weeds to seed.

Costs

It is not intended to compare the costs of the two methods of weed control as herbicides must not be considered as a complete answer to weed problems but only as an additional method available to the farmer. Herbicides must fit into the farm programme of operations and will become more and more valuable as the labour supply becomes shorter. It is realised that a tractor can cultivate large acreages but it is not always possible nor desirable to cultivate too often: it is here that herbicides are useful and their value can not be assessed in mere £ s. d.

Conclusions

It is apparent that weeds can be controlled either by herbicides or the usual methods of cultivation and weeding. If herbicides are used it appears desirable that the cane should be cultivated at some period, in order to increase rooting and place the cane deeper where more moisture is available. There does not appear to be any advantage in breaking down the furrow prior to spraying.

Acknowledgments

We would like to thank Mr. du Toit, of the chemical department, for doing the sucrose analysis, and Miss Gravett, the statistician, for doing the statistical analysis.

[For discussion of this paper see page 133]
in the control of perennial grasses. Thus the success of any new herbicide will depend largely on its ability to give an effective suppression of perennial grasses and nut grass at economical rates. To mention but a few that may prove valuable to the cane grower:—

T.C.A. (Trichloro-acetic acid)

T.C.A. is classed as a root poisoning herbicide for the control of grasses, and the best results are obtained when the chemical is absorbed through the roots of the plant, consequently moisture is essential for its absorption and dry conditions are often responsible for the slow and sometimes unsatisfactory results. This material is used extensively overseas, especially in Louisiana, to control Johnson grass (Sorghum halepense). In South Africa, it has been the subject of exploratory work for use only in sugarcane fields, but it could be used profitably where a particular grass problem exists.

2-2-Dichloro Propionic Acid

This compound is similar to T.C.A. in its selective effect against grasses, but in this case it can be absorbed and translocated more readily by the foliage. Although the toxic effects are slow in developing, it appears to have a higher phytotoxicity than T.C.A. and can be used at lower rates in selective weed control. In Hawaii it has been noted that 2 lb. of this material is equivalent to 15 lb. of T.C.A. in the control of Couch Grass (Agropyron repens).

Substituted Ureas

C.M.U. [3(p-chlorophenyl) 1.1 dimethyl urea] and P.D.U. (phenyl dimethyl urea) both possess most of the desirable properties of a herbicide. They are highly phytotoxic and are therefore effective at low dosages against a wide range of weeds, furthermore, the stability of these compounds enables them to resist decomposition in the soil, thus extending the period of weed control. The substituted ureas are primarily pre-emergent herbicides, but due to the insolvency of these compounds their action is much slower than many other weed-killers. The effects on the growing plant are first exhibited by a wilting and chlorosis of the leaves, followed by a progressive
die-back and finally death of the plant itself. Although light applications of up to 8 lb. per acre can be used for selective weed control in sugarcane, heavy rates of 40-80 lb. per acre can eradicate all vegetation for a long time. When water is used as the diluent for applying substituted ureas, continual agitation is required to keep the insoluble material in suspension. This necessitates the inclusion of a special agitating mechanism, which is an important practical limitation.

More recently amino triazole has shown promise in the control of nut grass (Cyperus rotundus) in the U.S.A. The compound induces a chlorosis of the leaves, especially the young growth, but the water grass is not eradicated and may recover eventually. However, more research is still required to determine the full value of this chemical.

The amides of chloro acetic acid are still another range of compounds which have not yet been fully tested, but have already shown promise in the control of certain grasses.

LIMITATIONS OF CHEMICAL WEED CONTROL

It is important to bear in mind that chemical methods of weed control are only supplementary to cultural practices and as far as one can safely predict chemicals will never replace cultural methods.

Selective herbicides will invariably fail to kill some weeds and furthermore some herbicides will damage some crops because the protoplasm of desirable plants is similar to that of undesirable plants we call weeds. It follows that continuous and injudicious use of a particular selective herbicide will encourage a resistant type of weed to flourish and predominate. For example injudicious use of 2.4-D may control broad leaf weeds, but cause resistant grass weeds to predominate and create a more serious problem.

