PROCEEDINGS OF THE

ANNUAL CONGRESS
1956

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.

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South African Sugar Technologists' Association

Thirtieth Annual Conference

The Thirtieth Annual Congress of the South African Sugar Technologists' Association was held at the M.O.T.H. Memorial Centre, Old Fort Road, Durban, on 9th—13th April, 1956.

The following members and visitors were present:

J. B. GRANT, *President*

ADAM, D.
ALEXANDER, J. B.
ALEXANDER, K. E. F.
ALMOND, F. L.
ARMSTRONG, H.
ASHE, G. G.
AYRES, J. E.

BAILEY, G.
BARKER, A. N.
BARNES, A. C.
BARNES, Mrs. N. N.
BARTON, L.
BEATER, B. E.
BEESLEY, E.
BENTLEY, J. P. N.
BONFA, N. J. A.
BOOTH, C. E.
BOOTH, Mrs. C. S.
BOUCH, W. G.
BOULLE, P. F.
BOYD-SMITH, Mrs. N.
BOYES, P. N.
BRASSEY, T. B.
BRETT, P. G. C.
BROWN, A. C.
BUCHANAN, W. K.
CHRISTIANSON, W. 0.
DAMANT, E. L.
DANIEL, P.
DAVIES, W. F.
DE BROGLIO, A.
DENT, C. E.

DICK, J. McD.
DODDS, H. H.
DREDGE, F. B.
DUCASSE, A. F.
DU TOIT, J. L.
DUVEKOT, C. D.

ELYSEE A.D.
ESSERY, G. V.
EVANS, C. S.

FABIEN, R.
FARQUHARSON, J. C.
FAULDS, Miss T.
FELTHAM, O. A.
FRANGS, G. B.
FRAZER, H. H.
DE FROBERVILLE, L. F.
DE FROBERVILLE, P. F.

GARLAND, H. L.
GTRDLER, J.
GLEN, D. C.
GRAVETT, Miss I. M.
GUNN, J. R.
GUTHRIE, J. DE V.

HAMMOND, A. G.
HARDY, R. L.
HASTINGS, H. E.
HASTILOW, D.
HAYNES, J. W.
HEDGCOCK, G. W.
HEDLEY, E. P.
HEMPSON, W. J.
HENDRY, D. W. W.
HESLOP, W. B.
HIBBERT, A.
HILL, M.
HINDSHAW, W. A.
HUNTLEY, J. K.

JOHNSTONE, C. W.
JOHNSTONE, P.

KAPP E. P.
KlLIN, G.

KING, N. C.

LINCOLN, M. A.
LlNDEMANN, W. C.

MACBETH, F. B.
MACGREGOR, W. I.
MACLEOD, D. A.
MAHON, P. D.
MAIN, J. W.
MACKINLAY, F. R.
MCIVER, N. F.
McKlNLAY, D.
MARTINDALE, A. E.
MATHEW, G. E.
MAYNE, P.
MOODIE, J.
MORRISON, E.
MULDER, W. G.
MUMBY, B. C.
MUNRO, D. J.
MURRAY, P.

NADAULD, G. E.
NICKSON, G.
NORTH, 0. A. B.

ODENDAAL, G. A.

PACKHAM, F.
PATERSON, A.
PEARCE, K. W.
PEARSON, C. H. 0.
PERK, C. G. M.
PHIPSON, E. H.
VAN DER POL, C.
POPE, R. J.
PORTEOUS, J.
POUGNET, J. F.
POYNTON, Miss M.
PURDHAM, C. C.

RABE, A. E.
RAULT, J.
RENAUD, C. L.
RENNIE, L. L.
LA RESERVEE, L. L.
REYNOLDS, N.

ROSS D. C
Rossouw, G. S. H.
ROUTLEDGE, D. A.
RUDDEN, B. A.

SAUNDERS, C. J.
SCHMELZ, G. M.
SCHMIDT, H. F. W.
SCOTT, G. B.
SEXTON, T. A. F.
SHURMANN, J. B.
SIMPSON, R. M. O.
SMITH, E. L.
SMIT, A. E.
STARLING, C. P. N.
STEPHENSON, R. A.
STEWARD, E.
STEWART, M. J.

TALBOT, E. G.
TAYLOR, H. A.
THOMPSON, G. D.
THOMSON, G. H.
THUMANN, J. D.
TREWREN, F. G.
TWINCH, J. F.

VENTREN, R. G.
VERINDER, H. N.

WADMAN, P. E.
WAGER, V. A.
WAGNER, C. L.
WALSH, Miss E. W.
WALSH, G. H.
WATSON, R. G. T.
WHEELER, F. D.
WHITEHOUSE, R.
WIESE, C. K.
WILLIAMS, A. R.
WILSON, G. C.
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YELLAND, F. R.
YOUNG, C. M.

THIRTIETH ANNUAL CONGRESS

Proceedings of the Thirtieth Annual Congress of the South African Sugar Technologists' Association, held at the **M.O.T.H.** Memorial Centre, Old Fort Road, Durban, on

J. B. GRANT *(President)* was in the Chair.

OPENING CEREMONY

The President: Ladies and Gentlemen—I have much pleasure in asking Mr. W. K. Buchanan, chairman of the S.A. Sugar Association as well as of the Natal vSugar Millers' Association, to open this Congress.

Mr. Buchanan: Mr. President, Ladies and Gentlemen—All of us in this hall today are bound by one common interest. Everyone here is dependent, to a greater or lesser degree, on the well-being of the Sugar Industry. On its progress and development depends the progress and livelihood of us as individuals. This is our common bond, even though our individual interests may lie in the most diverse and seemingly most isolated fields.

I am not a scientist, nor an engineer, nor even, in the widest sense of the word, a technologist. Yet throughout my life I have been in extremely close contact with all three of these maj or interests. Most frequently, however, I have had to deal with economics and my outlook has been conditioned by the need to apply the fundamentals of economics to everything I have attempted to do. Because of this I want to put to you a point of view which I believe to be simple, but very apt to be overlooked. It is a point which I believe must be the foundation of any primary industry.

The Sugar Industry of South Africa has come a long way since Edmund Morewood made his first crude sugar at Compensation **105** years ago. In that time this Industry has risen to a position of eminence and its development has spread along the whole of the coastal region of Natal. It has encountered many vicissitudes and it has been subject from time to time to stress and strain for a number of reasons. It has been through periods when disease has threatened the whole of its cane supplies; it has had to adapt and adopt manufacturing processes which again have come a long way since the days of the early mills.

Million Ton Production

The position today is very different. In the season just ended, almost 939,000 tons of sugar have been manufactured from over eight million tons of cane. I recall very well the address delivered to vour Association a few years ago by Dr. G. S. H. Rossouw, chairman of the Sugar Industry Central Board, in which he predicted that at least a million tons of sugar would be needed to see the Industry through each year. I recall, too, the scepticism with which his prediction was met in some quarters.

Today we are very close to that million-ton mark and that some years before the date Dr. Rossouw suggested we might achieve this target. Our local consumption is rising steadily and last year we were able to meet all our export commitments. We, gentlemen, are dealing today with products which represent something over £25 million in revenue to South Africa.

The point I want to make is this—and I believe there is need for plain speaking from an industrial point of view. We must aim at an even greater quantity of sugar in the field and more sugar in the bag. To get that, we want more sugar per acre and the greatest possible mill efficiency to extract sugar from the cane.

The Sugar Industry today is at an extremely important point in its development. It has a responsibility to South Africa which it must discharge, the responsibility for seeing that there is adequate sugar for domestic consumption and for all manufacturing purposes at a reasonable price. It has a responsibility to the countries which buy our export sugar. They are dependent on us and we are obliged to do whatever we can to meet their needs.

Onus of Responsibility

As I see it, the onus for discharging those responsibilities as efficiently as possible rests squarely on the technologists in our Industry. You, gentlemen, are the men who are working with the problems in the field and in the mills; you are the only men to whom the Industry can look for a solution to those problems. There is no need for me to go into them. We have our agricultural problems which are pressing. We have our milling problems which are no less urgent in the need for their solution. It is enough if I mention only two. We are urgently needing new varieties of cane to avoid our complete dependence on the one or two which are doing so well at the moment. And on the milling side, we are troubled with the problem of starch, which may seriously affect the refining of our raws.

If we are to discharge all our obligations, and want to maintain the Industry as a closely integrated whole, we must improve because through improvement comes progress. Herbert Spencer, in his "Social Statistics" said: "Progress is not an accident, but a necessity. It is a part of nature." The emphasis must be on planning, particularly where research is concerned. No industry can afford to haphazardly; without adequate planning there can only be spasmodic, haphazard progress, if there is any progress at all.

President Paul Kruger, of the old Transvaal Republic, advised us to take from the past what is good and build on it for the future. The lessons of the past are clear. Three times in its history the Industry has nearly gone under, twice from economic causes and once from disease in our canes. It managed to weather the economic crises, but at great cost; it came through the disease crisis largely because of the miracle of Uba cane.

Many Problems

If we are to use these lessons from the past, it must be obvious to all of us that the Industry has to be firmly founded. Administratively and financially we have done, and we are doing, everything we can to ensure stability. The problems in these fields are being tackled effectively. But in the technical fields there are many problems that have to be overcome—and when they are, others will arise in their place. The solutions for which the Industry looks cannot be obtained through working in watertight compartments. There must at all times be the fullest degree of co-operation. The effects of a problem in the fields may follow right through into the mill; the solution to a field problem may equally have its repercussions in the factory. We cannot, for example, control nature, but we can try to off-set the effects of her vagaries.

We must try to get the broad picture of the Industry, to see where our individual efforts fit in, and to see what the effect of our work may be. Without this picture, we are working in the dark.

I suggest that our first duty is the fundamental one of improving and developing wherever we can. Our primary task is the direct application of our work to the Industry as a whole, whether we be in the research field, engineering field, agricultural, milling or growing fields.

Bread and butter may be uninspiring, but without it we cannot live. The bread and butter of sugar cane technology is the application of all our efforts to the commercial maintenance and betterment of our Industry. Hundreds of thousands of pounds are spent every year on research and development work. The monev comes from the Industry and the Industry expects the results of this work to be brought back in lowered costs, improved output or in any one of the scores of ways in which research and developments can be of benefit. Without this aspect, sordid as it may seem to some people, and without constant improvement and progress there can be no money for the jam of pure research and investi-

No Clear Division

There is no clear division between research and development work and their application in any industry. There must always be some degree of empirical development in any industry. Equally, there must be some time for pure research—for delving into those matters which may or may not be of some advantage and some benefit to industry. But basically, research and development sponsored by an industry carry with them the moral obligation to apply those research and development results directly for the betterment of that industry as a whole.

At this stage in the Sugar Industry's life, it falls to every one of us to ensure that, however much we may dislike it, there is this constant emphasis on bread and butter. The application of our efforts must be to the mundane, down-to-earth fundamentals of getting more sugar into the fields and more sugar into bags. Without this basic approach on the part of its technological experts, any industry will slow down and must eventually come to a stop. With this thought always in mind, there is no limit to the progress that can be achieved.

Mr. J. L. du Toit: Mr Chairman, .Ladies and Gentlemen—Mr. Buchanan stated that he is no scientist, no engineer nor even in its widest sense a technologist and that he feels greatly honoured by having been asked to open our conference here today. I must conclude from these remarks, Sir, that Mr. Buchanan is an extremely modest man. not be a scientist, I believe he is an engineer and I do know that he is a technologist. He is and has been ever since he came to this industry a member, and an active member, of our Sugar Technologists' Association. I may say, Mr Chairman, that our Technologists' Association was one of the first to recognise the outstanding capabilities of Mr. Buchanan and to make use of them. His wisdom and experience assisted us in council and committee and two years ago, he as an ordinary member of our Association, proposed on behalf of us a vote of thanks to Mr. Charles te Water who then opened our conference. We therefore rejoiced with many others in the industry when Mr. Buchanan was appointed chairman of the Millers as well as the Sugar Association for we knew that we had a friend in the highest places who understood our aims and aspirations and who appreciated fully the past achievements and future potential of our Association. It is therefore we who are honoured today in having Mr. Buchanan with us and in having had him open our proceedings with such an able, well balanced and constructive address.

Mr. Buchanan referred briefly to the beginning of the industry, the ups and downs experienced and made a sterling call for a maximum effort by all working in close co-operation so that the industry can reach new record peaks of perfection and production.

Allow me too, Sir, to refer briefly to the recent history of the industry and our Association. Some thirty years ago the production of sugar was 240,000 tons annually. More or less at that time the Experiment Station was started, the Fahey Agreement made and a group of technical workers on their own initiative formed the South African Sugar Technologists' Association. These three events singly and jointly had a far reaching effect on the wellbeing of this industry. I entered the industry some twenty years ago and coming from some other province I knew to some extent the feeling of the rest of the Union towards this industry. In those days whenever sugar was mentioned, the reaction was immediate—a parasitic industry, heavily subsidised by the rest of the country, selling its product cheaply overseas. About ten years sugar was in short supply for the domestic market, prices compared more than favourably with overseas prices and the story about a subsidised industry was forgotten and the industry was assumed to be somewhat nonopolistic and extremely wealthy. The term subsidised industry was changed to "sugar barons." Today, and I hope the industry is no less prosperous, these terms are seldom heard IS a general and genuine admiration for what has been achieved by this South African industry as a result of co-operation and applied research. Two years ago Mr. te Water in opening our conference referred to the cane growers as the most research conscious of all South African farmers and to this industry as a "model of self-sufficiency and independence" Four years ago Dr. Rossouw in opening our conference called on scientists and technologists to bring about a second technical revolution in order to produce 1,000,000 tons of sugar. Production for that year stood at 530,000 tons. This year the production was 939,000 tons. Few present on that occasion could have thought we could get so near to the target in so short a time. Admittedly the area under cane has increased somewhat and, most important, weather conditions were favourable, but again science and technology have played their part and the foundation and structure of the technical revolution were there at the time the address was given. What a remarkable increase in production, but more so what a remarkable change in outlook and sentiment. The parasitic, subsidised industry of 20 years ago has become a model of self-sufficiency, efficiency and independence. The "sugar barons" of 10 years ago have become "the most research conscious of all South African farmers." We as technologists rejoice in these changes because we are an integral part of the sugar industry and because we know our own efforts have done much to bring about this happy state of affairs.

Mr. Chairman, Mr Buchanan has paid a handsome tribute to our Association and has called for further effort. He stated that we cannot live without bread and butter and I know he will agree that we cannot live on bread alone either. The industry has reached a high peak of efficiency and we are justly proud of it, but human happiness is infinitely more important than efficiency. It does seem to be the case that the more efficient a system gets the more subordinate the individual gets to the system. That has fortunately not happened in this industry and it must never happen that the individual becomes the slave of the system or to efficiency. Here again we are very fortunate in having Mr. Buchanan who apart from being a technologist was also public relations officer to the industry. He understands the need for efficiency, co-operation and a happy relationship of all concerned, as he has also demonstrated in his opening address.

It therefore give me very great pleasure, Mr. Chairman, in proposing a very hearty vote of thanks to Mr. Buchanan for opening our conference. Our thanks to Mr. Buchanan as Chairman of the Millers' ion, as Chairman of the South African Sugar Association and as a member of our own Association.

THE PRESIDENT'S ADDRESS

Mr. Grant (President): Mr. Buchanan, Ladies and **gentlemen. The late Mr. Buchanan in his presi**dential address in 1948, stated that business matters were not the concern of this association. Mr. Buchanan may have envisaged business purely from the financial angle, but I consider that maintaining an efficient and contented staff at our factories and the benefits that would accure therefrom is a business angle which is our direct concern. Quite a number of our members hold executive positions at the factories and one of their principal worries is the difficulty of maintaining an adequate and efficient staff.

Why does this difficulty arise? At present this does not only apply to our Industry but is common throughout this country and probably in most industries throughout the world. For this reason should we sit back and accept it as something beyond our control? We are a major Industry carrying a fairly large staff who live and bring up their families in our midst. The majority of these youngsters are trained in our Mills, invariably as artisans, some go on to the universities, but how many come back or remain in the Industry? Very few.

What are the reasons for this state of affairs? Can it be that conditions are more arduous in our Industry compared with others? Are the prospects of promotion too limited? Does the question arise that a young man does not wish to specialise in our Industry fearing that circumstances may arise when he is compelled to seek employment elsewhere, and he will not have the necessary qualifications? Is it because our Industry is mainly in rural areas, and that young men have a natural inclination for the big cities and the recreational and cultural amenities that are more readily available there? Can it be that living conditions and amenities as provided at the mills are unsatisfactory? Are our salary scales comparable with other industries where the previously mentioned disadvantages do not arise? Finally, has any real effort been made to attract or retain the suitable young man?

Questions Analysed

Let us analyse these questions individually.

Are conditions more arduous than in other Industries? From the engineering angle and after discussion with engineers employed in the Industry, the general opinion is that conditions are more arduous than most industries. The reasons are that sugar factories are normally not provided with spare major items of plant and consequently considerable maintenance has to be carried out during the week-end shutdown. Breakdowns on the milling tandems have to be repaired immediately, compared with most other types of factory where stand-by plant can be brought into commission and the breakdown repaired during normal working hours.

During Congress there will be a paper read on controlled maintenance where the question of maintenance is treated on a more modern scientific basis. Without entering into discussion on this question now, it does appear that the application of this system may to some extent alleviate the conditions as they are at present. Factories are being modernised and the possibility of factories running seven days a week is also being considered. If this proves to be a practicable proposition and adequate stand-by plant is provided, I am sure it will have the blessing of all mill engineers. On the process side, conditions are a bit better, although the variations in the raw product necessitate the process supervisor being continually on the alert.

Promotion Prospects

Are the prospects of promotion too limited? I consider this to be a major reason. During a survey carried out by the Education Committee in 1953 it was ascertained that the requirements of the Industry for process personnel for ten years would only be two factory managers, three chief chemists and four overseers. Is it surprising then that parents are loath to enter their sons into laboratory or process work in the factories? The position with regard to factory overseers is extremely acute and steps should be taken to rectify it.

In this respect engineers are not so vitally concerned, as the lack of prospects of advancement can be overcome by their taking up employment in another industry. We should endeavour, however, to retain in our Industry the brilliant apprentice who has served his training period with us.

The question of loss of employment for any reason, does weigh largely with parents not wishing their sons to take up positions in the processing departments, and is quite understandable when there are so many opportunities offering elsewhere.

The Sugar Milling Industry is however not alone in this respect but we must pay serious attention to this fact when trying to arrive at the solution of the problem.

Living in rural areas is one big disadvantage in the opinion of the average young man, although living conditions and amenities provided by the milling companies are of a fair standard. Some are excellent, and domestic amenities are equal to those obtainable in urban areas. These factories do not have the difficulty in **retaining** staffs **as have the** factories where the living conditions are not so good. However, I consider that all the milling companies realise the necessity for modern housing and most of them are improving these amenities rapidly. This is bound to have a beneficial effect.

It also appears that the factories situated farthest from Durban have the greatest difficulty in retaining their staffs. In this case I am referring principally to the artisan, operating and junior clerical staffs.

Finally, do wage and salary scales have any bearing on the question? This is usually the important factor by which a person decides if he will accept a position. If there are certain disadvantages he anticipates some additional monetary compensation. Most milling companies provide free quarters which in the past has been a big inducement to prospective employees. I do not think that this is the attraction that it was as young married couples feel that owning their own homes, which will provide for them after retiral, is of paramount importance. They are prepared to sacrifice some things to attain this. Furthermore, employees who have not the advantage of free accommodation are usually paid a higher cost of living allowance than is the custom in the Sugar Industry. In addition, the cost of the education of their children is more expensive to those residing in the rural areas.

The Benefits

It may appear that so far I have stressed only conditions that may be to the disadvantage of prospective employees. What then are the benefits of being employed in the sugar factories ? Firstly, I would place stability of employment and security in retirement, providing one's work is carried out conscientiously. Most of the companies have their pension or superannuation funds and provide certain medical benefits gratis. They also contribute to medical benefit funds to help those unfortunate employees who require additional medical or surgical treatment.

Human and sympathetic understanding is most conspiculous between employer and employee. This is probably not as pronounced as in the past, with the older generation of employee who had been with the company for many years retiring or passing away, and the new generation not remaining long enough to experience" this. Many years ago I had the occasion to apply for a position at one of our South Coast factories. I was told that a vacancy only occurred when somebody died! This was during the period when employment was not difficult to obtain.

What a different story today, when a reliable artisan is welcomed with open arms. Living conditions then were not as good as they are today, but the employer and the employee were in close relationship to each other. I consider that that position still holds today.

A further inducement to employment in sugar is the variety of problems that occur. Variety is said to be the spice of life. Let us persuade the young man come to us and enjoy it. He will certainly be able to indulge to the full. What can be more soul destroying than monotony? Therefore, to him who has the qualifications to reach an executive position, and who wishes to obtain the most enjoyment from his profession, I say look to the Sugar Industry for the future. It will not be all beer and skittles—far from it—but I am sure there will be innumerable occasions where he will have the thrill of accomplishing the difficult—sometimes, at first sight, the impossible—and surely this is the most satisfactory compensation that one seeks.

In addition there is the probability that the Sugar Industry with its innumerable possibilities of byproducts, can be the central core of a South African chemical industry. This should create tremendous opportunities for the qualified man.

The Main Problem

Now the mam problem is what steps should be taken to attract and maintain permanent staffs at our factories. To arrive at some conclusion it is advisable to divide the staffs into various groups, namely: the artisan, the process operator, the chemist, the process executive and the engineering executives. The artisan or shift engineer cannot hope for promotion further than a departmental or workshop foreman, unless he should obtain his **certificate of competency in engineering. This is** the necessary qualification stipulated by Government regulations before a person can be appointed in a factory. This is beyond the capabilities of most artisans and although it deprives one, who has the other qualifications necessary, of prospects of attaining an executive position, it has nevertheless proved a wise proviso in practice.

How then can we improve the position of the artisan? Under the Industrial Conciliation Act Agreement for the Industry a minimum wage scale is laid down, with one week additional annual leave after so many years of service. Would not a long service increment in wages be a more satisfactory manner of showing appreciation of loyal service and an inducement for this type of employee to remain with us? We have much to be grateful for to those older employees still in this category, who have served us well, and the most of whom are intensely loyal to their employers.

The process operator is one category of employee whose replacement is causing the greatest anxiety. Where is it possible to find applicants to fill any vacancy that may arise? In the past suitable youths were employed firstly as cane testers by the Central Board at its laboratories. They were later taken over as required by the milling companies, and finally, if suitable, were promoted to factory overseers. During their term of employment in the laboratories they were sent to a special course in chemistry and sugar technology at the Technical College in Durban and were then able to sit the examination for the City and Guilds (London) Certificate.

Recruiting Candidates

This source of supply has now completely dried up and we are faced with the problem of filling these positions as they become vacant. It may be possible to obtain staff from Mauritius or Holland where there are colleges training youths in sugar technology and this would probably be the easiest solution. However, should we not make some endeavour to recruit candidates locally ?

I understand that a full time course in chemistry is carried out at the Natal Technical College. Would it not be possible for sugar technology to be included in the syllabus and then at some time towards the end of the course we could approach students with the object of interesting them in taking up employment with us. Any youth taken on in these circumstances would then have to serve a period of apprenticeship and during this period would be given training in the laboratory, in pan boiling and in general factory processing.

These persons would be trained only for work at sugar factories and there would be little or no scope for their training outside our Industry. This, I consider, is the biggest draw-back to obtaining personnel in this category. I have often felt that factory overseers should be trained in all branches of factory operations and during their shift should be in complete charge of the factory including the milling plant, boiler plant, laboratory shift workers as well as the processing departments. They could even be recruited from the engineering staff and trained accordingly. With proper training they would then be fully qualified to take over the higher executive positions.

Under this system your factory overseer would then hold a position comparable to the workshop foreman and only slightly junior to the assistant engineer. Chief chemists can graduate from the factory overseer's position or could be recruited direct from the Technical College or Universities. However, no matter from what source they come it would be advantageous for them to spend some time of their training at the Sugar Milling Research Institute. No doubt this can be arranged.

Bursaries

In recent years senior engineers have been mostly appointed from other industries, and referring to what I have already said about the brilliant apprentice, would it not be possible for the Industry to establish a bursary, so that periodically one apprentice could go for advanced training and then come back to us when he is fully qualified? Some companies have already carried out a similar procedure and have sent young graduates overseas for special-training, but I consider if there were bursaries available in each branch of the manufacture it would create an incentive to improve and also attract applicants for employment in our industry.

I trust I have put something forward that may give rise to further thought on the subject and improve the position as it exists today.

Mr. **Bentley:** In his address to us to-day our President has suggested that, in this his last duty of the year, he may not measure up to the standard set by previous incumbents of the post. When one considers that this position has been occupied by men of the stature of the late W. Buchanan, the late G. C. Dymoncl and H. H. Dodds to mention but a few, this must indeed appear to be a formidable

Nevertheless I am sure you will agree, gentlemen, that Mr. Grant has to-day justified the confidence placed in him by our Association, and you will be pleased to hear that by a unanimous vote of your Council he has been re-elected President for the ensuing year.

Mr. Grant has chosen as the subject of his address a matter of vital importance to our industry. In the field of sugar chemistry and sugar technology we have relied in the past on recruiting men from outside the industry and no organised plan for the proper training of our technical staff exists. Had it not been for unsettled conditions in countries such as Mauritius and Indonesia our source of supply would have dried up long ago. As it is, junior chemists are already becoming a *rare avis* because training facilities do not exist and his future is often shrouded in mystery.

, I would like to suggest that a proper apprenticeship be introduced for sugar technologists on the lines of the apprenticeship for engineering personnel. After two years in the laboratory and a year on the pan floor, the apprentice should spend at least one full year at the Sugar Milling Research Institute where suitable theoretical training could be made available. I do not believe that the Technical College as presently constituted is in a position to give the specialised training required for this branch of industry and I consider that it would be in the interests of the industry to enlarge the Research Institute to enable it to carry out this work.

However this is not the time nor the place for a detailed discussion on this subject and I will therefore conclude by thanking Mr. Grant for his many years of service to our Association and wish him continued success during the coming year.

THIRTY-FIRST ANNUAL SUMMARY OF CHEMICAL LABORATORY REPORTS

SOUTH AFRICAN SUGAR FACTORIES: SEASON 1955-56

By CHS. G. M. PERK

A, Production Data for South African Sugar Factories for Seasons 1946-1955

During the 1955-56 season, further records were established for the total tonnages of sugar produced and of cane harvested, transported and crushed, harvest amounted to 8,005,990 short tons, from which 938,980 short tons of sugar (tel-quel) were made. Th ree tact exceeded the 100,000 tons of sugar mark, i.e. Darnall which made 115,759 tons of raw sugar, Tongaat with 106,840 tons, and Natal Estates which bagged 100,529 tons of sugar, of which 87,236 tons were refined sugar.

The following table (A) shows the sugar and cane productions from the season 1946-47 onward in tons of 2,000 lbs.; the sugar tel-quel:

TABLE A

Sugar Production in South Africa in Recent Years

Season	Sugar Produced	Cane Crushed	Season	Sugar Produced	Cane Crushed
1946-47	474,769	3,990,017	1951-52	532,505	4,805,249
1947-48	512,005	4,543,255	1952-53	670,188	5,722,583
1948-49	607,845	5,216,144	1953-54	725,429	6,221,531
1949-50	561,122	4,929,580	1954-55	828,555	7,374,241
1950-51	685,789	5,721,390	1955-56	938,980	8,005,990

The figures show a steady incline in sugar production from 1951-52 onward and if this increase can be maintained it will not need many years before the one million tons sugar mark will be reached.

B. General

From here on the discussions and the tables in this summary will refer to the results of seventeen of the nineteen factories which have been in operation this season, viz. to those seventeen factories which report regularly to the S.M.R.I. Since these seventeen factories produced 99.1 per cent, of all sugar made and milled 98.9 per cent, of all cane harvested, the data shown and discussed in this summary are largely representative for the whole South African Sugar Industry.

With the increased quantities of cane which had to be crushed, more extensive work was demanded to deal with the crop and a further increase in the average crushing rate was recorded. Actually over 50 per cent, of our factories crushed at a rate of over one hundred tons of cane per hour.

The milling results show a decrease in extraction and an increase in moisture content of the bagasse. A gratifying feature of the process work is the continued upward trend which the boiling house performance has exhibited for some years. This improvement is a result of the better exhaustion of the final molasses in recent years and, with respect to last season's improvement, also of the reduction in undetermined losses and sucrose losses in filter

From an overall point of view we may state that the 1955-56 season has shown improvement, because:

(a) the average overall recovery was slightly higher and

(b) the average duration of the crushing season has been reduced by eight days, notwithstanding the larger crop handled.

C. Cane Quality

Umfolozi was, previous to 1954-, the only factory which regularly crushed late in the season. Since the 1954-55 season Umfolozi has been joined by Pongola, a factory which crushes cane with a much higher sucrose content than the other factories. In recent years, forced by the large crops, other mills had to extend their crushing seasons into the next year. It is therefore that the average sucrose content of the whole season is not a suitable base for comparison between different seasons. A better base can be found in the following table, where the qualities of the cane harvested in similar periods are compared. The season is therefore divided in an optimum period, i.e. the period from the beginning of July and ending at the end of November, and the balance of the crop comprising all other months.

Table B shows that during the last four seasons the portion of cane milled in the optimum period amounted to 65 to 59 per cent, of all cane milled, which is thus considerably less than the average of the previous (1945-1954) decade, which amounted to 70 per cent.

The sucrose content of the cane harvested during the July-November period, i.e. 14.45 per cent., is very satisfactory, when compared with the average of the optimum period of the previous decade of 14.14 per cent. Equally gratifying is the sucrose content of 13.04 per cent, for the balance of the 1955-56 crop, when we consider that 41 per cent, o the crop was harvested in months other than the optimum ones.

TABLE B

Comparison of Results from Cane Harvested during the July-November Period, compared with those of Earlier and Later Months of the Harvesting Season

	Per cent. Total Cane	Ratio Cane/ Sugar	Sucrose Per cent. Cane	Fibre Per cent. Cane	Purity Mixed Juice
Mean 1928-1934					
Optimum period...	76.29	9.46	13.64	15.51	85.37
Balance of crop ...	23.71	10.53	12.56	15.98	84.31
Mean 1935-1944					
Optimum period...	71.51	8.86	13.89	15.21	86.46
Balance of crop ...	28.49	9.79	12.61	15.46	84.72
1945 Optimum period	73.75	8.06	14.66	16.03	86.33
Balance of crop	26.25	9.01	13.21	15.88	85.95
1946 Optimum period	85.64	8.27	14.33	16.20	85.74
Balance of crop	14.36	8.96	13.49	16.27	86.48
1947 Optimum period	77.07	8.65	13.58	15.78	85.88
Balance of crop	22.93	9.57	12.45	15.87	85.43
1948 Optimum period	70.48	8.30	14.26	15.83	86.02
Balance of crop	29.52	9.22	13.01	16.07	85.68
1949 Optimum period	67.49	8.50	13.86	16.20	86.49
Balance of crop	32.51	9.36	12.81	16.17	85.66
1950 Optimum period	64.20	7.92	14.79	15.99	86.69
Balance of crop	35.80	9.14	13.11	15.46	85.88
1951 Optimum period	72.06	8.88	13.47	16.36	84.94
Balance of crop	27.94	9.26	12.98	16.06	84.87
1952 Optimum period	65.02	8.16	14.39	15.98	86.71
Balance of crop	34.98	9.24	12.91	16.32	85.40
1953 Optimum period	64.83	8.26	14.32	16.31	86.07
Balance of crop	35.17	9.15	13.22	16.31	84.75
Mean 1945-1954					
Optimum period...	70.09	8.35	14.14	16.06	86.20
Balance of crop ...	29.91	9.24	12.98	16.05	85.43
1955-56 Season					
Optimum period...	59.14	8.13	14.45	15.60	86.39
Balance of crop ...	40.86	9.12	13.04	15.95	85.27

Finally when we want to compare the average sucrose content of the whole season, i.e. 13,87 per cent., the Table VII at the end of this summary will be helpful. It shows that since the mean sucrose content of the 1945-54 period is 13.79 per cent., last season's sucrose percentage is very gratifying; again keeping in mind that so much more cane has been crushed outside the optimum period than as an average during the 1945-54 period.

We want to draw special attention to the lower fibre content of last season's cane, i.e. 15.75 per cent, compared with a mean fibre content of 15.96 per cent, for the 1945-54 period.

The average mixed juice purity, i.e. 85.96 of last season, is equal to the mean of the 1945-54 period; the reducing sugars sucrose ratio slightly higher (3.40 compared with 3.29).

D. The Changing Varietal Scene

TABLE C

Changes in Percentages of Varieties Crushed during Recent Years

	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56
Uba	0.23	0.16	0.13	—	—	—
P.O.J.	1.99	1.65	1.23	0.69	0.26	—
Co.281	35.99	25.34	10.97	5.71	2.34	1.01
Co.301	37.98	38.30	31.80	28.21	20.97	14.93
Co.331	7.87	12.51	15.87	22.01	25.27	23.46
N:Co.310 ...	15.07	21.12	37.86	41.35	49.41	55.66
N:Co.339 ...	—	—	—	—	0.05	1.35
N:Co.293 ...	—	—	—	—	0.10	1.00
Rest	0.53	0.92	2.15	2.02	1.60	2.59

The 1955-56 crop was again almost entirely composed of three varieties. More than half the cane crushed consisted of N:Co.310, less than a quarter of Co.331 and a seventh of Co.301.

Co.301 obtained its greatest extension in 1949-50, i.e. 41.89 per cent., and has decreased in importance ever since.

Co.331 obtained its greatest extension in 1954-55, i.e. 25.27 per cent., and is also on the decline.

N:Co.310 is still increasing.

Of the recently distributed varieties, the varieties N:Co.339 and N:Co.293 last season reached percentages of 1.35 and 1.00 respectively; compared with 0.05 and 0.10 per cent, during the 1954-55 season. In addition, small quantities of N:Co.276, N:Co.292 and N:Co.334 were crushed during the 1954-55 and the 1955-56 seasons.

Proportions of Cane Varieties Milled Monthly, for the Periods Ended as Shown

Period Ended	28 May 1955	2 July 1955	30 July 1955	27 Aug. 1955	1 Oct. 1955
Variety					
Co.281 ...	2.80	1.86	1.07	0.56	0.62
Co.301 ...	27.73	23.41	16.98	13.92	17.92
Co.331 ...	26.64	23.35	23.74	26.53	26.26
N:Co.310 ...	41.01	48.90	56.00	55.06	50.87
Miscellaneous	1.82	2.48	2.21	3.93	4.33

Period Ended	29 Oct. 1955	26 Nov. 1955	31 Dec. 1955	28 Jan. 1956	3 March 1956
Variety					
Co.281 ...	0.35	0.40	0.87	0.38	3.68
Co.301 ...	3.05	11.69	11.49	10.89	2.50
Co.331 ...	25.01	22.18	20.69	18.21	6.10
N:Co.310 ...	64.97	61.03	60.65	65.00	54.69
Miscellaneous	6.62	4.70	6.30	5.59	33.68

Owing to the steady increase in propprtion of N:Co.310 the harvesting of this variety has been accelerated again, In the 1953-54 season we had to wait till August before 40 per cent, of the cane harvested consisted of N:Co.310. In the 1954-55 season this percentage appeared two months earlier. Last season, however, the season started off with 40 percent N:Co.310 in the first month of crushing. The highest percentage for any period in the 1953-54 season amounted to 55.76 per cent.; in the 1954-55 season to 59.39 per cent.; and last season to 65 per cent.; in all cases the maximum fell in the January period. Also in the seasons previous to 1953-54 the highest percentage fell in the January period, because Umfolozi in those seasons already crushed a high percentage of N:Co.310.

E. General Factory Performance

The following table (Table E) shows how the last three crops were milled:

TABLE E

Season	1953-54	1954-55	1955-56
Number of Factories	16	17	17
Tons Cane Crushed	6,159,770	7,296,805	7,917,674
Total Hours Mills Open ...	75,524	87,748	84,832
Average Number of Weeks ...	33	36	35
Total Hours Actual Crushing	69,449	78,525	77,390
Average Days Actual Crushing	181	192	190
MEAN CRUSHING RATE (t.c.h.)	89	93	102
MEAN TIME EFFICIENCY (per cent.)	92	89	91
Total Hours of Stoppage per cent. Hours Mills Open ...	8	11	9
Hours of Stoppage due to Cane Shortage per cent. Hours Mills Open	4	5	4

The further increase in the crop was met by a further increase in crushing rate; the result being that notwithstanding the larger crop this season, 35 weeks only were required to mill the crop compared to 36 weeks in 1954-55.

The next table shows the part that each factory played in the increase in joint crushing rate:

TABLE F

Crushing Rates in Tons of Cane per Hour Actual Crushing

Season...	1951-52	1952-53	1953-54	1954-55	1955-56
PG ...	—	—	—	49	65
UF ...	131	137	145	151	158
ZM ...	100½	97	98	113	127
FX ...	90	87	90	100	135
EN ...	15	14	15	16	17
AK ...	87	88	94	103	106
DK ...	30	31	33	40	42
DL ...	119	121	150	171	182
GL ...	77	81	86	97	109
MV ...	33	36	36	40	50
CK ...	40	42½	44	43	42½
TS ...	169	170	171	174	190
NE ...	134	140	146	152	157
IL ...	49	62	59	64	71
RN ...	42	42	42	42	44
ES ...	44	48	—	—	—
SZ ...	88	98	108	124	118
UK ...	28½	28	28	31	33
Sum of all Rates ...	1277	1322	1345	1511	1647

Compared with the aggregate actual crushing rate of the 1952-53 season the joint rate increased from 1277 t.c.h. to 1647 t.c.h., or an increase of 29 per cent, in a period of only four years.

A comparison of average data of recent years with respect to performance of the milling trains is shown in Table G:

TABLE G

Season	1952-3	1953-4	1954-5	1955-6
Tons Cane per hour ...	80.56	88.70	92.92	102.01
Tons Fibre per hour ...	12.97	14.47	14.90	16.06
Lost Absolute Juice per cent. Fibre	40.8	41.7	44.1	45.5
Imbibition per cent. Fibre...	217	200	191	204
Imbibition per cent. Cane...	34.9	32.7	30.7	32.1
EXTRACTION	93.00	92.67	92.40	92.32
Sucrose per cent. Bagasse...	2.65	2.75	2.75	2.91
Moisture per cent. Bagasse...	52.52	52.47	52.92	53.18

The best average figure ever obtained for Lost Absolute Juice in Final Bagasse per cent. Fibre is 39.3 per cent., a figure achieved with the aid of 206 per cent. imbition on fibre during the 1950-51 season. Since that season the average figure for Lost Absolute Juice per cent. fibre has been steadily increasing; the same has to be said about the moisture content of the bagasse.

