MACKAY

PROCEEDINGS OF THE

TWENTY-FOURTH ANNUAL CONGRESS

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OF THE

SOUTH AFRICAN SUGAR TECHNOLOGISTS*
ASSOCIATION

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 tatter's Experiment Station at Mount Edgecombe.

PRINCIPAL CONTENTS

OFFICERS

1950-1951

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A. McMARTIN.

Vice-President.
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Hon. Secretary.
(Mrs.) N. BOYD-SMITH.

Hon. Technical Secretary.
W. O. CHRISTIANSON.

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1927-28	M. MCMASTER.	1935-36	G. C. WILSON.	1943-44	G. BOOTH.
1928-29	H. H. DODDS.	1936-37	G. C. WILSON.	1944-45	G. S. MOBERLY.
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1930-31	G. S. MOBERLY.	1938-39	P. MURRAY.	1946-47	W. BUCHANAN.
1931-32	G. C. DYMOND.	1939-40	P. MURRAY.	1947-48	W. BUCHANAN.
1932-33	G. C. DYMOND.	1940-41	E. P. HEDLEY.	1948-49	J. L. DU TOIT.
1933-34	B. E. D. PEARCE.	1941-42	F. W. HAYES.	1949-50	H. H. DODDS.

Former Vice-Presidents.

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1930-31	G. C. DYMOND.	1938-39	E. P. HEDLEY.	1946-47	G. C. DYMOND.
1931-32	A. C. WATSON.	1939-40	E. P. HEDLEY.	1947-48	G. C DYMOND.
1932-33	A. C. WATSON.	1940-41	F. W. HAYES.	1948-49	G. C DYMOND.
1933-34	G. C. DYMOND. E. CAMDEN-SMITH.	1941-42	A. MCMARTIN.	1949-50	J. L. DU TOIT.

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South African Sugar Technologists' Association,

Twenty-Fourth Annual Conference

The Twenty-fourth Annual Conference of the South African Sugar Technologists' Association was held at the Shakespeare Club, Kenilworth Tea Room, Beach, Durban, on the 3rd, 4th and 5th April, 1950, and at the South African Sugar Association's Experiment Station, Mount Edgecombe, on the 6th April, 1950.

The following members and visitors were present:—

H. H. DODDS, *President,*

Hon. D. G. SHEPSTONE,
Administrator of Natal.

ARMSTRONG, E. L.
ANDERSON, R. W.
ALMOND, F. L.
ALEXANDER, K. E. F.

BALCOMB, B. E.
BEATER, B. E.
BECHARD, R. M.
BATES, Dr. G. R.
BRETT, P. G. C.
BOOTH, C. E.
BOTHMA, M.
BENTLEY, JOHN.
BROWN, G.
BOYD-SMITH, Mrs. N.

CORNELL, H. H.
CARTER, R. A.
CARTER, A.
CHIAZZARI, L. F.
CHRISTIANSON, W, O.

DYMOND, G. C.
DYMOND, Mrs. M.
DICK, J. McD.
DICK, Dr. J.
DRAEGER, P.
DUCHENNE, J. 0.
DU TOIT, J. L.
DOUWES-DEKKER, Dr.
DODDS, Mrs. E. A.

EDWARDS, D. ,A.
ELYSEE, A. W.

FARQUAHARSON, J.
FELTHAM, 0. A.

GALBRAITH, W. G.
GARLAND, H. L.
GOLDING, C. D.
GRANT, J. B.
GRINDLEY, L. R.

HEDLEY, Dr. E. P.
HAWKINS, Jas.
HINDSHAW, W. F.
HILL, M.
HENDRY, D. W. W.
HALL, ERNEST.

JOHNSTONE, P.

KING, N. C.
KENNY, ALEX.
HANBURY-KING, P.

LINTNER, JOHN.
LAUBSCHER, P.

MCMARTIN, Dr. A.
MCMARTIN, Mrs. S. V.
MCCULLOCH, A. F.
MURRAY, P.
MCKENNA, H.

MURPHY, E. STANLEY.
MORILLION, C. C.
MILLAR, J. D.
MUNGLE, Major J.
MARTIN, W. '
MOBERLY, G. S.

ODENDAAL, G.

PEARCE, 0. W. M.
POUGNET, J. F.
PHIPSON, E. H.

ROBINSON, N. C.
RISHWORTH, A. H.
RENAUD, C.
RAULT, j.
RICHARDSON, T. A.
RABE, A.
ROSSOUW, Dr. G. S. H.

STEYN, C. L.
SEYMOUR, G. E.
STEPHENSON, R. A.
SHAW, H.

TONNER, D.
THOMPSON, GERALD D.
TWINCH, J. F.

VERINDER, H. N.
VAN VUUREN, R. J.

WATERSON, H. D.
WILLIAMS, ASTON R.
WALSH, W. H.
WAGER, Dr. V. A.

TWENTY-FOURTH ANNUAL CONGRESS

Proceedings of the Twenty-fourth Annual Congress, held in the Shakespeare Club, Kenilworth Tea Rooms, Durban, April 3rd 4th and 5th, and at the; Experiment Station, Mount Edgecombe, on April 6th, 1950.

H. H. DODDS *(President)* was in the Chair.

OPENING CEREMONY.

The PRESIDENT : Ladies and gentlemen,—I have much pleasure in asking the Administrator of Natal, the Honourable Mr. D. G. Shepstone, to open this Congress.

The ADMINISTRATOR : Mr. Chairman, ladies and gentlemen,—When I received your kind invitation to open this Conference, I was torn between two courses—whether to accept the honour and take the opportunity of paying my tribute in simple terms to the work which the Sugar Technologists have done over the course of years in the Sugar Industry of South Africa, or whether to bow my head to the humiliating fact that I have no knowledge of science, or its offspring, technology, and to admit that I could offer no useful contribution to a gathering of scientists such as this, and, therefore, to refuse the invitation.

As is so often the case in situations of this nature, my pride outstripped my better judgment and I accepted, and to-day I am here before you to pay the penalty of my folly in trying to address you on a subject in respect of which you hold all the aces and I hold the lowest cards in the pack. But I think, Mr. Chairman, that I can say that there is some similarity between our respective professions, slender though it may be, and here I refer to my profession of law. That similarity is this. In the exercise of your functions as research workers there must be that endless docility to facts, there must be that capacity to analyse facts and to deduce correctly from established facts, that relentless alertness of mind and powers of observation, and, above all, there must be the play of that powerful agent of discovery by which the gap between the known and the unknown is bridged. But here, Mr. Chairman, the similarity between my profession and your profession ends, because your profession is engaged in the search for absolute truth, whilst my profession, dealing with the frailties and limitations of humanity, must be content with approximate truth. Nothing less than absolute truth can be of any assistance to you in your work of research, for in your work you are creating new knowledge. In this search for truth that knowledge is absolutely essential and the application of the new knowledge gained by you through research is of inestimable value in the development and expansion of the industry which you serve and to the general prosperity of South Africa.

I read somewhere that minerals could be regarded as capital, which, once used, could never be replaced, but that the products of the soil could be regenerated from year to year, and in that sense they could be regarded as income or revenue. I think there is much substance in that statement, for the Sugar Industry in South Africa has been one of the greatest revenue-producing industries that we know and a great asset to our country. In proof of that I have only to recall the sugar industry of my boyhood. In those days there were a few plantations in Natal, and Zululand was an unknown quantity so far as sugar was concerned. To-day there is a complete transformation of the scene. You now have sugar lands from Umzimkulu right up to Matubatuba, and we read that in the Pongola district there is to be expansion of sugarcane and, probably, there will shortly be a mill in that locality. And all this has been achieved in one lifetime by the energy and foresight of the growers and millers, and by the labours and the results of the research work of the Sugar Technologists in the cause of their industry. Where there existed, in early days, probably one cane variety, you have to-day many varieties attuned to the conditions of their environment which are hardier, more disease-resistant and probably more profitable. The work of the geneticist, the botanist, and the agronomist has been of purpose and fruitful.

There is another aspect of this development, and that is the effect which science and technology have had on the social and economic life of this country. It will be conceded that the sciences were largely responsible for the industrial revolution in England, and continued research was the avenue which preceded industrial expansion. The same pattern is being repeated in our country, though perhaps on a different background, with even greater speed as a result of the gain of accumulated scientific knowledge and its practical application. What this may mean to the population is difficult to foresee. It opens up a vast field of speculative thought and it may well be that science and technology will have a very considerable part in directing the policies which will be adopted in the future of South Africa.

Two examples of the effects of research in this country which immediately occur to me are revealed in the wattle and sugar industries. So far as the wattle industry is concerned, it is not within the ambit of my function to-day to discuss the achievements by their scientific and technical staff except to say that I have had the privilege during my office as Administrator to open a conference of wattle growers and to see their products at the Agricultural Show. There research and experiment were reflected in terms of efficient material progress in processing and manufacture—particularly the factory which produces Masonite at Estcourt. It was an illuminating experience.

In so far as the sugar industry is concerned, the position is not quite akin. The prime object of that industry is to produce and supply an essential commodity for human consumption. But there have been tremendous developments in scientific investigation into the uses of sugar and its derivatives. You are all doubtless aware of the remarkable work of the Colonial Products Research Council of England, begun in 1928 under the leadership of Sir Norman Haworth of Birmingham University and followed up in the Sugar Research Foundation of New York under the directorship of Dr. Robert C. Hockett. The activities of these organisations have transformed the knowledge of sugars and their derivatives until to-day there is open a wide vista of their growing importance to human life and to industry. I remember reading some time ago an article on this subject which was of immense interest and I little thought then I should be called upon to address you who probably are well aware of the progress of the sugar research projects. I read there how Dr. Wiggins of the Birmingham University—now Director of The Imperial Research Institute of Trinidad—and his co-workers discovered the method of making nylon from sugar and produced a promising anti-freeze in *sodium levultnate.* They also "jockeyed" the sugar molecule around to team up with inorganic elements to produce drags of the sulpha type. There is also a derivative, sucrose octa-acetate, a white crystalline substance, from which laminated glass is made, and which can be formed into clear sheets and films. Then I read also of the derivation from sugar of laevulinic acid, from which more than a hundred other products have been derived and which may be used for industrial purposes.

These and many other discoveries of scientific research will be called to mind : sugar and sugar derivatives in pharmacy; sugar and its by-products in the plastics industry; the use of sugarcane bagasse for paper, board, plastics and chemicals; the production of lactic acid from sugars and molasses in rubber and alcohol production are among the remarkable list. It is an astonishing record. I have mentioned it because what is being done by the powerful world sugar industry—one of the five largest food industries of our universe—must unquestionably contribute greatly to the solution of many problems by which mankind will be confronted.

And now let me say this—I realise what we owe to the sugar industry. I think the whole of Natal realises it. And it seems to me from the indications of your recent Commonwealth Sugar Conference in England that there are substantial grounds for believing that the future of the Sugar Industry, for a number of years at least, is secure, and that you are, as sugar industrialists, to get a remunerative price for your work and your product. I hope that is so, because, after all, the whole of this country benefits from an industry of this nature. So I would say to the Sugar Technologists to-day that although yours may not be a spectacular profession—you may not be in the public eye as many other professions are—you are doing a most valuable work; you are applying all those qualities of mental integrity which I referred to in the early part of my address. Without those qualities, without the highly-developed sense of the research worker comprising the quality of mind which, as I say, approximates in some degree to my own profession, you would never be research workers. You are in reality the "backroom boys" of this industry. Now as a front-room boy—a very unhappy position to hold—I can pay my compliment to the backroom boy. I know his work in our Provincial Administration. I salute you "backroom boys" of the Sugar Industry and I hope this Conference will be a successful one and your work will assist not only this industry, but other industries in South Africa. With these few remarks purely from a layman's point of view, I would like again to thank you for the honour which you have done me in asking me to open your Conference to-day.

Mr. DU TOIT : Mr. Chairman, ladies and gentlemen, —His Honour the Administrator has once again demonstrated that he sees things very clearly, that he has an intimate knowledge of conditions in this country and also in other sugar-growing countries. He has again come forward with a most lucid and informative address. We appreciate his remarks a great deal. Praise given in that manner acts as a stimulus to further progress.

Our conferences have been opened in the past by distinguished people. We have been honoured on these occasions by other Administrators of this Province, by principals of colleges and universities, by permanent Government officials and by men who have made their mark in this industry and who have given a lead in a wider field. But, sir, I feel that our choice to-day has been a particularly happy one. I am not an historian and I don't know whether the sugarcane plant came to Natal before the first Shepstone or not; but I do know that this Province owes a great deal both to the Shepstone family and to the sugarcane plant. We realise that His Honour is a very busy man indeed, and we appreciate it the more that he has given us some of his valuable time to open our Conference and to give us additional courage to strive for the future, and I am very happy, therefore, in proposing a very hearty vote of thanks to His Honour the Administrator for having honoured us this morning and for opening the 24th Annual Conference in such an inspiring manner.

THE PRESIDENT'S ADDRESS.

Mr. H. H. DODDS (President) : Your Honour, ladies and gentlemen,—I much appreciate the honour of being again elected president of this twenty-fourth session of the Association, after an interval of twenty years, which I regard as a mark of continued confidence in me by my fellow members that I greatly welcome. At the same time I realise the difficulty the council has at times in getting suitable members to accept this post, so that they are sometimes obliged to call on one of the old-timers to act once more. This somewhat reminds me of the travelling dramatic companies we get in this country. For various evident reasons they travel with the smallest possible casts, so that one may see an actor who comes on in a new part in one of the later scenes of the play who seems vaguely familiar; then on referring to the programme one finds that he did, in fact, play a part that you had almost forgotten, in the first act.

This is in the nature of a valedictory address since although I look forward to the interest and pleasure of attending many more of these conferences it is not likely to be in an official capacity, because of my forthcoming retirement due to the march of time.

Although this is officially described as the twenty-fourth annual conference of this Association it is in reality the twenty-fifth. The first one was held in 1926 in conjunction with the fourth and last annual "Sugar Week" of the South African Sugar Association. In 1927 we had the first independent annual conference, now regarded as number one of the series and it may be of interest to look back to this period to see what the sugar industry looked like then compared with the present and, in the light of that comparison, to attempt an estimate of possible developments. Up to 1927 the industry had never reached an annual sugar output of 250,000 tons; the variety of cane exclusively under cultivation was still Uba, and it was not until 1935 that appreciable quantities of other varieties began to be delivered at the mills.

To get a picture of the growth of the industry from the early days, however, we must begin with the 1890—1900 period, when the average total annual production of sugar was 20,000 tons, or considerably less than the average annual production per factory to-day. From 1909 onwards there was a very marked increase due to cane from Zululand being milled in considerable quantities. The increase at this time from an average annual output of 40,000 tons over the period 1905—1909 to nearly 93,000 tons over the period 1910—1914, appears to be the biggest percentage increase over two successive five-year periods in the history of the industry, as far as available records show.

The growth of the industry from 1890 to the present day, shown graphically, depicts the typical first portion of what is known as a sigmoid curve, characteristic of the rate of growth of many things, such as for example a human child, a sugarcane stool, the population of a city, etc. There is first a relatively short period of slow growth, then a long period of rapid growth, if conditions continue favourable, eventually flattening out again to a reduced rate of growth as maturity is approached.

If we calculate the sugar output of this country in successive five-year averages, to level out the effect of occasional drought years and the like, we find, that there has never been a decrease from our first records in 1890 until the period 1945—1949, when there was for the first time a slight decrease in average annual output over the preceding five years. This was due to the remarkably prolonged drought cycle extending over the three successive years 1944, 1945 and 1946, when the average annual rainfall over the whole of the sugar-growing area was 33.48 ins. or 20 per cent, below the average. Annual rainfalls as low as these or even lower had been experienced, as in 1887, 1923 and 1941, but never before for more than two years in succession. This drought naturally had a cumulative depressing effect on the crop over the three successive years 1945 to 1947, from which the industry is only now recovering.

If we consider in a little more detail the average crop and factory results of the decade ending in 1934, it will include a period from the beginning of systematic collective factory laboratory records in 1925 to the end of the period when Uba cane formed practically the whole of every crop; it also covers the period of the beginning of this Association and its work. The average yield of cane per acre for this period was 20.66 tons. The average overall recovery, that is the percentage of sucrose originally in the cane obtained in the crystallised sugar, was 75.12, which implies that the percentage of sucrose in the cane lost in manufacture as far as the production of sugar is concerned (though by no means lost in the sense of being unrecovered in some useful product) was 24.88 during this period. From 1943 to the present the average overall recovery is 83.31, giving a loss in manufacture of only 16.69 per cent, of the sucrose originally in the cane, a figure that will bear comparison with that of most of the leading sugar manufacturing countries in recent years. This improved overall recovery integrated advances in both of the two main phases of sugar manufacture, viz., the extraction of juice from the cane, and the recovery of sugar from the juice by boiling, etc.

Another still more important manufacturing figure is the number of tons of cane required to make one ton of sugar, which takes not only manufacturing efficiency into account but also the percentage of sucrose originally in the cane. During 1925 to 1934 the average ratio of cane to sugar was 9.86, while since 1943 the average has been 8.64. This means that for the average annual cane crop in recent years of 5 million tons, an output of 578,700 tons of sugar would result from the present ratio of cane to sugar, while the same cane crop at the 1925—1934 ratio would yield only 507,100 tons of sugar. That is to say that the improved factory performance evolved over the past 20 years has resulted in an extra 70,000 tons of sugar per annum on the present crop being obtained, of an approximate value of £18 per ton, or rather more than £1,250,000 per annum in all. This does not take into account the value of the improved yield of cane per acre, which is another story, but only the improved factory performance.

To what causes can this valuable improvement be attributed? Partly no doubt to the improved quality of the cane, but mainly to improved equipment and technique in the factory. It is curious to find that the new canes, from which so much was expected and so much has been obtained, have not led to a greater increase of sucrose content of cane having been recorded. Thus the average sucrose content of cane during the 1925—1934 period was 13.29 per cent., and the average foi the 1940—1949 period 13.65, not a very large increase. Nor is the fibre content of the cane greatly improved. During the former period it averaged 15.78 per cent., and during the latter period 15.62, A somewhat more significant difference is in the purity of the juice, that is to say the percentage of sugar in the total solids in solution, a very important factor; this has increased from 85.09 for the ten years ending 1934 to 86.04 for the period 1940—1949.

But even this does not appear to afford anything like an adequate reason for the improved factory performance, which must therefore be largely attributed partly to improved equipment and partly to better technique. I suggest that some of the members of the Association have largely contributed to this, firstly by suggesting in the light of their knowledge and experience what new equipment is likely to be most successful, and secondly by seeing that such equipment when obtained is used to the best effect.

If not very much can be claimed from the new cane varieties on account of their relatively slightly improved quality over Uba under conditions in this country, where they do come in is in the greatly increased yields of cane and consequently the sugar per acre resulting from their use. Thus for the ten years 1924—1933 the cane, practically all Uba, gave an average yield per acre of 20.44 tons, while for the ten years ending 1947, the last for which official figures are at present available, the yield was 26.51 tons per acre. The area under cane and the area of cane harvested each year remained static from 1932 to 1947, so that the great increase in the quantity of cane milled annually, ranging from 3,673,375 tons in the 1933 season to 5,351,945 tons in 1944 and 4,929,580 tons in 1949, results from the increase in cane yield per acre and not from any increase in area harvested.- This is undoubtedly due mainly to the new varieties of cane that have replaced Uba, though some credit must be given to the more adequate and more rationalised application of fertilizer, when obtainable, which has by no means been always the case in recent years, and partly to the application of irrigation in a few limited areas. For example, the increase in yield of cane per acre in the Inanda division from 16.7 tons in 1926, then the lowest yield in any division, to 40.45 tons per acre in 1943, the highest yield in any division that year, which was also gained by Inanda in each successive year from 1939 to date is undoubtedly due largely to the use of irrigation by Natal Estates Ltd., and only secondarily to the introduction of the new varieties.

Nevertheless, I believe that over the industry as a whole an increased yield of cane and consequently of sucrose per acre amounting to 20 per cent, of the total is a very conservative estimate of the improvement that can be attributed solely to the replacement of Uba by the new varieties. This means that on the average area of 180,000 acres harvested per annum an increase in yield of rather more than one million tons of cane is being obtained annually from the overall increase in yields. One million tons of cane corresponds to 114,400 tons of sugar of a value of well over £2,000,000 at £18 per ton, due to these improved yields of cane as between the two periods. If we apply the 20 per cent, annual increase estimated to be directly attributable solely to the new varieties we get an increase of over 800,000 tons of cane per annum, corresponding to 90,000 tons of sugar of a total value of over £1,600,000 per annum. These increased values indicate only the increased revenue from the same area of land and not increased profit. The latter of course can only be determined by deducting the cost of production, which varies widely with circumstances and for which average figures are "not available as far as I am aware.

In presidential addresses to the South African Association for the Advancement of Science by General Smuts in 1925 and the late Mr. J. H. Hofmeyr in 1929, the question was asked and analysed "What can Science do for Africa?"

In commenting on this subject, Dr. P. J. du Toit in his presidential address to the same organisation in Durban in 1932 said that scientific research was looked upon in South Africa as a luxury that could be indulged in only in small doses and then only in times of prosperity. When the necessity for economy arose, research was usually the first to suffer, just when the need for the results of research was most urgent. Fortunately that view has since changed, at least in the sugar industry and certain other industries, and in his opening address to this congress last year Dr. Malherbe was able to ask why certain industries spent so much on research, and to supply the answer that they had found that it pays. I believe that claim can be made for the Sugar Experiment Station at Mount Edgecombe, not only in the introduction of new variety canes but also in the study of many other agricultural problems, and certain manufacturing ones in the past, and that before long the new Sugar Milling Research Institute will also be found to justify very fully its cost.

Indications point I believe to a very successful future for the South African sugar industry. It is true that the climatic features of Natal are not ideal for sugarcane, both in our long cool dry season when little growth is made, but unusually high sucrose contents as compared with those in most countries can be developed, and in our somewhat low and very variable rainfall. But in most other requirements of the industry this country is favourably located and well served and, with an assured market, progress may be confidently anticipated.

There is still much room for improvement and none for complacency, as pointed out last year by my immediate predecessor in this chair, Mr. J. L. du Toit. Only twice has an annual yield of 30 tons of cane per acre been exceeded in this country, and our normal crop extends over a two-year period instead of from 12 to 18 months as in most other countries. In the factories, with few exceptions, the residual moisture content of the bagasse and the purity of the final molasses are still high compared with those of the principal sugar manufacturing countries, and certain valuable components of the by-products of our industry still remain to be investigated and profitably exploited, if possible.

Now that the problem of promoting the formation of fertile sugarcane seed in this country from many of the varieties in the collection has been solved, there should not be much difficulty in developing new varieties as required in the future. With ample supplies of cane, mechanised agricultural equipment and extended and improved factory plant, the increased production already provided for seems assured. There are many new planters, largely ex-servicemen, and the area under cane has been extended, the first time for many years.

In these times of increased production the planter and the factory engineer are most prominent; but the need for efficient recovery of sugar at every stage of manufacture is ever present, and it is here where the chemist comes in. Some of the pioneers of the industry still recollect the times when it took 14 tons of cane to make a ton of sugar. But experience has shown that this can occur even in these days of modern machinery if chemical control of the manufacturer of sugar is completely neglected, and lesser losses no doubt occur if the chemical control is not most efficiently and conscientiously applied.

I know from my own experience the difficulty of getting scientifically trained staff at the present time, but this should not discourage the industry from employing highly qualified and experienced men in responsible technical positions such as those of chief engineer and chief chemist and field manager. I found when I lived in Louisiana and some of the other larger sugar-producing countries in that part of the world many years ago, and in subsequent visits, that such posts were usually occupied by graduates of local universities with post-graduate experience, or by men of equal qualifications.

In this province we have not had, until recently, facilities for local university education, and the small number of university graduates in our industry has tended to decrease in recent years; but the industry should in the near future profit by the local opportunities for higher education now available, and appoint trained men for work both in research and production, which lines will become more closely interwoven in the future.

Mr. G. S. MOBERLY : Your Honour, Mr. Chairman, ladies and gentlemen,—Dr. Dodds has given us a very searching analysis of the changes which have taken place in our industry over a number of years. But I think there is one point he might have made a little more clearly, and that is that round about a quarter of a century ago there occurred a number of events •which, together, constituted something of a revolution in this industry.

•I would mention first the event he has referred to in 1926 and 1927, the formation of this Association; then again, in 1926 and 1927, the Fahey Agreement, instituting a new era in the purchase of cane by analysis instead of by dead weight; then there was a third event which occurred a little earlier than those two, and that was the formation of the Sugar Experiment Station, to which our present President, Dr. Dodds, was appointed as the first Director. These events constitute together what I call a revolution in this industry which set us on a new course. Among these happenings I count the formation of the South African Sugar Technologists' Association not the least. Above all, I reckon very great progress has been made due to the fact that this organisation was under the direction of our present President in some of the early years.

Dr. Dodds referred in his address to an occasion at a conference which was held in 1926—the last of what was known as the old "Sugar Weeks," and the first which was in any way connected with this Association. An event occurred during that particular conference which was of great interest. Survivors of that now-diminishing band will remember that occasion when we all drove out to Mount Edgecombe in the afternoon. There was a solitary building of brick, which to-day constitutes the stables or native quarters or something of that sort, of the Experiment Station. There we sat on planks supported across oil barrels and ate sandwiches and listened to visionary promises of what the Experiment Station was to be. That was the beginning of the Experiment Station. I don't have to tell any of you what that institution Experiment Station is to-day. And during all these long years that station has been under the able guardianship of Dr. Dodds. To have created that organisation and then to have directed and built it up to what it is to-day is a task the value of which few of us could really comprehend; but we do know that throughout that period Dr. Dodds has been a source of energy, working hard at establishing this institution; that he has been not only its Director but its press agent and that he has never missed an opportunity to bring to the notice of the industry and the Province some idea of what was being done. That was a very important part of his work. His name has now become not merely one of great credit to us here, but something of international reputation. He has represented this country in a succession of international conferences, and I am happy to hear that, in the few months that remain to him as an active member of this industry, he is again to be one of our representatives at the International Congress at Brisbane.

Dr. MCMARTIN: Mr. Chairman, ladies and gentlemen,—Before this meeting finally disperses, there is one thing I think we might do. As you are aware, after a lapse of many years the International Society of Sugar Technologists is once again meeting in Queensland, and I think it is fitting that from this meeting we should resolve to send a message at the proper time conveying from the South African Technologists our greetings to the International Society and our best wishes for a successful meeting. I therefore put this as a proposition.

Mr. STANLEY MURPHY: May I take the opportunity to second Dr. McMartin's resolution? Dr. Dodds has done a tremendous lot for the industry, and as for the Sugar Technologists' Association, of which I can claim to be one of the foundation members, I think making Dr. Dodds available to the International Conference is an action which reflects honour on this Society. The Sugar Industry has gone on from strength to strength, I remember, in my early days, when I started planting, we were happy when we turned out 100,000 tons of sugar.

Dr. E. P. HEDLEY (Past President): It is some years since I had the pleasure of addressing this gathering of fellow technologists. I want to take this opportunity, as Dr. Dodds calls this his valediction, to say that I know the battles Dr. Dodds has gone through. I think you will all agree that his address reveals wonderful results through the years that he worked in the Experiment Station to bring it from its commencement to the efficiency it has now. When he went there, he told you, there was only Uba cane; when he leaves there will be a great increase of new canes which have meant a considerable benefit to the industry.

The PRESIDENT: Thank you very much. I suppose we may take it that Dr. McMartin's proposition is unanimously accepted?

I find I have one more duty still to perform before I vacate the chair; that is to give the Technologists' Prize to the most promising sugar student of the year at the Natal Technical College, and I would be very glad if Mr. A. Delamoir would come forward to receive it.

TWENTY-FIFTH ANNUAL SUMMARY OF CHEMICAL LABORATORY REPORTS

SOUTH AFRICAN SUGAR FACTORIES, SEASON 1949-50

By H. H. DODDS and J. L. DU TOIT.

The 1949-50 sugarcane crop was somewhat of a disappointment to the industry and was below official estimates. There were 4,929,580 tons of cane crushed and 561,122 tons of sugar manufactured, a ratio of cane to sugar of 8.79.

The production both of cane and sugar was lower than for the previous year, but better than for the three seasons preceding last year:

As usual, the vagaries of our very irregular annual rainfall form the principal cause of the falling-off in production.

The general rainfall for 1948 was only 35.25 inches with an extremely dry winter season. The winter rainfall at Mount Edgecombe was 1.52 inches in all for the months of May to September inclusive, against a 23-year average of 8.61 inches for this period. The annual rainfall for 1948 was very deficient at all stations north of Verulam, though the South Central area from Illovo to Mount Edgecombe had rainfalls appreciably above the average.

1949 had also an abnormally dry winter season, the rainfall from May to near the end of September being only 1.99 inches against an average for the period of 7.96 inches. The rainfall for March, which has the highest average monthly rainfall at the Experiment Station, 5.02 inches, was only 2.22 inches in 1949, and the aggregate for the year up to the end of September was only 19.57 inches or even less than in 1948. However, good rains in the last quarter of the year brought the total for the year above the average at most stations. In 1949, contrary to 1948, it was the South Coast that suffered a deficiency of rain, while the northern area beyond Chaka's Kraal came off very well. The total rainfall at the Experiment Station was 36.61 inches and the general average for the cane-growing districts 43.35 inches.

In some areas the harvesting of cane and transport to the mill was seriously hindered by excessive rains in December; and in both years there were indications of a falling off in quality of cane as regards sucrose, purity and fibre towards the end of the season, more rapid than in normal years, probably due to the effects of the prolonged drought.

The average sucrose content of the cane harvested during the season was 13.52 per cent., which is somewhat less than the average of the previous ten years, 13.65.

The ratio of cane to sugar was 8.76, which is higher than for most recent years, due mainly to the lower sucrose content of cane; the ten-year average is 8.74. A ratio of 8.76 corresponds to a yield of sugar per cent, of cane of 11.42 per cent, and of sucrose (at present polarisation of sugar) of 11.28.

As last year a large proportion of the crop was cut before July so that the largest proportion since 1944 was milled outside the optimum period of July to November, when the sucrose content of cane and purity of juice were considerably below standard, thus increasing considerably the ratio of cane to sugar.

Comparison of results from cane harvested during the July-November period, compared with those of earlier and later months of the harvesting season.

		Percent. total Cane.	Ratio Cane/ Sugar,	Sucrose per cent,	Fibre per cent.	Purity Mixed Juice.
Hcui, 1928/1942—						
	Optimum period ..	73.91	9 03	3 77	15.31	85.88
	Balance of crop .. .	26.09	10 15	2.56	15.65	84.50
1944	Optimum period ..	66.57	8 43		15.78	86.58
	Balance of crop .. .	33.43	9 20	3 01	15.93	85.41
1945	Optimum period .. .	73.75	8	4 66	16.03	86.33
	Balance of crop .. .	26.25	9 01	3 21	15.88	85.96
1946	Optimum period .." .	85.64	8 27	4 33	18.20	85.88
	Balance of crop ..	14.36	8 96	3	18.27	85.74
1947	Optimum period .. .	77.07	8 65	3 58	15.78	86.48
	Balance of crop .. .	22.83	9 57	2 45	16.87	85.43
194S	Optimum period .. .	70.48	8 30	4 26	15.83	88.08
	Balance of crop .. .	29.52	9 22	3	16.07	86.68
1949	Optimum period... ..	67.49	8 50	S 86	16.20	86.49
	Balance of crop	32.51	9 36	2 81	16.17	85.66

As in most past seasons, September was the peak month for sucrose when it was 14.45; December was the lowest with 12.47.

The purity of mixed juice was also at its maximum in September, when it was 86.83, and not in October as is more usually the case; it was at its lowest in December, when it was only 84.82.

The total for the season was 86.22 which compares favourably with the 10 year average of 86.04.

The reducing sugar ratio in mixed juice was 3.11 for the season, slightly less than the 10-year average of 3.35. It was at its lowest in July, 2.80, and as high as 3.89 in December.

The fibre content of cane for the season was 16.19 per cent., one of the few occasions on which it has exceeded 16. The average for the past 10 years is 15.62 and the highest on record for any season was 16.27 in 1927.

The fibre was lowest in August when it was 16.04 and highest in December when it was 16.42; this was exceeded only twice in any monthly period in our records.

Cane Varieties.

The same tendencies in change of varieties continue that have been noted in recent years. That is to say the older varieties, Uba, Co.290 and Co.281 continue to diminish while Co.301, Co.331 and N : Co.310 continue to increase; the P.O.J, varieties have increased slightly this year but still form less than 3 per cent, of the crop.

The changes in the percentage of varieties harvested in recent years are as follows :—

	1949-50.	1948-49.	1947-48.	1946-47.	1945-46.	1944-45.	1943-44.	1942-43.	1941-42.	1940-41.	1939-40.	1938-39
Uba.. ..	0.39	0.72	1.53	1.91	2.81	4.25	6.50	11.09	16.57	23.2	30.2	32.2
Co.281 ..	47.30	56.94	58.69	63.25	67.77	66.49	64.40	52.41	42 .44	37.5	28.3	21.0
Co.290 ..	0.71	0.98	1.54	2.65	4.36	7.23	11.23	19.08	26.51	28.2	30.0	35.2
Co'.301 ..	41.89	36.06	33.11	28.16	21.09	18.07	14.06	10.60	5.89	3.3	2.4	0.3
Co.331 ..	4.21	2.54	1.66	0.65	0.60	0.13	0.05					
N:Co.310..	2.60	0.07										
P.OJ. ..	2.90	2.69	3.46	8.37	3.34	3 .83	3.76	6 .82	8.59	7.8	9.1	10.0

The proportion of Co. 281 has fallen from a peak of 67.77 per cent, of the total crop in 1945 to 47.30 per cent, for the crop under review. During the same period Co. 301 has steadily increased in. proportion from 21.09 to 41.89 per cent.

Both Uba, which before 1938 constituted the bulk of the crop and for many years formed 100 per cent., and Co.290, the first cane to surpass Uba, which it did in 1938 and attained its peak of 35.2 per cent, the same year, are now only milled in insignificant quantities.

Co.301 reached 41.89 per cent, of the crop in 1949-50, but in view of the even more rapid rate of increase in Co.331 and N : Co.310 one may perhaps venture to prophesy that Co.301 will reach its peak within another year or two.

Both Co.331 and especially N: Co.310 have increased at a phenomenal rate over the past year or two and now form 4.21 and 2.60 per cent, respectively, of the crop. Apparently it is only during the last two or three years that Co.331 has been appreciated; it expanded very slowly for some years after its release in 1941.

The next table shows the proportions of cane varieties milled by months for the period ending as shown:—

Variety.	May 28 1940.	June 2 1949.	July 30 1049.	Aug. 27 1949.	Oct. 1 1949.	Oct. 29 1949.	Nov. 26 1949.	Dec. 31 1949.
Uba ,..' ...	0.11	0.55	0.55	0.57	0.32	0.28	0.81	0.24
Co.281. ...	61.16	57.20	52.65	48.47	43.28	40.73	36.45	41.39
Co.290. ...	0.47	0.31	0.44	0.51	0.50	0.57	1.20	2.24
Co.301. ...	38.14	39.90	41.53	42.29	45.07	45.42	48.22	37.40
Co.331. ...	1.79	1.72	2.52	3.85	4.89	5.84	6.03	6.39
N£o.310 ...	0.08	0.09	0.33	0.95	8.83	419	4.65	6.92
P.Q.J.	0.25	0.23	2.08	3.86	2.61	2.96	3.13	5.41

This table shows that Co.281 is cut largely early in the season, partly to benefit by its early ripening, and partly because there is relatively little plant cane of this variety.

The following is a summary of the arithmetic averages of the sucrose per cent, cane and crusher juice purity of the different varieties of all factories where the Sugar Industry Central Board conducts tests and includes 63.4 per cent, of the total cane crop.

Variety.	Per cent. cane.	Sucrose per cent. cane.	Crusher juice Purity.
Uba	0.23	13.47	87.28
Co.281	49.96	13.74	88.77
Co.290	0.93	12.81	87.40
Co.301	39.87	13.49	88.63
Co.331	5.33	13.03	88.60
N: Co.310...	2.79	14.34	89.35
P.O.J	0.90	13.37	88.80

The "per cent, cane" is given as weighted averages and the crusher juice purity as arithmetic averages, but the sucrose per cent, cane is the arithmetic average of all the factories where the average of each factory is on a weighted basis.

There are three large factories not included in the Central Board returns, and the sucrose percentages of the varieties at these three centres were as follows :—

	Tongaat Sugar Co.	Natal Estates Ltd.	•Umfolozi Co-operative Sugar Planteri Ltd.
Per cent, of the total cane crop	13.3	11.4	7.4
Uba	14.07	13.68	10.63
Co.281	13.98	13.86	12.53
Co.290	13.20	13.43	10.88
Co.301	13.91	13.58	13.01
Co.331	13.47	13.33	12.90
N: Co.310	14.57	13.70	12.97
P.O.J	13.58	—	12.62

•These figures calculated on a differential Java Ratio based on fibre, and not strictly comparable with the other factory varietal sucrose percentages.

The results from these three factories together with the Central Board returns account for 95.5 per cent, of our total crop. Sucrose percentages are available from 17 factories and from these the new variety N : Co.310, although as yet milled only in relatively small proportions, was found to be the highest in sucrose percentage at 11 factories, P.O.J, was highest at 2, Co.281 highest at 3 and Co.301 highest in one factory.

The P.O.J, varieties suffer rather unduly in a comparison of this nature as they are exclusively grown on flats and then compared with other varieties which come very largely from dry hill lands. Although Co. 331 is one of the lowest varieties in sucrose content the returns do not show it up in such a very unfavourable light; in fact it was thought that this variety would be lower in sucrose and with the excellent cane yields obtained from it at many areas, it is likely to be planted in increasing amounts.

General Factory Performance.

The number of factories in production during the]949-50 season remained at 20, but it is understood that New Guelderland in all probability has operated for the last time and that in future their cane supply will be crushed at the Mount Edgecombe factory.

18 of these factories, now producing 99.2 per cent of the total output of sugar, figure in our reports. The remaining two small factories are not in a position to give detailed returns, but their ratio of cane to sugar raises the average for this figure to 8.78 for the whole crop instead of the 8.76 previously recorded in this report for the 18 factories contributing returns to the Experiment Station.

The average (weighted) extraction for the season for these factories is 92.94 which is slightly less than for the three preceding years, but compares favourably with the average for the 10 preceding years of 92.84. The reduced extraction based on an assumed fibre content of cane of 12.5 per cent, is 94.78 which is only surpassed among countries of which we have recent information by Hawaii (96.74) and Queensland (95.78).

The average boiling house recovery of 89.68 was only surpassed in this country in 1943, when it was 89.84; the purity of mixed juice (86.56) was unusually high. The 10-year average for this figure is 89.05.

The average overall recovery is 83.35, which was surpassed in 1947 (83.73) and 1943 (83.52). The 10-year average for overall recovery is 82.68. The reduced overall recovery for the season is 83.98.

The overall recovery of 83.35 of course indicates a percentage of total losses of sucrose losses in cane during manufacture of 16.65.

The identity of the symbols used in the detailed table of manufacturing results with the factories, represented, and the code number formerly used, are as follows :—

Name of	Owners.	code No.	Index for tables,
Mount Edgecombe	Natal Estates Ltd, ...	1	NE
Umfolozi	Umfolozi Co-operative Sugar Planters, Ltd.	2	UF
Entumeni	Entumeni Sugar Milling Co., Ltd. ...	3	EN
Gledhow	Gledhow - Chaka's Kraal Sugar Co., Ltd.	4	GL
Maidstone	Tongaat Sugar Co., Ltd. ...	5	TS
Empangeni	Zululand Sugar Millers & Planters, Ltd.	6	ZM
Illovo	Illovo Sugar Estates, Ltd.	8	IL
Doornkop	Doornkop Sugar Estates, Ltd.	9	DK
Felixton	Sir J. L. Hulett & Sons, Ltd.	10	FX
Sezela	Reynolds Bros., Ltd.	11	SZ
Darnall	Sir J. L. Hulett & Sons, Ltd.	12	DL
Amatikulu	Sir J. L. Hulett & Sons, Ltd.	14	AK
Renishaw	Crookes Bros., Ltd.	15	RN
New Guelderland	New Guelderland Sugar Factory.	16 ,	NG
Umzimkulu	Umzimkulu Sugar Co., Ltd.	17	UK
Chaka's Kraal ...	Gledhow - Chaka's Kraal Sugar Co., Ltd.	18	CK
Melville	Melville Sugar Co., Ltd. ...	19	MV
Esperanza	Reynolds Bros., Ltd.	21	ES

The purity of final molasses for the season was 41.39, the 10-year average for this being 42.28.

The average moisture content of bagasse continues to be high and was 50.84 per cent., the highest for several years; the 10-year average is 50.87.

The peak month for extraction was August with 93.24, due to the fibre being at the minimum of 16.04 per cent, of cane for this month. Usually September has been the best month for both these figures.

August was the peak month also for boiling house recovery, when it was 90.24; in past years it has been distributed more or less equally over the central and latter months of the season.

It follows then that the overall recovery was also at its highest in August, when it was 84.14. August holds the record for the best overall recovery equally with September.

September was again the best month for ratio of cane to sugar, when it was 8.15. This month easily has the best record for this ratio, due to the sucrose content of cane being highest in September in 17 out of the past 23 seasons.

The average imbibition per cent, cane for the season was 33.70, which shows a progressive slight decrease annually since the peak year of 34.96 in 1945. The average imbibition for the past 10 years is 33.54.

Individual Factory Results.

(a) **Quality of Cane.** Once again the highest sucrose content of cane has been recorded at the southernmost factory, Umzimkulu, 15.16 per cent. The lowest was at Felixton where it was 12.59 per cent, and at Umfolozi 12.66 per cent., both these factories drawing their cane supplies largely from alluvial fiats.

There have been again some very high fibre contents of cane, notably Illovo with no less than 18.36 • per cent. As usual Umfolozi had much the lowest fibre content, 13.64 per cent., no doubt largely due to the high proportion of P.O.J, cane milled.

The highest purity of mixed juice was at Entumeni, 88.32, closely followed by Esperanza with 88.30, while at Umfolozi it was as low as 82.36.

New Guelderland had the lowest reducing sugar in mixed juice, 2.27, and Felixton and Umfolozi the highest, with 4.08 and 4.02 respectively.

(b) **Cane Varieties.** Only two factories, Natal Estates and Melville, crushed more than 1 per cent, of Uba, while three did not record any. Only Felixton crushed more than 1 per cent, of Co.290.

Some factories still depended very largely on Co.281, notably Umzimkulu with 99 per cent., Empangeni 82 per cent, and Entumeni 80 per cent. No mill crushed less than 26 per cent, of Co.281.

By comparison the distribution of Co. 301 is much more irregular, ranging from 0.2 percent, at Umzimkulu and 2.2 at Entumeni to 66 per cent, at New Guelderland.

Co.331 has expanded very rapidly in certain areas, especially Entumeni, where it formed 15.8 per cent, of the total crop, and Doomkop, where it was 14.5. On the other hand there was none recorded at Umzimkulu and insignificant amounts at certain other factories.

Another new variety that already forms an appreciable proportion of the cane supplied to certain factories is N: Co.310, of which almost 7 per cent, is recorded at Felixton and 6.5 per cent. at Gledhow.

P.O.J. 2725 is now largely confined to Umfolozi, where it formed 31 per cent, of the crop; there was 4£ **per** cent, at Felixton **and** little or none at any other factory.

(c) **Manufacturing Results.** Natal Estates, as in recent years, gained **the** highest extraction, 94.97. **Other mills with over 94 were Umzimkulu** 94.48, Esperanza 94.12 and Sezela 94.07. **Natal** Estates also had the lowest extraction ratio, 30.76, **and** the only sucrose content of bagasse less than 2 per cent.

No factory had an extraction less than **90.**

The highest boiling house recovery was again recorded by New Guelderland with 91.59. Other factories leading in this respect are Amatikulu, 91.31, Umzimkulu, 90.94, and Esperanza, 90.85. Only one factory had **a** boiling house recovery under 87."

The best overall recovery for the season, 85.92, was gained at Umzimkulu by virtue of a high extraction and high boiling house recovery. Other factories exceeding 85 are Esperanza 85.51, Amatikulu 85.33, and Natal Estates 85.22. There were two factories with an overall recovery of less than 80.

The lowest ratio of cane to sugar was again recorded by Umzimkulu with 7.53, or 7.37 based on an assumed polarization of sugar of 96°. As last year, Esperanza came second in this respect, with 7.92.

The lowest sucrose per cent, cane lost in manufacture this season was 1.97 at Amatikulu.

Considerably the lowest moisture content of bagasse, 43.72 per cent., was again recorded at Umzimkulu.

The lowest purity (apparent) of final molasses, 38.48, as last year, was gained by Doornkop, with Felixton second in this respect, 38.70 (Clerget). -It was less than 39 also at Esperanza and Gledhow.

Felixton had the lowest sucrose content of filter cake, 0.30 per cent., followed by Esperanza with 0.44.

Illovo had also a very low loss of sucrose in filter cake by virtue of a low weight of filter cake per cent, of cane.

Only four mills, Entumeni, 1.46, Chaka's Kraal, 0.38, Umzimkulu, 0.34, and Sezela, 0.29, recorded increases in extraction over the preceding year. Tongaat remained the same as before at 93.34.

The total crop extraction diminished from 93.32 in 1948-49 to 92.94 in 1949-50.

Ten factories showed increases in boiling house recovery, those by more than one unit being Felixton, 1.85, Empangeni 1.74, Darnall 1.69 and Natal Estates 1.15.

The total crop boiling house recovery increased from 89.14 in 1948-49 to 89.68 in 1949-50.

Nine factories recorded increases in overall recovery, one, Entumeni, 0.51, by virtue of an increased extraction only; five by **virtue** of an increased boiling house recovery **only, and three.**

Umzimkulu 0.59, Chaka's Kraal 0.52, and Sezela 0.43, by an all-round improvement in both extraction and boiling house recovery. Those recording the highest increase in overall recovery are Felixton 1.19, Empangeni 0.94, Darnall 0.89, Natal Estates 0.84, and Amatikulu 0.63, being those with the highest increases also in boiling house recovery.

Sezela has now improved its overall recovery in three successive seasons by 2.06, 1.67 and 0.43 units respectively, or 4.16 in all. The overall recovery at Sezela for the past season was 84.79.

The overall recovery for the crop increased from 83.19 in 1948-49 to 83.35 in 1949-50.

In ratio of cane to sugar only two factories improved on their 1948-49 record, Umzimkulu from 7.76 to 7.53 and Natal Estates 8.68 to 8.53; Sezela remained the same at 8.33.

The average ratio increased from 8.55 in 1948-49 to 8.76 in 1949-50.

As last season, the greatest output from any one factory was at the factory of the Tongaat Sugar Co. Ltd., at Maidstone, which made 78,102 tons of sugar of average polarization of 98.44 from 654,700 tons of cane during a season of slightly more than seven months.

The factory of Natal Estates, Ltd. at Mount Edgecombe made 66,026 tons of sugar of average polarization of 99.54 from 563,257 tons of cane, ,which was appreciably larger than the output of the previous season. The factory was in operation for rather less than seven months.

Sir J. L. Hulett & Sons, Ltd. made 141,717 tons >f sugar from 1,299,846 tons of cane in their three actories, Darnall, Amatikulu, and Felixton, amounting to 25.3 per cent, of the total sugar made in south Africa. Darnall factory crushed 518,975 tons >f cane to make 55,590 tons of sugar of 98.87 >olarization over a season of 7£ months.

Reynolds Bros., Ltd. at their two factories at gezela and Esperanza made 52,754 tons of sugar rom 431,485 tons of cane.

Zululand Sugar Millers and Planters Ltd. at their actory at Empangeni made 42,887 tons of sugar of 8-22 polarization from 386,118 tons of cane over seven months' season.

Umfolozi Co-operative Sugar Planters, Ltd. at their factory at Riverview made 39,555 tons of sugar of 98.19 polarization from 366,400 tons of cane over a $7^1/_2$ months' season. This output represents a small increase over that of the previous year.

The total output of sugar diminished from 607,845 tons in 1948-49 to 561,122 tons in 1949-50, but the cane estimates for the 1950-51 season point **to** a larger output of sugar from this country than ever before.

All weights are expressed in tons of 2,000 lbs. except where otherwise stated.

World Production.

The total estimated world production of sugar for the 1949-50 season, according to Willet & Gray is 32,184,331 long tons, of which 21,320,970 tons or 66.2 per cent, consist of cane sugar. This estimate if fulfilled will be the largest production of sugar on record and an increase of 684,048 tons over the previous year and an increase of over 10 million tons over the last of the war years.

The South African production in long tons is 501,000 tons which is thus 2.35 per cent, of the world output of cane sugar, or 1.56 per cent, of all sugars.

Cuba will again have the largest production, estimated at 5 million tons, although this will be the lowest for Cuba since 1945. American production generally is estimated at about the same as the last three years. Two other American countries, Brazil, with one-and-a-half million, and Puerto Rico will again exceed the million ton mark.

The only other cane sugar country estimated to produce over a million tons (though Australia should not be far off it) is India with an estimated production of 4,800,000 tons; 1,300,000 tons of this is white sugar, the remainder being gur.

Of the beet sugar countries Germany is estimated to produce again over a million tons and Russia 2,800,000 tons. The U.S.A. mainland is estimated to produce 1,300,000 tons of beet and 467,000 tons of cane sugar.

Estimated production for the British Commonwealth for the 1949-50 crop is as follows :—

	Long tons.	Per cent. of total.
India and Pakistan	3,500,000*	42.8
	1,300,000t	15.9
Australia	950,000	11.6
British West Indies	629,720	7.7
South Africa	501,000+	6.1
Great Britain	450,000 §	5.5
Mauritius	425,000	5.2
British Guiana	190,000	2.3
Fiji	140,000	1.7
Canada	100,361§	1.2
	8,186,081	100.0

•Gur. J Actual production, not estimated.
f White sugar. § Refined sugar.

With the exception of Germany, Japan, Taiwan (Formosa) and Java, all countries have now regained their pre-war scale of production and in many' cases have improved on it.

Sugar Production in South Africa in Recent Years.

Production of cane and sugar over the past 21 years is tabulated in tons of 2,000 lbs.