There has been much speculation as to the effect of herbicides on the soil micro-organisms and experiments are being conducted at this station to investigate this possibility. Overseas investigations have shown that neither 2.4-D nor P.C.P. reduce the microbial activity in the soil when used at recommended rates, i.e. below 4 and 2 lb. respectively. These results are supported by two papers, one written by Krotochvil and another written by Hoover and Colman.

In other countries harmful effects on cane have been observed from applying 2.4-D at certain stages of the cane’s growth, but in South Africa there has been no definite evidence of such harmful effects when recommended quantities of 2.4-D are used.

APPLICATION OF CHEMICAL WEED CONTROL IN CANE

SUGAR CANE

Sugarcane is a hardy crop and less susceptible to the effects of herbicides than most weeds, consequently the crop lends itself very well to chemical weed control.

The extent to which herbicides are used in the sugarcane areas of South Africa, has and will depend on a number of factors:

(a) the availability of labour;
(b) the cost of the herbicides in relation to cultural methods of control;
(c) the efficiency of the particular herbicides against the prevailing weed population; and
(d) the degree in which it aids cultural methods of control.

Thus it depends on the interrelation of all these factors whether or not chemical weed control can be justified in any particular case.

Nevertheless there is a definite advantage in applying a pre-emergent spray of 2.4-D, provided the area is not dominated by a resistant type of weed. Under favourable conditions excellent weed control can be obtained when the young plant cane is establishing a root system. At this critical stage moisture and nutrients should be readily available and this condition is only obtained when weed competition is eliminated. Mechanical and manual methods do not achieve the same results, because the young shoots are easily damaged and root development disturbed. In addition, pre-emergent spraying of hill-sides eliminates unnecessary cultivation and therefore reduces the chance of soil erosion.

Pre-emergent Spraying

Sodium M.C.P.A. has been in use for many years, but not so extensively as the ester and amine formulations of 2.4-D.

Both 2.4-D formulations have their merits, although under general field conditions they have the same herbicidal value.

Lee Ling describes and compares the more common herbicide preparations on the market today, and referring to 2.4-D formulations he rates the ester as having the most potent herbicidal action, the amine salt as intermediate and sodium salt the least potent.

Lee Ling adds that sodium M.C.P.A. produces the same herbicidal responses as sodium 2.4-D, but they appear to differ in their persistence in the soil,
M.C.P.A. having a longer herbicidal effect. Also M.C.P.A. is more effective against certain weeds and vice versa.

**Time of Pre-emergent Spray**

The most dramatic results from 2.4-D are obtained from pre-emergent sprays. However, the pre-requisites for a good control of broad leaf weeds and annual grasses necessitates:

1. early pre-emergent application before any vegetation has appeared above the soil surface; and
2. a moist soil with a fine tilth.

Under these conditions weed seeds germinate quickly and are killed by the freshly applied herbicide.

2.4-D has very little effect on grasses once they have developed beyond the seedling stage. On the other hand most broad-leaf weeds are easily destroyed in the seedling stage and they can also be suppressed in the adult stage, but in this case greater quantities of herbicide may be required.

**Method of Application**

In applying pre-emergent herbicides normally, both the cane row and interline are covered with the herbicidal spray. This method is termed a complete cover spray and recommendations for rates of application are usually made on this basis.

The above method can be modified by only spraying the cane line itself and leaving the weeds in the inter-row to be controlled by cultivators, and this method has a number of advantages:

1. weeds are controlled in the cane line with the least possible disturbance to the young cane;
2. labour normally used to weed in the cane row can be employed elsewhere;
3. cultivation of the inter-row not only destroys weeds but also helps to aerate the soil;
4. only half the quantity of herbicides per acre is required.

The disadvantage of treating the cane line only, is that weeds in the inter-row are not affected, and it may be necessary to cultivate at an early stage. This can cause untreated soils to fall into the cane line and nullify the effect of the pre-emergent spray.