A comparison of average data of recent years regarding the performance of the boiling house is shown in Table H:

TABLE H

Season	1952-3	1953-4	1954-5	1955-6
Tons Brix per hour ...	12.20	13.38	13.34	15.20
Tons Sugar per hour ...	9.47	10.37	10.47	11.99
Purity of Mixed Juice ...	86.25	85.61	85.86	85.96
Red. Sugars/Sucrose Ratio	2.92	3.66	3.28	3.40
Purity of Final Molasses ...	39.3	39.5	39.3	39.5
BOILING HOUSE PERFORMANCE	97.2	96.9	97.4	97.9
Boiling House Recovery ...	89.96	89.36	90.04	90.51
Percentage Undetermined Losses	1.46	1.59	1.44	1.21

The improvement in Boiling House Performance when comparing the 1955-56 season's average, i.e. 97.9, with the mean of the previous decade, i.e. 96.8, is caused mainly by the better exhaustion of the final molasses; the 1955-56 average being 39.5 against a 1945-54 average of 40.7. The further increase of Boiling House Performance experienced last season is the result of reduced losses in final molasses, and in filter cake, in addition to lower undetermined losses.

Regarding the higher gravity purity of last final molasses, i.e. 39.5 compared with 39.3 in 1954-55, it is not improbable that the true purity should not have shown a rise, perhaps itX would even have shown a slight drop. It has mainly been observed that defecation and sulphitation molasses with the same true purity show a different gravity purity; the defecation molasses showing the higher one. Since a greater part of the molasses produced in the season 1955-56 consisted of defecation molasses than during the previous season, it is possible that the higher purity is only apparent, and not true.

A review of all losses, i.e. in bagasse, in filter cake, in molasses and undetermined for recent years, is given in Table I:

TABLE I

Season ...	...	1952-53	1953-54	1954-55	1955-56
Lost in Bagasse	...	7.00	7.33	7.60	7.68
Lost in Filter Cake	...	0.43	0.49	0.54	0.47
Lost in Final Molasses	...	7.45	7.78	7.22	7.08
Undetermined I	...	1.46	1.59	1.44	1.21
Boiling House Losses: (B) + (C) + (D)	...	9.34	9.86	9.*20*	8.76
Total of A11 Losses: (A) + (B) + (C) + (D) ...	...	16.34	**17.19**	16.80	16.44
Overall Recovery	...	83.66	82.81	83.20	83.56
Sucrose in Cane ...	...	100.00	100.00	100.00	100.00

The sucrose losses in filter cake are lower because the quantity of filter cake and the sucrose content of the cake were less. Regarding the reduction in undetermined sucrose losses, the following table (J) shows the individual losses of those factories which weighed their molasses.

TABLE J '

Factory	Season:	1952-53	1953-54	1954-55	1955-56
PG ...	...	not in operation		2.59	1.46
UF	...	2.00	1.00	1.06	1.55
ZM ...	...	1.24	0.69	0.95	1.06
FX ...	...	1.04	0.95	1.17	(1.00)
EN	...	2.30	1.56	1.54	1.18
AK	...	0.71	1.05	0.74	0.66
DK...	...	3.15	2.20	2.17	1.34
DL ...	...	1.12	1.36	1.12	0.72
GL ...	...	1.40	1.38	1.54	1.33
MV...	...	1.16	1.26	1.34	0.77
TS	...	—	1.90	1.36	1.32
NE ...	...	2.72	3.34	3.30	1.84
IL ...	...	0.36	0.59	0.45	0.96
RN	...	—	1.41	0.74	0.90
SZ	...	—	—	—	—
UK...	...		—	—	—
Arithmetical Average:		1.56	1.45	1.43	1.14
Estimated Weighted Average:		1.46	**1.59**	1.44	1.21
Number of Participants:		11	14	15	14

Since, owing to extension of the factory, the molasses scale at Felixton was not in operation .during the 1955-56 season, the undermentioned losses of Felixton were calculated in the same manner as described in previous summaries and have been done so far for Sezela and Umzimkulu. In conformity with previous years the ratio of 0.83 was used for these calculations. This resulted in undetermined losses of 1.38 and 1.13 per cent, for Sezela and Umzimkulu respectively. In the case of Felixton, however, a ratio of 0.83 led to an undetermined gain. Assuming an undetermined loss of 1.00. per cent, for Felixton gave a ratio of 0.65. In order to peruse if perhaps the defecation process was the cause of this lower ratio, the ratios for all factories (for the sulphitation and the defecation periods separately) have been calculated.

The results are tabulated in Table K.

TABLE K

Calculated Ratios between Non-Sucrose in Mixed Juice and Non-Sucrose in Total Final Molasses for those Factories which Weighed Their Final Molasses in 1954-55 as well as in 1955-56

	Sulphitation	Defecation Season 1955-56	Average	Average 1954-55
PG	0.807		0.807	0.82
UF	0.728	0.750	0.739	0.82
ZM	0.831	—	0.831	0.88
EN ...	0.830	—	0.830	0.77
AK ..	0.731	0.668	0.704	0.74
DK	0.830	—	0.830	0.87
DL	0.766	0.659	0.798	0.86
GL	0.825	—	0.825	0.84
M V ..	0.793	—	0.793	0.76
TG	—	0.764	0.764	0.79
IL	—	0.751	0.751	0.68
RN ...	0.828	—	0.828	0.88
Arithmetical Averages:	0.797	0.718	0.792	0.81

Perusing the data of Table K, the only conclusion which can be drawn is that in general the ratio has been lower in 1955-56 than in the 1954-55 season. Since Umfolozi shows a higher ratio and Darnall and Amatikulu a lower ratio during the defecation period, a definite conclusion that defecation results in a lower ratio may not be drawn, although it is probably true.

The slightly higher purity of the mixed juice and the lower ratio in 1955-56 than in 1954-55 explains why the percentage sucrose lost in molasses has been lower.

_L xx JL) JL/JL^ *JLJ*

Final Mol 4l.2SHJ t5&5 Purities in Recent Years

	1951-52	1952-53	1953-54	1954-55	1955-56
PG ...	—	—	—	41.8	41.1
UF ...	41.8	40.0	39.5	**38.9**	39.7
ZM ...	40.4	40.9	37.1	37.8	38.2
FX	37.8	37.8	38.5	38.5	39.6
EN ...	43.5*	42.1*	40.8*	41.7*	42.6*
AK ...	40.1	36.8	37.7	38.9	39.3
DK ...	38.5*	39.4*	38.4*	39.3*	38.7*
DL ...	38.6	37.6	37.5	37.3	39.4
GL	40.1	39.1	39.3	38.7	38.3
MV ...	40.6	40.8	42.0	39.7	40.2
CK	38.5	39.5	38.6	39.2	39.6
TG	40.5	39.0	38.8	38.5	39.1
NE	43.7	47.2	47.3	47.2	45.4
IL	42.7	42.0	42.8	40.5	40.3
RN ...	39.0*	40.7*	39.4*	38.6*	39.2*
ES	37.8	39.0	—	—	—
SZ	38.0	37.7	37.5	36.8	35.4
UK ...	40.9*	39.0*	40.2*	38.5*	38.3
	10	10	8	7	10

* *Apparent Purity*

The figures under the columns indicate the number of factories showing molasses purities of more man 39.0. It shows that in 1955-56 a setback was suffered and there are again ten factories with molasses higher than 39.0.

Lime and Other Clarifying Agents

Table III at the end of this summary shows the average consumption figures for lime and other clarifying agents; in the following table (N) the consumptions of the defecation and sulphitation factories are shown separately.

TABLE N

SULPHITATION

	1954-55	1955-56
Lime		
lbs. per ton of cane ...	4.96	***5.03***
lbs. per ton of sugar...	44.51	42.90
Parts per 1000 parts brix ...	17.44	16.92
Sulphur		
lbs. per ton of cane	1.74	1.99
lbs. per ton of sugar	18.28	17.00
Parts per 1000 parts brix ...	7.16	6.70
Phosphoric		
lbs. per ton of	0.60	0.60
lbs. per ton of sugar...	5.41	5.09
Parts per 1000 parts brix ...	2.12	2.01

DEFACTION

	1954-55	1955-56
Lime		
lbs. per ton of cane	1.25	1.32
lbs. per ton of sugar	10.28	11.26
Parts per 1000 parts brix ...	4.20	4 47
Phosphoric		
lbs. per ton of cane ...	0.27	0.19
lbs. per ton of sugar...	2.20	1.62
Parts per 1000 parts brix ...	0.90	0.64

During the 1954-55 season the mixed juice of 589,320 tons of cane was treated according to the defecation method and 71,775 tons of sugar were made in this manner. The mixed juice of 5,951,061 tons of cane was treated according to the Natal sulpho-defecation process; 663,627 tons of sugar being made from this cane.
juice of 756,427 tons of cane the double carbonatation process was applied; 86,799 tons of sugar resulting from this cane.

During the 1955-56 season 2,523,428 tons of cane and 296,729 tons of sugar were handled by the defecation process; 4,542,956 tons of cane and 533,054 tons of sugar by the sulphitation process and 852,190 tons of cane and 100,529 tons of sugar by the carbonatation method.

Table 1.—CANE CRUSHED, CANE QUALITY, VARIETIES, SUGARS PRODUCED, TIME ACCOUNT AND THROUGHPUT

FACTORY	PG	UF	ZM	FX	EN	AK	DK	DL	GL	MV	CK	TS	NE	IL	RN	SZ	UK	Totals Averages
Crushing period From	8.6.55	2.6.55	2.5.55	9.5.55	2,6.55	3.5.55	11.5.55	2.5.55	19.5.55	9.5.55	20.4.55	26.4.55	2.5.55	3.6.55	9.5.55	10.5.55	10.6.55	20.4.55
Crushing period To	25.1.56	4.2.56	21.2.56	3.3.56	20.12.55	9.2.56	22.12.55	19.2.56	14.1.56	13.2.56	17.1.56	24.12.55	27.1.56	5.12.55	3.12.55	10.1.56	9.12.55	3.3.56
CANE CRUSHED Tons of 2,000 lbs.	275,437	735,533	697,047	681,591	65,782	567,515	171,102	975,745	505,013	245,165	220,865	884,430	852,190	233,675	176,792	536,332	93,446	7,917,674
CANE CRUSHED *Metric tons*	249,872	667,265	632,360	618,329	59,677	514,849	155,221	885,195	458,140	222,413	182,222	802,342	773,094	211,986	160,383	486,552	84,773	7,182,797
CANE QUALITY																		
Sucrose per cent.	15.58	13.94	14.09	13.05	13.81	13.75	13.64	13.84	14.13	13.78	13.74	13.73	13.93	13.60	14.40	13.73	14.55	13.87
Fibre per cent.	12.69	13.48	16.82	15.97	15.62	16.05	15.48	15.78	15.92	16.25	15.70	15.51	16.57	16.06	16.06	16.97	15.05	15.74
Java Ratio	82.48	79.38	77.46	76.69	75.88	78.61	77.71	77.43	77. 58	77.28	77.83	77.29	77.73	77.95	77.17	76.88	80.39	77.87
Tons Cane per ton Sugar	7.65	8.51	8.54	9.29	8.72	8.53	8.89	8.43	8.35	8.60	8.83	8.27	8.48	8.79	8.16	8.55	8.08	8.51
Tons Cane per ton Sugar of 96° Sugar	7.40	8.31	—	—	8.48	8.33	8.62	8.26	8.08	8.42	8.54	8.08	8.17	8.53	7.91	8.27	7.90	8,28
VARIETIES CRUSHED																		
Co.281 per cent.	0.32	1.38	5.65	1.53	—	0.75	0.08	0.31	0.08	0.17	0.02	0.24	0.26	1.12	0.01	—	4.16	1.01
Co.301 per cent	0.77	2.01	5.71	8.31	0.41	5.44	11.30	13.28	23.63	24.81	21.39	18.53	28.98	10.15	36.12	28.92	8.42	14.93
Co.331 per cent.	4.92	1.96	9.82	17.77	54.33	40.89	35.05	29.98	10.93	36.68	37.15	29.60	23.35	33.00	20 22	35.49	30.33	23.46
N.Co.310 per cent.	93.27	92.87	77.19	65.51	43.42	49.12	48.24	49.98	51.53	33.69	39.58	49.75	44.20	53.20	39.83	21.46	52.11	55.66
K:Co.339 per cent.	0.30	1.20	1.13	1.38	0.10	1.92	1.65	2.08	0.72	2.82	1.06	1.09	1.56	0.01	1.84	0.62	2.87	1.35
N:Co.293 per cent	0.34	—	0.38	0.66	1.55	1.87	3.68	1.58	0.17	1.74	0.78	0.70	1.30	0.02	1.85	1.72	1.43	1.00
Miscellaneous per cent	0.08	0.58	0.12	4.84	0.18	0.01	—	2.79	12.94	0.09	0.02	0.09	0.35	2.41	0.13	11.79	0.68	2.59
TOTAL RAINFALL, Year 1955 (ins.)	31.27	32.85	48.24	58.51	47.47	39.49	44.91	43.07	35.78	36.78	36.08	39.87	36.79	35.07	47.75	43.42	48.71	42.14
SUGARS																		
Tons of 2,000 lbs. White Sugar	20,440	—	—	—	4,056	—	9,902	—	38,614	—	13,223	—	87,236	13,939	9,135	35,222	33	231,800
Tons of 2,000 lbs. Government Grade	14,677	12,922	41,492	5,262	1,337	3,483	3,839	17,798	855	5,053	7,964	9,822	13,293	4,739	3,441	4,052	5,766	155,795
Tons of 2,000 lbs. Raw Sugar	600	73,506	40,149	68,094	2,112	63,022	5,502	97,1,62	21,011	23,467	3,825	96,972	—	7,906	9,102	23,424	5,763	542,717
Total Sugar made Tons of 2,000 lbs.	36,017	86,428	81,642	73,356	7,505	66,505	19,244	115,759	60,480	28,520	25,012	106,794	100,529	26,583	21,679	62,648	11,561	930,312
Total Sugar made *Metric tons*	32,674	78,405	74,065	66,547	6,808	60,333	17,459	105,016	59,867	25,873	22,691	96,882	91,199	24,116	19,666	56,879	10,489	843,965
White Sugar per cent. Total Sugar Made	57	—	—	—	54	—	52	—	64	—	53	—	87	52	42	56	—	25
SO_2 p.p.m. in White Sugar	65	—	—	—	—	—	—	—	—	—	—	—	—	—	—	48	—	—
SO_2 p.p.ni. in Government Grade	84	—	54	62	—	49	—	106	78	—	—	—	—	—	—	70	—	—
Safety Factor of Raw Sugar	—	0.30	0.36	0.24	—	0.34	0.34	0.22	—	0.43	—	—	—	0.31	—	—	0.34	—
Polarization of Government Grade	98.47	98.50	98.58	98.66	98.59	98.56	98.20	98.12	98.00	98.14	—	98.39	—	99.14	98.54	98.52	98.24	98.46
Polarization of Raw Sugar	—	98.22	98.28	98.37	98.50	98.34	98.20	97.90	98.00	98.00	—	98.28	—	97.14	98.39	98.31	98.24	98.20
Aveiage Polarization of All Sugars	99.20	98.26	98.43	98.39	98.76	90.35	99.04	97.93	99.18	98.02	99.28	98.29	99.66	98.92	99.01	99.24	98.24	98.65
OVERALL TIME EFFICIENCY (Hours Actual Crushing per cent. Hours Mill Open)	91.41	92.19	92.07	87.92	91.59	90.65	88.17	87.66	93.52	88.65	93.62	89.96	97.97	87.72	96.40	88.79	93.97	91.23
Hours of Stoppage due to Shortage of Cane per cent. Hours Mill Open	2.44	3.12	4.27	8,32	7.43	6.14	6.66	7.03	2.56	4.16	1.36	5.85	0.61	7.96	1.66	9.00	3.92	4.85
Hours Mechanical Losses per cent. Hours Mill Open	6.14	"4.69	3.66	3.76	0.98	3.21	5.16	5.31	3.92	7.17	5.02	4.19	1.42	4.32	1.93	2 21	2.11	3,92
THROUGHPUT per Hour Actual Crushing																		
Tons of Cane Crushed	65.19	158.36	127.00	134.86	17.21	106.45	42.17	182.26	108.76	49.58	42.45	189.60	156.89	70.75	43.60	118.13	32.54	102.01
Tons of Fibre Milled	8.27	21.34	21.36	21.54	2.69	17.08	6.53	28.76	17.31	8.06	6.67	29.40	26.00	11.36	7.00	20.05	4.90	16.06
Tons of Brix Processed	10.88	23.92	18.76	18.81	2.52	15.71	6.13	26.77	16.26	7.20	6.15	24.76	23.85	10.56	6.85	17.52	5.17	15.20
Tons of Sugar Bagged	8.52	18.61	14.88	14.51	1.99	12.47	4.74	21.62	13.02	5.77	4.81	19.86	18.50	8.05	5.35	13.81	4.03	11.99

Table. II.—SUCROSE BALANCE, RECOVERIES, BAGASSE, JUICES, FILTER CAKE AND SYRUP.

FACTORY ...	PG	UF	ZM	FX	EN	AK	DK	DL	GL	MV	CK	TS	NE	IL	RN	SZ	UK	Averages
SUCROSE BALANCE (Sucrose per cent. Sucrose in Cane)																		
Sucrose in Bagasse (A)	7.06	7.59	9.64	10.00	7.47	8.44	8.14	8.39	7.60	8.83	9.24	4.92	6.31	7.68	6.52	7.07	7.31	7.68
Sucrose in Filter Cake (B)	0.56	0.93	0.46	0.43	1.77	0.24	1.46	0.28	0.35	0.60	0.38	0.18	0.67	0.26	0.32	—	0.22	0.47
Sucrose in Final Molasses (c) ...	7.67	7.09	7.11	—	7.25	6.82	7.42	6.64	6.63	7.05	7.62	7.10	6.80	8.40	7.97	—	—	7.08
Undetermined Losses (D)	1.46	1.55	1.06	—	1.18	0.66	1.34	0.72	1.33	0.77	0.94	1.32	1.84	0.96	0.90	—	—	1.21
Sucrose lost in Boiling House (B)+(c)+(D) ...	9.69	9.57	8.56	8.87	10.20	7.72	10.22	7.64	8.31	8.42	8.94	8.00	9,31	9.62	9.19	8.46	9.18	8.76
Totalof aUloses (A)-f (B) + (c)+(n)	16.75	17.16	18.20	18.87	17.67	16.16	18.36	16.03	15.91	17.25	18.18	13.52	15.62	17.30	15.71	15.53	16.49	16.44
LOST ABSOLUTE JUICE PER. CENT. FIBRE	55.0	53.6	53.1	57.5	45.3	47.5	47.5	49.3	43.9	48.8	47.5	31.0	36.0	43.8	38.0	39.4	44.9	45.46
BOILING HOUSE PERFORMANCE	96.7	97.2	97.8	98.3	96.0	99.4	96.3	98.5	98.0	97.0	95.9	97.8	97.9	98.0	97.9	98.5	98.0	97.92
Imbibition Water per cent. Fibre	165	171	203	192	235	216	185	241	179	178	186	187	227	215	226	210	248	204.05
Imbibition Water per cent. Cane	20.9	23.1	34.2	30.6	36.7	34.7	28.6	38.0	28.6	28.9	29.3	28.9	37.6	34.5	36.4	35.6	37.3	32.12
EXTRACTION	92.9	92.4	90.4	90.0	92.5	91.6	91.9	91.6	92.4	91.2	90.8	95.1	93.7	92.3	93.5	92.9	92.7	92.32
BOILING HOUSE RECOVERY	89.6	89.6	90.5	90.2	89.0	91.6	88.9	91.7	91.0	90.8	89.1	91.0	90.0	89.6	90.2	90.9	90.1	90.51
OVERALL RECOVERY	83.2	82.8	81.8	81.1	82.3	83.8	81.6	84.0	84.1	82.8	81.8	86.5	84.4	82.7	84.3	84.5	83.5	83.56
FINAL BAGASSE																		
Sucrose per cent. Bagasse	3.63	3.25	3.42	3.38	3.06	2.93	3.20	2.98	2.93	3.33	3.09	1.99	2.39	2.95	2.72	2.53	3.29	2.91
Moisture per cent. Bagasse	53.32	54.43	53.20	54.18	49.67	55.76	51.51	55.61	52.79	51.35	52.41	51.70	51.67	50.76	49.92	52.43	49.19	53.18
Fibre per cent. Bagasse ...	41.89	41.34	42.33	41.39	46.31	40.52	44.51	40.54	43.51	44.49	43.68	45.62	45.14	45.38	46.51	44.19	46.55	43.02
Weight of Bagasse per cent. Cane	30.29	32.59	39.75	38.58	33.74	39.60	34.78	38.92	36.58	36.53	35.95	34.00	36.71	35.40	34.54	38.40	32.32	36.58
Lower Calorific Value (7,650-185-86.4*W* Btu/lb.) ...	**2978**	**2889**	**2992**	**2908**	**3303**	**2780**	**3142**	**2792**	**3036**	**3153**	**3066**	**3147**	**3186**	**3211**	**3288**	**3075**	**3341**	**3003**
FIRST EXPRESSED JUICE																		
Brix ... ... - - - • • •	21.37	20.17	20.69	19.55	20.24	19.89	19.79	20.31	20.62	20.20	19.99	20.17	20.37	20.21	21.01	20.31	20.72	20.33
Purity (Apparent)	88.4	87.0	87.9	87.0	89.7	87.9	88.7	88.0	88.0	88.3	88.3	88.1	88.0	86.3	88.8	87.9	87.4	88.00
LAST EXPRESSED JUICE																		
[illegible]	4.71	3.73	3.57	4.10	2.14	4.22	4.44	2.94	4.66	3.81	3.64	2.56	2.25	2.31	3.56	4.14	4.60	3.49
Purity (Apparent)	75.8	76.9	76.5	76.2	76.2	78.7	80.2	77.5	79.3	80.7	78.7	74.3	75.0	74.9	76.2	74.9	78.5	76.67
Purity Drop from First Expressed Juice	12.6	10.1	11.4	10.8	13.5	9.2	8.5	10.5	8.7	7.6	9.6	13.8	13.0	13.4	12.6	13.1	8.9	11.33
MIXED JUICE																		
Box ... ... ••-	18.42	16.69	15.63	15.15	14.25	15.52	15.48	16.82	16.26	15.73	15,54	15.86	15.06	15.05	15.43	15.25	15.20	15.60
Purity (Gravity) ...	86.5	85.3	86.2	84.2	87.1	85.3	86.24*	86.3	87.3	86.4	87.1	86.7	85.9	84.2	85.7*	86.1	84.8*	8596
Reducing Sugars/Sucrose Ratio	2 IS	2 75	3.41	4 27	3.54	3.91	—	3 60	3 18	3 6J	2 81	—	3 32	4 30	2 64	3 36	—	3.40
Purity Drop from First Expressed Juice	1.9	1.7	1.7	2.8	2.6	2.6	2.5	1.7	0.7	1.9	1.2	1.4	2.1	2.2	3.1	1.8	2.6	2.04
CLARIFIED JUICE																		
Brix	18.72	16.08	16.25	13.78	13.98	14.35	16.03	14.07	15.74	15.60	15.49	15.83	13.92	15.14	16.07	14.56	15.00	15.42†
Purity (Apparent)	87.0	88.1	86.8	85.6	88.2	86.6	87.7	87.0	88.2	87.0	87.6	87.8	91.7	86.1	86.6	87.2	85.6	87.07†
Reducing Sugars/SucroseRatio	2.11	2.51	3.19	3.52	2.84	3.75	—	3.50	—	3.40	—	—	1.54	3.72	2.62	3.23	—	3.13†
Average pH	7.0	7.2	7.4	7.1	6.9	7.3	7.0	7.3	6.8	7.3	6.8	—	6.9	7.4		6.9	7.2	7.11†
FILTER CARE																		
Sucrose per cent. Filter Cake	1.57	2.13	1.30	0.75	3.52	0.67	3.82	0.72	1.00	1.66	1.02	0.63	0.80	0.87	0.70	1.27	0.78	1.18†
Weight of Cake per cent. Cane	5.66	6.08	5	7.40	6.93	4.86	5.20	5.39	5.01	5	5.13	3.84	11.66	4	6.52	—	4	5.28†
SYRUP																		
Brix	58.2	59.3	52.8	52.5	61.8	52.3	51.0	55.6	51.8	52.8	48.1	51.6	60.2	61.5	60.4	59.9	52.6	55.14†
Purity (Apparent)	86.8	87.3	86.8	85.6	88.6	87.0	89.1	87.2	89.0	87.6	87.7	87.8	91.7	85.8	86.6	86.6	85.5	87.19†
Reducing Sugars/Sucrose Ratio ...	1.87	2.51	3.14	3.47	2.80	3.59	—	3.29	2.95	3.20	—	—	1.53	3.68	2.69	2.83	—	3.02†
Average pH	6.9	6.8	7.1	7.0	6.7	7.1	6.8	6.9	6.7	7.2		—	7.1	7.1	—	6.6	7.0	6.92†

* Apparent Purity † Exclusive Natal Estates

Table III.—MASSECUITES AND MOLASSES, CHEMICALS.

FACTORY	PG	UF	ZM	FX	EN	AK	DK	DL	GL	MN	CK	TS	NE	IL	RN	SZ	UK	Averages§
A-MASSECUITE																		
Cub. feet per ton of Brix†	24.2	25.3	19.6	24.2	21.5	23.7	29.7	23.6	26.1	25.7	24.5	19.9	37 4	28 6	—	21 3	22 8	23 26
Brix of Massecuite	91 9	92.8	93.3	92 9	91 3	91 8	90.0	92 5	90 5	91.4	90.4	92 8	91.4	92.0	93 2	92.1	91 6	91.91
Purity of Massecuite	85 0	84 6	86.2	81.4	88.7	84.4	87.7	83.7	89.2	82.8	88.2	87.9	93.8	86.2	86.3	86.3	85.0	85.84
Purity of Molasses	70.3	65.7	65.6	64.6	72.4	65.7	72.9	66.2	72.6	62.4	71.5	68.5	85.1	68.3	69.6	68.9	65.2	68.15
Drop in Purity	14.6	18.9	20.6	16.8	16.4	18.7	14.8	17.5	16.6	20.4	16.7	18.4	8.7	17.8	16.7	17.4	19.8	17.69
Crystal per cent. Massecuite	45.3	51.1	55.9	44.1	54.1	50.0	49.2	47.9	54.8	49.6	52.9	54.2	54.9	51.8	51.2	51.6	52.1	51.05
B-MASSECUITE																		
Cub. feet per ton of Brix†	7.6	8.0	11.4	12.35	9.8	11.2	10.0	11.8	10.2	13.5	14.6	11.1	22.7	11.0	—	10.6	8.2	10.85
Brix of Massecuite	96.5	95.5	97.4	96.6	94.2	95.3	94.0	95.4	94.8	94.2	94.3	95.0	94.2	93.1	97.7	95.3	94.2	95.22
Purity of Massecuite	73.6	73.1	70.8	71.6	74.0	70.9	75.8	71.0	72.3	68.5	73.4	74.5	82.9	75.8	72.2	73.4	73.3	72.76
Purity of Molasses	52.2	49.9	43.3	48.4	57.2	46.4	53.6	48.1	45.8	46.2	48.8	51.4	63.3	52.9	50.3	48.0	50.5	49.57
Drop in Purity	21.4	23.3	26.5	23.2	16.8	24.5	22.2	22.9	26.5	22.3	24.6	23.1	19.5	22.8	21.9	25.4	22.8	23.19
Crystal per cent. Massecuite	43.2	44.3	45.5	43.4	37.0	43.6	45.0	42.1	46.4	39.0	45.3	45.2	50.2	45.1	43.0	46.5	43.4	43.78
C-MASSECUITE																		
Cub. feet per ton of Brix†	6.6	7.0	7.1	7.3	9.3	6.6	7.9	6.4	6.1	6.8	7.0	7.4	7.3	7.6	—	8.0	8.2	7.20
Brix of Massecuite	100.2	98.5	99.2	98.1	96.0	96.3	96.4	96.6	96.0	96.4	96.2	96.7	99.5	96.0	100.7	99.4	96.5	97.44
Purity of Massecuite	61.5	. 59.7	58.3	59.5	63.6	59.6	62.4	59.6	58.6	56.4	60.5	62.2	68.4	60.0	59.3	58.2	56.1	59.73
Purity of Molasses	40.6	38.7	36.5	39.7	42.6	38.7	38.7	38.8	37.4	40.2	39.6	37.0	44.5	37.6	39.2	36.1	38.3	38.73
Drop in Purity	20.9	21.0	21.8	19.8	21.0	20.9	23.7	20.8	21.2	16.2	20.0	25.2	24.0	22.4	20.1	22.0	17.8	21.00
Crystal per cent. Massecuite	35.2	33.7	34.0	32.2	35.2	32.8	37.3	32.8	32.5	26.1	33.2	38.7	42.9	34.4	33.2	34.3	27.8	33.40
TOTAL CUB. FEET OF ALL MASSECUITES																		
Per ton of Sugar Made	49.1	51.9	48.0	56.9	52.0	52.4	61.5	51.8	52.9	57.5	58.9	47.9	86.8	62.0	—	52.0	50.4	52.28
Per ton of Brix†	38.5	40.4	38.0	43.9	40.6	41.6	47.6	41.9	42.4	46.0	46.0	38.4	67.4	47.2	—	41.0	39.2	41.31
FINAL MOLASSES																		
Brix	90.5	91.9	93.7	92.0	82.8	88.2	84.9	90.2	86.8	86.9	87.6	87.2	90.6	90.4	90.9	91.6	91.1	89.96
Gravity Purity	41.1	39 7	38 2	39 7	42.6*	39.3	38.7*	39.4	38.3	40.2	39.6	39.1	45.4	40.3	39.2*	35.4	38.3	39.58
Reducing Sugars per cent.	—	15.31	12.85	14.36	—	14.56	—	14.16	12.71	13.40	—	14.20	9.46	13.94	—	—	—	14.20
Sulphated Ash per cent.	—	17.71	15.57	12.87	—	11.59	—	12.45	—	—	—	—	14.59	13.60	—	—	—	13.96
Reducing Sugars/Ash Ratio	—	0.86	0.82	1.12	—	1.26	—	1.14	—	—	—	—	0.65	1.02	—	—	—	1.02
Weight of Molasses (at 85° Brix) per cent. Cane	3.21	2.92	3.08	—	2.27	2.82	3.08	2.74	2.82	2.84	3.07	2.86	2.45	3.34	3.44	—	—	2.95
CONSUMPTION OF LIME AND OTHER CLARIFYING AGENTS																		
Lime—lbs. per ton of Cane	6.46	2.76	4.24	3.03	7.66	2.68	5.41	2.25	5.38	6.00	4.65	1.04	CARBONATATION	1.60	5.78	6.80	5.30	3.71
lbs. per ton of Sugar	49.37	23.48	36.19	35.74	66.82	22.85	48.10	18.93	44.90	51.61	41.00	8.64		14.07	46.96	58.15	43.59	31.58
parts per 1,000 parts of Brix†	19.34	9.13	14.35	13.79	26.11	9.07	18.63	7.64	18.00	20.66	16.02	3.47		5.36	18.32	22.92	16.96	12.48
Sulphur—lbs. per ton of Cane	2.74	0.72	1.70	0.86	3.16	0.74	1.93	0.77	1.96	2.45	1.89	—		—	2.33	2.98	2.33	1.28
lbs. per ton of Sugar	20.93	6.15	15.24	8.02	27.59	6.30	17.15	6.50	16.37	21.03	16.71	—		—	19.00	25.52	18.86	10.92
parts per 1,000 parts of Brix†	8.20	2.39	6.04	3.09	10.78	2.50	6.64	2.62	6.56	2.46	6.53	—		—	7.41	10.06	7.34	4.31
Phosphoric—lbs. per ton of Cane	0.82	0.09	0.55	0.24	0.67	0.22	1.20	0.12	0.84	0.33	0.91	0.04		0.06	0.72	0.91	0.58	0.39
lbs. per ton of Sugar	6.27	0.79	4.71	2.24	5.83	1.90	13.51	1.03	7.01	2.80	8.00	0.32		0.51	5.90	7.82	4.65	3.33
parts per 1,000 parts of Brix†	2.46	0.31	1.87	0.86	2.28	0.75	4.14	0.41	2.81	1.12	3.12	0.13		0.19	2.30	3.08	1.81	1.31

*Apparent Purity †Brix present in Mixed Juice

§NOTE—All averages are exclusive of Natal Estates' figures, with the exception of the averages referring to Final Molasses

Table IV.—COMPARATIVE RESULTS OF FINAL DATA FOR RECENT YEARS.

COUNTRY	SOUTH AFRICA									
YEAR	1946.	1947.	1948.	1949.	1950.	1951.	1952.	1953.	1954.	*1955.*
CANE										
Sucrose per cent....	14.21	13.32	13.89	13.52	14.19	13.33	13.87	13.93	13.34	13.87
Fibre per cent.	16.21	15.80	15.90	16.19	15.80	16.28	16.10	16.31	16.03	15.74
JAVA RATIO	77.03	76.99	76.98	76.47	77.42	76.56	77.04	77.07	77.39	77.87
JUICE QUALITIES										
Purity of First Expressed Juice	88.22	88.48	88.12	88.64	88.70	87.60	88.60	87.48	87.94	88.00
Purity of Last Expressed Juice	75.1	75.0	75.5	67.2	75.8	74.5	76.2	76.46	76.81	76.67
Purity of Mixed Juice	85.9	86.24	85.92	86.22	86.40	84.92	86.25	85.61	85.86	85.96
Purity of Syrup	87.44	87.98	87.54	87.93	87.60	96.20	87.65	86.46	87.13	87.19
Purity Drop First to last Expressed Juice	13.08	13.45	12.58	12.48	12.90	13.10	12.40	11.02	11.13	11.33
Purity Drop First to Mixed Juice	2.36	2.24	2.20	2.42	2.30	2.68	2.35	1.87	2.08	2.04
Purity Drop First to Syrup	0.75	0.47	0.56	0.71	1.10	1.40	1.20	1.02	1.27	0.81
Purity Increase Mixed Juice to Syrup	1.60	1.75	1.64	1.71	1.30	1.30	1.40	0.85	0.81	1.23
Reducing Sugar/Sucrose Ratio of Mixed Juice	3.30	2.95	3.67	3.11	3.12	3.52	2.92	3.66	3.28	3.40
Reducing Sugar/Sucrose Ratio of Syrup	2.80	2.62	3.07	2.55	2.81	3.25	2.66	3.31	3.01	3.02
EXTRACTION AND RECOVERIES										
Sucrose lost in manufacture % Cane	2.42	2.26	2.33	2.25	2.32	2.33	2.26	2.39	2.24	2.26
Sucrose in Sugar % Sucrose in Cane (Overall Rec.) ...	82.94	83.73	83.19	83.35	83.65	82.50	83.66	82.81	83.20	83.56
Sucrose in Mixed Juice % Sucrose in Cane (Extraction) ...	93.07	93.44	93.32	92.94	93.33	92.98	93.00	92.67	92.40	92.32
Sucrose in Sugar % Sucrose in Mixed Juice (B.H. Rec.) ...	89.12	89.61	89.14	89.68	89.63	88.72	89.96	89.36	90.04	90.51
Imbibition % Fibre	217	218	214	208	206	215	217	200	191	204
Imbibition % Cane	35.2	34.4	34.1	33.7	32.8	35.0	34.9	32.7	30.7	32.1
Lost Absolute Juice % Fibre in Bagasse	40.5	39.8	39.8	41.0	39.3	40.2	40.9	41.7	44.1	45.5
Boiling House Performance	96.7	96.8	96.5	96.9	96.88	96.66	97.2	96.91	97.43	97.92
BAGASSE										
Sucrose per cent....	2.79	2.54	2.67	2.66	2.72	2.57	2.65	2.75	2.75	2.91
Moisture per cent.	50.32	50.46	50.53	50.84	51.22	51.71	52.53	52.47	52.92	53.18
Lower Calorific Value	*3252*	*3244*	*3236*	*3209*	*3176*	*3136*	*3063*	*3067*	*3028*	*3003*
FILTER CAKE										
Sucrose per cent....	0.96	1.06	1.29	1.12	1.20	1.28	0.94	1.05	1.18	1.18
Weight % Cane	5.91	5.99	5.90	5.91	5.51	5.68	6.34	5.86	5.48	5.28
GRAVITY PURITY OF FINAL MOLASSES	41.75	41.10	41.53	41.39	40.50	40.28	39.33	39.46	39.29	39.58
Average Polarization of All Sugars	98.70	98.83	98.93	98.84	98 77	98.80	98.63	98.66	98.51	98.65
YIELD										
Tons Cane per Ton Sugar	8.36	8.84	8.55	8.76	8.32	8.98	8.50	8.55	8.87	8.51
Tons Cane per Ton 96° Sugar	8.14	8.60	8.31	8.52	8.09	8.73	8.27	8.32	8.65	8.28
SUCROSE BALANCE										
Sucrose in Bagasse % Sucrose in Cane (A)	6.93	6.56	6.68	7.06	6.67	7.01	7.00	7.33	7.60	7.68
Sucrose in Filter Cake % Sucrose in Cane (B)	0.28	0.32	0.36	0.34	0.37	0.52	0.43	0.49	0.54	0.47
Sucrose in Molasses % Sucrose in Cane (C)	—	—	—	—	7.97	8.61	7.45	7.78	7.22	7.08
Undetermined Sucrose % Sucrose in Cane (D)	9.85	9.39	9.77	9.25	1.34	1.36	1.46	1.59	1.44	1.21
Boiling House Losses % Sucrose in Cane (B) + (C) + (D)...	10.13	9.71	10.13	9.59	9.68	11.28	9.34	9.86	9.26	8.76
Total Losses % Sucrose in Cane (A) + (B) + (C) + (D) ...	17.06	16.27	16.81	16.65	16.35	17.50	16.34	17.19	16.80	16.44

Table V.—AVERAGE MANUFACTURING RESULTS BY MONTHLY PERIODS FOR S.A. SUGAR FACTORIES REPORTING TO THE SUGAR MILLING RESEARCH INSTITUTE, SEASON 1955-1956

Period ended		28 May, 1955	2 July, 1955	30 July, 1955	27 Aug., 1955	1 Oct., 1955	29 Oct., 1955	26 Nov., 1955	31 Dec., 1955	28 Jan., 1956	3 Mar., 1956
Tons of 2,000 lbs. Cane Crushed ...	This period	—	1,056,177	915,307	925,095	1,140,322	876,160	825,321	877,473	541,834	201,746
	To date ...	548,226	1,614,403	2,529,710	3,454,805	4,595,127	5,471,287	6,296,607	7,174,086	7,715 914	7,917,674
Tons of 2,000 lbs. Sugar Made and Estimated	This period	—	115,483	108,065	113,846	145,341	109,506	98,841	99,717	61,671	21,555
	To date ...	56,408	171,891	279,956	393,802	539,143	648,649	747,490	847,207	908,878	930,312
Tons of Cane per Ton of Sugar	This period	—	9.15	8.47	8.10	7.85	8.00	8.35	8.80	8.79	9.36
	To date ...	9.90	9.39	9.04	8.76	8.52	8.43	8.42	8.47	8.49	8.51
Sucrose per cent. Cane	This period	—	12.91	13.83	14.48	14.98	14.72	14.08	13.49	13.43	12.96
	To date ...	12.20	12.67	13.09	13.46	13.84	13.98	13.99	13.93	13.90	13.87
Fibre per cent. Cane	This period	—	15.47	15.47	15.47	15.56	15.63	15.88	16.17	16.43	16.85
	To date ...	15.72	15.56	15.53	15.51	15.52	15.54	15.59	15.66	15.71	15.74
Java Ratio	This period	—	78.83	78.52	78.43	78.03	77.84	77.32	76.55	76.37	77.99
	To date ...	78.84	78.84	78.71	78.63	78.47	78.36	78.23	78.03	77.91	77.87
Sucrose per cent. Bagasse	This period	—	2.74	2.89	3.05	3.09	3.06	2.94	2.87	2.86	2.94
	To date ...	2.50	2.66	2.74	2.82	2.89	2.92	2.92	2.91	2.91	2.91
Moisture per cent. Bagasse	This period	—	52.84	52.65	52.94	52.74	53.12	53.35	53.69	54.03	54.84
	To date ...	53.35	53.02	52.88	52.90	52.86	52.90	52.96	53.06	53.13	53.18
Extraction	This period	—	92.50	92.60	92.47	92.53	92.43	92.27	91.93	91.72	90.70
	To date ...	92.58	92.46	92.54	92.52	92.52	92.51	92.48	92.41	92.36	92.32
Boiling House Recovery	This period	—	90.47	90.98	90.71	90.70	90.59	90.96	90.30	91.00	88.80
	To date ...	88.42	89.78	90.21	90.36	90.46	90.48	90.54	90.52	90.55	90.51
Overall Recovery	This period	—	83.65	84.25	83.87	83.93	83.75	83.93	83.02	83.46	80.53
	To date ...	81.86	83.05	83.48	83.59	83.69	83.70	83.73	83.65	83.63	83.56
Purity of Mixed Juice	This period	—	85.05	85.82	86.20	86.19	86.88	87.00	86.47	85.28	83.54
	To date ...	84.34	84.81	85.19	85.48	85.67	85.87	86.02	86.07	86.02	85.96
Reducing Sugar/Sucrose Ratio of Mixed Juice	This period	—	3–64	3.34	3.21	3.34	2.89	2.74	3.10	4.07	5.49
	To date ...	4.41	3.82	3.64	3.54	3.48	3.38	3.29	3.28	3.36	3.40
Reducing Sugar/Sucrose Ratio of Syrup...	This period	—	3.22	3.29	2.89	2.87	3.06	2.24	2.52	3.12	4.69
	To date ...	3.68	3.29	3.15	3.10	3.06	2.96	2.86	2.83	2.88	3.00
Gravity Purity of Final Molasses ...	This period	—	38.2	38.4	39.0	39.7	41.1	41.6	40.7	40.8	39.1
	To date ...	37.5	38.1	38.2	38.4	38.7	39.4	39.5	39.5	39.6	39.6

Table VI.-COMPARATIVE RESULTS FROM OTHER COUNTRIES FOR RECENT YEARS.