Season.	Cane crushed.	Inches of rainfall.	Sugar produced.	Ratio Cane/ Sugar.
1929/30	3,005,663	48.34	298,635	10.06
1930/31	3,803,883	37.30	393,205	9.67
1931/32	3,130,783	29.33	325,899	9.61
1932/33	3,489,960	48.37	358,905	9.72
1933/34	3,673,375	31.15	391,173	9.39
1934/35	3,874,215	44.74	358,738	10.80
1935/36	3,867,536	45.83	417,289	9.27
1936/37	4,180,973	50.13	446,409	9.37
1937/38	3,489,022	39.57	507,219	8.85
1938/39	4,658,962	40.33	522,732	8.91
1939/40	5,346,006	47.68	595,556	8.98
1940/41	5,309,227	43.48	572,880	9.72
1941/42	3,921,436	26.18	452,119	8.67
1942/43	4,704,430	49.40	524,975	8.96
1943/44	5,278,914	53.31	585,392	9.02
1944/45	5,351,945	36.45	614,358	8.71
1945/46	4,607,055	31.99	553,074	8.33
1946/47	3,990,017	32.02	474,769	8.36
1947/48	4,543,255	44.83	512,005	8.85
1948/49	5,216,144	35.25	607,845	8.58
1949/50	4,929,580	43.35	561,122	8.79

Experiment Station,
South African Sugar Association,
Mount Edgecombe.
February, 1950.

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Average Manufacturing Results by periods for Natal Sugar Factories Reporting to the Experiment Station, Season **1948/49.**

Period ending		**MAY 28, 1949.**	**JULY 2, 1949.**	**JULY 30, 1949.**	**AUG. 27, 1949.**	**OCT. 1, • 1949.**	**OCT. 29, 1949.**	**NOV. 26, 1949.**	**DEC. 31, 1949.**	**SEASON 1949.50.**
Tons of 2,000 lbs. Cane crushed	This period	252,488	735,730	671,170	704,544	810,960	636,683	561,-590	372,200	
	To date		1,018,496	1,689,665	2,394,210	3,205,171	3,841,853	4,319,720	4,789,746	**4,891,139**
Tons of 2,000 lbs. Sugar bagged and estimated	This period	26,664	80,192	77,610	84,748	99,543		61,274	38,937	
	To date		110,231	187,839	272,586	372,130	447,029	498,7.2	548,599	**558,32***
Tons Cane per ton Sugar	This period	9.47	9.17	8.65	8.31	8.15	8.60	9.17	9.56	
	To date		9.24	9.00	8.78	8.61	8.59	8.66	8.73	**8.76**
Tons Cane per ton of Sugar, calculated as sugar of 96° Pol.	This period	9.22	8.91	8.41	8.07	7.93	8.27	8.93	9.32	
	To date		8.97	8.74	8.53	8.37	8.34	8.42	8.49	**8.52**
Sucrose per cent. Cane	This period	12.87	12.98	13.62	14.12	14.45	13.89	12.89	12.47	
	To date		12.96	13.23	13.49	13.73	13.76	13.64	13.56	**13.52**
Fibre per cent. Cane	This period	16.10	16.32	16.11	16.04	16.25	16.16	16.39	16.42	
	To date		.16.25	16.20	16.11	16.17	16.17	16.21	16.22	**16.19**
Java Ratio	This period	76.78	76.66	76.84	76.78	76.68	76.31	75.80	75.09	
	To date		76.70	76.76	76.76	76.73	76.65	76.53	76.47	**76.47**
Sucrose per cent. Bagasse	This period	2.76	2.55	2.67	2.73	2.78	2.74	2.55	2.62	
	To date		2.59	2.62	2.65		2.70	2.67	2.67	**2.66**
Moisture per cent. Bagasse ...	This period	52.15	50.85	50.76	50.61	50.52	50.78	51.19	51.41	
	To date		51.16	51.00	50.89	50.80	50.79	50.92	50.88	**50.84**
Imbibition per cent. Cane	This period	34.34	33.98	33.64	33.65	33.87	33.77	34.28	33.03	
	To date		34.17	33.96	33.87	33.87	33.85	33.98	33.82	**33.70**
Extraction	This period	92.21	93.00	93.09	93.24	93.19	93.00	92.86	92.35	
	To date		92.86	92.96	93.04	93.08	93.07	93.04	92.93	**92.94**
Recovery on Mixed Juice	This period	87.94	89.22	90.00	90.24	89.99	80.86	89.86	89.44	
	To date		. 88.87	89.33	89.61	89.71	89.74	89.78	89.72	**89.68**
Overall Recovery	This period	81-.08	82.97	83.78	84.14	83.86	83.57	83.44	82.60 <	
	To date		82.53	83.04	83.37	83.51	83.52	83.53	83.40	**83.35**
Purity of Mixed Juice	This period	86.12	86.35	86.73	86.55	86.83	86.55	85.61	84.82	
	To date		86.27	86.46	86.49	86.58	86.57	86.44	86.33	**86.22**
Reducing Sugar Ratio	This period	3.65	3.11	2.80	3.01	2.85	2.85	3.21		
	To date		3.21	3.04	3.03	2.98	2.96	3.00	3!06	**3.11**
Purity of Syrup	This period	87.09	88.01	88.36	88.10	88.43	88.42	87. 3	86.48	
	To date		87.85	88.07	88.06	88.16	88.20	88.13	88.02	**87.93**
Sucrose in Filter Cake (A)	This period	0.78	0.98	1.13	1.04	1.18	1.19	0.99	0.97	
	To date		1.01	1.13	1.08	1.10	l.H	1.14	1.12	**1.12**
Purity of Final Molasses ...	This period	39.71	41.79	41.58	40.54	40.96	41.93	41.65	40.16	
	To date		41.72	41.68	41.30	41.22	41.41	41.43	41.47	**41.39**
Average Polarization of Sugar	This period	98.78	98.83	98.76	98.80	98.72	98-. 69	98.67	98.46	
	To date		98.85	98.82	98.81	98.78	88.77	98.73	98.73	**98.84**

(A) Arithmetic averages.

FINAL MANUFACTURING RESULTS, NATAL SUGAR FACTORIES, SEASON 1949/50.

FACTORY NUMBER	NE.	UF.	EN.	GL.	TS.	ZM.	IL.	DK.	FX.	SZ.	DL.	AK.	RN.	NC.	UK.	CK.	MV.	ES.	SEASON
Crushing period { From ...	12.5.49	5.7.49	4.7.49	21.5.49	1.5.49	16.5.49	1.6.49	27.5.49	4.5.49	12.5.49	4.5.49	4.5.49	20.5.49	20.5.49	10.6.49	21.5.49	24.5.49	5.7.49	1.5.49
Crushing period { To ...	7.12.49	[illegible]	17.12.49	24.12.49	16.12.49	19.12.49	14.12.49	1.12.49	13.1.50	23.11.49	18.12.49	22.12.49	15.12.49	8.11.49	23.10.49	30.12.49	29.11.49	10.1.50	[illegible]
Tons of 2,000 lbs. Cane crushed ...	583,257	266,400	46,861	286,477	664,700	390,116	171,341	67,824	400,740	278,644	518,975	380,132	156,074	107,982	74,553	162,560	106,620	152,841	4,871,100
Cane crushed—metric tons ...	526,986	241,673	42,671	259,892	602,945	350,336	155,440	61,516	363,451	252,786	470,814	344,855	133,560	97,959	67,634	147,482	96,726	138,657	4,437,896
Tons of 2,000 lbs. Sugar bagged and estimated ...	66,026	29,654	5,308	32,131	76,118	42,887	20,010	10,907	43,060	33,446	56,590	44,089	18,207	12,803	9,901	18,480	11,546	19,809	[illegible]
Sugar bagged and estimated—metric tons ...	59,899	26,864	4,815	29,149	70,669	38,907	18,153	9,896	39,166	30,341	50,431	39,979	16,703	11,615	8,985	16,780	10,494	17,517	506,518
Tons Cane per ton of Sugar ...	8.83	9.26	8.83	8.92	8.38	9.00	8.56	6.96	9.53	8.33	9.34	8.62	8.33	8.43	7.53	8.82	9.22	7.83	8.76
Tons Cane per ton of Sugar calculated to Sugar of 96° Pol	8.29	9.08	8.85	8.63	8.17	8.80	8.58	6.66	9.22	8.05	9.04	8.41	8.06	8.22	7.57	8.57	8.96	7.60	8.53
Time Crushing per cent. Available Time (no allowance for cane shortage) ...	94.37	80.80	88.33	90.31	90.31	92.11	83.45	90.07	93.68	90.43	92.26	93.83	91.89	89.67	98.60	88.61	85.80	53.87	91.16
Tons of 2,000 lbs. of Cane per hour Actual Crushing ...	161.88	91.40	16.84	72.10	159.25	95.15	49.41	30.66	80.84	69.09	118.17	83.02	43.04	35.23	27.88	40.71	32.60	44.66	94.96
Tons of 2,000 lbs. White Sugar made ...	51,281	42	3,351	19,649	—	—	18,446	8,114	38,882	20,406	11,318	—	8,067	—	24	5,664	6,488	10,628	182,881
Tons of 2,000 lbs. No. 1 Grade Sugar made ...	12,918	10,797	1,297	9,272	9,235	37,035	89	1,360	685	8,280	320	11,863	4,394	10,271	2,077	7,202	2,871	5,144	135,329
Tons of 2,000 lbs. Raw Sugar made ...	1,277	22,710	640	2,309	68,883	5,852	—	1,434	22,602	4,806	43,063	32,226	5,746	2,532	7,308	5,674	2,200	3,047	230,670
Sucrose per cent. Cane ...	13.69	12.66	13.72	13.46	13.02	13.25	13.60	13.66	12.59	14.07	13.25	13.60	14.42	13.79	16.16	13.57	12.62	14.06	13.52
Fibre per cent. Cane ...	15.35	12.64	15.47	16.39	10.19	16.65	15.36	14.74	15.73	16.00	16.14	16.67	10.85	15.96	15.44	16.27	16.41	16.01	15.39
Java Ratio ...	76.42	76.89	75.27	76.71	76.95	76.66	76.14	77.22	76.71	77.56	75.15	75.57	76.22	77.46	78.55	77.21	76.73	77.48	76.47
Extraction Ratio ...	50.76	49.41	52.10	50.92	41.24	48.16	33.77	42.86	44.47	37.08	59.60	39.35	39.10	47.64	35.75	43.68	56.42	39.66	43.79
Imbibition per cent. Cane ...	38.07	27.53	35.55	29.90	28.72	38.14	40.55	29.49	34.69	37.78	36.96	30.28	28.94	34.30	39.88	29.95	27.02	27.94	33.70
Extraction (Sucrose in Mixed Juice % Sucrose in Cane) ...	94.97	92.25	91.94	91.72	93.34	91.84	93.80	93.33	92.55	94.07	90.26	93.44	98.40	92.40	94.48	92.92	90.85	94.12	92.94
Sucrose per cent. Bagasse ...	1.97	2.51	3.40	3.10	2.61	2.84	2.24	2.86	2.50	2.43	3.92	2.86	2.67	3.04	2.85	2.74	3.45	2.55	2.66
Moisture per cent. Bagasse ...	50.44	52.46	48.14	50.50	51.12	51.11	47.62	47.00	50.79	50.19	53.90	52.21	49.22	49.52	43.72	49.88	49.97	49.18	49.84
Sucrose per cent. Cane lost in manufacture ...	2.06	2.06	2.49	2.34	2.18	2.34	2.29	2.46	2.17	2.14	2.66	1.97	2.52	2.12	2.14	2.37	2.58	2.12	2.35
Overall Recovery (Sucrose in Sugar % Sucrose in Cane) ...	85.22	83.72	81.85	82.56	84.85	82.31	83.05	81.71	82.74	84.79	79.98	85.35	82.49	84.63	86.92	82.52	79.00	85.51	83.26
Recovery on Mixed Juice (Sucrose in Sugar % Sucrose in Mixed Juice) ...	89.79	89.77	89.03	90.01	90.87	89.62	88.54	87.55	89.39	90.12	88.49	91.31	89.38	91.59	90.94	88.81	86.94	90.86	89.60
Sucrose in Bagasse per cent. Sucrose in Cane (a) ...	5.03	6.74	8.06	8.28	6.66	8.15	6.20	6.67	7.44	5.93	9.62	6.56	5.60	7.60	5.52	7.09	9.15	5.88	7.06
Sucrose in Filter Cake per cent. Sucrose in Cane (b) ...	0.45	0.27	0.88	0.33	0.16	0.49	0.15	0.28	0.18	—	0.70	0.34	0.22	0.11	—	0.21	0.68	0.17	0.34
Sucrose in Molasses per cent. Sucrose in Cane (c) ...	6.96	—	—	7.40	—	8.31	10.04	6.98	—	—	9.36	7.17	—	6.56	—	6.54	7.40	--	—
Undetermined Sucrose per cent. Sucrose in Cane (d) ...	2.35	9.27	9.21	1.48	8.82	0.74	0.56	4.36	9.70	9.28	1.40	0.60	10.60	1.02	8.56	1.64	3.62	8.44	9.32
Sucrose lost in Boiling House per cent. Sucrose in Cane (b)+(c)+(d) ...	9.75	9.54	10.09	9.18	8.99	9.54	10.75	11.62	9.82	9.28	10.46	8.11	10.91	7.77	8.56	10.39	11.97	8.61	9.69
Sucrose in total Losses per cent. Sucrose in Cane (a)+(b)+(c)+(d) ...	14.78	16.28	18.15	17.44	15.65	17.69	16.05	18.29	17.26	15.21	20.08	14.67	17.51	15.37	14.08	17.48	21.	14.49	16.44
FIRST EXPRESSED JUICE.																			
Brix ...	20.50	18.65	19.98	19.71	20.62	19.46	20.20	19.60	19.03	20.28	19.81	19.76	21.28	19.89	21.41	19.35	19.08	20.66	19.94
Purity (apparent) ...	87.41	87.42	91.34	88.60	89.10	89.00	87.29	89.70	87.40	89.12	89.06	89.70	88.90	89.57	90.10	88.43	88.80	90.70	88.64
LAST EXPRESSED JUICE.																			
Brix ...	2.42	2.88	2.64	4.72	3.21	2.65	2.08	4.40	5.51	2.02	4.25	2.88	3.76	3.69	5.42	3.24	4.28	2.75	3.21
Purity (apparent) ...	74.31	66.23	79.93	78.40	77.50	76.70	73.56	80.60	73.70	74.83	80.75	79.40	77.80	72.86	78.70	77.77	80.60	73.90	76.16
Purity drop from First Expressed Juice ...	13.10	21.20	11.41	10.20	11.60	12.30	13.73	9.10	13.70	14.29	8.31	10.30	11.10	16.67	11.40	10.66	8.20	16.80	12.48
MIXED JUICE.																			
Brix ...	14.71	14.87	12.85	15.13	16.89	14.65	14.45	14.91	14.03	14.62	16.04	14.48	16.89	16.70	14.81	15.22	15.55	16.09	14.85
Purity (Clerget) ...	85.67	82.36	88.32	86.90	87.80	86.40	84.77	86.70†	84.50	86.35	86.60	87.18	85.60†	86.80	87.60†	87.16	86.90	88.30	86.20
Reducing Sugar Ratio ...	2.80	4.02	2.82	2.84	—	3.27	3.40	—	4.08	2.76	2.64	2.98	2.86	2.27	—	2.99	3.00	2.95	3.11
Purity drop from First Expressed Juice ...	1.74	5.07	3.02	1.70	1.30	2.60	2.52	2.00	2.90	2.77	2.46	2.57	3.10	2.73	2.00	1.27	1.90	2.40	2.40

	NE.	UF.	EN.	GL.	TS.	ZM.	IL.	DK.	FX.	SZ.	DL.	AK.	RN.	NG.	UK.	CK.	MV.	EG.	SEASON
CLARIFIED JUICE.																			
Brix ...	12.31	14.21	14.57	16.17	14.83	15.52	14.43	16.20	13.42	14.74	14.10	14.05	17.66	14.26	—	15.19	16.97	16.10	14.49
Purity (apparent) ...	91.07	84.78	89.77	88.00	83.30	86.90	86.43	89.10	85.80	87.16	87.09	87.60	87.80	88.28	—	88.30	87.50	89.41	87.86
Reducing Sugar Ratio ...	1.41	2.68	2.29	—	—	2.37	2.85	—	3.90	—	2.77	2.07	2.54	1.88	—	—	2.60	2.27	2.44
pH ...	7.13	7.86	6.82	6.78	7.40	7.55	—	—	7.12	7.00	7.10	7.20	—	7.46	7.40	—	—	7.10	7.21
FILTER CAKE.																			
Per cent. Sucrose ...	0.62	0.78	2.64	0.90	0.83	1.08	0.60	0.77	0.80	0.84	1.61	0.87	0.56	0.42	5.80	0.62	1.54	0.44	0.95
Weight per cent. Cane ...	11.72	4.55	4.92	4.46 *	4.25	6.10	4.00	6.00	5.10	—	6.14	5.28	5.71	5.00	—	4.64	5.00	5.58	5.91
SYRUP.																			
Brix ...	58.62	57.09	47.39	52.03	48.82	44.59	58.02	53.00	64.46	55.68	60.20	60.22	54.88	49.97	60.31	50.73	60.28	55.27	55.45
Purity (apparent) ...	91.07	86.01	88.96	88.20	88.40	86.80	80.21	89.50	85.90	87.50	88.01	87.60	86.90	88.47	—	88.03	88.00	89.28	87.90
Reducing Sugar Ratio ...	1.46	2.52	2.34	2.39	—	2.30	2.61	—	3.62	—	2.97	2.64	2.80	1.76	—	—	2.40	2.02	2.55
pH ...	7.18	7.10	6.84	6.76	-	7.06	—	—	6.68	6.88	6.80	7.00	—	7.25	7.22	—	—	6.92	6.96
Purity drop from First Expressed Juice ...	−3.50	1.62	2.89	0.40	0.70	2.20	1.08	−0.60	1.60	1.58	1.05	2.10	2.00	1.06	—	0.40	0.80	1.42	0.69
Purity increase from Mixed Juice ...	5.40	5.56	0.83	1.30	0.60	0.40	1.44	2.80	1.30	1.24	1.41	0.47	1.10	1.67	—	0.87	1.10	0.98	1.73
FIRST MASSECUITE.																			
Brix ...	91.90	92.18	93.20	92.12	91.06	93.03	92.58	91.90	94.07	92.60	92.64	92.30	93.42	90.97	92.11	93.87	91.03	91.86	92.39
Purity (apparent) ...	92.30	86.28	90.40	86.50	88.20	84.70	84.10	87.30	84.20	85.84	86.50	81.70	86.30	87.07	81.00	87.28	88.00	85.60	86.42
Purity of Run-off ...	78.01	65.86	80.24	69.40	79.90	61.40	60.40	71.50	65.40	68.90	65.77	61.40	68.50	72.50	61.20	72.92	72.50	69.32	68.79
Cubic feet per ton of Sugar (all Massecuites) ...	68.40	62.69	55.29	50.38	—	48.55	—	59.10	56.98	53.00	43.07	40.34	—	49.74	—	—	48.20	—	52.60
SECOND MASSECUITE.																			
Brix ...	95.24	95.06	94.00	96.21	95.64	96.30	93.78	94.50	97.46	96.56	96.78	94.70	96.21	95.54	94.30	93.66	94.29	95.58	95.49
Purity (apparent) ...	79.15	76.11	74.79	70.90	76.20	72.40	77.50	77.80	73.00	80.37	71.71	71.60	74.10	73.48	70.20	74.65	75.40	78.63	73.89
Purity of Run-off ...	56.35	49.60	63.26	48.90	63.70	49.10	54.20	53.90	48.40	46.14	47.40	48.00	62.10	49.54	49.60	46.18	52.10	50.80	50.39
THIRD MASSECUITE.																			
Brix ...	90.82	97.42	94.70	96.72	90.30	97.63	93.79	98.10	96.54	97.90	90.02	96.60	96.20	97.44	95.20	93.93	97.20	96.21	97.39
Purity (apparent) ...	60.01	62.68	62.46	58.80	62.60	63.80	67.09	63.60	59.80	63.56	60.60	60.10	61.70	58.98	60.20	63.72	61.20	60.96	62.56
Purity of Run-off ...	46.95	40.90	44.76	39.30	42.10	42.90	47.14	38.48	38.20	39.08	41.18	40.60	42.30	41.37	39.65	43.21	41.00	38.85	41.44
JELLY.																			
Brix ...	—	—	—	—	—	92.83	90.79	—	—	96.99	93.07	93.60	—	—	—	—	—	93.88	93.58
Purity (apparent) ...	—	—	—	—	—	48.00	45.10	—	—	49.34	45.76	50.70	—	—	—	—	—	43.86	46.96
FINAL MOLASSES.																			
Brix ...	87.09	92.07	87.46	86.07	94.61	96.14	87.82	90.00	92.86	91.10	89.20	88.48	98.65	88.00	87.70	84.91	87.00	84.34	89.67
Purity (Clerget) ...	45.81	40.90	44.75†	38.90	42.10†	42.06	44.91	38.48†	38.70	39.05†	41.36	40.66	41.60†	41.18	39.65†	43.21†	40.60	38.88†	40.39
Weight per cent. Cane at 85° Brix ...	2.45	—	—	3.02	—	2.06	3.60	2.32	—	—	2.16	2.70	—	2.60	..	3.16	2.94	—	2.96
POLARIZATION OF SUGARS.																			
White Sugar ...	99.92	99.71	99.78	99.86	—	—	—	99.70	99.80	99.80	99.63	—	99.80	—	99.80	99.80	99.78	99.87	99.81
No 2 Grade Sugar ...	98.23	98.30	98.73	98.00	98.40	98.26	—	98.60	98.61	98.90	98.55	98.50	98.48	98.34	98.07	98.87	98.37	98.57	98.39
Raw Sugar ...	98.42	98.14	98.86	98.00	98.47	97.08	—	98.00	98.84	98.27	98.58	98.56	98.82	98.64	98.07	98.37	98.29	98.87	98.42
Average of all Sugars ...	99.54	98.10	99.41	99.13	98.44	98.22	—	99.33	99.22	99.36	98.97	98.49	99.17	98.38	98.98	98.78	99.15	99.36	98.84
SO_2 in parts per million ...	—	54	—	—	—	80	—	—	—	43	73	67	—	69	—	—	—	40	—
VARIETIES CRUSHED.																			
Uba per cent. ...	1.50	0.10	—	0.21	0.60	0.11	0.11	—	—	0.81	0.19	0.01	0.46	0.60	0.11	0.15	1.14	0.33	0.39
Co.281 per cent. ...	41.90	49.73	80.04	26.08	30.57	82.18	46.06	26.34	55.48	45.42	41.26	68.48	63.01	27.20	90.15	38.21	84.80	57.43	47.30
Co.290 per cent. ...	0.60	0.41	—	0.73	0.24	0.44	0.06	0.18	1.82	0.17	2.43	0.20	0.74	0.80	0.52	0.96	0.60	0.33	0.71
Co.301 per cent. ...	51.90	14.75	2.27	52.06	66.92	11.97	51.10	56.98	22.43	49.38	48.60	30.13	34.24	66.04	0.22	52.04	36.82	40.03	43.29
Co.331 per cent. ...	2.30	0.27	16.81	2.64	3.83	0.92	1.81	14.62	6.83	4.10	5.01	9.44	0.44	1.04	—	7.34	0.53	0.66	4.31
N:Co.310 per cent. ...	2.20	3.70	1.88	6.50	1.98	3.28	0.43	0.02	6.07	0.22	2.45	1.42	1.09	4.22	—	1.40	0.41	0.08	2.60
P.O.J.2725 per cent. ...	—	31.04	—	0.19	0.01	1.10	0.30	—	4.47	—	0.05	0.31	—	—	—	—	—	0.87	2.90
FACTORY NUMBER ...	NE.	UF.	EN.	GL.	TS.	ZM.	IL.	DK.	FX.	SZ.	DL.	AK.	RN.	NG.	UK.	CK.	MV.	EG.	SEASON

† Apparent purity.

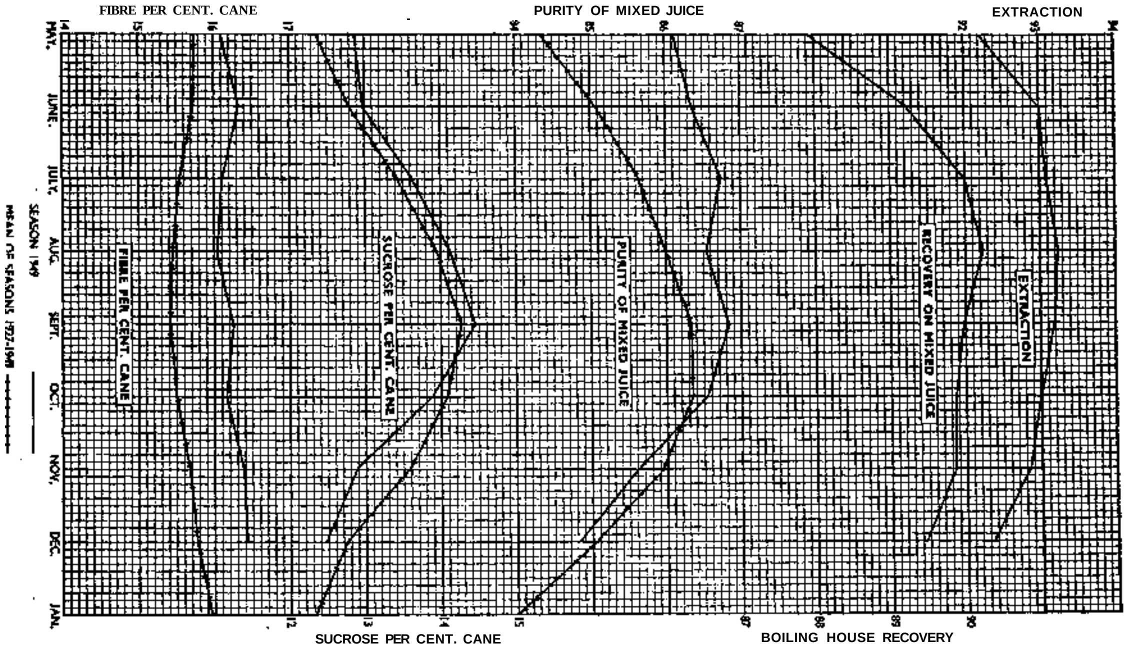
COMPARATIVE RESULTS FOR RECENT YEARS.

YEAR	1839.	1940.	1941.	1942.	1913.	1944.	1945.	1946.	1947.	1948.	1949.
	13.41	13.19	14.00	13.40	13.14	13.67	14.28	14.21	13.32	13.89	13.52
	14.80	15.56	15.66	15.24	15.26	15.83	15.99	16.21	15.80	15.90	16.19
JUICES—											
	88.45	87.44	87.94	88.27	88.70	88.35	88.33	88.22	88.48	88.12	88.64
Purity of Mixed Juice	86.46	85.34	85.67	85.96	86.56	86.19	86.23	85.86	86.24	85.92	86.22
	77.07	76.15	77.46	76.86	76.44	75.75	75.94	75.14	75.03	75.54	76.16
Purity of Syrup	88.12	87.11	87.69	87.85	88.12	87.81	87.82	87.44	87.98	87.54	87.93
Drop in purity Crusher to Mixed Juice	1.99	2.10	2.27	2.31	2.14	2.16	2.13	2.36	2.24	2.20	2.42
Drop in purity Crusher to last Roller	11.38	11.29	10.48	11.41	12.26	12.60	12.42	13.08	13.45	12/58	12.48
Drop in purity Crusher to Syrup	0.33	0.33	0.25	0.42	0.57	0.52	0.52	0.75	0.47	0.56	0.71
	1.66	1.77	2.02	1.89	1.57	1.63	1.61	1.60	1.75	1.64	1.71
Reducing Sugar Ratio of Mixed Juice	3.27	3.81	3.36	3.07	3.18	3.49	3.38	3.30	2.95	3.67	3.11
JAVA RATIO	78.70	77.94	77.74	77.67	77.78	77.38	77.36	77.03	76.99	76.98	76.47
BAGASSE—											
Per cent. Sucrose	3.11	3.02	3.03	2.88	2.76	2.73	2.77	2.79	2.54	2.67	2.66
Per cent. Moisture	51.79	51.60	51.50	51.24	50.80	50.23	50.19	50.32	50.46	50.53	50.84
EXTRACTION—											
Imbibition % Cane	31.28	32.59	34.76	32.82	31.62	33.70	34.96	35.25	34.37	34.06	33.70 *
Sucrose in Mixed Juice % Sucrose in Cane	92.24	91.91	92.37	92.69	92.97	93.13	93.28	93.07	93.44	93.32	92.94
Reduced Extraction (based on 12.5% Fibre)	93.62	93.72	94.13	94.19	94.42	94.78	94.96	94.88	95.01	94.95	94.78
FILTER CAKE-											
	2.19	2.03	1.71	1.19	1.11	1.17	1.13	0.96	1.06	1.29	1.12
	4.78	5.12	5.63	5.38	5.11	5.22	5.64	5.91	5.99	5.90	5.91
FINAL MOLASSES—											
Purity	42.67	42.91	43.45	43.24	41.81	42.37	41.98	41.75	41.10	41.53	41.39
RECOVERY—											
Sucrose % Cane lost in manufacture	2.42	2.52	2.57	2.34	2.16	2.30	2.42	2.42	2.16	2.33	2.25
Sucrose in Sugar % Sucrose in Cane	81.98	80.86	81.66	82.48	83.52	83.14	83.30	82.94	83.73	83.19	83.35
Reduced Overall Recovery (12.5% Fibre, 85° pur. Mixed Juice)	81.89	82.07	82.61	82.98	83.51	83.58	83.72	83.82	84.09	83.85	83.98
Sucrose in Sugar % Sucrose in Mixed Juice	88.88	87.98	88.40	88.98	89.84	89.27	89.29	89.12	89.61	89.14	89.68
Reduced Boiling House Recovery (based on 85" pur. Mxd. Juice)	87.47	87.57	87.76	88.10	88.45	88.18	88.16	88.34	88.51	88.31	88.61
YIELD—											
Tons Cane per ton Sugar	8.95	9.26	8.62	8.93	8.98	8.67	8.29	8.36	8.84	8.55	8.76
	8.73	9.03	8.39	8.69	8.74	8.44	8.08	8.14	8.60	8.31	8.52
LOSSES—											
	*7.76	8.09	7.63	7.31	7.03	6.87	6.72	6.93	6.56	6.68	7.06
Sucrose in Filter Cake % Sucrose in Cane (B)	0.78	0.60	0.52	0.41	0.36	0.37	0.35	0.28	0.32	0.36	0.34
Sucrose in Molasses % Sucrose in Cane (c)											
Undetermined Sucrose % Sucrose in Cane (D)	9.48	10.43	10.18	9.80	9.09	9.62	9.63	9.85	9.39	9.77	9.25
Sucrose lost in Boiling House % Sucrose in Cane (B) + (c) + (D)	10.26	11.03	10.70	10.21	9.45	9.99	9.98	10.13	9.71	10.13	9.59
Sucrose in Total Losses % Sucrose in Cane (A) + (B) + (c) + (D)	18.02	19.12	18.34	17.52	16.48	16.86	16.70	17.06	16.27	16.81	16.65
SUGAR—											
Average Polarization of all Sugars	98.36	98.44	98.58	98.65	98.59	98.62	98.73	98.70	98.83	98.93	98.84

COMPARATIVE RESULTS FOR RECENT YEARS.

COUNTRY	MAURITIUS		BRITISH GUIANA		HAWAII	QUEENSLAND		TRINIDAD		PUERTO RICO	INDIA
YEAR	1947.	1948.	1947.	1948.	1947.	1947.	1948.	1948.	1949.	1947.	1947-48.
CANE—											
Per cent. Sucrose	14.37	14.31	11.24	10.76	12.22	15.30	15.48	11.89	12.67	13.09	12.48
Per cent. Fibre	12.50	12.10	14.44	14.72	15.09	12.72	12.78	14.94	14.32	13.89	16.29
JUICES—											
Purity of First Crusher Juice	89.70	89.60	81.42	81.88	85.66	88.81	88.36	85.03	84.47	84.09	81.11
Purity of Mixed Juice	87.00	87.20	79.40	79.78	82.89	—	—	80.97	82.36	—	—
Purity of last Roller Juice	75.60	77.00	—	—	71.71	75.37	76.71	72.18	73.86	—	—
Purity of Syrup	87.10	87.20	79.83	80.96	83.78	87.61	87.36	82.99	84.30	82.92	—
Drop in purity Crusher to Mixed Juice	2.70	2.40	2.02	2.10	2.77	—	—	2.06	2.11	—	—
Drop in purity Crusher to last Roller	14.20	12.60	—	—	13.95	13.24	11.64	10.86	10.61	—	—
Drop in purity Crusher to Syrup	2.60	2.40	1.59	0.92	1.88	1.20	0.99	0.04	0.17	1.17	—
Increase in purity Mixed Juice to Syrup	0.10	0.00	0.43	1.18	0.89	—	—	2.02	1.94	—	—
Reducing Sugar Ratio of Mixed Juice	3.40	3.50	—	—	—	—	—	8.47	8.16	—	—
JAVA RATIO	79.61	80.61	76.06	77.80	—	82.28	82.06	77.75	77.44	—	—
BAGASSE—											
Per cent. Sucrose	2.96	3.13	3.29	3.08	2.15	2.43	2.58	3.68	2.78	2.65	—
Per cent. Moisture	44.90	46.20	46.20	46.01	43.86	48.49	47.66	48.20	48.22	48.66	—
EXTRACTION—											
Imbibition % Cane	22.90	21.30	22.32	22.73	34.08	—	—	20.52	21.88	25.47	22.07
Sucrose in Mixed Juice % Sucrose in Cane	94.90	94.80	91.45	91.56	95.94	95.86	95.74	93.15	93.44	94.07	91.61
Reduced Extraction (based on 12.5% Fibre)	94.90	94.60	92.76	93.01	96.74	95.90	95.76	94.43	94.39	94.75	93.66
FILTER CAKE—											
Per cent. Sucrose	8.60	8.10	4.08	3.99	1.54	2.95	3.30	2.28	2.92	2.87	—
Weight % Cane	1.68	1.54	2.04	2.28	6.00	3.31	2.96	2.66	2.42	3.97	—
FINAL MOLASSES—											
Purity	39.10	39.10	33.10	33.44	39.14†	47.67	46.70	31.76	32.20	30.99	33.68
RECOVERY—											
Sucrose % Cane lost in manufacture	2.11	2.09	2.51	2.23	1.79	2.39	2.24	1.93	1.09	1.94	2.45
Sucrose in Sugar % Sucrose in Cane	85.30	85.50	77.08	79.31	85.33	84.37	85.51	83.47	84.30	85.19	80.40
Reduced Overall Recovery (12.5% Fibre, 85° pur, Mixed Juice)	83.42	83.20	83.26	84.35	87.59	—	—	87.75	86.78	—	84.96
Sucrose in Sugar % Sucrose in Mixed Juice	89.80	90.10	84.95	86.63	88.94	88.00	89.31	89.61	90.22	90.56	87.85
Reduced Boiling House Recovery (based on 85° pur. Mxd. Juice)	87.90	88.00	89.75	90.69	90.54	—	—	92.93	91.94	—	90.71
YIELD—											
Tons Cane per ton Sugar	8.09	8.04	11.04	11.29	9.26	7.66	7.46	9.92	9.06	8.70	—
Tons Cane per ton Sugar of 96° Pol.	7.83	7.85	10.99	11.25	9.21	7.44	7.25	9.84	8.99	8.61	9.57
LOSSES—											
Sucrose in Bagasse % Sucrose in Cane (A)	5.10	5.20	8.55	8.44	4.06	4.14	4.26	6.85	6.56	5.04	8.49
Sucrose in Filter Cake % Sucrose in Cane (B)	0.95	0.87	0.89	0.83	0.76	0.63	0.67	0.62	0.68	0.72	0.83
Sucrose in Molasses % Sucrose in Cane (C)	—	—	9.22	9.20	9.71	6.90	6.90	7.57	7.34	7.46	9.31
Undetermined Sucrose % Sucrose in Cane (D)	8.65	8.43	3.66	2.25	0.14	4.16	2.76	1.59	1.24	0.70	0.97
Sucrose lost in Boiling House % Sucrose in Cane (B)+(C)+(D)	9.60	9.30	13.77	12.28	10.61	11.49	10.23	9.68	9.14	8.88	11.11
Sucrose in Total Losses % Sucrose in Cane (A)+(B)+(C)+(D)	14.70	14.50	22.32	20.72	14.67	15.63	14.49	16.53	15.70	14.81	19.60
SUGAR—											
Average Polarization of all Sugars	98.50	98.40	96.41	96.33	97.51	98.75	98.77	96.79	96.87	97.02	—

† Refractometer Sucrose Purity



FIBRE PER CENT. CANE
PURITY OF MIXED JUICE
EXTRACTION
SUCROSE PER CENT. CANE
BOILING HOUSE RECOVERY
14
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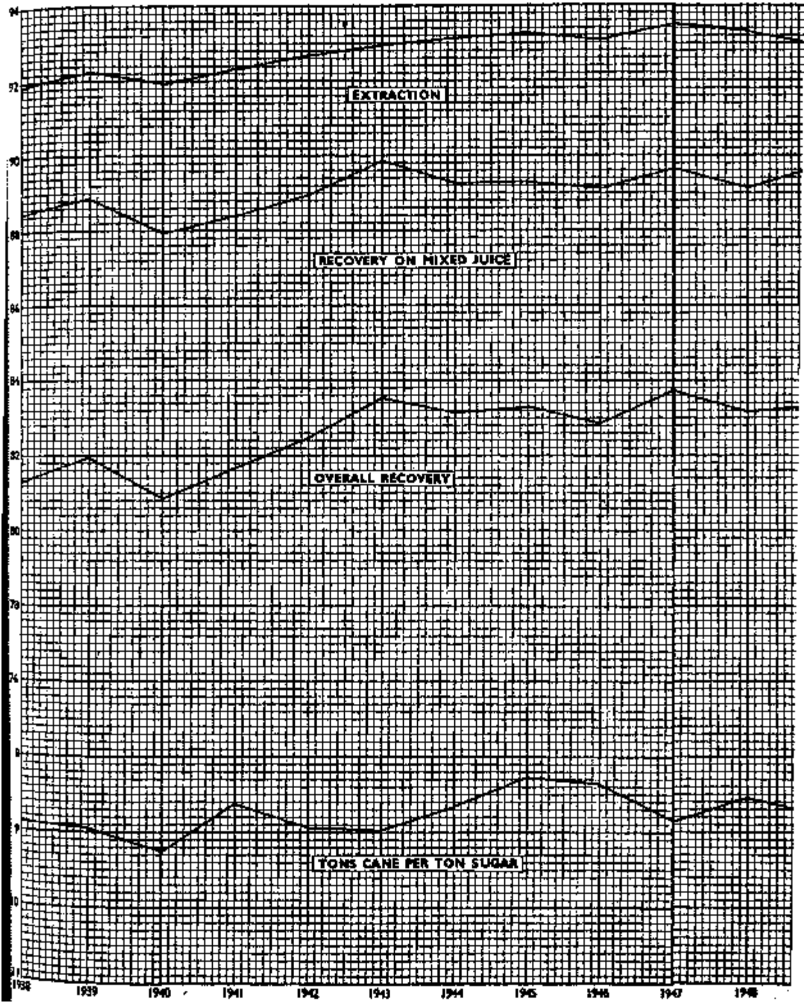
MAY.
JUNE.
JULY.
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FIBRE PER CENT. CANE
SUCROSE PER CENT. CANE
PURITY OF MIXED JUICE
RECOVERY ON MIXED JUICE
EXTRACTION
SEASON 1949
MEAN OF SEASONS 1927-1948

EXTRACTION AND RECOVERY FIGURES 1938-49



ANNUAL WEATHER REPORT FOR 1949

The weather for the year 1949 at the Experiment Station, Mount Edgecombe, was normal in respect of total rainfall, but, like 1948, 1945 and 1944 in recent years the distribution of rain was unfavourable in some respects, the months of March and May to August inclusive being abnormally dry.

The mean temperature for the year, 69.1°, like that of most years with a marked drought period, is appreciably above the 24-year average of 68.7°.

In other respects the weather records for 1949 do not vary greatly from the general averages.

Rainfall.

The year opened with somewhat deficient rains in January, which rather checked the summer growth of cane. February, however, proved to be the wettest month of the year, having 6.59 inches of rain, which was very beneficial for the growing crops; there was another check to growth during March, which was unusually dry for that month, which has the highest monthly average rainfall here. However, good rains in the latter part of April greatly improved the condition and prospects of the crop at that time.

In May one of the most severe winter droughts ever recorded here began and continued until towards the end of September, the total rainfall for this period being only 1.99 inches compared with an average rainfall of 7.96 inches. During July only 0.10 inches of rain fell, on one single day. There were 18 days of rain in all during the period, but with negligible quantities of rain. Thus between May 25th and September 7th there was no rainfall of more than 0.1 inches. This drought, besides very adversely affecting young cane for the 1950 crop throughout, during the latter two months or so began to have a marked adverse effect on the cane yields and manufacturing qualities of the cane being harvested.

From September 22nd, when the long drought broke, the weather changed entirely for the remainder of the year. Each of the last four months had a rainfall well above the average, the total for the period being 19.49 inches against an average of 13.57 inches, and from September 20th onwards there was no period of more than five consecutive days without rain, this giving 61 rain days out of a total of 103 days. There were no excessive or injurious rains and the net result was an excellent planting season and very good growing weather for young cane and for next season's crop.

The highest rainfall for any single day during the year was 2.82 inches on April 29th. Other days with over two inches of rain were December 1st with 2.40 inches and February 22nd with 2.04 inches. There were seven days with a rainfall of between one and two inches, two in February, one in October and two each in November and December. Next to February November was the wettest month, with a total of 6.53 inches on 18 days. The number of rain days during the year was 115, or slightly below the average of 117. The average rainfall per rain day was thus 0.318 inches or very close to the 24-year average of 0.312 inches.

The total rainfall for the year was 36.61 inches, which is very close to the 24-year average here of 36.53 inches.

Tabulated by months and compared with averages of the past 24 years, the rainfall is as follows:-

	1949.					Mean 1926-1949 inclusive.					
	Total for month inches.	Aggregate from 1st January	Per cent. of average aggregate,	No. of rain days,	Average rainfall per rain day in ins.	Total for month in ins.	Aggregate from 1st January.	No. of rain days.	Average rainfall per day.	Per cent, of wet days.	Average rainfall per rain day.
January ...	3.05	3.05	79.8	10	0.305	3.79	3.79	14	0.122	45	0.271
February ...	6.59	9.64	112.6	12	0.549	4.82	8.61	12	0.171	42	0.402
March	2.22	11.80	86.5	10	0.222	5.02	13.63	12	0.162	39	0.418
April	3.90	15.76	96.7	5	0.780	2.64	16.27	8	0.088	27	0.330
May	0.49	16.25	87.6	3	0.163	2.18	18.45	5	0.073	16	0.436
June	0.56	16.81	82.2	4	0.140	1.84	20.29	4	0.061	13	0.460
July	0.10	16.91	77.7	1	0.100	1.27	21.56	4	0.041	13	0.318
August ...	0.21	17.12	74.6	5	0.042	1.15	22.71	5	0.037	16	0:230
September .	2.45	19.57	78.6	12	0.204	1.97	24.68	8	0.066	27	0.246
October ...	4.72	24.29	86.2	18	0.262	3.33	28.01	14	0.107	45	0.238
November .	6.53	30.82	95.1	18	0.363	4.32	32.33	14	0.144	47	0.309
December...	5.79	36.61	100.2	17	0.341	4.20	36.53	15	0.136	48	0.280
Total...	36.61	36.61	100.2	115	0.318	Mean	36.53	117	0.100	32	0.312

Temperatures.

The mean screen temperature for the year at the Experiment Station was 69.1°, or the same as the mean of the past 11 years. Compared with the average screen record of the years 1928 to 1938 inclusive, which was 68.3°, there has apparently been a slight systematic rise in temperature; this is possibly due to an actual general change in mean temperature as calculated from the mean of the daily screen maximum and screen minimum temperatures, or it may be due to some obscure change in immediate local conditions.

January was the warmest month of the year and not February as usual. The mean temperature was 75.6°, the highest for January since 1944, when also the rainfall and number of rain days were below the average.

February was considerably below the average temperature, while most of the drought-stricken winter months were above their average temperatures.

There were a rather unusual number of 'days with a screen maximum temperature of round about 100° or over, these being September 19th with 107° (a temperature only exceeded once before at this station, on December 30th 1941, when it was 113.5°), September 4th with 100.5°, November 28th with 104.5° and December 18th with 99.5°. On the other hand there was one day, September 7th, with a maximum temperature of 58°; it is comparatively seldom that the maximum does not exceed 60° at this station. There was no unusually cold weather; the screen minimum of 43° on July 21st was the lowest for the year and the only time when it fell below 47°.

In June a grass minimum thermometer was again installed and the lowest recorded during the year was 38.5°, also on July 21st. July as usual was the coolest month of the year.

Following are the screen temperatures by months in degrees Fahrenheit at the Experiment Station, and compared with those of the preceding 21 years.

	1949.					1928-1949 include.			
	Maximum.	Minimum.	Mean,	minus average,	Daily range,	Malimum.	Minimum.	Mean,	Daily range
January..	82.1	69.0	76.2	+1.1	13.1	81.2	67.1	74~1	14~1
February..	80.4	65.9	73.2	-1.4	14.5	81.7	67.3	74.5	14.4
March ..	80.3	65.3	72,8	-0.2	15.0	80.2	65.7	73.0	14.5
April. ..	79.6	62.6	71.1	+1.0	17.0	78.3	62.1	70.2	16.2
May.. ..	76.9	55.5	66.2	-0.3	21.4	76.0	56.9	66.4	19.1
June. .,	74.0	54.0	64.0	+1.3	20.0	72.8	52.7	62,7	20.1
July.. ..	74.8	50.3	62.3	+0.4	24.0	72.2	51.7	61.9	20.5
August ..	74.3	64.4	64.3	+0.7	19.9	73.4	63.9	63.7	19.5
September.	76.9	58.8	67.8	+2.0	18.1	74.6	57.1	65.9	17.g
October..	75.3	60,7	68.0	-0.4	6.6	76.1	60.8	68.4	15.8
November.	77.3	63.1	70.2	-0.5	14.2	78.1	63.3	70.7	14.8
December.	80,5	66.5	73.5	+0,5	14.0	80.3	65.6	73.0	14.7
Means..	77.7	60.5	69.1	+0.4	18.6	77.1	60.4	68.7	16.7

Atmospheric Conditions.

The mean true atmospheric pressure for the year was 29.76 inches, which is identical with the average for this station. June had the highest average for the year, 29.95 inches, and December the lowest, with 29.60 inches.

The maximum barometer reading for the year was 30.26 inches on September 7th and October 8th; the lowest was 28.96 inches at 1.45 p.m. on November 28th. The latter is the absolute minimum for this station; the previous lowest recorded here was 29.08 inches in January, 1943.

The mean relative humidity of the atmosphere per cent of saturation was 75.72 at 8 a.m. and 62.94 at 2 p.m.

These averages are very close to those of the preceding year; in many respects the general weather records are remarkably similar to those of 1948.

The most humid months were February, March April and December and the most outstandingly dry month was July with only 66.2percent. humidity at 8 a.m. and 46.7 at 2 p.m.

The total evaporation for the year from a free water surface was 46.17, which is slightly below the average of 46.57 inches. The highest was 6.19 inches, during January as usual, and the lowest 2.08 inches for June, also as usual. February, October, November and December were months when the rainfall exceeded the evaporation. March is the only month whose average rainfall exceeds the average evaporation.

The total hours of sunshine recorded during the year were 2,437.5, or 55.6 per cent, of the total hours of daylight, which is slightly above the average for this station.

This year July had the most sunshine, 260 hours, and not May as usual; the proportion of sunshine during hours of daylight was 80.6 per cent., the highest for any month since July, 1928. November, as usual, had the fewest hours of sunshine, only 156.9, or 38.6 per cent, of total hours of daylight, the lowest total for any month since April 1947, though December 1948 had a slightly lower proportion of sunshine to hours of daylight.

Without an anemometer it is not possible to analyse wind conditions in much detail. The windiest months were January and September, October and November. During the dry months the winds were mainly from the N.E. to S.E. quadrant, with more southerly winds during rainy periods. There were frequent strong winds, but none of exceptional violence; on May 17th, October 20th, and November 2nd there were southerly winds of gale force (37). Hot Berg winds, mainly westerly, were more frequent than usual during the year. June was remarkable for its long and frequent periods of calm.

Table of Rainfall and Mean Temperature.

Year.	Rainfall in inches.	Per cent. of present mean.	Number of rain days.	Average fall per rain day.	Mean shade temperature.
1926 ...	25.42	69.80	116	0.219	[illegible]
1927 ...	42.46	116.58	128	0.332	[illegible]
1928 ...	27.56	75.67	114	0.242	67.8
1929 ...	43.83	120.35	129	0.340	67.5
1930 ...	30.03	82.45	123	0.244	67.8
1931 ...	28.01	76.91	112	0.250	68.8
1932 ...	41.36	113.56	126	0.328	69.2
1933 ...	27.14	74.52	109	0.249	68.9
1934 ...	39.42	108.24	127	0.310	68.9
1935 ...	53.25	146.21	111	0.480	66.8
1936 ...	45.36	124.55	110	0.412	67.9
1937 ...	33.21	91.19	101	0.329	68.8
1938 ...	37.97	104.26	117	0.325	68.7
1939 ...	42.87	117.71	134	0.320	68.1
1940 ...	37.31	102.44	108	0.345	69.9
1941 ...	24.35	66.86	107	0.227	69.9
1942 ...	45.41	124.68	116	0.391	69.4
1943 ...	51.32	140.91	124	0.414	68.2
1944 ...	30.32	83.25	105	0.289	69.5
1945 ...	28.50	78.25	105	0.271	68.9
1946 ...	29.55	81.14	110	0.269	69.4
1947 ...	36.74	100.88	131	0.280	68.9
1948 ...	38.66	105.83	122	0.317	69.0
1949 ...	36.61	100.22	115	0.318	69.1
Means	36.53	100.00	117	0.312	68.7

Rainfall Returns from other Sugar Growing Districts.

In 1948 the average rainfall from 44 stations contributing rainfall records to us was 5 inches below the average, but this deficiency was not due to shortfalls in the southern half of the coast, where the rainfall was close to the average, but due to severe shortages from the Umhloti northwards and particularly throughout the Zululand area.

In 1949 this position was reversed. The average rainfall from all areas was 43.35 inches, which was 2.44 inches or 6 per cent., over the general 21-year average of 40.91 inches. But in this instance the South Coast suffered drought, the rainfall being below the average on the coast everywhere south of Durban and particularly so south of Umzinto. At the 19 stations from Durban to Chaka's Kraal the rainfall was slightly above the average, but from Riet Valley north to the Tugela and beyond considerable excess of rain was recorded at each of 18 stations.