**Rates of Application**

1. **Complete Cover.**—For complete cover sprays 1½—2 lb. 2.4-D (ester or amine) per acre should destroy susceptible weeds and remain effective for a period of three to six weeks, depending on the soil and weather conditions, but in some cases control has been obtained for a period of ten weeks. However, the chemical is broken down quicker in heavy moist soils than sandy soils, and also heavy rains reduce the herbicides’ effective life.

2. **Cane Line.**—When only the cane line itself is to be treated, then half the above dose should suffice, as only 50 per cent. of the land is sprayed.

The presence of perennial weeds presents a different problem, and in the Natal sugar belt nut grass is generally considered to be one of the most troublesome weeds. It is a native of the tropics and warmer areas of the temperate zones. Botanically it falls into the family Cyperaceae of the order Cyperales, and there are two main types of economic importance to be found in Natal cane fields.

I. Cyperus rotundus (Fig. 1) is often associated with having a purple flower, but Cyperus rotundus L. forma has a yellow flower with long spikelets. Both these varieties possess a deep ramified system of strong wiry rhyzomes, which join a series of hard brown scaly tubers. The tubers nearer the soil surface produce aerial shoots and additional rhyzomes, hence the name “uintjies kweek,” because of its creeping habit.

II. Cyperus esculentus (Fig. 2) is also characterised by a yellow flower, but in this case the spikelets tend to be much shorter. The underground portion consists of a shallow, less ramified system of more succulent rhyzomes which sometimes terminate in a round succulent tuber, however surface rhyzomes are capable of producing aerial shoots, but the creeping habit is less apparent than in the case of Cyperus rotundus. In addition esculentus is easier to control than rotundus.

Further research into the growth habits, morphology and physiology of the different types of cyperus is still required in order to find a weak link, whereby it might be successfully controlled with herbicides.

In general pre-emergent applications of 2.4-D formulations at economic rates (2 lb./acre) have given little or no positive control of nut grass. Under particular conditions 2.4-D may retard the development of shoots and delay flowering to a certain extent, but this condition is only temporary and the weed soon recovers.

**Post-emergent Spraying**

Certain weeds, especially grasses, are resistant to post-emergent applications of 2.4-D. Consequently once these resistant weeds have fully germinated contact herbicides, or mechanical methods have to be used.
Fig. 1 CYPERUS ROTUNDUS

Fig. 2 CYPERUS ESCULENTUS
1. Mechanical methods not only eliminate weed competition, but also perform the important function of aerating the soil and breaking any hard surface crust. The disadvantages, however, is that fresh weed seeds are brought to the surface, however, the control of weeds can be extended by applying a pre-emergent application of 2.4-D. directly after cultivation to control the germination of fresh seeds.

2. Under certain conditions it is profitable to control resistant weeds by post-emergent contact herbicides, especially where heavy clay fields may be too wet to cultivate, or where there is an acute labour shortage.

Post-emergent Chemicals

Under Natal conditions the most satisfactory results with post-emergent chemicals in the suppression of grasses and nut grass have been obtained with contact herbicides. The best formulation consists of an aromatic oil fortified with P.C.P. and containing an emulsifying agent. 2.4-D can be added to the contact herbicide to make what is known as a total herbicide. This will increase the efficiency of the contact herbicide and inhibit the germination of susceptible weed seeds.

Time of Post-emergent Spraying

In order to derive the greatest benefit from one application a full flush of aerial grass shoots should have developed.

If the cane has germinated at the time of application and only the spikes appear above the soil surface, no precaution need be taken to protect the cane. Exposed cane leaves can be severely burnt if the herbicide is applied after the spike stage, and although the young shoots are not killed, cane growth is retarded and the object of weed control is defeated. It is possible to adopt a technique whereby the cane leaves are protected, and therefore the use of contact herbicides can be extended to any stage in the canes’ growth.

Rates of Application

Contact herbicides on the market today contain about ½lb. pentachloro-phenol per gallon of oil, and for this specification the following quantities are normally applied.

1. Complete Cover

(a) ½1b. 2.4-D ester
(b) 2-4 gallons contact herbicide per acre

2. Cane Line

Only half the above quantities are required.