COUNTRIES	Mauritius		Philippines		Jamaica		British Guiana		South Africa	
YEARS	1953	1954	1952-53	1953-54	1953	1954	1953	1954	1954-55	1955-56
CANE										
Sucrose per cent.	12.96	13.44	12.63	12.81	12.18	11.94	10.54	10.55	13.34	13.87
Fibre per cent.	11.65	11.68	11.58	11.76	14.31	14.04	15.13	15.17	16.03	15.74
JUICES										
Brix per cent. of First Expressed Juice	18.42	18.78	18.66	18.97	18.38	17.97	17.02	16.90	19.61	20.33
Purity of First Expressed Juice	87.2	88.0	84.4	84.5	84.0	83.8	82.0	82.3	87.9	88.0
Purity of Last Expressed Juice	74.3	74.4	77.0	77.3	76.4	75.9	74.7	75.3	76.0	76.7
Gravity Purity of Mixed Juice	85.1	86.1	83.9	84.1	82.2*	82.0*	79.7*	80.1*	85.9	86.0
Reducing Sugar/Sucrose Ratio	5.1	4.5	—	—	7.95	8.20	8.85	8.45	3.28	3.40
MILLING FIGURES										
Imbibition per cent. Fibre	167	197	100	98	134	184	156	151	191	204
Lost Absolute Juice per cent. Fibre	**44.8**	**42.4**	**62.5**	**60.6**	**33.4**	**35.9**	**48.3**	**51.6**	**44.1**	**45.5**
Imbibition per cent. Cane	19.5	23.0	11.6	11.5	19.2	19.6	23.7	22.9	30.7	32.1
Sucrose Extraction	94.8	95.3	92.5	92.5	94.4	94.5	91.4	91.3	92.4	92.3
Sucrose per cent. Bagasse	2.80	2.71	3.74	3.74	2.38	2.33	2.93	2.95	2.75	2.91
Moisture per cent. Bagasse	47.20	47.40	49.32	49.19	45.46	47.30	47.24	47.47	52.92	53.18
Lower Calorific Value of Bagasse	**3525**	**3506**	**3321**	**3400**	**3684**	**3521**	**3516**	**3496**	**3028**	**3003**
BOILING HOUSE FIGURES										
Boiling House Performance	96.2	97.0	99.1	98.7	97.9	98.2	97.8	97.5	97.4	97.9
Boiling House Recovery	88.5	89.7	91.1	91.0	89.1	89.3	87.8	87.8	90.0	90.5
Undetermined Losses per cent. Sucrose in Cane ...	—	—	0.48	0.47	1.54	1.52	1.03	2.03	1.44	1.21
AVERAGE POLARIZATION OF ALL SUGARS	98.6	98.5	97.39	97.37	96.91	96.91	96.79	96.89	98.51	98.65
FILTER CAKE										
Sucrose per cent. Cake	6.1	6.1	2.83	2.63	2.46	2.02	1.83	1.93	1.18	1.10
Weight per cent. Cake	1.94	1.99	1.83	2.02	2.28	2.29	2.85	3.11	6.11	5.97
FINAL MOLASSES										
Gravity Purity	37.6	37.3	36.2	35.5	33.2*	32.4*	31.0*	31.4*	39.3	39.6
OVERALL RECOVERY	83.7	85.4	84.3	84.2	84.1	84.3	80.3	80.1	83.2	83.6
TONS CANE PER TON OF 96° SUGAR	8.83	8.36	9.08	8.96	9.37	9.53	11.35	11.36	8.65	8.28

**Apparent Purity*

Table VII—COMPARATIVE DATA OF REPORTING S.A. FACTORIES FROM 1925 TO 1955 INCLUSIVE.

	Per cent. Cane		Tons of Cane per ton of		Extraction	Boiling House Recovery	Overall Recovery	Imbibition		Bagasse		Lost Absolute Juice per cent. Fibre	Mixed Juice		Purity Final Molasses	Boiling House Performance	Number of factories reporting of factories in operation	Percentage of crop covered
	Sucrose	Fibre	Sugar	96° Sugar				Per cent. Cane	Per cent. Fibre	Per cent. Sucrose	Per cent. Moisture		Purity	Reducing Sugar Ratio				
1925	12.55	15.88	10.77	10.46	89.30	81.98	73.28	—	—	4.03	49.38	60.7	84.47	—	44.5	89.4	11 of 25	60.4
1926	12.23	16.01	9.92	9.74	90.86	81.97	74.48	—	—	3.53	**49.33**	52.8	84.65	—	45.3	88.8	13 of 23	73.3
1927	13.66	16.27	9.69	9.48	89.30	83.01	74.13	—	—	4.06	49.89	58.3	85.47	—	46.1	89.6	14 of 21	81.0
1928	13.75	15.88	9.49	9.30	89.47	83.90	75.06	26.3	166	4.10	50.01	59.8	84.90	3.86	45.3	90.8	14 of 25	83.3
1929	12.95	15.52	10.06	9.87	89.02	84.39	75.13	25.5	164	4.07	50.69	63.2	86.04	3.35	45.1	90.7	16 of 25	91.0
1930	13.66	15.82	9.59	9.40	89.78	83.80	74.77	26.6	168	4.20	50.66	57.4	85.88	3.35	45.9	90.2	17 of 23	94.9
1931	13.84	15.75	9.53	9.33	89.40	83.27	74.39	27.9	177	4.22	50.09	60.0	85.27	3.55	45.0	90.0	16 of 22	94.5
1932	13.48	15.65	9.61	9.40	89.86	84.27	75.73	29.7	190	3.83	51.89	58.4	85.30	3.09	45.1	91.1	16 of 23	94.4
1933	13.88	15.78	9.28	9.03	90.28	84.88	76.63	30.4	193	3.71	51.62	55.9	84.92	4.01	44.9	92.2	15 of 23	90.0
1934	11.88	15.24	10.67	10.40	91.07	85.20	77.59	30.2	198	3.05	52.11	57.7	84.02	4.21	45.6	92.9	17 of 23	96.5
Average ...	13.19	15.78	9.86	9.64	89.83	83.67	75.12	27.6	175	3.88	50.57	58.4	85.09	3.65	45.3	90.6	15 of 23	85.9
1935	13.65	15.92	19.19	8.96	90.64	86.52	78.40	33.0	208	3.48	51.93	54.2	86.49	**2.65**	46.6	93.0	17 of 23	97.1
1936	13.30	15.01	9.29	9.06	91.08	87.44	79.64	32.4	216	3.40	52.76	55.6	85.43	3.04	43.9	94.6	17 of 23	96.2
1937	13.92	15.14	8.80	8.58	91.53	87.85	80.41	31.8	210	3.40	52.01	52.4	85.60	3.23	43.7	95.0	17 of 23	96.4
1938	13.64	**14.51**	8.89	8.66	91.90	88.48	81.31	31.7	218	3.30	52.17	53.1	86.36	3.08	43.1	95.4	17 of 23	96.6
1939	13.41	14.85	8.95	8.73	92.24	88.88	81.98	31.3	211	3.11	51.79	49.6	86.46	3.27	42.7	95.7	19 of 22	98.5
1940	13.19	15.56	9.26	9.03	91.91	87.98	80.86	32.6	209	3.02	51.60	48.9	85.34	3.81	42.9	95.3	19 of 22	99.0
1941	14.00	15.66	8.62	8.39	92.37	88.40	81.66	34.8	222	3.03	51.50	45.1	85.67	3.35	43.4	95.6	19 of 22	98.5
1942	13.40	15.24	8.93	8.69	92.69	88.98	82.48	32.8	215	2.88	51.24	45.1	85.96	3.07	43.2	96.2	19 of 22	98.4
1943	13.14	15.26	8.98	8.74	92.97	88.84	83.52	31.6	207	2.76	50.80	43.8	**86.56**	3.18	41.8	96.7	19 of 22	98.6
1944	13.67	15.83	8.67	8.44	93.13	89.27	83.14	33.7	213	2.73	50.23	41.1	86.19	3.49	42.4	96.4	19 of 22	98.4
Average ...	13.53	15.30	8.96	8.73	92.05	88.36	81.34	32.6	213	3.11	51.60	48.9	86.01	3.22	43.3	95.4	18 of 22	97.8
1945	**14.28**	15.99	**8.29**	**8.08**	93.28	89.29	83.30	35.0	**219**	2.77	50.19	39.3	86.23	3.38	42.0	96.4	19 of 21	99.0
1946	14.21	16.21	8.36	8.14	93.07	89.12	82.94	**35.2**	217	2.79	50.32	40.5	85.86	3.30	41.8	96.7	19 of 21	99.2
1947	13.32	15.80	8.84	8.60	**93.44**	89.61	**83.73**	34.4	218	**2.54**	50.46	39.8	86.24	2.95	41.1	96.8	18 of 20	99.8
1948	13.89	15.90	8.55	8.31	93.32	89.14	83.19	34.1	214	2.67	50.53	39.8	85.92	3.67	41.5	96.5	18 of 20	99.1
1949	13.52	16.19	8.76	8.52	92.94	89.68	83.35	33.7	208	2.66	50.84	41.0	86.22	3.11	41.4	96.9	18 of 20	99.2
1950	14.19	15.80	8.32	8.09	93.33	89.63	83.65	32.8	206	2.72	51.22	**39.3**	86.40	3.12	40.5	96.9	17 of 19	99.2
1951	13.33	16.29	8.98	8.73	92.98	88.72	82.50	35.0	215	2.57	51.71	40.2	84.92	3.52	40.3	96.7	17 of 19	99.5
1952	13.87	16.10	8.50	8.27	93.00	89.96	83.66	34.9	217	2.65	52.53	40.8	86.25	2.92	**39.3**	97.2	17 of 19	99.3
1953	13.93	16.31	8.55	8.24	92.67	89.36	82.81	32.7	200	2.75	52.47	41.7	85.61	3.66	39.5	96.9	16 of 18	99.3
1954	13.34	16.03	8.87	8.65	92.40	**90.04**	83.20	30.7	191	2.75	52.92	44.1	85.86	3.28	**39.3**	97.4	17 of 19	99.2
Average ...	13.79	15.96	8.60	8.36	93.04	89.46	83.23	33.8	210	2.69	51.32	40.6	85.95	3.29	40.7	96.8	18 of 20	99.3
1955	13.87	15.74	8.51	8.28	92.32	**90.51**	83.56	32.1	204	2.91	53.18	45.5	85.96	3.40	39.6	**97.9**	17 of 19	99.1

During the reading of the summary Mr. Perk drew attention to the fact that the average ratio of 0.83 had been used by him alone and only to calculate the molasses weight of those factories which do not weigh their final molasses. In this respect he drew attention to last year's discussion when he had pointed out that the ratio was only a mathematical form and no yardstick for removal of nonsucrose.

Mr. **Hendry** enquired how many factories in South Africa produced string proof sugar.

Mr. **Perk** replied that Sezela still boiled such sugar, the volume of which he had included in that of C massequite. In answer to a further question by Mr. Hendry he stated that since mixed juice was not weighed in Australia, the Australian data was not considered particularly suitable for comparison. Another difference was that Australia gave the true purity of final molasses, and although this was a better figure than gravity purity it made comparison difficult.

Mr. **Grant** (President) asked Mr. Perk, while drawing attention to the increased output of South African mills and the higher absolute juice lost per cent fibre, if the two were not very intimately connected?

Mr. Perk said that he would have liked to have given the same review of obtained crushing rates and capacity ratings as he did last year, but Felixton starting with one tandem and finishing with two prevented his repeating the review. Next year he would put this comparison again in the annual summary.

Mr. Rennie asked how could it be considered that efficiency had improved, whereas the overall recovery figures remained fairly constant.

Mr. Perk pointed out that overall recovery was not a very good figure on which to make such a comparison. Boiling House Performance was a better figure.

Dr. Dodds said he agreed with Mr. Hendry that it would be preferable to have a greater range of foreign countries with which to compare figures. He noticed that the figures from British Guiana, which were usually low, for reasons beyond their control, were generally published in such comparisons, as remarked by a British Guiana representative at the Australian International Congress.

Mr. Perk said that he could only publish the figures he received. Regarding the figures from British Guiana, the Boiling House Recovery was not bad at all when you took the low mixed juice purity into account.

Mr. **Hendry** asked if further figures from Java could not be published.

Mr. Perk pointed out that the S.M.R.I. regularly received Java data, but the figures were not totalized nor averaged.

Mr. Main pointed out that now Formosa was crushing such a large quantity of N:Co.310, it would be interesting to have their figures. He pointed out that they were getting very high extraction figures on this

Mr. **Perk** drew attention to two facts which would make comparison of milling data difficult. Firstly, the habit of the N:Co.310 grown in Formosa could be quite different from N:Co.310 grown in Natal. When in Formosa he could not recognize Java varieties, they had a different colour and a different stalk. Secondly, the cane preparation in Formosa is more intense than in Natal. The cane was really disintegrated by two sets of cane knives and a shredder before it arrived at the extracting units i.e., **the** mills. He would, however, endeavour to get the Formosan figures.

Mr. **Barnes** said that comparative figures were given in tons of 2,000 lbs. and in metric tons. He suggested that they should also be quoted in avoirdupois tons.

Mr. Perk replied that at the conclusion of the 3rd Congress of the I.S.S.C.T. a resolution was passed to publish all field and factory results in metric units, either exclusively or along with the customary units. Table I of the annual summary complied with this resolution.

Mr. Barnes stated that the big New York Sugar Brokers, Messrs. Willet and Grey expressed their weights in the three systems and, to make comparison easy, he offered a suggestion that the South African figures should be recorded similarly.

Mr. du Toit stated that primarily these figures were meant for domestic consumption. He was pleased, however, that so much attention was paid to them overseas. He considered it quite legitimate to record the British Guiana figures for comparison.

Mr. **King** said that **N:Co.376** and N:Co.292 were distributed about 15 months ago. N:Co.334, however, had not yet been distributed so he would like to know why it should be bracketed with the others and, furthermore, he would like to know where it came from,

Mr. Pearson explained that this cane was grown on Experiment Station property at Umhlatuzi and Chaka's Kraal. The cane was not released to planters, but it was sent into the mill for crushing.

WEATHER REPORT FOR THE YEAR 1st JUNE, 1955 TO 31st MAY, 1956

By J. L. DU TOIT

General

In this report the same procedure will be followed as was done in the four previous reports. This report will, therefore, deal mainly with the rainfall returns from 54 centres within the sugar belt for the period June 1955 to May 1956, but the rainfall data for the twelve months prior to June 1955 will also be referred to, as climatic conditions during this period will have a bearing on the mainly 2 year old cane crop to be cut during the 1956 season. The other meteorological data discussed, such as atmospheric temperatures, evaporation from an open water tank, etc. will strictly refer to the Experiment Station, Mount Edgecombe, only, but will in general reflect weather conditions in the cane area. Soil temperatures at 2 ft. depth are also available from two additional areas at Port Shepstone and Entumeni.

Rainfall Returns from Fifty-Four Centres

The centres from which rainfall data is recorded are well scattered over, and representative of, the whole sugar belt. The data is divided into the normal geographical divisions i.e. South Coast, North Coast and Zululand and further sub-divided into magisterial districts which facilitate a possible correlation fall and cane yield data.

Table I gives the rainfall for the past four years for the 54 recording centres and also the total rainfall for the period June 1954 to May 1956.

Table II gives the rainfall by magisterial districts and also for the three main divisions for each month of the year from June 1955 to May 1956.

Table III gives the mean rainfall distribution for the past 32 years, the calculated mean rainfall for the same period and the actual rainfall for the year now under consideration. Evaporation data taken at the Experiment Station, Mount Edgecombe, are also given in the same table.

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

Table V gives the monthly rainfall for the 54 centres for the past four years, the evaporation from an open water tank at the Experiment Station for the same period and the amount by which evaporation exceeded the rainfall.

TABLE 1

Magisterial District	*Rainfall for year 1st June 1952 to 31st May* 1953	*Rainfall for year 1st June 1953 to 31st May* 1954	*Rainfall for year 1st June 1954 to 31st May* 1955	*Rainfall for year 1st June 1955 to 31st May* 1956	*Rainfall for period 1st June 1954 to 31st May* 1956
Port Shepstone					
Mehlomnyama	40.02	41.61	54.59	46.05	100.65
Umzinto					
Hibberdene	35.92	38.76	48.11	51.47	99.58
Umtwalume	34.11	35.66	41.66	38.36	80.02
Sezela Mill	37.08	40.91	50.35	41.08	91.43
Esperanza Mill	33.82	40.80	49.72	42.03	91.75
Renishaw Mill	30.66	39.22	54.79	41.26	96.05
Dumisa	28.95	35.16	37.63	39.98	77.61
Durban, Camperdown, etc.					
Illovo Mill	28.12	31.80	43.80	36.57	80.37
Umbumbulu	30.50	31.61	38.72	39.74	78.46
Thornville	25.89	36.07	36.11	29.03	65.14
Inanda					
Mount Edgecombe					
Milkwood Kraal	39.41	37.24	39.04	29.92	68.96
Experiment Station	40.15	33.10	42.83	31.11	73.94
La Lucia	41.40	32.55	46.34	35.02	81.36
La Mercy	42.55	35.90	49.04	35.14	84.18
Canelands	34.86	31.12	41.42	29.26	70.68
Tongaat					
Frosterly	41.64	35.43	47.28	33.96	81.24
Inyaninga	40.98	33.77	49.04	32.89	81.93
Inanda	45.09	43.59	47.21	37.91	85.12
Tongaat					
Mwawine	44.85	37.53	49.45	39.21	88.66
Lower Tugela					
Maidstone Mill	39.13	37.65	48.20	37.99	86.19
Sinembe	35.27	37.47	47.29	38.37	85.66
Upper Tongaat	46.57	43.18	52.35	44.51	96.86
Frasers Estate	38.74	35.15	51.68	38.51	90.19
Chaka's Kraal Exp. Farm	41.96	38.37	49.50	36.80	86.30
Chaka's Kraal	36.96	42.66	51.92	39.84	91.76
Groutville	32.72	34.55	45.28	29.09	74.37
Kearsney	34.04	46.39	57.46	39.89	97.35
Doornkop Mill	31.19	40.10	41.84	33.09	74.93
Doornkop, Sprinz	43.57	52.21	55.13	47.37	102.50
Gledhow Mill	35.31	35.64	55.22	34.55	89.77
Darnall Mill	36.65	35.92	53.18	39.40	92.58
Tugela Mouth	30.38	42.61	59.11	45.70	104.81
Mtunzini					
Mandeni	28.50	39.74	53.03	38.50	91.53
Amatikulu Mill	33.44	41.14	48.08	41.91	89.99
Inyoni	34.02	36.34	47.01	39.34	86.35
Mtunzini	34.63	58.56	58.65	53.24	111.89
Blackburn	37.22	43.23	52.97	42.15	95.12
Eshowe					
Entumeni Mill	31.56	42.82	50.08	41.63	91.71
Eshowe	36.22	46.18	55.79	52.04	107.83
Nkwalini	22.53	26.93	38.91	27.59	66.50
Lower Umfolozi					
Felixton Mill	28.07	59.82	63.82	60.90	124.72
Empangeni West	26.88	40.04	43.49	37.48	80.97
Empangeni Mill	29.16	54.00	54.69	47.82	102.51
Logoza	26.17	49.47	51.77	41.48	93.25
Ukulu Properties	24.34	44.39	45.99	39.05	85.04
Mposa	26.09	45.89	44.14	39.72	83.86
Kwambonambi	29.11	48.10	44.47	43.26	87.73
Eteza	34.59	37.84	45.38	38.49	83.87
Hlabisa					
Mtubatuba Mill	25.09	37.92	33.36	29.15	62.51
U.L.O.A.	43.05	45.30	46.43	38.07	84.50
Nyalazi River	31.61	29.45	44.43	28.35	72.78
Hluhluwe	24.29	21.85	36.00	22.28	58.28
Ubombo					
Mkuzi	21.24	22.36	26.63	23.87	50.50
Piet Retief					
Pongola	23.34	25.19	30.76	28.64	59.40
Mean	**33.88**	**39.08**	**47.24**	**38.33**	**85.57**

TABLE II

Rainfall in Inches by Districts for the Months of June, 1955, to May, 1956, inclusive

District	*No. of Centres*	*June*	*July*	*Aug.* (1955)	*Sept.* (1955)	*Oct.* (1955)	*Nov.*	*Dec.*	*Jan.*	*Feb.* (1956)	*Mar.* (1956)	*Apr.* (1956)	*May*	*Total June 55 to May 56*
Port Shepstone ..	1	1.27	0.09	0.11	5.41	3.19	6.19	3.42	0.87	5.66	14.59	4.62	0.64	46.06
Umzinto	6	1.18	0.42	0.11	5.33	2.98	4.30	2.84	0.92	6.83	13.10	3.89	0.32	42.22
Durban, Pinetown, etc.	3	0.83	0.02	0.31	3.09	2.32	3.64	4.21	0.77	7.63	9.24	2.50	0.56	35.12
Mean South Coast..	**10**	**1.08**	**0.27**	**0.17**	**4.67**	**2.80**	**4.29**	**3.31**	**0.87**	**6.95**	**12.10**	**3.55**	**0.42**	**40.48**
Inanda	9	0.61	0.08	0.33	3.56	3.43	4.66	2.56	0.37	8.37	6.51	2.58	0.82	33.88
Lower Tugela ..	13	0.84	0.10	0.29	2.80	4.45	5.71	3.60	0.58	10.29	6.90	2.26	0.98	38.80
Mean North Coast..	**22**	**0.75**	**0.09**	**0.31**	**3.11**	**4.04**	**5.28**	**3.17**	**0.49**	**9.51**	**6.74**	**2.39**	**0.92**	**36.80**
Mean south of Tugela	**32**	**0.85**	**0.15**	**0.27**	**3.60**	**3.65**	**4.97**	**3.22**	**0.61**	**8.71**	**8.41**	**2.75**	**0.76**	**37.95**
Mtunzini	5	0.70	0.10	0.49	2.62	5.54	7.16	5.13	0.81	12.81	4.87	1.27	1.15	42.65
Eshowe	3	0.56	0.02	0.38	2.30	6.15	6.00	6.17	0.53	12.46	4.73	0.49	0.64	40.43
Lower Umfolozi ..	8	0.55	0.13	1.98	2.48	4.62	5.75	3.56	0.74	12.78	7.72	1.69	1.54	43.54
Hlabisa	4	0.56	0.04	0.86	1.15	3.70	4.71	2.25	0.14	7.28	4.94	0.98	2.88	29.49
Ubombo	1	0.15	—	0.04	0.06	3.75	5.82	3.21	0.33	7.03	1.83	0.61	2.04	24.87
Piet Retief	1	—	—	—	—	4.61	5.32	5.76	0.07	10.17	1.11	0.12	1.48	28.64
Mean Zululand and Piet Retief ..	**22**	**0.54**	**0.08**	**1.04**	**2.02**	**4.83**	**5.92**	**4.12**	**0.57**	**11.36**	**5.59**	**1.18**	**1.59**	**38.84**
General Mean ..	**54**	**0.74**	**0.12**	**0.58**	**2.96**	**4.13**	**5.36**	**3.59**	**0.59**	**9.79**	**7.26**	**2.11**	**1.10**	**38.33**

TABLE III

	Mean percentage rainfall distribution 1924–55	*Computed mean rainfall for 54 centres 1924–55*	*Actual rainfall for 54 centres June, 1955, to May, 1956*	*Evaporation at Experiment Station* — *Mean 1936–55*	*Evaporation at Experiment Station* — *June, 1955 to May, 1956*
June, 1955	4.15	1.56	0.74	2.36	2.30
July, 1955	2.98	1.12	0.12	2.57	2.65
August, 1955	3.67	1.38	0.58	2.91	3.32
September, 1955	6.36	2.39	2.96	3.64	4.16
October, 1955	9.18	3.45	4.13	4.10	3.56
November, 1955	11.31	4.25	5.36	4.78	4.18
December, 1955	11.97	4.50	3.59	5.37	4.89
January, 1956	11.52	4.33	0.59	5.60	7.19
February, 1956	12.24	4.60	9.79	4.73	5.12
March, 1956	14.29	5.37	7.26	4.43	4.15
April, 1956	6.76	2.54	2.11	3.34	3.45
May, 1956	5.56	2.09	1.10	2.82	3.06
	100.00	37.58	38.33	46.65	48.03

TABLE IV

Rainfall in Inches by Districts for the Two-year Period June, 1954, to May, 1956, inclusive

	No. of Centres	1954 *Winter Growth June–August*	1954 *Early Growth Sept. & October*	1954–55 *Optimum Growth Nov.–March*	1955 *Late Growth April & May*	1955 *Winter Growth June–August*	1955 *Early Growth Sept. & October*	1955–56 *Optimum Growth Nov.–March*	1955 *Late Growth April & May*	*Total for Two years June,* 1954 *to May,* 1956
Port Shepstone	1	2.34	21.64	28.66	1.95	1.47	8.60	30.73	5.26	100.65
Umzinto	6	2.64	17.35	24.98	2.09	1.70	8.32	27.97	4.21	89.26
Durban, Pinetown, etc. ..	3	1.94	11.81	23.21	2.58	1.16	5.41	25.49	3.07	74.67
Mean South Coast	**10**	**2.40**	**16.11**	**24.81**	**2.23**	**1.52**	**7.47**	**27.50**	**3.97**	**86.01**
Inanda	9	2.33	15.98	23.46	4.12	1.03	6.97	22.46	3.40	79.75
Lower Tugela	13	2.39	17.78	26.41	4.70	1.23	7.25	27.09	3.24	90.09
Mean North Coast	**22**	**2.36**	**17.03**	**25.21**	**4.46**	**1.15**	**7.14**	**25.20**	**3.31**	**85.86**
Mean south of Tugela ..	**32**	**2.38**	**16.75**	**25.07**	**3.77**	**1.26**	**7.25**	**25.92**	**3.52**	**85.92**
Mtunzini	5	2.96	16.76	26.93	5.37	1.28	8.15	30.74	2.42	94.61
Eshowe..	3	1.80	15.79	26.22	4.43	0.95	8.45	29.89	1.13	88.66
Lower Umfolozi	8	4.02	15.94	23.86	5.40	2.66	7.10	30.54	3.23	92.75
Hlabisa	4	2.31	11.08	24.40	2.27	1.45	4.84	19.31	3.86	69.52
Ubombo	1	0.84	7.58	15.44	2.77	0.19	3.81	18.22	2.65	51.50
Piet Retief	1	0.53	7.30	18.96	3.97	—	4.61	22.43	1.60	59.40
Mean Zululand and Piet Retief	**22**	**2.85**	**14.45**	**24.38**	**4.50**	**1.66**	**6.85**	**27.53**	**2.77**	**85.01**
General Average	**54**	**2.56**	**15.82**	**24.80**	**4.06**	**1.43**	**7.09**	**26.59**	**3.21**	**85.57**
Computed mean for 32 years..	54	4.06	5.84	23.05	4.63	4.06	5.84	23.05	4.63	75.16

TABLE V

Rainfall and Evaporation in Inches for the Past Four Years

	1952–53			1953–54			1954–55			1955–56		
	Evaporation	*Rainfall*	*Rainfall Deficiency*	*Evaporation*	*Rainfall*	*Rainfall Deficiency*	*Evaporation*	*Rainfall*	*Rainfall Deficiency*	*Evaporation*	*Rainfall*	*Rainfall Deficiency*
June ..	2.42	0.64	1.78	2.59	0.23	2.36	2.44	1.08	1.36	2.30	0.74	1.56
July ..	2.40	1.63	0.77	2.99	0.39	2.60	3.22	0.46	2.76	2.65	0.12	2.53
August ..	2.56	0.66	1.90	2.68	1.90	0.78	3.31	1.02	2.29	3.32	0.58	2.74
September	4.29	0.88	3.41	3.38	3.23	0.15	3.80	4.86	0.00	4.16	2.96	1.20
October ..	4.89	1.74	3.15	3.63	3.29	0.34	3.86	10.96	0.00	3.56	4.13	0.00
November	4.55	4.39	0.16	4.50	5.20	0.00	4.04	3.59	0.45	4.18	5.36	0.00
December	5.11	5.32	0.00	5.90	5.11	0.79	5.98	1.91	4.07	4.89	3.59	1.30
January ..	6.42	8.82	0.00	5.12	3.66	1.46	5.03	7.94	0.00	7.19	0.59	6.60
February ..	4.08	5.90	0.00	4.57	6.20	0.00	4.30	3.23	1.07	5.12	9.79	0.00
March ..	5.27	2.62	2.65	4.75	3.83	0.92	4.59	8.13	0.00	4.15	7.26	0.00
April ..	3.17	1.11	2.06	3.06	2.70	0.36	3.41	2.91	0.50	3.45	2.11	1.34
May ..	3.63	0.71	2.92	3.24	3.34	0.00	2.72	1.15	1.57	3.06	1.10	1.96
Total ..	**48.76**	**33.88**	**18.80**	**46.41**	**39.08**	**9.76**	**46.70**	**47.24**	**14.07**	**48.03**	**38.33**	**19.23**

Comments on Rainfall

The mean computed rainfall over the last 32 years for the 54 rainfall recording stations is 37.58 inches. The rainfall for these centres for the year ending 31st May, 1956 was 38.33 inches. This is now the third successive year with a rainfall above normal. Although the rainfall for the past year was not as good as the excellent total rainfall of 47.24 inches for the previous year, and although rainfall distribution was also not nearly as favourable as that of the previous year, this was on the whole a reasonably favourable year for the cane crop which benefited from the well above normal rainfall of the year ending 31st May, 1955. The total rainfall for the 24 months ending 31st May, 1956 was 85.57 inches.

During June 1955, with a rainfall of only 0.74 inches for the month some of the cane areas became rather dry. During July an average of only 0.12 inches of rain was recorded and this was followed by only 0.58 inches in August. The cane crop had then gone through four successive months with deficient rainfall and although it stood up well to these adverse conditions dry patches were common and on shallow soil even dying patches could be seen. Some welcome showers fell in parts of Zululand but the North and South Coasts experienced severe droughts. By the middle of September the crop had received a severe set-back as a result of the drought which was, however, broken particularly on the South Coast by a continuous cold drizzle on the 28th and 29th of September which brought up the month's total rainfall to 2.96 inches which was just above average. October was abnormally cold with mean screen temperature of only 65.7°F. Light well distributed rains averaged 4.13 inches for the month which was above normal. Similarly, November with a rainfall of 5.36 inches or well above normal was exceptionally cold with a mean screen temperature of 67.1°F. In fact the mean screen temperatures for these two months were the lowest ever recorded for October and November at the Experiment Station. Lack of heat and sunshine rather than deficient rainfall retarded the recovery of the cane crop. These abnormal conditions continued up to about the third week of December but then hot sunny weather set in. The average temperature for December, however, remained below normal and the rainfall 3.59 inches was also below normal. Towards the end of the month there were indications of some areas becoming dry. January was a most exceptionally dry, sunny, and desiccating month. The rainfall totalled only 0.59 inches with a normal of 4.33 inches. It was in fact the driest January experienced in the sugar belt for the past 32 years. To make matters worse the evaporation totalled 7.19 inches at the Experiment Station compared with a normal of 5.60 inches for January. This was the highest evaporation yet recorded at the Experiment Station for any month of the year for the past 20 years of recorded data. Similarly, the total hours of sunshine 270.9 was the highest for any month in 28 years of recorded results. Drought conditions developed in consequence and the crop received a severe set-back and small patches of dry or dying cane could be observed. Exceptionally heavy rains totalling 9.79 inches fell in February with flood conditions developing in parts of Zululand where the Umfolozi river flooded hundreds of acres of cane. Fortunately, however, the area drained fairly rapidly. The good rain of February made the cane respond rapidly. Exceptionally heavy rains totalling 7.26 inches also fell in March and this time flood conditions were experienced on the South Coast where Hibberdene had a total of 20.32 inches of rain for the month and 8.20 inches fell on the 19th. The crop was making excellent progress. This progress was continued during April with a somewhat below normal rainfall of 2.11 inches, but the crop was beginning to get dry towards the end of May for the rainfall was well below normal at 1.10 inches for this month.

Summarising the rainfall over the past two years it can be stated that the winter months of 1954 were dry but excellent rains fell during September and October of that year. During the period November 1954 to March 1955 average rains and good growing conditions were experienced and these conditions largely continued during April and May although the rainfall decreased. The winter months of June to August and the greater part of September 1955 were, however, very dry. With the better rains of September, October and the first part of December came exceptionally cold weather which retarded the recovery of the crop and extremely desiccating conditions of the latter part of December 1955 and the whole of January 1956 caused a severe set-back to the crop. Exceptionally heavy rains in February and March and normal rains in April resulted in excellent cane growth which was largely continued into May when it became somewhat dry again.

Temperatures

The mean screen temperature at the Experiment Station for the year ending 31st May, 1956 was 68.0°F. lower than the 1928-55 average of 68.7°F. With the exception of July, every month from June 1955 to January 1956 had mean temperatures below normal. There was some light frost on the South Coast in June but it was really the months, September to December, that were so exceptionally cold and this applied particularly to October and November with mean screen temperatures of 65.7°F. and 67.1°F. respectively, or 2.6° and 3.4°F below normal. With a mean screen temperature of **74.8°F** or 1.7° above normal for March and the excellent rainfall conditions already referred to, the cane started to grow exceptionally well during that month and continued growing well during April and to a lesser extent during May.

Soil temperatures were also well below normal averaging 70.3°, 70.8° and 70.9°F at 1 ft., 2 ft., and 4 ft. compared with the 1935-55 averages at the same depth of 71.7°, 72.7° and 74.8°F.

Summary and Conclusions

The industry has now experienced for the second year running, two successive years with rainfalls above normal. The mean rainfall over the past two years was 85.57 inches and for the. year ending 31st May, 1956 it was 38.33 inches compared with a 32 years mean of 37.38 inches.

Rainfall during this last year was, however, not well distributed. It was very dry during the winter of 1955 and also in January 1956 whereas excellent rains and floods were experienced during February and March.

The mean screen temperature was well below normal and lack of heat during the months of September to December 1955 retarded cane growth.

The crop benefited from the good growing conditions for the year ending 31st May, 1955 and the excellent conditions during February to April, 1956 and on the whole a good crop can be expected this year.

TABLE VI

The following are the Screen Temperatures by Months in Degrees Fahrenheit at the Experiment Station for the Year June, 1955, to May, 1956, compared with the Means for the Period 1928 to 1955

	This Period					*Average* 1928 *to* 1955 *inclusive*			
	Maximum	*Minimum*	*Mean*	*Plus or minus Average*	*Daily Range*	*Maximum*	*Minimum*	*Mean*	*Daily Range*
June	72.3	52.7	62.5	−0.3	19.6	72.9	52.7	62.8	20.2
July	73.6	52.2	62.9	+0.9	21.4	72.3	51.6	62.0	20.7
August	72.7	52.2	62.4	−1.1	20.5	73.2	53.8	63.5	19.4
September	72.9	54.9	63.9	−1.9	18.0	74.4	57.1	65.8	17.3
October	72.7	58.6	65.7	−2.6	14.3	75.8	60.8	68.3	15.0
November	73.2	61.0	67.1	−3.4	12.2	77.8	63.3	70.5	14.5
December	78.4	64.8	71.6	−1.2	13.6	80.0	65.7	72.8	14.3
January	81.7	65.8	73.8	−0.2	15.9	80.9	67.1	74.0	13.8
February	81.0	68.5	74.7	+0.1	12.5	81.6	67.5	74.6	14.1
March	81.5	68.2	74.8	+1.7	13.3	80.3	65.9	73.1	14.4
April	77.9	62.8	70.3	+0.1	15.1	78.4	62.1	70.2	16.3
May	75.0	57.9	66.4	−0.1	17.1	76.0	57.0	66.5	19.0
Mean	**76.1**	**60.0**	**68.0**	**−0.7**	**16.1**	**77.0**	**60.4**	**68.7**	**16.6**

TABLE VII

The following table gives **the Mean Monthly Earth Temperatures**

	Experiment Station Means 1934–55			*Experiment Station, June,* 1955, *to May,* 1956			*Umzimkulu Sugar Co., June* 1955 *to May,* 1956	*Entumeni Wattle Co., June* 1955 *to May,* 1956
	1 ft.	2 ft.	4 ft.	1 ft.	2 ft.	4 ft.	2 ft.	2 ft.
June	64.3	67.1	69.7	63.9	65.8	68.9	65.2	65.0
July	62.7	64.9	67.1	61.7	63.0	65.8	62.6	64.0
August	64.6	65.8	69.9	62.2	63.3	65.3	63.9	65.0
September	67.9	68.4	68.4	65.3	65.7	66.2	67.0	69.0
October	70.8	71.0	70.4	67.3	67.5	67.5	66.7	65.0
November	73.5	73.4	72.9	70.3	70.3	69.4	70.8	68.0
December	76.4	76.2	74.8	73.9	73.6	71.8	73.0	72.0
January	78.7	79.1	77.0	78.6	77.7	74.8	77.8	—
February	79.5	79.7	78.3	79.2	79.0	76.8	78.5	—
March	78.1	79.0	78.4	78.4	78.3	76.8	76.6	76.4
April	74.8	76.4	76.9	74.1	75.0	75.6	73.4	72.5
May	69.5	71.9	73.7	68.2	69.8	72.1	68.4	68.4
Mean	**71.7**	**72.7**	**74.8**	**70.3**	**70.8**	**70.9**	**70.3**	—

ANNUAL SUMMARY OF AGRICULTURAL DATA FOR THE SUGARCANE CROP 1953-54

By J. L. DU TOIT

General Sources of Information

In the compilation of this report extensive use is made of the *Special Census of Sugarcane Plantations,* 1953-54, compiled by the Union Government Department of Census and Statistics. Data are also obtained from the *Survey of Cane Production* by the Sugar Industry Central Board, the Annual Weather Report and the Annual Summary of Laboratory Reports. Information obtained from the Fertilizer Traders' Association on the amount of fertilizer used in the sugar industry is also used.