	Average rainfall for 1949 in inches.	for years 1929-1919 inclusive in inches.	1949 rainfall as per cent, of average.
South Coast: mean of 7 stations south of Durban ..	35.98	40.78	83.2
Durban to Chaka's Kraal: mean of 19 stations.. ..	40.35	39.61	101.9
Riet Valley to Riverview: mean of 18 stations.. ..	49.39	42.34	116.6
Weighted averages	43.35	40.91	106.0

The highest rainfall for the year at any station was at Eshowe, with 58.34 inches, the highest for Eshowe or anywhere else since 1943, when it was 68.80 inches at Eshowe. The absolute maximum recorded for any station during the 21-year period is 71.85 inches, also at Eshowe in 1934. The average annual rainfall at Eshowe is 51.26; only one other station records an average rainfall above 50 inches, Mtunzini, with 50.68 inches.

There were three other stations with rainfalls of over 52 inches in 1949; Mtunzini with 54.77, Kearsney with 52.74 and Eteza with 52.47 inches. The greatest excess of rain over the average was at Eteza, where it amounted to 13.51 inches or 34.7 per cent.

Other localities with rainfalls remarkably in excess of the average were Empangeni, where the three stations, Empangeni West, Empangeni Rail, and Empangeni Mill recorded an average rainfall of 48.50 inches or 20.7 per cent, above the average; also Darnall area, where the rainfall at the three stations Kearsney, Darnall South, and Darnall Mill averaged 50.16 inches or 19.4 per cent, above the average, and Milkwood Kraal, near Mount Edgecombe, where the rainfall was 40.19 inches, or 20.7 per cent, above the average of 33.31 inches, the second lowest average on the coast.

To turn to the other extreme: Umzumbi with 27.33 inches and Port Shepstone with 32.69 inches, the two most southern recording stations, were the only ones to have rainfalls below 34 inches. Thus Umzumbi had a rainfall of 31.6 per cent, below the average, while Port Shepstone was 21.9 per cent. under.

The only stations with an average rainfall under 35 inches are Effingham 33.07, Milkwood Kraal 33.31 and Riverview 34.64.

Many places near the sea, such as most of the South Coast stations and the Experiment Station, Cornubia, Natal Estates Beach Section, La Mercy, Tongaat,. Umhlali and Tinley Manor, all had rainfalls more or less lower than the 21-year average, while most places some distance from the sea had rainfalls above their average.

During the past 21 years Eshowe has had the most rainfall of all stations on 7 occasions, Mtunzini on 6, Port Shepstone twice and Kulu, Felixton, Umhlali, Westbrook, Durban and Umbogintwini once each.

Riverview has recorded the least rainfall 7 times, Effingham 6, Umzumbi and Milkwood Kraal twice each, and Empangeni West, Ottawa, Illovo and Renishaw once each.

Conclusions.

Like most of the recording stations from Durban to Chaka's Kraal, this Experiment Station had a rainfall in 1949 close to the average, and did not share in the drought of the South Coast or the unusual abundance of rain in Zululand.

As in recent years, the distribution of rain was far from satisfactory and, as in several of these years, notably 1948, 1946 and 1945, there was an unusually severe and prolonged winter drought. There were also deficient rains in January and March that no doubt held back crop growth. The rains over the last quarter of the year were excellent and created the best planting season for many years. February and November were the wettest months of the year.

The annual mean temperature was again slightly above the average. There were no unusually cold days, but there were a rather unusual number of hot Berg winds. As usual July was the coolest month and January, not February, the warmest.

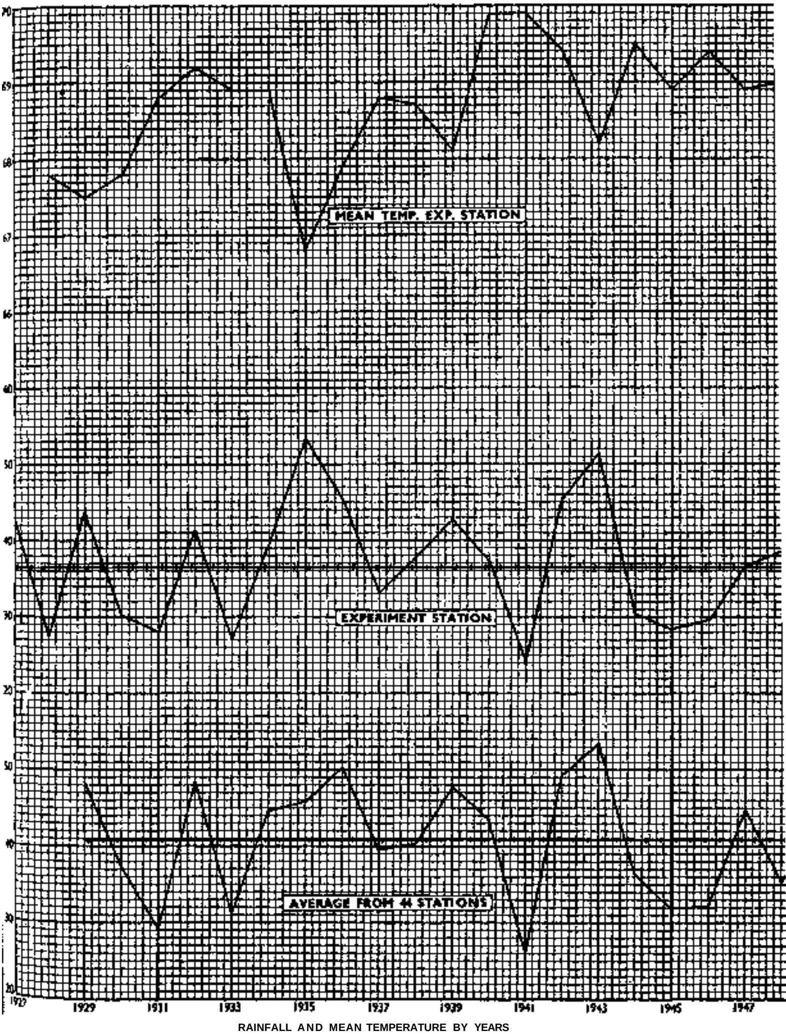
Experiment Station,
South African Sugar Association,
Mount Edgecombe.
February, 1950.

ANNUAL RAINFALL 1931-1949.

Station.	Recorder.	1931.	1932.	1933.	1934.	1935.	1936.	1937.	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.	1947.	1948.	1949.	Average
Port Shepstone ..	Lightkeeper, S.A.R. & H.	51.06	49.71	40.58	38.56	42.01	49.53	39.26	42.62	44.08	27.86	22.12	54.18	51.45	31.26	38.48	37.14	48.19	38.24	32.60	41.64
Umzumbi	A. H. G. Blamey	40.31	42.04	36.88	37.60	48.08	52.34	40.49	42.82	42.36	27.74	23.78	51.98	44.50	26.98	31.51	36.61	47.78	39.60	27.81	39.27
Hibberdene	Reynolds Bros., Ltd.	36.13	38.96	32.81	48.13	49.70	44.74	30.14	41.41	47.31	30.48	19.49	44.20	43.44	29.09	35.30	31.16	65.00	42.12	41.27	41.30
Renishaw.	Crookes Bros., Ltd.	31.86	41.56	34.48	42.17	42.69	46.10	44.40	36.18	46.90	31.83	26.16	48.33	40.74	35.26	24.85	29.62	48.09	38.41	38.42	39.14
Park Rynie	Ellingham Estate	38.94	44.14	37.71	46.52	47.88	52.85	48.10	43.22	36.25	34.46	27.40	47.14	31.26	40.16	31.78	35.30	40.64	42.61	42.54	40.61
Illovo	Illovo Sugar Estates, Ltd. ..	31.54	56.89	36.04	43.00	39.03	51.66	30.79	46.09	42.22	30.10	26.17	56.12	42.40	30.40	28.85	30.67	59.42	42.14	30.04	40.47
Umbogintwini ..	African Explosives & Industries, Ltd.	32.49	39.67	36.43	45.66	52.87	53.09	34.58	41.84	43.88	31.26	28.16	51.89	49.10	37.75	31.74	34.01	56.80	43.95	38.51	41.72
Durban (Berea) ..	Natal Herbarium	31.51	44.74	31.61	42.28	58.08	46.71	36.09	41.23	47.28	38.85	30.56	51.12	52.97	31.90	28.91	32.49	49.08	42.83	41.68	41.17
Durban (Point) ..	S.A. Railways & Harbours ..	43.88	49.46	34.42	47.45	50.93	54.55	46.84	41.80	52.57	40.99	24.86	58.91	61.86	34.04	28.63	29.91	52.55	41.09	49.15	46.22
Effingham	Natal Estates, Ltd.	21.88	30.64	19.88	30.67	48.80	42.28	28.75	32.40	35.33	28.75	22.15	42.90	48.88	29.80	29.08	28.05	45.77	42.80	36.63	33.97
Westbrook	Natal Estates, Ltd.	27.08	45.62	31.18	39.49	55.06	52.14	33.56	41.66	45.75	40.06	20.09	52.42	50.15	37.04	33.78	31.18	40.87	44.29	43.40	41.00
Milkwood Kraal ..	Natal Estates, Ltd.	23.17	33.04	22.15	31.90	43.07	36.45	23.40	34.98	38.24	34.97	28.02	45.08	48.66	27.36	26.70	27.83	40.90	37.99	40.11	32.31
Mount Edgecombe	Natal Estates, Ltd. (Mill) ..	22.98	40.19	30.94	40.02	57.41	49.60	36.55	42.12	48.08	40.23	28.34	51.60	55.40	52.56	30.31	30.06	40.03	41.29	41.24	40.61
Mount Edgecombe	S.A.S.A. Experiment Station ..	28.01	41.36	27.14	39.42	58.25	45.36	33.21	37.97	42.87	37.31	24.36	46.41	51.92	40.12	29.30	29.55	36.74	38.64	36.61	37.30
Cornubia	Natal Estates, Ltd.	27.85	42.55	29.98	40.25	50.21	52.27	40.37	44.84	51.66	42.90	30.66	58.17	59.51	38.12	24.78	29.26	43.42	41.90	41.26	41.90
Burnside	Natal Estates, Ltd.	27.01	39.79	27.88	39.61	59.28	47.49	34.01	39.76	46.87	44.91	20.84	60.69	56.39	33.71	32.49	31.81	42.46	39.96	40.69	39.82
Blackburn	Natal Estates, Ltd.	23.78	27.32	24.04	33.94	48.78	43.67	34.70	35.40	40.84	26.99	22.88	46.46	51.98	28.73	28.49	27.96	25.50	36.00	30.36	34.62
Beach	Natal Estates, Ltd.	30.16	51.64	31.65	45.18	60.00	49.12	38.02	44.24	54.88	40.81	28.76	46.74	49.53	33.07	27.26	32.70	46.50	36.81	39.68	42.82
[illegible]	Natal Estates, Ltd.	29.76	38.37	20.22	42.39	51.05	33.98	32.07	38.91	42.05	38.41	23.73	46.67	51.70	34.14	32.04	28.53	40.84	36.93	40.02	38.09
Ottawa	Natal Estates, Ltd.	24.40	34.72	28.72	39.08	47.55	44.60	47.32	37.69	41.96	39.15	22.18	52.57	55.55	32.65	27.16	31.60	40.03	36.81	38.12	37.74
La Mercy	Gewigny Bros.	29.26	56.65	31.16	37.64	56.27	45.65	35.17	45.30	49.41	42.62	26.28	51.89	50.84	32.34	31.89	34.57	39.40	34.21	39.34	40.99
Tongaat	Tongaat Sugar Co., Ltd.	26.88	45.70	26.50	38.44	47.54	30.87	35.61	40.85	44.67	40.87	22.72	55.67	53.08	31.37	30.76	33.90	39.64	31.16	34.65	39.14
Sinembe	H. C. Herman	30.88	52.71	38.64	49.99	41.84	58.60	35.77	42.07	45.80	42.68	28.25	51.84	50.42	34.15	30.96	35.48	47.21	32.69	45.39	41.68
Umhlali	G. P. Ladlau	29.09	49.86	35.13	41.20	59.61	54.57	40.29	46.83	58.14	39.72	29.49	54.74	62.60	37.18	34.25	37.12	43.92	34.67	38.94	43.32
Chaka's Kraal ..	Waldene Sugar Estate	22.52	43.09	30.14	35.09	43.38	44.74	32.87	38.40	42.27	30.61	21.78	47.42	44.63	31.01	32.15	30.67	39.01	31.31	30.72	35.12
Tinley Manor ..	Sir J. L. Hulett & Sons, Ltd. ..	30.07	47.44	36.44	41.20	50.07	56.68	38.38	46.35	46.98	41.16	24.67	47.73	47.78	32.49	27.46	32.30	46.05	33.58	40.14	40.68
Riet Valley	H. E. Essery	26.38	34.64	37.96	47.70	44.33	63.99	35.28	41.00	51.39	45.90	27.37	54.76	61.35	39.17	36.31	32.66	45.75	31.96	51.50	42.72
Kearsney	Sir J. L. Hulett & Sons, Ltd. ..	28.31	55.49	37.46	38.57	38.42	64.24	39.73	44.30	47.46	50.30	31.91	49.74	58.02	37.05	32.67	30.16	47.96	34.32	52.74	44.47
Darnall	Mrs. Mann	28.08	44.16	26.45	49.91	44.04	56.32	40.68	45.50	44.64	48.48	25.49	49.19	54.84	43.20	34.88	32.28	48.02	31.17	40.18	41.28
Darnall	Sir J. L. Hulett & Sons, Ltd. ..	24.81	52.27	29.22	48.24	40.28	62.08	30.75	43.74	43.80	47.10	25.27	46.02	52.46	23.59	28.48	30.58	41.27	30.54	46.55	40.36
Mandini	St. Andrews Estate	24.40	50.09	27.41	55.84	45.58	61.25	36.34	40.90	38.34	41.01	24.70	43.91	56.47	41.28	30.24	30.41	47.18	26.84	44.90	40.31
Amatikulu	Sir J. L. Hulett & Sons, Ltd. ..	21.09	47.10	29.86	47.98	43.41	47.86	35.08	37.24	47.63	50.40	27.80	48.87	33.37	38.08	28.45	26.24	38.61	25.21	44.39	37.57
Gingindhlovu ..	P. C. Lilburn	24.60	53.85	35.06	50.91	63.16	59.68	39.62	40.10	34.12	58.75	30.35	56.40	62.72	47.02	36.28	29.98	42.55	30.28	51.64	44.44
Mtunzini	G. V. W. Roberts	32.92	51.97	40.08	58.29	53.02	63.62	43.67	44.28	65.11	62.16	30.06	60.31	64.31	33.71	50.98	30.63	50.17	39.65	54.77	48.40
Eshowe	District Forest Officer	30.35	66.05	47.32	71.85	46.16	66.61	47.68	46.40	62.55	70.67	36.57	47.44	46.80	50.17	45.40	41.67	52.04	37.37	58.34	51.36
Felixton	Sir J. L. Hulett & Sons, Ltd. ..	33.03	69.09	31.45	58.72	50.16	56.71	51.96	29.62	54.90	61.15	30.06	43.45	62.49	48.62	37.62	39.40	56.40	41.40	51.22	46.90
Empangeni West ..	W. H. Simpson	20.56	43.32	22.92	41.08	36.40	30.62	39.10	32.03	47.01	41.24	24.50	40.74	48.47	29.05	28.64	25.00	37.82	26.80	43.51	36.49
Empangeni Rail ..	F. S. Mann	30.85	49.58	27.72	46.00	37.28	47.54	46.31	35.99	52.02	53.48	26.79	45.11	64.13	44.67	33.98	36.13	50.85	31.78	50.64	41.94
Empangeni	Zululand Sugar Millers & Planters.	31.06	55.34	29.55	45.72	38.18	49.46	47.87	38.49	51.79	53.11	24.54	45.06	50.06	38.36	30.78	39.21	50.88	31.65	51.56	41.80
Kuhu Halt	S. B. Forrest	25.96	46.64	30.15	48.28	35.08	46.19	56.80	30.95	52.91	37.61	23.07	52.29	66.75	43.02	32.45	31.75	30.74	30.35	61.84	42.08
Mposa	W. Springorum	24.28	59.32	25.43	40.45	29.59	46.81	51.50	39.08	47.68	51.62	20.58	43.50	44.54	34.04	29.40	28.05	42.88	27.79	44.06	38.09
Kwambonambi ..	S. Larsen	28.14	64.34	29.88	64.21	34.27	41.64	49.37	32.42	42.91	53.82	20.81	47.01	50.76	36.30	28.88	27.44	39.48	28.04	44.63	41.11
Etam	Haworth Bros.	31.27	59.48	29.85	44.05	26.73	42.21	49.96	35.98	41.26	61.51	22.04	41.15	54.36	32.55	26.80	24.47	38.29	37.12	52.47	38.96
Riverview	Umfolozi Co-op. Sugar Planters, Ltd.	22.59	51.29	26.05	37.34	31.44	55.86	39.65	36.32	39.93	54.95	18.46	38.92	50.42	26.11	33.97	22.88	28.06	19.98	43.41	34.64
		30.53	48.87	31.16	44.74	45.80	50.18	39.57	40.33	47.68	41.46	28.18	49.40	55.81	36.45	31.99	32.02	44.84	35.25	43.55	40.91

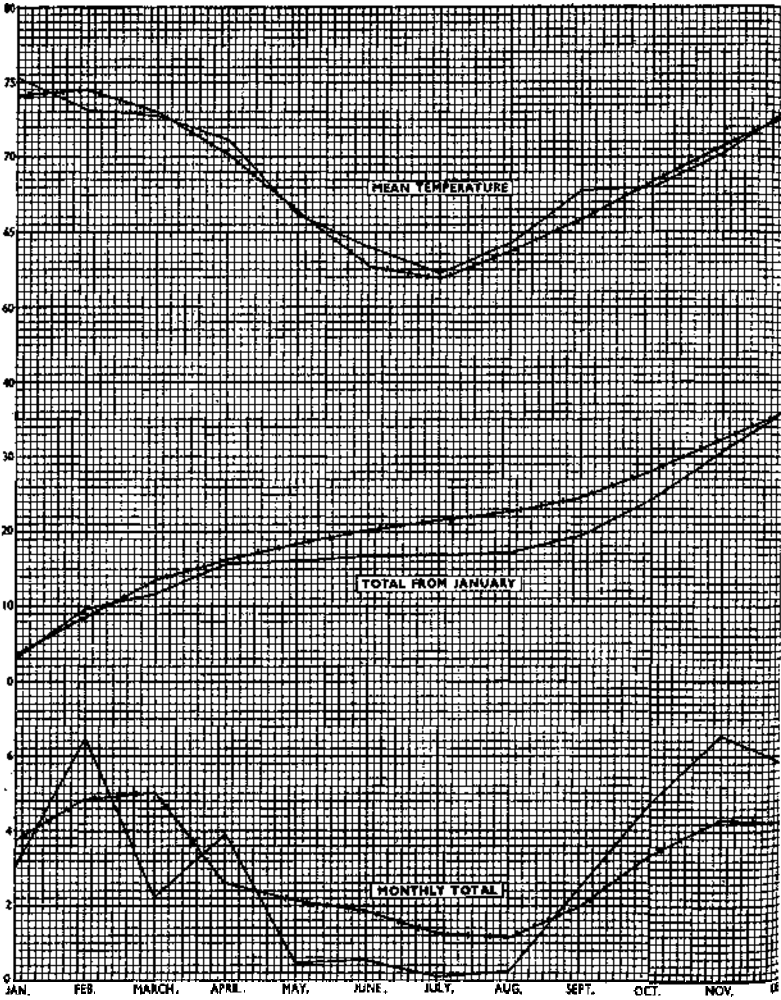
Note.—The 1929 and 1930 records have been omitted for lack of space.

ANNUAL RAINFALL AND MEAN TEMPERATURE



RAINFALL AND MEAN TEMPERATURE BY YEARS

RAINFALL AND TEMPERATURE AT THE EXPERIMENTAL STATION BY MONTHS



RAINFALL 1949 ———————— MEAN TEMPERATURE 1949

RAINFALL AVERAGE 1926-1949 .... MEAN TEMPERATURE AVERAGE 1926-1945

APPENDIX—SUGARCANE CROP STATISTICS 1948-49

According to the "Special Census of Sugarcane Plantations, 1948-49—European Planters Only," 4,612,243 tons of 2,000 lbs. sugarcane were harvested from 172,120 acres during the 1948-49 season. The average yield of cane per acre was therefore 26.80 tons, which is still well below our best yield of 30.87 tons cane per acre in 1943 and 30.22 tons per acre in 1939; but it is appreciably better than the previous season's, when it was 24.47 tons per acre.

The average yields of cane per acre for the last six years were as follows:—

Year	Yield per acre	Year	Yield per acre
1948	26.80 tons	1945	25.70 tons
1947	24.47 „	1944	29.08 „
1946	21.99 „	1943	30.87 „

The rainfall during 1948 was well below average and particularly deficient in the Zululand area, which had only 72 per cent, of its normal rainfall.

Census returns were made by 720 individuals, with a total farm area of 745,770 acres, of which 359,196 acres were under cane on the 30th April, 1949. There were still 80,639 acres of virgin land suitable for cane production in this area and 15,292 acres of virgin land had been planted up during the 12 months ending 30th April, 1949.

	Area of farms	Area under cane	Per cent. area under cane	Available virgin land as per cent. area under cane	Virgin land planted as per cent. area under cane
South Coast ..	180,220	81,240	45.1	19.3	2.1
North Coast..	235,639	145,728	61.8	10.1	3.1
Zululand. ..	329,920	132,228	40.1	38.0	6.8
Total for Industry	745,770	359,196	48.2	22.4	4.3

In the Inanda district only 2,261 areas of virgin land, or 4.9 per cent, of the area already under cane, is considered suitable for cane cultivation; but in the Hlabisa district suitable virgin land forms .101.3 per cent, of the 10,521 acres at present under cane and the one return from Piet Retief of 960 acres under cane gives another 10,000 acres as suitable.

These census returns do not include data concerning non-European planters, but information obtained from the Sugar Industry Central Board allows us to calculate the percentages for the different groups:—

	Per cent, of total crop
European planters	58.8
European miller-cum-planter companies	32.8
Bantu planters	0.7
Indian and other non-European planters (including 1 miller-cum-planter company)	7.7
Total crop	100.0

The P.O.J, canes grown on fertile alluvial flats again gave the best average yield of 37.06 tons cane per acre. Of the other varieties Co.331, with 34.07 tons per acre, was the best, followed by N:Co. 310, of which 286 acres were harvested, with 33.07 tons per acre.

Co.301 again outyielded Co.281, their respective yields being 28.90 tons cane per acre and 25.29 tons cane per acre. Co.301 has increased rapidly in popularity compared with Co.281 in recent years, and there is a widespread feeling that Co.281 is not nearly as good now as it used to be. It may therefore be of some interest to compare the yields of Co.281 and Co.301 from 1944, the first year that the yields from these varieties were given in the census:—•

	Plant Cane			First Ratoon	Second Ratoon	Total Crop
	Co.281 tons per acre	Co.301 tons per acre	Co.281 per cent. Co.301	Co.281 yield per cent. Co.301 yield	Co.281 yield per cent. Co.301 yield	Co.281 yield per cent. Co.301 yield
1948 . .	28.50	33.57	84.9	91.4	102.3	87.5
1947 . .	26.16	31.98	81.8	88.9	91.0	81.6
1946 . .	24.18	25.86	93.5	89.9	93.5	88.2
1945 . .	29.51	30.87	95.6	100.5	99.7	93.4
1944 . .	33.25	33.72	98.6	96.9	106.2	94.7

These results certainly show a consistent decrease in yield of Co.281 compared with Co.301 from 1944 to 1947, but the position was somewhat better in 1948.

Less Co.281 is now planted and on 30th April, 1949, Co. 281 formed only 34.1 per cent, of the total plant cane whereas it was 47.3 per cent, the previous year. Co.301 has also dropped from 41.1 to 36.7 per cent. N:Co.310 has increased from 2.7 to 17.0 per cent, and Co.331 from 6.5 to 10.6 per cent.

The following table gives the percentages of the various varieties as plant cane in the different areas on 30th April, 1949:—

Variety	South Coast	North Coast	Zululand	Total for Union
Uba	0.1	0.2	0.0	0.1
Co.281	30.8	15.9	52.4	34.1
Co.290	0.0	0.9	0.4	0.6
Co.301	53.4	49.7	17.3	36.7
Co. 331	6.2	11.2	11.9	10.6
N:Co.310... ..	9.4	21.9	15.8	17.0
P.O.J.'s	0.1	0.0	2.1	0.9
Other varieties .	0.0	0.1	0.0	0.1

Port Shepstone still has by far the largest proportion of Co.281 in plant cane, 89.8 per cent., and Hlabisa has 62.5 per cent. At Umzinto 63.0 per cent, of the plant cane is Co.301 and Eshowe has the largest proportion of Co.331, 22.9 per cent, of the total plant cane. At Inanda no less than 31.7 per cent, of plant cane is N:Co.310 and Co.281 forms only 23.1 per cent, of plant cane. Co.281 has dropped to only 13.2 per cent, of plant cane in the Lower Tugela district. At Hlabisa the P.O.J, varieties form 9.1 per cent, of the plant cane and at Lower Umfolozi 2.9 per cent. The proportion of P.O.J, cane in the other districts is negligible.

Except for the Piet Retief district, with one return, Inanda leads as usual in yield per acre with an average of 31.58 tons cane, followed by Lower Umfolozi with 30.11 tons per acre. The yield of tons cane per acre has improved in every district compared with the previous season except in the Port Shepstone district.

The average yields of the main sugar areas over the last few years are as follows:—

	YIELDS TON'S CANE PER ACRE		
	1946	1947	1948
South Coast	18.01	20.12	21.79
North Coast	24.23	26.72	29.03
North of Tugela	22.15	24.54	27.46
Total for industry ...	21.99	24.47	26.80

The South Coast was responsible for 18.6 per cent, of the total crop, the North Coast for 43.9 per cent. and Zululand for 37.5 per cent. Lower Tugela was again the district with the biggest total production of cane, 1,299,218 tons, or 28.2 per cent, of the total crop.

AREA OF CANE HARVESTED AND YIELDS FOR DIFFERENT VARIETIES AND RATOONS.

(EUROPEAN PLANTERS ONLY) 1948-49.

COMPILED FROM UNION DEPARTMENT OF CENSUS RETURNS.

VARIETY.	PLANT CANE		FIRST RATOON		SECOND RATOON		THIRD RATOON		FOURTH RATOON		OTHER RATOONS		TOTAL	
	Acres,	Tons/ acre.	Acres,	Tons/ acre.	Acres,	Tons/ acre.	Acres,	Tons/ acre.	Acres,	Tons/ acre.	Acres,	Tons/ acre.	Acres,	Tons/ acre.
Uba	13	14.77	13	41.92	36	16.00	254	15.50	146	11.84	694	17.14	1,156	16.33
Co.281	23,616	28.50	21,342	27.10	27,987	24.77	21,986	22.84	8,174	21.45	5,155	22.42	108,260	25.29
Co.290	374	25.64	347	25.21	308	24.64	209	21.48	238	26.98	398	34.85	1,874	27.06
Co.301	19,894	33.57	13,262	29.66	12,560	24.21	5,939	24.12	1,405	20.10	614	23.68	53,674	28.90
Co.331	2,300	36.41	892	30.59	203	27.03	115	27.61	7	19.43	2	34.50	3,519	34.07
N:Co.310	236	34.87	33	25.61	2	29.00	—	—	15	21.73	—	—	286	33.07
P.O.J.2725 and 2878	794	60.08	442	41.55	241	31.13	501	33.28	336	28.12	1,014	31.14	3,328	37.06
Other Varieties	6	41.50	8	36.25	3	36.67	6	30.83	—	—	–	„	23	36.26
Total	47,233	31.39	36,339	28.29	41,340	24.64	29,010	23.23	10,321	21.47	7,877	23.80	172,120	26.80

AREA OF CANE HARVESTED AND YIELDS BY DISTRICTS (EUROPEAN PLANTERS ONLY) 1948—49.

COMPILED FROM UNION DEPARTMENT OF CENSUS RETURNS.

DISTRICTS.	Uba.		Co.281.		Co.290.		Co.301.		Co.331.		N:Co.310		P.O.J.2725 and 2878.	
	Acres.	Tons/ acre.	Acres.	Tons/ acre.	Acres.	Tons/ acre.	Acres.	Tons/ acre.	Acres.	Tons/ acre.	Acres.	Tons/ acre.	Acres.	Tons/ acre.
Port Shepstone	—	—	3,696	21.62	13	14.15	138	18.20		—	5	30.00	9	8.44
Umzinto	222	19.06	19,257	20.75	311	17.14	8,009	25.31	341	30.75	29	25.41	31	33.32
Durban and Pinetown	17	7.65	4,560	21.70	20	30.00	2,705	19.11	55	13.29	12	27.83	—	—
Total South of Umgeni River ...	239	18.25	27,513	21.02	344	17.78	10,852	23.67	396	28.33	46	26.54	40	27.73
Inanda	749	15.82	11,899	31.35	31	44.94	9,691	32.94	394	34.25	55	34.00	36	22.64
Lower Tugela	36	16.39	20,859	24.92	666	25.88	23,850	29.87	1,154	35.57	65	34.54	135	42.30
Total for North Coast between Umgeni and Tugela Rivers...	785	15.85	32,758	27.26	697	26.72	33,541	30.76	1,548	35.24	120	34.29	171	38.16
Total for Natal South of the Tugela	1,024	16.41	60,271	24.41	1,041	23.77	44,393	29.03	1,944	33.83	116	32.14	211	36.18
Mtunzini	22	5.68	16,244	24.55	213	29.37	3,636	28.17	623	31.13	18	46.67	53	39.85
Eshowe	19	13.05	8,743	22.83	66	39.50	1,532	29.16	335	36.76	8	21.25	256	28.02
Lower Umfolozi	91	18.68	19,000	29.97	198	27.72	3,802	27.39	591	26.57	40	39.45	1,915	35.48
Hlabisa	—	—	3,842	23.47	356	32.63	165	29.15	6	10.00	54	28.43	855	43.30
Piet Retief			160	53.97			146	45.86	20	37.25			38	37.76
Total North of the Tugela	132	15.70	47,989	26.39	833	31.17	9,281	28.31	1,575	34.36	120	34.36	3,117	37.12
TOTAL FOR UNION	1,156	16.33	108,260	25.29	1,874	27.06	53,674	28.90	3,519	34.07	286	33.07	3,328	37.06

YIELDS OF CANE HARVESTED BY DISTRICTS (EUROPEAN PLANTERS ONLY).

COMPILED FROM UNION DEPARTMENT OF CENSUS RETURNS.

DISTRICT.	PER CENT. OF TOTAL TONNAGE.												
	1936.	1937.	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.	1947.	194S.
Port Shepstone	1.5	1.8	1.8	1.8	1.7	1.2	2.0	2.0	1.6	1.3	1.8	1.9	1.8
Umzinto	14.8	17.0	15.7	15.4	15.3	12.7	13.7	14.1	14.9	12.6	13.9	12.8	13.5
Durban and Pinetown	3.9	3.0	4.4	4.4	4.0	4.7	4.6	4.0	3.4	3.2	3.9	3.7	3.3
Total South of Umgeni River	20.2	21.8	21.9	21.6	21.0	18.6	20.1	20.1	19.9	17.2	' 19.6	18.3	18.6
Inanda	16.5	15.1	16.2	16.7	17.0	17.4	18.2	16.8	16.8	17.6	16.4	17.1	15.7
Lower Tugela	31.1	27.9	26.5	26.5	27.1	25.6	26.3	27.5	26.7	27.2	27.9	28.7	28.2
Total for North Coast between Umgeni and Tugela Rivers	47.6	43.0	42.7	43.2	44.1	43.0	44.4	44.3	43,5	44.8	44.3	45.8	43.9
Total for Natal South of the Tugela	67.8	64.3	64.6	64.8	65.1	61.6	64.6	64.4	63.4	62.0	63.9	64.1	62.5
Mtunzini	10.9	10.7	10.9	10.9	10.6	11.8	10.7	11.0	11.4	11.1	9.6	10.3'	11.5
Eshowe	3.2	3.7	4.6	5.0	5.0	6.0	5.7	5.5	6.0	5.6	5.7	5.4	5.8
Lower Umfolozi	16.2	17.5	16.6	16.0	16.0	16.7	15.4	15.6	15.7	17.7	16.6	16.2	16.7
Hlabisa	1.9	3.3	3.3	3.2	3.3	3.8	3.6	3.5	3.5	3.7	3.9	3.6	3.2
Piet Retief													
Total North of the Tugela	32.2	35.2	35.4	35.1	34.9	38.4	35.4	35.6	36.6	38.0	36.1	35.9	37.5
GRAND TOTAL FOR UNION	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

YIELDS OF CANE HARVESTED BY DISTRICTS (EUROPEAN PLANTERS ONLY).

COMPILED FROM UNION DEPARTMENT OF CENSUS RETURNS.

DISTRICT.	TONS CANE PER ACRE.												
	1986.	1937.	1988.	1989.	1940.	1941.	4942.	1943.	1944.	1945.	1946.	1947.	1948.
Port Shepstone	13.51	21.53	29.33	26.52	18.15	13.73	23.08	31.32	22.95	19.18	19.26	22.68	21.45
Umzinto	18.22	22.41	23.50	25.94	23.02	16.47	20.20	24.68	24.18	19.51	17.59	19.70	22.13
Durban and Pinetown	19.77	20.42	27.65	31.76	24.74	20.28	25.63	24.01	24.16	20.11	19.05	20.47	20.69
Total South of Umgeni River	18.02	22.04	24.65	27.00	22.83	17.05	21.48	25.07	24.07	19.59	18.01	20.12	21.79
Ratio to 1936 (= 100)	97.72	119.52	133.68	**146.42**	123.81	92.46	116.49	135.95	130.53	106.24	97.67	109.11	118.17
Inanda	25.95	26.19	31.27	36.57	33.24	28.20	32.94	40.45	37.51	32.32	27.20	30.42	31.58
Lower Tugela	22.61	22.90	25.19	29.51	27.35	21.30	24.42	31.10	29.49	26.58	22.77	24.90	27.78
Total for North Coast between Umgeni and Tugela Rivers	23.67	23.96	27.19	31.89	29.35	23.64	27.31	34.09	32.14	28.57	24.23	26.72	29.03
Ratio to 1936 (= 100)	127.19	128.75	146.10	171.36	157.71	127.03	146.75	183.18	172.70	153.52	130.20	143.58	155.99
Total for Natal South of the Tugela	21.65	23.27	26.27	30.07	26.87	21.18	25.18	30.64	29.08	25.35	21.90	24.43	26.41
Ratio to 1936 (= 100)	116.71	125.44	141.62	162.10	144.85	114.18	135.74	165.18	166.77	136.66	118.06	131.70	142.37
Mtunzini	18.85	20.97	24.67	27.86	27.06	22.67	24.96	30.71	27.19	23.73	18.02	22.01	25.47
Eshowe	17.26	20.69	28.03	29.89	26.62	23.53	25.11	27.46	27.27	22.68	20.27	21.35	24.34
Lower Umfolozi	23.04	28.81	34.40	33.25	31.00	26.10	26.51	33.45	31.47	30.07	25.83	27.39	30.11
Hlabisa	18.60	25.36	30.91	28.81	29.60	26.31	29.84	30.79	29.00	25.52	23.68	25.64	27.52
Piet Retief											39.16	38.15	**48.11**
Total North of the Tugela	20.52	24.63	29.62	30.51	28.91	24.55	26.09	31.28	29.08	26.30	22.15	24.54	27.46
Ratio to 1936 (= 100)	86.11	103.57	124.30	128.03	121.32	103.02	109.48	131.26	122.03	110.37	92.95	102.98	115.23
GRAND TOTAL FOR UNION	21.27	23.75	27.37	30.22	27.55	22.36	25.49	30.87	29.08	25.70	21.99	24.47	26.80
Ratio to 1936 (= 100)	104.06	116.19	133.90	147.85	134.78	109.38	124.71	151.03	142.27	125.73	107.58	119.72	131.12
Rainfall of all Districts (inches) (*Average from 44 centres*).	50.13	39.57	40.33	47.68	43.48	26.18	49.40	53.31	36.45	31.99	32.02	44.83	35.25

YIELDS OF CANE HARVESTED BY DISTRICTS (EUROPEAN PLANTERS ONLY).

COMPILED FROM UNION DEPARTMENT OF CENSUS RETURNS.

DISTRICT.	YIELD OF CANE IN TONS										
	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.	1947.	1948.
Port Shepstone	74,866	89,585	81,811	43,704	84,444	97,113	79,993	57,630	67,743	78,890	82,835
Umzinto	663,609	744,981	733,332	457,518	582,516	682,713	728,879	528,593	515,571	532,675	624,009
Durban and Pinetown	188,183	213,958	193,938	167,970	191,737	195,923	165,164	136,253	146,087	153,073	152,443
Total South of Umgeni River	926;648	1,048,524	1,009,081	669,192	858,697	975,749	974,036	722,476	729,401	764,638	859,287
Ratio to 1926 (= 100)	207.9	235.2	226.3	150.1	192.6	218.9	218.5	162.1	163.6	171.5	192.7
Inanda	683,261	807,094	816,215	627,454	774,840	812,986	823,041	737,413	608,736	714,066	722,277
Lower Tugela	1,122,528	1,285,888	1,299,769	921,709	1,120,740	1,331,681	1,310,186	1,144,887	1,035,855	1,195,584	1,299,218
Total for North Coast between Umgeni and Tugela Rivers	1,805,789	2,092,982	2,115,984	1,549,163	1,895,680	2,144,667	2,133,227	1,882,300	1,644,591	1,909,650	2,021,495
Ratio to 1926 (= 100)	218.0	252.7	255.5	187.1	228.9	259.0	257.6	227.3	198.6	230.6	244.1
Total for Natal South of the Tugela ..	2,732,437	3,141,506	3,125,065	2,218,355	2,754,277	3,120,416	3,107,263	2,604,776	2,373,992	2,674,288	2,880,782
Ratio to 1926 (= 100)	214.5	246.6	245.3	174.1	216.2	244.9	243.9	204.5	186.3	209.9	226.1
Mtunzini	462,271	525,787	507,644	426,608	457,698	533,560	556,524	465,147	358,378	429,676	529,967
Eshowe	193,847	243,829	240,962	217,695	243,392	264,198	293,602	236,115	211,170	225,903	266,752
Lower Umfolozi	703,527	777,371	765,381	601,315	655,366	758,217	769,436	741,972	618,269	674,790	771,913
Hlabisa	140,794	155,776	158,176	138,416	154,945	168,982	171,555	153,689	145,062	149,372	145,318
Piet Retief									9,321	18,886	17,511
Total North of the Tugela	1,500,439	1,702,762	1,672,163	1,384,034	1,511,401	1,724,957	1,791,117	1,596,923	1,342,200	1,498,627	1,731,461
Ratio to 1926 (= 100)	165.1	187.4	184.0	152.3	166.3	189.8	197.1	175.7	147.7	164.9	190.5
GRAND TOTAL FOR UNION	4,232,876	4,844,268	4,797,228	3,602,389	4,265,678	4,845,373	4,898,380	4,201,699	3.716,192	4,172,915	4,612,243
Ratio to 1926 (= 100)	193.9	221.9	219.8	165.0	195.4	222.0	224.4	192.5	170.3	191.2	211.3

The VICE-PRESIDENT explained that he had taken the chair in order to give the President, who was the senior author of the paper, the opportunity of reading it. Dr. Dodds had been the senior author of this Annual Summary from the time it was started 24 years ago, with the exception of one year; but, owing to his retirement in the near future, this was the last time he would be connected with its compilation.

Mr. RAULT enquired if any member present could give his factory experience of N:Co.310 during the past year. His company had had expectations of very high sucrose content in this variety, but these hopes had not been realised from the small quantity crushed. The sucrose content of this variety was only slightly better than that of Co.281.

Dr. DODDS considered that the amount of N:Co.310 that had as yet been crushed was too small to give very representative information. Within the next year or two, however, large quantities would be milled. He thought that N:Co.310 would not have justice done to it as regards sucrose content as long as this was calculated from the mean Java Ratio. This Ratio would be lowered by the milling of canes of much higher fibre content than N:Co.310, to the advantage of such canes and the disadvantage of N:Co.310.

The VICE-PREISDENT stated that while factories had reported low sucrose figures for N:Co.310, on the average it was not really lower than Co.281 in sucrose content.

Tests at the Experiment Station indicated a comparative sucrose content higher than that shown in the factories for N:Co.310. While it was to be hoped that in the case of this variety an increase in sucrose content could be expected when larger quantities were milled, one should not be too optimistic. In the case of other varieties, tests at the Experiment Station had pointed to a general increase in sucrose content when they were released, but this increase had not eventuated.

Mr. MCKENNA stated that the variety that gave most trouble in his factory last year was Co.310, which on occasion gave very cloudy juices.

Mr. PHIPSON asked if anyone had found that the trash adhering to N:Co.310 was difficult to remove from the stalk.

The VICE-PRESIDENT said he had found at the Experiment Station, that if no attempt were made to trash it, N:Co.310 would have far more trash adhering to it than would, say, Co.281. However, this trash was very easily removed, the leaves were big, and when dead, did not adhere closely as in the case of canes such as Uba, for example.

He enquired if Mr. Galbraith could explain the consistent improvement in overall recovery shown by Sezela Factory during the past three seasons.

Mr. GALBRAITH explained the increased overall recovery at Sezela in 1947 as being due to the improved extraction resulting from the addition of a fifth mill to each tandem. When he went there in 1948 he altered the boiling house system to that he had worked at Esperanza, and this resulted in better yields from massecuites. Clarification was improved by increasing the quantity of phosphoric acid used, and a more accurate system of pH control. Furthermore, more attention was paid to mill hygiene, and this was improved in 1948, and still further in 1949.

He ascribed the improvement to general all-round better work rather than to anything spectacular; but in the main the chief factor was the better class of massecuite produced. The big trouble in sugar factories was the re-circulation of molasses, and if that could be cut down the recovery would undoubtedly increase.

Mr. RAULT thought it would be of advantage if the Annual Summary could indicate alteration to factory equipment, for that had a large bearing on results. In this connection, the short reports on the year's working sent in by chemists in the past were most useful.

Dr. DODDS agreed that notes on alteration to factory equipment would form a valuable contribution to the data already presented in the Summary. It was possible that, in the future, this Summary, or at least the manufacturing side of it, would be prepared at the Sugar Milling Research Institute, and in view of that, he passed the suggestion on to Dr. Douwes-Dekker for his consideration.

The VICE-PRESIDENT, referring to Mr. Rault's remark about the useful reports contributed by factory chemists in the past, said that only a few went to the trouble to send them in year after year. If others had also done this, the procedure would have been continued with advantage.

As it had been suggested that the Annual Summary be prepared in future by the Sugar Milling Research Institute, he asked Dr. Douwes-Dekker if he would indicate something of his plans for the future in this connection.

Dr. DOUWES-DEKKER thought he would continue the Annual Summary on the same lines as the Experiment Station had done so admirably in the past.

With regard to equipment, it was certainly the intention of his Research Committee to send out a questionaire to the factories, as he wished to compile data on the plant in use in Natal. Such information would be very useful when questions were asked about equipment.

The VICE-PRESIDENT said that of the progress made by the industry since the establishment of the Experiment Station, it would be difficult to assess how much had been due to the compilation of the Annual Summary. The mere fact of its giving a comparison between factories had no doubt stimulated a lot of improvement.

By starting and continuing with this Annual Summary, Dr. Dodds had done great service to the industry.

Dr. DODDS was grateful that the work of the author in compiling the Annual Summary was appreciated so much. It had been interesting work, but without many others who had collaborated with him, and the help given by several of the Experiment Station staff, it could not have been accomplished.

SOME NOTES ON. THE PRINCIPLES OF OUR MANUFACTURING PROCESSES.

By K. DOUWES-DEKKER.

Sugar manufacture has grown through the ages from a small hand-worked process into a modern large-scale industry working on principles developed to a stage of great reliability by long experience and by constant scientific and industrial research.

But if we compare sugar manufacture with some other modern chemical industries, e.g. oil refining, plastics, vitamins and antibiotics and others, which make wide use of the techniques of high pressure and vacua, extreme temperature limits and plant constructed of the best and newest materials, we may conclude that the scientific principles of these industries are even more extensively studied and better known than those of our good old sugar industry.

There seem to be two explanations for this divergence. In the first place, the raw material to be worked in the mills is of an extremely complicated structure which varies from seasonal effects and from place of growth. This complexity of the juice makes it often difficult to generalise and to systematise our knowledge of the behaviour under different conditions of alkalinity and temperature.

In the second place, we have to take into consideration that many of our manufacturing processes have gradually and empirically developed to a stage which seem to yield satisfactory results. Granting this, the question "Why conduct expensive investigations?" may be fairly asked.

It is the aim of this paper to discuss a few principles underlying the different manufacturing processes and to see how well defined modifications of these principles can lead to new ideas and new applications.

We all know that the normal course of the manufacturing process is: juice clarification; concentration; crystallization; and we are inclined to accept this sequence as logical and therefore correct. But if, however, we observe the heavy scaling of some evaporator tubes, or the excessive degree of turbidity of syrup and first and second molasses, or the stickiness of the last boilings, some doubt is apt to arise about the correctness of the application of the juice clarification method when this juice is at its maximum dilution. We are inclined to ask: "Can this flocculation of non-sugars in evaporators and vacuum pans be prevented by a clarification at a higher brix?"

Such considerations, based on the simple principle that, with less water, less non-sugars can be dissolved, have led to experiments with the aim of finding a clarification process at a higher density. From these experiments a process has evolved, known in Java under the name of midsap clarification, and it is used in one of the larger mills. As originally applied, the mixed juice was limed at the boiling point to pH 7.2 and subsequently settled in the usual way. In order to eliminate the filter presses the sludge was returned to the mills and spread over the bagasse apron from the second mill. The clear juice was, as usual, pumped into the quadruple and concentrated, with this difference, however, that the juice from the third body, at a brix of 40°to 45°, was taken from the evaporator and, after being cooled to 130°F., subjected to the double carbonatation process.

The pH of the double-filtered juice, being about 8.7, was then reduced with $S0_2$ to about 6.9 and the juice was further concentrated in the fourth body to normal syrup density. By this method, based on the principle that at higher concentration more non-sugars are removed per unit weight of brix, with about two-thirds of the amount of lime usually required for the carbonatation of mixed juice, a higher rise in purity and a corresponding increase in recovery was attained. In this respect the midsap carbonatation process was certainly satisfactory.

There was one difficulty, however; the colour of the sugar was somewhat disappointing. This was believed to be due to the long time (1 to $1^{1/2}$hours) that the hot limed juice was allowed to settle and an improvement of the process was suggested by omitting the settling of the neutralised mixed juice. In this modification, the limed, unsettled, and therefore very turbid mixed juice was to be concentrated to 40° to 45° brix, carbonatated and filtered. The obvious objections were the anticipated heavy scaling of the evaporator tubes and the possibility of very difficult filtration of the mixed defecation and carbonatation precipitate from the concentrated and therefore somewhat viscous midsap.

Pilot plant tests showed, however, that the turbidities of the juice, instead of scaling the evaporator tubes, kept them clean. The speed of nitration of, the mid-sap also appeared to be reasonable. As a consequence of these results, the new process was about to be applied on factory scale when the war broke out.[1]

From these results it may be concluded that clarification at a higher brix deserves to be considered too in the Natal sugar industry. Natal juices of 15 brix are more diluted than Java juices, and more likely to keep non-sugars, especially lime salts, in solution.

Although the adverse effect of high percentages of lime salts is well known, the special attention of the Natal technologists is drawn to the importance of their removal. Honig and Alewijn[2] state that all lime salts in excess of 150 mg. CaO per litre clarified juice are apt to be precipitated during the concentration and crystallization processes. It is also known that the amount of coloured matter included in the sucrose crystal is adversely influenced by the presence of lime salts in the crystallizing mother liquor. Reduction of the percentage of lime salts should therefore be pursued anyway, and clarification at higher brix is one of the methods to attain this goal.

The principle of removal of non-sugars at a higher brix has been applied in other ways too. The Bach process is an example of the combination of a clarification at mixed juice, and a clarification at syrup density. It has been demonstrated,[3] however, that the advantages over the normal sulphitation process did not warrant its continuation.

The Bach process is a combination of two chemical clarifications. The usual chemical juice clarification has, however, also been 'combined with physical processes, the physical treatment in this case being applied at higher densities. The idea behind these processes was the improvement of the velocity of boiling of the low grade massecuites by the removal of suspended matter. Expecially in those factories where the sugar from the last boilings is remelted, sometimes after double purging, it was hoped to improve the quality of the sugar by the physical removal of suspended matter from the second molasses and the melts.

Such a treatment was often a filtration after addition of materials like vegetable carbon, including coUactivit, diatomaceous earth, paper pulp, sand, calcium carbonate, vegetable fibres (duq), etc., and also centrifugal separation.

The idea of centrifugal separation of syrup with the aim of improving the boiling properties of syrup and molasses was very attractive and has been studied in many cases.[4] One of the first results of these studies showed that it was more profitable to separate syrup after it had been sulphited to a pH of about 6.0, since this simple acidification tended to flocculate a considerable amount of non-sugars, mainly calcium sulphite and sulphate. It was, for example, possible to remove by centrifugal separation 6.25 grams precipitated scums from 1 kilogram of untreated syrup against 10.8 grams from sulphited syrup.

A more important discovery, however, was that, even if a completely brilliant syrup was worked, the amount of non-sugar precipitated during the crystallization process in the first, second and third boilings exceeded many times the weight of non-sugars which had previously been removed by separation from this syrup. For example, in a carbonatation mill, the following figures were found:—

Material.	Purity.	Precipitated non-sugars/ dissolved non-sugars. $\times 10^4$
Syrup ...	89.4	0.156
First molasses	73.9	0.790
Second molasses	53.8	6.69
Third molasses	46.1	7.42
Final molasses	32.9	9.90

indicating an enormous flocculation during the second boiling.

Sulphitation syrup usually contains more turbidities than carbonatation syrup; but, while the increase in suspended matter is considerable, it is relatively not as well marked as in carbonatation syrup, as is shown by the following figures:—

Material.	Purity.	Precipitated non-sugars/ dissolved non-sugars. $\times 10^4$
Syrup ...	83.8	9.8
First molasses ...	63.2	18.1
Second molasses	54.5	21.0
Final molasses	34.4	27.5

Improvement of the properties of the lower-grade boilings being the aim of centrifugal separation, it appears to be much more profitable to apply this process to the second and first molasses than to syrup. This means a considerable reduction in the capacity of the apparatus needed to obtain the same effect.