Although only low volumes are required for pre-emergent spraying, relatively high volumes are necessary for contact herbicide application.

The volume to which the above materials should be diluted is dependent on a complete coverage of the weed vegetation. Invariably nut grass control is the main object of post-emergent treatments and the volume rate should be consistent with thorough crown penetration. When sufficient liquid runs into the central axis (crown), the herbicide penetrates and kills the growing point. In the case of Cyperus esculentus the succulent basal bulb is killed completely and regrowth will be dependent on healthy rhyzomes and tubers. The basal bulb of cyperus rotundus is not killed unless it is very small and succulent, however the bud which formed the aerial portion is usually destroyed, but regrowth can easily take place from a healthy bud on the same tuber.

A dilution of at least 50—60 gallons per acre is necessary to suppress a full flush of nut grass successfully with a complete cover spray. When only the cane line itself is being sprayed, this quantity is halved.

Equipment

Owing to the difficult terrain and relatively small acreages to be sprayed at any one time, the knapsack sprayer has proved very satisfactory and even on large estates it has been both economical and efficient. Furthermore the selective placement of contact herbicides is accomplished well by the knapsack sprayer and it is difficult to visualize a better method for hill-side cane fields of Natal.

Where tractor-mounted spray equipment can be used economically the operation is carried out quickly and more efficiently than with a knapsack sprayer.

Aeroplane spraying is used extensively overseas, where large areas can be sprayed at any one time (50 acres/hour), but on account of the high operating costs (for spraying small areas) the use of aeroplane spraying is limited in South Africa and in the sugar belt, only one company (Natal Estates) possesses an aircraft for this purpose.

In considering the type of jets used in herbicide spraying, the ceramic T-jet is the most satisfactory type for present methods and techniques. This type offers better penetration of the weed foliage, more selective placement of the herbicide and better control of spray drift than in the case of cone jets.

However, in the case of a jet becoming blocked, cone-type jets are easily cleaned and replaced, and this is an important practical consideration.
OVERSEAS WEED CONTROL

No direct comparison can be drawn between overseas practices and those commonly used in South Africa. Climatic conditions, weed populations, cultural methods and labour economics vary in overseas cane-growing areas and, consequently, the problem of weed control presents itself in a different light. Although their findings offer very useful fundamental information, the value of particular field practices and methods must first be assessed in the light of our own local conditions.

In reviewing overseas literature, Hawaii, Queensland and Mauritius have been chosen to represent the development of chemical weed control in other sugarcane growing areas of the world.

HAWAII

Du Toit in his report wrote "In Hawaii weed control is particularly highly-developed as a result of the natural luxuriant weed growth, high labour costs and excellent work conducted by the chemical department of the H.S.P.A. Experimental Station, under Dr. Hance." The report adds that owing to the prohibitive expense of importing herbicide preparations, it was found essential for them to prepare their own herbicide mixtures from the raw materials.

Soon after the discovery of 2.4-D this material came into general use as a pre-emergent herbicide, and then in order to combat more resistant weeds which escaped 2.4-D, a C.A.D.E. (concentrated, activated diesel-oil emulsion) was introduced by Dr. Hance consisting of the following ingredients:

- 67 gallons diesel oil
- 7 lb. penta chloro-phenol
- 14 lb. wetting agent
- 33 gallons of water.

Later it was found that by increasing the aromatic content of the oil constituent, the herbicidal properties were improved. Thus a modified and more effective herbicide emerged known as A.R.C.A.D.E. The addition of 2.4-D to the above contact herbicides extended their value by inhibiting the germination of weed seeds in the soil.

T.C.A. has also been found useful for the control of grassy weeds and the H.S.P.A. reports that a mixture of 2.4-D and T.C.A. is of value in a mixed weed population as the two herbicides supplement each other in controlling broad-leaf weeds and grasses respectively. Another mixture is based on a combination of T.C.A. and C.A.D.E. and in this case the oil content of the C.A.D.E. is said to facilitate the entry of T.C.A. into the plant tissue.

Still another mixture consists of T.C.A., C.A.D.E. and 2.4-D and here again the three components are said to have a complementary effect.