Total Yields and Areas

During the year 1953-54, a total of 6,221,594 tons of cane were crushed to make a record of 725,430 tons sugar. The *Special Census of Sugar Plantations,* 1953-54 deals with European cane production only and does not in fact cover that production completely. Thus the total yield given in these returns amounts to 5,455,868 tons or 87.7 per cent, of the total crop. According to the Central Board survey, European production amounted to 93.1 per cent, of the total crop, so that this census accounts for 94.2 per cent, of the total European production.

The Central Board survey reveals the fact that the yield per acre of non-European cane fields is much lower than that from European farms. Thus European production is given as averaging 29.06 tons cane per acre compared with an average yield given by the *Special Census of Sugarcane Plantations,* 1953-54 of 28.75, but the non-European yield only averages 18.33 tons per acre and the total average for all races is given as 27.92 tons cane per acre. This latter figure will reduce to 27.62 tons per acre on the basis of the *Special Census of Sugarcane Plantations* 1953-54 returns, and this yield will be used in computing the total areas in the cane belt in the last column of the following table.

	Special Census Returns	Total Industry
Tons cane harvested ...	5,455,868	6,221,594
Tons cane per acre ...	28.75	27.62
Area in acres harvested ...	189,774	225,257
Area under cane, 30th April, 1954	394,961	468,805
Area under cane and fallow, 30th April, 1954 ...	443,951	526,959

The Central Board returns enable us not only to calculate the average yields per acre for the various groups of growers, **but** also their percentages of the total crop, as given in the following table.

	Yield per Acre	Per cent. of Crop	Per cent of Area
European planters ...	29.16	64.4	61.7
Miller-cum-planters ...	28.82	28.7	27.8
Indian planters ...	18.40	5.8	8.9
Bantu planters ...	18.00	1.1	1.7

Yield and Climatic Conditions

The average yield of cane for the 1953-54 season was 28.75 tons per acre for European planters. This is an increase of 2.46 tons per acre compared with the average yield of the year before. The following table gives the average yields as given in the *Special Census of Sugarcane Plantations,* 1953-54 returns, over the past ten years, as well as the average rainfall from forty-four centres in the cane belt.

Year	Yield in Tons per Acre	Rainfall in Inches
1944	29.08	36.45
1945	25.70	31.99
1946	21.99	32.02
1947	24.47	44.83
1948	26.80	35.25
1949	24.70	43.35
1950	26.41	30.70
1951	23.28	35.10
1952	26.29	33.42
1953	28.75	41.15

The 1953 yield of cane per acre was the best obtained in the industry since 1944 and it also appears the the rainfall was well above normal, but the rainfall recorded for the calender year 1953 could have had little effect on the yield of that year and is more likely to affect the yield of the following year. Actually the rainfall recorded from fifty-four centres for the year ending 31st May, 1953, was below normal and the relatively better yield recorded for 1953 must be largely attributed to a better distribution of rainfall than for the previous season and a progressive replacement of Co.281, the failure of which had much to do with the low yields recorded over the past nine years.

The crop harvested during the 1953-54 season was largely affected by the rainfall during the twenty or twenty-four months prior to June, 1953.

After a bad winter drought in 1951, the crop had a good start with excellent spring rains in that year. The 1951-52 optimum growing season was somewhat disappointing, but good late rains ensured an extended growing season. The spring months of

September and October, 1952, were dry, but the crop had a relatively good optimum growing season from November, 1952, to March, 1953.

The following table gives the monthly rainfall for the period June, 1952, to March, 1953, for fifty-four centres in the sugar belt, as well as their computed mean rainfalls for the past thirty-one years:

	June	July	Aug.	Sept.	Oct.	Nov.
This period ...	0.64	1.63	0.66	0.88	1.74	4.39
Computed mean	1.59	1.15	1.41	2.37	3.43	4.21

	Dec.	Jan.	Feb.	Mar.	April	May
This period ...	5.32	8.28	5.90	2.62	1.11	0.71
Computed mean	4.53	4.34	4.61	5.46	2.56	2.12

The rainfall for the year under review for fifty-four representative stations was therefore 33.88 inches compared with a computed mean of 37.78 inches. The rainfall distribution was better than the previous year, but still left a lot to be desired. However, the rainfall for the years ending May, 1954 and again May, 1955, were above normal and well distributed, so that much better yields can be expected, particularly for the 1954-55 season.

Effect of Varieties on Average Yield

As pointed out part of the reason why cane yields have been so low during the last nine years is the general failure of Co.281, and the fact that this variety is now rapidly being eliminated and replaced by more productive varieties was partly and largely responsible for the increased yield per acre during the 1953-54 season. The following table shows the average yield obtained from all varieties during the 1953-54 season, the yield that would have been obtained if *(a)* the same-acreage of Co.281 had been harvested as in 1952-53; and *(b)* no Co.281 had been harvested.

	Cane Yield Tons per Acre
Average yield, 1953-54, all varieties ...	28.75
Computed yield if acreage of Co.281 had remained the same as 1952-53	27.32
Computed yield if no Co.281 had been harvested	30.36

Of the varieties now grown, the areas under Uba, Co.290 and the P.O.J, varieties, are so small that no valid comparisons on yield potentials can be made. If, however, the average yields of Co.281, Co.301, Co.331 and N:Co.310 are compared for a number of seasons the degeneration of Co.281 can be clearly

	Yields in Tons Cane per Acre			
	1948	1950	1952	1953
Co.281	25.29	21.78	15.00	16.3
Co.301 ...	28.90	26.80	24.42	25.1
Co.331 ...	34.07	32.25	28.18	28.8
N:Co.310 ...	33.07	39.36	35.55	36.3
Yield of Co.281 percentage N:Co.310 ... percentage	76.5	55.3	42.2	44.9
Yield of Co.301 percentage N:Co.310 ...	87.4	68.1	68.7	69.1

Actually the quantitative decline of Co.281 is probably even more
the very worst fields of a failing variety will naturally be eliminated first, leaving only the better fields from which further crops and records will be obtained.

The following tables will show the changes in the dominant varieties over the last few seasons:

	Percentage Area Harvested			
	1950	1951	1952	1953
Co.281	45.0	33.7	21.5	11.5
Co.301	34.9	38.1	34.0	32.3
Co.331	7.0	11.3	14.5	21.6
N:Co.310 ...	10.6	15.3	28.9	33.6
Other varieties ...	2.5	1.6	1.1	1.1

	Percentage Area Under Cane on 30th April			
	1947	1950	1953	1954
Co.281	65.5	41.4	9.0	4.3
Co.301	28.7	35.3	29.7	23.7
Co.331	1.6	9.4	23.4	26.6
N:Co.310 ...	—	12.1	37.0	43.3
Other varieties ...	4.2	1.8	0.9	2.1

	Percentage Area of Plant Cane on 30th April			
	1951	1952	1953	1954
Co.281	8.5	3.9	2.0	1.1
Co.301	26.5	22.3	17.5	10.5
Co.331	23.6	27.1	32.7	32.3
N:Co.310 ...	40.9	46.0	47.1	51.7
Other varieties ...	0.5	0.7	0.7	4.4

It will be noticed that there was a sudden increase of "other varieties," both in area under cane and more particularly in area under plant cane. This is, of course, not clue to the industry reverting to the older varieties Uba, Co.290 or P.O.J., but rather that by the 30th April, 1954, appreciable areas have been planted up with the new varieties N:Co.339 and N:Co.293, which were both first distributed in 1952.

N:Co.310 continues to gain in popularity at the expense of Co.281 and Co.301 and there are indications that Co.331 has reached a peak at about one-third of the area under plant cane.

Yields from Different Areas

The average yield of tons cane per acre for the whole industry for the 1953-54 season was 28.75. The South Coast averaged only 20.99 tons cane per acre and the North Coast once again had the best average yield of 31.13 tons per acre, followed by Zululand with 30.60 tons per acre.

The following table gives some of the past yields recorded for the industry and its main sub-divisions.

	Average Yield 1938-42	Average Yield 1943-47	Average Yield 1948-52	Average Yield 1953
South Coast ...	22.60	21.37	19.69	20.99
North Coast ...	27.88	29.15	27.34	31.13
Zululand ...	27.94	26.67	26.96	30.60
Total industry...	26.60	26.42	25.50	28.75

It will be seen that while the averages of the North Coast and Zululand for 1953 were well above the normal averages, the yield of the South Coast was not as good as its averages from the years 1938 to 1947, although it was somewhat better than the 1948-52 average. It must be pointed out that the Pietermaritzburg district, which is geographically largely on the North Coast, is now included in the South Coast and that the average yield from this district was only 16.6 tons cane per acre, but the area harvested, 134 acres, is so small as to be of negligible importance in affecting the averages of the South and North Coast.

Of the regular and larger sugarcane producing districts, Port Shepstone had the lowest yield per acre with 17.94 tons and the best yields were obtained in the Hlabisa district, with 40.00 tons cane per acre.

General Information

The *Special Census of Sugarcane Plantations,* 1953-54 gives returns from 853 individuals with a total farm area of 799,923 acres of which 394,961 acres were under cane on the 30th April, 1954. There were a further 56,593 acres of virgin land suitable for cane production and 48,990 acres were under long fallow. During the twelve months ending 30th April, 1954, an area of 7,611 acres of virgin land was planted to cane and 32,285 acres of cane land was ploughed out and planted again, or was given a short fallow treatment. The average age of cane ploughed out was 6.2 years.

Of the 394,961 acres under cane, given in this census, the following areas were under plant and ratoons:

	Area in Acres	Per cent. of Area under Cane
Plant cane	135,481	34.3
First ratoon	127,617	32.3
Second ratoon	90,757	23.0
Third ratoon	31,019	7.9
Fourth ratoon	5,813	1.5
Other ratoons	4,274	1.1
Total under cane ...	394,961	100.0

The table shows that most cane is ploughed out after a second ratoon and assuming a two-year-old crop, which still appears to hold good for the industry, the average age of cane when ploughed out, given above as 6.2 years, agrees well with a computed age derived from this table. It is felt that with a more liberal application of fertilisers the number of ratoons and age of cane, at ploughing out, might well be increased.

Fertilisers Used

The yield of cane per acre is, of course, affected by climatic conditions, variety, etc., and also very appreciably by the amount and type of fertiliser used. Where the effect of variety and climate on cane yields is discussed in this report it is considered equally important to give all available information on fertiliser usage and this is now largely possible as a result of data supplied to us by the Fertiliser Traders' Association.

During 1954, or rather during the year ending February, 1955, the sugar industry used 34,431 tons of mixtures containing the following amounts of plant foods:

Tons N.	Tons P_2O_5	Tons K_2O
1,675	3,658	1,485

The average of all these mixtures therefore approximates a non-existing mixture of the following analyses: 5—10.5—4.5. The amount of mixtures used was much higher than that of the previous year and the average composition was higher in nitrogen, much higher in potash and lower in phosphate than that used the year before.

In addition, the industry used the following quantities of straight fertilisers:

13,370 tons nitrogenous fertilisers containing 2,841 tons N.

12,210 tons phosphatic fertilisers containing 2,346 tons P_2O_5.

2,214 tons potassic fertilisers containing 1,328 tons K_2O.

Once again nitrogenous and potassic fertilisers are up on that used the previous year and phosphatic fertilisers have dropped very appreciably.

Filter cake application may account for plant food additions of the order of 750 tons N., 2,500 tons P_2O_6 and 200 tons K_2O. In addition, there are certain amounts of manures, composts and fertiliser materials added but it is impossible to estimate these quantitatively and in any case these are not big. If we now add the main items enumerated above we get the following totals:

Tons N.	Tons P_2O_5	Tons K_2O
5,266	8,504	3,013

Assuming now the area harvested and therefore the area to be fertilised was 230,000 acres, then the average application of plant foods per acre would have been:

Nitrogen	...	46 lbs. as N.
Phosphate	...	74 lbs. as P_2O_5
Potash ...	...	26 lbs. as K_2O

Compared with the previous year there has been a most gratifying increase in nitrogen and potash applications, although the nitrogen application still seems low and potash application most inadequate with phosphate application remaining high.

Ignoring the amounts of plant foods in filter cake, manures and low grade fertiliser materials the following table gives a comparison of the quantities of straight and mixed fertilisers used during the seasons 1951, 1953 and 1954.

	1951	1953	1954
Tons mixed fertilisers...	25,277	19,817	34,431
Tons nitrogenous fertilisers	5,280	11,882	13,370
Tons phosphatic fertilisers	15,297	17,883	12,210
Tons potassic fertiliser	125	2,060	2,214

The tons of N, P_2O_5 and K_2O contained in these straight and mixed fertilisers were as follows:

	1951	1953	1954
Tons nitrogen as N ...	2,135	3,327	4,516
Tons phosphates as P_2O_6......	6,526	5,725	6,004
Tons potassium as K_2O...	842	1,712	2,813

From this table it appears that nitrogen consumption has more than doubled since 1951 and potash usage increased 334 per cent. However, the picture is by no means as bright as this for far too little nitrogen was used in 1951 and potash, contrary to actual requirements, was hardly used at all, and at the same time there has been an increase in the area under cane and cane production increased from 4,805,249 tons in 1951 to 7,374,241 tons in the 1954-55 season. Probably a more realistic and informative way of giving the fertiliser used during these seasons is to convert it to pounds plant foods applied per ton of cane harvested. If this were done we would get the following table:

	1951	1953	1954
Pounds N. per ton of cane	0.89	1.07	1.22
Pounds P_2O_5 per ton of cane	0.72	1.84	1.63
Pounds K_2O per ton of cane	0.35	0.55	0.76

This table reveals a most gratifying trend; an increase use of nitrogenous and potassic fertilisers and a decrease in phosphates, but the drain on potash in the soil remains most alarming, as only about a quarter of what is removed in the cane crop is being returned in the form of artificial fertilisers.

Experiment Station,
South African Sugar Association
Mount Edgecombe.
February, 1956.

AREA OF CANE HARVESTED AND YIELDS FOR DIFFERENT VARIETIES AND RATOONS (EUROPEAN PLANTERS ONLY) 1953-1954

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	23	55.9	33	29.8	26	16.6	14	14.9	—	—	73	18.4	169	25.1
Co.281	1,141	23.6	5,615	17.4	7,230	14.8	4,687	16.4	1,222	14.4	1,878	15.6	21,773	16.3
Co.290	118	37.7	142	19.4	33	18.0	12	33.1	—	—	157	41.0	462	30.7
Co.301	13,380	30.2	15,544	25.2	19,142	23.1	9,213	22.8	2,489	20.8	1,574	26.1	61,342	25.1
Co.331	20,349	30.3	13,526	28.2	5,440	25.3	1,372	23.5	142	21.5	189	49.2	41,018	28.8
N:Co.310	31,676	37.3	22,881	34.2	7,335	38.0	1,692	37.6	127	35.5	66	42.2	63,777	36.3
P.O.J.2725 and 2878 ...	16	29.9	113	35.7	397	45.7	329	38.6	137	39.3	112	41.2	1,104	41.1
Other Varieties	89	48.7	40	27.5	—	—	—	—	—	—	—	—	129	42.2
TOTAL	66,792	33.5	57,894	28.7	39,603	24.9	17,319	22.8	4,117	20.0	4,049	23.4	189,774	28.7

AREA OF CANE HARVESTED AND YIELDS BY DISTRICTS (EUROPEAN PLANTERS ONLY) 1953-1954

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	—	—	2 007	10.3	—	—	570	30.6	409	22.7	849	25.3	—	—
UMZINTO	82	18.8	2,661	8.9	1	39.0	14,845	20.5	4,754	26.1	4,859	28.1	31	24.0
DURBAN AND PINETOWN	2	23.0	933	10.7	—	—	3,172	19.6	2,876	17.1	2,665	27.6	—	—
Total South of Umgeni R.	84	18.9	5,601	9.7	1	39.0	18,587	20.7	8,039	22.7	8,373	27.6	31	24.0
INANDA	36	15.8	1,083	19.4	215	23.8	8,897	31.7	3,271	34.9	6,703	38.0	3	45.7
LOWER TUGELA	33	27.4	1,429	13.7	41	21.7	22,864	26.4	13,362	32.0	17,644	35.3	—	—
Total North Coast between Umgeni and Tugela Rs.	69	21.3	2,512	16.2	256	23.5	31,761	27.9	16,633	32.6	24,347	36.0	3	45.7
Total for Natal South of the Tugela River ...	153	20.0	8,113	11.7	257	23.5	50,348	25.2	24,672	29.3	32,720	33.9	34	25.9
MTUNZINI	3	20.0	3,212	19.2	117	45.8	3,291	26.4	8,971	29.5	7,710	38.8	83	39.9
ESHOWE	—	—	1,613	21.9	45	25.3	2,208	21.4	3,291	24.9	3,791	31.1	34	39.9
LOWER UMFOLOZI ...	—	—	6,946	19.3	—	—	5,174	25.0	3,262	27.0	13,983	36.1	517	33.2
HLABISA	—	—	1,889	15.5	43	37.8	321	19.3	802	24.7	5,161	51.7	436	51.9
PIET RETIEF	13	86.5	—	—	—	—	—	—	20	62.0	412	37.3	—	—
Total North of the Tugela	16	74.1	13,660	19.1	205	39.6	10,994	24.5	16,346	27.9	31,057	38.7	1,070	41.6
TOTAL FOR UNION ...	169	25.1	21,773	16.3	462	30.7	61,342	25.1	41,018	28.8	63,777	36.3	1,104	41.1

YIELDS OF CANE HARVESTED BY DISTRICTS (EUROPEAN PLANTERS ONLY)

Compiled from Union Department of Census Returns

DISTRICT	TONS CANE PER ACRE												
	1941	**1942**	**1943**	**1944**	**1945**	**1946**	**1947**	**1948**	**1949**	**1950**	**1951**	**1952**	**1953**
PORT SHEPSTONE	13.73	23.03	31.32	22.95	19.18	19.23	22.68	21.45	19.42	19.24	19.44	16.33	17.94
UMZINTO	16.47	20.20	24.68	24.18	19.51	17.59	19.70	22.13	19.76	18.63	17.60	20.48	21.69
DURBAN, UMLAZI, ETC.	20.28	25.63	24.01	24.16	20.11	19.05	20.47	20.69	18.66	21.16	18.03	20.47	20.21
Total South of Umgeni River ...	17.05	21.48	25.07	24.07	19.59	18.01	20.12	21.79	19.48	19.23	17.90	20.03	20.99
Ratio to 1926 (=100)	92.46	116.49	135.95	130.53	106.24	97.67	109.11	118.18	105.64	104.28	97.07	108.62	113.83
INANDA	28.20	32.94	40.45	37.51	32.32	27.20	30.42	31.58	29.10	28.36	26.38	29.92	33.55
LOWER TUGELA	21.30	24.42	31.10	29.49	26.58	22.77	24.90	27.78	28.85	27.66	23.33	28.20	30.25
Total for North Coast between the Umgeni and Tugela Rivers...	23.64	27.31	34.09	32.14	28.57	24.23	26.72	29.03	26.92	27.85	24.23	28.67	31.13
Ratio to 1926 (=100)	127.03	146.75	183.18	172.70	153.52	130.20	143.58	155.99	144.65	149.65	130.20	154.06	167.27
Total for Natal South of the Tugela	21.18	25.18	30.64	29.08	25.35	21.90	24.43	26.41	24.23	24.84	21.97	25.68	27.59
Ratio to 1926 (=100)	114.18	135.74	165.18	156.77	136.66	118.06	131.70	142.37	130.62	133.91	118.46	138.44	148.73
MTUNZINI	22.67	24.96	30.71	27.19	23.73	18.02	22.01	25.47	24.11	26.62	21.74	24.73	30.85
ESHOWE	23.53	25.11	27.46	27.27	22.68	20.27	21.35	24.34	23.13	26.42	21.59	23.77	25.96
LOWER UMFOLOZI	26.10	26.51	33.45	31.47	30.07	25.83	27.39	30.11	27.45	31.57	26.72	27.93	29.23
HLABISA	26.31	29.84	30.79	29.00	25.52	23.68	25.64	27.52	25.75	31.51	35.88	36.70	40.00
PIET RETIEF	—	—	—	—	—	39.16	38.15	48.11	39.52	40.21	32.79	33.32	39.89
Total North of the Tugela	24.55	26.09	31.28	29.08	26.30	22.15	24.54	27.46	25.49	29.05	25.47	27.27	30.60
Ratio to 1926 (=100)	103.02	109.48	131.26	122.03	110.37	92.95	109.98	115.23	106.97	121.91	106.88	114.44	128.41
GRAND TOTAL FOR UNION	22.36	25.49	30.87	29.08	25.70	21.99	24.47	26.80	24.70	26.41	23.28	26.29	28.75
Ratio to 1926 (=100)	109.38	124.71	151.03	142.27	125.73	107.58	119.72	131.12	120.84	129.21	113.89	128.62	140.66
Rainfall of all Districts (inches) ... ... (*Average from 44 centres*)	26.18	49.40	53.51	36.45	31.99	32.02	44.83	35.25	43.35	30.70	35.10	33.42	41.15

YIELDS OF CANE HARVESTED BY DISTRICTS (EUROPEAN PLANTERS ONLY)

Compiled from Union Department of Census Returns

DISTRICT	PER CENT. OF TOTAL TONNAGE												
	1941	**1942**	**1943**	**1944**	**1945**	**1946**	**1947**	**1948**	**1949**	**1950**	**1951**	**1952**	**1953**
PORT SHEPSTONE	1.2	2.0	2.0	1.6	1.3	1.8	1.9	1.8	1.8	1.6	2.0	1.4	1.3
UMZINTO	12.7	13.7	14.1	14.9	12.6	13.9	12.8	13.5	12.2	10.6	11.4	11.1	10.8
DURBAN, UMLAZI, ETC.	4.7	4.5	4.0	3.4	3.2	3.9	3.7	3.3	4.0	3.7	3.8	3.7	3.6
Total South of Umgeni River ...	18.6	20.1	20.1	19.9	17.2	19.6	18.3	18.6	17.9	15.9	17.2	16.2	15.7
INANDA	17.4	18.2	16.8	16.8	17.6	16.4	17.1	15.7	15.6	12.1	13.5	12.5	12.4
LOWER TUGELA	25.6	26.3	27.5	26.7	27.2	27.9	28.7	28.2	28.3	30.8	28.4	31.4	30.7
Total for North Coast between the Umgeni and Tugela Rivers...	43.0	44.4	44.3	43.5	44.8	44.3	45.8	43.9	44.0	42.9	41.9	43.9	43.2
Total for Natal South of the Tugela	61.6	64.6	64.4	63.4	62.0	63.9	64.1	62.5	61.9	58.8	59.1	60.1	58.9
MTUNZINI	11.8	10.7	11.0	11.4	11.1	9.6	10.3	11.5	12.1	12.8	10.9	12.1	13.2
ESHOWE	6.0	5.7	5.5	6.0	5.6	5.7	5.4	5.8	6.0	6.3	5.5	5.4	5.2
LOWER UMFOLOZI	16.7	15.4	15.6	15.7	17.7	16.6	16.2	16.7	16.2	18.1	17.5	15.8	16.0
HLABISA	3.8	3.6	3.5	3.5	3.7	3.9	3.6	3.2	3.5	3.8	6.8	6.4	6.4
PIET RETIEF	—	—	—	—	—	0.3	0.5	0.4	0.3	0.2	0.2	0.1	0.3
Total North of the Tugela	38.4	35.4	35.6	36.6	38.0	36.1	35.9	37.5	38.1	41.2	40.9	39.9	41.1
GRAND TOTAL FOR THE 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.

YIELDS OF CANE HARVESTED BY DISTRICTS (EUROPEAN PLANTERS ONLY)

Compiled from Union Department of Census Returns

DISTRICT	YIELD OF CANE IN TONS										
	1943	**1944**	**1945**	**1946**	**1947**	**1948**	**1949**	**1950**	**1951**	**1952**	**1953**
PORT SHEPSTONE	97,113	79,113	79,993	57,630	67,743	78,890	82,825	80,330	83,333	90,643	68,794
UMZINTO	682,713	728,879	528,593	515,571	532,675	624,009	555,307	537,457	551,033	559,063	590,796
DURBAN, UMLAZI, ETC.	195,923	165,164	136,253	146,087	153,073	152,668	179,668	189,824	168,492	184,476	195,019
Total South of Umgeni River ...	975,749	974,036	722,476	729,401	764,638	859,287	815,305	810,614	770,168	814,559	854,609
Ratio to 1926 (= 100)	218.9	218.5	162.1	163.6	171.5	192.7	178.9	181.8	172.76	182.71	191.69
INANDA	812,986	823,041	737,413	608,736	714,066	722,790	709,790	616,033	602,855	625,034	678,481
LOWER TUGELA...	1,331,681	1,310,186	1,144,887	1,035,855	1,195,584	1,299,218	1,287,492	1,563,652	1,274,693	1,575,747	1,677,077
Total for North Coast between the Umgeni and Tugela Rivers ...	2,144,667	2,133,227	1,882,300	1,644,591	1,909,650	2,021,495	1,997,282	2,179,685	1,877,548	2,200,781	2,355,558
Ratio to 1926 (= 100)	259.0	257.6	227.3	198.6	230.6	244.1	241.2	263.2	226.72	265.75	284.44
Total for Natal South of the Tugela	3,120,416	3,107,263	2,604,776	2,373,992	2,674,288	2,880,782	2,812,587	2,990,299	2,647,716	3,015,340	3,210,167
Ratio to 1926 (= 100)	244.9	243.9	204.5	186.3	209.9	226.1	220.8	234.7	207.83	—	251.98
MTUNZINI	533,560	556,524	465,147	358,378	429,676	529,967	549,090	652,558	490,409	606,817	722,561
ESHOWE	264,198	293,602	236,115	211,170	225,903	266,752	273,448	318,883	244,590	273,070	285,158
LOWER UMFOLOZI	758,217	769,436	741,972	618,269	674,790	771,913	734,567	919,627	782,050	793,977	873,521
HLABISA	168,982	171,555	153,689	145,062	149,372	145,318	158,309	192,248	304,745	321,455	346,711
PIET RETIEF	—	—	—	9,321	18,886	17,511	14,937	10,858	11,442	5,598	17,750
Total North of the Tugela	1,724,957	1,791,177	1,596,923	1,342,200	1,498,627	1,731,461	1,730,351	2,094,174	1,833,236	2,000,9 7	2,245,701
Ratio to 1926 (= 100)	189.8	197.1	175.7	147.7	164.9	190.5	190.4	230.5	201.75	220.21	247.14
GRAND TOTAL FOR THE UNION	4,845,373	4,898,380	4,201,699	3,716,192	4,172,915	4,612,243	4,542,938	5,084,473	4,480,952	5,016,337	5,455,868
Ratio to 1926 (= 100)	222.0	224.4	192.5	170.3	191.2	211.3	208.1	233.0	205.30	229.83	249.97

SOME RECENT DEVELOPMENTS IN CANE TRANSPORTATION AND HANDLING IN NATAL

By J. P. N. BENTLEY

The necessity to investigate the possibility of transporting cane by means other than the conventional methods used in the Natal sugar industry was brought about by the increasing inability of the South African Railways to handle the volume of cane required to maintain steady crushing conditions at our factory.

At the outset it was appreciated that the economic movement of cane depended on the transportation of heavy loads with minimum delay during loading and unloading.

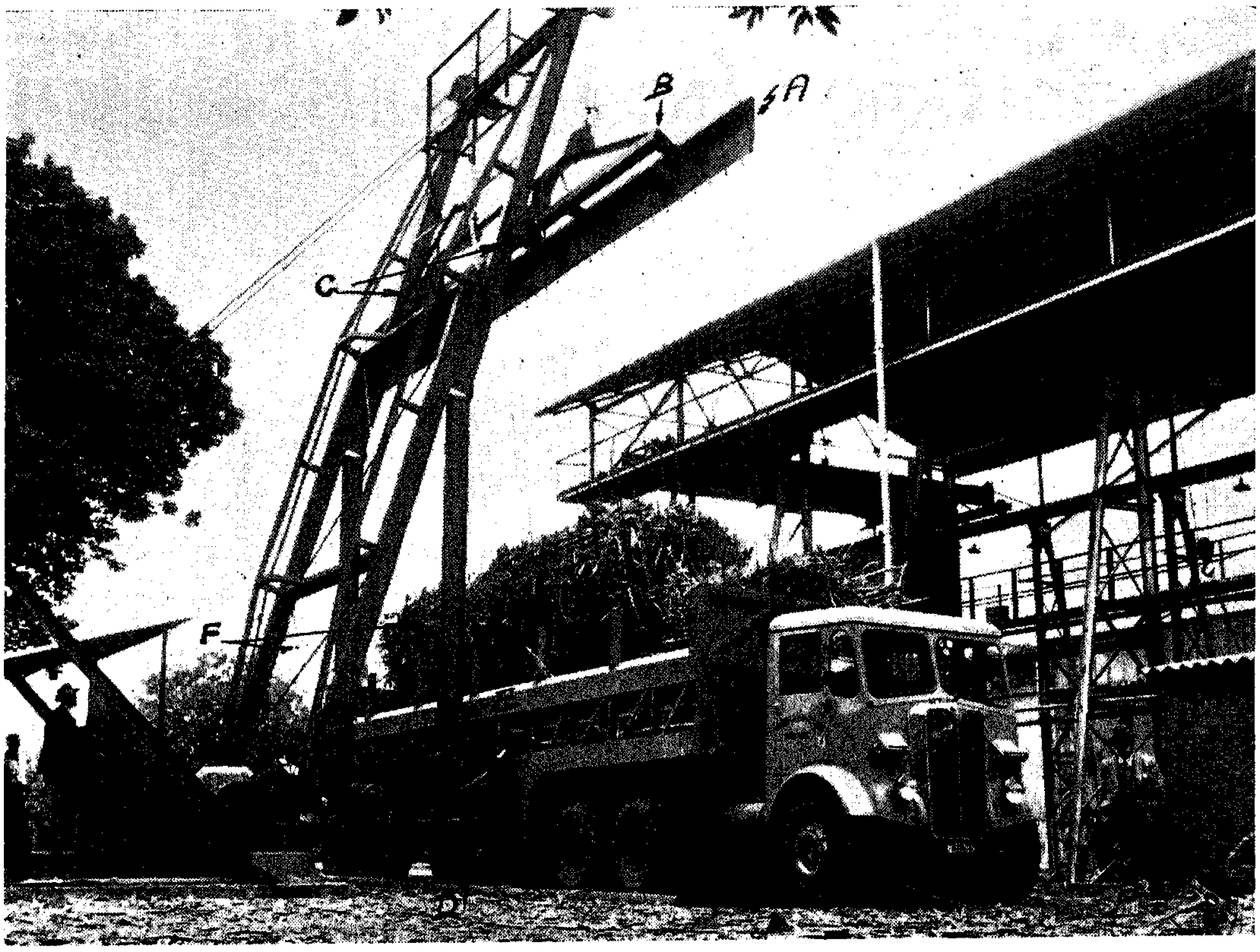
With this in mind the methods used in various parts of the world were carefully studied and it was found that the islands of Hawaii had made great strides in this direction and had developed extremely efficient methods of moving large tonnages of cane and sugar by road. Rail haulage on these islands has been almost completely superseded by heavy diesel-engined road vehicles and transportation costs are quoted as low as 8 cents (6½d.) per ton mile. Approximately two-fifths of this is the cost of getting the cane from the fields to the main road. The heaviest of these vehicles can carry as much as forty tons of cane. Those of the Tournahauler type are mounted on only four rubber-tyred wheels, are fitted with engines front and rear, and travel through the fields over irrigation ditches and via estate roads to the factory. Severe soil compaction in the fields used by these vehicles is taking place and some observers are of the opinion that the use of heavy vehicles in the fields will have a deleterious effect on productivity.

However, the key to Hawaii's success with road transportation lies in the rapidity and simplicity with which the vehicles are unloaded. Details of this unloader will be discussed later on in this paper.

The problem that had to be faced originally at Tongaat was to make up a daily shortfall of one thousand tons of cane and it was decided to copy the Hawaiian methods, but design the vehicles to meet the requirements of the Road Ordinance, so as to ensure use of the vehicles on public roads, as well as estate roads.

Drawings were prepared by Ed. Watt, of Hilo Equipment and Manufacturing Co., to our specification and two units were built to these drawings in Durban. These semi-trailers (see Fig. 1) may be drawn by any suitable Diesel-engined unit of at least 150 b.h.p. Carrying capacity of twenty-five tons of cane is obtained by using the maximum dimensions permitted by the Road Ordinance. Notable features of the trailer are the complete absence of any chassis (the structural members of the body being used to carry the load), and the low

Fig. 1



centre of gravity brought about by keeping the floor of the trailer as low as possible.

These two units operated from a siding two miles from the factory, were loaded by four-ton gantry crane in ten minutes, took fifteen minutes to travel the two miles under load, required three minutes to offload and twelve minutes to return to the loading point. As drivers and loaders became more accustomed to the work, these times were reduced. Operating for two shifts each per day these two units handled the cane at an average rate of sixty tons per hour—completing the one thousand ton task in seventeen hours. Running costs, including maintenance, fuel, wages and depreciation, amounted to 5|d. per ton mile.

The same short haul by S.A.R. was costing 2s. 9d. per ton of cane, i.e. 1s. 4½d. per ton mile.

As stated earlier in this paper, the secret of successful operation of any road haulage scheme is the rapidity with which the load can be placed in the vehicle at the receiving end and removed at the factory end of the run.

Dealing with the factory end first. These trailers use what is known as the net unloading system. In this system a series of chains are fixed to the top of one side of the trailer, hang freely down that side across the floor and up to the other side, where they are attached to a removable beam (A) (Fig. 2). These chains are spaced at 12 inch centres along the whole length of the trailer and are more satisfactory than steel wire rope for this purpose. By lifting the chains the load is spilled over the side of the trailer.

At the unloading site a wall is required and should be eight feet high, extending at least the full length of the trailer. This wall serves two purposes: the trailer leans against it when the load comes on to the one side, thus preventing severe overloading of the springs on that side; and it prevents the cane falling under the wheels of the trailer after discharging of the load.

The unloading rig is a most ingenious piece of equipment and is the brain child of Ed. Watt, of Hilo. It consists basically of two parallel jibs to which are splice-welded two rolled steel joists hinged near the centre (Fig. 2). Running between the flanges of these two rolled steel joists are two trollies (C) and fixed to the trollies is a horizontal boom (B) thirty-two feet long. Two winches driven by a single motor raise and lower the boom at a speed of twenty feet per minute. The boom is fitted with a series of fingers that engage with the removable beam along the top of one side of the trailer.

In operation the boom hangs well clear until the driver of the trailer has brought his vehicle to rest.

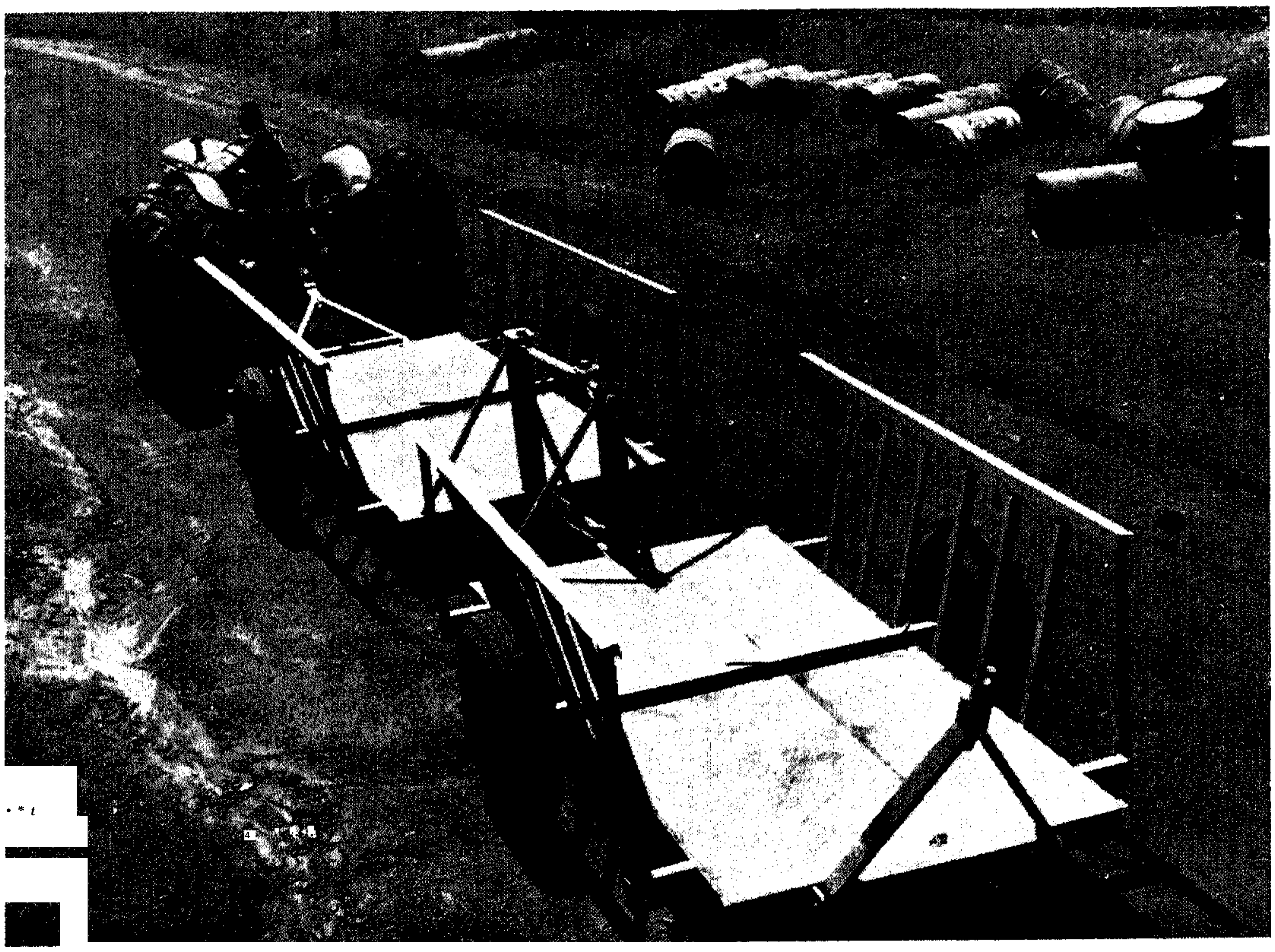


Fig. 3

As he operates the controller of the hoist motor, the boom rises and at the same time a follow-up block (E) (Fig. 2) releases the tension on a steel wire rope (F) and allows the hinged sections of the rolled steel joists to move towards the trailer, bringing the boom with them. When two locating arms (D) engage with the side of the trailer the fingers of the lifting boom will be in line with the removable beam on the side of the trailer. Further hoisting lifts this beam, together with the chains attached to it, and the cane spills over the fixed side of the trailer on to an auxiliary carrier, or on to a loading table. By arranging a trip at the top of the hoist just before the chains become taut, and another at the bottom of the hoist with the boom in its "at rest" position, the whole operation can be carried out by press-button control.