It seems obvious that the increase of precipitate in the lower-grade molasses cannot be ascribed only to the reduction of the amount of water in which they were dissolved. The process probably should be considered as a flocculation of suspended colloidal matter, which is governed by other rules than the simple decrease of solubility. Of the composition of the precipitate, typical analytical figures from sulphited syrup of two sulphitation mills are:—

	Per cent.	Per cent.	Per 100 carbonated ash.	Per cent.	Per cent.
Moisture	35.48	24.66	Insoluble in HCl	82.18	46.89
Carbonated ash	8.97	18.88	SiO_2	0.53	2.79
Ignition loss ...	55.55	55.75	$Fe_2O_3+Al_2O_3$	3.93	7.88
Polarization ...	41. 2	34. 8	CaO	6.13	26.20
Wax	0.44	1.44	MgO	traces	0.97
Pentosans	0.72	1.01	SO_3	4.57	14.28
Crude albumen .	1.32	1.93	P_2O_5	2.34	3.30

From the results of the analysis of the suspended matter in first and second sulphitation molasses it would further be concluded that the precipitation of SiO_2 and CaO tended to increase during the crystallization process. The percentage of organic lime salts also increased and the organic acid was probably aconitic acid.

Removal of suspended matter not only facilitates the boiling process, but also improves centrifugal efficiency, as was shown by a simple experiment.

Two portions of dry refined sugar were mixed with *(a)* an untreated final molasses; (b) with the same final molasses, from which, however, turbidities had been removed by separation. Next both artificial massecuites were centrifuged under similar conditions, resulting in sugars with polarizations of 85.5° and 91.0° respectively.

Summarizing, it was proved by the discussed investigation that the removal of suspended matter by centrifugal separation from first and second molasses resulted in a smoother boiling, in a more regular grain and in a better centrifugal efficiency. Whether or not these advantages are sufficiently important to warrant the installation of the rather expensive and rather powerful separators should be decided on the merits of each case. The separation of syrup appeared to be of low efficiency compared with the separation of second and first molasses, since proportionally large amounts of non-sugars are precipitated during the crystallization process.

Having demonstrated that there arc some advantages in changing the normal manufacturing sequence of clarification—concentration-crystallization into concentration—clarification—crystallization, or into clarification—concentration—second clarification—crystallization, we may also ask if it is necessary to keep the crystallization as the final process. The answer seems obvious: since we want a crystallized product, the crystallization process must be the last. But this answer does not cover the whole field. We all know that it is extremely difficult to manufacture, directly from mixed juice, a mill white sugar as pure as a refined sugar, even if such processes as ion exchange and decolorisation of syrup and molasses with vegetable carbon are applied. Because there exists a definite relationship between the purity of the material a sugar is crystallized from, and the purity of the resulting sucrose crystals, the considerable rise in purity of the mixed juice required to boil a sugar of refined purity is difficult to realise.

Our questions can therefore be better asked in this form: "Is it practically possible to raise the purity of mixed juice in a single clarification operation to the required value?" Up to the present the answer is in the negative. To obtain sufficiently pure solutions we must resort to a different sequence of our manufacturing processes by the introduction of a second crystallization. The manufacturing sequence therefore becomes: clarification - concentration —, crystallization — remelting — second clarification — second crystallization.

To obtain the sucrose solutions of the required purity we have to apply the principle of purification by recrystallization—a principle well known in the chemical industry. But we also see this second clarification applied at high densities, which method we have seen to give superior results. In fact, the refining industry employed high density clarification before it was applied in mill white manufacture. The combination of two clarifications gives rise to the following question: "Should the first clarification be made as thorough as possible, or should more stress be laid upon the second one?"

Although it is not possible to answer this question in a few words, we may conclude from the excellent results of high density clarification that the second method is likely to be more economical. This view is confirmed by the following practical results. If we compare

(a) a process in which mixed juice is clarified by double carbonatation and the resulting white sugar is refined by remelting without any purification of the melt, with

(b) a process in which mixed juice is clarified by the ordinary defecation process without SO_2 or CO_2 and the resulting raw sugar is refined, the melt, however, now to be clarified by the carbonatation process,

we find that the quality of the refined sugars is about the same, but in the first case about 30 per mille limestone on cane is required, and in the second case only 10 to 12 per mille.

The aim of the above is to demonstrate that the usual sequence, clarification — concentration — crystallization, can be modified in many ways. Each separate case brings the introduction of new principles which, correctly understood and applied, should result in valuable technical and economical improvements. A preliminary investigation, however, should yield the data required on which to base the technical application.

Next, I come to the introduction of a pure technological principle in the sugar industry. I mean the principle that continuous processes should be preferred to batch-type processes, because continuously conducted processes allow a better and more consistent adjustment of variables such as temperature, pressure, vacuum, reaction, velocity, etc. and therefore lead to better results. Moreover, the apparatuses for this kind of processes are often smaller, require less floor space and are apt to save labour.

One of the best-conducted continuous processes in a sugar mill is the continuous subsider, which has almost completely superseded the old square settling tanks. The advantages are well known and do not need to be discussed here in detail, and we should turn our attention to the results of processes which are less satisfactory.

The characteristic of a continuous process should be the consistency of the properties of the material leaving the process, but this is not all that is required. The filtrate from our rotary filters, for example, is consistently turbid, this being no reason to call these filters entirely satisfactory! In many cases, however, the consistency of the properties of the effluents leaves much to be desired. There is an explanation for this shortcoming. It is often difficult to say which are the optimal characteristics of a process, and often we do not know exactly what are the effects of deviations from these optimal values, and it is tempting to assume that they are negligible. Mr. Laubscher, in his lecture, gives the variations of the pH of the juice leaving the sulphur towers of three factories. They are enormous, and, although it is at the moment difficult to say what is the actual influence of these variations on the manufacturing results, we know that this influence must be adverse. Attempts should therefore be made to improve the regulation of the action of the sulphur tower and, if these attempts fail, it is better to have the towers replaced by a properly constructed continuous sulphitation tank or other suitable apparatus.

Although not a continuous process in the proper sense, there is another operation in our mills which has been proved to give better results by maintaining constant external conditions, i.e. the boiling process. In many factories the boilings have to be made under widely fluctuating conditions of temperature, vacuum, and steam pressure. It is true that an experienced pan man may get results which are fairly satisfactory, but when they are compared with results from pans for which all variables are kept controlled, a considerable difference in steam consumption, quality of the grain and crystal yield is shown. It certainly is Webre's merit to have repeatedly pointed out the advantages of consistency of the variables of the boiling process. The same applies to the evaporators. How is it possible to get a syrup of consistent density when the steam pressure fluctuates, as it often does, and how can we expect a pan man to get maximal results when his syrup density varies from 40° to 60°?

One of the best-studied and specified clarification processes is the de Haan carbonatation process, for which is required a temperature not exceeding 130°F., an alkalinity during carbonatation not exceeding 800 rngrms. CaO per litre and a final alkalinity of 400 rngrms.

Originally this process was conducted as a batch process and controlled with Dupont paper. Depending on the construction of the intermittent tanks, the circulation was sometimes insufficient, resulting in local excessive alkalinities. Especially the application of perforated baffles, with the aim of improving the absorption of the gas, often prevented adequate circulation. The introduction of continuous carbonatators allowed the process completely to comply with the above-mentioned specifications of alkalinity.

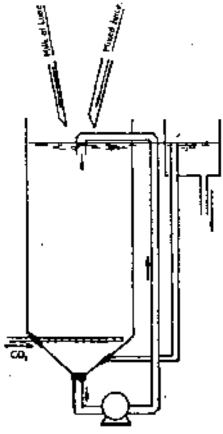


Fig. 1.

The first type of continuous carbonatator, as sketched in Fig. 1, was provided with an external circulation pump. The purpose of the circulation is to prevent excessive alkalinity. If the proper volume of milk of lime is added to the mixed juice in the required proportion (100 gals. of 15° Be per 1,000 gals. of mixed juice), the alkalinity is very high, i.e. about 14,000 mgrms. of CaO per litre. To reduce this high alkalinity to the required value of 800 mgrms., an excess of circulation juice, the alkalinity of which is kept at 400 mgrms. of CaO, is simultaneously added to the mixed juice. The required proportion of circulation juice to mixed juice (33 : 1) can easily be calculated from the given alkalinity values and is adjusted by the regulation of the flow of circulation juice. The alkalinity of this circulation juice, which is also the alkalinity of the juice leaving the tank, is regulated by the gas valve.

From the required proportion of 33 : 1 it appears that the circulation pump should be of considerable capacity. This was the reason that the construction of a more simple apparatus was attempted, leading to the examination of the properties of a second type of tank, provided with an internal circulation

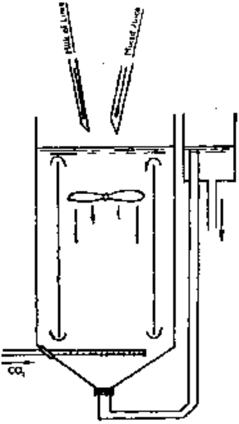


Fig. 2.

device (Fig. 2). This circulation device consisted of an internal concentrical cylinder through which the juice was forced downwards by a big propeller. Both the first and second type of tank were, in respect of the gas which had to be adsorbed, of the counterflow type. Precautions had therefore to be taken that the speed of the downward juice did not exceed the normal speed with which the gas-bubbles tend to rise. This second type of continuous tank has, for several reasons, not been found satisfactory.

In the third type the counterflow type of gas adsorption was abandoned and the parallel flow type was introduced. Simultaneously the energy of the rising gas bubbles was used to promote the circulatipn of the liquid. To ensure an adequate speed of circulation, a preliminary investigation had shown the most advantageous shape of the concentric cylinder (Fig. 3), the use of which made the circulation pump superfluous. This simple type of continuous carbonatator proved to be entirely satisfactory. It can be applied in the sulphitation process and in the carbonatation and sulphitation of remelted sugar solutions too. The speed of circulation is regulated by the height of the juice level above the circulation cylinder, which also can be adjusted to various heights. It is, however, not my intention to

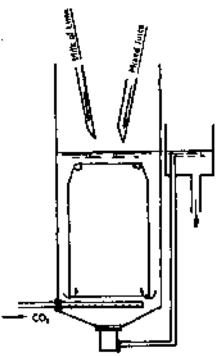


Fig. 3.

discuss these apparatuses in detail; my purpose was to give you an example of a process the chemical requirements of which have been accurately specified and to show how it is possible, by using a simple continuous apparatus, to comply with these specifications.

References.

[1] Netherlands Patent 61916.
[2] Mededeelingen Proefstation voor de Java Suikerindustrie 1933, p. 33.
[3] Unpublished report.
[4] Honig and Alewijn, I.e.

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The PRESIDENT said the paper pointed to some intriguing possibilities, such as that of dispensing with mechanical apparatus for mixing chemicals with the juice. The author stated that the colour of the sugar produced in the early mid-sap carbonatation experiments was disappointing. One could expect this as the juice had been in contact with lime when hot, and the resulting decomposition of reducing sugars would lead to the formation of dark coloured products.

Dr. DOUWES-DEKKER, replying to questions asked by Mr. Phipson, Mr. Carter and Mr. du Toit, stated that in the mid-sap carbonatation process, as actually applied in one of the Javan mills, a preclarification of the mixed juice by the normal defecation process was effected, and the clarified juice of the settling tanks was concentrated in the first three vessels of the quadruple before being submitted to double carbonatation. Cooling of the juice from the third vessel to 55°C. was necessary, and the final concentration from about 45° to at least 60° Brix was done in the fourth vessel. The mud from the settling tanks of the defecation process was returned to the bagasse blanket of the mills; pH during the first step of the concentration process was somewhat above 7. The boiling house recovery of this mill was 93.7 per cent., comparable with 93.6 for the average Java carbonatation mill in the same year. For details about the removal of non-sugars, Dr. Honig's article in *Sugar*, September, 1950, should be consulted.

Mr. GALBRAITH, referring to continuous sulphitation tanks, was reminded of the sulphuring tanks used in this country before sulphur towers became common. These tanks were very inefficient, and he asked what type of apparatus Dr. DOUWES-DEKKER considered would advantageously replace the present tower.

Dr. DOUWES-DEKKER said that if he had to advise upon the most suitable continuous sulphitation tank, it would be as illustrated in fig. 3 of the paper.

But it should be appreciated that results of even the best sulphitation tank are unsatisfactory if control on pH and temperature is insufficient.

Mr. PHIPSON asked if an acid syrup of 5.3 pH and 60° brix were produced, would this not lead to a high loss of sucrose through inversion?

Dr. DOUWES-DEKKER did not think this loss would be important. In Java it was customary to sulphite syrup to a pH of even at times as low as 5. The temperature of the syrup was of course not very high, and it was kept in the tanks as short a time as possible. As soon as the syrup entered the vacuum pan, the pH started to rise, due to the loss of sulphur dioxide, so that on the whole loss of sucrose through inversion was negligible.

Replying to a question by Mr. McKenna, he said that in the case of mid-sap clarification there was no special screening of the juice.

Mr. RAULT said that many of the points raised in the paper had been the concern of the technical staff of the only factory that used the carbonatation process in South Africa, especially a reduction in the high consumption of limestone and also of the unduly high elimination of glucose already present in rather small quantities in South African cane juice. With this object in view, the following steps were taken at some time or other in the course of the last 30 years:—

De Haan's modification of carbonatation (simultaneous liming and gassing at low alkalinity).

Higher temperature carbonatation than that tolerated elsewhere for cane juices, in order to improve filtration rates and cut down chemicals.

Introduction of non-Uba variety canes—supposed to be less refractory.

Action of residual muds left in CO_2 tanks (nucleus for easier filtered precipitate).

Improved design of CO_2 tanks and better distribution of gas.

Extensive studies on the factors influencing the settling and filtration rates of juices.

Different methods of lime addition and end points in carbonatation.

Sharpter scientific control by instruments as well as numerous physical and chemical tests.

Continuous carbonatation methods.

Pre-liming, progressive liming, and the like.

These lines of investigation, successful in divers ways, were not very fruitful in lime economy, as other factors of equal economic importance were militating against them. These were the discarding of the plate and frame pressure filters in favour of continuous automatic labour-saving systems, which demanded juices of high filtrability and settling rates, and also the aim at a higher elimination of non-sugars for improved quality product and recovery.

In common with South African technologists, he had found that our juices would not respond to the mild treatment given to tropical juices. Every attempt at simple defecation had failed and mill whites as good as those of Java could not be obtained with juices treated with only 1 gram of SO_2 per litre and its lime equivalent. In the carbonatation process in Natal, even a 4 per cent, limestone on cane could never keep a factory going, and still less a 2.5 per cent. of limestone as in Java with the de Haan's modification. Raw juice heaters are quickly fouled after a few hours of work, and it is difficult to imagine a factory owner bold enough to run his evaporator a muddy juice with an additional amount of incrustating material in the way of lime without previous subsidation, as described in the paper.

The Milling Research Institute will have done a great service to the industry if, in the near future, our factories are able to equal Javan practice where evaporators can keep running for three weeks without requiring cleaning operations.

Regarding the advantages of continuous liming and carbonatation in one tank and its claim of constant pH reaction during gassing with beneficial effect on glucose destruction, he had visited many beet factories in the U.S.A. and always found a workman controlling, by an alkalinity test every minute or so, the end point of the overflowing juice. In spite of the claims made there of uniformity of reaction due to free circulation, he had found, in the same tank, large fluctuations in the alkalinity of juices from different levels of the juice—e.g. 600 mg. to 900 mg. CaO per litre. He was, accordingly, very interested in the design of the continuous carbonatation tank shown in No. 3 sketch, especially if circulation did not deter high efficiency of gas absorption, which, for want of a better system, had up to now been successfully realised by a series of perforated baffle-plates in the path of the gas.

The PRESIDENT remarked that Mr. Rault had called attention again to the difference between cane juice in this country and that of tropical countries. In tropical countries juice could be efficiently clarified by the use of lime and with little or no sulphitation. That was not possible here, and the nature of the difference was a problem that the Experiment Station had long wanted to investigate by detailed analysis of juice from different varieties grown in this country.

He noted that the author apparently did not have a very favourable opinion of the Bach process. He had recently visited a factory in Portuguese East Africa that was using that process, and the operators expressed themselves as very pleased with it.

Mr. RAULT said the Bach process had been tried in Natal, but had to be abandoned as not being suitable.

Dr. DOUWES-DEKKER assured Mr. Rault that he was aware of the difference in the properties of Natal juices as compared with those of tropical countries like Java. He was not prepared to call this difference a fundamental one, but thought it rather a difference in degree. Certain juices are easy to clarify, others are difficult, and this was a problem his Institute would make a point of studying. While the results he had given were those from Javan factories, and he was aware that exactly the same methods could not be applied in Natal, he thought the results obtained in Java would be of use to indicate the lines upon which research might be carried out here.

Mr. Rault had stated that unless large amounts of lime were used, he found carbonatation juices difficult to filter. It should be remembered that in Natal the Mauss vacuum filter was used with a pressure difference of only about 10 lbs, per square inch, whereas in Java filter-presses, with a pressure of 40 lbs. per square inch, rendered filtration much easier.

The Bach process was used in Java with good results, but when certain factories stopped using this process and clarified with the ordinary sulphitation process, with careful control of the pH of the juice, they obtained just as good results with the simple process as they had with the sulphitation process plus the Bach process.

Mr. WALSH thought the paper had introduced some new ideas to the local industry. With regard to centrifugal separation of precipitates from juices and other liquors, he recalled that much work had been done in the past in Natal on this problem. A great difficulty lay in the cost of the machinery and its limited capacity.

Continuous subsiders, with their considerable saving in labour costs, would be hard to compete against, but he had not the slightest doubt centrifugal separation would come. With the mid-sap process for instance, the capacity of the separator would be very much higher because the juice was concentrated. Much remained to be learnt, however, before centrifugal separators could be successfully applied.

Dr. DOUWES-DEKKER agreed that we had not yet sufficient information. One difficulty was the cost and the amount of power required, but he understood that some experiments had been carried out last season with centrifugal separation of syrup.

SOME NOTES ON THE FUNCTIONING OF SULPHUR TOWERS

By P. J. LAUBSCHER.

The tendency in industry is to replace batch processing of materials by continuous processing, because the continuous processes have many advantages over the former. In any process it is always our aim to keep within narrow limits to the optimum conditions that have been determined for the process. This is especially true for the juice clarification process in the sugar industry, where only small deviations from the optimum pH values and temperatures can be allowed.

The sulphur tower is used for the continuous sulphuring of limed mixed juice, and the object of the present investigation was to find out what variations from the optimum pH we get in juices sulphured by them. In the second place, the efficiency of the sulphur dioxide absorption was determined by analysis of the gas entering and leaving the tower. The tests done were simple and they were done only at three factories, but it is believed that they served the purpose of the investigation. The effect of variations in the pH of juice sulphured by the tower upon the clarification process was not investigated.

Design and Operation of the Sulphur Towers.

All three sulphur towers worked on were more or less similarly constructed. Their dimensions are given in Table 1. The towers are square and the walls are made of wood. Inside, they have a system of trays through which the juice falls. These consist of parallel, horizontal-running, wooden bars or boiler tubes. The tubes or bars of consecutive trays run in perpendicular directions. On top of the towers are chimneys through which the exhausted gas is blown by a steam or air injector.

Limed mixed juice enters at the top of the tower just below the injector and falls on a device which spreads it. The gas enters at the bottom through a slit, 1 inch to 2 inches wide and in length 1 foot shorter than the width of the tower, in the bottom of the 8-inch pipe bringing in the gas from the sulphur burner.

The sources of SO_a are rotary sulphur burners from which the gases pass to a combustion chamber for the completion of the combustion. For cooling, the gas pipes pass through water, but at one factory the gas was cooled by passing for a fairly long distance through air. In the factory B (see Table 1), the gases also pass through a scrubber to remove any sublimed sulphur.

TABLE 1.

	Factory A (2 towers)	Factory B	Factory C
Height of	45'	: 25'	40'
Width of	4'6"	4'	3'6"
Dimensions of chimney	4' 9' x 9* x 7*		
Injector	¥ steam pipe	3J* air pipe	1* steam pipe
Trays— lower half .	2* tubes 1* apart		2" tubes j* apart*
top half ...	2* tubes 1* apart	~	2* wooden rods 2" apart
Distance between trays	2'	2'	3'
Dimensions of burner	12'6* x 1'8*	8' x 1' 8*	6' 6* x 2'
Dimensions of combustion chamber ...	3' 6* x 3' 6* x 8'	4' x 4' x 3' 9*	4'x4'x9'
Cooling	9' water	5' water	air
Tons mixed juice handled per hour ...	**117**	**56**	100

Note: Factory B uses an air injector just below the neck of a Venturi tube of 5 inches minimum diameter.

At Factory A the sulphur burner is hand-fed and at such a rate that ±250 lbs. of sulphur is burnt per hour, the operator judging the time for feeding from the flame he sees through a slit between the furnace and the combustion chamber. The lime in mixed juice is so regulated that the pH at which the sulphured juice comes out is ±7.3. Indicator paper is used for this purpose; the checking of the pH and the adjusting of the lime valve is done more or less once in 10 minutes.

At Factory B, sulphur is fed mechanically and continuously to the burner. The lime added is so regulated that the juice, after sulphuring, has a pH of 7.6 to 8. This test is done more or less once every five minutes, with a suitable indicator.

The practice at factory C is to lime to 11 pH, which is done with the help of a Beckman pH meter. The burner is hand-fed and the sulphuring is regulated by adjusting the steam flow through the injector when necessary. The pH aimed at in this factory is 5.9.

From the sulphur towers the juice flows into tempering tanks, where phosphoric acid is added, usually to give a P_a0_4 content of 300 mg. per litre, and the pH is then tempered with lime to 7.3 to 7.6; the juice is then settled and filtered, after which the pH is 7.0.

Experimental.

The mills' test laboratories do pH determinations on hourly composite samples of sulphured juice and, as these showed only small variations, the determination was not repeated. pH determinations were done on samples of sulphured juice obtained from the trough bringing the sulphured juice to the tempering tanks; such samples were collected at intervals of 5 and 1 minutes. The determinations were also done on samples collected from each tempering tank when filled up before any phosphoric acid or lime was added. For the determination of the pH of the cooled samples a Beckman pH meter was used.

. The apparatus for the determination of the $S0_2$ content of the gas entering and leaving the tower was a flask of 1 litre ± capacity fitted with a rubber stopper through which pass the stem of a dropping funnel reaching to the bottom of the flask, and a short glass tube connected with a rubber tube to a rubber bulb pump which draws the gas sample.

With the tap of the dropping funnel open, gas is pumped through the flask till all air is displaced; then the tap of the dropping funnel is closed. More gas is then pumped into the flask to get the gas at a pressure well above atmospheric when the connecting rubber tube is shut with a pinch cock. After cooling to room temperature, the excess gas is allowed to escape slowly, leaving the flask filled with gas at room temperature and at atmospheric pressure.

A known volume of a standardised N/10 iodine solution is now washed into the flask through the dropping funnel and shaken up with the gas. After making sure that all the $S0_2$ has reacted with iodine, the excess iodine is titrated against a standard N/10 sodium thiosulphate.

For the gas entering the tower this method was found very satisfactory, but for the gas leaving the tower it was less suitable, because gas after passing through the juice is saturated with water vapour at a high temperature which condenses in the flask, and, due to the high solubility of SO_a in water, one can expect that the determined $S0_2$ by this method for the gas leaving is high. It was found, however, that the $S0_2$ content of the gas leaving was so low that a great error in this determination does not seriously affect the resulting calculated efficiency.

$_x$The efficiency of the tower can be calculated from the $S0_2$ percentages in the gas entering and leaving the tower by making use of the formula:—

$$\text{Per cent, efficiency} == 100\frac{(100p_x - 100p_2)}{Pi\ (100 - p_2)}$$

where p_x = percentage pressure due to $S0_2$ in gap entering tower, p_2 = percentage pressure due to $S0_2$ in gas leaving tower.

Seeing that this test on the efficiency runs only for a few minutes, it does not take into account sulphur lost through stoppages and mechanical losses.

Results.

Figure 1 is a graphic representation of the pH values of the juice versus time at the factories A, B and C. For A and B, samples were collected every five minutes and for the curves d samples were collected every one minute. C_2 are the pH's of samples collected from each tempering tank when filled up. (The time required for a tank to fill up was from 6 to 7 minutes).

Table 2 below gives the results of the efficiency determinations on the towers:—

TABLE 2.

Factory.	Per cent. $S0_2$ in gas entering.	Per cent. SO„ in gas leaving.-	Efficiency per cent.
A ...	6.88	0.23	96.8
A ...	6.53	0.73	89.4
B	11.12	0.03	99.77
B	12.97	0.02	99.87
B	12.62	0.02	99.86
C	10.7)	0.01)	
	7.88 L	0.01 j	99.9
	7.2 }		

Discussion of **Results.**

The fluctuations in the pH of the juice from the sulphur tower, from whatever pH is aimed at, is rather high and undesirable for good work. Fluctuations in the pH of the sulphured juice can be due to one of the following causes:—

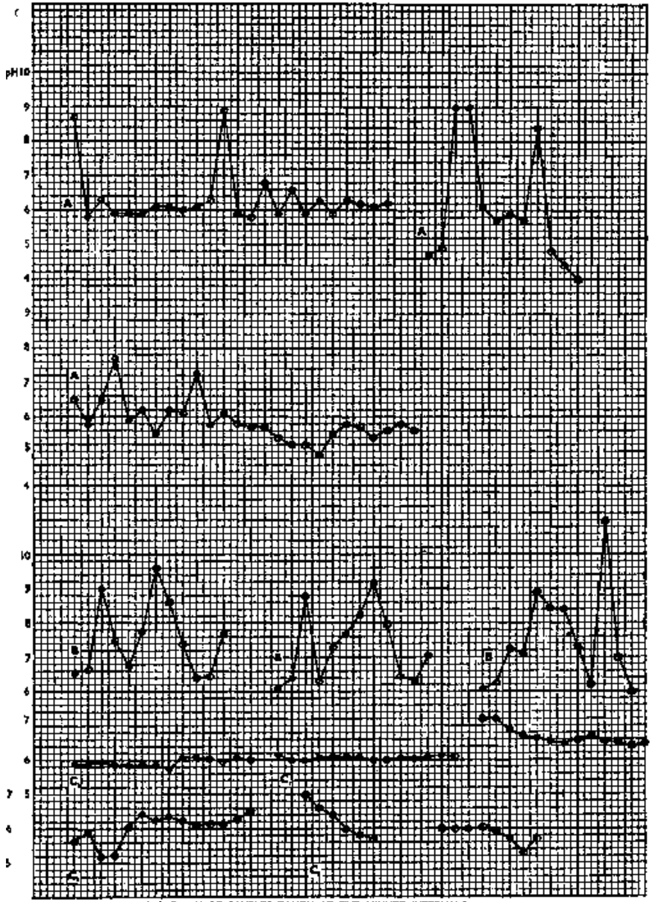
(1) Changes in the rate of flow of *(a)* juice or *(b)* gas through the tower.

(2) Variations in the $S0_2$ content of the gas entering the tower caused either by 1 *{b)* or irregular feeding of sulphur to the furnace.

(3) Variations in the lime content of the juice going to the tower.

(4) Variations in the properties of the juice. Semi-quantitative experiments by Mr. Dymond showed up to 100 per cent, variations in the amount of lime required to produce the same pH rise in equal quantities of juice.

It is interesting to note that for the curves C_3 (samples taken from successive tempering tanks) we get greater variations than for Cj (one-minute samples).



A ft B pH OF SAMPLES TAKEN AT FIVE MINUTE INTERVALS
C, pH OF SAMPLES TAKEN AT ONE MINUTE INTERVALS
C, pHOF SAMPLES TAKEN FROM SUCCESSIVE TEMPERING TANKS

The large excess of air in the sulphur dioxide air mixture seems undesirable, because excess oxygen favours sulphur trioxide formation and the thorough contact of the hot juice with oxygen may be harmful to the juice.

Summary.

The variations in pH of juices sulphured by the sulphur towers at three factories were determined.

The efficiencies of the sulphur towers were determined by analysis of gas entering and leaving the towers.

Sugar Milling Research Institute,
Howard College,
Durban.
February, 1950.

The PRESIDENT said that the subject dealt with was very important in all sugar growing countries, but particularly in South Africa, where it seemed impossible to make even raw sugar without the use of sulphur dioxide.

Mr. DUCHENNE noted that the author had recorded an efficiency of 99.9 for factory C. This was Umfolosi, where he was process manager. He considered the actual efficiency much less than 99, for he had found the overall absorption to be about 75 per cent. by measuring the sulphites in the juice before entering, and after leaving, the sulphur tower and the sulphur dioxide produced. It was necessary to measure the sulphites in the juice entering the tower for those factories which had Oliver-Campbell filters and which returned the filtrate to the raw juice.

Mr. ELYSEE referred to the author's remarks about a large excess of air in the gas entering the tower being undesirable, because of the excess oxygen favouring sulphur trioxide formation. With the rotary furnaces now in use with secondary and even more combustion chambers, a large amount of heat was evolved which might well give too high a temperature, thus leading to dissociation of the sulphur dioxide with subsequent formation of sulphur trioxide. He had found that after working for a while, more and more sulphur was required to reach a certain sulphur dioxide content in the juice.

Furthermore, he had had to abandon water-cooling of the pipes conveying the hot gas, as any attempt to cool them led to rapid corrosion, and having to replace a corroded pipe was very inconvenient in mid-season. His experience was that when the pipes corroded and water entered, the factory recovery was lowered by about 2 per cent. This had occurred about four times. A loss of 2 per cent. in recovery in a factory was very serious, and unfortunately when this loss was determined it was too late to change a pipe and it had to remain until the following week-end. This meant the loss in recovery continued for another week.

Mr. CHIAZZARI said that there was no mention in the paper of the temperature of the juice entering the tower. He was of the opinion that the absorption of sulphur dioxide was affected by the temperature of the juice.

Mr. LAUBSCHER regretted that he had not recorded the juice temperatures, but in any case he did not think that a variation in this of ten degrees would have a noticeable effect on efficiency.

Mr. DYMOND thought that the possibility of using liquid sulphur dioxide should be further explored, for it had many advantages. Enquiries he had made had resulted in his calculating that the cost of using the liquid gas would be approximately the same as the cost of the sulphur and the burning of it.

Dr. DOUWES-DEKKER said he had discussed the question of liquid sulphur dioxide with the manufacturers, and had come to the conclusion that the cost would be much higher, and that at the moment it was not possible to consider using liquid sulphur dioxide.

He wished to ask Mr. Elysee what kind of pipes he employed, and if it were not usual in Natal to use lead pipes.

Mr. ELYSEE replied that his experience had shewn him that the excessive heat produced with his sulphur-burning plant would melt lead pipes.

The pipes he had used were of cast-iron, 8 inches in diameter, the vertical ones being 25 feet long, and the horizontal ones 20 feet. Both were water-jacketed.

The horizontal pipe corroded first and he event-abandoned the use of a pipe in this position and used a brick conduit instead.

Dr. DOUWES-DEKKER drew attention to the fluctuation shown in the graphs. In the first curve, where the average was about 6.5 pH, the variation was from 9 pH to 4 pH. This seemed rather unsatisfactory, and he thought the best way of pH control should be thoroughly studied.

Mr. DUCHENNE agreed that this was most important. During the last three years he had been experimenting with, and applying a pre-liming pH of above 10.0, using a pH recorder. This pH had caused a greater reduction of impurities and colouring matter. He hoped to put in a "Foxboro" automatic pH meter, recorder and controller to control also the pH of the juice leaving the sulphur tower this season.

In reply to a question by Dr. Douwes-Dekker, he stated that at his factory new sulphiting apparatus had been installed, but the machine had to be used in connection with a sulphur dioxide cooler. As the latter was still in the experimental stage, he could not give any figures as to the efficiency of the machine. This apparatus was of the "Quarez" type, and had a six-jet injector set over a tailpipe 25 feet high. He hoped to lose less sulphur dioxide with this device.

Mr. RAULT considered figures of over 99 per cent, efficiency for a sulphur tower to be rather high, and in view of the difficulty of testing waste gases he thought testing the juice for sulphur dioxide to be a more practical method. For a factory where the sulphur tower was only 25 feet high the efficiency seemed very high, as this would seem to indicate that a tower 40 or 50 feet high was unnecessary.

As far as the variation in pH of juice coming out of the sulphur tower was concerned, it should be remembered that this was not a final stage of chemical treatment of juice. This was always brought to the desired end-point by lime and phosphoric acid. There is no evidence that liming first and sulphuring after produces very different results from sulphuring first and liming after, when the final point and the total quantity of lime used is the same.

Dr. DOUWES-DEKKER considered that it should be our aim to adhere strictly to detail in any method of juice clarification. He did not think it was enough for only the end-point to be correct. The carbonatation process was one of the best-studied processes, and we knew exactly the required temperature and pH limits during the juice treatment.

Mr. PHIPSON said it was practically impossible to measure sulphur tower efficiency in a factory where the Oliver-Campbell filtrate was returned to the preliming tank, unless the weight of the filtrate was accurately known.

As far as juice temperatures were concerned, he related that during the last season he had found that there was a drop in purity from mixed juice to syrup in the early stages of the season. At that time the raw juice was heated to 140°F. When the temperature was reduced to 130°F., the purity of the syrup was increased to as high as one degree above that of the mixed juice.

Mr. DUCHENNE was glad to note that so many factories in South Africa were paying attention to the pH of the primary liming. This was not done in the past. At Umfolozi they were pioneers in this work. Many colloids and other impurities were precipitated during the primary liming, but he was of the opinion that much of that good work was nullified by the subsequent neutralisation.

He was glad to see that the efficiency of the sulphur tower, as used here, was so high. The overall efficiency could not be measured by the tower, however. What also counted was the sulphur dioxide in the juice compared with the amount of sulphur burned, and he considered that, to determine the efficiency, testing of the juices for sulphites was a good method. By this method he had found the overall efficiency to be about 75 per cent.

Mr. RAULT thought that the Natal Estates towers gave an efficiency of about 90 per cent.

Mr. ELYSEE wondered if one got greater efficiency from a longer tower than from a shorter one. The shorter tower certainly gave more flexibility. At Amatikulu the concentration of the gas could be regulated and he had noticed that incrustations in the tower depended upon the concentration of the gas.

He did not return filtrate through the tower, and thus the efficiency of the latter could be easily calculated.

The PRESIDENT enquired if the author had any analytical figures to illustrate the amount of sulphur trioxide formed during the burning of the sulphur.

Mr. LAUBSCHER replied that he did not have such figures, but since the reaction $2\ SO_2 + O_2 \rightleftharpoons 2\ SO_3$ is exothermic when going from left to right, low temperatures favour the formation of sulphur trioxide. It is also clear from the above reaction that a high oxygen content of the gas mixture favours sulphur trioxide formation.

Mr. DYMOND considered that work should be done to determine the conditions under which nodules of calcium sulphite were formed, as compared with those under which crystals were formed.

Mr. CARTER asked what the final effect of cooling the gas was. He had found that at times he could not get any juice to clarify satisfactorily, and had resorted to sulphuring first and liming afterwards. He would revert again to the usual process but might have to change the pH. Certain juices caused great difficulty and he did not find that the standard process would work equally well with all juices.

Mr. ELYSEE stated that when he cooled the sulphur dioxide gas he could easily control the sulphur dioxide content of the sugar to below 70 parts per million. Without cooling he could not do that.

The PRESIDENT said it was noticeable that recently some factories tended to have a sulphur dioxide content of sugar above the standard laid down some years ago. The question of this sulphur dioxide content might rise again and we should be prepared to meet it.

• Mr. DUCHENNE enquired why it was that sugar was allowed the very low sulphur dioxide content of

70 parts per million, while dried fruits could be exported with 3,000 to 6,000 parts per million.

The PRESIDENT thought that the sugar industry was placed under a severe handicap as far as the sulphur dioxide content of its main product was concerned. In some foodstuffs it was not used in the manufacturing process but was added as a preservative. Naturally, if the sulphur dioxide content was found to be high, suspicion was cast on the quality of the original material. That was not the position as regards sugar, where sulphur dioxide was merely a residue of manufacture and not added subsequently, but it was doubtful if the authorities always realised that fact.

OLIVER-CAMPBELL BAGACILLO

By L. F. CHIAZZARI.

It cannot be denied that the standard of sucrose recovery in the Natal industry has now attained a position of high efficiency; and, to effect a further improvement, the manufacturing superintendent must look very far afield. Indeed, the search for improvement is becoming one for the specialist, and means delving into the minutest details.

Purity.

The subject of sucrose recovery can be reduced, broadly, to. terms of purity. A high initial purity in the raw material with a low purity in final molasses is the ideaL To accomplish this, the clarification station must remove impurities and increase the initial purity, and thus afford a better working product right through the process, with the attendant lower quantity and purity of final molasses. The necessity of eliminating existing impurities and avoiding the introduction of new ones cannot be overstressed. This may well be condensed to give us the axiom:—"Watch the non-sugars and the sugars look after themselves."

The Oliver-Campbell Filter.

The Oliver-Campbell filter has been an important adjunct to the Natal industry for some fifteen years and has caused more discussion than any other innovation of recent date. It must be agreed that it is a great boon to us in many ways, and probably none of us would care to resort to the old plate and frame presses: but, it must be admitted, it has certain shortcomings. It has been referred to as a poor type of strainer which should really be operated with a pre-coating of some filter aid, that the scum should be thickened before filtering, that the filtrates should be further separately defecated, and sundry other points. There is one aspect, however, that may have been realised but has never received much attention; that is, the introduction of impurities to the process by the bagacillo filter medium generally used.

The average composition of dry bagasse is:—

Cellulose	40 to 45 per cent.
Pentosans	25 to 30 per cent.
Lignin	22 to 27 per cent.
Ash	2 to 3 per cent.

and, to quote from C. A. Browne, we find:—"By the treatment of plant membranes with hot solutions of dilute alkalies and acids the lignin, pentosans and other so-called 'encrusting substances' are split off from the complex, leaving the cellulose behind as an insoluble residue." Hence it would appear to be a distinct possibility that part of the bagacillo, in its normal use in the Oliver-Campbell filter, would dissolve and introduce additional impurities in the filtrate. It also seems desirable to increase the effectiveness of the bagacillo by having it as an aid rather than just a filtering medium.

Bagacillo Treatment.

With these objects in view, the following tests were carried out at Gledhow. The bagacillo was digested in an abundance of water for fifteen minutes, with a small addition of lime to a pH of about 9.0, the extract roughly expressed by hand and then subjected to a further digestion with pure water. Finally, a thorough washing with cold water was given. From observations it would seem that the quality of the cane has a tremendous bearing on the quality of bagacillo. A study of this aspect once again reveals the importance of a good and clean cane supply.' Besides the impurities already mentioned, a surprising amount of grit and sand prevails and, when a process is designed to lixiviate the medium, this removal of sand must also be considered. In the thorough lixiviating and drying of bagacillo a good, fairly white, fluffy medium can be obtained, which, when puddled with water, has the appearance of a paper pulp. Paper pulp, as you are aware, is used in conjunction with Vallez filters fairly extensively overseas, in a patented process.

Laboratory Results.

Samples of scum were mixed with treated and untreated bagacillo in average factory proportions, filtered, and the filtrates analysed for purity and colour, with the following results:—

Untreated Bagacillo.				Treated Bagacillo.			
Bx.	Pol.	Pur.	Light Absorption.	Bx.	Pol.	Pur.	Light Absorption.
7.91	6.63	84.89	68	7.85	6.71	85.48	65
9.14	7.85	85.89	94	9.07	7.83	86.33	74
8.76	7.50	85.62	88	8.79	7.56	85.89	51
8.49	7.31	86.10	86	8.56	7.36	86.03	76
10.63	9.05	85.23	74	10.58	9.10	86.01	61
9.81	8.34	85.02	66	9.60	8.31	86.56	40
7.99	6.88	85.84	83	8.01	6.92	86.39	68
9.63	8.22	86.26	31	9.36	8.19	87.50	19
8.04	6.81	84.70	77	7.90	6.79	85.95	49
9.11	7.77	85.29	47	9.07	7.77	85.67	37
9.70	8.25	85.05	107	9.71	8.31	85.58	82
8.13	6.99	85.98	49	8.00	7.00	87.50	39
8.75	7.47	85.37	63	8.69	7.46	85.84	43
9.06	7.81	86.20	76	9.08	7.83	86.23	65
8.61	7.06	85.31	61	8.69	7.61	87.57	28
Av. 8.92	7.63	85.54	69.5	8.88	7.66	86.34	51.5

The above figures show a higher purity and greatly improved clarity of the filtrate resulting from the use of treated bagacillo as compared with that from the untreated material. The removal of colour and turbidity was very apparent and a clear, sparkling juice was frequently obtained.

Future Developments,

This short paper has been presented to the Conference with the idea of endeavouring to introduce the subject to others, in the hope that it will stimulate some interest and further experimenting. The newly-formed Natal Sugar Milling Research Institute has the facilities to carry the matter to finalisation; and then, if warranted, the engineers will find useful scope for their endeavours in effecting the best means of lixiviating.

A start in this connection was made last season, but unfortunately, owing to pressure of work, the mechanical staff could not complete the idea. Available space was also difficult. The intention was to take the evaporator sweet waters, mix them with the bagacillo and lime, bring to the boil in a juice heater, screen, maybe macerate again, and finally pass through a small mill or mangle to remove as much as possible of the extract. Experiments were also conducted to determine whether a centrifugal would suffice. The results were fair, but whether all impurities could be removed without a thorough pre-diffusing, and using the centrifugal just for drying, or effecting the extraction of impurities by heavy washing in the centrifugal itself, is a moot point; and unfortunately, in our case, this was not brought to a conclusion. There is no doubt, though, that the centrifugal offers possibilities. A disadvantage, however, is batch working and labour costs.

Conclusions.

It is most likely that impurities can be introduced into the factory process by way of the bagacillo used as a filtering medium in the Oliver-Campbell filter. Intensive lixiviation of this material in a hot alkaline medium is a promising method of improving it.

Experiments of a preliminary nature indicate that the effectiveness of bagacillo as a filter aid is also increased by the treatment described. The filtrate obtained when using such treated bagacillo shows a marked improvement in both purity and clarity, but further experimentation is needed to develop a satisfactory technique of carrying out the necessary lixiviation on a factory scale.

The PRESIDENT said that the paper, being a short, practical one, was particularly welcome. He had often wondered what changes might take place in the composition of juice during the milling process. What, for example, was the effect of exposure to the atmosphere and the bringing of juice repeatedly into intimate contact with the bagacillo ?

Mr. DYMOND thought the work described in the paper was long overdue. He enquired what amount of solids was extracted from bagacillo by hot lixiviation at 9 pH, pointing out that he had found 13 per cent. of non-sugars were removed by hot water at neutrality.

Mr. RAULT asked why the Brix was so low. He considered that the extraction of solids from untreated bagacillo would increase the Brix of the filtrate. Many factory operatives had strong views on the probable deleterious effects of bagacillo on juice clarification, but while it was considered likely that impurities, including some which might colour white sugar, were being forced into the clarified juice, not enough research had yet been done on the effects of such impurities.

Mr. CHIAZZARI replied to Mr. Dymond that he had not been able to carry the work to finality and had not measured the amount of solids extracted by the lixiviation process used.

In reply to Mr. Rault, he said that the low Brix figures were due to the secondary juice at Gledhow being more dilute than the ordinary clarified juice in other factories. The figures seemed to indicate that the difference in purity was due to a difference in Brix rather than in polarization.

The filtration was not easy to accomplish. Dilution, pH and temperature were all important factors. In some cases the pH had to be corrected during filtration, and he had used a dilute solution of sodium hydroxide for this purpose.

The measurement of colour is attended by a certain amount of difficulty. He used a colorimeter of the photo-electric cell type, and although it is a good instrument he thought that all that could be hoped for was comparative figures.

Dr. DOUWES-DEKKER considered that the work done was a fine example of the kind of test which could be carried out in factory laboratories and more of this type should be done. He wished to know the amount of bagacillo used per unit of juice at Gledhow, and how it compared with that used at other factories.

Mr. CHIAZZARI said that the local agent for the Oliver-Campbell filter had told him that 20 per cent, (dry weight) of bagacillo on juice was about the average figure for this country, but he thought that at Gledhow they used more. For these tests, however, he used this 20 per cent. figure.

Dr. DUCHENNE asked if at Gledhow the filtrates were returned to the raw juice. He had found considerable drops in purity between the Oliver-Campbell filtrate and the clear juice. This had the effect of lowering the purity of the raw juice in the tempering tanks, so that those factories which returned the filtrate to this point obtained a greater rise in purity between mixed juice and clarified juice during clarification than that recorded.

Mr. MORILLION enquired if the variety of cane from which the bagacillo was obtained were recorded.

Mr. DYMOND desired to know the moisture content of the bagacillo used. Dried bagacillo had a better filter-aid effect than had that which contained the normal amount of moisture.

Mr. CHIAZZARI explained that at Gledhow the filtrate was returned to the raw juice. He had not a record of the variety of cane from which the bagacillo was derived, but it varied considerably, and some was rather dirty. All the bagacillo used, both treated and untreated, was air-dry.

A PROGRESS REPORT ON SOME CLARIFICATION PROBLEMS OF NATAL CANE JUICES

By G. C. DYMOND

INTRODUCTION.

Twenty-five years ago a paper was presented at one of our original Sugar Weeks by the author, entitled "Notes on Some Problems of the Industry. Cane Wax and Colloids. Micro-Organisms and Fermentation."

This paper might be entitled Part II.

In the first paper the author said: "Uba has, as would other types of cane after long cultivation under adverse natural conditions, adapted itself to natural laws. The resistance of plants to drought is attained by a hardy growth; in the case of sugarcane by a hard rind, high percentage of fibre associated with shorter internodes and increased surface rind, waxes and gums." And "real advancement is not secured by the introduction of new processes with the object of, say, the greater exhaustion of our waste molasses, a problem the result possibly of bad practice in an earlier step in the manufacturing process, and which might not have existed, at least not in such an intense form, had initial conditions been first investigated." And "the first principle of raw juice treatment, independent of what subsequent process is used, is the elimination of the maximum amount of cush-cush and cane wax *before* any heat or chemical treatment is applied."

Those sentences still stand, despite the fact that the supposed cause of all our troubles, Uba, has almost gone and despite the anticipated benefits of our varietal revolution. New varieties have come and gone, others will replace the few in use to-day, each bringing with it new problems in milling, steam raising and clarification in the general problems of a mixed cane supply in Natal.

There is, in the author's opinion, no raw material in any industry so varied as the raw mixed cane juices of Natal. Our soils, climate, time between cutting and milling, extraneous matter—trash, tops, dirt, cane wax and colloids—still remain the bugbears of sugar manufacture in this country. The problems are variable, peculiar and intense, and for all these years we have not advanced beyond our general method of clarification—sulpho-defecation.

In the following paper the author has endeavoured to throw some further light on some of these problems of clarification and to indicate the steps that should be taken to lessen them.

PRELIMINARY COMPARISON OF PROCESSES.

With the co-operation of the Sugar Milling Research Institute a preliminary series of tests was carried out by P. Laubscher on four methods of clarification, namely, simple defecation, fractional liming and double heating (Davies, Duncan & Yearwood, Int. Sugar Journal, 1936, 298), standard sulphitation and acid sulphitation (Dymond). These experiments demonstrated the superior clarity of juices from the acid clarification process, but showed much higher sulphur dioxide contents. The investigation was primarily conducted to prove whether or not these relatively high sulphur dioxide figures were due to increased lime salts or not. The standard sulpho-defecation process was used as a means of comparison. The preliminary figures referred to were as follows:

	Turbidity		SO_2%
	Luximeter	Kopkc	solids
Simple defecation ...	49.8	42.0	—
Fractional liming and double heat	49.3	39.7	—
Standard sulphitation.	64.7	68.3	0.051
Acid sulphitation. ...	79.3	100+	0.174

Considering the poor showing of the first two methods, the investigation was confined to standard sulphitation and the acid method.

PRELIMINARY EXPERIMENTS. LIME SALTS.

In the foregoing figures the sulphur dioxide content of the acid clarified juices is over three times that found in standard sulphitation. If this in fact means a corresponding increase in lime salts, then the acid clarification process has a serious defect. The following investigation proves that in fact the converse is true.

Every sugar man versed in the complexities of clarification in Natal knows the variable absorption ratios of lime in the raw juice. A common saying is that a particular juice will or will not take lime. The following catch samples of juice illustrate this normal variation.

Initial pH arranged in ascending order	C.cs standard milk of lime required to bring 2 litres of juice to 7.3 pH
4.45	6.5
4.55	4.0
4.68	6.0
4.75	5.0
4.96	2.5
4.85	2.9
5.20	4.5

(Standard milk of lime used. 24° Brix containing 19.36% solids. 1 drop from 1 c.c. pipette = 1/21 c.c.)

Initial lime absorption is apparently either a function of the normal • ion concentration, or, in abnormal cases, the result of acidity, due to staleness of cane or actual fermentation in the juice. In the last case the quantity of lime required rises enormously. The staleness of our normal cane supply is probably unique in the sugar world, where freshness is considered an essential of marketability. Spencer Mead (page 80) states that "the pH of the juice from all ripe normal canes lies between 5.10 and 5.40." Very few samples of this order were obtained.

CALCIUM SULPHITE.

The formation and precipitation of calcium sulphite under various conditions were dealt with in an excellent paper by R. G. W. Farnell in the Journal of the Society of Chemical Industry, December 4th, 1925. In summarising he states that "the factors concerned in the precipitation of calcium sulphite are the extent of neutralisation of the sulphurous acid, the time and temperature for precipitation, the initial concentration of sulphurous acid and calcium hydroxide and the presence or absence of colloids."

His facts were based on pre-sulphitation and no comparisons were made with other processes, such as our standard sulpho-defecation. The following investigation endeavours to cover these comparisons, together with the part played by the addition of sodium carbonate to waters and juices.

1. EXPERIMENT WITH DISTILLED WATER.

To one-litre samples of distilled water increasing quantities of sodium carbonate were added. Sulphur dioxide gas was then passed to give a pH of 3.1. The solution was then limed to 7.1 pH, boiled and cooled. The results were: —

Initial pH	Gms. Na_2CO_3 added per litre	pH	Drops lime from 3.1 to 7.1 pH	SO_2 gms. per litre	Hardness	CaO parts per 100,000
6.4	Nil	6.4	14	0.05	3.7	8.5
6.4	0.2	10.2	24	0.17	5.0	11.5
6.4	0.4	10.4	41	0.12	4.6	6.9
6.4	0.8	10.6	77	0.23	2.8	2.5

Repeat Experiment.