The new herbicide C.M.U. was subjected to pot tests in 1951 and the preliminary results presented by Dr. Hance shows that 1—2 lb. C.M.U. controls weeds well and has little effect on the cane itself, but as the rates of application are increased, the cane becomes progressively stunted, until at 30 lb./acre growth is completely inhibited.

During the year 1953 C.M.U. continued to be the principle herbicide under investigation and a large number of co-operative field tests were carried out. Results indicate that pre-emergent applications of 4—5 lb./acre appear to be optimum and no harmful effects are observed at this rate, but at 10 lb./acre harmful effects become evident. Although C.M.U. has been used on a field scale over the past two years the problem of this chemical building up a residual toxic effect in the soil is being examined. Recently Dr. H. M. Baker of the Du Pont Company has been investigating this possibility, however results are not yet available, but preliminary investigations have shown that the greatest concentrations are in the top three inches of soil, while concentrations at the 3—6 inch level are markedly lower.

C.M.U., being insoluble in both water and oil, must be kept in suspension by continual agitation, and the Hawaiian Experimental Station has found C.A.D.E. and A.R.C.A.D.E. to be an ideal dispersing agent for C.M.U., while water, dilute molasses and aromatic oils are found to be less effective.

Du Toit quoted the cost of weed control in relation to other items and on one plantation the cost of fertilizers amounted to 0.9 dollars and that of weed control to 1.3 dollars per ton of cane. On an irrigated plantation a break-down of the costs of growing the crop to maturity showed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Percentage of Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation flumes and pumping</td>
<td>37.0</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>15.7</td>
</tr>
<tr>
<td>Weed control</td>
<td>18.5</td>
</tr>
<tr>
<td>Cultivation</td>
<td>4.8</td>
</tr>
<tr>
<td>Cleaning, hand ploughing and planting</td>
<td>9.2</td>
</tr>
<tr>
<td>Preparation of ratoons</td>
<td>10.3</td>
</tr>
<tr>
<td>Agricultural research</td>
<td>2.3</td>
</tr>
</tbody>
</table>
He also found that the normal rates of herbicide application in Hawaii were as follows:

- 2.4-D at 2-4 lb. diluted in 20-30 U.S. gals./acre
- C.M.U. 4-6 lb. diluted in 20-25 gals.
- C.A.D.E. 20-30 gals.

QUEENSLAND
(Australia)

A preliminary investigation into the chemical control of weeds with the hormone herbicide 2.4-D commenced in 1941, but it was not until 1949-50 that field trials were conducted.

The success of these trials and the high cost of labour in Australia added impetus to the use of 2.4-D in cane fields, and the two techniques of chemical control were evolved:

1. a pre-emergent treatment with 2.4-D to inhibit weed seed germination;
2. post-emergent spraying with a contact herbicide to control the more resistant weeds which were unaffected by the pre-emergent treatment.

Pre-emergent Treatment

Pre-emergent applications of 2.4-D were carried out over a wide range of soils and climatic conditions. Results showed that freedom from weeds and grasses could be obtained for periods ranging between eight to twenty weeks.

Before applying a pre-emergent spray it is considered desirable to carry out a single cultivation in order to remove the sharp shoulders of the furrow sides. Planting furrows generally have an almost vertical side and as the soil dries out if falls back into the furrow, and this reduces the efficiency of the herbicide by exposing untreated soil. However, planting furrows vary considerably from one district to another, deep wide furrows are favoured in the north, while shallow, almost imperceptable drills are preferred in the Mackay district. Furthermore, where planting is spread over a week this method of cultivation destroys the grassy weeds which have already germinated. An immediate application of 2.4-D prevents the germination of remaining weed seeds. King states "the open furrow favours tillering and there is no necessity for soil to be worked into the cane row in the early stages. Under some conditions the initial spraying with weedicide is sufficiently long-lasting in its effects to prevent any weed growth before the cane has 'covered'."

Some growers believe in the need to stir up the soil regularly, in which case the herbicide can be applied directly to the cane row in a strip two feet wide, leaving the untreated inter-row to be cultivated at regular intervals.