At the loading end of the run rapidity of loading is again of prime importance. This is achieved by the use of light in-field trailers, which are drawn out of the field by a rubber-tyred tractor to a suitable loading point, where the either stored or transferred directly to the larger trailer unit by means of gantry crane, a motorised Scotch derrick type crane or a mobile crane.

The in-field trailer chosen for this work is also of a new design (see Fig. 3) and has been adapted from a trailer first used by certain estates in Trinidad. It is made up of two two-wheeled units coupled together by a special universal joint which gives the stability of a four-wheeled vehicle with the mobility of a two-wheeled trailer. A tow-bar attachment at each end facilitates coupling up, and underslinging the chassis beneath the axle lowers the centre of gravity and makes hand loading extremely simple. The floor of the trailer is plated with 16-gauge steel and is only eleven inches off the ground. It is a simple matter for the cane cutter to step into and place his load, or alternatively deposit his cane over the side of the trailer, which is not more than shoulder high. Each half trailer, two halves to one unit, can carry a three-ton load and this is considered a safe maximum to avoid compaction, and is a suitable load for any standard 35 h.p. tractor, fitted with dual rear-wheels. This addition to a wheel tractor is a definite improvement from the traction point of view, and in the case of the Fordson tractor the performance is vastly improved. Wherever possible, advantage should be taken of terrain and loading planned so that full trailers are hauled down hill and empty trailers hauled uphill. The body design of the light in-field trailer is of importance as the dimensions of the load it carries must be evenly divisible into the overall length of the large trailer, so as to avoid the necessity of splitting a bundle in order to obtain the full payload.

With this new type of trailer experiments have been carried out and it has been established that not only can a greater productivity be obtained per boy as opposed to the older method of small tram trucks, but also there is a lowering of transportation costs. (See comparative field costs.)

Experience so far gained with the methods of transportation briefly outlined in this paper nas established that within a radius of some ten miles, depending on terrain, the movement of cane by road compares favourably with movement by standard gauge rail trucks, the shorter the radius the greater the economic advantage accruing to road haulage. Haulage by narrow gauge tramline, in common use on the Natal coast, offers no serious competition to the modern road vehicle and it is possible that the picturesque "Puffing Billy" will soon have to give way to the fast, versatile semi-trailer unit. It has been argued that during wet weather the road vehicles would be brought to a standstill. This can be overcome by the construction of strategic all-weather roads, macadamised if necessary, and motorised transport has proved itself in places such as Trinidad and Hawaii, where the rainfall on certain estates is up to one hundred inches per year—with heavy rains often falling in the harvesting season.

ROAD TRANSPORT COSTS 1955-56

2 A.E.C. UNITS AND 2 HILO TRACTORS

	£	s.	d.	£	s.	d	*Cost per Ton (Pence)*
Wages and Rations				76	3	0	.88
Garage Service Charges				93	19	0	1.08
Labour	16	3	5				
Spares	24	8	8				
Diesel Fuel	47	10	8				
Oil and Grease	5	16	3				
Depreciation				750	11	6	8.65
Insurance				30	14	0	.35
Licences				8	16	8	.10
				£960	4	2	11.06
Tons Cane Hauled	20,818						
Mileage (Siding 299 to Siding 450)	2						
Cost per Ton Mile							5.53

So successful have these first two vehicles proved that a further five units are now on order and it is anticipated that in the thirty-two weeks of the coming crop these seven units will transport between them a total of 350,000 to 400,000 tons of cane.

COMPARATIVE FIELD COSTS — UMHLOTI VALLEY SECTION

1st SEPTEMBER TO 31st OCTOBER, 1955

2 FORDSON TRACTORS AND 2 TRAILERS

53 WORKING DAYS

4,590 TONS CANE CUT AND HAULED TO SIDING 533

	Cost £	s.	d.	Cost per Ton Pence	
CUTTING AND LOADING					
Cutters and Loaders					
Wages: 1,845 Units @ 2/6¾d.	236	14	5	12.38	
Rations: 1,845 Units @ 1/4d....	123	0	0	6.43	
Bonus: 1,822 Tons @ 1/8d....	151	16	0	7.94	
	£510	10	5	26.75	
Non-Cutters					
Wages: 406 Units @ 2/11¼d.	59	12	8	3.12	
Rations: 406 Units @ 1/4d....	27	1	4	1.41	
Bonus: 20% of Cutters ...	30	7	2	1.59	
	£117	1	2	6.12	
Livestock					
Field Operation	—			—	32.87
TRANSPORT					
Main Tramline Transport					
Based on 1954-55 Season's Costs					
Tractors and Trailers					
Fuel Oil: 855 galls. @ 1/7d.	69	9	5	3.63	
Engine Oil: 19 pints. @ 1/2¾d.	1	3	0	0.06	
Grase: 12 lb. @ 1/4d. ...		16	0	0.04	
Maintenance:					
2 sets, Tyres and Tubes... 452 5 0					
8 Tyres and Tubes (Trailers) ... 170 7 8					
Spares ... 80 0 0					
Labour (68 hrs. @ 2/1d.) ... 7 1 8					
53/365ths of ... £709 14 4 =	103	1	1	5.39	
Depreciation (53/365ths of £2,511 0s. 0d.) ... =	72	18	4	3.81	12.93
	£247	7	10		
TOTAL	£874	19	5		45.80

AVERAGE TONS PER UNIT = 2.487

CANE TRUCKS

53 WORKING DAYS

3,693 TONS CANE CUT AND HAULED TO SIDING 533

	Cost £	s.	d.	Cost per Ton Pence	
CUTTING AND LOADING					
Cutters and Loaders					
1,704 Units	218	6	6	14.19	
1,704 Units	113	12	0	7.38	
1,137 Units	94	15	0	6.16	
	£426	13	6	27.73	
Non-Cutters					
814 Units	119	11	2	7.77	
814 Units	54	5	4	3.42	
20% of Cutters	18	19	0	1.23	
	£192	15	6	12.42	
Livestock					
616 Units @ 1/9d.	£53	18	0	3.50	43.65
TRANSPORT					
Main Tramline Transport					
3,693 Tons @ 1/2¾d.	£226	19	4		14.75
TOTAL	£900	6	4		58.40

AVERAGE TONS PER UNIT = 2.168

SUMMARY

	Cost per Ton
Per Cane Trucks	58.40
Per Tractors/Trailers	45.80
TOTAL SAVING	12.60

MAIDSTONE,
MARCH, 1956

Mr. J. B. Grant thanked Mr. Bentley for his paper and said that there could be no doubt that motor transport was bound to come. He was also grateful to see that Mr. Bentley had given cost figures. He was indeed interested to see that the costs shown at Maidstone were so much in favour of road transport.

Mr. W. A. Campbell enquired of Mr. Bentley if the system would be easily applicable to very steep cane lands.

Mr. J. P. N. Bentley pointed out that the big 25 ton hilo trailers did not go into the cane fields. They were loaded either from tram trucks or from the smaller infield trailers.

Dr. G. S. H. Rossouw said that he noticed that Mr. Bentley claimed that the tramline could not compete with road transport, but he wished to know who was going to pay for the roads.

Mr. Bentley pointed out that the roads used were very largely established estate roads.

Dr. Rossouw stated that quite a lot of the transport was carried out on public roads where the cost was not borne by the company. This meant that the motor transport was not debited with a certain amount of maintenance of the roadways such as had to be borne by the tramline system.

Mr. G. H. Walsh said that the saving shown was largely on the transportation side but took no count of any cutting and loading savings. He also pointed out that whereas the road transport was used to its fullest capacity that was not the case with the tramlines. He agreed also that while the costs of maintaining the tramline were charged against the tramline, no such charge was made against motor transport. He though that 16 units a day to handle only 17 trucks was very high. He said also that other estates which had taken to diesel locomotives had been able to save tremendously on their operating costs as against steam tramline charges. He thought that where large quantities or tonnages were handled by tramline there was a very strong case for the diesel locomotives. He considered that quite a big saving would be involved if infield trailers were used to the central loading depot which would then be transferred by tramline.

Mr. Bentley replied that the comparative figures given by him were obtained under two different methods of transport operated under identical conditions. He said that the Company did have other loading sites where the tramline costs were lower. The infield trailers were put into one of the high costing sections. He was not attempting to compare the system shown in the costing figures with other estate railways.

Mr. Campbell said that some companies were dependent upon tramline transport for haulage up to 20 miles. He thought that it would be difficult to discard such a system.

Mr. Bentley replied that in Hawaii they had no hesitation in discarding tramline transport for road transport.

Mr. Saunders stated that the infield trailer illustrated in the paper could virtually be used in almost any terrain. He said that in hilly country this type of trailer was the best one that had been developed. It was very hard to beat for economic costs and economic operation. As far as the heavy hilo trailer was concerned the licence costs took care of public road maintenance. He pointed out that most of the roads being used for infield trailers and the heavy hilo had already been constructed and properly graded for steam locomotives. There would however be some that would have to be specially constructed. He pointed out that there would be a big saving in labour because leader boys, mule boys, track-laying boys, etc. would not be required for motor transport. Actually as far as loading from tramlines to heavy trailer instead of to S.A.R. trucks was concerned, they had been able to reduce from 170 to 60 boys a day. As far as the comparative costs shown between tramline and road transport were concerned, no costs were charged for locomotive haulage as this was done by tractor and mule, so that ordinary tramline costs would be higher than those shown, for this section at least. He considered that up to five miles motor transport was much more economic than steam tramline.

Mr. Campbell pointed out that a large storage space would be required in the mill yard.

Mr. Saunders replied that the place to store cane was not in the mill yards but rather at the loading sites.

Mr. N. C. King enquired if it would not be possible to carry the tramline from the old Tongaat loading siding to Maidstone Mill. He had heard that there were various difficulties in the way, but if it could be done he thought it might be cheaper than using heavy motor transport.

Mr. Bentley said that this matter had been considered for many years but there were many difficulties such as ownership of land as well as the necessity of building a bridge across the river which made this an impractical proposition.

He said that as he previously remarked had the land been in the possession of the Company they probably would have put in a tramline years ago and would now be busily engaged in tearing it up again.

Mr. Campbell stated that one of the big troubles at the moment was the factory's inability to get S.A.R. trucks to bring the cane in.

Mr. J. W. Main inquired if Mr. Bentley could draw up comparative costs of this motor transport as compared with those put up last year by Mr. E. Steward.

Mr. E. Steward said that in preparing his paper on transport, read last year, he found that the cost of transport per ton mile with diesel lorries was just under 4d. This he considered was a conservative figure as he had taken the life of a lorry as six years, while, in fact, it was longer than that.

Although road transport was undoubtedly becoming more popular he considered that in continuous wet weather there was no method, other than tramline, which would ensure the cane being delivered to the mill. He said that although it was expensive to pick up and relay portable line the cost of making macadamised roads, as had been advocated by Mr. Bentley, was tremendous.

Comparing the tractor and trailer system with the existing light railway system, the increased tonnage per unit of labour with the former system was interesting and from the summary of field costs this increase seemed to be due to the reduction in the number of non-cutting units rather than to any labour saving in the cutting and loading.

It should be noted that the cane hauled per day with the tractors and trailers was only 86 tons and that hauled on the light railway only 70 tons. For the light railway this represented something less than one train load which would naturally make the railway figures appear high, when obviously the number of tractors and trailers which would be used would be just sufficient to keep them all continuously occupied.

The figure of l/2|d. per ton for the cost of rail transport no doubt included a substantial figure for track maintenance whereas there appeared to be no allowance made for either the initial cost or for the maintenance of the roads used by the tractors and trailers.

There was a saving in non-cutter costs of 6.3d. per ton and he assumed that these non-cutters were the train crew, including brake boys, etc. In the case of the light railway, 814 units for 53 days gave 16 units per day to handle a single train of 70 tons pay-load. This appeared to be rather on the high side and he felt that these 16 units ought to be capable of dealing with a considerably greater tonnage daily with a consequent reduction in the cost per ton.

Experience on other sugar estates using Diesel locomotives shewed that the total railway operating costs could be greatly reduced below those costs, when using steam locomotives. It might well be possible, therefore, to effect a considerable reduction in the costs shown in the comparison table, where on the actual transportation of the cane there was little difference in the cost between tractors and trailers and the railway costs.

Whilst he agreed with Mr. Bentley that the "Puffing Billy" was on the way out, he felt that the road vehicles show up to best advantage only on the shorter hauls and particularly where public roads can be used. On longer hauls and where large tonnages are to be handled there was little to compete with the modern Diesel locomotive, particularly where hauling was done round the clock and where the larger type of cane cars could be used.

There was, however, a very strong case for a combination of both systems, particularly where it was possible to use tractors and trailers which are loaded directly in the fields and can run over poor roads to transfer points where the cane can be handled into cane trucks mechanically and thence transported by locomotives

Mr. Bentley said that the figures he had quoted for Hawaii were greatly influenced by the distance and terrain over which their cane was hauled. On long distances up to 40 miles he thought that the costs could be much lower than those he quoted. As far as depreciation was concerned he said that the depreciation of 20 per cent was on a reducing value and did not mean that the vehicle would last only five years. Some of the roads over which this transport would be conveyed were already macadamised and some they had intended macadamising in any case. The cost of macadamising roads by the company was much less than those of public bodies.

Mr. Steward asked if it were possible to write-off the cost of a vehicle if an annual deduction of 20 per cent of the reduced were made, and, if so, how long would this take?

Mr. Bentley replied that it was necessary of course to fix the residual value, when a formula of the form $K = 1 - \sqrt[N]{\frac{R}{P}}$ would give the required information.

Mr. Saunders stated that when comparing the Hawaiian costs with those of Natal enormous difference in wages had to be taken into consideration, and if one allowed for this difference one would find that costs in both countries would become more comparative.

THE APPLICATION OF ALTERNATING CURRENT ELECTRIC MOTORS AND CONTROL GEAR

By N. J. A. BONFA

Introduction

At the present time electric motors and their associated control gear are in such universal use and perform so satisfactorily that there is the risk of their importance being overlooked in the general scheme of electrical engineering. In this age of mass production we are all only too easily led to consider things in a general way so that particular characteristics are often grouped loosely together in the need for haste which is pressed upon us by our modern way of life. This, one particular item of plant may be classed generally with another, even though the detailed characteristics of each may be different, and in this way we can be led into errors of application which can cause loss of time, production and money. In presenting this paper an attempt will be made to cover some of the many interesting points concerning the application of alternating current electric motors and control gear and to show where the leading variations in the characteristics of the plant are of importance.

There are three main factors to be considered when applying electric motors and control gear. The first is the specification of the motor, the second is the specification of the control gear and the third is a knowledge of the driven machinery. The importance of the characteristics of the driven machinery is of some account and it is here that many of the errors of application are made. Other factors are the regulations of the electricity supply authorities and abnormal conditions of supply, such as low voltage. The regulations of the supply authorities are a safeguard against misuse of their supply and very necessary to protect the interests of other consumers. However, they are sometimes framed on a basis which makes them difficult to apply, as the limiting starting currents are graded and not necessarily correlated with the types of motors and control gear, which are normally available. Also, account is sometimes not taken of the limitations imposed by the driven machinery and this leads to various anomalies. It is fortunate that in the case of larger installations the size of the power supply is such as to permit considerable relaxation of the limiting starting currents and greater freedom may be exercised.

Electric Motor Specification

When specifying an electric motor, we need to consider the following system, output and rating particulars, together with the basic types which are available and the various mechanical features desirable to meet the requirements of the driven machinery and the situation where the motor will be employed.

System:	Single or three phase, frequency, low or high voltage.	
Type:	*Single Phase*	*Three Phase*
	Split phase.	Standard squirrel cage.
	Capacitor.	High torque squirrel cage.
	Repulsion induction.	Slipring.
		Commutator type.
		Compensated induction.
		Synchronous.
		Auto-synchronous.
Output:	Horsepower and speed.	
Rating:	Continuous, short time, continuous light running, overload capacity, temperature rise, ambient air temperature, altitude.	
Enclosure:	Screen protected, drip-proof, single-pipe ventilated, double pipe ventilated, filter ventilated inlet, totally enclosed, totally enclosed fan-cooled, weatherproof, hose-proof, closed air circuit with heat exchanger, flame-proof, pressurised explosion-proof.	
Mechanical Features:	Constant speed, variable speed, multi-speed. Shaft: horizontal, vertical, inclined. Foot mounting on floor, wall or ceiling. Flange: horizontal or vertical with or without skirt. Resilient mounting with or without automatic belt tensioning device. Carcass mounting.	
Bearings:	Ball and roller or sleeve endshield bearings. Ball and roller or sleeve pedestal bearings. Third outboard bearing.	
Mechanical Coupling:	Belt drive, chain drive, gear drive, direct solidly coupled, direct flexibly coupled, single outboard bearing direct solidly coupled, flywheel mounted.	
Noise Level:	Industrial or special.	
Windings:	Special connection arrangements when required, Class A insulation, Class B insulation.	
Cable Entries:	As required.	
Other Features:	Continuously rated sliprings and brushgear, electrical interlock on rotor short circuiting gear.	

Control Gear Specification

Similarly, with control gear, we need to consider the following particulars:

System:	Single or three phase, frequency, low or high voltage.
Rating:	To suit motor output and rating.
Mounting:	Wall, floor, switchboard, cubicle.
Enclosure:	Enclosed, totally enclosed, dust-proof, weather-proof, hose-proof, flame-proof.
Operation:	Manual, automatic, local or remote.
Contacts:	Air-break or oil-immersed.

	Squirrel Cage	*Slipring*
Type:	Direct-on.	Combined stator-rotor.
	Direct-on reversing.	Stator C.B. and rotor starter.
	Direct-on multi-speed.	Stator C.B. and drum controller.
	Star-delta.	Stator C.B. and speed controller.
Protection	Under-voltage release, under-voltage no-close device, over-current releases.	
Fault Capacity:	To suit system if required.	
Cable Entries:	As required.	
Other Features:	Ammeter, floor stands, isolating switch, sequence interlocks, auxiliary contacts.	

Electro-Mechanical Characteristics

The choice of a suitable motor and its control gear depends on a knowledge of the features which are available with makers' standard design ranges in relation to the electro-mechanical characteristics of the motor with its control gear and the nature and characteristics of the driven machine. The most important electro-mechanical and duty characteristics are the starting torque of the motor, the frequency of starting and the starting time. The first is dependent on the driven machine and influences the choice of the type of motor and control gear. The second and third decide the design of the control gear and may have a bearing on the design of the motor if either the frequency of starting is high or the starting time is prolonged.

The typical average electro-mechanical characteristics of motors with their control gear are given below:

Single Phase Motors

Type of Motor	*Method of Starting*	*Starting Torque Per cent. of F.L.T.*	*Starting Current Per cent. of F.L.C.*
Split phase	Direct-on ...	200/220	650/700
Capacitor	Direct-on ...	300/400	450/600
Repulsion induction	Direct-on ...	300/400	300/400

Three Phase Motors

Type of Motor	*Method of Starting*	*Starting Torque Per cent. of F.L.T.*	*Starting Current Per cent. of F.L.C.*
Standard squirrel cage	Direct-on ...	100/175	450/750
	Star-delta ...	33/ 55	150/250
	Auto-transformer	20/ 80	100/400
High torque squirrel cage	Direct-on ...	225	325/600
	Star-delta ...	66	100/175
	Auto-transformer	30/110	110/300
Slipring	Rotor resistance	Up to 200	Up to 250

Driven Machine Starting Characteristics

It is in connection with the starting characteristics of the driven machine that difficulty is most often met in choosing a suitable electric motor and control gear combination. There are so many factors to be considered that it can be difficult to predetermine the starting characteristics to be expected and we often have to rely on experience to guide us. Some makers of mechanical equipment have given attention to the problems and are able to give accurate information, from tests and practical experience, which is of great help to the electric motor and control gear application engineer. With this information available, the engineer is better able to predetermine with sound judgment what equipment to apply. Otherwise, he must rely on his own experience of the characteristics inherent to the basic types of driven machinery and in this respect he is wise to employ a conservative view in order to apply equipment which he can be confident will meet the duty required.

Where the required starting torque to cause sufficient acceleration is moderate, no difficulty is likely to be experienced, but the more onerous and special starting characteristics need more careful consideration. Typical of the duties which can be difficult are those met with machinery having high static or break-away torques, equipment starting loaded and those cases where the torque increases with the speed during acceleration. Then there are machines with high inertia where the starting time may be of long duration.

The table below gives a useful guide to the starting-torque commonly met with various basic classes of driven machinery.

Type of Driven Machinery	*Starting Torque Per cent. of F.L.T.*
Line shafting	33/ 50
Pumps, centrifugal, against closed valve	33/ 50
Pumps, centrifugal, against open valve ...	33/100
Pumps, reciprocating	100/200
Fans	33/100
Compressors, centrifugal	33/100
Compressors, reciprocating, unloaded	60/100
Compressors, reciprocating, loaded	150/200
Machine tools	100
Textile machinery	100/200
Conveyors, loaded	125/150
Haulages, loaded	125/150
Crushers...	100/200
Tube mills	200

Choice of Motor Rating

When deciding what rating of motor should be applied to a drive, due allowance has to be made for the contingencies which are likely to be met in practice. Low voltages and the possible variations in the estimation of the actual load lead us to allow a reasonable margin over the estimated actual load. Often an arbitrary margin of 15 per cent, is used when deciding the motor rating. This is a safe figure with medium-sized motors, but it is on the high side for large machines and it is hardly sufficient with many drives requiring small or fractional h.p. motors. Fortunately, with the latter, the grading of the ratings normally manufactured is such that it is difficult to apply an unsatisfactory rating if the matter is handled along engineering lines. Nevertheless, poor application is common in this field.

Overload is one of the keys to reasonable motor application. With electrical plant, excluding switchgear, the weight of the constituent materials governs the thermal capacity of the plant and so its ability to safely absorb the extra heat generated under overload conditions. Thus, generally speaking, the overload capacity of motors is dependent on their size and the smaller the machine the lower is its overload capacity. Conversely, with the driven machinery, the likelihood of overloads occurring is usually much greater with small machines than with the larger units. This will make it clear why greater should be exercised when applying small and fractional H.P. motors.

High Starting Torque Squirrel Cage Motors

These motors have been developed to bridge the gap between the starting characteristics of standard squirrel cage motors and slipring machines. They can be applied in a number of cases where standard squirrel cage motors are not entirely suitable and where it is desired to economise on the higher cost of slipring motors with their control gear and at the same time enjoy the advantages of the greater simplicity and easier maintenance which the squirrel cage type of machine affords. It is of interest that, notwithstanding the better starting characteristics of the high starting torque motor, the acceleration is inherently more smooth than with a standard squirrel cage motor and less shock is transmitted through the drive during starting. This characteristic enables specially designed high starting torque motors to be successfully applied to wire drawing machines and certain classes of textile machinery, such as ring spinning frames.

There is a case for the greater employment of high starting torque squirrel cage motors and many borderline cases would be better handled by them, particularly where the starting characteristics of the driven machinery are known to be in the difficult bracket and where high inertia starting loads are present.

Multi- Speed and Variable-Speed Drives

Squirrel cage motors of the change pole or multi-winding type may be used where constant speed operation at two or more of the normal A.C. speeds is required. Up to four separate constant speeds in one mechine are usually available with two separate change pole windings. The change pole windings are of the consequent pole type and the higher speed is twice the lower speed for each winding.

The control gear for multi-speed motors has **to** be designed for the switching arrangement required by the motor windings and over-current protection has to be provided for the output rating corresponding to each speed. Contactor gear is therefore, of necessity, more complicated than that required for single speed machines.

Continuously variable speed drives necessitate the use of either slipring motors with rotor resistance control or commutator type machines. With the former there are the losses in the rotor circuit to be considered and it is important to know the torque/speed characteristics of the driven machine to design the rotor resistor. A faceplate type rotor controller or drum controller having balanced notches may be used, but very fine adjustment of the speed is difficult to achieve without special equipment and the commutator motor with speed control by brush rocker movement is generally more suitable where the speed has to be set to close limits. Typical of cases where speed control within fine limits is required are rotary-printing presses and sugar mills with electric motor drive. With sugar mills the associated group of motors may be connected to an alternator running separately from the remainder of the generating plant and the speed of the group of motors is varied by alteration of the speed of the prime mover driving the alternator.

Short Time Rated Continuous Light Running Motors

Many machine tool operations require varying outputs from the driving motor over a cycle which is repeated. Automatic turret machines carry out operations where the full output is required for only a short period of the total operating time. Economies in capital and operating costs may be effected by using short time rated motors designed to run continuously at light load and these motors are termed continuous light running motors. Apart from their lower capital cost they keep down the maximum kVA demand and improve the power factor, which are important points where power is purchased on a kVA demand basis.

Flywheel Drives

Presses, punches and similar machines which incorporate a flywheel to deliver a large amount of power over a relatively short period during each operating cycle are successfully driven by motors having a higher than normal slip. This enables the machine to slow down during the power stroke and draw power from the energy available in the flywheel rather than from the motor. The basically constant speed characteristic of standard induction motors causes them to draw high peaks of power from the supply during the power stroke and the motors have to be rated to deal with the heating effects of the current peaks which flow so that larger motors than actually necessary have to be used. In addition, the heavy peaks of power transmitted by the motors cause greater belt wear than is normally expected.

With large machines, slipring motors having a fixed slip resistor in the rotor circuit are used and the resulting performance shows such a marked improvement over that possible without the slip resistor that high slip high torque motors have been developed for the small and medium sizes, The slip at full load with these machines is about 10 per cent. and this enables the flywheel to drop about 12 1/2 per cent in speed during the power stroke without motor current peaks of a high order. Some surprising economies have been achieved in practice and, in addition to the reduction in the capital cost of the motors and control gear, belt reduced and a much better overall power factor may be expected with an installation consisting of a large number of machines.

Winding Insulation and Impregnation

Class A insulating materials, consisting of cotton, silk, paper and similar organic materials suitably impregnated and also enamelled wire are in general use and lend themselves to easy and economical manufacture. Special cases where the ambient air temperature may be high, necessitates Class B insulating materials which comprise mica, asbestos and similar inorganic materials in built up form combined with binding cement and the motors cost more to manufacture.

It is sometimes thought that Class B insulation is better than Class A, but this is not necessarily the case and in fact there is some justification for the reverse opinion. Asbestos is difficult to handle, lacks mechanical strength and is very hygroscopic. Glass is in itself a poor insulator, because of its low resistance to surface creepage. Both matenals are difficult to impregnate. Mica is undoubtedly the best Class B insulation material, but it is expensive to apply and can only be used effectively with heavy section conductors.

Impregnation of Class A insulating materials has reached a very satisfactory stage with the use of polymerising synthetic resin varnishes of the thermosetting type. Such varnishes are easy to apply and are readily absorbed by cotton covered wires. The finished product gives a winding which is thoroughly impregnated, mechanically strong, with excellent insulation and a high degree of resistance to moisture and acid.

The tendency today is strongly towards the use of synthetic covered wires of which there are well-known brands. These coverings are tough and pliable, have excellent electrical properties and their use enables the slot size to be reduced because of their better space factor when compared with cotton covered wires. Modern designs make extensive use of these synthetic covered wires and this is generally to the satisfaction of operating engineers.

Sliprings, Commutators and Brushes

It is fair comment to point out that sliprings, commutators and brushes are the weakest link in any electrical machine. Sliding contact such as is necessary in electrical machines has always been a problem to electrical designers and a great deal of thought and ingenuity has been put into the design and application of equipment which will give very satisfactory performance within the limits of its ability.

This whole subject is now the sphere of the expert and we can always avail ourselves of his help, which is so readily available, when problems arise. The important points to be borne in mind are that the life of brushes is limited, as wear must take place, and that the performance is dependent to a very high degree on regular and careful maintence. Also, variations in performance are to be expected with variations in operating speeds and atmospheric conditions.

Noise

All industrial class motors make noise, especially during starting, and the degree of sound emitted varies with the electrical design, output and speed. It is particularly dependent on the use of ventilating fans to assist the inherent ventilation characteristics of the machine. The fact that a cylindrical rotor with its winding has sufficient fan action enables many ratings to be constructed without the inclusion of a separate internal fan to pump air through the motor. Such machines are relatively quieter than those with separate internal ventilating fans.

An important point is that the actual sound emitted is not normally taken as a measure of the noise. What is commonly used is the apparent sound which is the difference between the actual sound emitted and the threshold of sound of the surroundings. This is what is heard by the ears, because of their unique type of sensitivity to sound, and whereas a motor can be noisy where the threshold of sound is low, exactly the same motor would be considered quiet in different surroundings with a higher threshold level.

It is unreasonable to expect quietness of operation from industrial class machines and all makes of motors have probably received adverse criticism at some time or other in this respect. Also, if one rating of a particular make appears to be quiet, it does not follow that another rating of the same make will give equal performance.

Special motors are made which are designed to operate with a low level of sound emission. Various classes are available and lower than normal sound levels are achieved by electrical design modifications and the omission of ventilating fans. Where very low sound levels are desired, sleeve bearings are essential.

Over-Current Protection

It is standard practice to include over-current protection with the control gear and its function is to automatically disconnect the motor from the supply in the event of abnormal operating conditions. The over-current releases may be operated either magnetically or thermally and both types are in general use. The magnetically operated type are more costly to produce, but have a greater inherent ability to carry high over-currents of fault current magnitude and can be relied upon to maintain their calibration indefinitely.

In addition to giving protection against abnormal conditions of operation the over-current releases must, at the same time, be capable of carrying the starting currents without giving rise to inadvertent operation. An inverse time lag characteristic with a definite minimum time characteristic during starting and an over-riding instantaneous characteristic for heavy fault currents is probably the ideal, but this can only be obtained with special equipment. Standard types of over-current releases either include devices which achieve the desired characteristics to a sufficient degree for normal applications or are of a type where the characteristic is partially inherent, as is the case with thermal over-current releases.

Magnetically operated over-current releases incorporte time lag devices which may be of the oil dashpot type or of a mechanical pattern. With the oil dashpot type the special characteristic required during starting is achieved either by restrainers, which are simple flap valves designed to close the normal overload time lag orifice in the piston of the dashpot device by movement of the oil through the orifice, or compound spring loaded dashpot pistons giving progressive restriction.

The adjustment of the time lag with oil dashpots is achieved very simply by providing a selection of orifices of different diameter in the piston assembly and an oil with a reasonably constant viscosity over the range of temperatures normally to be expected is usually provided with the control gear for use in the dashpots. Further adjustment of the time lag may be achieved by the use of oils of higher viscosity and long time lags to meet awkward starting conditions are possible. The adjustment which is possible to the time lag characteristic of oil dashpot time lags is a useful feature as it can be achieved without altering the over-current settings.

On control gear with magnetic over-current releases, settings are usually provided for currents about 20 to 25 per cent. in excess of the normal F.L.C. of the motor although lower settings are available if necessary. These settings will provide protection against abnormal operating conditions.

Where motors operate under borderline conditions of overload it may not be possible to get low enough settings with the over-current releases supplied with the control gear and it may be necessary to install over-current releases with lower settings. However, it is unreasonable to expect the control gear to provide over-load protection for motors which have been incorrectly applied. Such cases are only too common and require an alteration in the motor rating to correct an unsatisfactory position.

Fault Protection

Where control gear is used on systems having a high fault capacity, either equipment designed for the fault rating may have to be used or special steps may have to be taken to protect standard control gear types. On high voltage systems the use of circuit breakers of adequate fault rating does not present any real difficulty as suitable equipment is readily available. With low voltage systems, however, the need for providing control gear of high inherent fault rating is fortunately not so necessary from an engineering point of view, although the importance of this matter should not be underestimated and special cases may require more detailed consideration.

The factors which assist with low voltage equipment are the relatively small size of the vast majority of the circuits and the attenuation of the fault by the impedance of the cables and the fault arc. Where the cable runs are short or the equipment is of relatively large capacity, greater care should be taken. With large motors, circuit breakers of suitable fault rating may be employed, but with small motors H.R.C. fuses are usually used to give back up protection. Where H.R.C. fuses are used they should always be chosen in relation to the starting currents which are likely to flow and it is good practice to allow a reasonable margin in their rating.

Single Phasing

What is termed single phasing, that is, the inadvertent single phase running of three phase motors is a common fault and very often it is due to a misunderstanding of the performance of fuses during starting. It has been and will probably continue to be the cause of many motor failures. The matter is aggravated by the fact that it is most difficult to provide protection against single phasing for delta connected motors developing about 50 to 66 per cent. of their normal load without special equipment. In fact, even where specially manufactured motor protective relays operated by over-current are used, protection can only be ensured if the motors are star connected. Relays incorporating a resistance-reactance network are used and there are also other types of relays operating on current differential which are claimed to be effective.

With single phase running a number of factors come into the case and it has been suggested by some investigators that the line current increases by about 65 per cent. For a star-connected machine the increase in the current carried by the two windings in series across the single phase supply is the same as the increase in the line current and the over-current protection normally included with the control gear is equally as effective as for three-phase running. However, with a delta connected motor the position is quite different. The line current will still increase by about 65 per cent. but, according to the same investigators, the current in the winding directly across the single phase supply increases by about 90 per cent. and that in the two windings in series across the single phase supply decreases by about 5 per cent. Thus, in the case of a motor carrying a medium load of about 55 per cent, of normal, such that the line current increases to the 100 per cent. figure under single phase running, the winding directly across the single phase supply will carry an overload in current of about 15 per cent. This overload in the winding across the supply can increase to about 45 per cent. before over-current releases set at 125 per cent. of the normal full load current can detect the condition and this will make it clear why standard control gear cannot be expected to cater for the contingency.

Star-Delta and Auto-Transformer Starting

With squirrel cage motors, star-delta and auto-transformer starting may be used where the starting torque is within the limits of the motor characteristics and where it is desired to limit the starting current. This type of starting should be avoided with borderline cases and instances are met where the motor is incapable of accelerating the load satisfactorily in the start position of the control gear. With some of these cases the motor may fail to accelerate beyond a fairly low speed and the position is most unsatisfactory from the point of view of the motor in particular and, in addition, difficulty can be experienced with the control gear which is expected to be able to switch the motor from the start to the run position under the most onerous conditions. The performance is aggravated by low voltage where the motor torque falls off in proportion to the square of the voltage. Also, such simple things as tight glands in pumps and the running in which is often a feature of certain types of mechanical equipment can give rise to difficulties. Very often the difficulties which are experienced may justifiably be put clown to poor application of the equipment and a great deal of unnecessary trouble is caused to all the parties concerned.

The transient currents which can occur with these methods of starting are of importance. These transients are indeterminate and depend on the size of the motor, the fault capacity of the system, the impedance of the motor with its connections and the instant of time when the final switching is made. With large motors, transients of a very severe character may be met and it is usually impracticable to use star-delta and auto-transformer starters of the conventional type with high voltage motors. Before this problem was fully appreciated and understood, many high voltage motors had their windings damaged by high transient currents. The explanation of the phenomena is that the magnetic field system of the motor tends to persist during the period when switching from the start to the run position and the motor generates a voltage which is decaying in value and frequency during the transition period. At the instant when the final switching is made, the supply is connected to a system of differing voltage, frequency and phase relationship being generated by the motor and transient currents of about thirty times normal have been recorded during investigations of this problem.

The difficulty may be overcome either by directly switching the motors or, in the event of current limitation being necessary, by using continuous torque starters of the Wauchope resistor switching or Korndorfer auto-transformer type which are arranged to keep the motor connected to the supply during the transition period. These starters also have the advantage that they considerably reduce the transmission of shock to the drive during the changeover from the start to the run positions and there are many cases where they can be applied to advantage with large motors for use on both high voltage and low voltage systems.

Direct-On Starting

Direct-on starting is the simplest way of controlling squirrel cage motors and very large motors can be handled in this manner. Low voltage motors have windings which are suitable for carrying the relatively higher starting and transient currents, except in some special cases such as two pole motors, where the coil pitch is long in relation to the diameter of the machine and special means are not used to support the overhang. With large high voltage machines the support of the overhang of the windings is relatively more important and attention is given to this point by the designers.

Apart from the lower cost of the control gear, direct-on starting offers the advantage that the maximum torque is available from squirrel cage motors and considerable economy is possible, because they can be used where slipring motors were once considered essential. Due allowance should be made for the relatively rapid acceleration which can occur, together with the rising torque characteristic during acceleration, and the transmission devices between the motor and the driven machine should have sufficient margin in their design.

An interesting modern development connected with direct-on starting is the use of special couplings, such as the fluid or centrifugally operated type, which enable the peak starting torque of the motor to be utilised to start difficult drives with a worthwhile saving in the cost of the motor and with much lower transmission of shock to the driven equipment. A typical application is the starting of long-conveyors of the endless belt type and it is claimed that the maintenance of the mechanical equipment is considerably reduced. Also, these coupling devices enable squirrel cage motors to be used where previously slipring machines or motors with similar starting characteristics had to be applied.

Starting Slipring Motors

The highest starting torque/starting current ratio is that obtainable with slipring machines started by the rotor resistance method. Starting torques of at least twice full load torque are available with standard machines and higher torques are possible with special designs. The fact that the starting torque may be varied to suit the requirements of the driven machine make it a relatively simple matter to apply the correct equipment provided the characteristics of the driven machine are known. With manually-operated control gear, notching up the starter will usually cater for an awkward case, but this is not necessarily so with automatic equipment, where greater care in the design of the rotor resistor is necessary.

With control gear incorporating resistors, the rating of the resistor is chosen to suit the starting duty and it is important to specify this in detail, indicating in particular the frequency of starting which is required. Without this information, the control gear application engineer must work to conservative margins which he knows will give satisfactory performance under the worst conditions likely to be met.