Initial pH	Gms. Na_2CO_3 added per litre	pH	Drops lime from 3.1 to 7.1 pH	SO_2 gms. per litre	Hardness	CaO parts per 100,000
7.4	Nil	7.4	12	0.04	4.9	9.0
7.4	0.1	10.2	23	0.08	6.5	8.75
7.4	0.2	10.4	26	0.07	5.8	11.25
7.4	0.3	10.6	31	0.05	11.9	24.00
7.4	0.4	10.6	35	0.06	10.4	17.6
7.4	0.5	10.7	46	0.07	8.4	14.75
7.4	0.6	10.75	58	0.10	6.3	5.6

These results show that, in distilled water, the addition of increasing quantities of sodium carbonate causes an initial increase or curve in hardness and lime, which finally drops below the control. The crystal formation ranged from nil in No. 1 to plates and rosettes in Nos. 2, 3, 4., spherical clusters to a mixture of rosettes, clusters and spheres in Nos. 5, 6 and 7.

The same type of experiment was then conducted on river water, cloudy with colloidal matter after rain. The effects of colloids and salts were very marked, for, as Farnell states: "The presence of colloids retards the precipitation and alters the form of the precipitated calcium sulphite to spherical granules, the size of which increases with temperature, time, pH and initial concentration of sulphurous acid and calcium hydroxide."

2. EXPERIMENT WITH RIVER WATER.

The same treatment as in No. 1.

Initial pH	Gms. Na_2CO_3 added per litre	pH	Drops lime added from 3.1 to 7.1 pH	SO_2 gms. per litre	Hardness	CaO parts per 100,000
6.7	Nil	6.7	17	0.07	6.5	13.25
6.7	0.2	9.6	37	0.12	6.2	11.75

Repeat Experiment.

Initial pH	Gms. Na_2CO_3 added per litre	pH	Drops lime added from 3.1 to 7.1 pH	SO_2 gms. per litre	Hardness	CaO parts per 100,000
6.6	Nil	6.6	15	0.04	6.4	14.50
6.6	0.2	9.5	32	0.10	6.8	12.75
6.6	0.4	9.9	52	0.15	4.0	6.00
6.6	0.8	10.2	90	0.25	2.9	3.75

With river water the results show an increase in lime used, a steady increase in sulphites and a *decrease* in hardness and in lime salts. The colloidal matter present caused an increase in spherical clusters and spheres. In cane juice, as will be seen later, only spheres are found.

The chemical reactions involved appear to be as follows:—

$$Na_2CO_3 + H_2SO_3 = Ne_2SO_3 + H_2CO_3$$

$$Ca(OH)_2 + H_2CO_3 = CaCO_3 + H_2O$$

To what extent the weak salts of the alkali metals normally present in cane juices can be expected to react with sulphur dioxide in a similar manner is problematical. The calcium salts of oxalic, succinic, glycolic and malic, which are found in only small quantities (Yoder, Ind. Eng. Chem. 3,640) are generally soluble in water or sucrose solutions, whereas aconitic acid, which constitutes 80 to 90 per cent, of the non-volatile acids in the cane, may be at least partly precipitated as calcium aconitate during clarification (McCalip& Siebert, Ind. Eng. Chem., May, 1941., p. 637).

3. EXPERIMENTS WITH CANE JUICES, LIME SALTS.

A preliminary experiment, using standard quantities of phosphoric acid paste and increasing quantities of sodium carbonate gave the following results:—

Gms. phosphoric per litre of mixed juice	Gms. Na_2CO_3 per litre	C.cs lime added from 3.2 to 7.3 pH	SO_2 grams per litre	Hardness
0.4	Nil	5	0.38	23.4
0.4	0.8	8	0.40	16.0
0.4	1.6	10	0.42	9.8

With this indication of a reduction in lime salts, a complete series of experiments was carried out. All of these tests were done towards the end of the crop when the quality of the juices was low and clarification difficult. It is hoped that throughout next season a further series of experiments can be conducted, thereby demonstrating the considerable variations of cane juices within the cutting season and the methods necessary to combat them.

SERIES 4.

The object of this experiment was to determine the effect of adding sodium carbonate to the juice, with and without additional phosphoric paste. Also the effect of no additions of either in the acid clarification process—the results being compared with standard sulpho-defecation.

Six samples were treated in each series, the treatments being as follows:—

A. 0.4 grams of phosphoric acid paste per litre added to the cold mixed juice. Thereafter sulphited to 3.2 pH. The first precipitate removed and filtered. The supernatant liquid limed to 7.3 pH, then raised to the boiling point and allowed to settle. The first precipitate, the second, and part of the clarified juice were retained for detailed analysis.

B. The same as A, with the addition, after adding phosphoric, of 0.3 grams per litre of sodium carbonate.

C. The same, but with no addition of either phosphoric paste or sodium carbonate.

D. Comparative sulpho-defecation. 0.4 grams of phosphoric paste added to the cold mixed juice and thereafter limed to 9.6 pH; sulphur dioxide was then passed to 7.3 pH. The juice raised to boiling point, settled, and samples retained as in A, B and C.

Purity Comparisons.

Mixed Juice	Clarified Juice Purity				pH			
	A	B	C	D	A	B	C	D
80.5	78.1	78.6	78.9	79.2	7.0	7.1	7.0	7.0
87.2	88.3	88.2	88.1	88.5	6.4	6.5	6.5	6.8
85.4	83.7	83.9	84.2	83.7	6.95	6.9	7.0	7.0
83.5	82.3	82.6	81.2	82.5	6.0	7.0	7.1	6.9
85.3	86.2	85.7	85.4	85.9	6.7	6.85	7.0	6.75
79.6	79.4	79.0	78.5	80.0	6.9	7.3	7.2	8.5
Av.: 83.6	83.2	83.0	82.7	83.1	6.7	6.9	6.9	7.1

Clarification Details

Initial pH Mixed Juice	C.cs lime added from 3.2 to 7.3 pH			C.cs lime 9.6 pH sulpho-defecation	SO_2 grams per litre				Hardness			
	A	B	C	D	A	B	C	D	A	B	C	D
6.2	8.2	9.0	8.0	6.7	.64	.72	.68	.36	11.6	6.2	8.8	11.0
4.7	6.1	5.6	6.2	10.7	.20	.30	.30	.14	12.6	7.7	9.5	12.5
5.1	8.0	7.8	7.8	7.5	.62	.62	.60	.42	14.9	7.5	7.7	12.0
4.8	4.1	5.0	4.5	5.5	.38	.52	.56	.26	10.5	6.4	8.5	9.4
4.7	4.5	5.5	5.0	6.0	.36	.50	.52	.26	8.1	6.7	8.2	7.3
5.16	9.5	10.5	9.2	8.0	.60	.58	.70	.08	9.3	6.7	8.8	7.5
Av.: 4.9	6.6	7.2	6.8	7.4	.47	.54	.56	.25	11.2	6.9	8.6	10.0

Notes on Results.

Except in Nos. 2 and 5 of the series there was a general drop in purity. This is discussed later.

In final clarity A and B series were far superior to series C and D . The addition of sodium carbonate in B gave quicker settlement in the second precipitate. Spherical granules of calcium sulphite were present in A and B but absent in C and D.

The absence of additional phosphoric acid in C was marked, resulting in poor clarification and a small second precipitate. The sulphur dioxide contents of A, B and C were twice that in D. The hardness was lowest in B with sodium carbonate added, somewhat higher in C where phosphates had not been added. Sulpho-defecation came next, with the normal acid clarification highest.

The value of hardness tests in juices can, however, only be taken as a general guide, as the actual calcium oxide present was considerably higher in the sulpho-defecation juices than in those obtained from the acid clarification.

Thus:

Hardness ...	11.2	6.9	9.6	20.0
CaO % ash	12.5	12.5	10.7	19.2

SERIES 5.

Following upon the results obtained in Series 4 this series was designed with the object of determining the effect of increasing quantities of sodium carbonate, all other factors being constant. Thus the normal amount of phosphoric paste was first added (0.4 gms. per litre), with nil, 0.3, 0.6 and 1.2 grams of sodium carbonate per litre, respectively. The juices were then sulphited to 3.2 pH, the first precipitate collected, the supernatant liquid limed to 7.3 pH and brought to the boil, then settled, the second precipitate collected and the clarified juice analysed.

Purity and other Comparisons.

Mixed Juice	Purity A	Purity B	Purity C	Purity D	pH A	pH B	pH C	pH D
83.1	83.4	84.0	83.8	83.8	6.7	6.9	7.1	7.3

Initial pH Mixed Juice	Gms. Na_2CO_3 per litre A	B	C	D	pH A	B	C	D	C.cs. lime added from 3.2 to 7.3 pH A	B	C	D
5.0	Nil	0.3	0.6	1.2	4.9	5.7	6.3	7.05	5.0	5.2	6.5	9.5

SO_2 gms. per litre A	B	C	D	Hardness A	B	C	D	CaO % Ash A	B	C	D	Mixed Juice	Ash % A	B	C	D
.038	.52	.52	.50	9.8	7.1	5.9	5.4	16.39	16.89	11.09	5.88	.36	.23	.28	.26	.32

Notes on Results.

With increasing amounts of sodium carbonate the volume of the second precipitate decreased, D being half the volume of A. The weight, however, in grams per litre increased as follows:—

A	B	C	D
2.10	2.23	2.70	3.37

Increasing amounts of sodium carbonate gave no increase in sulphur dioxide over the first increase of 0.14. There was a progressive increase in the amount of lime used with a progressive decrease in the hardness. The total ash was reduced with an appreciable reduction in calcium oxide with amounts of sodium carbonate from 0.6 grams per litre upwards. Effervescence in the second precipitates of B, C & D indicated the presence of carbonates.

SERIES 6.

In these experiments the effect of pre-liming to 7 pH in the cold was determined.

A. Control: 0.4 grams of phosphoric paste added per litre, then sulphur dioxide passed to a pH of 3.2, the first precipitate filtered and the supernatant liquid limed to 7.3 pH, then boiled and settled as in the normal acid process.

B. As in A, but the cold juice first pre-limed to 7 pH.

C. As in B, but with the addition of 0.3 grams of sodium carbonate per litre immediately after the addition of phosphoric paste.

D. As in C, but with no addition of phosphoric paste.

Purity and other Comparisons.

Mixed Juice	Purity A	Purity B	Purity C	Purity D	pH A	pH B	pH C	pH D
85.0	84.1	84.9	84.2	84.2	6.9	6.9	6.9	7.0

SO_2 grams per litre A	B	C	D	Hardness A	B	C	D	Initial pH of Mixed Juice	Grams phosphoric per litre A	B	C	D	Grams Na_2CO_3 per litre A	B	C	D	C.cs lime added from 3.8 to 7.8 pH A	B	C	D
.34	.42	.42	.46	7.6	6.3	5.6	7.4	4.7	0.4	0.4	0.4	Nil	Nil	Nil	0.3	0.3	3.7	5.0	6.0	4.7

The effect of pre-liming caused more rapid settlement, with a decreased volume of precipitate. The clarity was improved, but without phosphoric paste the quality deteriorated.

Hardness decreased progressively with pre-liming and the addition of sodium carbonate, but returned to the original figure when phosphoric paste was omitted.

With these preliminary points determined, the final experiment was designed to cover the most important comparisons.

SERIES 7.

The normal acid clarification process, pre-liming to 7 pH and adding sodium carbonate, is compared with sulpho-defecation.

A. 0.4 grams phosphoric paste added. Sulphur dioxide passed to a pH of 3.2, the first precipitate removed and the supernatant liquid limed to 7.3 pH, then boiled and settled.

B. Same as A, but the juice is first pre-limed to 7 pH.

C. Same as B, with the addition of 0.2 grams of sodium carbonate per litre.

D. Standard sulpho-defecation as described in 4D.

Purity and other Comparisons.

Mixed Juice	Purity A	Purity B	Purity C	Purity D	pH A	pH B	pH C	pH D
85.9	87.2	87.9	88.5	88.2	6.75	6.75	6.8	6.7
84.7	83.8	83.9	83.9	84.0	7.0	6.95	6.9	6.9
81.9	82.8	83.1	83.3	82.4	6.95	6.95	6.95	7.0
79.9	80.1	81.9	80.2	80.8	6.9	6.8	6.8	6.8
83.1	82.9	83.6	83.7	83.5	6.8	6.9	6.8	6.9
Av.: 83.2	83.4	84.1	84.0	83.8	6.9	6.9	6.8	6.9

Initial pH Mixed Juice	C.cs lime added 3.2 to 7.3 pH A	B	C	C.cs lime 9.6 pH sulpho-defecation D	SO_2 grams per litre A	B	C	D	Hardness A	B	C	D
4.6	3.9	5.5	6.0	6.2	.32	.40	.42	.32	5.4	5.0	4.0	7.0
4.7	6.0	7.5	8.1	8.0	.52	.54	.54	.40	4.8	4.7	4.6	4.7
4.9	7.5	8.9	10.0	7.5	.54	.52	.52	.38	6.6	4.9	5.0	4.6
4.75	5.0	6.5	7.0	7.5	.40	.48	.50	.30	4.8	4.7	4.4	6.1
4.3	5.5	7.5	8.5	7.8	.40	.36	.36	.42	5.1	4.0	4.4	4.0
Av.: 4.65	5.6	7.2	7.9	7.4	.44	.46	.47	.36	5.1	4.7	4.2	5.1

Mixed Juice	CaO % Ash				Mixed Juice	SiO_2 % Ash			
	A	B	C	D		A	B	C	D
4.38	18.83	16.67	17.48	23.38	18.82	2.34	2.78	2.90	4.01

Notes:

This final series done at the end of the season, when clarification problems are most intense, tended to confirm the observations made in the previous experiments.

PURITY RISES AND DROPS.

No conclusive explanation is offered for the rises and drops in purity found throughout these experiments. In the above series a maximum rise of 2.6° occurred. Most frequently drops in apparent purity were obtained.

In one particular case a truck of NCo./349 was tested. The initial purity was 85.5% and the clarified juice 84.3%. The dry substance removed in the first precipitate was 0.33 per cent, on juice containing 22.9 per cent, cane wax and 80.5 $Si0_2$ per cent, of ash. The juice was brilliant and sparkling.

It will be observed that no reducing sugar records have been included in these experiments. The reason is that so many figures previously obtained showed no abnormal inversion that this extra work was omitted.

This question of rises and falls in purity is one of subtle interest and importance and well worth further study. It is probable that the presence of starch complexes affects the polarization, with the consequence that the apparent purity of the mixed juice is too high. By partial removal in the clarification process a drop in polarization occurs in the clarified juice, with a consequent drop in apparent purity. (See Summary.)

SUMMARY OF RESULTS.

The results of these experiments show that the acid clarification process is generally superior to sulpho-defecation. The higher sulphur dioxide recorded in all samples of acid clarification juices is apparently not due to increased lime salts, but to the formation of potassium and sodium sulphites from the potash and sodium salts contained in cane juices.

When organic acids with insoluble lime salts are present in quantities greater than normal, or if alkali carbonates such as sodium carbonate are added, more lime is required, lime salts and hardness are reduced, the rapidity of settlement increased, with a decrease in the volume of the precipitate with increased weight. Phosphoric acid is a necessary factor in any improved results.

Pre-liming of the cold mixed juice to 7 pH gives improved clarification generally.

The addition of sodium carbonate in practice will need further study in order to prove that any benefits obtained, such as decreased scale and quicker settling, will more than pay for the increased quantity of molasses which will be produced by the introduction of such a melassigenic salt.

THE FIRST PRECD?ITATE.

This is composed usually of from 76 to over 80 per cent, of organic matter, containing variable percentages of cane wax—usually from 15 to 25 per cent. One sample showed 7.3 per cent, pentosans with nitrogen 1.89 per cent. The ash, which like the organic matter is variable, usually ranging between 15 and 28 per cent., contains high percentages of $Si0_2$—from 60 to over 80 per cent. Efficient precipitation is important. The exact conditions for all the variations of cane juices require further study.

Some, such as the sample of NCo./349 already mentioned, throw out a lightish-coloured precipitate which settles rapidly and contains practically all the cane wax present. Others, especially those towards the end of the season, deposit a smaller black precipitate, leaving the supernatant liquid brownish and very cloudy with colloids. With such juices a little puddled clay is effective in securing better precipitation.

The effective precipitation and removal of this precipitate from Natal juices will constitute an important step forward in clarification. By eliminating the cane wax and most of the silica, reversible colloids and non-sugars, viscosity and scale formation will diminish, and general improvement in clarification and recovery should result.

Apart from the sugar manufacturing angle, the precipitate is in itself valuable. Waxes are in diminishing supply and cane wax is reported to be worth £250 per ton in the U.S.A. The minimum quantity which could be produced by the industry is 2,000 tons per annum. Obviously an efficient method of removing this precipitate with a minimum loss of sucrose is the key to this important process. There are several lines of approach.

1. When sugar is in short supply, some form of filtration would be necessary. Precoat filtration with hyflo-supercel, with or without previous

dilutions and re-settling, will probably prove the most successful. Another method using existing Oliver filters and utilising the second precipitate with fine bagasse as a filter for the first precipitate is worthy of further experimentation.

2. Dilution and reprecipitation, the dilute liquid being used in the imbibition water.
3. When there are sugar surpluses the precipitate can be fermented for power alcohol and the wax recovered from the evaporated slop.

The analytical figures for the precipitates and juices in the foregoing experiments are as follows:

FIRST PRECIPITATE.

	Series 4 A	Series 4 B	Series 4 C	Series 6 A	Series 6 B	Series 6 C	Series 6 D	Series 7 A	Series 7 C	Series 7 D	N.Ca.319
Dry substance % juice	0.06	0.06	0.04	0.20	0.18	0.20	0.23	0.29	0.29	0.20	0.31
Total organic matter % ds ...	81.4	79.7	80.3	77.7	84.9	80.8	75.5	71.8	75.7	73.9	86.6
Total ash % ds	18.6	20.3	19.7	22.3	15.1	19.2	24.5	28.2	24.3	26.9	14.4
Wax % ds...	19.1	24.2	17.4	18.8	19.6	16.6	15.9	10.4	16.0	9.0	23.0
Ash Analysis.											
Silica	80.8	84.8	88.3	63.5	68.0	60.8	69.7	87.3	84.9	85.4	90.5
Iron and alumina	8.6	10.1	6.7	3.7	6.0	3.2	6.7	3.3	3.3	3.2	4.5
Lime	5.4	0.7	1.3	4.5	5.8	4.2	8.0	1.3	2.7	1.6	trace
Magnesia	1.2	0.9	0.8	2.9	3.0	1.3	1.7	1.0	1.0	1.0	trace
Sulphates	1.0	0.9	0.9	6.4	9.4	10.1	3.7	2.8	3.3	2.4	—
Undetermined	5.0	2.9	6.5	18.5	10.8	20.4	12.2	4.3	4.2	6.2	-

SECOND PRECIPITATE.

	Series 4 A	Series 4 B	Series 4 C	Series 4 D	Series 5 A	Series 5 B	Series 5 C	Series 5 D	Series 6 A	Series 6 B	Series 6 C	Series 6 D	N.Ca./319
Dry substance % juice	0.08	0.04	0.03	0.08	0.20	0.21	0.26	0.32	0.11	0.22	0.61	0.43	0.15
Total organic matter % ds ...	59.5	52.8	57.5	79.0	72.8	70.7	67.0	49.0	82.4	70.3	59.2	77.3	56.0
Total ash % ds...	40.5	47.2	42.5	21.0	27.2	29.3	33.0	51.0	17.6	29.7	40.8	22.7	44.0
Wax % ds...	4.1	3.3	8.1	16.4	1.9	4.0	1.1	.0	10.5	9.6	5.5	6.2	0.04
Ash Analysis.													
Silica	3.2	2.0	6.4	68.5	34.3	30.5	24.7	16.5	71.2	45.2	47.5	69.5	1.4
Iron and alumina	39.3	30.4	38.2	16.1	11.8	14.0	8.0	10.5	17.6	39.4	29.0	14.0	23.3
Lime	21.8	20.4	45.3	8.0	15.4	21.4	28.4	25.8	3.8	15.0	12.2	2.4	14.5
Magnesia	0.6	1.0	1.2	2.3	2.2	1.2	0.6	0.5	0.8	0.5	0.4	0.4	trace
Undetermined	16.4	15.7	7.9	5.2	28.9	24.7	15.7	19.6	4.1	8.6	12.9	9.7	--

MIXED AND CLARIFIED JUICES.

	Series 4 Mixed Juice	Series 4 A	Series 4 B	Series 4 C	Series 4 D	Series 6 Mixed Juice	Series 6 A	Series 6 B	Series 6 C	Series 6 D	Series 7 Mixed Juice	Series 7 A	Series 7 B	Series 7 C	Series 7 D
Ash % juice	0.58	0.61	0.63	0.62	.060	0.34	0.23	0.28	0.26	0.32	0.44	0.45	0.43	0.48	0.43
Ash Analysis.															
Silica	18.2	5.6	5.0	6.7	6.1	40.6	13.9	5.0	7.5	7.1	18.9	2.3	2.8	2.0	4.9
Iron and alumina	16.0	1.6	2.5	1.8	1.9	15.9	4.1	1.7	1.2	1.2	10.8	2.2	2.7	2.2	6.4
Lime	2.9	12.5	12.5	10.7	19.2	4.0	16.6	16.9	11.0	5.9	4.6	18.8	18.7	17.6	23.3
Magnesia	5.6	9.8	9.8	10.8	9.9	4.8	11.5	12.3	14.9	10.8	7.8	7.8	8.8	9.9	5.5
Sulphate	11.6	20.9	23.3	19.9	20.4	12.5	20.5	33.8	39.1	30.6	17.9	23.7	24.8	22.5	22.1
Undetermined	45.7	40.4	47.5	40.0	42.5	10.2	24.9	30.3	27.4	44.6	51.9	44.2	44.8	40.0	38.4

SUMMARY.

1. Additions of sodium carbonate to distilled water and subsequent acidification with sulphur dioxide to 3.0 pH, thereafter liming back to 7.3 pH, boiling and cooling, gave a *curve* of hardness and lime salts. The addition of 0.4 to 0.5 grams of sodium carbonate per litre required to give a lower figure than the control. Lime requirements progressively rose.

Crystal formation ranged from plates to rosettes, spherical clusters and spheres with increased quantities of sodium carbonate.

2. The same experiment with river water, cloudy with colloids after rains, gave a progressive increase in the sulphur dioxide content and lime requirements, but the hardness and lime salts *progressively dropped.*

The colloidal matter present affected the crystal formation, spherical clusters and spheres being predominant. In cane juices treated by the acid process only spheres are found. In sulpho-defecation none are present.

3. The chemical reaction with additions of sodium carbonate appears to be:—

$$Na_2C0_3 + H_2S0_3 = Na_aS0_3 + H_2C0_3$$

$$Ca(OH)_2 + H_2CO_2 = CaC0_3 + 2H_20$$

To what extent the weak salts of the alkali metals normally present in cane juices can be expected to react with sulphur dioxide in a similar manner is problematical. The calcium salts of oxalic, succinic, glycolic and malic, which are found in only small quantities (Yoder, Ind. Eng. Chem., 3,640), are generally soluble in water or sucrose solutions, whereas aconitic acid, which constitutes 80 to 90 per cent, of the non-volatile acids in the cane, may be at least partly precipitated as calcium aconitate during clarification (McCalip & Siebert, Ind. Chem. Eng., May, 1941., p. 637).

4. Experiments were conducted on cane juices. The acid clarification process, with and without additional phosphoric acid, with and without additional sodium carbonate, with and without preliming to neutrality, were compared with sulphodefecation.

The increased sulphur dioxide content of juices clarified by the acid clarification process is apparently not due to calcium sulphite. Alkali sulphites, with formation of calcium carbonate carried down in the second precipitate, were shown to be present. The use of additional phosphoric acid is essential.

The progressive addition of sodium carbonate caused more lime to be used and resulted in decreased hardness and lime salts. With additional sodium carbonate the second precipitate settled more rapidly to a smaller volume. The weight, however, was progressively greater.

Pre-liming was beneficial in the same respects, but may only be necessary under difficult conditions. The normal acid clarification process uses less chemicals than in sulpho-defecation. Pre-liming increases the quantities used.

The acid clarification process and its modifications were, in these and previous experiments, found to be superior to the sulpho-defecation process.

5. **The First Precipitate.** The efficient precipitation and removal of the first precipitate is the key to the acid clarification process. The problem is not insuperable and, as priority No. 1 in progress, every means should be explored for its solution; for by its removal from the cold mixed juice, most of the cane wax, silica, reversible colloids and other non-sugars are removed, thereby reducing subsequent viscosity and scaling and improving clarification and recovery.

The precipitate in itself is valuable. The wax content on the dried and washed precipitate ranges from 12 **to** over 20 per cent.

The maximum figure recorded was 30 per cent.

With cane wax said to be worth £250 per ton in the U.S.A., the total value recoverable in a season will be approximately £500,000.

6. Methods of removal. Methods are discussed and cover precoat filtration with hyflo-supercel, precoat filtration using the second precipitate with fine bagasse as a filter for the first precipitate.

Other methods include dilution and re-precipitation, the dilute sucrose solution being used in the imbibition water and, finally, fermenting the sucrose in the precipitate, recovering the alcohol, then drying and recovering the wax in the residue.

7. **The Second Precipitate.** By the removal of waxes, colloids, etc., in the first precipitate, the second precipitate can be more easily filtered. Its rapid precipitation is a function of pre-liming and the addition of alkali carbonates.

8. **The Clarified Juice.** The pecularities of rises and falls in purity are briefly discussed. Increases in reducing sugars are negligible and do not account for drops in polarization causing lower apparent purities. Removal of non-sugars in both precipitates should obviously cause a rise, whereas the frequent drops in purity in series is a matter of conjecture.

A logical conjecture is that starches and dextrin, which frequently occur in Natal juices and effect the simple polarization, have been partially removed. This possibility lends weight to the proposal that Clerget sucrose should be determined in the clarified juice as well as in the mixed juice. (See unpublished paper "Sucrose Irregularities," by G. C. Dymond, 1947.)

The clarity of the acid-clarified juices were always superior to sulpho-defecated juices. Lime salts were less with smaller quantities of chemicals used, while, owing to the intense treatment, juices remain clear and free from fermentation, sometimes for days.

The high impurities peculiar to Natal juices are, in the author's opinion, cane wax, silica, starch complexes and high lime salts. The acid clarification process, as described in the foregoing experiments, removes a high percentage of these non-sugars and tends to reduce the lime salts at an early stage, the ensuing juice becoming more readily clarified, with highly probable beneficial results in the manufacturing process.

Acknowledgements.

In the analytical work the author wishes to thank the Darnall staff, and in particular Messrs. G. Odendaal and S. M. Sellier, whose willing help is hereby acknowledged.

Mr. DYMOND said that he was suspicious of many of the so-called rises in purity between mixed juice and clarified juice, of the way in which this rise varied from factory to factory and from time to time in the same factory. He thought that one explanation might be the fact that while the purity of the mixed juice was worked out from the Jackson and Gillis polarization, only the apparent purity was determined for clarified juice. Another possibility was the variation in the amount of starch present in the juices, for this might give too high a figure for the clarified juice's apparent purity.

He considered the invertase method of inversion better than the acid one.

He was unable to explain the differences between purities of mixed and clarified juice shown in his experiments, in some of which there were considerable drops in purity while others showed a normal rise.

The PRESIDENT in thanking Mr. Dymond for his paper said that, when he first read it, he could not help but ask who it was that years ago claimed that Uba was the cause of all our clarification troubles.

Mr. Dymond had referred to the value of cane wax. There had been a great many enquiries both from this country and overseas for cane wax, and a few also for aconitic acid. He was sure that the recovery of these important secondary products could be studied with considerable profit.

Mr. DYMOND said that with regard to Uba he had held the view for some years that Uba, properly grown, was quite a good cane, while some of the new varieties were bad canes.

Mr. RAULT enquired of Mr. Dymond if he ascribed "hardness" as being due to lime. He asked because some of our juices contained more magnesia than lime and, while in clarified juice from the carbonatation process most "hardness" was due to lime, in sulpho-defecation juices there might easily be half as much magnesia as lime salts.

Mr. DYMOND said that he realised this fact, but while the test was not accurate it did show that, where there was a reduction in hardness, this was due to a removal of lime salts.

He asked if Mr. Walsh could suggest a filter for what he called the "first precipitate."

Mr. WALSH stated that centrifuge manufacturers were interested in the sugar industry and he was sure that such machines would be introduced sooner or later.

Mr. DYMOND said that he tried a centrifuge without success, but had heard of a new filter using hollow candles of hyflo-supercel. In using this filter, precipitates were also mixed with hyflo-supercel.

Mr. PEARCE, remarking on the keeping qualities of juices clarified in Mr. Dymond's experiments and standing in the laboratory, thought that air temperature might well explain that while such juices kept well at a certain time in the year, they would deteriorate quicker with the higher air temperature prevailing with the approach of summer.

Mr. DYMOND agreed that this was the most probable explanation.

Mr. MCKENNA enquired if sodium aiuminate had been tried by Mr. Dymond for juice clarification.

Mr. DYMOND replied that he had not used it in this series of experiments, but he had used it previously, with not very promising results.

Mr. RAULT asked if Dr. Douwes-Dekker would give his view of the possibility of the use of sodium carbonate in the sulpho-defecation process, with the high amounts of lime, phosphoric acid and sulphur used here. Substitution of sodium in place of calcium might be a step in the wrong direction as far as molasses formation was concerned.

Dr. DOUWES-DEKKER said that in the beet sugar industry it was normal to use sodium carbonate, and its effect was to reduce the lime in the clarified juice from 70 to 90 milligrams per litre to as low as 20 or even 10 milligrams of calcium oxide. To bring cane juice with as high as 1,000 milligrams of lime per litre to such a low figure would require so much sodium carbonate as to make its use far too expensive.

Mr. DUCHENNE mentioned that sodium carbonate at a concentration of .035 lbs. per ton of tempered juice had been employed at Umfolozi as standard practice for the past two seasons. This had resulted in evaporator scale being reduced by one half and softened.

Mr. CHIAZZARI asked the author to describe the "first precipitate."

Mr. DYMOND replied that it might occupy as much as 10 per cent. of the volume of juice, but it was possible to reduce its volume by use of a slow-stirring device. To reduce the volume was important but it was very difficult to filter, for it contained those substances which were the causes of all manufacturing troubles in this country.

Mr. MCKENNA asked how much sulphur and lime were used to obtain the "first precipitate."

Mr. DYMOND said that lime was not normally used, but when it was employed early in the season precipitation was hastened. The method might have to be varied according to seasonal changes. He did not know the amount of sulphur used, but much less chemicals were required by the pre-clarification process than were used *in* the present ordinary sulpho-def ecation process.

Reducing sugars were not determined, because previous work had shown loss of sucrose by inversion to be negligible.

Mr. GALBRAITH asked if Mr. Duchenne could explain the big drop in purity between crusher juice and mixed juice at Umfolozi.

Mr. DUCHENNE said that the big drop had been in evidence during the past two seasons. This was explained by the fact that extraction had been increased from 92 to 94 per cent., resulting in a lower purity of mixed juice. This was accentuated by the crusher's being opened out to crush 100 tons per hour, thus resulting in a higher purity of crusher juice.

Mr. RABE said that at Illovo when the extraction went up over 94 per cent. the last mill purity had been down to 65 degrees, but he could not say if this was due to the higher extraction, or what effect this had on the mixed juice purity.

Mr. RAULT remarked that the large purity differences between first expressed juice and mixed juice shown at Umfolozi were seldom experienced at his factory in Natal, where a three-degree drop was a rare occurrence. The first crusher was comparatively wide opened to accommodate heavy tonnages, and accordingly the extraction from that unit was poor, and a great deal of reliance was placed on the subsequent units of the milling train, which had to do an extra heavy duty in order to make up for the poor start and attain the 95 extraction, notwithstanding high-fibred canes. In comparison with these results, he was at a loss to explain the cause of the extremely low purity of Umfolozi last mill juices and mixed juices, as high pressures and high extractions of a more intense degree than at Natal Estates did not seem to fit the case.

Granted that all necessary precautions had been taken to ensure the accuracy of these figures, one could only surmise that the low-fibred canes, grown under a semi-tropical climate at Umfolozi, had a different structure from the ones grown in the drier districts of Natal, and responded in a different way to milling.

Mr. DUCHENNE agreed that much depended on the nature of the cane, but the fact that Umfolozi had six mills must be taken into consideration.

SOME INDUSTRIAL APPLICATIONS OF ELECTRONICS

By A. F. MCCULLOCH.

Introduction.

1. It is only recently that the application of electronic engineering techniques in the industrial field has become established. Formerly the applications of electronics were associated mainly with radio broadcasting, wireless communications and television; but during 1939—1945, under the impetus of new developments such as radar and the production of radioactive materials, some remarkable advances were achieved which can be invaluable if applied to the gentler arts of peacetime industry. But the comparative slowness with which industry is making use of the techniques may be due to the reason that the scope and possibilities of these new tools are not adequately realised.

2. Electronics is a product of scientific effort and research and modern developments have provided a tool of versatility and precision which yields results unattained previously by applications of older and more widely-known techniques. During the present circumstances of industrial expansion, of demands for increasing productivity and of rising costs and scarcity of labour, every effort should be made to achieve a very high standard of industrial efficiency. The scope of the applications of electronics for such a purpose is boundless and substantial process improvements and reductions of manufacturing costs could be achieved if sufficient thought be given to utilising the possibilities offered.

If an interest in the applications of electronics to industrial problems is encouraged, the purpose of this paper will have been served.

3. In all electronic components such as thermionic valves, photo-electric cells, gas and vapour-filled tubes, cathode ray tubes, etc., a moving stream of electrons is caused to flow between two or more elements by the application of a voltage. This stream has a negligible inertia owing to the minute mass of the electronic particles, and this property enables control of the motion of the stream to be achieved with an instantaneous response by insignificant changes of energy. For instance, in the photo-electric cell, the flow of power is controlled merely by changes of illumination. The commonest types of components used, their construction and the methods of utilising their characteristics are described. When properly selected, arranged and connected, these components may rectify, amplify, measure, control, time and perform many operations of a similar nature which are an essential part of some manufacturing process.

Typical Electronic Components and their characteristics.

4. ***(a)*** **Thermionic Diode,** This is a two-element tube or valve and is illustrated in Fig. 1. A glass

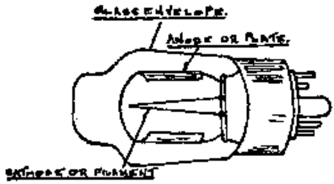


Fig. I. Thermionic diode. Filament heater is not shown,

envelope which is exhausted to a high vacuum contains the two elements known respectively as cathode (or filament) and anode (or plate).

The cathode is generally coated with a thoriated material or barium oxide and will eject electrons when heated. If a closed external circuit is made by connecting the two elements through a battery or generator, the electrons will flow from cathode to anode and the intensity of this flow will vary with the voltage applied by the battery as indicated by the characteristic of Fig. 2. Electrons will flow

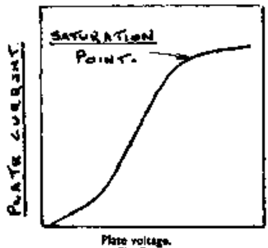


Fig. 2.

only if the anode is connected to the positive (+ve) side of the battery and the cathode to the negative (—ve) side. In practice, great care must be taken in designing the form of the cathode heater in order to suppress any magnetic fields which may cause spurious signal effects. The diode has rectifying properties; i.e., if the battery is replaced by an alternating current generator only the +ve half of the voltage wave is passed through the circuit and the —ve half is suppressed as shown in Fig. 3. By

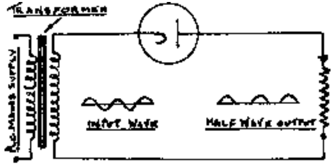


Fig. 3. Rectifier effect of diode.

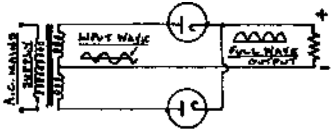


Fig. 4. Two diodes used for full wave output rectifier.

connecting two diodes as shown in Fig. 4 full wave output is achieved and, if suitable filter circuits are added to the arrangement, an output scarcely distinguishable from a steady direct current may be obtained, as shown *in* Fig. 5.

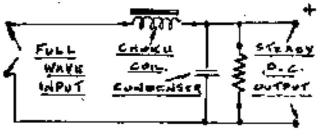


Fig. 5. Use of filter circuit to produce stead/ D.C. from full wave supply.

{b) **Thermionic Triode.** This is a three-element valve and is shown in Fig. 6. With the exception of the third element, known as the control grid, this valve is similar to the diode. The control grid has very important effects on the valve characteristics, since by varying the grid voltage a wide range of

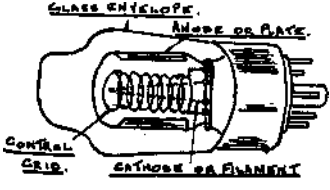


Fig. 6. Thermionic triode. Filament heater Is not shown.

control may be achieved over the current passing between the anode and the cathode. The reason for the spiral construction of the grid is that electrons from the cathode may flow through it on to the anode. There are other types of valves—tetrodes and pentodes—which have two and three grids respectively. These perform similar functions to the triode, but differ in their characteristics.

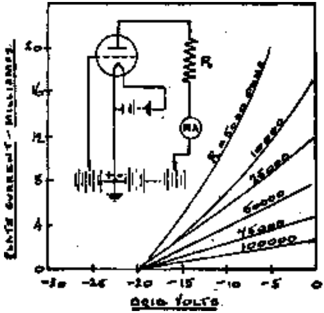


Fig. 7. Change of plate current with change of grid voltage and load resistance.

A typical triode characteristic is shown in Fig. 7, which reveals how the anode current changes with grid voltage and with the load resistance R. For relatively small values of R the plate current changes more rapidly than for relatively large values, so that in the latter case the curve is straighter. The amplifying effect of the triode is shown in Fig. 8,

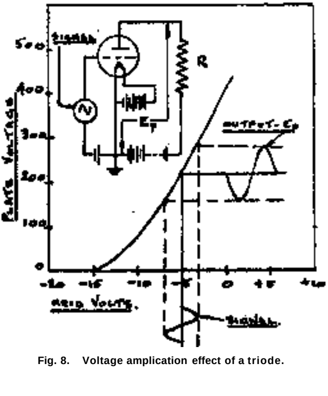


Fig. 8. Voltage amplication effect of a triode.

where a signal voltage is shown applied between grid and cathode and the corresponding change in output voltage Ep. Thus if the operating grid voltage changes from —5 volts to —3 volts due to the signal, the plate voltage Ep changes from 210 volts to 280 volts. Similarly, if the signal changes the grid voltage to —7 volts, Ep changes to 140 volts. This vields a voltage amplification of (280-H0)-(7-3)=35; i.e., the signal has been amplified 35 times by the valve.

A — ve grid voltage is important for two reasons. Firstly, in order to obtain undistorted amplification, the straight part of the characteristic only must be used. If the curved portion of the characteristic is used, the output will not have a shape similar to the input. Secondly, if the grid is kept —ve, no electrons flow between grid and cathode; i.e., there will be no grid current and hence no power is taken from the signal source.

(c) **Cascading of triode amplifiers.** A single triode does riot always provide adequate amplification and, when large amplifications are required, it is necessary to couple several stages. The most common methods of achieving this coupling are resistance coupling, impedance coupling and transformer coupling. Circuit diagrams for these couplings are shown 'in Figs. 9, 10 and 11. In Fig. 9 the voltage developed

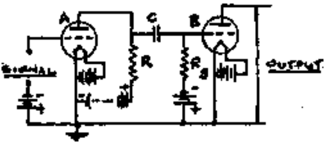


Fig. 9. Resistance coupled amplifier.

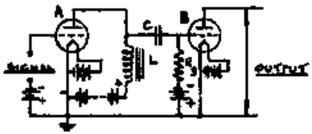


Fig. 10. Impedance coupled amplifier.

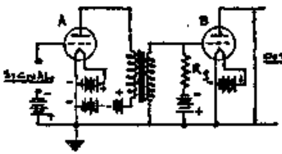


Fig. 11. Transformer coupled amplifier,

across R is applied across Rg through a condenser C.' This condenser prevents the plate voltage of the valve A being applied to the grid of valve B, so that the —ve voltage bias of the grid is maintained. No current flows in the grid circuit of valve B and the full voltage of the bias battery is applied to the grid. The advantage of impedance coupling, Fig. 10, as compared with resistance coupling, is that direct current is more easily passed and alternating current components are more readily suppressed, which enables a high load impedance to alternating current to be obtained without excessive direct current voltage drop that would diminish the plate voltage.

Transformer coupling has an advantage over resistance coupling similar to impedance coupling. Since there is no direct connection between the two windings of the coupling transformer, valve A plate voltage is isolated from valve B and the coupling condenser C is not required. There is also the advantage that the primary winding output voltage may be stepped up proportionally to the turns ratio of the transformer.

Resistance and impedance couplings are used mainly for voltage amplification, and transformer coupling mainly for power amplification. Voltage amplification is required where the output of one valve is applied to a second valve. On the other hand, power amplification is required when the valve output is used to drive a control mechanism or where power has to be delivered to some form of load. In power amplification grid current flows wholly or partly during the cycle of operations.

5. Gas-filled Tubes. *(a) Gas-filled Thermionic Diode.* In the valves described in para. 4 there is a high vacuum inside the glass envelope. If the envelope is filled with a suitable gas or mercury vapour the resistance to flow of current between the cathode and anode is reduced under certain conditions and the tube is then capable of carrying large currents. When a voltage is applied to the electrodes, Figs. 12 and 13, only a small current flows until a certain critical voltage is reached at which the gas becomes a good conductor and a luminescent glow is initiated

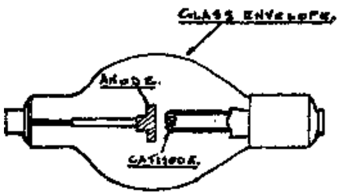


Fig. II Gas filled diode.

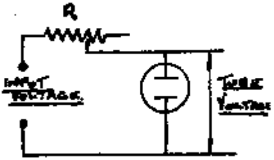


Fig. 13, Gas-filled diode connections.

at the cathode. This effect is called ionisation and the magnitude of the current is only limited at this point by the resistance R. If R is gradually reduced, the glow area increases in size and intensity and finally takes on the characteristics of an arc in which the voltage drop across the electrodes is substantially less than in the glow discharge, and for this reason the gas-filled diode may be used as a most efficient alternating current rectifier.

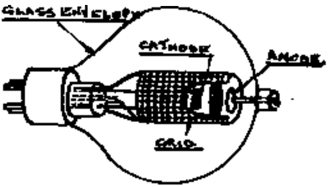


Fig. 14. Gas-filled triode. (Thyratron).

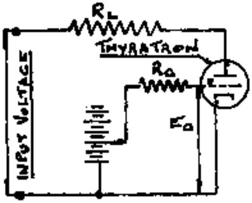


Fig. I5. Thyratron connections. For a given input voltage the tube fires suddenly at a critical value of Eg.

(b) Gas-filled Thermionic Triode or Thyratron. A typical gas-filled triode is shown in Fig. 14 and the characteristics of this tube are shown in Fig. 16. Flow of current through the tube may be prevented by maintaining the grid sufficiently —ve with respect to the cathode. In Fig. 16, as the negative voltage is changed, a certain critical voltage is reached at which an arc forms between the anode and the cathode. When this arc forms the grid has no further controlling effect and the current rises instantaneously to a value determined by the input voltage and the circuit resistance. In order to stop the discharge the input voltage must be reduced to zero for an instant and when this is done the negative grid assumes control again. A comparison of the characteristics of a gas-filled triode and a vacuum triode is shown in Fig. 16. The sudden rise of current at the critical grid voltage is shown at AB and is usually referred to as the firing point. The value of the critical grid voltage depends on the input voltage as indicated in Fig. 11 (a).

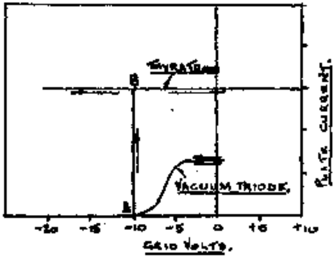


Fig. 16. Comparison of thyratron and vacuum triods characteristics.

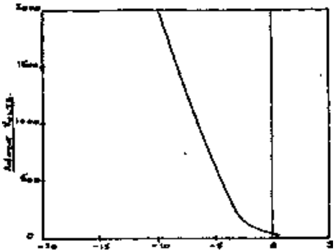


Fig. IIa. Variation of critical grid voltage with anode voltage.

6. Photo-sensitive Cells. *(a) Photo-electric Cells.* The photo-electric cell is a tube which permits an electric current to flow in a circuit when the tube is suitably illuminated by a source of light. The cell is a two-element tube and consists of an anode and a cathode which are sealed in a glass envelope as shown in Fig. 17. The action of the cell depends on the fact that certain metals, notably caesium, are photo-sensitive, i.e. emit electrons due to the effect of light. In most of the photo-electric cells used for industrial applications, the cathode is coated with

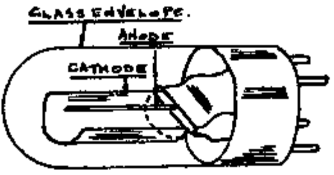


Fig. 17. Photo-electric cell.

a thin film of caesium-silver oxide which may vary in colour from light straw to dark chocolate. Other types of coatings may be used, principally caesium-antimony and caesium-bismuth, since these combinations have greater sensitivities to shorter wave-length light.

Like the vacuum and gas-filled tubes described above, photo cells may be either gas-filled or vacuum type and the characteristics of the two types of cell differ. Gas-fillings of argon and helium are often used.

If a cell is connected as shown in Fig. 18 and the lamp illumination is kept constant, characteristics as indicated in Fig. 19 are obtained which show that

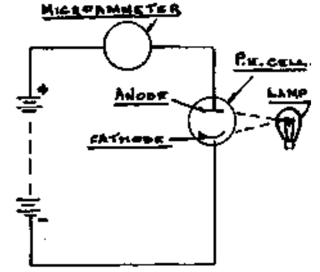


Fig. 18. Simple P.E. cell circuit diagram.

the vacuum cell is less sensitive than the gas-filled cell. At the same time the vacuum cell is seen to have a very stable characteristic when the applied voltage exceeds 20 volts, whereas the sensitivity of the gas-filled cell varies with the applied voltage.

If the voltage is increased sufficiently, a glow discharge is initiated; but a cell should never be used under these conditions, since the performance is changed completely.

If the applied voltage is kept constant and the intensity of illumination changed, the characteristics

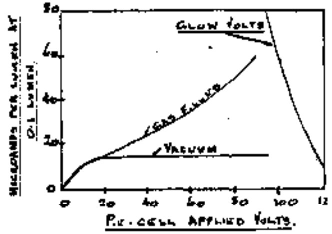


Fig. 19. Comparison of characteristics for constant illumination.

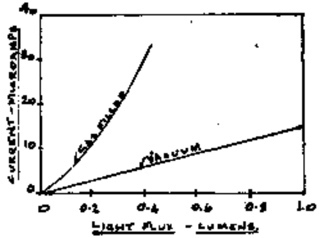


Fig. 20. Comparison of P.E. cell character for constant applied volts.

of Fig. 20 are obtained and show that, in the case of the vacuum cell, the current is directly proportional to the intensity of illumination. Photo-cell currents are always quite small and usually of the order of 10^{-6} ampere. For this reason a high insulation resistance between electrodes is vital, particularly where a cell is used in measurement work. Care should be taken to eliminate leakage paths between pin terminals when the cell is in use.

(b) Photo-voltaic Cells. The photo-voltaic cells consist of a sandwich formed of a light-sensitive surface, a semi-conducting material such as selenium and a ferrous base. The construction is shown in Fig. 21. The light-sensitive layer is usually covered with a thin transparent metal film and when it is illuminated a voltage appears across the external faces.

This cell differs from the photo-electric cell, since no external battery or source of electrical energy is required to drive the current through the circuit; and in this respect it may be regarded as a true voltage generator, since only the energy of the incident light is required to initiate the voltage. The cause of photo-voltaic action is not known with certainty.

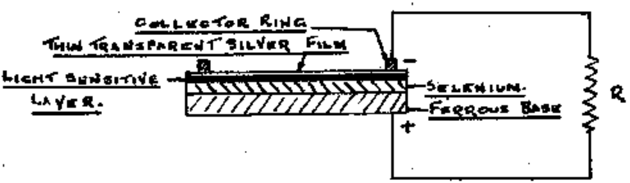


Fig. 21. Photo voltaic cell.

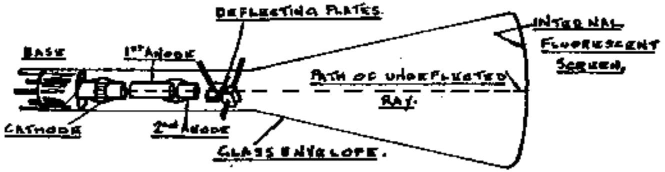


Fig. 22. Cathode ray tube.

7. Cathode Ray Tubes. The Cathode Ray Tube is one of the most useful electronic tools for the study of rapidly changing phenomena. A sketch of a typical tube is shown in Fig. 22. In the tube a beam of electrons is ejected from the cathode and is accelerated to high velocity by the two anodes. The anodes are hollow cylinders and the second has a small aperture at the end adjacent to the deflecting plates. The first anode operates at about 500 volts and the second between 1,500 and 3,000 volts. The intention of the second anode is to constrict the size of the electron beam in order to produce a fine intensely defined spot on the fluorescent screen.

The beam is displaced from the axial path by two pairs of deflecting plates which are set normal to each other. By imposing a voltage of known frequency on one pair of plates the beam is deflected to produce a straight fine time base; and by imposing a voltage to be studied on the second pair of plates a figure is produced on the screen showing how the latter voltage varies with time. By this means it is possible to study visually events lasting only for 1/20,000 sec. Control of the deflection of the beam may be attained by changing the voltage applied to the second anode as indicated in Fig. 23.

A series of screen traces obtained by imposing voltages of different frequencies to the deflecting plates is shown in Fig. 24.

One of the most recent and spectacular applications of the Cathode Ray Tube is in the television receiver, where the electron beam is swept at high speed in a series of successive horizontal lines across the screen by means of the deflecting plates. The intensity of the beam is controlled by the television broadcast signals. The high-speed sweep of the beam creates the illusion of a continuous single picture and the variation of the beam intensity creates the light and shade effect which is required for definition.

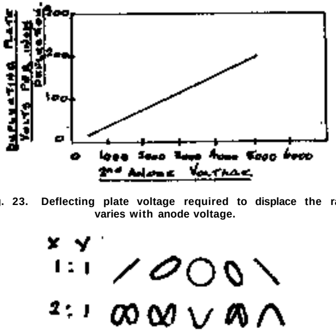


Fig. 23. Deflecting plate voltage required to displace the ray varies with anode voltage.