Post-emergent Treatment

In dryer areas the pre-emergent effect may wear off before the cane has covered in and two courses can be followed:

1. to destroy the weeds by cultivation and follow with another pre-emergent spray;
2. or apply a contact (diesel oil or creosote) containing 2.4-D.

In nut grass areas 2.4-D has no pre-emergent effect on this weed, but post-emergent applications of 2.4-D and methoxone have been found useful in killing the aerial portion and suppressing its growth for three to six weeks, however, only the surface tubers are killed and new growth is produced by healthy tubers.

Under certain conditions post-emergent contact herbicides can be useful in the control of resistant weeds in the cane line itself before the cane has made leaf, or as a cover spray in the interline before the cane has "covered in."

The concentrated contact herbicide contains the following ingredients:

- 70—80 per cent. diesel oil or creosote
- 3 per cent. P.C.P.
- 3—5 per cent. 2.4-D
- and an emulsifier.

Vallance recommends the use of 4 lb. sodium 2.4-D. (80 per cent.) in twenty gallons of water per acre, for both pre- and post-emergent applications. For post-emergent contact spraying, four gallons of the above-mentioned concentrated contact herbicide and 3 lb. 2.4-D. (80 per cent.) in thirty gallons of water are recommended. When only the cane row itself is to be sprayed, then the above quantities can be halved.

Tooley and Mathews observed that in addition to the above chemicals, T.C.A. has shown promise as a root poisoning herbicide for special grasses in the Mackay district, and while contact herbicides have not proved entirely satisfactory for the control of couch and guinea grasses, T.C.A. has been found promising.
MAURITIUS

Chemical weed control has been an important item of research during the past ten years, and the results of more recent advances have been published by Rouche couste. For pre-emergent treatments it is found that:

1. sodium M.C.P.A. at the rate of 3—4 lb./acre gave the best results and treated plots remained weed-free for a period of six weeks to three months;

2. the sodium and amine salts of 2.4-D are found to be the second best treatments;

3. The ester formulations of 2.4-D, however, are found to be less effective than the others, and produce a marked retardation in cane growth when used at rates over:

   1 lb. 2.4-D ethyl ester/acre
   1½ lb. 2.4-D isopropyl ester/acre
   1½ lb. 2.4-D butoxy-ethanol/acre

This stunting effect became evident two weeks after application, when scorching of leaves and the occasional death of young shoots was observed.

In post-emergent treatments the esters are found to be more efficient than sodium M.C.P.A., sodium 2.4-D, and amine 2.4-D. Here again the danger of retarding the cane still exists and care must be taken not to exceed the rates of application as recommended in the previous paragraph.

Where an area, to be planted with cane, is heavily infested with perennial grasses, it may be necessary to eradicate them before planting operations begin. Rochecouste recommended the following chemicals for perennial weed control: 100 lb. sodium chlorate or 100 lb. T.A.C. in 100 gallons of water per acre, this should be applied one to three months before planting to avoid any toxic effects on the plant cane.

Immediately after planting, the interlines can be harrowed to destroy any weed growth and a pre-emergent application of 3-4 lb. sodium M.C.P.A. in thirty gallons of water per acre should be applied.

When the effects of the initial spray have been exhausted the field can be cultivated and given another pre-emergent spray. The other alternative is to omit the cultivation and apply a contact herbicide.

Recently a semi pre-emergent herbicide has been developed in Mauritius for use in fields where weeds may have already germinated, and especially in ratooning cane. The formulation consists of: P.C.P. (¼-½ gallon Monsanto 15 per cent, emulsion concentrated) which acts as a contact herbicide for growing weeds; T.C.A. (5 lb.) for grass control; and M.C.P.A. (1½-2 lb.), kills broad-leaf weeds and prevents the germination of seeds. The above quantities are diluted to 45 gallons of water and applied to 1½ acres.

Experiment Station,
South African Sugar Association,
Mount Edgecombe
March, 1955.