Power Factor Correction

Power factor correction may be applied with auto-synchronous machines and, when new motors of medium size are to be installed, consideration can be given to the advantages of this type of machine. They start with a slipring motor characteristic and synchronise automatically with a minimum of shock to the supply system. The degree of power factor correction is easily controlable within the rated limits and they are free from any possibility of troubles which can be caused by resonance, harmonics in the supply system and voltage increases which are commonly met during off-peak load conditions. They can be applied equally well to constant or variable loads and, in the case of the latter, there is no risk of swinging the overall power factor to leading values except under exceptional circumstances. Furthermore, it is not necessary that they should be running continuously where kVA demand limitations have to be met as shutting down the auto-synchronous motor will, in most cases, drop off sufficient load to keep the kVA demand within the prescribed limit.

Conclusion

In this paper a summary has been made of some of the points which are of interest in the application of alternating current electric motors and control gear. This is a. large field and many applications have interesting features which it has not been possible to include in this brief survey, but which arc the special sphere of the electric motor and control gear application engineer. If this paper has succeeded in stimulating interest and also drawing attention to some of the lesser-known features of this fascinating branch of electrical engineering, the author's small contribution will be amply rewarded.

The President stated that he was grateful for the paper and for the remarks made by the author in thanking the operating engineers for their assistance in the past. As an operative engineer himself he wished in turn to express his thanks generally to the commercial engineers for their assistance and advice. As was mentioned in the paper, he also had experience of conveyors which were driven by squirrel cage motors. They had proved difficult to start and had to be started by throwing the starter over immediately on to full current.

Mr. Bonfa said that Star Delta Starters could only be successfully applied where the starting was reasonably light and difficulty would always be experienced when using this type of starter on big machines starting heavy loads.

Mr. Scott considered that an important point missed in the paper was the ventilation of motors. He considered that not enough attention was paid to ventilation and warned that this was one cause of over-heating.

Mr. Bonfa replied that this was an interesting point and on the Reef he had experienced the necessity of actually removing fans because of vibration problems with certain types of machinery. However, if the fans and the air circulation system were properly designed, no trouble should be experienced on this score.

Mr. Lindemann enquired why it should be that motors developing, say, 100 h.p. at the coast would not give more than about 90 per cent at higher altitudes.

Mr. Bonfa replied that the reason for this was the lower density of air at the higher altitudes, and, therefore, less heat was removed by the lighter air at higher altitudes.

Mr. Guim said he had recently discovered a motor, manufactured in England, which is a uni-directional motor.

Mr. Bonfa said there are many motors made with very efficient fans, which, however, would only function in the one direction.

Dr. van der Pol said that on numerous occasions squirrel cage motors on centrifugals had failed. Could this be due to work-hardening of the copper strips owing to the high frequency of starts and stops, causing increases and decreases in temperature, resulting in continuous expansion and contraction of the metal?

Mr. Bonfa pointed out that with the squirrel cage motor the losses occurred inside the machine and where one got repeated starts, as with centrifugals, the motor must be designed to cater for the frequency of starting.

Mr. Farquharson enquired if Mr. Bonfa had had any experience in starting up squirrel cage motors with resistors. It has often been said that in the sugar industry a totally enclosed motor was the answer to all our troubles, but the fact remained that a totally enclosed machine had little overload capacity and this meant employing a very big motor.

As far as ventilation was concerned, this often depended upon the situation in which the motor was placed and another factor was the large amount of dirt which was drawn into the motor.

As to Mr. Gunn's point, Mr. Farquharson said that if the manufacturer knew beforehand the direction of rotation of the motor, he could design a much more efficient fan and one which would function in either direction.

As far as the failure of squirrel cage motors driving centrifugals was concerned, Mr, Farquharson considered the big factor was vibration rather than heating and cooling.

This 50 Cycle vibration plus the heating when starting and regenerating made the windings loose so that they rattled and eventually broke down mechanically.

Mr. Bonfa said that the method of starting squirrel cage motors by resistors had definite applications in specific cases, particularly where the starting torque was low.

He mentioned there was a new British Standard for motors and that previous overload specifications were no longer being employed. This at present affected motors above 50 h.p. per 1,000 r.p.m.

Ventilating electric motors was a specialist's job and, as far as small macnmes were concerned, the simplest types of fans were used.

As far as centrifugals were concerned, h that both explanations put forward, namely, overheating and fatigue due to vibration, came into the picture. Losses would be experienced whichever type of drive was employed and losses in the fluid coupling drive could be very high.

BOILER EFFICIENCIES IN SUGAR CANE MILLS

By S. G. COLINESE

INTRODUCTION

According to the *S.A. Sugar Year Book* **1953-54**, there is "scope for the improvement of the efficiency of many of the steam generators in the Natal Sugar Industry."

The year book does not provide any test data or any direct indication of what these efficiencies might be expected to be. It is, however, obvious that in many cases the equipment necessary for carrying out tests is inadequate and certain suggestions were made regarding the provision of CO_2 recorders and steam flow or water meters.

The purpose of this paper is to discuss the minimum equipment and to present test data as some kind of guide to those who are anxious to effect improvements. Since the tests referred to were not carried out in Natal there can be no question of divulging confidential information and the presentation of the test can be criticised without fear or favour.

THE PSYCHOLOGICAL APPROACH

It is not to be expected that the high boiler efficiencies attainable in modern power plants will be reached in the average sugar mill. (From 80 per cent. to 90 per cent.).

From 75 per cent. to 85 per cent. may be reached in exceptional cases where integral steam power plant operates at a high pressure and temperature, and the process steam is reduced in pressure and temperature to suit the evaporators in the boiling room. Refinements such as economisers and superheaters, and perhaps air heaters, would be incorporated in a plant of this description. It should be possible to reach at least 70 per cent. with simple plant generating dry staurated steam and having no economisers or air heaters.

Given an attainable and precise objective the engineers and chemists will team up well providing they are persuaded they will receive a fair share of the credit when substantial improvements are made. The personnel of many sugar mills form isolated rural groups and to use the obvious cliche they plough rather lonely furrows. Like others similarly circumstanced they are not over-fond of the technical "shooting stars" who flash over their horizon from time to time and make imposing suggestions after cursory inspections. The writer's experience in dealing with the problems of combustion in cane sugar mills shows that valuable improvements could be made without recourse to expensive modifications, providing the enthusiastic co-operation of the staff was first obtained in a planned atmosphere of good will.

MINIMUM EQUIPMENT FOR TESTING

1. Some means of obtaining the dryness fraction of the steam as it leaves the boilers is essential. This is of course unnecessary if the steam is superheated. The efficiency of a boiler cannot be accurately determined if the quality of the steam is unknown. Many of the losses attributed to the "Boiling House" are in fact due to the wetness of the steam received from the "Boiler House." It is not necessary to fit a throttling or separating calorimeter. They have their limitations as every student of "steam" well knows. A forty-gallon drum half filled with cold water, a well-lagged steam drain pipe of small bore and fitted with a stop valve, and a calibrated thermometer arc the only requirements. It is assumed that reliable steam tables are available.

At the risk of appearing to be pedantic the method of finding the dryness fraction is given below. Frequent tests could be made to obtain a working mean value.

Example

The data given below refers to an experiment made to determine the dryness fraction of steam from a boiler having a working pressure of 140 lb. per square inch gauge. The small-bore steam pipe was well lagged and previous to commencing the test the steam was allowed to blow through the pipe freely to heat up the pipe and remove accumulated moisture.

Weight of water in drum at start	200 lbs.
Weight of water in drum at end	210 lbs.
Temperature of water at start	72°F
Temperature of water at end	126°F

Deductions (All heat units are in B.T.U.'s)

Heat units in water at start: 200 × (72–32)	8,000
Heat units in water at end: 210 × (126–32)	19,740
Heat units in 10 lbs. of steam: By diff. ...	11,740
Heat units in 1 lb. of steam	1,174

From steam tables for dry saturated steam (140 lbs. per square inch):

Sensible heat is ... ... 333.3 units
Latent heat is ... ... 862.3 units
Total heat is ... ... 1,195.6 units

If x be the dryness fraction then:

$$333.3 + x(862.3) = 1174.0$$

$$x = \frac{840.7}{862.3} = 0.975$$

Comment

It may be thought that this relatively high dryness fraction is hardly worth consideration. It represents, however, about 1.8 per cent. of the total heat and when the feed water is supplied at say 200°F is about 2.2 per cent. of the heat supplied.

If the steam is very wet the "dry pipe" or Tracy Purifier is not so efficient as it should be. Alternatively the boilers are being forced above their normal designed evaporative capacity. Personally I am convinced that dryness fractions of 0.9 to 0.95 are quite common in boilers being forced when their heating surfaces are dirty.

The moisture content of steam is one of primary interest to both engineers and chemists in cane sugar mills.

2. **Carbon Dioxide and Carbon Monoxide Recorders**

These instruments require close and expert attention to keep them in order. In those mills where it is found that they are not quite robust enough to stand up to the prevailing conditions a CO_2 indicator is sometimes to be preferred. The slotted sampling pipe should run well across the width of the flue in a horizontal position and about one-third of the flue height as measured from the base. CO_2 is much heavier than the N_2 in the flue gases and a poorly positioned sampling pipe will give unsatisfactory results.

3. **An ORSAT Flue Gas Analyser**

This enables a complete check to be carried out on CO_2, CO and O_2. The analysis could be carried out, if necessary by the chemist, once per week. The sum of the percentages of $C0_2$, CO, and O_2 should be close to 19.5. CO of course should not be present. Less than 5 per cent, of O_2 may lead to the formation of CO or CH_4 (methane). The furnace brickwork, etc., should be carefully checked for signs of infiltration of air before the analysis is carried out.

4. **Feed Water Meter**

This is to be preferred to a steam flow meter as it ensures that a record is made of the total evaporation including auxiliary steam, safety valve losses, etc. If a feed water meter is supplied it is essential to fit a by-pass. It is of course possible to measure the total evaporation in a tank, and this is perhaps the most reliable when such a tank is available. Hotwell tanks are often used for this purpose.

5. **Pyrometer**

A pyrometer should be available for measuring the flue gas temperature at the chimney base.

6. **Optical Pyrometer**

For special occasions a portable optical pyrometer could be borrowed for giving instantaneous readings of the furnace temperatures. For good combustion the temperature would be from 1,850° to 2,000°F.

N.B.—It is taken for granted that the following are part of the normal equipment:

(*a*) thermometer for taking atmospheric tempera-

(*b*) sootblowers or steam lances for cleaning the external surfaces of the tubes,

(*c*) a gauge for measuring the draught in inches W.G.,

(*d*) facilities for weighing the bagasse,

(*e*) means of obtaining the L.C.V. of the bagasse by approved methods.

COMMERCIAL TESTS FOR BOILER EFFICIENCY

A commercial test may be defined as one in which no specialist operatives are engaged in supervision. The results will show what is happening from day to day under normal working conditions. The data obtained can be interpreted and used by the staff to suit local conditions.

Commercial tests could be carried out for a period of say four hours and at least three times during each season. Expert advice could be asked for if necessary. It is the "man on the job", however, who will have to decide, as a rule, upon the conditions best suited to an all-round efficiency. If it is found, for example, that a fairly high $C0_2$ with a correspondingly high furnace temperature shortens the life of the furnace refractories then the optimum $C0_2$ will have to be decided by trial. It may be found that a slight reduction in the $C0_2$ will lengthen the life of the brickwork and also increase the thermal efficiency. After a few commercial tests have been carried out it may be advisable to have a full-scale supervised test in case there should be any points needing clarification.

LOWER CALORIFIC VALUE

Before commencing a test the explicit method to be used in arriving at the lower calorific value of the bagasse should be agreed upon. There is no reason why unanimity should not be reached for general application throughout the industry. Reference is made to this is an Appendix. Source of steam tables should be mentioned.

A TYPICAL TEST

The fullest possible details of a typical test and the general manner in which it is carried out is given below. For convenience it is grouped under several headings—

(a) Purpose of test.
(b) Plant data.
(c) Test data with calculations and comments.
(d) General observations.

Purpose of Test

To ascertain the equivalent evaporation per pound of bagasse as fired, and subsequently to compare the result with those obtained over a whole season in a sugar mill in an adjoining terrain.

To estimate the efficiency and prepare an approxi-mate heat balance the following are required:—

Callendar's Steam Tables.

Dr. G. L. Spencer's Handbook for approximate ultimate analysis.

Proximate analysis from staff chemist.

Method of calculating available heat in the bagasse as shown in Appendix.

Plant Data

There were five water tube boilers each having a heating surface of 3,580 square feet. Stepped grates of 40 square feet per boiler. Ratio of heating surface to grate area about 90 : 1. Soot blowers were fitted but were not used during the test as they tend to disturb furnace conditions for some time. No economisers or superheaters. The furnace walls were in good condition. The daily crush of cane was 920 long tons. Bagasse was 32 per cent, of the cane. No auxiliary fuel was used. Recorded excess bagasse after pans were shut down was 2 per cent.

Test Data

Plantation Analysis

Fibre	51.17 per cent.	Moisture	44.89 per cent.
Sucrose	2.89 per cent.	Non-Sucrose	1.05 per cent.

Ultimate Analysis Approximate (Dry Fuel)

Carbon	46.5 per cent.	Hydrogen	6.5 per cent.
Oxygen	46.0 per cent.	Ash	1.0 per cent.

Steam and Water

Steam pressure (lbs. per sq. in.) 135.9
(Assumed to be dry saturated)
Feed water temperature . . . . 165°F
(Normally this was 200°F)
Actual evaporation (four hours) . . . . . 248,400 lbs.

Air and Flue Gases

Atmospheric temperature at boiler front ... 100°F
Temperature of gases at chimney base . ... 530°F
Draught in inches W.G. 0.75
CO_2 .... 14.5 per cent
O_2 .... 5.0 per cent
N_2 .... 80.0 per cent
per cent

Fuel

Weight of bagasse burned (four hours). 109,900 lbs.

Comments

A large bagasse platform of structural steel and having a concrete floor made weighment relatively easy. It served also as a reserve bunker. Handrails were tubular and carried water service to reduce fire hazards.

Eaporation

Actual evaporation per lb. bagasse ... 2.26 lbs.
Equivalent evaporation . . . . 2.48 lbs.
Evaporation per square foot of H.S./hr. 3.46 lbs.

(This latter figure is based upon the actual evaporation.)

Heating Surface

Heating surface per long ton hour 471 sq. ft

Conclusions

The equivalent evaporation of the bagasse as fired was 2.48 lbs. from and at 212°F. In cane sugar mills in an adjacent terrain the equivalent evaporation over a full season of 3,363 milling hours was 2.34 lbs. from and at 212°F.

The second value is about 5.65 per cent, less than the first but serves to indicate the difference between a supervised test of short duration and the normal conditions prevailing during a whole season. The equivalent evaporation should always be used for the purpose of making comparisons. The heat required to change one pound of water at 212°F to steam at the same temperature was assumed to be 970 R.T.U.'s.

Estimated Boiler Efficiency and Heat Balance

These calculations are shown separately, as the primary purpose of the test was to find the equivalent evaporation per pound of bagasse. For the benefit of those who may wish to state the equivalent evaporation in terms of dry fuel the result from the supervised test with the fuel at 55 per cent, of the bagasse becomes 4.509 lbs. of steam from and at 212°F for each pound of dry fuel. Reduced to these terms comparisons are easier to make.

Heat put into Dry Saturated Steam by One Pound of Bagasse

From the steam tables the total heat per pound of dry saturated steam at a pressure of 136 lbs. per sq. in. is 1,195 B.T.U.'s. Deducting the heat in the feed water which is (165—32) B.T.U.'s the heat put into each pound of feed water is **1,062** B.T.U.'s. Also 1,062X2.26 is 2,400, and 970X2.48 is 2,400.

Calorific Value of Bagasse

The Higher Calorific Value was estimated to be . . . . 4,571 B.T.U/s
The available heat was estimated to be . . . . 3,451 B.T.U/s

(Refer Appendix for details).

Estimated Boiler Efficiency

This is $\frac{2{,}400 \times 100}{3{,}451}$ = approximately 70 per cent.

Comment

It was considered that the calculated efficiency was good. Also that the average efficiency based upon the evaporation of adjacent mills over a whole season of 3,363 milling hours would be about 66 per cent., and a good sustained performance without special supervision.

Heat Balance

The available heat of 3,451 B.T.U.'s is the basis upon which the heat balance has been prepared. It should be noted that a deduction for the heat absorbed in raising the temperature of the moisture in the bagasse from 100°F to 212°F and subsequently converting into steam at this same temperature has already been made. Also that the hydrogen, combining with the oxygen, in the fuel to form steam has been treated in precisely the same manner.

Heat Lost in the Chimney

Weight of air supplied per pound of dry fuel. This from the standard deduced equation is:

$$\frac{N_2 \times \text{Carbon per cent.}}{33(CO_2 + CO)}$$

From data previously supplied: Carbon—46.5 per cent.; CO_2—14.5 per cent.; CO—Nil; Nitrogen—80 per cent. 33 is a constant.

Weight of air supplied per pound of dry fuel is:

$$\frac{80 \times 46.5 \times 2}{33 \times 29} = 7.78 \text{ lbs}$$

Products of Combustion Per Pound of Dry Fuel

Weight of nitrogen $\frac{77 \times 7.78}{100} = 5.99$ lbs.

Weight of CO_2: $\frac{0.465 \times 11}{3} = 1.70$ lbs.

(1 lb. of carbon unites with 2.66 lbs. of oxygen to form 3.66 lbs. of CO_2.)

Weight of steam: $0.065 \times 9 = 0.585$ lbs.

(1 lb. of hydrogen unites with 8 lbs. of oxygen to form 9 lbs. of steam.)

Weight of oxygen: $\frac{5 \times 32 \times 5.99}{80 \times 28} = 0.428$ lbs.

(Relative weights of equal volumes will be the same as the relative molecular weights.) The above value was also checked by comparison with CO_2.

Total ... ... 8.703 lbs.

As a check it will be noted that 7.78 lbs. of air plus 1 lb. of fuel weighs 8,78 lbs. The difference of about 1 per cent, is negligible.

Heat Lost in the Gases (Per Pound of Dry Fuel)

It may be noted here that the gases are heated from 100°F to 530°F. The steam is heated from 212°F to 530°F as a deduction has been already made for the heat required to raise it from water at 100°F to steam at 212°F.

Heat lost =

Weight X temperature difference X specific heat.

$C0_2$	1.7 X 430 X 0.224	=	136.5 B.T.U.'s
N_2	5.99 X 430 X 0.251	=	650.0 B.T.U.'s
0_2	0.428 X 430 X 0.225	=	41.5 B.T.U.'s
Steam	0.585 X 318 x 0.45	=	84.0 B.T.U.'s
		Total	912.0 B.T.U.'s

Heat lost per pound of bagasse =

912 X 0.55 = 502.0 B.T.U.'s

Heat Lost in Chimney due to Superheating the Moisture in Bagasse

Taking moisture as 45 per cent, and the mean specific heat as 0.45 the heat lost in the chimney, but excluding the products of combustion is:

0.45 X (530 - 212) X 0.45 . . . . . 64.5 B.T.U.'s

Heat Balance

Heat given to steam	2,400 B.T.U.'s
Heat lost in chimney by products of combustion	502 B.T.U.'s
Heat lost in chimney by superheating moisture	64.5 B.T.U.'s
Radiation, etc., by difference	484.5 B.T.U.'s
Total ...	3,451 B.T.U.'s

Heat Lost by Radiation, etc.

This of course includes losses by hot ashes, combustible in ash and perhaps miscellaneous minor leakages. In this case it is about 10.5 per cent, of the total heat in one pound of bagasse as fired. It is difficult to estimate radiation losses with accuracy. The somewhat value estimated here suggests the advisability of carrying out a test over a longer period.

Checking Excess Air

It is interesting to check the excess air as it serves to confirm or to question the accuracy of some of the calculations and observations.

The minimum air required for one pound of dry fuel is deduced as follows:

Oxygen to unite with carbon:

0.465×2.66	1.24 lbs.

Oxygen to unite with hydrogen:

0.065×8	0.52 lbs.
Total oxygen required:	1.76 lbs.
Subtract oxygen present in fuel	0.46 lbs.
Net oxygen required	1.30 lbs.
Minimum air required $\frac{1.3 \times 100}{23}$ =	5.65 lbs.

Since the air supplied is 7.78 lbs. then the excess air is 2.13 lbs. This is approximately 38 per cent, and it is of interest to note that, according to B & W's useful tables page 115, a 14.5 per cent, of CO_2 is stated to represent an excess air of about 40 per cent (wood fuel).

Comments

There is no need for the staff of a sugar mill to prepare a comprehensive test report. A few commercial tests will provide a lot of useful data. If a heat balance is considered to be desirable it could be prepared and checked externally. The preparation of a heat balance is akin to an auditor's trial balance. It quickly reveals inconsistencies, irregularities and errors in observation. A few years ago it was quite common to insert a "tolerance clause" in contracts with a specified efficiency. This amounted to 5 per cent, for so-called errors in observation. It was a plus or minus value, and was considered to be fair when penalties could be imposed or bonuses claimed for performances deviating from the fixed level.

Finally, and with particular reference to the supervised test of short duration, it will be noted that the CO_2 at 14.5 per cent, (and an excess of air of only 38 per cent.) must be regarded as a maximum. If some of the heat from the chimney gases could be used to preheat the air supplied for combustion there would be an added economy but there are serious technical difficulties in the way of modifying plant so that this can be done cheaply and efficiently. Afterthoughts are usually expensive.

Careful treatment of feed water with the object of reducing or eliminating scale-forming constituents is worth consideration but no suggestions are offered here as they are considered to be outside the scope of this paper.

REFERENCES

Cane Sugar Handbook. Spencer/Meade.

A Handbook for Cane-Sugar Manufacturers and their Chemists. (John Wiley & Sons, Inc., New York; London: Chapman & Hall Ltd.). 1929.

Callendar's Steam Tables 1939 (London: Edward Arnold & Co.).

APPENDIX

Calorific Value of Bagasse

Heat in fibre:	... $8440 \times 0.5117 =$	4,340 B.T.U.'s
Heat in sucrose:	$7120 \times 0.0289 =$	206 B.T.U.'s
Heat in glucose,etc.:	$6750 \times 0.0105 =$	71 B.T.U.'s
	Total	4,617 B.T.U.'s

(See page 52.)

Subtracting 1 per cent. for ash the H.C.V. is . ... 4,571 B.T.U.'s

Available Heat in Bagasse

The heat expended in heating the moisture and evaporating it when the boiler house temperature is 100°F is (112 + 970 R.T.U.'s) per pound. This is 1,082 B.T.U.'s.

The heat lost in this way is:

$$1{,}082(H_2 \times 9 + \text{moisture}).$$

The percentage hydrogen is 6.5. The percentage moisture is say 44.89. (See page 3.)

$$\frac{1{,}082\ (6.5 \times 9 + 44.89)}{100} = 1{,}120 \text{ B.T.U.'s}$$

The available heat is therefore (4,571 — 1,120) which is 3,451 *B.T.U.'s.*

This value is less than the laboratory determination for the L.C.V., but its chief merit lies in the fact that it takes into consideration the actual conditions under which the fuel is being burned in the boiler house.

Some authorities have in the past suggested that the latent heat of steam at atmospheric pressure (970) should be used whilst others prefer to use the latent heat of steam at 60°F (1,055). Where the moisture content is so great as it is with bagasse the method outlined above seems to be preferable.

Mr. J. B. Grant thanked Mr. S. G. Colinese for his most interesting paper, and threw it open for discussion,

Mr. Liedemann said that it was known that the thermal efficiency of a heat engine depended upon the relationship of $\frac{T_2 - T_1}{T_2}$ or $1 - \frac{T_1}{T_2}$, in absolute units of temperature.

Since a steam raising boiler was a heat exchanger it was reasonable to adopt a similar view in its case.

It could be shewn that efficiency figures obtained by this simple method (T_1 and T_2 being the furnace and exhaust gas temperatures respectively) agree with those reached in actual boiler trials within a tolerance of three per cent. If T_1 be taken as the furnace temperature, T_2 as the exit gas temperature of the boiler, and assuming dry fuel at 14,500 B.T.U.'s with the ambient temperature of the boiler of 100°F, the per cent Thermal Efficiency = $100\left(1 - \frac{\text{Temp. of Exit Gases}}{\text{Temp. of Furnace}}\right)$. To allow for moist and lower grade fuels a correction must be added to the foregoing expression.

Generally it would appear that a difference of 10 per cent exists between low and high grade fuels, reducing the efficiency figure proportionately from 10 to

$$\left(10 - \frac{\text{Fuel calorific value in B.T.U.'s}}{1450}\right)$$

Substituting the figures mentioned in the paper in the formula, namely furnace temperature at an average of 1925°F, gases at chimney base 530°F, bagasse fuel at 3,451 B.T.U.'s and the ambient temperature at 100°F (which reduces the absolute figure of 460°F to 360°F), reveals a Thermal Efficiency of 53.5 per cent which is considerably less than that given in the paper—70 per cent.

The following table disclosed the small differences existing between the results of the Boiler Trial Survey and formula based upon data taken from the Proceedings of the South African Sugar Technologists Association.

Moisture in Bagasse	Temperature F. Furnace	Boiler exit	Thermal Efficiency Test %	Formula	Difference %	Type of Boiler
48.3	1600	500	47.0	49.1	2.1	Multi
46.5	1840	580	48.4	50.3	1.9	Multi
51.8	1646	469	35.6	51.7	16.1	Stirling
51.4	1854	462	44.1	55.8	11.7	Stirling
51.6	1584	465	53.7	50.6	3.1	B & W
53.0	1663	550	48.4	48.0	0.4	B & W
49.1	1550	526	43.3	46.6	3.3	B & W

On the question of baffling, it is my firm opinion, that an improvement in efficiency can be achieved by the removal of the back-wall baffle and placing it alongside the down-comer tubes. This would mean passing the exhaust gases underneath the mud drum to the base of the smoke stack, thus ensuring proper convection circulation, allowing each tube to generate its quota of steam, which at present is doubtful.

Hence in order to keep a daily check of the boiler efficiency the engineer would require a furnace pyrometer and thermometer in the boiler exit flue, recording type or otherwise, thus satisfying the engineer's dream for simplicity.

Mr. **Colinese,** in reply to Mr. Lindemann, said that as no furnace temperatures were recorded during the test under discussion no deductions could be made from the use of the upper and lower temperatures. The use of the Carnot Cycle efficiency was not admissable. It was purely hypothetical and had never been reached in practice. The formula given by Mr. Lindemann was interesting but there were no means of reaching such a high efficiency. It was to be regretted that the moisture content of the steam was not taken. It was assumed however that the steam was dry as the evaporation per square foot of heating surface was low. The efficiency figures published in the past by the Associations' various Boiler Committees were good but we should go forward and improve upon them.

Mr. P. Murray said that the Boiler Committee in the past did an excellent job and he did not think that the efficiency obtained as a result of their work could easily be improved upon.

Dr. C. **van der Pol** supported Mr. Colinese in his statement that the formula given was quite inapplicable to ordinary boiler practice. He wished to know why in the figures given by Mr. Colinese 1 per cent was deducted for ash, and asked when the heat value of the fibre was calculated, if the ash was included as well.

Mr. **Colinese** replied that when the heat values of the fibre, sucrose, etc., were deduced from the ash free fuel it became necessary to allow for the ash in the fuel as fired.

Mr. J. M. Cargill inquired if combustion of the fuel could not be improved, and a higher boiler efficiency obtained by giving the operator something which would make the control of the boiler more easy as far as fuel and air control was
experience of oil fired boilers where means were provided for testing the smoke in the flue gases. He wished to know if any such device had been applied in the sugar industry.

Mr. **Colinese** said that in feeding bagasse it was difficult to regulate the fuel to air ratio; far more difficult than in the case of coal or oil fired furnaces.

Altough smoke and smog were not liked, the fact remained that close to the black smoke line the boiler was at its highest efficiency.

Mr. Reynolds said that he had no doubt that the majority of Natal sugar mill engineers would be surprised at the figure of 70 per cent which was given as the efficiency of the installation referred to by Mr. Colinese. He thought that few boilers in Natal operated at such a high efficiency, due largely to the fact that the rates of evaporation per square foot were in general much higher in Natal practice than in the case referred to in the paper. Furthermore, combustion rates per square foot of grate area were also considerably of those mentioned by the author. Overloading and high efficiency do not go hand-in-hand, and unless ratings on the majority of boilers in Natal could be reduced, it could not be expected that efficiency figures of 70 per cent could be attained.

Commenting on Mr. Lindemann's remarks, Mr. Reynolds said that removing the rear baffle from a Babcock and Wilcox Boiler would have the effect of reducing the mass flow of gases, and accordingly would reduce the rate of heat transfer from gas to water considered that such a modification would result in a reduction of evaporation instead of the increase which Mr. Lindemann had suggested.

Mr. W. B. **Heslop** said that assuming that the boiler plant was correctly designed from the point of view of capital cost, etc., a big improvement could come through the extensive use of instrumentation and to more regular attention to blow-down and to feed water.

Mr. Colinese stated that the Heat Engines Trials Report published by the Institution of Civil Engineers in co-operation with the Institution of Mechanical Engineers and the Institution of Electrical Engineers is still regarded as the best and most comprehensive work on Plant Efficiencies, and the manner in which tests should be carried out. It is a magnificent publication and was published originally at a price of about five shillings. Its codes are accepted without qualification by a great majority of contractors and purchasers. It would be unwise to attempt to depart from their carefully considered recommendations. If, as a matter of curiosity, it is thought to be worth while to estimate a rough approximation of the maximum attainable efficiency of a boiler plant based upon the upper and lower temperatures it must be borne in mind that there is a vast difference between the specific heat of the furnace gases at say 2,245 degrees F (as given in the 1934 proceedings) and the mean specific heat of the chimney gases at a temperature of say 530 degrees F.

Gas	*Specific heat at* 600 F.	*Specific heat at* 2,000 F.
CO_2	0.222	0.310
O_2	0.216	0.231
N_2	0.247	0.265

It may be of interest to owners of plant in the Natal sugar mills to know that, in view of the relatively low grade labour available for construction and operation in certain countries outside the Union, all brickwork was constructed with an additional half brick thickness, furnace volumes were kept rather large, rate of combustion per square foot of grate area was kept low and the rate of evaporation per square foot of heating surface was accomplished without forcing.

FURTHER NOTES ON MILL EXTRACTION RESULTS

(REVIEWED IN THE LIGHT OF INDIVIDUAL UNITS CONTROL)

By. J. RAULT

Introduction

Industry's Mill Extraction and Loss of Potential Production

The last paper presented on this subject (Proc. Ninth Annual Congress S.A.S.T.A.) dealt witn conditions existing twenty years ago, when the average extraction for the whole industry stood at 91.07 per cent, with the composition of final bagasse brought down to 3.05 per cent, sucrose and 52.11 per cent, moisture.

From that time many changes have taken place, especially after the war years, and yet we are only up to 92.32 extraction with the bagasse at 2.91 per cent, average sucrose carrying to the furnace a moisture content risen to 53.18 per cent., probably one of the highest in the world cane sugar industry.

On the other hand, the efficiency of the more complex operations of sugar manufacture expressed by the term "boiling house recovery" has nevertheless risen from a level of 85.2 per cent, in 1934 to the present 90.5 per cent, of this season, notwithstanding many cases of an improved product placed on the market.

The major factor, slowing down the rate of possible progress in mill extraction, has been put down to the too-rapid expansion of the industry's production, out of proportion with the steps already taken to meet the progressive rise in factory crushing rates (60.8 tons per hour in 1934 and 102 tons in 1955).

A secondary factor is also the deteriorating state of cleanliness of the raw material sent to the mills, with ever-increasing amounts of extraneous fibrous matter, due to inadequate labour forces in the fields. We are admittedly the worst country in this respect, apart from those who are forced to fall back on mechanical harvesting.

The presence of 5 to 10 per cent, of extraneous matter in the way of dry trash, green leaves, **roots** and tops, sent in with the genuine cane stalk of the comparatively low-fibred N:Co. varieties, has not made milling conditions easier than previous to 1935, ably reviewed at the time of the Ninth Congress, by Mr. F. B. Macbeth, and qualified by the title "Milling Uba Cane."

Out of the final figures of the 1955-56 season, the extraction figures of the seventeen factories, issuing figures to the S.M.R.I., can
progression as follows:

No. of Mills	Approximate Extraction shown	No. of Mills	Approximate Extraction shown
1	90.0	4	92.5
1	90.5	3	93.0
2	91.0	2	93.5-93.7
2	91.5	1	95.1
	(91.2-91.5)	-	-----
1	92.0	17 season	92.32

It is not the first season when a level of 95 per cent, extraction has been maintained in the past by one factory or other, which means that the final bagasse was brought down to a sucrose content of 1.90 to 2 per cent, with a moisture of 50 to 52 per cent. Notwithstanding the comparatively high fibre ranges, 15 to 17 percent., of the South African raw material—a factor discounted in at least two northern Zululand mills with 12.5 to 13.5 fibre—there is no insuperable condition preventing other factories reaching this excellent standard of performance, when equipped with the appropriate machinery.

By falling short of the 95 per cent, extraction, the last season's average of 92.32 per cent, represents a bulk shortage of 27,000 tons of commercial sugar that should have been in bags and not burned as fuel in the bagasse furnaces (calculated on the sucrose entering the cane carrier).

When this total loss is distributed *pro rata* of the individual factory shortfall, the potential increase in production is over 4,000 tons for at least three factories, and over 1,000 tons in the case of seven others.

We need no apology for stating that under present conditions of expansion, the capital outlay for improving the milling results of most factories, is a very sound investment which would bring immediate and high interest on this initial capital expenditure.

Capacity versus Extraction

With reference to the optimum conditions of equipment for capacity and extraction, there is no straightforward answer as to whether the size of the rollers, or the number of mill units, or the splitting of the work on two batteries is the most economical, as this must be answered according to local conditions.

Very seldom is a mill unit added, for the sole purpose of improving extraction, without the legitimate demand for an increase in production rate, obscuring the

NATAL ESTATES MOUNT EDGECOMBE

AVERAGE WORK OF INDIVIDUAL UNITS OF THE MILLING TRAIN

	TOTAL EXTRACTION (UP TO UNIT)							EXTRACTION BY UNIT PER CENT. SUCROSE ENTERING UNIT											
Year	Crusher	First	Second	Third	Fourth	Fifth	Extn. Last Mill	Crusher	First	Second	Third	Fourth	Fifth	Tons Fibre per Hour	Fibre per cent. Cane	Sucrose per cent. Cane	Tons Cane Crushed per Hour	Water Added % Cane	Year
1933	36.89	70.19	82.03	87.58	91.00	94.21	3.21	36.89	52.77	39.72	30.88	27.54	35.66	16.18	15.75	14.40	102.74	41.02	1933
1934	38.33	73.11	83.75	89.04	91.41	94.20	2.79	38.33	56.40	39.60	32.50	21.60	32.50	16.72	15.28	12.95	109.43	38.91	1934
1935	32.90	71.55	83.35	88.64	91.87	94.52	2.65	32.90	57.60	41.50	31.80	28.40	32.60	17.57	15.39	14.18	114.18	41.45	1935
1936	27.47	71.23	82.71	88.31	91.75	94.62	2.87	27.47	60.34	39.91	32.39	29.43	34.78	17.69	15.42	13.94	114.76	42.32	1936
1937	35.30	72.81	84.16	88.83	91.91	94.80	2.89	35.30	58.00	41.70	29.50	27.60	35.70	18.45	15.43	14.36	119.61	44.26	1937
1938	37.76	74.27	84.66	88.52	91.77	94.79	3.02	37.76	58.66	40.38	25.14	28.30	36.69	18.68	14.47	13.73	129.09	39.21	1938
1939	36.37	74.22	85.14	88.99	92.25	94.65	2.40	36.37	59.50	42.30	25.90	29.60	31.00	19.78	14.28	13.63	138.52	40.99	1939
1940	34.59	72.06	83.12	88.03	90.88	94.40	3.52	34.59	57.28	39.58	29.09	23.80	38.60	20.89	15.39	13.52	135.73	41.29	1940
1941	37.20	72.50	83.40	88.30	91.50	94.50	3.00	37.20	56.20	39.50	30.00	26.70	35.90	20.00	15.74	13.74	127.09	41.08	1941
1942	28.48	72.17	83.28	88.52	91.90	94.95	3.06	28.48	61.08	39.90	31.32	29.49	37.84	20.92	15.44	13.34	135.50	38.94	1942
1943	23.54	70.58	85.28	89.04	91.72	94.88	3.16	23.54	61.52	49.96	25.55	24.45	38.16	22.70	15.84	12.996	143.34	38.43	1943
1944	20.38	71.38	84.87	89.04	91.74	94.86	3.15	20.38	64.05	47.41	27.54	24.38	38.00	22.72	15.81	13.795	143.74	36.86	1944
1945	23.76	68.06	84.13	88.15	91.61	94.78	3.17	23.76	58.11	50.29	25.34	29.18	37.79	22.68	16.28	13.997	139.29	39.16	1945
1946	30.85	70.81	84.51	89.29	91.97	94.73	2.76	30.85	57.79	46.94	30.86	25.02	34.37	21.11	15.81	14.003	133.51	39.73	1946
1947	33.43	71.30	83.73	88.85	91.92	95.33	3.41	33.43	56.89	43.31	31.47	27.54	42.21	22.30	15.73	13.345	141.79	37.26	1947
1948	27.31	65.40	81.20	87.59	91.24	95.26	4.02	27.31	52.40	45.67	33.99	29.44	45.89	22.15	15.98	13.60	138.60	38.83	1948
1949	28.32	67.08	80.71	86.48	90.71	94.97	4.26	28.32	54.07	41.40	29.91	31.29	45.86	23.20	16.35	13.693	141.88	38.07	1949
1950	26.48	66.52	80.27	86.72	90.50	94.79	4.29	26.48	54.46	41.07	32.71	29.50	45.08	24.10	16.64	14.35	144.85	37.88	1950
1951	27.86	66.00	80.41	86.45	89.85	94.43	4.58	27.86	52.87	42.38	30.84	28.68	42.40	22.35	16.64	13.266	134.30	39.36	1951
1952	27.61	65.87	79.44	86.11	90.44	94.25	3.81	27.61	52.85	39.75	32.44	31.21	39.88	22.10	15.86	14.19	139.32	38.10	1952
1953	42.45	65.54	78.99	85.57	90.53	94.43	3.90	42.51	40.06	39.02	31.32	34.39	41.19	24.51	16.79	14.20	146.00	37.87	1953
1954	37.09	64.72	76.49	83.36	89.93	94.02	4.09	37.09	43.92	32.87	29.72	33.46	46.02	27.01	17.73	13.70	152.34	39.97	1954
1955	38.49	68.72	77.74	84.99	89.85	93.69	3.84	38.49	49.15	28.84	32.56	32.38	37.88	26.00	16.57	13.93	156.89	37.65	1955

The addition of one or even two units of similar size to the existing ones, becomes a means of raising the crushing rate, by opening or speeding the front units, with a drop in the former individual performance, i.e. a redistribution of the total effort of extraction, with a small gain at the end.