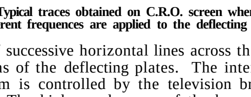


Fig. 24. Typical traces obtained on C.R.O. screen when voltages of different frequences are applied to the deflecting plates.

8. **Application Techniques.** (a) *Measurement of Displacements and Gauging.* In many engineering problems it is necessary to measure small displacements accurately or to make accurate measurements of components. The electronic micrometer[1] provides a very simple and accurate means of measuring displacements continuously. The principle of the micrometer is shown in Fig. 25. If a displacement is

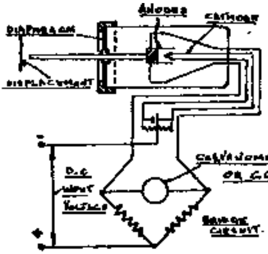


Fig. 25. Gunn micrometer. Electronic method of measuring displacements or accelerations.

applied to the end of the lever the two anodes are displaced relatively to the cathode and a signal voltage is generated which is proportional to the displacement. By amplifying the signal and applying it to a cathode ray tube a visual record of trie displacement can be exhibited and measured. The micrometer may be adapted to automatic gauging by applying the amplified signal to a machine which is controlled to separate undersize, standard and oversize components. If a very small mass is secured to the lever the micrometer may be used for measuring rapidly changing accelerations up to a maximum of 90 g at 10,000 cycles per sec.

(b) Use of Photo-sensitive Cells. Photo-sensitive cells are applied in many and various ingenious ways to industrial control problems. One great advantage of the photo-cell is that no constraint is imposed on the input source. For instance, in the application of the valve micrometer mentioned above, a very small force has to be applied to deflect the lever, but in some applications even a very small force cannot be tolerated and resort must be had to the photo-sensitive cell, which requires nothing more than a beam of light to excite it.

(c) Water Level Control. A very simple type of Water Level Control is shown in Fig. 26, where a beam of light from the source A is directed on to a glass tube B. If the water level exceeds height H, the light is refracted by the water on to a photo-cell at C which stops a pump-driving motor. If the water

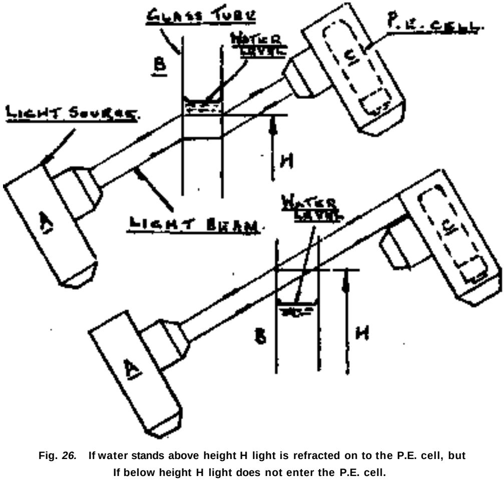


Fig. *26.* If water stands above height H light is refracted on to the P.E. cell, but If below height H light does not enter the P.E. cell.

level falls below H the light is not refracted by the water and the light does not enter the photo-cell, which now starts the pump motor.

(d) Continuous Gauging of Strip and Wire. A method of continuous gauging of strip and wire has been developed[2] in which a photo-electric cell is used as a micrometer. Referring to Fig. 27 the material to be gauged is moved across a slit cut into a measuring plate which is illuminated by means of a lamp. The shadow of the material is projected on to the cathode of a photo-electric cell which initiates a voltage signal proportional to the area illuminated. Similar slits are cut into the measuring plate corresponding to the upper and lower size limits of the material and by means of a rotating scanning disc the three slits are exposed to the illumination in sequence. Signals corresponding to each slit are initiated and applied to a common amplifier circuit and on to the vertical deflection plates of a cathode ray tube.

A sweeping voltage synchronised with the scanning disc rotation is applied to the horizontal plates of the cathode ray tube, which exhibits traces on the screen corresponding to each slit of the measuring plate.

Each signal is exhibited simultaneously as a horizontal straight line which is shown without interruptions. If variation in the size of material occurs the test slit signal varies proportionately and the corresponding trace on the screen changes position relative to the limit traces, which do not change their positions.

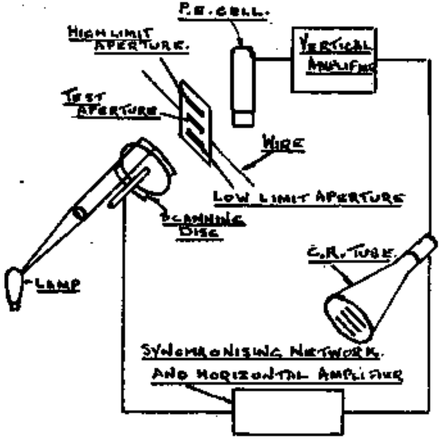


Fig. 27. Electronic micrometer for the continuous gauging of wire and strip.

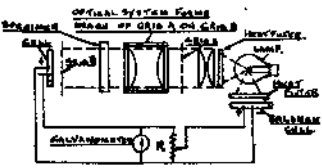


Fig. 28 Turbidity meter circuit diagram.

(e) Turbidity Meter. In turbid liquids light is scattered by the suspended particles and this effect is used to measure turbidity by electronic methods.[3] Referring to Fig. 28 a mesh grid A is illuminated by a lamp. The shadow of the mesh A is focussed by the optical system on to a similar mesh grid B, If no specimen is inserted for test, the grid B stops light from entering the specimen cell, but if a specimen is inserted the light-scattering effect occurs which illuminates the specimen cell and causes a galvanometer deflection. Since the relationship between turbidity and light-scattering is nearly linear, the galvanometer deflection is a measure of the turbidity.

(f) *Temperature Control.* A method of using a photo-electric cell for temperature control is shown in Fig. 29, which emphasizes the advantage of photo-electric systems not imposing any restraint on the input system.

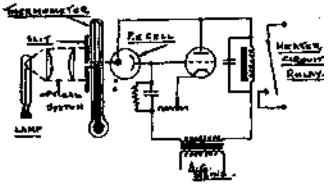


Fig. 29. Use of P.E. cell for temperature control.

In this application light is focussed through a narrow slit on to a transparent mercury-in-stem thermometer by means of an optical system. The temperature is controlled by the displacement of the mercury level in the stem, which permits or obstructs light from entering the cell. A sensitive control can be achieved by providing a carefully designed optical system and a narrow slit, and the control level may be regulated by raising or lowering the thermometer.

Since the energy available in the mercury stem is very small it will be clear that no system of electrical contacts could be operated directly.

9. **Use of high frequencies for detection of tramp metal.** The problem of foreign or tramp metal objects being mixed with process materials is a serious one for many industries, since stoppages and heavy damage may be caused to plant and machinery if such objects pass through fixed clearance rollers. Devices based on various effects have been developed in the past as safeguards and in one method recently introduced[6] the effect of metal causing distortion to the form of a high-frequency field associated with a coil has been exploited. The distortion effects arise from three causes, namely, eddy currents, hysteresis and dielectric losses; and the choice of the operating frequency and the design of the coil are such as to emphasize the effect of the foreign material and reduce the effect of the conveyer structure and the process materials.

The field is established in a large coil which is energised by a stable valve oscillator. The approach of foreign material to the coil, which is shown diagrammatically in Fig. 30, distorts the field and the effect is reflected back into an amplifier circuit as a change of resistance, which yields a voltage signal. If the signal has the appropriate sign and has sufficient steepness and amplitude, an alarm signal is given and the conveyer is shut down.

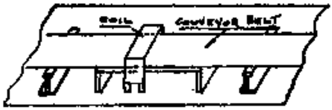


Fig. 30. High-frequency field method for detection of tramp material.

10. Application to chemical measurements. ***(a)*** *pH Meter,* Electric currents are frequently measured by the voltage drop across a resistance and this procedure is used in the pH meter or Hydrogen Ion Concentration Meter. Dissociation effects in solutions generate voltages which may be used to measure the pH value of the solution, but, in order to measure this voltage accurately and continuously, a glass electrode is necessary. The resistance of this electrode is very high—several hundred megohms—and the current is so minute that conventional types of sensitive galvanometers are inadequate.

The measurement problem has been successfully overcome by using a low grid current valve or electrometer valve which is adequate for measuring currents of the order of 10^{-15} amp or even less. The pH meter is well known, but it may not be clearly recognised that in measurements involving very high resistances the effects of electrical leakages which would be of no significance with resistances of a few thousand ohms may cause serious errors. This source of error often arises in electronic measurement techniques and it may be easily eliminated by use of a guard ring. The effect of the guard ring may be seen in Figs. 31 and 32, in which the unknown resistance R is measured by the deflection of the galvanometer G, which is in series with R and the battery. This deflection is compared with that obtained when R is replaced by a calibrated resistance. There is, however, a surface leakage resistance L present between the terminals T_1 and T_2 to which R is connected, and this will affect the deflection. By securing a metal ring to the insulator on which T_2 is mounted and connecting this to the —ve side

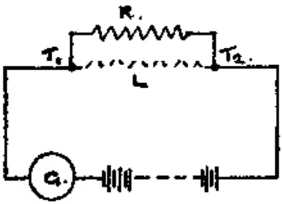


Fig. 31. Circuit diagram for resistance measurement. Leakage currents may flow from T_1 to T_2 through the leakage resistance and yield erroneous results.

of the galvanometer two resistances X* and Lg are substituted for L, 1^ is in parallel with the battery arid now has no effect on the deflection; L, is in parallel with G but, since it is large compared with the resistance of G, the shunting effect is negligible. It is also possible for leakage to arise from the battery directly to $T_{1(}$ which may again cause errors; but, by mounting the battery on a metal plate and connecting the latter to the guard point P, the effect of the leakage on the measurement is also negligible.

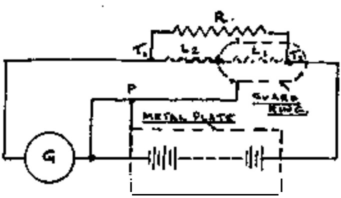


Fig. 32. Leakage currents through L_2 are conducted through the guard ring to the —ve terminal of the battery and do not affect the galvanometer: since the resistance of this part of the circuit is small, the effect of L, is negligible. The effect of battery leakage currents is eliminated by connecting the metal plate to point P.

In the pH meter the electrode voltage is applied to the grid circuit of the electrometer valve and affects the voltage drop across the plate circuit resistance. This voltage drop is measured by means of a conventional type galvanometer. The valve thus greatly amplifies the electrode voltage and it is important to ensure that the grid circuit connections and all points from which leakage currents may arise are adequately guarded.

{b) Polarographic Method of Analysis. A system for displaying the polarographic curve (or current-voltage curve) of a chemical solution on the screen of a Cathode Ray Tube has brought this method of chemical analysis within the range of electronic technique.[9] A study of the traces exhibited on the Cathode Ray Tube Screen enables different substances in dilute solution to be identified.

Referring to Fig. 33 the solution to be analysed is placed in an electrolytic cell. The upper electrode or cathode contains mercury and terminates in a capillary tube from which droplets of mercury flow at intervals of 2 to 4 seconds and the lower electrode or anode is a pool of mercury. When a direct current voltage is applied to the electrodes, a galvanometer reading is made and observations are repeated for different applied d.c. voltages. If the results are plotted, a curve of the form shown in Fig. 34 is obtained from which both the identity and concentration of the substance present may be deduced.

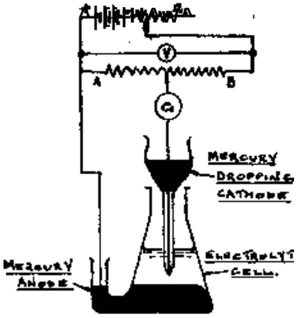


Fig. 33. Basic circuit for polarographic analysis.

Referring to Fig. 34, when the applied voltage is gradually increased there is a small increase of current as shown at a-b. When the voltage reaches the decomposition potential b the current increases suddenly with voltage and reaches a limiting value d-e. If several substances are present in the

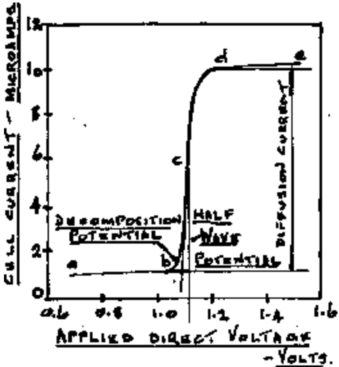


Fig. 34. Example of current/voltage curve obtained by polarograph.

solution the curve obtained will have a number of steps similar to Fig. 34, and the widths of the steps will be determined by the decomposition potentials of the respective substances; the heights of the steps will represent their concentrations.

Polarographic curves are symmetrical with respect to the applied voltage, at which one-half the limiting current flows, and this voltage is called the half-wave potential. This value is characteristic of the electrolyte, is independent of the concentration and is sufficient to identify the ion present. The magnitude of the limiting current establishes the concentration.

The polarographic method was developed about 25 years ago, but was not widely adopted owing to the labour involved in plotting the observations. In the electronic development, Fig. 35, a d.c. voltage is applied to the anode by potentiometer R_a and is measured on the voltmeter V. An alternating current voltage is also applied from the transformer T_x by means of the potentiometer R_5, and the resultant current is passed through the primary winding of a transformer T_a, which initiates a signal to the deflection plates of the Cathode Ray Tube, When the polarographic curve has linear characteristics as at a-b, c and d-e, the superposition of the a.c. wave on to the applied direct current will not change the shape of the wave; but where the curve is not linear, as at be and cd, the wave shape will be distorted.

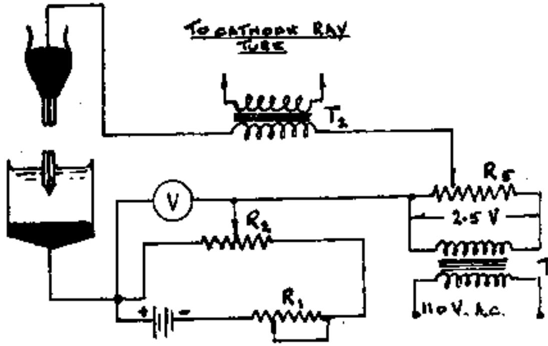


Fig. 35. Polarograph circuit permitting the use of a cathode ray tube for the identification of ions in a solution.

By applying the a.c. voltage to the horizontal pair of deflecting plates and the signal voltage to the vertical plates, the traces indicated in Fig. 36 may be obtained.

The trace a is symmetrical and indicates that the voltage is less than the decomposition potential. Trace b is unsymmetrical and corresponds to the region b-c, Fig. 34. Trace c is symmetrical and indicates that the half-wave potential has been reached. Traces d and e show the effect of changing the direct voltage hy±0.2 volts compared with c.

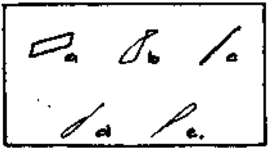


Fig. 36. Traces obtained on the CR. tube as the direct voltage Is increased in steps. The potentiometer is adjusted until the pattern C is obtained and the direct voltage giving this pattern is the characteristic half-wave voltage of one substance of th e solution. Complex solutions may be analysed in a few minutes by this met hod.

11. **Automatic Moisture Control.** In textile weaving the warp threads must be moistened to withstand the effects of abrasion and flexing, and control of the moisture content of these threads is necessary, since too little may cause breakage and too much may cause mildew. The moistened threads pass over a steam-heated roller and the moisture content is regulated by controlling the speed of the roller. Electronic control is achieved by measuring the electrical resistance of the threads on the roller.[8]

Referring to Fig. 37, the threads are passed between two rollers at A; the lower roller is earthed and the upper roller is insulated. If the moisture content of the threads changes, the grid voltage of the triode B changes and a direct current signal voltage is initiated across CD which is applied to the converter and changed to an alternating current signal. This a,c. signal is amplified and applied to the motor M_1 which drives the indicator pointer to a new position on the scale, drives the slider on R_5 to a position which will restore balance to the bridge circuit BCD and displaces R_1 to initiate **a** change of roller speed. Since the moisture content/resistance relationship is not linear, a cam has to be used to drive the indicator pointer and R_s has to be tapered.

If the roller speed were controlled directly by M_1, wide speed oscillations or hunting would occur owing to the sensitivity of the bridge circuit; and, in order to prevent this, a speed adjustment is applied which is proportional to the moisture content deviation.

As the position of R_1 is changed by M_1 a signal is applied to the a.c. amplifier which energises motor M_4. This motor changes the speed of the rollers and also drives the slider of R_3 to a new position from which a signal is applied to the a.c. amplifier to balance out the signal from R_x, and the system is restored to equilibrium at a new speed.

Final restoration of the speed to yield the desired moisture content is achieved by means of the floating switch SW_3, which is pre-set by manual control knob. When the moisture content differs from the pre-set value, SW_3 closes and energises motor M_2, which drives a slider on R_4 and unbalances the bridge $R_1R_aR_3R_4$ so as to correct the drift from the pre-set value. Thus the rotation of M_4 is initiated not only by the position of R_1 but also by the relative positions of the sliders on the four resistances R_1, R_2, R_3 and R_4; and any unbalance in this circuit causes M_4 to rotate until a speed is reached which produces the pre-set moisture content.

If manual control is required, the speed may be set by a control switch. The change from automatic to manual control is achieved by moving the switches SW_1 and SW_2 over, which changes the a.c.

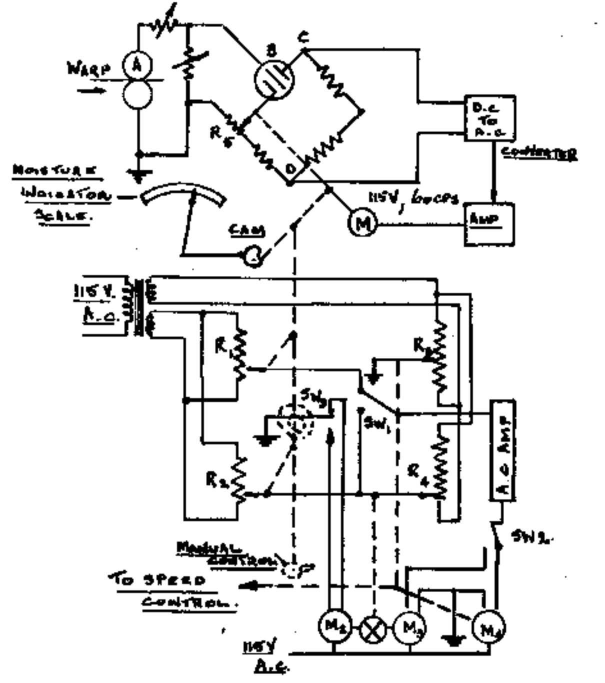


Fig. 37. Automatic moisture content control. Circuit diagram.

amplifier input connections to R_3 and R_4 and the output connections to Motor M_3. The operator adjusts the speed until the indicator shows that the pre-set moisture content has been attained, at which point R_1 and R_2 are in balance; at the same time M_3 is energised to drive the slide of R_4 to retain a balance with R_3. By this means the bridge is kept accurately adjusted and ready to take charge again as soon as the control switch is restored to automatic operation.

12. **Automatic Control of Machine Tools.** An electronic contour controller enables the manufacture of variable shapes and contours, e.g. cams, dies and roller forms to be achieved automatically by duplicating the contours of a master template.[a] The equipment consists of an electronic system, a tracing head and two motors which are geared to the longtitudinal and cross slides of the machine tool and rotate independently of each other.

The tracing head is shown in Fig. 38 and is secured so that the stylus may keep in contact with the template. A small force is adequate to deflect the stylus and templates made of wood or plaster may be used.

When the stylus is displaced by the motion of the template, signals are generated and applied to the electronic system which drives the motors so as to, reproduce the motion required by the signal direction at the cutting tool. Referring to Fig. 39, a voltage of 2,000 cycles per sec. frequency is applied to inductances 1 and 3 and a similar voltage displaced in phase by a quarter-cycle from the former is applied to inductances 2 and 4. The inductances 1, 2, 3 and 4 form the arms of a bridge circuit. When the stylus is deflected the inductance air-gaps change and signals are generated in either or both of the coils as indicated. The electronic system is devised so that the drive to the motors ensures that the stylus is always kept in contact with the template.

The method is capable of providing very accurate reproductions of complicated forms.

13. **Speed and Performance control of Electric Motors.** In many industrial applications of motor drives, e.g. the textile, chemical and paper-making industries and machine tools, a wide range of driving speed is required which is usually provided by the use of direct-current motors. Generally, public power supplies are alternating current and means have to be provided to change this to direct current. The requirements are easily achieved by an electronic system which is capable of providing a speed range of 1 : 10 or 1 : 100 on the motor if desired.

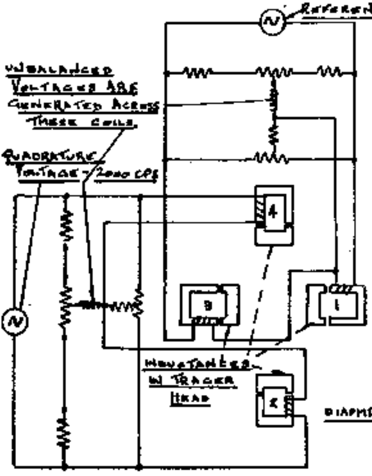


Fig. 39. Tracer head bridge circuit.

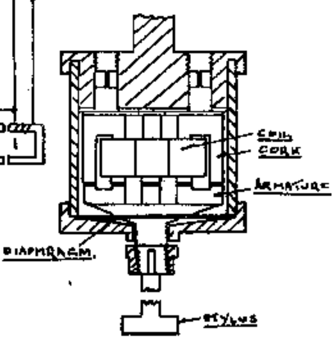


Fig. 38. Magnetic tracing head.

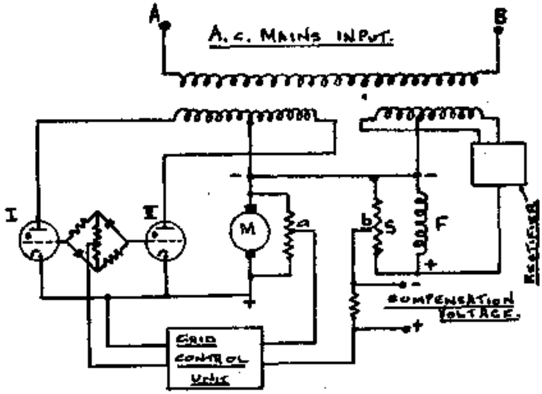


Fig. 40. Thyratron control of direct current motor. Circuit diagram.

Referring to Fig. 40, the a.c. supply voltage is applied to the transformer terminals A, B and the output is applied to the thyratrons I, II, which are connected to provide full-wave rectification. The thyratrons are connected to the motor armature M and the power supply for the motor shunt field F and the speed regulator S is provided from a separate rectifier.

By changing the incidence of the grid voltage with respect to the anode voltage, the thyratron firing point is changed and the output voltage also changes, which enables the motor speed to be adjusted. This effect is illustrated in Fig. 41 (*a*), *(b)* and *(c)*. In Fig. 41 *(a)* the anode voltage is represented by the sine wave ACDB and the critical grid voltage by the horizontal line AHB. If a grid control voltage EFG is applied, the thyratron will fire at point 1 and continue firing for the interval IH. In other words a rectified voltage is applied to the motor armature for a period IH in each half-cycle of the anode voltage. This is illustrated in Fig. 42.

Referring to Fig. 41 *(b)* the grid control voltage is displaced by applying a d.c. voltage to it and under these conditions the thyratron fires at point 2 and continues firing for the interval 2H. By displacing the grid control voltage as illustrated in Fig. 41 (c) firing is delayed until point 3 and the armature voltage is applied only for the short interval 3H. The second thyratron is controlled similarly and a continuous control between zero and maximum of the output voltage is obtained.

Referring to Fig. 40, by connecting the points a and b to an amplifier in the grid control voltage unit very sensitive control of speed is obtained, since the voltage at point a is always proportional to the motor armature voltage. Any small variation of the

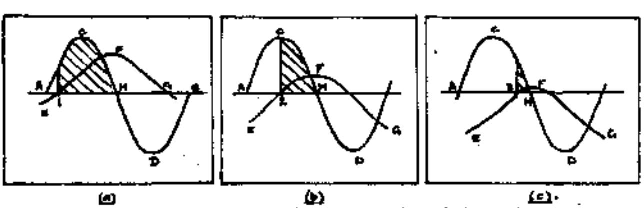


Fig. 41. Control of thyratron point by changing the grid control voltage incidence.

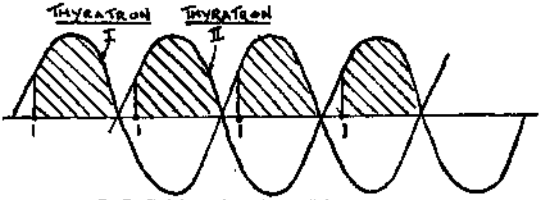


Fig. 42. Shaded areas show voltage applied to motor armature.

voltage between a and b is amplified and changes the incidence of the grid control voltage EFG substantially.

In the shunt-connected direct-current motor the speed falls as the load is increased, but this effect may be corrected with the electronic system by applying a compensating voltage to the armature, proportional to the armature current. Speed-load curves showing the effect of compensation are shown in Fig. 43.

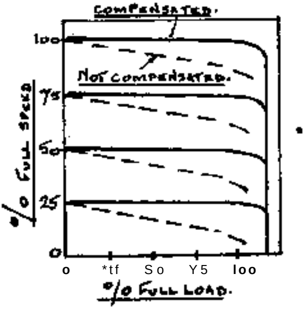


Fig. 43. Load-speed characteristics of a thyratron controlled D.C. motor with load compensation.

Conclusion.

14. The modern application of electronics to industrial processes has opened up a new perspective for the future and provides a means for achieving substantial progress in accuracy of control and making many operations fully automatic. By the advantages it possesses in sensitivity and rapidity of response, process lag can be eliminated. Future applications will become increasingly diverse and limited only by a lack of ingenuity in devising the methods of application and unwillingness to make use of them.

Summary.

15. The introduction of electronic methods to industrial processes is only of recent growth, but many successful applications of the technique have been made. This paper introduces a description of some typical electronic components and their characteristics and then discusses a few applications. The method possesses great versatility and a development of the applications described will be made increasingly as the advantages become better known and recognised.

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Sugar Milling Research Institute,
Howard College,
Durban.
February, 1950.

The author illustrated the paper by means of epidiascope slides, and then showed a film demonstrating several industrial uses of electronic devices.

The PRESIDENT asked if the author knew of any applications of such devices in sugar factories or refineries.

Mr. MCCULLOCH replied that, with the exception of the pH indicator, he was not aware of any other applications at the present time.

Mr. MCKENNA thought that a number of factory operatives would welcome automatic control of juice heating and of pan boiling, and he enquired if such control could be effected through electronic means.

Mr. MCCULLOCH considered that such control could be comparatively cheaply and simply evolved. A temperature control method was described in the paper and this could easily be applied. Without having seen such devices at work it was difficult to realise the extent to which they could be utilised.

The PRESIDENT said that while it was possible to imagine all kinds of possible uses for such apparatus, it was evident that much development was required before full advantage could be taken of electronics in sugar factories and refineries.

NITROGEN AND DRAINAGE

By 0. W. M. PEARCE.

Seventy-five to eighty per cent. of the earth's atmosphere consists of nitrogen gas. It is not strange, therefore, that every living thing, both plant and animal, contains nitrogen within its cell-like structure or cells of its body.

The purpose of this paper is to consider very briefly some of the complicated processes taking place in the soil (and some of the variable factors influencing them) that make nitrogen available to plants.

The main sources of nitrogen in the soil which as such are unavailable to the plant are :

(1) Nitrogen gas found in the soil air.
(2) Nitrogenous compounds in the dead vegetable matter located in and on the soil.
(3) Nitrogen compounds in the bodies of soil micro-organisms.

The nitrogen of the three above sources of nitrogen is not available to the plant until it has been converted to ammonia, the nitrites or nitrates. In sugarcane probably the most important of the above three compounds is the nitrate nitrogen form. When added to the soil in a commercial fertilizer, nitrate nitrogen, if applied in fairly large quantities, under certain conditions can also be the most uneconomical type, for it is readily leached from the soil during and after a heavy rain. The result is that very little or any available nitrogen may be left for the nutrition of the plant. In contrast, commercial inorganic nitrogen in the ammonia form is not readily leached from the soil. This form, however, tends to make the soil acid. This disadvantage can be easily overcome by addition of lime to the soil.

Nitrogen, when added to the soil in the ammonia form, is slowly converted to nitrites by nitrosomonas and nitrosococcus bacteria, and, secondly, by nitrobacter bacteria to nitrates, in which form nitrogen is readily taken up by the plant.

The nitrogen gas in the soil air is made available to the plant mainly by two methods. One is through the agency of legumes; the other by the fixing of nitrogen from the gas by bacteria living a free existence in the soil.

The legumes, and the bacteria that are associated with them in the root nodules, by some obscure process are able to fix atmospheric nitrogen from the soil air. This nitrogen eventually is taken into the body of the plant itself, and, according to Waksman and Starkey, "under conditions where legumes make good growth, there are usually between one hundred and two hundred pounds of nitrogen fixed per acre."[1]

Of the amount of nitrogen fixed by legumes when in symbiotic association with legume bacteria about seventy-five per cent. is located in that part of the plant that is above the ground (i.e. the stem and leaves). The quantity of nitrogen found in the root system of the legume that is grown in a soil low in nitrogen is the other twenty-five per cent. This amount represents approximately the quantity of nitrogen that is obtained by the plant from the soil.

It is obvious, therefore, that farmers who grow legumes in order to improve their soils, and who cut and remove the legume crop from the field, or graze animals on the field, are not getting the full benefit of the legume crop as a soil improver.

Most legumes grow best at soil reactions close to neutrality. Lupines, however, will tolerate and put on good growth in fairly acid soils.

In order to ensure that the root system of the legume is adequately supplied with air from which the symbiotic association of the legume and its bacteria is able to fix nitrogen, the soil must be well prepared and, if necessary, drained prior to planting. This is particularly necessary in heavy clay soils which are inclined to be somewhat compact.

As mentioned earlier, the other method by which the nitrogen gas of the soil air is fixed is the method by which certain soil bacteria are able to fix the nitrogen as complex organic and simple inorganic compounds. These bacteria are known as non-symbiotic nitrogen-fixing bacteria, as they are not associated with any higher plant in the fixation process, as, for example, are the bacteria found in the nodules of legumes.

Like all other living things, bacteria of the soil do best on a balanced diet. They also do best when the environmental conditions of their habitat (in this case, the soil) are conducive to their rapid growth.

The question now arises as to what is regarded as a balanced diet for bacteria and what are the environmental conditions best suited for their growth.

As to what constitutes a balanced diet for bacteria, the answer is not known to the writer, and, if it were, it would be far too complex a subject for a paper of this type.

It may be said, however, that if the soil is well supplied with organic matter from which the nitrogen-fixing bacteria are able to obtain carbon as a source of energy, and if there are adequate supplies of phosphorus and potassium (superphosphate and potash fertilizers) and sufficient calcium (lime) and smaller quantities of other minerals, the nutrient requirements of the bacteria are as well supplied as is possible under practical farming conditions.

The desired environmental conditions are satisfied by having a well-drained soil of good friable structure, and a soil which is neither too acid nor too alkaline. The friable structure of the soil permits easy access of air (which contains the necessary nitrogen gas). The well-drained soil is conducive to the growth of aerobic bacteria, and reduces the degree of denitrification caused by anaerobic bacteria that thrive in conditions lacking oxygen.

The bacterium Azotobacter is one of the most important agents by which nitrogen is fixed in the soil. It is very sensitive to soil reaction and soil temperature conditions. Its optimum requirements are :

(1) A reaction close to neutrality, that is, a pH of 6.0 to 7.6.
(2) A temperature of approximately 82°F.
(3) A soil moisture content of about 50 per cent. of the soil's moisture-holding capacity.

Under these conditions strictly controlled in a laboratory, D.S. Byrnside and the writer found that Azotobacter, contaminated by Radiobacter, fixed as much as a hundred pounds and more nitrogen to the acre. These results, however, are of academic interest only, as all the environmental conditions required by Azotobacter are very seldom found in nature at any one given time. Nevertheless the bacterium can and does fix valuable quantities of nitrogen in the soil under field conditions.

Micro-organisms in the soil contain complex nitrogen compounds within their bodies. This nitrogen, as previously stated, is only available to the plant after it has been converted to simpler inorganic nitrogen compounds, such as ammonia and the nitrates which are available to the plant. And also, of minor importance, are the nitrites which are taken up by a few plants.

The conversion of unavailable complex organic nitrogen compounds to the simpler inorganic ammonia compound is accomplished by an involved microbiological process.

One very important factor in this process is the carbon-nitrogen ratio of the organic material involved therein. If the carbon-nitrogen ratio is low, say from 10-30 to 1, the conversion of complex nitrogen forms to the simpler inorganic form is not held up by the carbon-nitrogen ratio factor.

The carbon-nitrogen ratio of many types of microbial cells is from 4-10 to 1; therefore the nitrogen within their bodies is readily converted by other micro-organisms to inorganic ammonia.

On the other hand, if the organic material has a wide carbon-nitrogen ratio arid there are large quantities of this type of organic matter in the soil, it will be some considerable time, possibly two or three months, or even longer, before any useful quantities of nitrogen become available to the commercial crop.

Bacteria that decompose organic matter characteristically assimilate about 10 parts of carbon to 1 part of nitrogen. The carbon-nitrogen ratio of the dead leaves of sugarcane is approximately 80-90 to 1. The mechanical inclusion into the soil of this material means that it is going to influence to a great degree the available nitrogen to the following plant crop. The more thoroughly the trash is mixed with the soil, and the greater the quantity added, the less will be the nitrogen immediately available to the crop.

This condition can be improved somewhat by the addition to the soil of commercial inorganic nitrogen fertilizers. In some cases a cane-grower may find it more profitable to get rid of the high carbon-nitrogen ratio material (i.e. the trash) by burning and adding to the soil comparatively low carbon-nitrogen ratio material in the form of a green manure crop. On the other hand, if the soil is already high in organic matter (and such a condition is found characteristically in some of our higher-altitude soils), it may pay to burn off the trash, short-fallow, and add the nitrogen by commercial fertilizers.

Where some of our coastal soils are low in organic matter, this condition should be alleviated by the addition of organic matter with a fairly low carbon-nitrogen ratio. A green manure legume crop with a relatively low carbon-nitrogen ratio of 30-40 to 1 will result in improved soil conditions.

No hard and fast rule can be applied, however; every situation must be treated on its own merits.

Involved with the nitrogen-soil complex is the question of drainage.

A poorly-drained damp soil is usually very acid, and low, or even lacking, in available nitrogen. This nitrogen deficiency is caused to a large extent by anaerobic denitrifying bacteria that exist in the oxygen-deficient environment of boggy soils.

For the growth of profitable crops in soils of this type it is essential to have an efficient drainage system. There are many and various types of drains to be seen in the cane-fields of the Natal Sugar Industry. Some are six inches deep and less, others are of various depths up to fifteen feet and more.

The purpose for which a drain is constructed, that is to be considered here, is that type of drain that will remove as efficiently as possible excess water found in damp spots within the field itself.

A.—The requirements in a drain of this nature are :—

(1) That it shall remove excess water.
(2) That it shall interfere as little as possible with agricultural operations within the field itself.
(3) That it shall cause as little erosion as possible.
(4) That it shall remove from the soil a minimum of plant foods.
(5) That it shall improve the crop in the drained area.
(6) That it shall be economical in construction and maintenance.

The answer to the above requirements in most cases is a deep drain, and, for preference, a French drain four feet deep.

B.—The advantages of a French drain over an open drain are that:—

(1) It does not interfere with the use of agricultural implements in the field as does an open drain.
(2) During its useful life it costs nothing to maintain; an open drain does.
(3) With the same drainage gradient it carries away less soil than an open drain.

Points (1), (2) and (3) in Section B satisfy all the requirements of Section A except for the cost of construction in Point (6).

The construction of a French drain will always be considerably more expensive than an open drain of the same depth. The cost, however, can be modified somewhat by the choice of, and availability of materials.

The types of materials used in the construction of French drains in Natal cane-fields, known to the writer, are bushwood, stones, bamboo and cane trash. Cane trash is used as a "seal" between the overlay of soil and the drainage medium of bushwood, stones or bamboo.

In most cases French drains can be constructed with vertical sides. This feature results in the removal of less earth than in the case of the open drain of the same depth and results in the consequent saving of the cost of earthworks.

The final filling-in of the French drain with the necessary materials does, however, make it more expensive than the deep open drain.

It is not possible to give any costing figures at this stage, but it is felt that the advantages of the French drain over the open drain make it by far the most economical proposition.

The construction of the. French drain after the completion of the earthworks is, briefly, as follows:—

(1) Bushwood, stones, or bamboo are placed in the bottom of the drain to a depth of approximately one foot.

(2) Loose cane trash, to a vertical cross-section depth of two to three feet, is placed on top of the "percolating" medium, i.e. bushwood, etc. This trash is compressed down to a thickness of approximately six inches within a few weeks by the weight of loose earth placed on top of it.

The net result of this construction is that the drain has one foot of "percolating" medium, a ""seal" of six inches of trash, and a final section of two feet six inches of earth.

The vertical section of two feet six inches of earth above the trash permits the efficient operation of all field implements, including the use of the subsoiler.

At this stage it is well to compare the relative merits of shallow open drains from six inches to one foot in depth with those of the French drain.

The shallow drain :—

(1) Per running foot is cheaper to construct than a French drain.

(2) Has maintenance costs, whereas the French drain has not.

(3) Does not remove water from the surface of the soil as quickly as does the deep French drain; therefore, to remove water at an equivalent rate, more shallow drains are needed.

(4) In operation carries off a high percentage of water from the first six to twelve inches of surface soil. By comparison, the French drain does not.

Points (1) and (2) of the relative merits of the two types of drains are self-explanatory.

With reference to points (3) and (4), the French drain, because of its depth, removes a great deal of the water it carries off from the subsoil area. The reason for this is that the pressure exerted at its base by a column of water four feet high is approximately 1.73 pounds per square inch. In a four-foot drain the effective value of this pressure in the movement of water into the bottom of the drain is modified a great deal by the resistance to the movement of water set up by the type and structure of the subsoil.

Even in a heavy clay subsoil there is a high rate of water seepage into the drain at its base.

The removal of water by the drain at its base results in the lowering of the water table in the surrounding area. The surface water, therefore, instead of moving in a lateral direction, as it would do in the case of a shallow drain, tends to move in a downward direction.

To summarise, the significant points of the above facts are that :—

(1) A shallow drain, because it entirely removes a great deal of water from the first six to twelve inches of soil, also removes out of the reach of the plant considerable quantities of plant foods, which include soluble nitrogen.

(2) In the case of the deep drain, because the surface water tends to move in a downward direction, the plant foods are still available to the deeper-growing roots of the plant.

(3) Deep drainage or underdrainage increases the soil area accessible to the roots of plants by the removal of free water from the lower regions of the soil. Because of this fact, the effects of drought are reduced.

All the foregoing opinions on field drains are of little value unless they can be substantiated by practical results.

In waterlogged soils in a certain area French drains were made. The result is that the plant-cane now growing in these soils is estimated to cut out in October at the rate of thirty-five to fifty tons per acre. The same soils, which formerly were served by shallow drains or "bed-lines," grew a maximum of ten to fifteen tons of cane per acre in the plant-cane cycle, and considerably less in the ratoon cycle.

It should be mentioned that, prior to the planting of the last crop, a considerable quantity of lime was added to the soil.

(l)Waksman, S.A., and Starkey, R.L. The Soil and the Microbe. Chapter V. John Wiley & Sons Inc. New York, 1934.

The PRESIDENT remarked that when the Experiment Station was first opened the cane planter paid little attention to nitrogenous fertilizer, although he had realised the necessity for application of phosphate. This was due to the lack of response obtained from the mixed fertilizer then used, and it was only in recent years, when nitrogen came to be added as a straight fertilizer, that the benefit derived from its application became apparent.

He thought that the author might have mentioned another important source of nitrogen—that obtained directly from the atmosphere and washed into the soil by rain, although the amount available from this source had been perhaps exaggerated in certain papers presented to this Congress in previous years.

Commenting on the remark about the removal of portions of legume green manure crops from the field, he pointed out that green manures had been found to benefit the following plant cane crop, but very seldom the ratoons, even though the nitrogen supplied by the green crop was more than necessary for the plant cane. It appeared that there was some loss of nitrogen therefore, possibly by leaching, and some of this could be saved by removing the surface crop for animal feed or composting. While lupines were excellent for fairly acid and poor soils, they appeared to require winter rains, and were not suited to Natal conditions.

On the question of drainage, which was very important in ordinary cultivation, but especially so where irrigation was carried out, it had been found that in heavy clay soils, with underlying stiff shale, French drains sooner or later became clogged.

Mr. PEARCE said that as much as 20 lbs. per acre of nitrogen had been found to be fixed within the atmosphere and brought down into the soil by rain, at Rothamstead the figure being 8 to 10 lbs. per annum. The reason for some of the nitrogen made available by legumes being lost was that it was changed from the unavailable form in the plant to the nitrate form quicker than the cane could take it up. There was thus a temporary excess which could be lost by leaching.

Mr. STEYN drew attention to the experience on the South Coast, where, on trashing cane, the ratoons had been found to deteriorate so much that burning of cane had been again resorted to.

Mr. PEARCE mentioned that many had found that ratoons of trashed cane sometimes did not shoot up well and were stunted and yellow. Pot experiments at the Experiment Station had shown similar results. This indicated the possibility of shortage of nitrogen within the soil. The explanation suggested by Dr. McMartin was the carrying down of soluble carbohydrates contained in the trash. This resulted in the micro-organisms, which used the carbon as a source of energy, locking up the nitrogen in the soil so as to maintain within themselves a very low carbon-nitrogen ratio.

Dr. MCMARTIN had heard it stated that the coastal soils had no azotobacter. On two occasions, however, he had found it to be present, and he thought that if it were not found, that might be due to soil conditions being unsuitable for its development. Sir A. D. Hall had suggested that, in tropical countries like Africa, azotobacter could take the place of the legume bacteria of Europe. We might, therefore, help ourselves more by maintaining the organic content of the soil, rather than by growing legumes for their nitrogen-fixing bacteria.

The bad effect of trash lying on the soil could be much exaggerated, and it was noticeable mostly in the colder months. Canes growing with trash lying on the soil grew much better than those which had trash mixed with the soil, and this suggested denitrification. Mr. du Toit had found that canes grown with trash lying on the soil were suffering from nitrogen starvation, and the suggestion was therefore made that carbohydrates were being washed down into the soil from the trash.

Mr. PEARCE said that in connection with azotobacter and soil conditions, he had found that the optimum pH for its development was about 7.6, which under practical conditions was very high. He had been astounded to find a pH of as low as 4.1 in hillside soils which had grown cane for many years. Under such conditions one could not expect any fixation of nitrogen by azotobacter, but it could do good work at a pH of 6.6.

The PRESIDENT described results obtained in a field experiment at the experimental farm at Chaka's Kraal. In this experiment, for the first few months, first ratoons in plots covered with trash were very backward as compared with those of burnt plots. However, a remarkable difference was in evidence later, and there was every indication that the trashed cane would give a much better ultimate yield than the burnt cane. It seemed that where there was much difficulty in getting ratoons to germinate after trashing, this might be due to lack of air and excessive moisture. In that case it might be best to relieve the trash so as to make narrow channels for air and for the new shoots to grow in.

Dr. DICK considered that probably under dry conditions a blanket of trash was of benefit in preventing evaporation, whereas under very wet conditions it might keep the soil too wet and lead to denitrification.

Mr. PEARCE described conditions in a field of fairly light soil from which cane was cut in August two years previously. The yield was 30 tons per acre and the resulting trash was left undisturbed on the soil. It was afterwards top-dressed with 400 lbs. of "H" mixture of fertilizer which was broadcast as evenly as possible by hand over the trash. It was remarkable now to see the porosity of the soil, due to the animal fife beneath the trash. The estimated yield of cane from that field at present was 35 tons per acre.

There was another field, too, in which the same system had been applied. In this case the soil was heavier, but the results of the treatment were similar. With the present drought, the soil was hard, yet still very porous, and when the rain did come it would go easily into the soil, taking with it the necessary air for the action of aerobic nitrogen-fixing bacteria. There would be no run-off unless there were exceptionally heavy rain.

Mr. DU TOIT thought that when referring to acid soils Mr. Pearce had the higher altitude soils in mind. Some of these were rather acid, and the action of azotobacter might be small. However, these soils were probably the least responsive to nitrogen applications, and had been limed without beneficial result.

He agreed that leaving a blanket of trash had led to the improvement of soil conditions in a number of places, but he felt that not enough was known to justify this as a general practice. Mr. Steyn had shown the opposite side of the picture, and Dr. McMartin had mentioned some cane that grew very slowly and looked yellow when grown under a layer of trash. The cause of this was still unknown, although in a small pot experiment at the Experiment Station nitrogen was found to be lower in the pots where trash was left on the soil than it was in those free from trash. The chemist could play a very important part in determining the explanation of results obtained in trashing experiments carried out in different localities.

Dr. BATES said that it was only in recent years that it had been realised that improvement in soil conditions could be due to the flora of the soil. This suggested that at present we were dealing with a lot of surmises. He thought that not only was microbiological examination desirable, but it would also be interesting to know the soil microbiological population at different levels, as well as the distribution of the cane roots at these levels in relation to the availability of plant foods.

With regard to trashing of cane, he remarked that under the very arid conditions in Rhodesia, trashing was done largely with the idea of conserving moisture. With certain varieties, particularly Co.281, when trash was left as a general cover over the cane lines, very erratic germination of ratoons resulted. Average growth was better, and far more uniform, where the trash was placed between the lines. He doubted that this was due enitrely to a chemical factor and thought the possibility of a disease factor should be considered.

Mr. RAULT stated that while there were controversial views on the use of molasses as a fertilizer, in other countries it was used extensively. While it supplied an enormous amount of carbohydrate, it also supplied potash and it was known that the residue from distilleries had a beneficial effect. He enquired if there was any local experience in the application of molasses to the soil.

The PRESIDENT said that molasses had been tried as a fertilizer at the Experiment Station with negative results either for or against. In Australia he had seen a very striking experiment. A particular soil had been found no longer to tolerate a certain variety of cane. This condition had been rectified by sterilising the soil in various ways. One way was to apply molasses. The first result of fermentation of the molasses was to sterilize the soil. This effect of the fermentation products would pass off and they would change into other substances, leaving the soil a virgin field for new bacteria, and giving it, in many cases, a new lease of life.

Mr. DU TOIT mentioned that interesting work had been done in Queensland on the use of molasses, and he had seen photographs illustrating the increased microbiological activity in the soil which had much improved its condition, and which had followed the application of molasses.

Dr. MCMARTIN described soil tests with Co.281 carried out at the Experiment Station two years previously. The greatest weakness of Co.281 was its susceptibility to root diseases. In these pot tests Co.281 was planted in a soil, some of which was partially steam-sterilised, some treated with molasses equivalent to about *i* tons per acre, and some was untreated. The cane planted in the untreated soil grew rather poorly, but there was a marked improvement in both the partially steam-sterilized and the molasses-treated soil, with no obvious difference between these two.

Mr. PHIPSON enquired if the molasses was diluted before application to the soil.

Dr. MCMARTIN replied that in the test he had described the molasses was put on undiluted. A different type of micro-biological growth followed the application of diluted molasses, compared with that which resulted from the concentrated molasses. This was shown by experiments in Mauritius, where it was claimed that a result was obtained with diluted molasses different from that which resulted from the use of undiluted molasses.

Mr. DU TOIT stated that two semi-chemical experiments had been carried out at the Experiment Station, using soil treated with molasses and mercuric chloride. In both cases cane growth was much better in soil so treated as against the untreated soil.

Mr. BEATER pointed out that concentrated molasses had been used, but the soil was watered shortly afterwards.

Mr. DU TOIT considered that a very interesting point about the work done in Queensland was the fact that the soil structure was much improved by molasses.

Mr. ELYSEE enquired if the pH of the soil was affected by molasses, because of the formation of acids on fermentation. At a small factory in Zululand the molasses had to be discharged on to a field in dilute form. There was no growth at all of cane where the molasses was discharged.

Mr. BEATER replied that no effect on the pH of the soil had been found in the experiments previously described.

GROWTH-RATE METHOD FOR DETERMINING FERTILIZER REQUIREMENTS OF SUGARCANE

By J. L. DU TOIT.

Chemical analyses of both plants and soils to investigate problems of soil fertility have been practised with success for a long time. The technique of soil analysis has been greatly improved, but there is not, and there probably never will be, a method which gives the total nutrients available to the plant throughout its life. In plant analysis the emphasis is shifted to the plant itself, but here again there are complications and, although many can be eliminated and, with standardisation, the method can be made a most useful tool in investigating soil fertility, it is the growth of the plant itself which has the greatest appeal and which in the end must supply proof of the diagnosis based on soil and plant analytical methods.

A number of pot experimental techniques have been developed whereby either the actual growth (usually weight) of the plant itself, or more often some indicator plant, serves as a measure of response to a particular fertilizer, or the chemical composition of the plant or some visual symptom may be used to show deficiencies. Here again objections may be raised. The artificial conditions in the pot are one. Indicator crops may react differently to the actual crop under investigation. AH these methods have their drawbacks, but that is no reason why they should not be used very intensively, for their advantages far outweigh their disadvantages and, if more than one method is used, exceedingly valuable information can be gained. The normal fertilizer field-plot experiments take a long time and are expensive. This is particularly so with a crop such as sugarcane, which takes, in this country, about two years before the crop is harvested. For reliable results to be obtained several cuttings are desirable, as climatic conditions during the long period of two years may often be so abnormal that the results obtained from a single crop may not be a guide at all for subsequent years. Nevertheless the properly conducted field-experiment, and of course success in the commercial large-scale plantations, must be regarded as the final test of these diagnostic procedures, because here the actual crop under investigation is used under field conditions.

A method which appears to have many of the advantages of pot tests, in so far as quick results and flexibility are concerned, and share with field trials the great advantage of being conducted on the more or less undisturbed soil under field conditions and on the crop which is under investigation, was described by Evans.[1] Here the total increase in length of sticks is taken as a measure of the growth of a cane-stool over a given period. Fertilizers are applied to individual stools and responses arrived at by comparing the increased elongations of treated with control stools. The method depends on the fact, which has been reaffirmed here, that a correlation of a very high order exists between the growth of sugarcane stools during one month and the following month. Evans selected 25 stools (5 rows of 5 alternate stools) so as to enable him to impose a latin square design. These stools were measured during the period of active growth and the measurement repeated a month later to ascertain the growth for that period. The following treatments were then applied : O, N, P, K and NPK. The method of fertilizer application was by removing some soil so as to expose a dense matting of roots in a circle of about a foot radius around the cane-stool and then making holes 6 to 8 inches deep with a small crowbar and applying the fertilizer in the holes and as a broadcast over the partly exposed roots and then covering up. After another month all the sticks in stools, including newly formed tillers, are measured again and the difference between the two increments statistically analysed.