Dr. McMartin, in the Chair, stated that weed control was a matter which had been of vital importance to agriculturists throughout the ages, but only in the last few years had chemical science come to their assistance. These new herbicides had different effects on different plants and when studying the literature it was necessary to know exactly which plants were being referred to as the same weed might have different names in different countries. The meeting was very grateful to Mr. Stewart, for introducing all the different facets of the subject.

Mr. King asked if one of the delegates from Mauritius would tell us what happened in Mauritius.

Mr. Bax said that Mr. Park was more qualified than he to reply to that question, but he would like to mention that what struck him from the results of applications of weed-killers was that in fields heavily infested by grasses, T.C.A. was applied after the young canes had grown, and that under such conditions the weed-killer could only be applied at low concentrations.

In Mauritius, for fields that were to be replanted and that were heavily infested with grasses, the recommended practice was to apply, per arpent, 100 lb. of a mixture of 60 per cent. T.C.A. and 40 per cent, sodium chlorate in 150 gallons of water, at least two months before planting the cane. This was in order that the weed-killers might have time to translocate to the roots and kill the whole grass plant before it was removed and planting started. Where necessary, localised applications were made when the canes had grown, but this was done carefully with the aid of inverted funnels on the sprayers, in order not to damage the cane plants. He added, however, that recently sodium chlorate had been abandoned, not only because it was difficult to obtain, but because of its explosive properties and the danger during storage.

Dr. McMartin asked if the hazard of storing sodium chlorate was not reduced by adding calcium chloride. He said that it had been abandoned in Natal, not because of the difficulties of storage, but it could not do the work effectively.
Mr. Park referred to so-called "cocktail mixtures" of various herbicides in Mauritius. He gave details of various mixtures used and the strength applied. Such mixtures had helped tremendously owing to labour difficulties and would most unlikely be abandoned now.

Mr. Dymond inquired what harmful residual effects these herbicides had when they eventually found their way into the soil.

Mr. Stewart said that if recommended quantities of these herbicides were used they would have little effect on insects, however their possible effect on the soil micro-organisms was being investigated at the Experiment Station.

Mr. Main wished to know if Mr. Stewart could detail anything new about the use of hydrazine. His interest was more directed towards the suppression of weeds in irrigation furrows. He said that this was used extensively in America, for the purpose of merely stunting plants and not to eliminate them altogether.

Mr. King said that Mr. Main was probably thinking of maleic hydrazide, when he referred to hydrazine. He had conducted small experiments on teff, using maleic hydrazide and had found that it definitely retarded the growth. As regards T.C.A. and sodium chlorate, the application was costly and in Mauritius the cost of an application was sometimes as high as £10 per acre, but he was led to understand that this was only the case in small areas. The cost at the higher rates of application would be prohibitive in Natal. When speaking of costs it appeared that in those countries where labour was short and the cost was high, that they used herbicides more extensively. In South Africa we are now being confronted with a shortage, and not particularly in the high cost, of labour. It was the shortage of labour which would induce the planters to make use of herbicides.

Mr. Bax said that heavy applications of T.C.A. in Mauritius were rather limited to those fields which were heavily infested by grasses, and that the high initial cost was offset in the long run by easier and cheaper weedings.

Mr. Boyes said that prior to entering the sugar industry he was employed by the Shell Refining and Marketing Co. Ltd., in Essex. The two principal weed-killers manufactured there were di-nitro ortho cresol and penta chlor phenol. He was surprised that the former was not mentioned in the papers. It was a weed-killer extensively used by the Royal Dutch Shell Group in Venezuela, but it was very toxic and had been responsible for a number of deaths among labourers. In a series of tests which he had supervised, using D.N.O.C. weed-killer, the labourers were made to wear white overalls and caps, goggles, rubber-boots and gloves. They were not allowed to carry canisters of weed-killer on their backs and the liquid at 0.5 to 5.0 per cent, strength was pumped from a bowser. If any liquid fell on an article of clothing, the article had to be removed and be replaced by a clean one.

He mentioned these facts to draw attention to the hazardous nature of some weed-killers. Manufacturers would be in a position to inform buyers of the necessary safety precautions and these should be adhered to.