Another controversial point is the relative importance of the front versus tne final unit on total extraction results.

According to the S.M.R.L calculations (Royston Formula) the factory with the highest standard of extraction (95.1 per cent.) deals with a fibre tonnage, 78 per cent, of its rated capacity—whereas the four factories with the lowest extraction, 90 to 91 per cent., are forcing their plant at a rate of 110 to 125 per cent, of the standard.

In the case we are particularly concerned with, the 115 per cent, rated capacity work is being carried out with an extraction still maintained between 93.7 and 94.0 per cent.

It is accordingly felt that the data on page 2, collected on the results of this same milling plant+ for over twenty years, could be of some interest to our fellow technologists. They are taken day after day on all the individual units and are true representative conditions of a very long period of years, including variables of crushing rates, fibre content and state of cleanliness of the canes, alterations in mill settings, groovings, hydraulics, etc.

In the course of its history two important alterations were carried out in this milling plant previously described in the Proceedings of the Tenth Annual Congress of the S.A.S.T.A. (Electrically-Driven Sugar Mills, by F. B. Macbeth) viz.:

(a) For the 1947 season, the only steam-driven unit (last mill) was brought into line with the others by being motor-driven. It also had its housings strengthened, allowing of better adjustments for the life of the rollers.

This alteration had an immediate beneficial effect on extraction which reached its optimum.

(b) In the year 1953 the front unit two-roller "zig-zag" crusher was replaced by a heavily-grooved three-roller crusher, driven by the same original motor and gear.

Although the addition of this one roller did show a rise of 10 to 15 per cent, on the poor extraction results of the first stage of crushing, this advantage was not apparent at the next stage (first mill) and was completely dissipated at the final stage.

It may be claimed that this addition of one roller was an economical means of raising the throughput of an overloaded milling plant.

This claim is somewhat weakened by the results previously realised (1950 season) by the two-roller. crusher, which dealt with 24.1 tons fibre per hour, maintaining a final extraction of 94.79 per cent., in spite of the very poor start at 26.48 extraction from this very opened two-roller crusher.

These yearly statistics show a progressive rise in the hourly crushing rate from 103 to 157 tons, notwithstanding a general deterioration in the state of cleanliness of the cane

This rise is equivalent to a progressive fibre intake of 16.2 to 27.0 tons per hour, which according to Royston's Formula means a stepping up from 70 to 115 per cent, of the rated capacity.

The effect of this increasing
altogether been detrimental to extraction, which starting at 94.2 soon increased to 94.7 and reached subsequently 95 per cent., and kept above this level for two years, but began to decline after 1950 until it fell down to 93.7 for this last season, with the highest cane throughput per hour which did not quite coincide with the highest fibre tonnage.

It is peculiar that during this last season when a record crop put a premium on speed of production, and crushing rates shifted between 150 to 170 tons per hour, the weekly extraction result was insensitive to this variation of 15 tons per hour and remained stable round 93.7 to 94.0 per cent, except at the end of the very long nine months campaign.

At this end period with the wear and tear of the rollers and increasingly trashy canes, a turn for the worse was experienced in extraction, in spite of crushing rates reduced to nearer 150 tons per hour.

One must come to the conclusion that a train of mills such as ours is a very flexible machine from which moderately good extraction can still be obtained within a fair range of crushing rates.

We believe that with the thick bagasse blanket on our carriers, imbibition has to be maintained between 35 to 40 per cent, cane, i.e. 230 to 240 per cent, fibre, for optimum efficiency, and we have not benefited by further increases of water.

We have never succeeded in obtaining from our first crushers, extractions of 50 to 60 per cent, shown lately by other South African factories, and still less the 70 per cent, claimed by overseas factories operating with closer settings on tropical canes, carrying fibres of 11 to 13 per cent.

Even with the two squeezes from our three-roller crusher the bagasse leaves this unit with a moisture content seldom less than 64 per cent.

It has been suggested that together with the large volumes of extraneous trash packing the genuine cane stalk and enforcing wide roller opening, the weakness lies with the limitations of the motor power at that stage and for this reason a proposed alteration to a more powerful steam turbine drive in the near future will be watched with interest.

Ewa milling results (tabulated in the paper by J. Rault, 1934 Proceedings) showed a consecutive drop of five seasons in crusher extraction from 72.5 to 61.4 per cent, without appreciable difference in the final extraction which remained at the remarkable level of 98.2 per cent.

The present position of the mill work, judged by individual units control, shows clearly that in the course of the past few years, in spite of the substitution of a three-roller for the old two-roller initial unit, the efficiency up to the third mill has practically declined to that reached up to the second mill, when optimum results were being obtained a few years back—a deficiency partly but insufficiently made good by the last two units.

The addition of a powerful sixth mill to be erected next season is the logical step from which much is expected, as it will be a challenge for obtaining a high individual extraction performance and not so much a further increase over the present rate of 160 tons per hour.

Our past experience confirmed by the exceptional performance of the last unit from another factory leading in extraction results, inclines us to attach a paramount importance to the last unit's performance as a more fruitful source of improved milling in more ways than one, rather than by expecting too much from the first crusher.

This may be an interpretation of results prejudiced by abnormal conditions of high fibre throughputs, and our opinion probably is not shared by milling experts, who, dealing with well-balanced milling plants, endeavour to extract the maximum possible by dry crushing in order to minimise the duty of the following units and the work of imbibition.

Through the courtesy of the milling company that regularly exchanges with us the details of their individual milling performance, it is possible to illustrate by actual results the validity of our statement, in the following tables.

It constitutes a remarkable example of one last unit performance, being able to raise the total extraction to a record high level, the more remarkable as the total extraction of the preceding four mills and crusher had not even equalled the "up to the fourth mill extraction" reached by the other larger milling train, dealing with the same-cane supply, controlled by the same technical staff, under the same roof.

A_1 and A_2 refers to the results of the two trains of mills of this factory for the 1955-56 season.

b_1 refers to Natal Estates results for five years from 1942 to 1946.

b_2 refers to Natal Estates results for three years from 1947 to 1949 (highest extraction).

b_3 refers to Natal Estates results for three years from 1952 to 1955 (working with three-roller crusher instead of two-roller crusher).

	A_1	A_2
Tons cane per hour	130.00	68.00
Tons fibre per hour	20.41	10.47
Tons fibre per hour rated capacity	23.39	14.07
Actual crushing per cent. rated capacity...	87.30	74.50

	Total Extraction up to Unit (3-roller)	(2-roller)	Extraction by Unit (3-roller)	(2-roller)	Extract on per cent. Sucrose entering Unit (3-roller)	(2-roller)
	A_1	A_2	A_1	A_2	A_1	A_2
Crusher ...	52.38	52.67	52.38	52.67	52.38	52.67
First mill...	71.87	70.27	19.49	17.60	40.9	37.2
Second mill	81.26	80.56	9.39	10.29	33.8	34.6
Third mill .	87.28	85.83	6.02	5.27	32.1	27.1
Fourth mill	91.02	90.11	3.74	4.28	29.4	30.2
Fifth mill...	94.73	95.76	3.74	5.65	41.3	57.1

	b_1	b_2	b_3
Period	1942 to 1946	1947 to 1949	1952 to 1955
Tons cane per hour	139.10	140.80	151.70
Tons fibre per hour	22.03	22.55	25.84
Tons fibre rated capacity ...	21.84	21.84	23.39
Actual crushing per cent. rated capacity	100.90	103.30	110.50

	Total Extraction up to Unit			Extraction by Unit			Extraction per cent. Sucrose entering Unit		
	b_1	b_2	b_3	b_1	b_2	b_3	b_1	b_2	b_3
Crusher ...	25.40	29.69	39.34	25.40	29.69	39.34	25.4	29.7	39.3
1st mill ...	70.60	67.93	66.33	45.20	38.24	26.99	60.6	54.4	44.5
2nd mill ...	84.42	81.88	77.74	13.92	13.95	11.44	47.0	35.7	33.9
3rd mill ...	88.81	87.64	84.64	4.39	5.76	6.90	28.2	31.3	31.0
4th mill ...	91.78	91.29	90.10	2.97	3.65	5.46	26.5	29.6	35.5
5th mill ...	94.80	95.19	94.05	3.02	3.90	3.95	36.7	44.8	39.9

The above comparative statistics of the Natal Estates and the other factory, indicate a different set of milling conditions, where a more favourably equipped capacity versus actual crushing rate, plays an important role in the other factory.

This factory starts in consequence with a first unit extraction 15 to 25 points ahead of the Natal Estates efficiency, invariably poor at that stage for reasons already explained.

The poort start of Natal Estates is apparently no lasting impediment to final good results specially during the 1947 to 1949 seasons. There is, however, a definite falling-off, after the crushing rates have been further increased to 110 per cent, of the fibre rated capacity.

The record of 95.76 per cent, extraction of the one milling train, is the result of a remarkable effort of the last unit, which extracts 57 per cent, of the sucrose entering that unit.

In conclusion it is hoped that a larger number of factories will also undertake this type of control that should be the means of collecting valuable data on this aspect of sugar technology.

The time-consuming method of sucrose and moisture determination in bagasse can now be considerably shortened by the use of laboratory shredders, and Dietert moisture tellers, which allow a larger number of tests to be carried out on one individual mill bagasse, thus enhancing the service value of chemical control to the milling section of the factory.

Mr. J. B. **Grant** thanked Mr. Rault for his paper and said that although this work had been carried out very systematically and over a long period, Mr. Rault was still, however, unable to reach irrefutable conclusions. If more mills carried out these individual mill tests and these were available to Mr. Rault, he had no doubt that we would be a long way towards finding the final answers to our extraction problems.

He pointed out that the loss of so much sugar, some 27,000 tons per annum, meant a tremendous amount of money lost to the industry. It was the intention to carry out such tests at Felixton. He considered that the loss of efficiency shown over the last few years was due to the increased output expected of these plants. Owing to the recent rapid expansion in the last few years, the mills were not properly equipped and until the full equipment was installed good results could not be expected.

Mr. Rault stated that more complete details on the equipment of the factories listed in his paper, would give a better insight into the factors influencing some of the variations in efficiency of South African Mills, which were admittedly poor in the way of extraction. He hoped that this information would be collected in the near future by such an institution as the S.M.R.I.

He had been able to quote the results of one factory, which had volunteered to supply him with relevant facts, together with their mutual milling control figures.

Mr. J. Antonowitz said that loss of milling efficiency was intimately tied up with the extraneous matter such as trash on cane which increased the tons fibre per hour. He thought that one of the difficulties was to persuade the mill management to enable the milling staff to carry out trash testing experiments on say 200 lbs. of cane from each consignment.

Mr. Rault replied that the determination of the extraneous fibrous matter sent to the mills had already been carried out at one of the mills by a select committee studying this very controversial subject between manufacturers and cane growers. His company had also investigated this question and accumulated accurate date in the course of the 1954 season. Notwithstanding the well known damaging effect of excessive fibrous matter on factory efficiency, he had been occasionally puzzled by the loose relationship of fibre content of cane and tonnage througput. Apparently the numerical expression of fibre content was insensitive to the different action on milling, from the compact genuine fibre of the cane stalk, and that of the loose fibre brought in by the extraneous dry and green leaves, roots, tops, and the like.

This determination of extraneous fibre at all mills would however consume a large labour force.

Mr. D. W. W. Hendry said that at the other factory quoted in the paper he was not surprised that there had been no increase in the efficiency of extraction by the third mill as they had tried everything in the past to improve upon it. He would like to know what the individual maceration figures were for each tandem.

idered that the record total extraction of the smaller plant studied in his paper, was made possible by the comparatively low throughput of that mill, 74.5 per cent of rated capacity. Such a statement was not belittling the successful effort of the staff, who had the foresight of providing themselves with an equipment proportionate to the dictates of expansion in the near future.

The outstanding performance of the last unit of this milling train, had confirmed his experience on the popularity of a powerful final unit, as a "goal keeper/' making up for the deficiency of the other units of the team.

He also referred to a most up to date and lucid publication *(La Sucrerie de Cannes)* with a chapter on milling written in French by Mr. E. Hugot, an eminent sugar technologist from our neighbour island of Reunion. This book deserved a wider recognition in the English language and he hoped that at some future congress, Mr. Hugot would be a welcome guest invited by the industry.

It happened sometimes, that one mill unit appeared to show an abnormally high or low performance which was not confirmed in the course of the following weeks, although no alteration had been carried out on that special unit. The interpretation of such results should not be too dogmatic, and required a certain amount of experience, for the sampling of a material of variable composition for calculating an average set of conditions was seldom perfect, and conclusions should not be hastily drawn on a small number of tests, for altering mill settings.

Dr. C. **van der Pol** inquired what sort of liaison existed between the milling staff and the Laboratory.

Mr. Rault replied that there was a very great degree of co-operation between the milling and laboratory staff, in carrying out this control, where there was a risk of unrepresentative samples or interrupted production nullifying the value of this work.

Apart from the usual moisture and sucrose content of final bagasse, imbibition, sucrose content of cane, issued to the shift engineer's office, the total extraction and tonnage per hour was also worked out every eight hours shift, including the percentage of various varieties crushed.

The average individual mill performance was in in the hands of the chief engineer every Saturday night, for the constant readjustments of the week-end stop, and in the course of the week, the relative drop of moisture and sucrose from unit to unit was closely watched. Any particular unit requiring investigation, had numerous consecutive tests so as to eliminate the disturbing effect of hourly cane variations in passing judgment on a fair average of those tests.

Mr. **Main** said he did not really want to speak on this subject until some of the engineers had expressed their views, particularly as mill extraction should really be a subject of more direct concern and interest to the engineer than to the chemist.

In this case, the author of this paper is a chemist and all the observations to-day have thus far come from chemists or men on the process side, but since Mr. Rault had kindly invited his expression of opinion he would give his views at this stage of the discussion.

He found Mr. Rault's paper most interesting and it was worthy of our deep consideration. It was of personal interest to him also as Mr. Rault had kindly sent him a copy in 1935 of his previous paper on mill extraction. So, to-day, we meet again to face the startling fact that for 21 years mill extraction in Natal has remained practically unchanged. This surely must be a challenge to our Engineers to start a fresh drive to equal the mill extraction achieved in many other countries.

In the Begg Sutherland group of Sugar Mills in India the mill extraction had also remained below standard for many years previous to the advent of Noel Deerr and Alexander Brooks, who introduced a very stimulating system of Mutual Technical Control in their group of factories.

This quickly improved all recovery figures and seasonal averages of 1.5 per cent sucrose in bagasse and 45 per cent moisture in bagasse became quite commonplace in 17 roller mills under identical conditions as regards cane and with the same personnel who had previously considered such high mill extraction figures quite unattainable.

When he went to Umfolosi Mill in 1947 he found that by a fortunate co-incidence Umfolosi at that time had similar large percentages of Co.281 and P.O.J.2878 canes to that which were milled in the Indian mill he had recently left. This made it easy to intiate comparative tests.

The Umfolosi mill extraction responded to the same efforts which had achieved such good results in India and despite many major mechanical handicaps in the old Umfolosi milling plant, it proved possible to raise the mill extraction up to 95 per cent. Further progress was halted by the critical staff position with the result that the drive for increased mill extraction had to give way to the large reconstruction programme.

He had carried out subsequent research at the Natal Technical College on the fibre stress ratios of different cane varieties under Natal conditions and this evidence had further convinced him that equally good mill extraction results could be achieved in Natal if the correct milling technique and system of Mutual Technical Control could be followed.

He realised that the diversity of mill ownership in Natal made it difficult to apply any system of Mutual Control in the same way as Noel Deerr had done in India. The Sugar Milling Research Institute was obviously faced with that problem here and despite the fact that technical data is already being circulated among the Natal mills, the same stimulating system of enforcement could not be introduced.

Many variable factors have to be closely controlled to achieve high mill extraction and this cannot easily be achieved by individual effort in any Mill. It required suitably experienced technical direction with a permanent system of teamwork and specially trained milling technique.

Mr. Rault had pointed out that 27,000 tons of commercial sugar was lost in Natal each year due to the low mill extraction. At roughly £25 per ton, this equal to an annual financial loss of £675,000. In the case of three mills, the loss of over 4,000 tons of sugar is therefore equivalent to a loss of £100,000 each per annum. If the Natal Sugar Millers decided to capitalise this at 12| per cent for interest and redemption, a total sum of £5,400,000 could be provided for new milling equipment, if it were needed.

This enormous sum was quite unnecessary however for improved mill extraction, as our milling machinery in Natal was already equal to the best he had seen elsewhere.

Mr. M. Hill stated that the practical engineer knew what sort of extraction he could expect, if the mills were working within a reasonable capacity and properly loaded and the rollers had a good gripping surface. The chemist could tell the engineer what his extraction was, and also which mill in a train was lagging, something which the engineer probably already knew but he could not tell him what to do to improve things, and all the engineer could do then was to check back upon his settings. He therefore considered that the only thing that could be done to improve extractions was to have an experimental unit so that the settings, etc. could be experimented with. He aimed, as far as pressures were concerned, at a 50 tons per foot of roll on 54 inch rolls but this was not always possible on certain varieties of cane, when loading would have to be reduced to 40 tons or sometimes less, in order to maintain continuity, a very important factor in milling efficiency. If the engineer could get maximum loading with top roll floating and his mills were working smoothly, that was all he could do.

He agreed with Mr. Main that a lot depended upon personnel on shift.

CONTROLLED ENGINEERING MAINTENANCE

By H. E. HASTINGS

Introduction

With increasing mechanization in industry and mining the emphasis for supervision begins to swing toward the problem of maintaining the machines at fullest utilization. The expert "organization" of direct productive labour has but limited value if machines are not in running order.

Down time on machines results in production Josses, which in turn cause profit losses.

Breakdowns of machines mean that some components have been run to destruction. The effect of allowing this to occur is likely to shorten the lives of other components.

It has been shown in the United States that the combined costs of the labour that maintains the machines, and of the parts consumed in running are not uncommonly, greater than total nett profits earned.

If these statements are accepted it will be recognised that in maintenance, management is faced with a problem of major proportions.

It cannot be denied that speaking generally, management has not accepted the challenge. It has not applied the concentrated thinking to the organization of maintenance that it has to "Direct Production." One reason for this may be the relative unfamiliarity of the average senior executive with the maintenance trades. It happens in general that senior executives work their way upward through "production" departments. "Maintenance" remains to them an unexplored mystery. The manager is usually a layman in this field, leaning heavily on his staff. If the amount of down time does not seem too great the manager is apt to conclude that he has a good maintenance staff and happily let it go at that. He has no real measure of how good the maintenance work is or how much better it might be made, because there is no yardstick with which to assess the position. It is not too much to say that frequently insofar as the maintenance department is concerned, the manager figuratively drives a vehicle with neither brakes nor steering.

Without providing a means of measuring the work of maintenance it is unreasonable of management to expect a skilful job of supervision from maintenance foremen.

In the case of supervisors on direct production, there is always a target to shoot at; the productive capacity of men and machines are fairly well known; management is acutely aware, day by day, if not hour by hour, whether the production target is being met and if not, why not. The atmosphere of a production department is permeated with a consciousness of output and of the urgency of time. In maintenance work prodigies of achievement may be performed in emergencies when men work round the clock to repair breakdowns. But these instances represent or should represent a small fraction only of the working year. Between emergencies the maintenance staff, with no recognisable goal to attain and no measure of accomplishment, inevitably develop an outlook which is unaware of time and its proper use. This is not necessarily laziness nor even indifference. It is lack of direction. Time between breakdowns tends to be spent ineffectively or in unrecorded idleness.

The result of these circumstances is the condition in which many plants are found today. Maintenance labour costs are excessive, production is lost through avoidable breakdowns, money is spent unnecessarily on spares which have been run to destruction, spares inventories are too high through lack of standardization and knowledge of usage rates, and machinery deteriorates too rapidly, requiring replacement too

None of these things is inevitable. They can be prevented by the use of a scheduled maintenance programme which foresees the failure of components and ensures correct action in time to avoid such failures.

A proved, practical plan, applied in more man fifty mines and plants, will now be described by means of which management is able to systematize and control maintenance work, to determine an equitable work loading for maintenance men, to minimise overtime and to reduce plant breakdowns to a minimum.

Preventive Maintenance

The phrase "preventive maintenance" is self-explanatory. It means in effect that maintenance artisans are chiefly employed in preventing breakdowns and only to a minor degree in repairing them. Common practice is the reverse of this.

In theory if a machine is correctly lubricated, if all nuts are kept tight and if worn components are repaired before failure, the machine can only break down through an accident. Accidents are comparatively rare. The airlines carry their maintenance fairly close to the theoretical potential because lives and property depend on the fact that machinery must not come apart in the air. The relatively insignificant number of technical failures in all the millions of air-miles flown yearly are ample proof that machine stoppages can be almost eliminated. It remains then to industry merely to measure the economics of intensive preventive maintenance before deciding to employ it. Clearly if better maintenance can be achieved at little or no increased expenditure it must be attractive to management. Indeed, it must be recognized as an essential in *good* management.

Maintenance must be considered in two categories, i.e. work done on site, and work done in the shop. The two are to a considerable degree independent, but it is essential to develop suitable shop controls, if the entire maintenance organization is to be considered satisfactory.

Initiation of Preventive Maintenance

It will be held by some that preventive maintenance is a fine ideal and should be adopted in all new plants, but that it is impracticable in old plants in bad condition, more particularly if stand-by units are not available. The theory is that such plants cannot be put onto a preventive schedule without shutting down and reconditioning all bad equipment. Since production must go on, this is impracticable and so the plant must stagger on, accepting as inevitable all the grief that follows faltering machinery. This is simply not true and its unreality has been demonstrated many times. The fact is that the majority of breakdowns originate in one of three things: first, faulty lubrication; second, loosening of connections through vibration; and thirdly, dirt and uncleanliness.

These faults can be remedied without shutting down plant. Actual experience shows that within six to eight weeks of systematically and determinedly attacking these points, breakdowns begin to drop measureably. Once breakdowns come even partially under control and lost time declines, opportunities arise to stop machines with less effect on production than arose from a previous high incidence of breakdowns.

Making Preventive Maintenance Work

It can be accepted as a first principle that in so far as is possible, the extent to which agreed maintenance schedules are in fact carried out should be an open book. By this is meant it should be easy for the resident engineer and the general manager to see, at a glance, whether or not schedules are being maintained. If, to do this, requires digging details out of reports and log books, the maintenance system cannot be considered satisfactory.

The solution to the problem has been found in visual controls. These are designed so that everyone from the artisan to top management at any time, can see what work lies ahead, what work is behind the programme and how much it is behind, what each individual has to do and when it must be done. From every standpoint of team work, mutual confidence, clarity of thinking and decision making, these controls have proven beneficial. The effect on labour relations and on the relations between production departments and service departments is notably good. All men like to know in advance what is expected of them and they like to know that the division of work is reasonably equitable. Much of the friction between service staff and production is eliminated if shutdowns are jointly planned, well in advance. A good deal of unnecessary discussion and even loss of confidence between top management and the engineers can be avoided if the current standing of maintenance programmes and the work load on personnel is factual and not merely a matter of opinion.

The necessity for extra men or extra overtime or more machines becomes self-apparent and the making of decisions in such matters is thereby greatly simplified. To achieve these ends a number of visaul controls have been devised and two of these will be described.

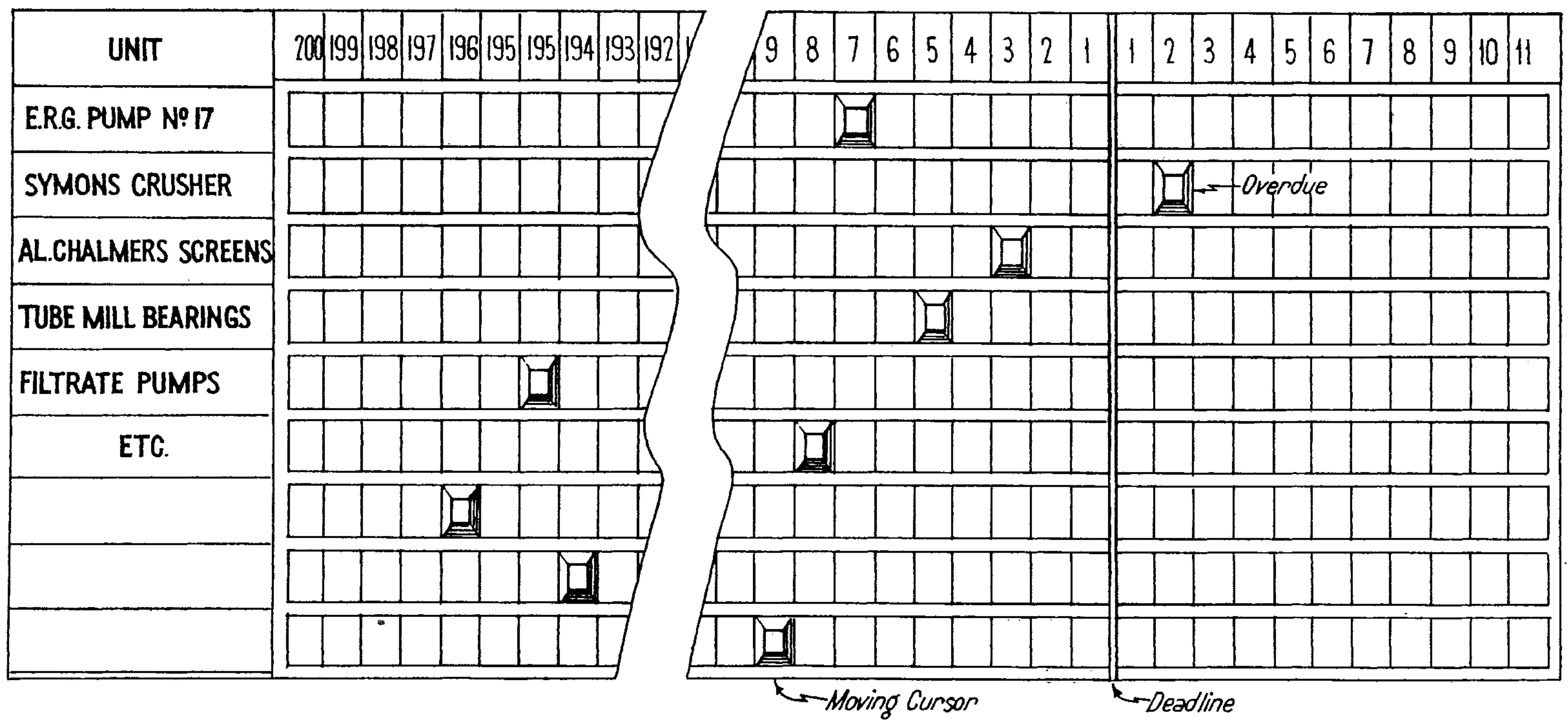
Visual Controls

The Running Time Control Board (Fig. 1) is the most important type of visual control. The purpose of this device is to highlight at once the immediate jobs due and those overdue. Each horizontal line is devoted to a particular unit or machine and each space between vertical lines represents a day. On each horizontal line is a movable cursor which is slid along toward the "dead line" as running time progresses. All cursors to the right of this line represent units overdue and the number of spaces they have been moved beyond the dead line indicates the number of days they are overdue.

The great virtue of this board is the fact that units overdue stand out in the most glaring manner. Neither men nor foremen relish the necessity to explain why an individual cursor has passed to the light of the dead line. This becomes a powerful stimulus in keeping schedules up to date.

An essential of planned and loaded work is, of course, so to stagger the schedules that the work load is as nearly uniform as possible on every day throughout the year. If this is not done it is obvious

RUNNING TIME CONTROL BOARD



that a number of units can fall due for service on the same day. In such an event either serious loss of production must ensue and/or an excessive labour force must be carried constantly, merely to meet peak demands. The Running Time Control Board makes it possible to see at a glance whether or not the schedule has succeeded in staggering inspections in a logical and. satistactory manner.

Work Loading Board

The Running Time Control Board shows the extent to which the work is up to date and evenly staggered. There is required in addition a visual indication of each individual's programme of work. This is done by the use of the Allocation Board (Fig. 2).

This board carries the name and trade of every man under a foreman's direction. One is supplied to each foreman for his own use and to be operated by himself. The foreman loads separate job cards in priority order on the board under each man's name. It is his duty to see that each job card is loaded only after he has written on it any necessary instructions and has made available a sketch, sample, material and machine, where required. The artisan removes his job card from the board in priority order and proceeds with his task without the necessity to find and consult with his foreman.

Since **a** foreman may, of necessity, often require to be out of his office, this mechanism enables him to keep in constant touch with the state of work-loading merely by periodically glancing at the board on returning to the office.

Preventive Maintenance on Site

This is comprised of two major parts:

1. Common sense everyday precautions (lubrication, cleanliness and tightening).
2. The forecasting of times at which trouble will begin to develop, if parts are not replaced.

Effective preventive maintenance must establish procedures and create enthusiasms which will ensure that the elements named above are strictly carried out. It is quite futile merely to issue general instructions on maintenance and expect they will be performed. As a general guide to the maintenance of plant, such instructions are useful but they do not provide an adequate system of preventive maintenance because they lack certain vital features. For example:

They do not indicate sufficiently in detail what precisely is to be done.

They do not specify who is to do it.

They do not say how long the job should take.

They do not provide any specific check that the job was actually done.

There is no provision for any incentive to encourage the carrying out of the job.

They do not provide a penalty for failing to carry it out.

To be effective a Preventive Maintenance Plan must spell out every step required.

All steps required in each service must be defined so clearly that a minimum of knowledge, thought or memory is required of the maintenance man. The criticism that this kills initiative in men and creates a force of robots is simply unrealistic. What it does do is to ensure that the same kind of attention is given to every machine at every service period, that this is neither too much nor too little and that men are properly trained in correct procedures.

The next step is to determine the time that will studies are employed for this purpose supplemented by method study, ratio delay observations, analytical estimating and other recognised techniques commonly employed to establish work standards. Measured allowances must, of course, be made for walking, which in some plants may sometimes exceed actual working time. Since routes are pre-determined the calculation of travelling time does not entail serious difficulty.

Method study should not be passed over lightly in this discussion. As can be imagined it is a fruitful field for achieving reduction of the work content in maintenance jobs. The mere fact that attention is focussed on standard times for standard jobs serves as a challenge to men and foremen to exercise ingenuity which previously lay dormant for lack of inspiration.

Frequency of Inspections

As has been said, standard time allowances for all features of maintenance work can be established through orthodox methods of time study or allied procedures. An equally important feature however, is the frequency with which inspections must be made to forestall component failures.

Frequencies must initially be determined largely on the basis of are not always available and even when fhey are can seldom be considered as more tnan a rougn, guide. Local conditions vary so much it is usually necessary to consider each case on its own merits.

Since much of the success of a maintenance plan depends on the enthusiastic support of the human

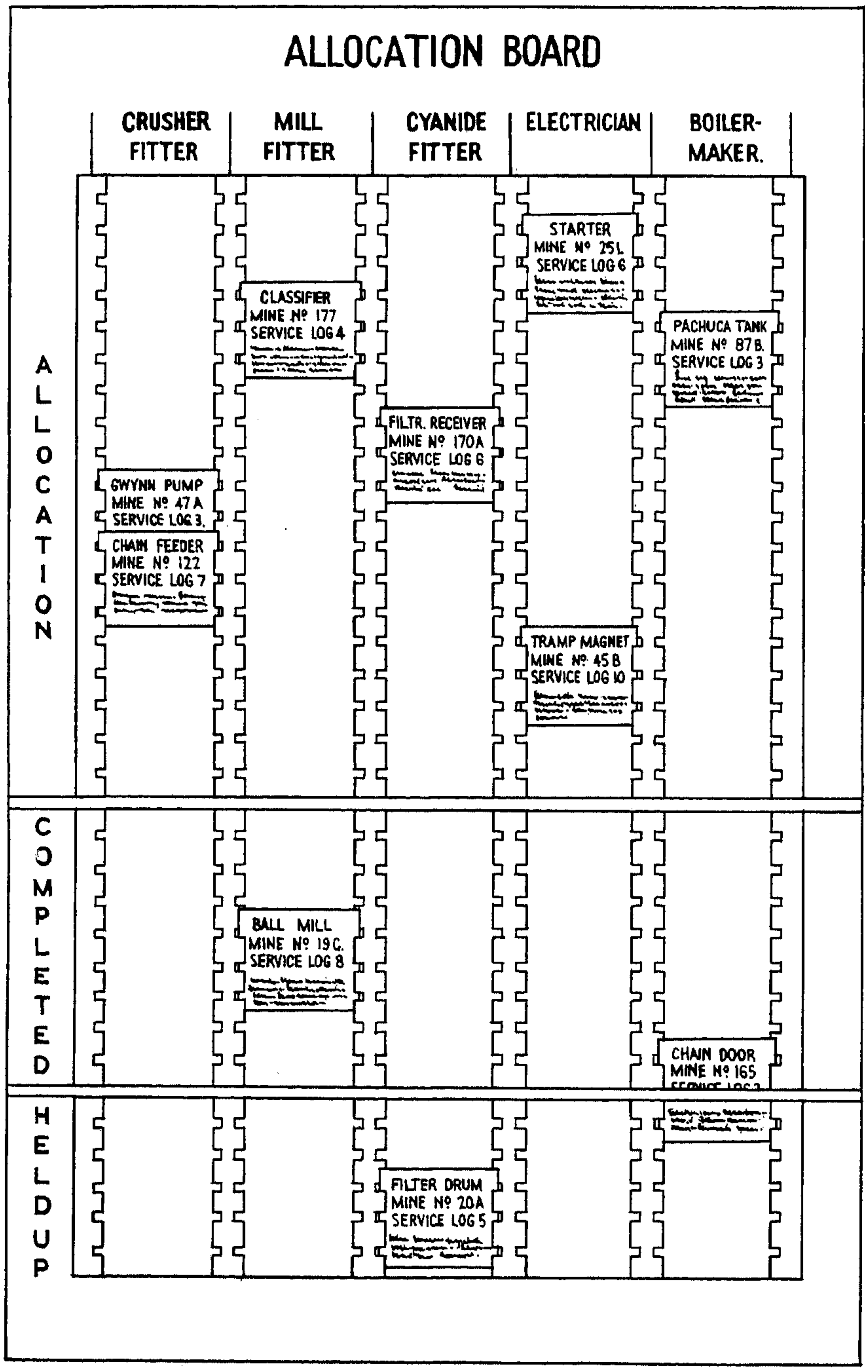

ALLOCATION BOARD
CRUSHER FITTER
MILL FITTER
CYANIDE FITTER
ELECTRICIAN
BOILER-MAKER.
ALLOCATION
COMPLETED
HELD UP
STARTER
MINE Nº 251
SERVICE LOG 6
CLASSIFIER
MINE Nº 177
SERVICE LOG 4
PACHUCA TANK
MINE Nº 87B
SERVICE LOG 3
FILTR. RECEIVER
MINE Nº 170A
SERVICE LOG 6
GWYNN PUMP
MINE Nº 47A
SERVICE LOG 3.
CHAIN FEEDER
MINE Nº 122
SERVICE LOG 7
TRAMP MAGNET
MINE Nº 45B
SERVICE LOG 10
BALL MILL
MINE Nº 19C
SERVICE LOG 8
CHAIN DOOR
MINE Nº 165
FILTER DRUM
MINE Nº 20A
SERVICE LOG 5

Fig. 2

beings involved, it is wise to give very careful consideration to all opinions expressed. To ride rough shod over the views of mechanics or foremen in matters which, after all, are usually considered to be questions of opinion, is to create resentment and frequently to court failure. At the same time experience has shown that in very many cases the estimates of suitable frequencies for inspection are wildly inaccurate and almost universally on the high side. It is quite understandable that this should be so where no accurate records have been kept of breakdowns. Human memories are fallible and it is not unnatural for a man to exaggerate in his mind the frequency with which he has had trouble with a machine. Since the frequency of inspections has a major bearing on the work load which will be assigned to the maintenance staff, it is unlikely that either men or foremen will voice opinions calculated to minimise that load. Preventive maintenance is specifically designed to improve progressively the condition of machines, and as this result is achieved the frequency of necessary inspections should materially decrease. It is not to be expected that the maintenance personnel will be in a position initially to estimate the extent to which frequencies will ultimately be extended through improved machine conditions.

With continuous auditing and comparisons between plants it is expected that very substantial reductions in maintenance staff will be made concurrently with improving condition of plant.

The operation of the Preventive Maintenance Plan should be a dynamic thing. It should not be looked upon as a cut-and-dried system which once installed can be expected to perpetuate itself. With the accumulation of data continuously and intelligently analysed, improvements and economies can be expected to flow perpetually from this source.

Checking Work

It is obvious that merely laying down a scheduled routine without a positive method of checking to ensure it is carried out can be a waste of time. Experience has shown that merely to instruct foremen to check the work of mechanics is not adequate. The foremen, themselves, must be provided with a definite programme of work. Theoretically, of course, a major function of a foreman is to assure himself that the work of his men is correctly carried out. In practice it is more the exception than the rule to find this being done. It is considered a reasonable thing to demand the foreman shall devote a percentage of each week to making spot checks of the condition of equipment through the use of approved sampling techniques.

Incentive Pay

The use of incentive pay in connection with maintenance work is highly desirable since it sustains the interest of all concerned in carrying out the planned schedules. It also operates to reduce unnecessary overtime and makes it possible to apply penalties in cases where schedules are not being carried out.

The most suitable type of incentive is that based on time studies which establish accurate standard times, including appropriate allowances for rest and personal needs. Methods have been devised for establishing standards for non-repetitive work during recent years which are proving entirely satisfactory to management and to men. In the case of scheduled maintenance, a great deal of the work done is in fact repetitive.

In cases where it is not practicable to employ meticulous time study methods, recourse may be had to the "Maintenance Allowance Plam." A great deal of basic time study data has been accumulated under a wide range of mine and factory conditions. This information in experienced hands, combined with local knowledge, can be utilised to set up workable standard times for all operations likely to be encountered. After inspection and lubrication frequences have been laid down and standard times established it becomes a comparatively simple matter to lay out equal work sections for all men.

Incentive is calculated on the generally accepted basis tnat a man who performs at 100 per cent, effectiveness is entitled to incentive pay of 33 1/3 per cent. more than his basic rate. Having regard for the fact that in practice emergencies are inevitable, no attempt is made to load all men fully with ''bonus'' work. To simplify calculations and make it easy for men to understand the basis of payment, a price is set on each unit of equipment. The price, of course, varies for the different types of service. The daily service will be relatively quick and the "overhaul" service will be lengthy and thorough. Each has an appropriate price. There is, therefore, an ever-present incentive for men to ask for larger sections.

For each breakdown exceeding one hour in lost time which can be traced to failure to carry out a schedule for which a man has signed, an appropriate penalty is levied against his weekly premium. Similar penalties are assessed for sub-standard work, and it is understood that a man cannot earn both premium and overtime in his own section unless the overtime is necessary for some reason outside the man's control.