This method of testing out responses to fertilizers in the field" during the short period of two months seemed to have such possibilities in a general programme of research on soil fertility that it was tried out at the Experiment Station.

Preliminary Experiments.

The first experiments were necessarily exploratory, for it was not known what quantities of fertilizers had to be applied to individual stools of cane to get the best responses, neither was it known how early these experiments could be started or how late they could be continued with a reasonable chance of success. Thus in the first experiments carried out on a wind-blown sand at Bellamonte near Umhloti no responses were indicated on a 5 by 5 latin square design when fertilizers were applied at the rate of 300 lbs. ammonium sulphate, 300 lbs. superphosphate and 150 lbs. potassium chloride per acre. It was then realised that, although the dressings were quite normal in field trials, and were in fact those used by Evans, except that he used 300 lbs. precipitated calcium phosphate instead of super, they may not be adequate to force individual stools sufficiently, because cane adjacent to the fertilizer stools will share in the applications.

On increasing the applications to 1,088 lbs. ammonium sulphate, 461 lbs. superphosphate and 273 lbs. potassium chloride per acre a significant response to N and NPK was obtained on a similarly designed experiment in the same field. The latin square design was, however, difficult to arrange on stools not originally planted for this purpose and there was the possibility of biased results. This would necessitate the analysis of the results by the co-variance method involving long and complicated calculations for a rapid and simple method and leaving us with adjusted totals which are not so readily understood. It was then decided to arrange experiments in randomised blocks, each block consisting of stools of rather similar growth-rates. This procedure made it advisable to ascertain the growth-rate of a number of additional stools, so as to leave a better selection, but it simplified the calculation a great deal and in addition the experiment could now be applied to any shape or size of plot or field. An experiment of this lay-out at Bellamonte again gave significant results, N being better than NPK and both better than O, P and K. When this last experiment was later repeated on an adjacent plot and the fertilizers applied in April no response was found, the reason probably being that the cane had passed its active growing period, with a consequent drop in sensitivity of the method and a lower fertilizer demand by the cane plant.

Attempts to simplify the work by measuring only five sticks in each stool, or five adjacent sticks in a row, failed because the total response to fertilizers is often largely the result of increased tillering which will not be accounted for in these shortcuts. As stated before, a high positive correlation was found between one month's growth and the succeeding month's growth, but a simple arrangement in blocks based on the size of stools instead of growth-rates, thereby eliminating one measurement, also proved unsuccessful.

Method.

The method finally decided on was to measure 30 to 40 stools and to repeat the measurement after about one month's growth during the best growing period and then to arrange in blocks according to the determined growth-rate. The necessary treatments, e.g. O, N, P, K and NPK properly randomised and replicated, say, five times, are now applied. The final measurement is taken after about a further month and the results analysed on the actual increment in growth after the fertilizer application.

The following example will illustrate the procedure for a test carried out on a field at the Experiment Station which was shown by leaf analyses to be extraordinarily low in nitrogen :—

	Monthly growth increments in inches before treatment.					Monthly growth increment in inches after treatment.				
Block... ...	O.	N.	P.	K.	NPK.	O.	N.	P.	K.	NPK
A	10	16	17	16	[illegible]	31	81	24	[illegible]	96
B	14	13	15	14	16	15	86	22	25	89
C	17	14	15	14	12	26	79	24	[illegible]	81
D	10	16	15	19	9	30	59	19	15	69
E	9	8	9	8	7	25	64	15	11	45
Average ...	13.2	13.8	13.6	13.4	13.0	25.4	73.4	21.0	28.2	71.[illegible]

Significant difference at P=.05 is 12.4.
at P=.01 is 17.1.

It will be seen therefore that N and NPK gave highly significant increases in the rate of growth over all other treatments.

The amount of fertilizers applied in this case, as in all experiments since the beginning of 1949, were equivalent to: ammonium sulphate 1,088 lbs., superphosphate 922 lbs. and potassium chloride 546 lbs. per acre.

The measurements were taken from the top of a grid resting on a fixed iron peg next to the stool to the last dew-lap of each cane stick. The grid is fitted with two spirit levels. Measurements are done by means of a steel measuring tape and the readings taken to the nearest 1/4 inch, but the totals per stool rounded off to the nearest inch.

Results.

From the time that growth measurements have been started at the Experiment Station some 30 tests have been completed, including the trials already described at Bellamonte. A further experiment some distance away and on a slightly heavier sandy soil gave a significant response to NPK only.

A test at the Experiment Station in field M, consisting of a heavy black loam, was planted to conform to 6 by 6 latin square design and the following treatments applied : O, N, P, K and NPK as top dressings and an additional P as a basal dressing. Here an analysis by the co-variance method gave a significant response to N and NPK only.

At Doornkop, Sprinz section, an experiment on rather old plant cane was carried out with the following treatments: O, N, P, K, NPK, lime and molasses. No significant results were obtained. Young cane on the same section planted on two adjacent plots, one of which received no lime and the other 4 tons of slaked lime per acre about three months before planting, was tested out for responses to N, P, K and NPK, but in neither case had these any significant effects. This Doornkop area is part of the mist-belt soils. A test on old ratoons on a mist-belt soil at Inanda gave a significant response to N and NPK, while K was found significantly better than P.

The following experiment was carried out on a red recent sand on the farm of D. Ackerman, Ginginдhlovu:—

Treatment :	C.	N.	P.	K.	NP.	NK.	NPK.
Mean increment in inches	51.6	67.4	51.2	52.4	68.4	70.6	65.5

The spectacular increases due to nitrogen and nitrogen combinations are evident. N, NP and NK are significantly better than C, P and K. The treatment NPK fails in significance due to poor growth and damage to two stools.

At Chaka's Kraal Experimental Farm six growth measurement tests were carried out. Four of these tests were done where a field trial had shown significant nitrogen responses. In all four cases the growth-rate method gave similar responses. In one of these tests different levels of nitrogen were applied and the results were as follows :—

Nitrogen as lbs. ammonium sulphate per acre ...	0	544	1,088	[illegible]
Mean increment in inches	160.0	188.4	215.3	[illegible]

All the differences between treatments are significant.

The other two tests were done as a result of leaf analyses. It was found that nitrogen in leaves was high in one case and low in the other. Growth measurements showed no responses in the first test and a response to nitrogen as a top dressing in the second case. At Powerscourt no response was obtained from nitrogen in a rapid test and a field experiment also failed to show such a response.

Growth measurement tests therefore agree very well with field experiments and also with leaf analyses as far as nitrogen is concerned.

Tests were carried out in three areas where phosphate field trials were in progress and where phosphate responses were obtained. . At both Gingindhlovu and Powerscourt the growth rate method gave increases due to the application of P and more so to NPK; but none of these results was significant. The results of the Gingindhlovu tests were :—

Treatment :	C.	N.	P.	NP.	NPK.
Mean increment in inches	49.0	52.0	61.3	66.1	78.2

Some interesting growth tests were done at the third centre, Compensation, on cane that was about a year old. Different levels of superphosphate were tried out, but there was no significant difference between the control and any of the levels. The results were as follows :—

Lbs. Superphosphate per acre	0	461	922	1,844
Mean increment in inches	49.8	48.5	50.1	58.4

In a trial consisting of the following treatments, O, N, P, K and NPK, however, the NPK dressing gave a highly significant response and was the only treatment that resulted in a real increased growth. It may be mentioned that phosphate concentration was very low in the leaves and that the nitrogen per cent. leaf was also low. These percentages were somewhat increased by phsophate and nitrogen dressings, but not nearly to the extent as when the NPK treatment was applied. The following combinations were then tried out, O, NP, NK, PK and NPK, and the results were as follows :—

Treatment :	O.	NP.	NK.	PK.	NPK.
Mean increment in inches	42.5	64.0	49.4	43.5	61.3

Significant differences : 13.28 at P= .01 and 9.64 at P= .05.

Now, both NPK and NP were significantly better than any other treatment. In this experiment under the then existing conditions it is clear that a top-dressing of superphosphate, or ammonium sulphate or potassium chloride by itself gave no responses, but either NP or NPK gave significant responses.

After this field was cut and the whole experiment top-dressed with 200 lbs. of ammonium sulphate, a growth test was again done. The cane was then about six months' first ratoon. In this test N, P and K and all their possible combinations were tried out as well as precipitated calcium phosphate, which was originally used by Evans. The same amount of precipitated calcium phosphate (922 lbs. per acre) as superphosphate was used. The results of the experiment were as follows :—

Treatment :	C.	N.	P.	Px.	K.	NP.	NK.	PK.	NPK
Mean increment in inches.	44.6	40.2	69.5	69.4	43.4	78.2	41.4	72.4	81.5

Significant differences : 22.8 at P= .05 and 30.7 at P= .01.

The effects of P and its combinations are clearly shown. It can also be seen that there is no difference in the experiment between results obtained from superphosphate and precipitated calcium phosphate, headed Px.

When the field trial was cut a significant response to a top-dressing of superphosphate was also found; but it seems very doubtful whether this result would have been obtained had the dressing of ammonium sulphate not been given.

Unfortunately, due to the long distances involved, it was not possible to conduct such a detailed investigation on the Powerscourt and Gingindhlovu experiments; but it has been demonstrated how useful such tests can be. Phosphate responses can certainly be obtained by this method and the fact that initial tests failed, even with very high dressings of superphosphate, shows that responses could not be obtained at that stage because of a lack of something other than phosphate—in this case nitrogen. The growth measurement tests have therefore complemented the field trial and rendered information which the latter in its present form could not provide.

In a burning-trashing-fertilizer field trial in field G2 at the Experiment Station it was noticed that some of the burnt plots were exceedingly poor. Leaf analyses gave a strong indication of potash deficiency amongst other things, but there were no potash deficiency symptoms. Growth tests were then conducted on two such plots (plots 16 and 23) and on a third trashed plot, No. 20, where potash was high and the growth excellent. In the latter plot no potash response was found, but a highly significant response to N and NPK. In a similar experiment in plot 23 there were responses to N, K and NPK. In the third test in plot 16, different levels of potash were tried out with the following results :—

Potassium chloride lbs. per acre	0	150	300	450
Mean increment in inches	35.0	50.0	61.2	50.2

Significant difference : 16.29 at P=.01 and 11.98 at P=.05.

The potash deficiency might have been created artificially by removing the tops of the cut cane from the burnt plots.

Areas in which potash deficiency is obvious are not common in the sugar belt and, when such a field was found at Mtunzini, where visual symptoms and leaf analyses pointed to a deficient supply of potash, a field trial was put down and a growth test done on some adjacent cane rows. The field trial showed a highly significant response to potash. The growth-rate experiment, however, gave no such response, but a highly significant increased growth-rate was obtained from a dressing of ammonium sulphate. The effect of nitrogen was not tested out in the field trial; but the potash results appear at first sight contradictory and a response was expected in both cases, although there happened to be no deficiency symptoms in the cane used for the growth test. The leaves of all plots in the field trial and the different treatments in the growth trial were analysed and this provided a full explanation of the responses obtained. The analysis of the growth-test samples revealed the cane to be very low in nitrogen and the potash content high in comparison to most control plots in the field trial. In fact the control plots in the field trial became more normal in potash content the nearer they were to the growth trial; and this was also reflected in the yields. Further investigation has therefore completely explained an apparent contradiction.

A growth experiment was put down in the Kearsney area, where potash deficiency was again apparent. Here stools showing actual deficiency symptoms were used and, although the experiment was carried out very late in the season, a significant response was obtained from the potash application and, although it was no longer the most active growing period, the symptoms in the younger leaves disappeared soon after the K dressing was applied. The whole field was then treated with molasses ash and when last seen looked really well.

A number of experiment results have been given in detail and others have just been referred to. The detailed results of tests not yet recorded in full are given in the following table. The results given under the treatments are the mean actual increments in inches per stool of cane after fertilizer application; or in a few cases the mean adjusted increments, † and * signify significance over control at P=.01 and P=.05 respectively. The fertilizers used were equivalent to :—

A: Ammonium sulphate 300, superphosphate 300 and potassium chloride 150 lbs. per acre.

B: Ammonium sulphate 1,088, superphosphate 461 and potassium chloride 273 lbs. per acre.

C: Ammonium sulphate 1,088, superphosphate 922 and potassium chloride 546 lbs. per acre.

TABLE OF RESPONSES.

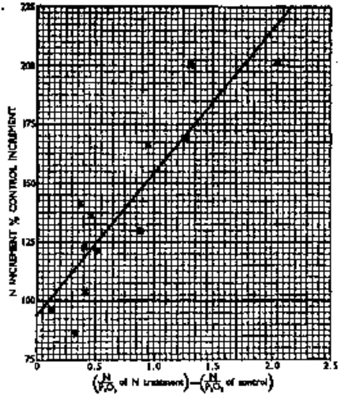
Locality.	Soil or formation.	Amount of fertilizer	Approx. age of cane.	C.	N.	P.	K.	NPK.
Bellamonte, Umhloti	Recent sands ...	A	12 P	34.8	36.2	38.4	29.4	41.0
" "	" "	A	13 P	66.2	47.4	42.0	40.8	78.2
" "	" "	B	14 P	43.4	56.7*	40.2	41.9	63.7†
" "	" "	B	14 P	61.0	116.6*	66.6	65.0	92.1*
" "	" "	B	15 P	91.5	109.6	99.0	90.2	133.7*
Experiment Station M_1...	Black clay loam ...	B	5 P	317.6	359.0*	360.0	318.3	373.8*
" " Ghost Plot 20 ...	Black dolerite ...	B	8 R	109.0	142.1†	114.4	102.1	160.0†
" " Ghost Plot 23 ...	" " ...	B	3 R	31.8	63.6†	46.2	55.0*	79.2†
Chakaskraal Experimental Farm	Dwyka loam... ...	B	6 R	143.8	209.0*	145.4	189.6	229.8*
" " " " ...	" "	B	6 R	85.2	161.2†	24.8	46.2	126.2†
" " " " ...	" "	B	6 R	141.4	180.4†	152.6	121.8	213.4†
Compensation	Recent sands ...	B	13 P	42.6	45.8	45.0	43.8	78.4†
Powerscourt	Mist-belt soil ...	B	15 R	29.4	25.7	32.6	33.6	38.1
Doornkop	" "	B	16 P	44.5	48.2	45.6	42.8	49.0
Doornkop—limed	" "	C	7 P	245.0	210.6	219.9	260.0	221.4
Doornkop—not limed	" "	C	7 P	214.4	208.4	225.4	168.8	202.2
Inanda	" "	C	8 R	47.2	58.0*	41.6	54.8	58.6*
Chakaskraal Experiment Farm ...	Dwyka loam... ...	C	7 R	29.2	48.8†	27.3	29.2	45.4†
" " " " ...	" "	C	8 R	65.2	66.8	61.8	69.4	73.2
Mtunzini	Recent sands ...	C	8 R	33.6	68.0†	27.6	32.4	72.6†
Kearsney	T.M.S.	C	6 P	36.2	43.8	26.6	46.6*	56.4†

The age of the cane is given in months, P stands for plant cane and R for ratoon.

Leaf Analyses and Growth-rate Tests.

This paper does not deal with leaf analysis as such, but it has been referred to, and has often offered an explanation of the results obtained. Unfortunately leaf analyses have not been done systematically for some of the earlier experiments. Leaf analyses have been done on composite samples of the various treatments in 15 growth-measurement tests. Phosphate and potash responses have not been found often enough to attempt correlations. Nitrogen responses have been more common, but of course the experimental material, cane, varied, in age and variety and the samples were not all taken during the same months or seasons. All these factors affect leaf composition. It is therefore somewhat surprising that, in spite of these causes of variability, a highly significant correlation coefficient, r= —0.6651, is obtained for the 15 comparisons between per cent. leaf nitrogen of the control stools, on the one hand, and the growth-increment of the nitrogen-treated stools expressed as a percentage of the corresponding growth-increment of the control stools on the other. If we exclude the two tests where phosphate deficiency apparently prevented the nitrogen dressing to take full effect, the correlation coefficient rises to —0.7326. It is, however, not necessarily only the nitrogen content of the leaves that controls the response to nitrogen, but often the nitrogen/phosphate ratio, and it is possible that this ratio is less sensitive to age and perhaps variety and may tend to a constant with well-balanced nutrition. The correlation coefficient between percentage nitrogen response and the nitrogen/phosphate ratio of N treatments, less the nitrogen/phosphate ratio of controls (excluding 3 negative values), is 0.8902 for 12 comparisons and is highly significant. The regression equation becomes: $E=93.7+60.558X$, where E=increment of N stools per cent. increment of C stool; X= (nitrogen/phosphate ratio of N) — (nitrogen/phosphate ratio of C.)

The following figure illustrates this relationship. Similarly a highly significant correlation co-efficient of 0.8116 for 10 comparisons is obtained between increment of NPK treatments per cent. C increment and the N/P_2O_5 ratio of NPK less N/P_2O_6 ratio of C. Here again negative results, which probably indicate phosphate responses, are excluded, as are also tests where significant K responses were obtained.



Conclusions.

The growth-rate method is quite simple, but it does entail a considerable amount of work. It is, however, a relatively rapid method of ascertaining possible deficiencies in a field and the responses to fertilizers. The tests are generally, and can always be, carried out on young cane and the results obtained can be applied to the field to improve the crop. If these tests are of practical use in showing responses so soon that corrective measures can be applied in the field to benefit the crop, it is of even greater importance in a general programme of soil fertility research. It can be used in conjunction with field trials, as has been shown, and, together with leaf analyses, which it must often follow, it becomes a most useful tool in elucidating points of interest.

It is carried out during the best growing season, not only because the quick growth reduces the relative error in measurement, but also because the cane is then most sensitive to plant-food shortages. The result is that large responses are often found which tend to overcome the rather high experimental error of the method.

Summary.

The growth-rate method of determining fertilizer reponses in sugarcane which was proposed by Evans has been tested out at the Experiment Station. After preliminary experiments the method was altered and standardised to suit our conditions. The quantities of fertilizer used have been increased and the randomised block design based on initial increments is now used. The results are obtained by a statistical analysis of the increments in growth after fertilizer application.

About 30 experiments have been completed. In general there was good agreement between field trials and this rapid technique where such comparisons were made. Apparent contradictions could be explained after further investigation.

Leaf analyses done on some of these tests proved instructive. Certain correlations found between nitrogen per cent. leaf as well as the nitrogen/phosphate ratio and nitrogen response are given.

The method is considered a useful tool in research and the results can also be applied directly in the field.

Acknowledgments.

The writer wishes to acknowledge the co-operation of fanners and managers of the estates where the tests were done. Special thanks are also due to Mr. W. O. Christianson, who pioneered these tests at the Experiment Station, and to Mr. K. E. F. Alexander, who was very largely responsible for carrying out the later experiments.

REFERENCES.

[1]Evans. H. (1942): An Investigation on Physiologica Methods of Determining Nutrient Deficiencies in Sugarcane Annals of Botany VI, No. 23, 413.

Experiment Station,
South African Sugar Association,
Mount Edgecombe.
March, 1950.

The PRESIDENT said that this was a very attractive method of determining fertilizer requirements of sugarcane, of direct appeal to growers, and it had been worked on for a long time.

When the Experiment Station first considered carrying out experiments of this kind, letters were written to various parts of the world in an endeavour to obtain information as to what work had been done on these lines. At first very little help was forthcoming, and even the Department of Agriculture in Washington could give no suggestions for carrying out the necessary measurements. Fortunately Dr. Evans, of the British Colonial Service, formerly of Mauritius and now of Trinidad, who had done a great deal of work of this kind, paid us a visit, and as a result of his help we were able to go ahead with experiments in this matter.

Mr. PHIPSON enquired if there were any standards by which one could tell if a cane was being sufficiently nourished.

Mr. DO TOIT replied that such standards had not been established in this country. Except for knowledge obtained from Mauritius and Hawaii, where they had certain standards, we had no information to go on. However now, with this knowledge, and with the help of growth rate experiments, we had been able to get closer to establishing standards by which to judge the results of leaf analysis here. At this stage he could give no definite rules, but at least low values, indicating cases where responses could be expected, could be found. Results depended on the leaf taken for the test. In the tests mentioned the third youngest leaf was used.

The PRESIDENT remarked that with application of large quantities of nutrients to sugarcane and plants in general, one found what was known as luxury intake. Not unlike human beings, for instance, if a plant found more food than it required available to it, it would take in more food.

Mr. DU TOIT agreed that to a certain extent luxury intake might take place in sugarcane. As far as nitrogen was concerned however, it was not certain that the plant would keep on absorbing it and the leaf rise in percentage indefinitely. In the paper he had quoted one case of potash deficiency where the leaf of the young plant shewed abnormal potash and nitrogen contents, so that what appeared to be luxury consumption of one element might well be symptomatic of a deficiency in another.

The PRESIDENT asked if the author would comment on the rather large quantity of fertilizer required for these tests, as compared with the ordinary field dressing.

Mr. DU TOIT pointed out that the first experiments carried out with small dressings did not give the expected response, although Dr. Evans had successfully used similar quantities. We were looking for a method which would give results, and if possible, spectacular results. This was a diagnostic method, and not a means of finding the correct amounts to use as field dressings. The quantities used in the tests were applied to small areas and not over the whole field, so that it was not certain that all the roots of a particular stool could get at the fertilizer. There was also competition from adjoining cane, adjacent stools shewing obvious benefit from the dressings applied to the stool tested. Another reason for adopting the heavy dressings was that no depressing effect was found.

The PRESIDENT believed that experiments in Hawaii showed that benefit from the fertilizer treatment applied to one plot extended to the adjoining three rows in the next plots. In a field experiment carried out at Chaka's Kraal it was found that, at pre-war prices, 600 lbs. of ammonium sulphate per acre gave the maximum profit, but later, when the price increased, 400 lbs. became the most profitable dressing. 800 lbs. gave the maximum yield, but a still heavier dressing showed a definitely depressed yield. Similarly, dressings of more than 1,200 lbs, of superphosphate showed a depressing effect, particularly in certain phosphatic soils, but not so regularly as in the case of ammonium sulphate.

Mr. DU TOIT said it was realised that, while the concept of diminishing returns operated and one could even get depressing effects, there was generally a large latitude. The law of the minimum had also to be considered, as was illustrated in the one experiment where no response to phosphate was obtained until nitrogen had been supplied.

Mr. PEARCE enquired of the President the period over which the field experiment with ammonium sulphate was carried on, and if this period included drought years. It was possible during a drought that the concentration of salts in the soil could reach such a density that the root system of the plant was precluded from taking up other nutrients besides nitrogen, and that this caused the depressing effect.

The PRESIDENT replied that the experiment was started during the early part of the war and finally ploughed out in 1946. At least two crops showed the results he had mentioned. One of these grew during a drought period, but he did not think this applied particularly in the case of the other crop. The results were recorded in our 1946 Proceedings.

He thought the depressing effect might be due to the acidity resulting from the use of ammonium sulphate. While it had been found that repeated dressings of 1,200 lbs. had not been able to affect the acidity of that particular soil very much, later tests had shown that the use of heavy applications of ammonium sulphate did begin to affect the acidity, and this would have to be taken into consideration when further experiments of this nature were carried out.

Mr. DU TOIT said that Mr. Pearce had brought up a very important factor, and that was moisture. A drawback to the field experiment run over two years was that, while the whole period was not dry, part of it might be too dry. Moisture, of course, also came under the law of the minimum.

Mr. PEARCE described a rough experiment in which applications of 600, 800 and 1,000 lbs. of ammonium sulphate were made to plant cane. The treatments were given some months ago and since then there had been a considerable amount of rain. Now there was definitely much greater growth shewn by the 1,000 lb. treatment.

Mr. CHRISTIANSON drew attention to the fact that the discussion had veered away from the heavy applications used in the growth-rate experiments to heavy field dressings. It should be remembered, as the author had pointed out, that these growth-rate experiments were qualitative tests and were not designed to determine economic field dressings. One would not expect to find a depressing effect in these tests, because they were carried out in the summer period when there was usually plenty of rain, and when maximum growth took place.

CO-ORDINATION IN SOIL CONSERVATION

By J. F. TWINCH, (Soil Conservation Officer, A. E. & C. I. Ltd).

The passing of the Soil Conservation Act in 1947 made it possible for tremendous progress to be made in the protection of our soils from erosion and exhaustion, our veld from mismanagement, and the agriculture, so vital in this country, from eventual collapse. It is a doubtful point whether people in South Africa are "soil-conscious" or not; it is to be hoped that they are.

A general understanding of the advantages of soil conservation is not sufficient; how many people are aware of and understand the various aspects of soil conservation? These aspects embody the protection of (1) our soil from wash, from exhaustion and from incorrect use; (2) our veld from overstocking, unscrupulous burning, from being ploughed up and generally mismanaged; (3) our forest areas from abuse and fire; (4) our watersheds and natural storage areas from any form of exploitation.

It is not the object of this paper to deal with all these aspects in detail; the primary concern is the co-ordination of these conservation measures into a sound fanning programme. These many aspects of soil conservation cannot be considered apart from one another. While they each constitute an important entity, no large scheme can ever be a success without co-ordination; and the agriculture of South Africa is large and vitally important to the population.

It is too often the case that farms suffering from soil loss by erosion and fertility depletion from too severe a cropping programme are contoured, but no co-ordinated plan is laid out. The result is that soil loss is checked but fertility depletion continues. Farmers are inclined to regard contouring as something akin to magic. Contouring alone is not sufficient and the contours themselves must be carefully planned and well constructed. If not, the results can be disastrous. In some cases agricultural lands cannot be contoured and sterner measures have to be applied.

Consider the soil conservation measures applicable to agricultural land; the stabilisation of the soil by strip-cropping, contouring and correct tillage. By slowing down the run-off of storm water the farmer automatically minimises the danger of floods. Then there is the maintenance of fertility by prevention of wash and by the rotation of crops and the more difficult task of building up the fertility by ley farming and by correct fertilisation.

The correct preparation of agricultural land means the correct use of agricultural implements. According to present-day standards, the faster a land can be prepared then the more efficient is the implement. Whilst speed is desirable in agriculture, the preparation of light soils, for instance, with the wrong implement may result in the pulverising of that soil —a most undesirable and dangerous state of affairs. Farmers should give more consideration to this idea of "the right implement for the right soil."

The pastoral side of our agriculture is concerned with the careful management of our veld so that the stocking rate is in proportion to the carrying capacity. Veld deterioration upsets the running of the farm by forcing the farmer to draw from his agricultural areas food that should be produced on the grazing areas. In veld management veld types must be fenced off and managed so as to give maximum returns; this is achieved by timely grazing, mowing, resting and burning if necessary. The protection of watersheds and vleis is essential for effective water conservation, while the afforestation of suitable areas should be a part-time task for all farmers.

These aspects, considered as a co-ordinated whole, give us our farm plan; a farming programme based and managed on correct land use. Correct land use is the foundation of stable agriculture and this concept of farm planning aims at the prevention of the damage caused by incorrect land use.

The compiling of a farm plan is no easy task; it is one that entails a thorough investigation of the whole farm. All the factors mentioned above are taken into consideration and soil samples taken to determine the value of the ground.

In the aerial photograph lies the first step in farm planning, for it is from the aerial photo that the farm can be quickly and reasonably accurately mapped. It is the aerial photograph that provides the bulk of the detail and the relative position of everything on the farm. Once the skeleton of the map has been completed it remains for ground surveys to be done in order to classify the land. Land is classified according to various standards. American classification ranges from Class I land, which is near-level ground requiring no conservation measures—soil good—to Class VII land, which is wasteland requiring protection purely for the conservation of water and preservation of wild life. Other information that should be on the map is the size of all arable areas, grazing paddocks, plantations, and so on; also the pH value of all arable lands. This last is a useful guide to correct crop selection for a certain soil type or an indication of what treatment is necessary in 'order to create suitable conditions for crops not tolerant of acidity,

A farm plan drawn up in this way determines the farming policy and ensures the safekeeping of the natural resources. In some cases the implementation of a farm plan of this kind is very difficult because of previous mismanagement. In some cases of severe erosion large areas of a farm are rendered economically useless for the period required for their rehabilitation, but eventually these areas must fall into the overall plan.

I am not suggesting that this detailed type of farm plan is necessary for the sugar farmer; nevertheless it would be a most useful contribution to the efficient running of the farm. Aerial photographs are easily available and not very expensive. We might perhaps develop a technique 'whereby we could demark areas of the same size for rotation purposes, roads and railways could be mapped, and in general better co-ordination maintained on the farm.

This concept of co-ordination in conservation is very important to those of us who are concerned with soil conservation in Natal, and especially Umvoti County. This is an area of high rainfall and a watershed area supplying water to the coastal areas where the cane is grown. Soil conservation is, therefore, a primary concern to you, even if you are concerned only with what could be classed as a soil-stabilising crop. The stabilisation of agriculture in an area like ours can only be made possible by the co-operation of all farmers and the co-ordination of soil conservation practices.

In Umvoti the rainfall is high and heavy storms frequent, the soils are erodible and the topography steeply undulating. We therefore have a great deal of bad erosion. This is due mainly to the fact that land has never been classified and land that should never be used for annual cultivation has been under the plough for many, many years. We are fortunate in being in an area where grass is both easy and profitable to grow and much of this land that should not be ploughed is being established to pasture. The planning of farms according to correct land use is progressing slowly and we hope that farmers soon will all be conscious of the advantages of these farm plans and not regard them as an imposition and a threat to their independence. We would like you to have the water from our catchment areas, but we begrudge you the soil from our lands.

The PRESIDENT said that the sugarcane crop was a heavy one with a large root system, and where contour cultivation was properly carried out the land was not so vulnerable to soil erosion as was the case with other crops. There were cases where contour cultivation was not done, but these were not so much in evidence as they were years ago.

However, it should be remembered that while the total area of sugar estates in South Africa was some 700,000 acres, only 350,000 acres were under cane at any one time. That meant that at least half the land was under grass or other crops, or being fallowed, while probably another 40,000 acres were under cane in the first stages of growth. Thus there were nearly 400,000 acres of land as much subject to erosion as any in the country, and to this the author's advice and remarks fully applied.

In the sugar industry the benefit to be derived from aerial photographs was realised to some extent, and they were becoming more and more used, not only for survey purposes, but also to enable the cane grower to get a better picture of the progress of his farming operations.

Mr. TWINCH said that he had not realised that there were some 400,000 acres not under cane.

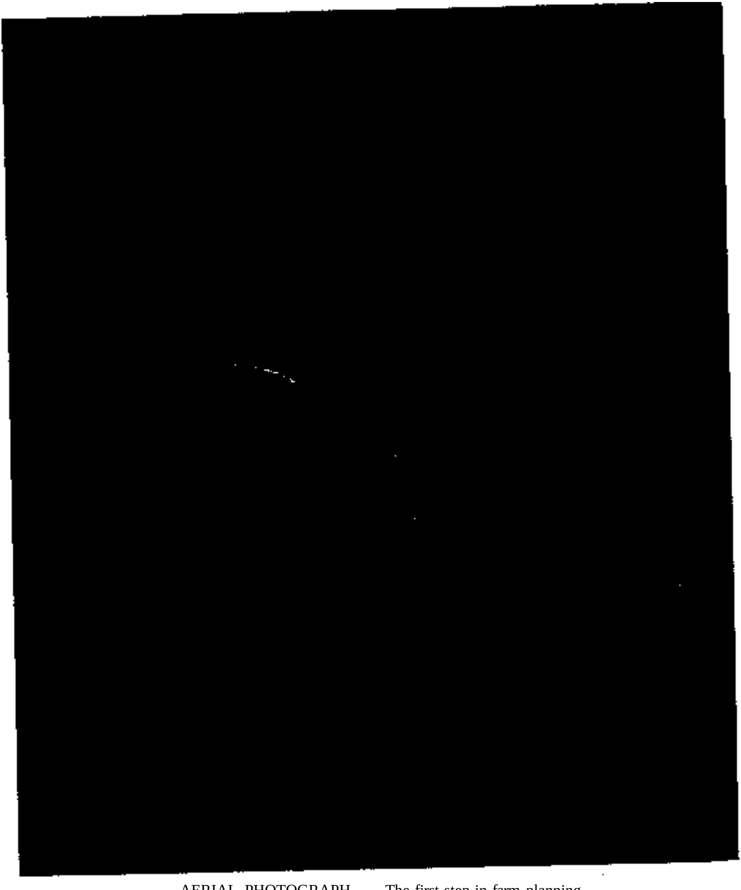
Dr. BATES considered that, to be effective, soil conservation must be general, and he would be interested to know what organisation existed in South Africa for handling the subject on a national scale.

Mr. TWINCH informed the meeting that the only national organisation was the Government's Extension Service. The country was divided up into conservation areas, each area being considered as a separate entity, and this constituted the overall planning under the Department of Agriculture. The field officers such as himself went on to the farms and worked out the details with the farmers.

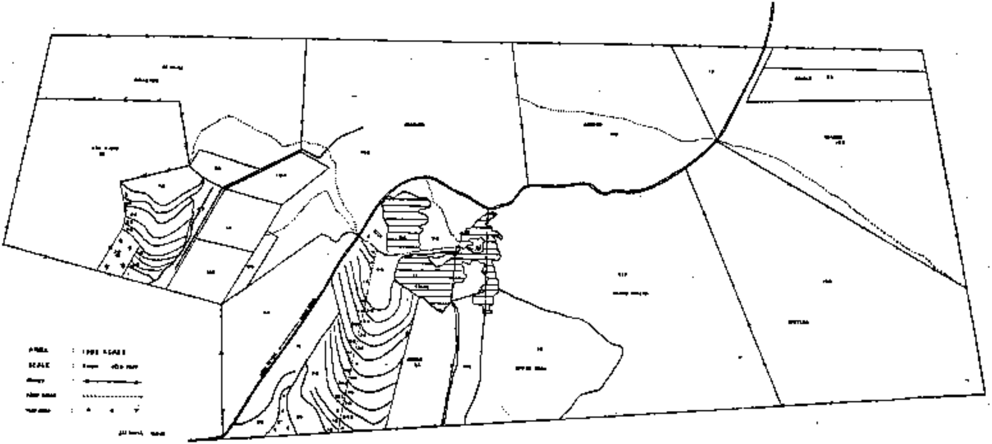
In reply to a question by the President, he stated that his firm had an agricultural advisory staff of seventeen, of which nine were in the field and scattered over the country. He was the only one stationed in Natal.

Mr. DU TOIT wished to know what help the Government offered the farmer through its Extension Service; how many conservation districts there were; if there were local committees which drew up a co-ordination plan to which all farmers had to adhere, and if any necessary surveying was done free of charge.

Mr. TWINCH replied that there were 207 conservation districts of varying size scattered over the country. Each was controlled by a district committee and the Government Conservation Officer was an ex-officio member, but was instructed by this committee. Surveying had to be done by a Government surveyor and was free of charge. A farmer, not in a conservation district, could get a



AERIAL PHOTOGRAPH. The first step in farm planning.



FARM PLAN. Drawn up from aerial photograph and ground surveys.

33 1/3 per cent. subsidy with a maximum of £50 for conservation earthworks; but if he were in a proclaimed district he could obtain a 50 per cent. subsidy. In the case of his firm there was no subsidy involved, and the fanner was under no obligation whatever, but on the other hand he must do all work at his own expense.

Dr. BATES was happy to say that in Rhodesia practically the whole of the European farming zone was split up into Intensive Conservation Districts.

Mr. TWINCH pointed out that of the 80 students who qualified with himself in South Africa, 25 went to Southern Rhodesia.

A THIRD SERIES OF INSECTICIDE TESTS AGAINST THE ELEGANT GRASSHOPPER

By. J DICK.

In an account of insecticide tests against the elegant grasshopper, *Zonocerus elegans* Thnb., presented to this Association at last year's congress, attention was drawn to some disappointing results obtained from a brand of benzene hexachloride dusting powder which was stated by the makers to contain 2 per cent of the gamma isomer of benzene hexachloride. Further tests have now been carried out in an attempt at discovering why this material caused a significantly lower mortality than Bexadust. The latter contains 5 per cent. technical benzene hexachloride and is advertised as containing not less than 0.5 per cent. of the gamma isomer, the actual amount of this isomer being generally between 0.6 and 0.65 per cent.

In a preliminary trial, carried out in November 1949, sets of 100 hoppers of *Z. elegans* were dusted at a rate equivalent to about 12 pounds per acre with new samples of the two dusts and with dust which had been kept for a year in the original containers, eight replications being carried out for each treatment. The mortality after five days is shown in Table I, in which the powder stated to contain 2 per cent, of the gamma isomer is referred to as BHC 2 per cent.

TABLE I.

Mortality per hundred hoppers after five days.

Cage No.	Control.	BHC 2 per cent, old.	BHC 2 per cent. new.	Bexadust, old.	Bexadust, new.
1	1	36	78	100	100
2	1	43	65	100	100
3	3	19	67	99	100
4	2	11	79	99	100
5	2	46	76	100	100
6	5	40	59	100	100
7	5	51	70	100	100
8	1	41	77	100	99
Totals... ...	20	289	571	798	799

Significant difference between totals: 59.3 at 19 to 1.
80.0 at 99 to 1.

It will be noticed that the old Bexadust is just as effective as the new, while the old BHC 2 per cent. is significantly less effective than the new. However, the powders were not stored under controlled conditions and the following experiment was therefore designed to discover whether comparable results would be obtained when samples of the two dusts were allowed to age under the same conditions.

Samples consisting of 50 c.c. of each of the powders were spread out over an area of 400 sq. cm., giving a mean thickness of 1.25 mm., and were exposed to the atmosphere under the same conditions. The powder was stirred at weekly intervals to expose new surfaces, one sample of each material being kept for two months and another for one month.

Sets of 100 hoppers each were then dusted with the equivalent of about 12 pounds per acre of each of the exposed powders and with fresh samples of the same materials, six replications being carried out for each treatment. Figures showing the mortality two days and five days after dusting are given in Tables II and III respectively.

TABLE II.

Mortality per hundred hoppers after two days.

Cage No.	Control.	BHC 2 per cent., 2 months.	BHC 2 per cent., 1 month.	BHC 2 per cent., new.	Bexadust, 2 months.	Bexadust, 1 month.	Bexadust, new.
1	0	0	0	31	31	59	79
2	0	0	0	28	32	52	70
3	0	0	0	39	39	60	61
4	0	0	0	25	49	70	80
5	0	0	0	31	38	61	72
6	0	0	0	32	40	62	74
Totals ...	0	0	0	188	236	364	436

Significant difference between totals: 30.7 at 19 to 1.
41.3 at 99 to 1.

TABLE III.

Mortality per hundred hoppers after five days.

Cage No.	Control.	BHC 2 per cent., 2 months.	BHC 2 per cent., 1 month.	BHC 2 per cent., new.	Bexadust, 2 months.	Bexadust, 1 month.	Bexadust, new.
1	6	9	23	52	95	100	100
2	6	8	38	57	100	100	100
3	2	6	50	52	100	100	100
4	3	8	49	60	100	100	100
5	4	7	38	55	98	99	100
6	5	6	42	56	99	100	100
Totals ...	26	44	240	332	592	599	600

Significant difference between totals: 29.0 at 19 to 1.
39.1 at 99 to 1.

As far as the Bexadust is concerned, the mortality figures for the second day after treatment show that the lethal effect has been significantly retarded by exposure of the powder, especially by exposure for two months. However, the final mortality as shown by the figures for the fifth day after treatment is practically the same for the exposed and the new powder.

With the BHC 2 per cent. powder, on the other hand, the final mortality is significantly lower for the exposed powder than for the fresh, the material exposed for two months not being significantly better than the control.

These results suggest either that the BHC 2 per cent. powder is more readily decomposed than the Bexadust, or that the gamma benzene hexachloride content of the former is not as high as it is claimed to be. A rough estimate of the total benzene hexachloride content of the two powders was arrived at, as described below, and would appear to explain the anomalous results.

Weighed samples of the two powders were heated to about 300°C. for two hours. This was thought to be sufficient to drive off practically all the benzene hexachloride, which has a boiling point of 218°C. at atmospheric pressure. After being allowed to cool, the samples were weighed again. The Bexadust was found to have lost 6.09 per cent. (by weight) on heating, while the other BHC powder had lost only 3.32 per cent. The decrease in weight would include a certain amount for loss of moisture, but this amount would probably be nearly the same for the two powders, which had been stored under the same conditions. As far as Bexadust is concerned, the loss in weight is consistent with the stated benzene hexachloride content.

When the powders were heated, the benzene hexachloride was given off as a white cloud of smoke. It was noticed that the smoke given off by the Bexadust was considerably greater in quantity than that given off by the other powder. If the gamma isomer content of this powder is 2 per cent., the total benzene hexachloride content should be between 15 and 20 per cent., and the loss of weight on heating should be considerably greater than the figure obtained. It would appear, therefore, that this powder is considerably lower in benzene hexachloride content than it is claimed to be.

The results of the tests against the elegant grasshopper would then be explained as follows. Even after exposure to the atmosphere for two months, Bexadust still contained sufficient active material to kill practically all the hoppers.. The other powder, however, containing less active material at the start, no longer contained enough to be effective after two months.

In the course of these observations a certain amount of information was collected on the nature of the diluents used in the preparation of the two benzene hexachloride powders. This information does not now appear to have much bearing on the results of the mortality tests; nevertheless it is summarised here for reference.

The inert carrier used in the preparation of Bexadust is stated to be talc. Its specific gravity, after heating to remove the benzene hexachloride, was found to be 2.64. Information on the carrier used in the other material not being available, the substance was analysed by Mr. Beater, and it was found to contain silica (as SiO_2) 58 parts, and alumina (as Al_2O_3) 31 parts per hundred, these figures being consistent with the composition of a clay of the kaolin type. The specific gravity of this carrier was found to be 2.56.

Microscopic examination of the two powders was carried out by dusting equal quantities of each on to glass slides and measuring the diameter of all particles in the field of view, the slide being moved until 1,000 particles had been measured for each sample. The results are tabulated in Table IV. The figures for the smallest particles may be inaccurate, as particles may have been present which were too small to be observed under the magnification used.

TABLE IV.

Range of particle size in carriers.

Diameter of particles in microns.	Number of particles BHC 2 per cent.	Number of particles Bexadust.
Up to 0.35...	31	16
0.35 to 0.70	117	33
0.70 to 1.05	374	102
1.05 to 1.40	171	82
1.40 to 1.75	106	77
1.75 to 2.10	56	71
2.10 to 2.45	35	68
2.45 to 2.80	23	95
2.80 to 3.15	24	122
3.15 to 3.50	35	154
3.50 to 5.25	16	94
5.25 to 7.00	7	47
7.0 to 10.5	3	18
10.5 to 14.0	2	9
14.0 to 17.5	—	4
17.5 to 21.0	—	2
21.0 to 24.5	—	2
24.5 to 28.0	—	1
28.0 to 31.5	—	1
31.5 to 35.0	—	1
35.0 to 42.0	—	1
Mean diameter in microns ...	1.57	3.33

Thiophos and Aldet Insect Powders.

A test was also carried out to compare the toxicity to *Z, elegans* of Aldet insect powder and Thiophos (Parathion) agricultural dusting powder with that of Bexadust. Aldet insect powder is stated to consist of 5 per cent. DDT and 2.5 per cent. benzene hexachloride in a talc carrier. It probably contains about 0.3 per cent. of the gamma isomer of benzene hexachloride. The Thiophos dust used contained 1 per cent. Parathion (o, o-diethyl o-p-nitrophenyl thiophosphate).

Sets of 100 hoppers were dusted with Aldet insect powder, Thiophos and Bexadust, at a rate equivalent to 12 pounds per acre, eight replications being carried out for each treatment. Figures showing the mortality after one day and after five days respectively are given in Tables V and VI.

TABLE V.

Mortality per hundred hoppers after one day.

Cage No.	Control.	Bexadust.	Aldet.	Thiophos.
1	0	14	43	82
2	1	27	19	83
3	1	17	40	84
4	0	15	36	86
5	2	25	32	80
6	1	22	26	76
7	0	25	26	75
8	1	16	56	71
Totals	6	161	278	637

Significant difference between totals: 64.0 at 19 to 1.
87.1 at 99 to 1.

TABLE VI.

Mortality per hundred hoppers after five days.

Cage No.	Control.	Bexadust.	Aldet.	Thiophos.
1	2	100	100	100
2	5	100	100	100
3	4	100	100	100
4	4	100	100	100
5	6	100	100	100
6	3	100	100	100
7	5	100	100	100
8	7	100	100	100
Totals	36	800	800	800

Significant difference between totals: 6.8 at 19 to 1.
9.3 at 99 to 1.

These figures show that Thiophos is more rapid in its action, Aldet being intermediate in this repsect between Thiophos and Bexadust. The final kill obtained after each treatment, however, was the same, each insecticide causing a mortality of 100 per cent. of the hoppers.

As Thiophos is toxic to man, and can be absorbed through the skin, the makers advise that the following precautions should be taken when it is being applied:—

Do not get on skin, in eyes, or on clothing.

Wear protective clothing and goggles.

Do not breathe dust or vapours; wear a respirator.

Keep away from food or food products.

Wash hands, arms and face after handling and before eating or smoking.

Acknowledgement.

My thanks are due to Mr. B. E. Beater for analysing and determining the specific gravity of materials used as carriers in the benzene hexachloride dusts tested.

Summary.

An account is given of a number of laboratory tests on insecticides against the elegant grasshopper. Disappointing results obtained with a particular make of benzene hexachloride powder are explained as probably being due to this material not having as high a content of the gamma isomer as is claimed for it. In one experiment Bexadust (a powder containing 5 per cent. technical benzene hexachloride), Aldet (a powder containing 5 per cent. DDT and 2.5 per cent. technical benzene hexachloride) and Thiophos dust (a powder containing 1 per cent. parathion) each killed all the hoppers.

Experiment Station,
South African Sugar Association,
Mount Edgecombe.
February, 1950.

The PRESIDENT wished to know if the two benzene hexachloride insecticides mentioned in the paper were of local manufacture. Apparently a good deal depended on the length of time benzene hexachloride was stored, and this was a serious drawback when one wanted to use it, perhaps, very occasionally. It was remarkable that of the four forms of benzene hexachloride, only one, the gamma form, was useful as an insecticide. All four had the same chemical composition in the sense that their molecular constructional differences could not be shown on paper, for being differences in the spatial arrangement of the atoms around the benzene nucleus, they could only be explained with solid models.

Dr. DICK replied that both of the benzene hexachloride insecticides were of local manufacture. He did not think that benzene hexachloride decomposed very rapidly on storing. The Bexadust form kept well for a year and was then nearly as effective as the new material. Even when exposed to the atmosphere for two months, it was still effective, but the other material could not stand exposure to the same extent.

The four forms of benzene hexachloride known showed differences in specific gravity and in boiling point.

Mr. BECHARD asked whether the insecticides were applied to the hoppers, or their food, or to both.

Dr. DICK said that both grasshoppers and their food were dusted. The substances used were all contact insecticides, but while benzene hexachloride was a stomach poison as well, it was usually employed as a contact insecticide, which meant that one had to hit the insect with it. This was quite easy to do in the field. The hoppers were dusted shortly after they had hatched out, when they clustered together in little groups in the early morning and in the evening. It was a simple matter to apply one puff of dust to each group, and this was all that was required.

Mr. BECHARD considered that there was less chance of the insecticide deteriorating if it was in the form of a material that was always being used by farmers such as "Dubble Benhex."

Dr. Dick stated that this substance was designed as a dip for animals, but, while he had not tested it on these insects, the active agent was the same benzene hexachloride, and it would probably be as effective in this liquid form.

The PRESIDENT pointed out that as the boiling point of benzene hexachloride was 218°C, it must be volatile to some extent, as glycerine, which had a similar boiling point, was slightly volatile at ordinary temperatures.

He enquired to what extent D.D.T. was volatile. This substance, being much more complicated in chemical constitution, he would not expect to be as much so as benzene hexachloride.

Dr. DICK considered that D.D.T. was not volatile to the same extent. The residual effect of D.D.T. used as a spray seemed to last a long time. He had had some beds in the native compound painted with this spray, and could still see the deposit of white powder two years later.

INVESTIGATIONS ON SUGARCANE BREEDING IN NATAL DURING 1949

By P. G. C. BRETT.

The past season has been a successful one for sugarcane breeding and for the first time more seedlings were raised than could be planted in the Experiment Station fields. This success was due partly to the good results obtained in increasing pollen fertility and partly to plenty of inflorescences being available for crossing. Although adversely affected by drought later on, the season on the whole was a good one for flowering, and the special breeding plots planted several years ago in different areas proved their usefulness by supplying many of the tassels used for crossing.

Experiments on increasing Pollen Fertility.

A method of increasing pollen fertility by keeping under artificial conditions cut canes that were going to flower has been described previously.[1,2] In the first experiments on this work, temperature, day-length and humidity had all been increased, but an increase in the daylength was later on found to be unnecessary. From the results obtained during the last season it would appear that increased humidity also is not essential, for just as successful results were obtained in the one cubicle in which the humidity was not increased as were obtained in the other three cubicles which were made more humid by steam. From these results it would appear that temperature is the only factor which limits the formation of fertile pollen of sugarcane in Natal.

Varieties differ fairly considerably in the way they react to the artificial conditions under which they are kept after cutting. All show a certain amount of injury, but in some this is very slight. The damage is usually less if the canes root quickly in their surrounding tins of compost and hence soon cease to depend upon the preserving solution for their water supply. No inflorescences emerged when cut canes of the varieties N:Co.291, N:Co.310, Co.301 and Co. 432 were kept in the solution only, though at least some canes of all these varieties flowered when they were given the opportunity of rooting. A few varieties are apparently so slow in rooting or react so severely to the preserving solution that the tassels are usually all killed: no inflorescences emerged in an experiment with three canes of P.O.J.2725 and six of a seedling from a cross between N:Co.79 and Glagah. The canes of this seedling were found to have been attacked by *Thielaviopsis paradoxa*,

TABLE I.

The Effect of Warm Conditions on the Fertility of Pollen of Sugarcane.