Mr. Brassey said that difficulty as far as danger to labour was concerned had been, experienced with 2,4-D. oil emulsions.

Mr. Palairet suggested that there was a need for a total weed-killer that could be used on roadways, tramlines and the like. He asked if Mr. Stewart, could indicate any herbicide which would be effective against perennial grasses without any danger of eventual translocation into the cane.

Mr. Stewart replied that sodium chlorate and T.C.A. were soluble in water and could be carried into the cane-fields by run-off water. Heavy doses of these herbicides could eliminate grasses by sterilising the soil.

C.M.U. was a very stable and insoluble compound which would not readily be washed into the cane-field. Experiments with this herbicide have shewn that heavy applications of 40—80 lb. per acre could cause complete elimination of all vegetation for many months, however, the high cost of this material restricted its use as an economic proposition.

Mr. Bax said he thought that sodium arsenite had been used successfully in destroying grasses, but it was highly dangerous to allow labourers to collect the grasses for feeding their animals, which would thus be killed.

Mr. Stewart said that he had concentrated on the less toxic types.

Mr. Coignet asked if it were possible to concentrate on some herbicide which might leave a residual fertilising effect in the soil, such as cyanide.

Mr. Twinch said that during the war weed-killers were mixed with fertiliser. This was discontinued, as it was desired to get the fertiliser into the soil and a herbicide on top of the soil. As far as hydrazide was concerned, this appeared to be used in America and only for domestic purposes, and not a field scale.

Mr. Pearson referred to the differences between herbicide treatment and cultivation and it would
appear that the heavier yields seemed to be reached when pre-emergent spray, cultivation and weeding were applied. He pointed to the treatments No. 8 and 9 in Messrs. King and Almond's paper, where cultivation had not been performed for some eleven weeks and the yields were particularly low. He found that in carrying out trash blanketing and other protective coverings, yields were not as good when the ridge and furrow formation of planting was not levelled out.

Mr. Rault stated that it was interesting to split the sucrose per acre yield into its component parts, i.e. tons cane and sucrose per cent. cane.

It was sometimes stated that a well-cultivated high-yielding field was at a disadvantage for sucrose content of cane, compared with the short and thin material from poor soils and dry areas. The results quoted in Messrs. King and Almond's paper do not support this statement, which should be qualified by saying that rank growth of 60 to 80 tons per acre promoted by excess of moisture and heat, may result in low density juices and corresponding sucrose.

Within the average of 30 to 50 tons, good cultivation should not be blamed for lowered sucrose content of cane.

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11 (1954), H.S.P.A. Experiment Station Committee Report, 73.
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BIBLIOGRAPHY
For those wishing to gain more detailed information on chemical weed control practices in the South African sugar industry, the following articles can be recommended:

INSTRUCTIONS TO AUTHORS

1. All papers for the Congress must be in the hands of the Technical Secretary fourteen days before the meeting. It is requested that authors will endeavour to send their papers earlier than this date so as to facilitate the work of printing.

2. Where possible the manuscript should be typewritten; when not possible the paper should be submitted in a form easily read.

3. References at the end of the paper should be arranged as follows: Name and initial(s) of author; year of publication in brackets; exact title of paper; contracted title of periodical; volume number; beginning page number of article. Thus:

4. All the authors referred to should be arranged in alphabetical order.

5. Illustrations and diagrams accompanying the papers must be carefully drawn on smooth, white drawing paper in Indian ink so as to be suitable for reproduction. Any lettering on margins should be in pencil so as to allow of easy replacement by printer’s type. The size of the largest diagram, curve, etc., should not be greater than 10 by 15 inches. Curves should be drawn on black graph paper, which can be obtained from the Technical Secretary.

6. Careful correction of typographical and other errors should be carried out by authors; this would save time on the parts of the Editor and Printers.

7. A summary of the main features described in the paper should be given at the end of the paper, immediately before the REFERENCES.

8. Authors may have 25 copies of their papers on application to the Technical Secretary. Any additional copies required by the author will be charged for.

9. Papers read at the Congress will not necessarily be published in the Proceedings.