Date experiment started.	Variety subjected to warmer conditions.	Number of inflorescences, Total.	Failing to emerge.	With slight dehiscence.	With good dehiscence.	Number of cross in which tassels used. (Refer to table 2)	Fertility of tassels in the field.
May 8 ..	N:Co.310	3	—	2	1	4	Anthers with only a few and badly distorted pollen grains and some disorganised tissue.
May 25 ..	Co.301	18	8	—	10	7	No starch-filled pollen grains found.
June 1 ..	N:Co.310	12	6	5	1	15	No starch-filled pollen grains found.
June 3 ..	N:Co.291	6	—	6	—	—	No starch-filled pollen grains found.
June 3 ..	Co.432	6	3	—	3	17	Dehiscence occuring, but distinctly less than that of treated canes.
June 22-29 .	Co.331	18	1	—	17	19, 20, 21 25, 28, 30	On August 8th, when some treated canes were dehiscing, no starch-filled pollen grains were found, but by Sept. 13th all tassels examined had some pollen grains with starch, though no dehiscence was seen.
June 29 ..	Co.290	6	1	—	5	32, 34	No flowering occurred.
July 12 ..	Co.312	12	7	—	5	29	Pollen grains large, abnormal and without starch—perhaps really aborted pollen mother cells.
July 12 ..	Co.421	12	9	—	3	27	Some pollen grains as for Co.312; others of normal size but also without starch.
August 8 ..	Co.356	12	3	—	9	31, 33	Dehiscence occurring, but distinctly less than that of treated canes.

a fungus responsible for the "pineapple" disease of sets after planting and normally not attacking growing canes. In the case of Uba, only one of four embryonic inflorescences developed so far as to start emerging, but it showed no starch-filled pollen grains and died soon afterwards. In all the other varieties subjected to treatment at least some of the tassels emerged fully and in these at least a few anthers were found to have dehisced; the fertility of all the inflorescences that emerged appeared to have been increased by the treatment. These results are summarised in Table I. In these experiments the thermostats were usually set so that the cubicles would start heating as soon as the temperature fell to 70°F., although in the first experiment with N:Co.310—started on May 5th—the minimum temperature was set for 75°F. *(See Table 1 on p. 1.)*

The fact that Co. 421 was induced to form fertile pollen is interesting, as at the cane-breeding station of Coimbatore in India—where sugarcane normally shows very good fertility—this variety can be used as a female only, though it has been reported to produce viable pollen under increased daylength.[3]

At the same time as eighteen canes of Co. 301 were put into cubicles with their minimum temperatures set for 70°F., six canes of this variety were put into the main part of the glasshouse, which received no heat except through such leakage as there was from the cubicles, and another six were put outside. In each of the two groups of six canes only one inflorescence completely failed to emerge though the others took longer to develop than those kept in the cubicles. Of the five inflorescences to emerge outside only one showed any pollen grains filled with starch, and in this one the number of such pollen grains was very small. In the field, too, most inflorescences appeared completely sterile, only a few having any starch-filled pollen grains. This similarity in fertility of the tassels in the field and those from the cut canes placed outside the glasshouse indicated that the method of preserving the cut canes did not in itself have any effect on fertility. Of the inflorescences that emerged in the main part of the glasshouse four showed fair dehiscence and one profuse. Although fertility in these inflorescences was not as high as in those which had been kept in the cubicles—where all that emerged showed profuse dehiscence—there was nevertheless a marked increase in fertility compared with tassels from the field. Although no attempt had been made to heat the glasshouse, there were fairly marked differences between the temperatures inside it and those in the field. The minimum screen temperatures for the period May 26th to July 11th, i.e. from the start of the experiment until the time when all the inflorescences to emerge were fully expanded, were 53°F. for the average minimum and 48°F. for the absolute minimum. There were not enough thermometers for complete records to be kept in the main part of the glasshouse but, during a period of nine days, the minimum temperatures averaged nearly 4°F. higher than those of the screen, while the maximum temperatures averaged just over 11°F. higher than those of the screen.

Replacing the phosphoric acid of the preserving solution by a mixture of mineral nutrients, or by mineral nutrients and sugar, was tried when the varieties Co.312 and Co.421 were subjected to treatment. These substances seemed to interfere with the uptake of solution by the cut canes, possibly because of the impurities they contained. Though rather few inflorescences emerged, all that did so showed good dehiscence irrespective of the solution in which they had been kept.

Temperature and Flowering in Sugarcane.

The production of fertile pollen by inflorescences of Co.290 subjected to treatment is probably of less interest than the actual emergence of the inflorescences in the first place. Co.290 rarely flowers in Natal; the embryonic inflorescences which sometimes form nearly always fail to develop properly, and eventually die while still enclosed within their surrounding leaf-sheaths. This happened during the last season in the plot from which the canes used in the experiment had been taken; in fact, the only tassels seen of this variety last year were the five that emerged in the cubicle—one of the original six canes had been dissected before emergence—though two of these had some imperfectly developed branches.

Earlier flowering of canes in the cubicles compared with those in the field has been noticed several times in the past, and this suggests that temperature is the factor limiting the rate of development in the field. In the case of the variety Co.290 it appears that field temperatures lie below not merely the optimum, but the minimum temperature necessary for floral development. As this factor seems to limit not only pollen fertility but also the development of inflorescences, it is possible that it is responsible as well for the relatively small amount of flowering in this country. In an experiment with Co.312, there were found to be only embryonic inflorescences—less than an inch long—in two canes dissected nearly two months after being put into one of the cubicles. These canes had had to be selected in the field at rather an early stage of development. It seems likely that in selecting them a mistake was made and two canes were taken which had not at the time started to flower but which began to do so after being put into one of the cubicles. This of course does not imply that the canes would not have started to flower it left in the field, but it indicates that the artificial conditions to which the canes were exposed did not in themselves prevent the initiation of flowering. One attempt was made to induce flowering by keeping cut canes under relatively warm conditions. Twelve shoots of the variety Uba Marot were put into one of the cubicles on September 2nd, that is to say at a time of year when the length of day was—or soon became—what is usually regarded as correct for the initiation of flowering in sugarcane. The minimum temperature of the cubicle was set for 70°F. The only effect of the treatment, however, was greatly to stimulate vegetative growth.

Although this experiment gave negative results, it is intended to continue with work on these lines; the effect of temperature—especially night temperature—upon the flowering of plants is well-established, and there is some evidence that it may account for the distribution of flowering in sugarcane in Natal. Flowering of sugarcane in this country is on the whole rather poor, at any rate in comparison with tropical parts of the world. It is usually most profuse close to the sea, becomes sparser inland and eventually ceases altogether at the higher altitudes. In contrast to this apparent effect of high altitude decreasing flowering, there is a tendency for the sugarcane within a given area to flower more readily on the hillsides than in the valleys below. These effects would be explained if the temperatures over the whole cane-belt lay fairly close to the lower limit for flowering, only rising above this limit close to the sea and on the hillsides further inland, and falling below it in the other parts of the cane-belt with their colder nights. It is interesting that in some tropical countries, such as Java and Puerto Rico, it has been found that flowering is more profuse at higher altitudes.[4] If this effect is produced by the same cause, it would mean that the temperatures capable of producing good flowering lie within rather narrow limits.

It is generally believed that the length of day favourable for the initiation of flowering in sugarcane is about twelve hours. Except near the equator, periods of this day length occur only at the time of the two equinoxes, and it might be expected that each period would be followed by a distinct flowering season. This is not so in Natal, nor apparently, in other parts of the world. It is interesting that profuse flowering seems to occur after the autumnal equinox only, that is to say after the equinox with the higher temperatures.

Some Effects of Drought on Flowering.

The most obvious effect of drought upon flowering is to reduce its intensity. This appears for the most part to be due to many of the embryonic inflorescences—which are apparently far more susceptible than growing points in the vegetative state—being killed by the unfavourable conditions. It is possible that drought may also prevent the actual initiation of flowering. It would seem, however, that apart from preventing the initiation of inflorescences or killing them after their formation, drought may also cause their reversion to vegetative growth. That it can do so was suggested by the following occurrence.

Sets of a seedling from a cross of N:Co.310 with Amu Darya were planted in a drum on November 11th, 1948. The soil was allowed to dry out almost completely between the 16th and 18th of April, 1949, by which time flowering had started. The whole stool was severely damaged; tassels which had already emerged were killed. On May 13th a shoot was noticed whose topmost—and fully-developed—leaf did not enclose any younger leaves. This shoot did not, however, show the usual indications of flowering such as shortening of the blades and elongation of the sheaths of the upper leaves. On dissection a malformed embryonic inflorescence was found which looked as if it would either fail to develop further or give rise to a so-called "bunch-top." This is an abnormality in which the single terminal growing-point is replaced by a number of buds, and these, continuing to grow, eventually give rise to a thick cluster of leaves at the top of the stem. By May 28th this type of leaf-cluster was beginning to emerge from the youngest leaf-sheath of one abnormal shoot, and in another the bunch-top condition was found after dissection. The only other shoot not in the typical vegetative condition was, one showing the usual signs of flowering, and a normal inflorescence was found within the enclosing leaf-sheaths. No bunch-tops were found in this variety in the field, but it had stopped flowering before the drought of last season became severe.

When the variety collection at the Experiment Station was examined on October 26th, 1949, by which time the severe drought of the preceding months had broken, many dead embryonic inflorescences were found in many varieties. C.P.29/116, C.P.34/118 and C.P.29/103 showed in addition to dead or unhealthy-looking inflorescences, a bunch-top condition of some of the shoots. N:M.37, N.M.51, P.O.J.36M and P.O.J.213 all showed some abnormal shoots similar to those of the seedling of N:Co.310 and Amu Darya and, on dissection, they too were found to contain bunch-tops at an early stage of development. This type of abnormality had not been seen anywhere in the field before the drought became severe.

It would seem that the bunch-top condition is produced because an embryonic inflorescence has a number of growing points, and when drought causes a reversion from flowering, many of them give rise to vegetative growing points. This reversion to vegetative growth has apparently some effect on the upper leaves, which do not develop the characteristics of leaves subtending an inflorescence.

It is interesting to contrast this behaviour with that of cane attacked by the disease known as "smut," for then the last-formed leaves usually resemble those of a flowering cane. It has been suggested that the "whip" produced in this disease is the product of a malformed inflorescence, first initiated and then attacked by the smut fungus. This suggestion is probably wrong, for whip and inflorescence are distinct even in their embryonic stages. It may be that, although the fungus does not produce a flowering hormone, it does form a growth substance which is similar to that made by the developing inflorescence and which, amongst other things, causes elongation of the sheath and shortening of the blade.

TABLE II.

List of Crosses made during 1949.

Cross No.	Parentage.	No. of female inflorescences.	Number of Seedlings. Germinated.	Transplanted.	Planted in field.
1 & 3	N:Co.79 × (N:Co.310 × Amu Darya) ...	2	1200	519	300
2	N:Co.310 × (Co.205 × Glagah)	1	400	258	199
4 & 16	N:Co.79 × N:Co.310*	2	700	690	640
5	N:Co.310 × Glagah	2	1100	220	196
6	P.O.J.2725 × Glagah	2	140	137	137
7	N:Co.79 × Co.301*	5	8000	5523	2330
8	N:Co.79 × Co.285...	2	4500	4000	1137
9	N:Co.147 × Co.285	1	3	2	1
10	P.O.J.2803 × Co.285	1	2000	1000	189
11	N:Co.310 × (Co.205 × Glagah)	1	300	211	196
12	P.O.J.2725 × (Co.205 × Glagah)... ...	2	11	12	10
13 & 22	N:Co.310* selfed	4	400	219	200
14	P.O.J.2725 × Co.285	4	900	827	644
15	P.O.J.100 × Glagah	2	4	4	4
17	P.O.J.2725 × Co.[illegible]*	2	1400	1346	701
18	P.O.J.2725 × Co.482	1	0	0	0
19 & 30	Co.421 × Co.331*	6	7000	3354	3453
20	Tuc.2846 × Co.331*	1	0	0	0
21	Tuc.5142 × Co.331*	2	80	76	76
23	Co.421 × Co.285	3	1600	1525	1282
24	N:Co.154 and Co.421 × Co.285	4	650	490	235
25	P.O.J.2725 × Co.331*	2	3000	1751	1482
26	Co.412* selfed	3	1500	318	216
27	Uba × Co.421*	1	8	8	7
28	Co.331* selfed	14	2500	540	439
29	Uba × Co.312*	1	20	19	19
31	Uba × Co.350*	1	30	29	28
32	N:Co.310 × Co.290*	2	20	15	15
33	N:Co.310 × Co.356*	2	10	10	10
34	Co.290* selfed	3	200	182	175
35	Uba × Co.301	1	0	0	0
36	C.H.64/21 × Co.301	3	260	15	15
	Total ...	82	37,425	24,173	13,331

* Pollen fertility had been increased by treatment.

Types of Crosses made.

A list of the different crosses made during 1949 is given in Table II. A few first crosses with Glagah were made again this season; it is hoped that after several further crosses seedlings may eventually be obtained similar in type to the Co. varieties at present grown in Natal but with greater resistance to mosaic. Any *Saccharum spontaneum* "blood" in these Co. varieties is derived not from Glagah—the Javanese form of the species—but from one of the Indian forms, which do not usually impart their own mosaic immunity to their seedlings. Local seedlings from a cross of Co.205 with Glagah were also used in crossing. These seedlings should incorporate some of the characteristics of both the above-mentioned forms of 5. *spontaneum*, as Co.205 is itself a seedling from a first cross with the Indian'form. As Amu Darya—another type of *S. spontaneum*—is believed to impart its cold-resistance to its progeny, seedlings from a cross of this variety with N:Co.310 were in turn crossed with a thicker type of cane although they did not appear to show resistance to mosaic.

Crosses such as those mentioned above are unlikely to give rise directly to seedlings of agricultural value, and in the hope of obtaining more immediate results other crosses involving thicker types of cane were made. The largest number of seedlings planted in the field came from a cross of Co.421 with Co.331, and the seedlings are therefore similar in derivation to the newly released N:Co. varieties and have the same proportions of different *Saccharum* species in their make-up. The next largest number of seedlings came from a cross of N:Co.79 with Co.301, and are therefore derived from the varieties Co.281, Co.301 and P.O.J.2725.

Some crosses were made with forms of S. *stnense,* and a few seedlings from Uba—the inflorescences of which were obtained from the Umzinto district—and C.H.64/21 were raised. More selfings were made during the last season, mostly with the object of obtaining breeding canes.

Not all the seedlings raised could be planted in the Experiment Station fields; about four thousand were planted on the Burnside section of the Natal Estates and many more were discarded. Of 13,331 seedlings planted in the field, 8,793 {or nearly two-thirds) were from crosses in which the fertility of the male parents had been increased by subjecting them to artificial conditions. The practical value of this method of increasing pollen fertility is therefore well-established, and the chief difficulty in raising sugarcane seedlings in Natal would appear no longer to be the poor fertility of pollen in the field, but rather the relatively small amount of flowering that occurs in this country.

Summary.

In Natal temperature is apparently the factor limiting not only the fertility of pollen of sugarcane but also the development of the inflorescences. Although embryonic inflorescences are sometimes formed, Co.290 rarely flowers in this country, apparently because the prevailing temperatures are too low for the proper development of the tassels. Floral development is completed in this variety if cut canes are kept under warm conditions such as have been found to increase the pollen fertility of many varieties. Temperature may also be the factor responsible for the rather small amount of flowering in Natal and for the manner in which it is distributed.

It appears that a severe drought can cause a reversion to vegetative growth after embryonic inflorescences have formed, and that the condition known as "bunch-top" is usually produced in this way.

During the last season seedling raising proved very successful. From 29 different crosses more than thirty-seven thousand seedlings were raised, and thirteen thousand were planted in the field. About two-thirds of these came from crosses in which the fertility of the male parents had been increased by artificial treatment.

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Experiment Station,
South African Sugar Association,
Mount Edgecombe.
March, 1950.

The PRESIDENT said that the paper outlined a very important branch of the work of the Experiment Station. It was now possible to raise a large variety of hybrids from various canes—certainly a far wider range than before.

The variety Co.421, which was doing well in many parts of the world, had proved a failure at the Experiment Station and at Tongaat. In view of its success in other countries, however, it was worth while trying on alluvial flats like Umfolozi, and a small stock was therefore being built up for that purpose.

Mr. RAULT asked if the amount of flowering in canes was a varietal feature, and also what was the effect of the flowering on the cane.

Mr. BRETT replied that the amount of flowering did depend very largely on the variety. Some varieties had never flowered here at all, while others flowered every year.

The PRESIDENT stated that in the majority of modern varieties the cane did not fall off in sucrose after flowering. It did put a stop to growth, however, and if the cane were not big enough to send to the factory it might be a rather serious matter. If otherwise healthy, such canes made very good planting material, but there might be more than was required for such purpose, especially if the particular variety flowered extensively in a particular locality.

Mr. BECHARD said that flowering was a serious matter for the grower, for cane flowered when it was too young to mill and often when only four or five months old. He would like to know of any method whereby flowering could be controlled. It was noticeable that last year when his neighbour's N:Co.310 had all flowered, he had not a single flower in this variety. Furthermore, the experimental farm at Chaka's Kraal showed but little flowering, while all the surrounding carte was in flower.

Mr. DU TOIT said that, as far as sucrose content was concerned, tests showed that flowering, as such, had no effect. If anything it might tend to raise the sucrose slightly. Even cane which had flowered the year before and had side shoots about three feet long was unaffected. However, cane which had flowered might more easily get diseased, and this could bring down the sucrose content very much.

The point raised about the control of flowering was important and should be followed up. Fertilizers might have an effect.

Dr. MCMARTIN thought that Mr.du Toit's reference to flowering leading to disease concerned a certain field of Co.290. This cane was thought to have red rot, but actually what had happened was that some sticks had attempted to flower in their first year of growth. In the second year many of these sticks had died and were not sent into the mill. Others had produced side shoots, thus keeping alive, but at the end of the second year were in a very deteriorated condition, testing only 6 or 7 per cent. sucrose. The cane going into the mill was thus a mixture of one-year-old tillers and the canes which had produced a growth of side shoots. The reported outbreak of red rot was not a disease condition and the low test was a result of flowering.

An important point about the paper was that it indicated the progress of the study undertaken by the author a few years ago on the physiology of pollen formation. This study could have remained one of academic interest only, but it was developing on lines which appear likely to give very good practical results. He considered that we were now witnessing, in the glass-house, the sythesis of varieties likely to come into commercial production in the not-too-far distant future.

Mr. CHRIST1ANSON enquired about the bunch-top, saying that some people claimed that after the fully developed flower had died off, the growing point could grow again.

Mr. BRETT replied that he thought that was not so. The bunch top was merely the growing point subdividing into several shoots.

Mr. PEARCE said that he had found that N:Co.310 cane planted in late December and early January did not flower, while that planted in October and November, in soil which was to all appearances the same, flowered a great deal. Another interesting point was that where there was 100 per cent. of flowering of N:Co.310 at seven months old, there were now none of the original sticks left. They had all died off and the field was now growing only the secondary shoots.

In another field, at the bottom of a valley where the cane was very good, it did not flower, whereas just a few yards away there was profuse flowering. It was difficult to understand why this should be, because both had been irrigated and had had considerable nitrate of soda. The nitrate of soda had been applied in an attempt to stimulate flowering, but seemed to have no effect at all.

He understood that in Hawaii success in inhibiting the flowering of cane had been obtained by applying light about midnight, but he could give no details as to the varieties of cane or the intensity of the light applied.

Mr. BRETT commented that, while the inhibition of flowering by using fight had not been tried, the Experiment Station intended to arrange tests during the next flowering season. He was surprised to hear Mr. Bechard say that cane flowered at four to five months.

Mr. BECHARD was of the opinion that cane planted in October or November, if it flowered at all, would do so in March or April.

Mr. BRETT thought it might be possible to avoid some flowering by planting late. N:Co.310 was particularly inclined to flower early.

Mr. BECHARD pointed out that he planted at the same time as his neighbour, and whereas his neighbour's cane flowered, his did not show a single tassel. Also cane at the experimental farm at Chaka's Kraal showed but little flowering, and he asked if these two facts could be followed up to investigate if there were any cultural methods which could be followed to inhibit flowering.

Mr. GARLAND said the effect of flowering in N:Co.310 was worse than in any other variety, and he strongly advised not planting N:Co.310 in fields where cane flowered badly, especially on sandy soil. As an example, sandy fields which normally yielded 45 tons to the acre would give less with N:Co.310 which flowered. N:Co.310 died after flowering on sandy soils, whereas Co.301 did not.

The PRESIDENT remarked that experience at the experimental farm at Chaka's Kraal showed that N:Co.310 which had flowered heavily had still given a very good yield. He thought a good deal depended on the conditions under which the cane had been grown.

When he was at Canal Point, Florida, floodlighting all night had been tried in order to promote flowering. That had been tried here also, but without definite results. He had read that in Hawaii light had been used under certain conditions to inhibit flowering. That also would be tried here.

The case described by Dr. McMartin, in which Co.290 after showing incipient flowering in the first year, gave a poor crop in the second year, had been repeated on several occasions. That was one of the faults of Co.290. Nevertheless he thought that Co.290 had so many good points that it was well worth keeping, and planters would be well advised to grow small quantities in suitable areas. Stocks were being built up at Chaka's Kraal to see what could be done with Co.290. This variety suffered not only from red rot, which was prevalent only in the mist belt, but because it could not tolerate being kept for three years. Its period of maximum development coincided with the period of overflow production of cane when a good deal of cane was left over for a year or more after maturity before cutting.

Mr. GARLAND said that growers were concerned about what variety they could use to replace Co.281. No variety yet released could do so well on areas affected by drought and where the soil was shallow. It was important that we should have a variety to replace Co.281 for these conditions. In effect, we want a drought-resistant cane for these conditions.

Mr. BECHARD considered that the Co.281 growing at the experimental farm at Chaka's Kraal was superior to any growing in the vicinity of his farm; he also thought that too much interest was taken in N:Co.310, which, apart from a slight tendency to smut disease, flowered young, and came away badly the first year. Co.331 was also not very satisfactory, as it often showed a hollow centre, and also a large percentage of dead sticks was found in the field at cutting time, if at all delayed; he could not say if incipient flowering, as in Co.290, was the cause. That cane was also more intolerant to excessive moisture than was Co.301. He was therefore anxious to know what varieties could replace Co.281 and Co. 301.

The PRESIDENT stated that it had been intended to release three new varieties, N:Co.291, N:Co.339 and N:Co.349, but owing to secondary infection of mosaic disease their release had been delayed. As yet there was not much known of the range of these three varieties, and how far they could replace Co.281 depended a good deal on locality.

Mr. BECHARD said that a high sucrose cane was required in this country because of the high transport costs.

The PRESIDENT agreed with this view, and also pointed out that as high sucrose was associated with high purities, they were desirable from that point of view also.

Mr. BECHARD said, that he was convinced that at equal purities, one-year-old cane yielded its sugar more easily than cane that had stood through more than one winter; he thought that the reason could well be that during the cold months condensation products of sucrose had accumulated in the cells of the cane.

Mr. ELYSEE had had the same experience and said that extraction of sugar by the milling plant became more difficult as the age of the cane increased.

Mr. RAULT had found that when canes were cut at about 12 months old, they produced about 25 tons per acre, as against 40 tons per acre when left to grow two years. It would seem that the second period of growth was a very slow sugar producer.

Mr. PEARCE thought that a figure which would be useful in judging the value of cane from the grower's point of view would be. the number of pounds of sucrose produced per acre for each month of the cane's life. He enquired about the difference in lignin content of cane at 12 months old as compared with four months old.

Dr. MCMARTIN stated he had done some work on the subject, and had found big differences in the proportion of lignified tissues to unlignified tissue between different varieties.

He enquired of the author if it was possible to tell, by splitting up the tops of samples of cane, if there were going to be profuse flowering or not.

Mr. BRETT considered it would be possible, if a sufficient number of sticks were examined, to forecast a few months ahead whether flowering would be profuse or not in a particular field.

FURTHER DEVELOPMENTS IN CHEMICAL WEED-KILLERS

By A. McMARTIN.

In a paper given last year (McMartin[3]), the possible use of chemicals to control weeds in canefields was discussed, with particular reference to the hormone types of weed-killers, and the opinion was expressed that, while there would be many instances in which these materials would be of benefit, there would be many situations in which their use would be restricted owing to the presence of large numbers of weeds not affected by them—in particular members of the grass family.

Similar situations have been experienced elsewhere, and have led to the examination of other chemicals for their toxicity to grasses, with the hope of developing a weed-killer which would have a much wider application than the hormones in areas where the weed flora consisted of a mixture of types resistant and susceptible to these hormones.

In Puerto Rico the problem has been investigated by Crafts and Emanuelh[1,2] who have advocated the control of grasses by means of a fortified-oil spray, to which 2.4.D. may be added to eradicate weeds not affected by the oil. Various formulations of oil sprays have been given by these authors, and recent experimental work undertaken at Mount Edgecombe has mainly been towards the formulation of similar types of sprays with material which is available locally, and the testing of these on our canefield weeds.

The basis of these sprays was the fact that unrefined diesel oil was toxic towards certain plants, but that, as such oil became more and more refined, so its toxicity decreased, and the further discovery that the toxic properties could be attributed to the aromatic substances which' are removed in the refining. Diesel oil, therefore, with its aromatic content increased by the addition of these aromatic substances, forms the basis of one type of spray; but its toxicity is still greatly increased by the addition of sulphur, pentachlorophenol or dinitrophenols. The material used in our trials here has been pentachlorophenol, and the oils have consisted of diesel oil alone, diesel oil-aromatic oil mixtures, diesel oil-paraffin mixtures, and aromatic oil alone. Some mixtures were for use undiluted, while others were used diluted by emulsifying with water; in these latter cases the addition of a stabiliser or wetter, or both, to the emulsion becomes necessary.

Our trials so far have not demonstrated conclusively that the use of aromatic oil alone as the solvent for the pentachlorophenol is better than a diesel oil-aromatic oil mixture, but results appear better for the first few days after the spray has been applied to the weeds, indicating a quicker mortality, if not eventually a larger one. What has been demonstrated forcibly, however, is the necessity of the pentachlorophenol in an oil spray when used dilute as an emulsion, weeds sprayed with such an emulsion without this substance being apparently quite unaffected.

Based on our first trials with these oil sprays, when the use of an aromatic oil alone appear to give quicker results, the following mixture, formulated by Crafts, has been mainly used for further trials and demonstrations :—

4 galls. . . . . oil of high aromatic content
2 lbs. pentachlorophenol
2 lbs.... wetting agent (such as Stanvac wetter)
(Other stabilising and wetting materials are Teepoll and hexylene glycol, used at 1/2 per cent. and 5 per cent. respectively.)

These are mixed and the pentachlorophenol dissolved by applying slight heat. This is then made into an emulsion with 96 gallons of water (a little water should be added to the oil first and emulsified, then the remainder of the water added). This emulsion is used at the rate of 100 gallons per acre, for average conditions, but this may require to be increased or decreased depending upon the nature of the weed cover, the age of the weeds, and other factors. If a hormone such as 2.4.D. is also being used, it can be dissolved in the water which is added to the oil, if the sodium salt is used; but if the amine or ester formulation of 2.4.D. is used it may be added to the oil first. In our experiments all three forms have been used at the rate to supply the equivalents of 1 lb. or 2 lbs. 2.4.D. per acre.

The complete weed-spray as used in our trials, therefore, consists of the fortified oil emulsion plus one form of 2.4.D., and it soon became apparent that the mixture of the two types was greatly superior to the use of either alone in a field of mixed weeds, particularly where grasses and nutgrass occur.

Some species which are tolerant towards the oil spray, e.g., wandering sailor (or pigweed), are killed by the 2.4.D., while species resistant to the latter are affected by the oil spray. Nutgrass, which required 4 lbs. of 2.4.D. alone per acre to destroy the tops, is susceptible to 1 lb. of 2.4.D. in the oil mixture, and most grasses appear to be severely affected.

Sugarcane itself, of course, while unaffected by 2.4.D., is affected by the oil spray; but, if spraying is done when the cane is high enough to have trash forming on the lower joints, the most damage that has so far been noticed under normal spraying conditions in the field has been the production of a few burned spots on some leaves, which are barely obvious. Some stools of cane which as an experiment were thoroughly sprayed were at first completely burned, but the growing points were not damaged and after a few weeks they were completely green again.

Small field trials carried out recently in canefields where the cane has been over two feet high, and where a mixture of blackjacks, ageratum, pigweed, amaranthus, nutgrass, grasses, and many other common weeds have occurred, have indicated that a clean weeding can be done, with practically no damage to the cane, with the oil emulsion used at 100 gallons per acre, plus 1 lb. of 2.4.D.

There yet remain to be discovered, however, the best manner in which these chemical weed-sprays can be employed and the most economical manner of their utilisation; and field techniques would require to be varied according to the weed problem presented to the grower. For example, many broad-leaved weeds are susceptible to a hormone spray alone—pigweed is extremely susceptible and can be eradicated with 1/2 lb. of 2.4.D. per acre—and hence many fields where the weeds are mainly hormone-susceptible could possibly be profitably sprayed with that type of weed-killer alone for a first spray, to be followed up later by a spray of the oil emulsion type, with perhaps a hormone added, which may only require to be used in spots where the weeds are left. As more than one spraying would usually require to be done in any case in a field, it would in such cases be cheaper to use the combined spray only after the weed population had been reduced by the hormone spray—i.e., using the former as a "touch-up" spray.

On the other hand there are situations where an oil spray could perhaps be used without dilution, e.g., in clearing tramlines, ditches, etc., where the weed population often consists mainly of the grass family. So far we have considered only the possibility of these chemical weed-sprays as controls for growing weeds.

A very important aspect of chemical weed control, however, is that which owes its existence to the fact that so many weeds are more susceptible in their earliest stages of germination than at a later date. Many members of the grass family, for example, which are tolerant to the hormone sprays when well established, are affected if some of that material is in the soil in which the seed germinates, and the susceptible broad-leaved weeds cannot produce seedlings from seed in such soil, or young seedlings are produced and quickly die off. The phenomenon has led to the technique known as the pre-emergent spray.

The Pre-emergent Spray,

This promises to be the most important development in the use of chemical weed-killing, and can be used where the crop is one tolerant to the weed-killer used. It consists simply of treating this field after the crop has been planted, but before the weeds have appeared, and it has the effect of permitting germination to occur under conditions of a considerably reduced weed growth. Thus, spraying with 2.4.D. has been found elsewhere to keep germinating fields free from weeds for periods up to eight weeks, without materially affecting the germination of the cane.

Pre-emergent trials carried out here have shown that almost complete freedom from certain weeds has been obtained by spraying the bare ground, and once again the superiority of the mixed oil emulsion-hormone spray over the hormone spray alone has been demonstrated.

The most difficult weed to control appears to be nutgrass, but the numbers which do appear above ground can be considerably reduced by means of a pre-emergent spray; while pigweed, blackjack, ageratun and others can be reduced to negligible proportions. The number of grasses which appear above ground are markedly reduced, and many that do appear are unhealthy.

Pot tests carried out here have failed to show any effect on cane germination of spraying the combined spray on the soil at the rate of 100 gallons per acre.

The possibilities of a technique such as this are considered very promising and field trials along these lines are now being carried out.

Spraying Technique.

The type of sprayer used at present is the knapsack type, delivering a spray under pressure by means of a pump in the sprayer. With the type of nozzle at present in use, i.e., that supplied with the sprayer, only spraying rates using large amounts of spray per acre—100 gallons—have been possible; it is possible, however, to obtain nozzles which give a finely atomized spray and use low amounts of liquid per acre—down to 10 gallons, or less. This saves considerably on the amount of water to be carted, and as far as the hormone spray is concerned the important matter is the amount applied per acre, i.e., 1 lb. or 2 lbs; whether in 10 gallons or 100 gallons is immaterial. The effect of low gallonage concentrated oil emulsion spraying has not yet been tried.

The possibility of pre-emergent spraying of course opens the road to large-scale mechanised power-spraying, and several machines are being placed on the market which are either drawn by, or mounted on, a tractor for this particular purpose, capable of spraying up to 30 feet of ground and using about 10 gallons of liquid per acre.

A complete weed-spraying programme would thus consist of pre-emergent spraying, mechanised where possible, to be followed as required at later dates with spray gangs operating in the cane rows with portable sprays.

Cost of Weed Spraying.

At present it would be premature to give anything but an approximation of the cost of the materials required for weed-spraying.

The hormone 2.4.D. can be purchased for about 8/- per pound from several manufacturing firms; the prices for the fortified oils appear to depend upon several factors, but one interested company has suggested that at present the cost would be just over £1 per acre, so that the combined spray using 1 lb. of 2.4.D. per acre should at present not cost more than £1 10s. Od. per acre, using 4 gallons per acre of the oil. There is thus at the outset this initial cost of material which is not involved in mechanical or hand-labour methods of weeding, and of course there is a capital outlay on spraying equipment.

On the other hand, spraying methods promise to be quick and require less labour than other methods; and in times of labour shortage they might with advantage be used either when available labour cannot cope with the weed growth, or to reduce the number of labour units used in weeding to release them for other jobs.

It is not intended to present a picture of our weed problem completely solved by means of chemical weed-sprays, but it is felt that the results now obtained are sufficiently promising to draw attention to their possibilities and to recommend to growers that where possible they try this method for themselves.

It is with this object that this paper has been written; as several trials are still under observation it has not been possible to write up fully an account of the results.

Thanks are due for supplies of the materials used in making the sprays to Messrs. Shell Chemical Co., Messrs. Standard Oil Co., and Messrs. Cooper and Nephews; and the writer wishes to acknowledge the work done by Mr. N. C. King of the Experiment Station in carrying out the experimental work on this subject.

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Experiment Station,
South African Sugar Association,
Mount Edgecombe.

The PRESIDENT said that chemical weed-killers were becoming increasingly important. Some indication of what might develop was given a few years ago, when the principle of hormone control of weeds was first suggested, although the cost was then prohibitive and the substances known could control only certain types of weeds. We were now, however, in sight of an important economic method for the control of all weeds in cane fields. There were experiments on view in this matter at the Experiment Station.

He enquired if the word "aromatic" had been used by the author in its chemical sense referring to substances such as benzene.

Dr. MCMARTIN replied that the word "aromatic" was used in its chemical sense.

Mr. BECHARD endorsed the President's view of the importance of the subject, stating that with the present shortage of labour, weeding was the biggest problem of the grower. It was illuminating to see what could be done by spraying, and he was particularly interested in the pre-emergent spray. It had occurred to him that the best time to tackle weeds was just prior to ploughing. However, weeds of the type of "water grass" are somewhat fostered by ploughing, and he enquired if that type of weed and also the "wild gooseberry" could be controlled by the pre-emergent spray. He also wished to know what quantity of spray would be required in a heavy growth of weeds. The control of weeds in the line, in particular, was a very big problem.

Dr. MCMARTIN replied that in the case of "water grass" he thought that the better technique might be to plough it in and then spray. He had found that with this method a considerably smaller amount germinated. As far as the wild gooseberry was concerned, results had not been quite conclusive with 2.4.D, although the weeds were considerably reduced.

Opinions differed as to whether it was advisable to spray the rows of cane themselves, or in between the lines where machines could be used for weeding. If one wished to economise it might be better to spray in the lines only, although he considered the best method would be to use a pre-emergent spray followed by spraying in the rows.

The quantities of spray indicated in the paper were calculated on the area of ground covered, but when there was a very dense, rank growth of weeds, more would be required. This could be balanced, however, by using less where the weeds were young and succulent.

Dr. BATES asked how long the pre-emergent spray remained effective.

Dr. MCMARTIN said that he had no data about the particular spray mixture he now used, but with 2.4.D as used in Hawaii and Louisiana it was said to keep the field clean for eight weeks. He did not know how often it would be necessary to spray again after that time had elapsed.

Mr. DU TOIT stated that he had seen a reference to the sucrose yield from cane in Cuba being increased by the use of 2.4.D. It had been found that when cane had been sprayed with hormones some ten days before cutting, the sucrose content had been increased by between 1.8 and 2 per cent. on cane. Experiments along such lines here would be useful. Hormones, after all, were growth regulators.

The PRESIDENT pointed out that the original application of hormones was made with a view to stimulating normal growth, and their effect in producing other and excessive stimulation was a secondary development.

Dr. MCMARTIN said that in field trials there appeared to be a certain amount of stimulation of growth in some weeds that were left. When "water grass" was sprayed, the few plants which came up afterwards were of a darker green colour.

Dr. BATES drew attention to the difficulty of ridding spraying equipment of these hormone chemicals. There was a certain amount of danger in using spray apparatus for other purposes, after use with these substances.

Dr. MCMARTIN agreed with this view and stated that plants often shewed peculiar symptons, but in cane they would be safer than in general use, or for market gardens.

He had experienced difficulty in obtaining a small sample of the ester form of 2.4.D. The suppliers were exercising some caution before putting this form on the market, because of its volatility. One could visualise that if spraying was done with this form in the vegetable garden, and the vegetables died, chemical weed-killers generally would be given a bad reputation.

ABSTRACT OF PAPERS

TWENTY-FIFTH ANNUAL SUMMARY OF CHEMICAL LABORATORY REPORTS

By H. H. DODDS and J. L. DU TOIT.

Although the average rainfall for 1949, 43.35 inches, was above normal, the cane crop was adversely affected by the deficient rainfall in 1948 and an abnormally dry winter season during 1949.

During the 1949-50 season 4,929,580 short tons of cane were crushed to make 561,122 tons of sugar with a ratio of cane to sugar of 8.79.

The average sucrose of the cane was 13.52 per cent. with a peak of 14.45 per cent. in September. The fibre content was exceptionally high and averaged 16.19 per cent. The mixed juice purity, 86.22 compared favourably with the average over the past 10 years.

Co.281 formed 47.3 per cent of the crop and Co.301 41.9 per cent. Co.331 and N:Co.310 have increased to 4.2 and 2.6 per cent. respectively.

The average extraction for the season was 92.94 per cent. and the reduced extraction 94.78. Boiling house recovery was high at 89.68 and the overall recovery 83.35 per cent.

Of the 18 factories reporting, Tongaat Sugar Co. had the highest crushing rate, 159.25 tons of cane per hour. There were two other factories crushing more than 100 tons per hour and two factories had a crushing rate of less than 30 tons per hour.

The average yield of cane per acre for the 1948-49 season was 26.80 tons and the Inanda district led, as usual in Natal, with 31.58 tons of cane per acre.

SOME NOTES ON THE PRINCIPLES OF OUR MANUFACTURING PROCESSES

By K. DOUWES-DEKKER.

As a first example of a deviation from the normal manufacturing sequence—clarification, concentration, crystallization—the mid-sap carbonatation process is described. In this process, which was developed and put into practice in Java, the partly clarified raw juice is concentrated to 40-45° brix and subsequently more thoroughly clarified by the double carbonatation process. Next the juice is concentrated to syrup. By this method, based on the principle that at a higher concentration more non-sugars are removed per unit weight of brix, with about two-thirds of the amount of lime usually required for the carbonatation of mixed juice, a higher rise in purity and a corresponding increase in recovery was attained.

Next the Bach process is mentioned as an example of the combination of two chemical purifications and the centrifugal separation of syrup and molasses, as an example of the addition of a physical purification to the normal (chemical) clarification. Although a considerable amount of precipitated non-sugars can be removed from syrup by centrifugal separation, a still greater amount is likely to precipitate during the subsequent crystallization process. Therefore, in order to improve the properties of the last boiling, and to facilitate the separation of sucrose crystals and final molasses, centrifugal separation of second molasses is more effective and easier to apply than separation of syrup.

The principle of high-density clarification is also applied with superior results in the refinery. In this case, however, good use is made as well of purification by recrystallization. Since the usual juice clarification methods give rise to a limited increase of the purity of the juices, and since the purity of the crystals is closely related to the purity of the mother liquor, it is unlikely that without recrystallization the purity level of first class refined sugar can be attained.

Finally, the preference for continuous manufacturing processes is discussed. Continuous subsides are mentioned among the best known examples of this type of apparatus, and attention is drawn to the rotary filters, which, although continuous, are in some respects unsatisfactory.

One of the best studied clarification processes is the. de Haan carbonatation. The evolution of continuous tanks, allowing strict adherence to the requirements of this process, is discussed.

SOME NOTES ON THE FUNCTIONING OF SULPHUR TOWERS

By P. J. LAUBSCHER.

This paper is a report of the tests done on sulphur towers generally used in sugar mills for absorbing sulphur dioxide in limed mixed juice, by passing the latter down the towers countercurrently to the stream of gases from sulphur burners.

The design of the towers and the methods of operating them at three factories are described.

Efficiencies of the sulphur towers was determined by a gas analysis method and pH values of juice from the towers was recorded. The efficiency of sulphur dioxide absorbtion was found to be high, averages being 94 per cent., 99.8 per cent. and 99.9 per cent., for the three towers worked on, but fluctuations from the optimum pH of sulphured juice aimed at are high, varying between 4 and 9, 6 and 11, and 5.9 and 7.2. Such fluctuations are undesirable for good work.

OLIVER-CAMPBELL BAGACILLO

By L. F. CHIAZZARI.

Certain shortcomings of the Oliver-Campbell filter have long been realised. Among the most common are:—

(1) Poor mud retention,

(2) Turbid filtrates,

(3) Introduction of new impurities and, concomitant with all these,

(4) Undesirable recirculation.

With this in mind, laboratory tests were conducted on the lixiviating of the bagacillo filter medium generally used, and it was found that two digestions of 75 minutes duration each in an abundance of water limed to a pH of about 9, with a final digesting in pure water, greatly improved the quality. In fact the treated bagacillo became a filtering aid rather than just a filtering medium.

Samples of scum were then mixed with treated and untreated bagacillo to average factory proportions, filtered, and the filtrates analysed for purity and colour. It was found that a higher purity and a greatly improved clarity of juice were obtained from the treated bagacillo as compared with that from the untreated material. The average of 15 analyses showed an improvement of 0.8° in purity and 18.0 in light absorption, with maximums of 1.76 and 28.0 respectively. The removal of colour and turbidity was very apparent and a clear, sparkling juice frequently obtained.

A PROGRESS REPORT ON SOME CLARIFICATION PROBLEMS OF NATAL CANE JUICES

By G. C. DYMOND.

The author shows that the addition of small quantities of sodium carbonate to cold raw cane juices results in a decrease in hardness and in lime salts.

Further, a new clarification process is described, in which the juice is sulphited to 3.2 pH in the clod. A precipitate settles out which contains high percentages of cane wax, silica, and other non-sugars. Experiments are in progress to deal with this refractory precipitate. The liquid • decanted off is neutralised with lime, heated and settled, when a second precipitate is obtained. This acid preclarification process, it is stated, results in valuable wax recovery, with beneficial effects in sugar manufacture.

SOME INDUSTRIAL APPLICATIONS OF ELECTRONICS

By A. F. MCCULLOCH.

This paper is of a descriptive form and is concerned with the apphcations of electronic techniques in the industrial field.

In the opening part of the paper, the author gives an elementary description of the most common types of electronic components such as thermionic and gas-filled diodes and triodes, photo-electrical cells and cathode ray tubes. The detecting, amplifying, rectifying and other characteristics are illustrated.

The second part of the paper is devoted to a description of the methods of utilising these characteristics in a number of typical circuits which have been applied to industrial control and measurement problems such as continuous dimension gauging, control of liquid levels, temperature, moisture content and electrical motor performance, turbidity measurement, chemical analysis by polarographic methods, the protection of machinery against tramp metals and the automatic control of machine tools.

Mention is made of the precautions needed where high input impedance occurs, such as in the pH meter, to ensure that reliable measurements are obtained.

NITROGEN AND DRAINAGE

By O. W. M. PEARCE.

A brief review of the processes which make nitrogen available to plants is made, together with some of the factors which influence these processes.

The application of large amounts of nitrate nitrogen in a commercial fertilizer is often uneconomical, as this form is readily leached out of the soil by heavy rains.

While organic matter should be conserved, ploughing into the soil sugarcane trash with a carbon: nitrogen ratio of 80 to 90:1 may result in the following plant cane crop suffering from nitrogen starvation for a considerable time. In some soils, relatively rich in organic matter, it might be advantageous to burn off the trash, and, after a short fallow, add nitrogen by application of a commercial fertilizer.

Legumes, through the action of symbiotic nitrogen-fixing bacteria, may add to the soil as much as 200 lbs. of nitrdgen per acre, provided the land is well prepared to allow their root systems to be adequately supplied with air. The use of leguminous green manure crops for certain conditions is advised.

Drainage is all-important, as poorly drained soils are usually deficient in nitrogen because of the action of anaerobic denitrifying bacteria present in the oxygen-deficient environment. Various types of drains are used in the South African sugarcane fields and their advantages and disadvantages are listed.

The author gives reasons for preferring the French drain, even though it is more expensive to construct than the other types. The materials used for this type of drain in the cane fields are brushwood, stones or bamboos, sealed by an overlay of trash with a final covering of *2 1/2* feet of earth.

The use of French drains in a certain area resulted in an estimated yield of 35 to 50 tons of plant cane per acre, compared with the previous plant cane crop of 10 to 15 tons per acre when this area was served by shallow surface drains.

GROWTH RATE METHODS FOR DETERMINING FERTILIZER REQUIREMENTS

By J. L. DU TOIT.

The total height of each of 30 to 40 cane stools was determined, the measurement repeated after a month and the stools arranged in blocks according to the determined growth rates. The necessary treatments, e.g. O, N, P, K and NPK, properly randomised and replicated, were then applied and the growth increments resulting from these treatments determined after a further month and statistically analysed.

About 30 experiments were carried out and, in general, there was good agreement between the rapid technique and field experiments. Apparent contradictions could be explained after further investigations.

Leaf analyses proved instructive. Certain correlations found between nitrogen per cent. leaf, as well as nitrogen/phosphate ratio of the leaf and nitrogen responses are given.

The tests entail a considerable amount of work, but are considered useful in research and the results can be applied directly in the field.

CO-ORDINATION IN SOIL CONSERVATION

By J. F. TWINCH (Soil Conservation Officer, A. E. & C. I. Ltd.)

Planned agriculture is the co-ordination of all aspects of soil conservation into a sound farming programme. Soil conservation, as a general term, embodies the protection of (1) our soils from wash, from exhaustion and from incorrect use; (2) our veld from overstocking, unscrupulous burning and from being ploughed up and generally mismanaged; (3) our forest areas from abuse and fire; and (4) our watersheds and natural storage areas from any form of exploitation.

These aspects, considered as a co-ordinated whole, give the farm plan—a farming programme based and managed on correct land use. Correct land use is the basis of stable agriculture, and this concept of farm planning aims at the prevention of the damage caused by incorrect land use.

The initial essential in farm planning is the classification of the land and the subsequent* use of the land in accordance with its capabilities.

The use of aerial photographs in farm planning still remains an insufficiently used asset. Farms can be accurately and quickly mapped from aerial photographs and, besides this, the farm can be carefully studied, eroded areas isolated, veld types differentiated, and stock and water facilities investigated. This is merely a fraction of the information that the photographs provide for both the farmer and the planner.

A THIRD SERIES OF INSECTICIDE TESTS AGAINST THE ELEGANT GRASSHOPPER

By J. DICK.

An account is given of tests with a" number of insecticides against the elegant grasshopper, *Zonocerus elegans.*

The effect of exposure to the atmosphere for one or two months, on Bexadust (a powder containing 5 per cent, benzene hexachloride, and at least 0.5 per cent. of the gamma isomer), and another powder stated by the makers to contain 2 per cent. of the gamma isomer, was investigated. Although exposure slowed down the action of Bexadust, the final kill produced by powder exposed for one or two months was as high as that produced by fresh material. With the other powder, exposure not only slowed down the action but considerably reduced the final kill. Even fresh samples of this powder were not as effective as Bexadust.

A rough estimate of the total benzene hexachloride in the two powders suggests that the powder stated to contain 2 per cent, of the gamma isomer does not actually contain this amount.

Some information is given on the inert carriers used in the preparation of these powders.

In an experiment in which the toxicity of Aldet (a powder containing 5 per cent. DDT and 2.5 per cent. technical benzene hexachloride) and Thiophos dust (a powder containing 1 per cent. parathion) was compared with that of Bexadust, all these insecticides killed 100 per cent. of the hoppers, Thiophos being the most rapid in action, with Aldet intermediate between Thiophos and Bexadust.

INVESTIGATIONS ON SUGARCANE BREEDING IN NATAL DURING 1949

By P. G. C. BRETT.

Further work on the effect of different factors upon sugarcane pollen fertility had indicated that the usual male sterility of tassels under Natal conditions is due to one factor only—low temperature. By subjecting canes to warm conditions before flowering, pollen fertility was increased in nine varieties, all except the variety N:Co.291 having some tassels with good dehiscence. Dehiscence in the variety Co.421 was of particular interest, as this variety is reported to be male sterile under the tropical conditions of the cane-breeding station at Coimbatore.

The effect of warm conditions was also found to hasten the time of emergence of the tassel and, even in the case of the variety Co.290, to enable this emergence—which does not normally occur in the field—to take place.

The importance of low temperature in producing these effects in the field suggests that this factor may also be responsible for the relatively small amount of flowering in Natal and for the manner in which it is distributed; it is sparser at the higher altitudes inland, but within a particualr area tends to be more profuse on the upper part of hillsides than in the valleys below.

It appears that a severe drought may not only prevent the initiation of flowering, but if this has already occurred, may even produce a reversion to vegetative growth, resulting in the condition known as "bunch top".

Partly because of the relatively large amount of flowering, and partly because of the good results obtained in increasing pollen fertility, seedling raising during the last season proved very successful.

From 29 different crosses more than 37,000 seedlings were raised, and 13,000 were planted in the field. About two-thirds of these came from crosses in which the fertility of the male parents had been increased by artificial treatment.

FURTHER DEVELOPMENTS IN CHEMICAL WEED-KILLERS

By A. MCMARTIN.

In a paper given to this Association the previous year, the opinion was expressed that the use of selective weed-killers of the hormone type would be restricted by the presence of resistant weeds in large enough numbers to create another weed problem; this, in Natal sugarcane fields, would be the case where large numbers of grasses were present and chemical control was attempted with weed-killers which suppressed only broad-leaved weeds.

Trials have now been carried out with 2.4.D. mixed in fortified oils, as recommended by Crofts and Emanuelli in Porto Rico, by means of which a greater control of all weeds in cane fields, including grasses, has been attained. The mixture used has been—

4 gallons oil of high aromatic content,
2 lbs. pentachlorophenol,
2 lbs. Stanvac wetter.

This has been made into an emulsion with 96 gallons of water, and used at that rate per acre, with 2.4.D. added to supply either 1 lb. or 2 lbs. per acre.

This is used as either a pre-emergent or post-emergent spray; in the latter method some spotting of the cane leaves has occurred, but no permanent damage has been done.

Trials have shown that the complete mixture of oil spray plus 2.4.D. gives better results than either alone. Pre-emergent spraying also promises to be of more value than post-emergent spraying.

Although all spraying has been done at the rate of 100 gallons per acre, it is realised that the bulk of the water can be considerably reduced, and experiments are to be carried out with the same mixture used at the rate of 10 gallons per acre.