Case History Card

This is a card on which to record the entire life history of every item of equipment. Once a week the planning clerk enters on the case history sheets details of work done during the week and inspection schedules carried out. Done weekly this consumes very little time, but it provides an invaluable record for a new man or a relieving man in a section. He can see at a glance the life history in detail of every piece of equipment which is his responsibility. In case of accident the full story of the treatment accorded each machine in the past is available, including the names of the individuals involved. For comparing various types or makes of equipment in similar or different conditions the case history has obvious value, and for carrying out the perpetual comparative audit to determine whether frequencies are being suitably revised, it is indispensable. The case history, in fact, is one of the most useful adjuncts of the preventive maintenance plan.

Shop Control

The establishment of preventive maintenance procedures may throw a heavier work load on the shops for a time and it is accordingly important to introduce steps to increase their productivity by suitable means.

The most desirable form of shop control is, of course, an incentive plan based on work study from which synthetic times can be built up. This can be done quite satisfactorily on non-repetitive repair work and no other method can be considered nearly so satisfactory. However, in cases where insufficient time is available to take time studies, very good relative improvements can be obtained by other means.

Some recent results from a group of ten mines show a saving of 5,054 man-hours per week. The work output per man has increased by 80 per cent. The saving in equivalent mechanics amounts to about 120 men. The time required to achive this result was about two years and considerable further economies are expected. The saving in wages is, of course, considerable, but the more important economy stems from the fact that an apparently impossible backlog of work is now about caught up, construction nas moved ahead and advantage can now be taken of subsequent natural wastage of men to reduce the permanent maintenance staff.

In the case of these mines, it was not practical to make use of time study methods. The alternative adopted is an interesting one. A major difficulty in shop control, where time study standards are not in operation, is the lack of a yard-stick to measure performance. It has been established after lengthy trials that the "workshop order" may involve thirty minutes of work or it may take three days. Nevertheless, a graph plotted on the basis of a three-monthly moving average, will be based on thousands of orders and the irregularities will average out sufficiently to indicate significant trends.

The most tangible evidence of increased work through the shops is the decrease in the backlog of work. On one mine orders which are over two weeks in process have decreased from an average of 180 odd to 25 or 30.

Since good maintenance cannot be achieved if shop capacity becomes a bottleneck the control of shop work is a necessary corollary to the development of an effective preventive maintenance programme.

Results Achieved

The techniques which have been described were first introduced in 1950 and are now in use in more than fifty mines and plants covering a wide range of industries. Some of the results which have been achieved are shown graphically in the charts which follow:

Fig. 3 shows the relationship between man-hours spent on the repair of breakdowns and man-hours spent on maintenance at a large gold mine. Whereas in August 90 per cent. of all the available hours were spent on repairing breakdowns, and only 10 per cent. on maintenance, five months later this had decreased to 20 per cent. on breakdowns and increased to 80 per cent. on maintenance. This took place despite a considerable reduction in total hours worked, amounting to 25 per cent.

The costliness of breakdowns is demonstrated by the experience in a gold reduction plant processing 75,000 tons of ore per month. The lost time on key units was reduced from 7.1 hours per day to 4.0 hours, making it possible to mill a further 4,000 tons. This is a four pennyweight mine and since variable costs of production amount to 20s. per ton, the extra tonnage obtained produced £5,000 additional net profit.

At a new mine, where the scheme has been in operation for a year, twice the amount of plant is being maintained by the original number of men. Breakdowns underground have decreased from eighteen per month to one.

Fig. 4 illustrates the effects of applying preventive maintenance to Diesel locomotives. Prior to adopting the scheme, 2,150 man-hours were spent on the repair of the locomotives. This was reduced to 860

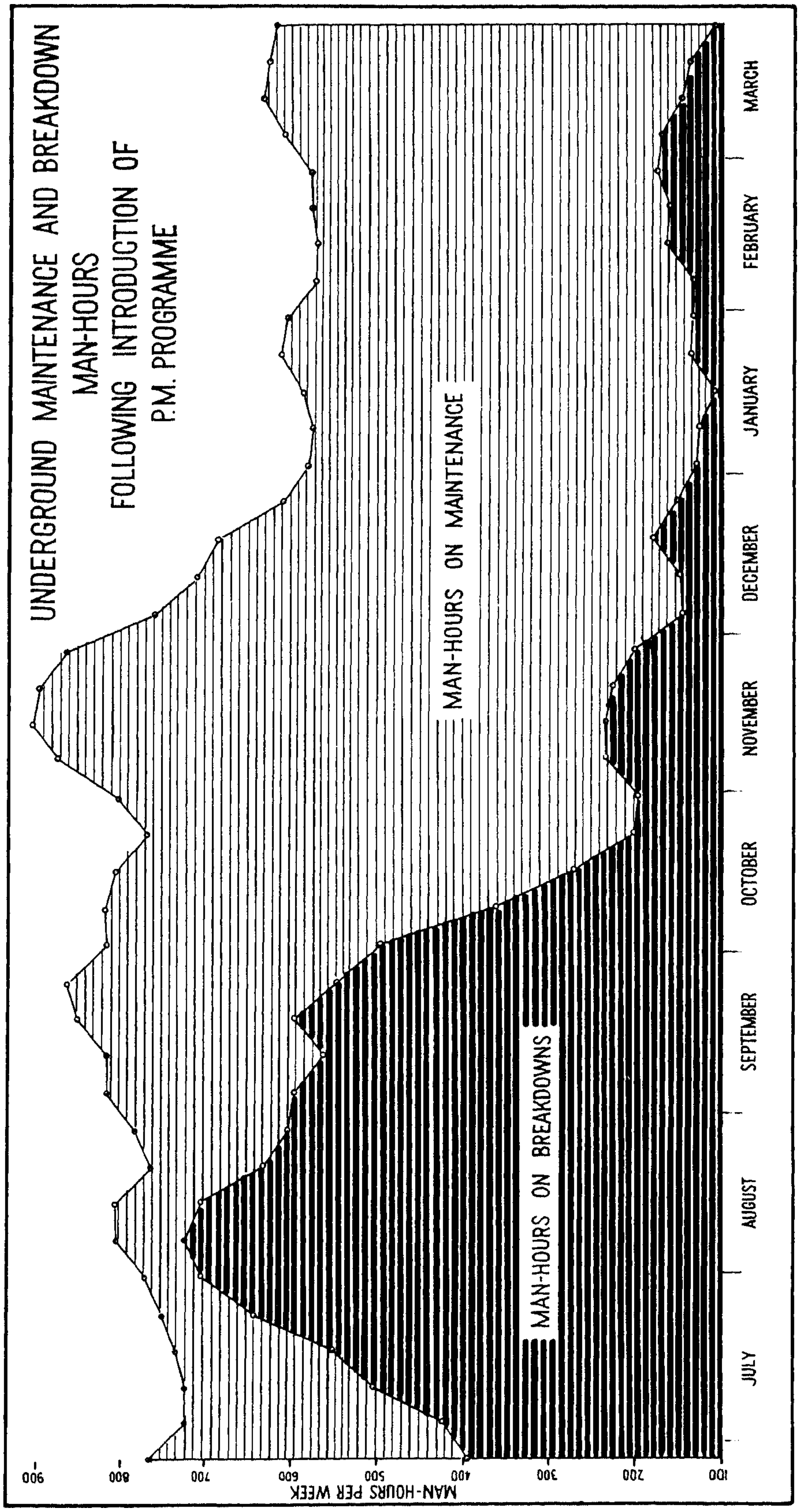

UNDERGROUND MAINTENANCE AND BREAKDOWN
MAN-HOURS
FOLLOWING INTRODUCTION OF
P.M. PROGRAMME
MAN-HOURS ON MAINTENANCE
MAN-HOURS ON BREAKDOWNS
MAN-HOURS PER WEEK
900
800
700
600
500
400
300
200
100
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH

Fig. 3

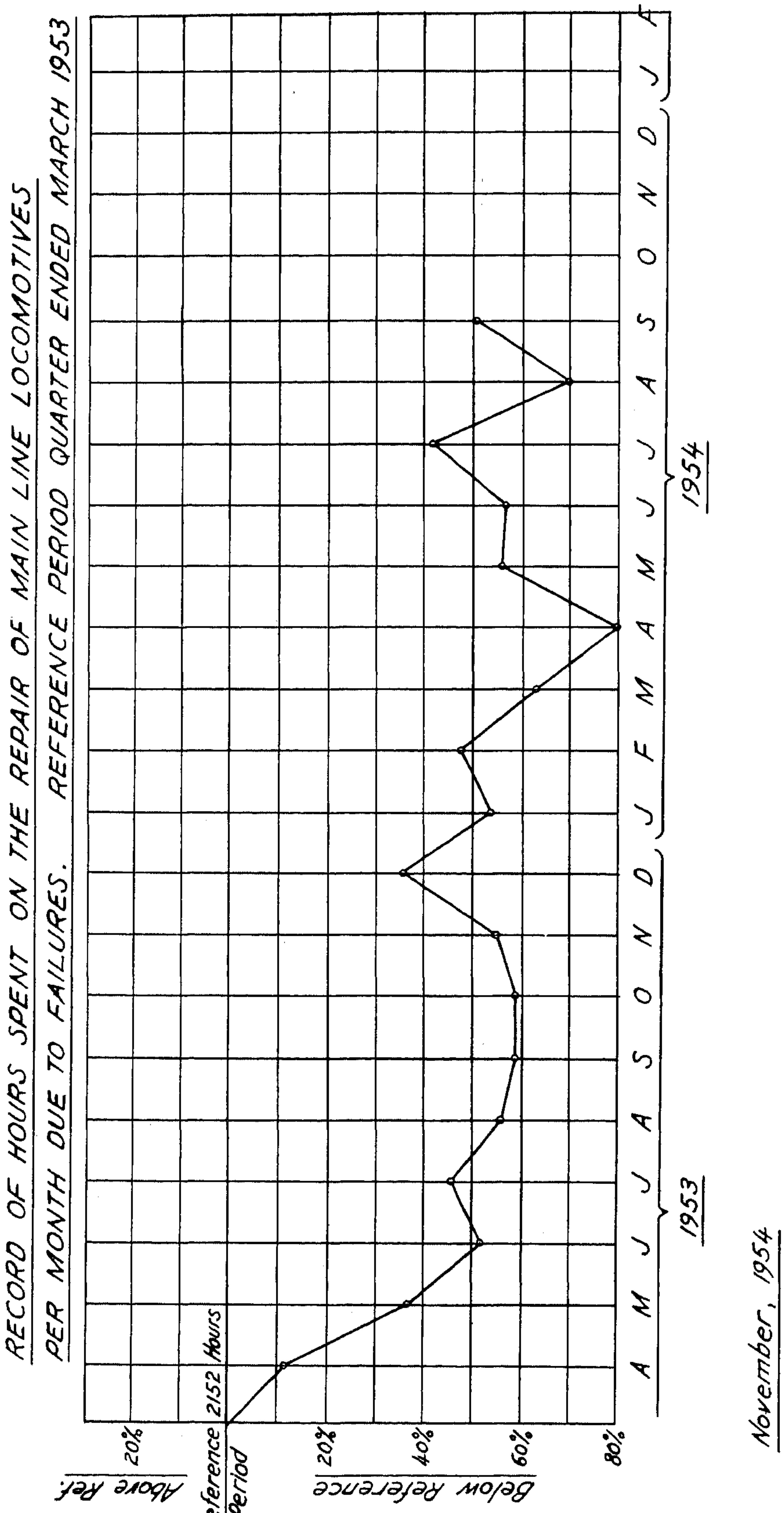

RECORD OF HOURS SPENT ON THE REPAIR OF MAIN LINE LOCOMOTIVES
PER MONTH DUE TO FAILURES.
REFERENCE PERIOD QUARTER ENDED MARCH 1953
Above Ref.
20%
Reference Period
2152 Hours
20%
40%
60%
80%
Below Reference
A M J J A S O N D J F M A M J J A S O N D J A
1953
1954
November, 1954

Fig. 4

hours, with an increase in utilization in terms of mileage operated amounting to 25 per cent.

At this same property, maintenance standards for trucks and the application of incentives to the track gangs were responsible for a drop in derailments from an average of fifty per month to five.

A large power station which has recently adopted preventive maintenance techniques reports the following features:

(a) Labour hours spent on repair of defects which were 2,200 hours in the first month of record fell to 800 hours after full implementation of the scheme.

(b) Week-end work which used to be as high as 2,000 hours per month, is now as little as 600.

(c) 60 men (as opposed to the normal establishment of 70) are capable of performing all work requirements.

The re-deployment of 47 men at a colliery in the United States and the introduction of controlled maintenance effected a reduction in overtime of 238 hours per week. At $3.65 per overtime hour, this mine is saving $44,000 per annum. What is more important however is that production has increased by 10 per cent.

Overtime has become a decided evil in many parts of South Africa and almost impossible to control by normal means. Planned maintenance coupled with incentive has been especially effective in accomplishing the required control. Fig. 5 shows how overtime was reduced in the case of twelve fitters and electricians employed underground. This control took on added importance in November, 1955, when the cost of an overtime hour rose by 25 per cent., through the incorporation of a portion of c.o.l.a. into basic wage.

Conclusion

I will close this discussion on preventive maintenance by recapitulating its purposes. These are:

1. To eliminate avoidable breakdowns as far as possible.
2. To improve the standard of maintenance.
3. To act as basis for training maintenance men.
4. To provide continuity of maintenance when there is a turnover of manpower.
5. To ensure that no unit is neglected, while other equipment may be over-maintained.
6. To standardize maintenance.
7. To act as a basis for suitable of section for a maintenance man.
8. To provide a current list of all maintenance work overdue, so that special arrangements can be made if necessary for carrying it out.
9. To allow maintenance work to be so as to fit in with production requirements.
10. To provide a basis of comparison between plants and types of equipment, thus indicating possible improvements.
11. To act as a basis for applying an incentive bonus based on individual performances.
12. To obtain an increase in productivity.
13. To assure the completion of jobs in their correct order of priority.
14. To gear the shops to maintenance requirements.
15. To improve safety.
16. To achieve a reduction in costs.

Experience in many mines and factories has proven that the adoption of controlled maintenance involves no possibility of loss, but every opportunity for substantial gains.

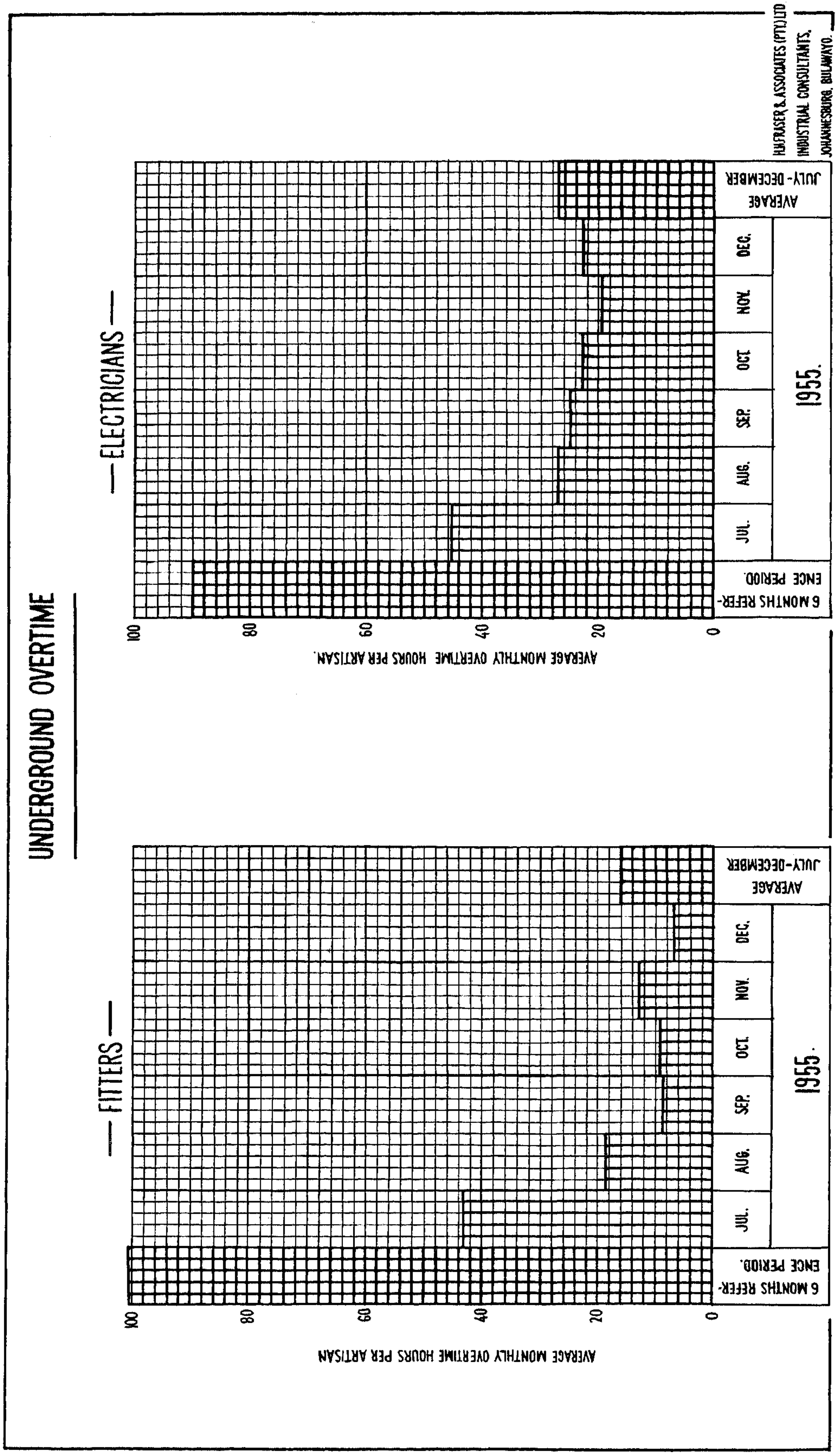

UNDERGROUND OVERTIME
— FITTERS —
— ELECTRICIANS —
AVERAGE MONTHLY OVERTIME HOURS PER ARTISAN.
100
80
60
40
20
0
6 MONTHS REFERENCE PERIOD.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
AVERAGE JULY-DECEMBER
1955.
H.M.FRASER & ASSOCIATES (PTY) LTD
INDUSTRIAL CONSULTANTS,
JOHANNESBURG, BULAWAYO.

Fig. 5

The President stated that this paper was something new in our annals and should provoke much thought **in** the industry.

Mr. Scott said that stress was laid in this paper on the reduction of artisans and similar staff, but it was not mentioned how many extra higher operators and executives would be required. He wished to know what extra amount of paper work would be involved in carrying out this system of Preventive Maintenance.

Mr. Hastings replied that it was planned that in one large unit in the sugar industry, the assistant resident engineer would be responsible for overseeing this system and he would be assisted by a single planning clerk, who would analyse the figures that came forward, weekly or monthly, and hand them on to the executive whose responsibility it was to see that the work was carried out. It was not estimated that the assistant engineer would have to spend all his time on this work, and he would be merely performing the work which he was supposed to be doing in any case. There would be an extra cost in installing this system, because consulting engineers with experience of it would have to be called in, but this was in the nature of a capital cost.

On large gold mining properties, only a planning engineer, a clerk, and a typiste, are required to operate the scheme.

The President stated that sugar mills were not normally supplied with spare major units so that during week-ends maintenance work had to be carried out. It might be to some extent haphazard, but even so, and in spite of the spare units, the bigger companies budgeted only for a loss of about 3 per cent of available time which allowed for stops such as mill chokes, lack of steam, trip-outs and the like, as well as mechanical breakdowns.

Mr. Hastings would find conditions in sugar factories rather different from what he had experienced up until now.

The President wished to know if the system of incentive bonuses was accepted by labour unions and industrial councils.

Mr. Hastings replied that there was sometimes objection by the unions to piece work in shops and factories but they raised no objection to incentive bonuses for maintenance work. This system was vastly different from conventional systems of incentive.

He said he had had experience in large power stations, cement works, and chemical plants. What these various plants got out of the system depended upon their particular circumstances and problems.

Mr. Gunn asked if this preventive maintenance scheme had ever been applied successfully without an incentive bonus.

Mr. Hastings replied that it had been. One important thing about the scheme was the incentive bonus did give one an opportunity of applying penalties for overtime, breakdowns and poor work. Such penalties however could only be applied after earnings had been increased by incentive bonuses.

Mr. Munro pointed out that in the sugar industry there was a considerable off-crop, during which the staff must be employed, and that gave an opportunity of doing additional overhauling and maintenance work. As the work has to be done in any case, the question arises as to whether it would be economical to employ the extra control staff to carry out this system of preventive maintenance.

Mr. Hastings replied that it was all a question of economics and he was unable to say whether it would pay or not, but he pointed out that in one large plant where it was the custom to close down for one month each year, this was no longer necessary.

In the sugar mills, he realised the off-crop was forced upon them, but he could not state dogmatically whether it would be an economical proposition in the sugar industry to save the work done during the off-crop by carrying it out during the crushing

The President pointed out that there was a tendency to leave things to the off-crop which should be maintained during the

Mr. Scott said that in the case of gold mines, time study departments were established, and to begin with they saved a lot of money, until it eventually reached a point where savings completely nullified the extra cost of applying the time study method.

He asked if the same thing could not occur with the system described by Mr. Hastings.

Mr. Hastings replied that while it was true that on the reef some mines had discontinued their study departments, some of them on the other hand were still expanding them.

He realised that this system would always mean a certain amount of extra paper work, but it was hoped to keep this to a bare minimum.

EXPERIENCE GAINED IN SIMPLE DEFECATION DURING THE 1955 SEASON

Introduction

In 1936 the Australian and British West Indian sugar industries experienced great difficulty clarifying the juices from recently introduced P.O.J. varieties. Their research institutes came to the simultaneous conclusion that the traditional cold liming technique of clarification would have to be replaced by a fractional liming double heating system, when clarifying these cane juices.

South Africa at this time relied on sulphitation to handle her refractory juices. The Tongaat factory used a type of Harloff process where the juice was heated to 170°F., most of the lime added, and then sulphitecl to a pH of 7.0 at the tower exit. Secondary lime was added to the sulphited juice and the alkalinity corrected with phosphoric acid to give a clear juice of 7.5 pH. The treated juice was heated to 220°F. and allowed to settle in subsiders. In effect, a double liming double heating process was being used with sulphitation super-imposed. Following the successful experiments at the Illovo sugar mill, Tongaat introduced defecation in August, 1954, by merely discontinuing the use of sulphur and reducing the quantity of phosphoric added.

The method employed at the beginning of the 1955 season was to use phosphoric paste at the rate of 0.35 lbs. per ton sugar made, lime the primary juice to 6.5 pH, heat to 150°F., then add secondary lime to pH of 8.0—8.4 and heat to 220°F., giving a final clear juice of 7.4 pH. Later in the year, towards the end of September, phosphoric acid was dispensed with when available P_2O_5 in raw juice varied between 320—450 ppm.

During the year a number of experiments were carried out to improve clarification and these form the subject of this paper.

Addition of Lime to the Subsider Muds prior to Filtration

Filter operation throughout the year was poor, due partly to blockage of the filter screens, but mostly to lack of bagacillo. Both clear and cloudy filtrates passed quantities of mud and the resultant clear juice from the subsiders appeared very cloudy.

Determinations of available P_2O_5 (see Table 1) showed that the filtrate in the subsider muds contained a much lower P_2O_5 content than the clear filtrate from the Olivers.

TABLE I

Available Phosphate Contents of Juices

Method.	Test.	Primary Juice from Mills. ppm. P_2O_5	Clear Filtrate from Olivers. ppm. P_2O_5	Juice after Primary Heating. ppm. P_2O_5	Juice after Secondary Liming and Phos. Addition. ppm. P_2O_5	Clear Juice. ppm. P_2O_5	Juice in Subsider Mud. ppm. P_2O_5
Before continuous liming of mud ...	1	382	122	—	61	26	35
	2	322	113	200	61	43	61
	3	332	139	288	104	43	70
	4	334	148	224	100	76	100
After continuous liming of mud	1	220	10	100	—	36	52
	2	322	10	181	47	19	29
	3	400	14	350	—	—	76
	4	410	24	350	57	47	67

This lead to the conclusion that phosphate was going back into solution at the filters. It is possible that di-calcium phosphate formed in the acid stage of the process is prevented by a layer of freshly formed tricalcium phosphate from dissociation. Dissociation then takes place with aqueous dilution at the filter station. We were able to demonstrate that by continuously liming the mud we were able to prevent this solution. The average P_2O_5 of clear filtrate was 130 ppm. before and only 14 ppm. after liming.

Liming the mud produced a denser cake free of slime, which peeled off the filters. Retention of the mud was on the whole good, but at times was extremely poor (see Table II). With good retention and low recirculation of mud in clear and cloudy filtrates, a sparkling clarified juice was obtained. The significance of bagacillo ratio on retention will be discussed later.

TABLE II

Filtration with Continuous Liming of Mud

	Feed to Oliver Filters.			Solids in Filtrates.		Press Cake.			
Test.	Solids Percentage.	Bagacillo Percentage.	Bagacillo Ratio.	Cloudy.	Clear.	Mud Percentage.	Bagacillo Percentage.	Bagacillo Ratio.	Overall Retention of Mud Percentage.
1	9.80	4.47	45.7	0.78	0.25	18.4	9.7	52.6	85.0
2	7.97	2.71	33.9	1.32	0.90	18.2	10.4	57.2	59.4
3	5.90	1.19	20.2	2.13	0.70	19.4	10.3	53.0	38.0
4	6.30	0.84	13.3	3.09	0.60	21.4	9.8	46.0	29.0
5	8.00	3.26	40.7	1.28	0.26	19.4	10.3	53.0	76.8
6	6.50	2.38	34.8	1.42	0.60	18.1	11.4	62.0	59.0
7	6.38	2.84	47.0	0.89	0.04	19.6	10.1	51.5	92.0
8	6.28	4.15	66.0	1.12	0.17	14.8	10.6	72.0	91.5

Adding lime to the mud must be controlled to prevent excessive alkalinity at temperatures of about 200°F., causing total destruction of invert sugars. At Tongaat the pH of clear filtrate was kept between 8.0-8.5, but even this could result in some invert destruction. Before liming of the mud can be accepted a study of invert losses involving the effect of pH, time and temperature will have to be made.

Fractional Liming with Double Heating and Simple Cold Liming

The British West Indies and Australia were quite satisfied to use simple cold liming for clarification, until refractory P.O.J. juices had to be processed.

Smith[1] experimented with clarification techniques using cold liming, hot liming, fractional double hot liming and fractional double hot liming with superphosphate. He concluded that for P.O.J. juices fractional double hot liming was the best technique. One technique was deemed better than another by its ability to remove in the most practical and economic way those impurities in the raw juice which had a deleterious effect on:

(a) Percentage of sugar that can be removed from the juice.

(b) The ease of recovering this sugar.

(c) The refining and other qualities of the recovered sugar.

He therefore analysed the raw and clear juices to ascertain the removal of reducing sugars, organic non-sugars, asn, P_2O_5, gums, waxes and insoluble matter. These analyses were coupled with plant scale trials to study the analyses of molasses and sugars, together with the refining quality and recovery of sugars. The juice analyses gave fluctuating and inclusive results, due to the ever-changing initial quality of the raw juice. Process data however showed that fractional liming with double heating was the superior method.

Behne[2] determined pH values giving optimum overall purity rises. His conclusions are summarised below:

TABLE III

Optimum pH Values for Clarification

Factory.	Method of Clarification.	Juice prior to Final Heating and Settling.	Clear Juice.
Invicta	Cold	8.0	6.8
	Fractional liming double heating	7.1—7.4	6.2—6.5
Isis	Fractional liming double heating	8.1	7.4—7.7

He observed that optimum conditions would have to be determined for each mill. At Tongaat we are more interested in obtaining a clear juice having a steady pH at the optimum value. The rise in purity between raw and clear juice is influenced by the condition of the Oliver filtrate, which mixes with raw juice directly after weighing. For this reason purity rise was studied for hot and cold liming on a small scale. The apparatus was a small square tank with a conical bottom, holding approximately 1 cu. ft. of raw juice, fitted with vertical sightglass, heating coils and stirrer. A known quantity of lime was added to the juice either cold or at 140°C, followed by rapid heating to the boiling point, allowing the precipitate to settle for two hours before sampling for purity. Comparative results for three series are given in Fig. I. The optimum pH for clear juice is about 7.4 for Hot Liming and 7.6 for Cold. Larger purity rises were obtained than those in practice, the difference being partly attributed to the recirculation of mud in filtrates. In practice we haye found that a clear juice pH of 7.4 is obtained by liming to 8.0-8.4 before final heating and settling.

Davies compared the refractive juices from P.O.J. 2878 variety with the high claribility juices of B.H. 10/12 cane variety. An exhaustive study of each cane during maturity revealed that the P.O.J, variety differed by having" high total P_2O_5 (mean 350 ppm.) and organic silica contents. It was thought that part of the P_2O_5 was not available. Honig[4] in a study of phosphates in clarified juice concluded that of a total content of 25-80 ppm. only 10-40 ppm. were inorganic. Davies decided that organic silica was a major contributing factor to claribility. It is interesting to note that Uba cane with 0.128 per cent. organic silica on total solids was almost as high as P.O.J. 2878 0.142 per cent as compared to 0.056 per

Davies, Duncan & Yearwood[6] varied the liming procedure on a lab. scale and concluded that for P.O.J.2878 additional phosphoric resulted in voluminous muds and cut it out altogether. The best results were obtained by double liming double heating. This was confirmed at later trials in the College Sugar Factory. There was an all-round improvement in removal of non-sugars and a remarkable increase in gravity purity rise of 1.72 over cold liming for the P.OJ. cane.

TABLE IV

Comparative Operating Data for Fractional Liming Double Heating

	College Sugar Factory,[5] 1936.	Guanica Puerto Rico,[6] 1938.	Tongaat, 1955.
Primary lime pH	6.4	6.2—6.4	6.5
Primary heating temperature ...	180—212°F.	200°F.	150°F.
Secondary lime pH	7.6	8.0—8.4	8.0—8.4
Secondary Juice temperature ...	212°F.	216—218°F.	220°F.
Clear Juice pH	—	7.2—7.4	7.4

Table IV compares factory results using fractional liming with double heating and indicates that the primary heating temperature at Tongaat may be too low.

Having stressed the reason for Tongaat's adoption of the F.L.D.H. process and the fact that this technique was introduced to handle refractory juices, it seems only fit to compare this process with cold liming.

Plant Scale Trials
Fractional Double Liming vs. Cold Liming

The factory experimented with cold liming from Friday, 14th October to Saturday, 29th, thereby giving a two weeks' trial. 5°Be. lime was added to the cold juice and heating to 220°C. was accomplished in two stages—primary heating to 150°F. and secondary heating to 220°F. The following observations were made:—

Liming

Davies[5] showed that one of the advantages of the fractional liming method was a saving in lime of 36.6 per cent. over cold liming. This was not borne out at Tongaat, where during the period of test the reverse was found (see Table VIII).

The lime requirements for a given clear juice pH will depend amongst other things on the amount of phosphate removed. Thus if less lime is required for fractional liming the ratio $\frac{\text{CaO added}}{P_2O_5 \text{ removed}}$ will be less than in cold liming for the same P_aO_5 removal and final pH. Thirty-one determinations were made using the laboratory apparatus previously mentioned and results showed no definite tendency, although on the average corresponding $\frac{CaO}{P_2O_5}$ ratios were higher for liming hot (see Fig. II). In these laboratory experiments true fractional liming and double heating was not followed, and all the lime was added and digested at a temperature of 140°F. before the secondary heating to 212°F.

pH Control

The changing quality and flow rate of the mixed juice, together with the high drop in pH from cold limed juice to clarified made manual pH control very difficult for cold liming. Over and under liming took place continuously about a mean of 8.6 pH, giving clear juice pH's varying from 7.1-7.6. Under these conditions syrups and sugars darkened in colour, due to colour formation in the evaporators. There was an immediate improvement in sugar colour when the factory returned to fractional liming.

Filtration of Muds

During cold liming a series of tests were made to determine the retention of mud (see Table V).

FABLE V

Filtration During Cold Liming

	Feed to Oliver Filters.			Solids in Filtrates.		Press Cake.			Overall
Test No.	Solids Percentage.	Bagacillo Percentage.	Bagacillo Ratio.	Clear.	Cloudy.	Mud Percentage.	Bagacillo Percentage.	Bagacillo Ratio.	Retention of Mud Percentage.
1	9.8	2.3	23.4	.50	—	18.5	10.0	54.0	43.3
2	8.6	2.3	26.7	.45	—	23.6	9.4	40.0	67.0
3	11.9	2.3	19.3	.55	3.35	18.8	8.8	46.5	42.5

Performance was extremely poor and large quantities of mud were recirculated. Comparing the results of Table V with Table II it will be seen that cold liming produced heavy muds of 10 per cent. solids compared to 6-7 per cent. with fractional liming. The quantity of bagacillo at Tongaat was inadequate for those high mud solids.

Foster[7] showed that with increasing $\frac{\text{bagacillo}}{\text{solids}}$ ratios in the feed, mud retention improved at a practically linear rate for constant mud solids. By increasing mud solids (i.e. thicker muds) and maintaining the bagacillo ratio, better retention was obtained. However, Foster only investigated mud solids up to 5.4 per cent. and in this paper results are given in the range 5.9 per cent.—11.9 per cent. It can be shown in Fig. III that retention does not improve materially by increasing mud solids above 6.0 to 6.5 per cent. However increasing the bagcillo ratio from 20 to 40 per cent. will increase the retention 50 per cent. Davies[8] in a recent paper shows that the optimum conditions for maintaining 90 per cent. retention is to keep mud solids between 5.0—7.0 with a bagacillo ratio of 50 per cent.

Mud solids during fractional liming were satisfactory and when the bagacillo ratio was above 40 per cent, excellent retention was obtained. During these periods the clarity of the clear juice was brilliant. Muds produced by cold liming were too thick and with inadequate bagacillo poor retention caused recirulation resulting in very muddy filtrates. For this reason purity rises could not be compared satisfactorily and no figures are given.

Factory Data Comparison

A further comparison between fractional and cold liming is obtained from weekly factory data giving the analysis of molasses, the pol. of sugars produced and sugar recovery for the period preceding and following the cold liming tests.

During the two weeks of cold liming sucrose losses increased, giving higher true molasses purities. Only when the factory reverted to fractional liming did the sucrose return to normal.

Sugar pol. remained normal during cold liming. Sugar colour visibly darkened and only improved on reversion to fractional liming.

B.H.R. dropped during cold liming. In the second week all losses were high. Increase in undetermined losses was probably due to fermentation at week-ends.

Deterioration at Week-ends

During week-ends deterioration appeared to be greatest for cold liming (see Table IX). On the week-end of 15th October fermentation was so bad that one subsider bubbled and frothed. It was noticed that the juice in contact with the mud was always acid for cold liming, being 6.8—6.9 pH, that for fractional liming was 7.1—7.4 pH. Possibly the precipitate formed in the mud is more basic tor

TABLE VI

Analysis of Final Molasses

Week Ending.	Liming Method.	Brix.	Gravity Purity.	Dry Substance.	Clerget Sucrose.	Invert Sugars.	Organic Matter.	Sulphated Ash.	True Purity.
15.10.55	Fractional liming double heating	86.0	41.6	77.9	35.8	13.0	18.4	11.9	45.8
22.10.55	Cold liming	87.2	42.4	78.6	37.0	12.0	18.3	12.5	47.2
29.10.55	Cold liming	86.6	44.4	76.2	38.5	11.0	16.2	11.7	50.5
5.11.55	Fractional liming double heating	86.5	42.6	77.5	36.8	10.8	19.5	11.6	47.5
12.11.55	Fractional liming double heating	87.0	42.2	79.1	36.6	10.4	20.4	13.0	46.3

TABLE VII

Analysis of Sugars

Week Ending.	Liming Method.	Refinery Pol.	II Grade Pol.	Export Pol.
15.10.55	Fractional liming double heating	98.26	98.46	98.12
22.10.55	Cold liming	98.33	98.20	98.27
29.10.55	Cold liming	98.40	98.40	98.32
5.11.55	Fractional liming double heating	98.33	98.46	—
12.11.55	Fractional liming double heating	98.44	98.31	—

TABLE VIII

Recovery of Sugar

Week Ending.	Liming Method.	T.C.H.	Press Cake Percent. Cane.	Lime lbs./ton Sugar Made.	Sugar Losses Percent. Sucrose in Cane			B.H.R.
					Press Cake.	Molasses.	Undetermined.	
15.10.55	Fractional liming double heating	184.2	4.78	8.70	0.20	6.47	1.87	91.01
22.10.55	Cold liming	154.0	4.48	8.35	0.18	7.22	0.79	91.37
29.10.55	Cold liming	181.6	4.61	8.18	0.24	7.58	2.06	89.61
5.11.55	Fractional liming double heating	167.9	4.77	8.34	0.21	6.20	1.47	91.71
12.11.55	Fractional liming double heating	186.7	3.77	8.45	0.18	7.23	0.45	91.72

fractional liming than cold liming. Three precipitates of phosphate are known to exist[9]:—

Dicalcium phosphate	$CaHPO4$
Tricalcium phosphate	$Ca_3(PO4)_2$
Hydroxyapatite	$3Ca_3(PO4)_2Ca(OH)_2$

The ratio of CaO : P_2O_5 is theoretically 1.31 for hydroxyapatite but precipates having a more basic character have been observed. Possibly a precipitate having the hydroxyapatite composition is formed during fractional liming, while cold liming produces the tricalcium phosphate precipitate predominantly.

TABLE IX

Deterioration of Juices During Week-ends

Week Ending.		Process.	Clear Juice Purity. Shut Down Saturday.	Clear Juice Purity. Start Up Sunday.	Clear Juice Purity. Difference.	Clear Filtrate Purity. Shut Down Saturday.	Clear Filtrate Purity. Start Up Sunday.	Clear Filtrate Purity. Difference.
8 Oct.	...	Fractional liming	89.6	87.7	—1.8	86.0	86.1	+0.1
15 Oct.	...	Cold liming	90.0	83.5	—6.5	85.7	82.0	—3.7
22 Oct.	...	Cold liming	89.2	85.6	—3.6	85.6	81.3	—4.3
29 Oct.	...	Cold liming	88.6	87.9	—1.7	87.0	82.8	—4.2
5 Nov.	...	Fractional liming	89.7	89.4	—0.3	83.1	82.9	—0.2
12 Nov.	...	Fractional liming	89.1	86.6	—2.5	83.0	83.4	+0.4

Summary

Tongaat has applied the Double Liming Double Heating technique of defecation since August, 1954 With available P_2O_5 contents of 320—450 ppm. it has been found unnecessary to add phosphoric acid paste.

Phosphate appeared to be redissolving in the clear filtrates of the Oliver Filters. To counteract this and displace the dissociation equilibrium, muds were continuously limed. It was found that a dense cake, free of slime, which peeled off the filters, was produced. When mud retention was satisfactory brilliant clear juices were obtained. pH control was essential to prevent invert destruction and before liming can be accepted, this disadvantage must be investigated.

Cold liming was found to be unsatisfactory under prevailing conditions at Tongaat. Manual control of the limed juice pH was difficult, resulting in over and under liming. This caused darkening of syrups and sugars. Very thick muds were produced and an inadequate bagacillo supply resulted in poor retention. Recirculation of mud caused very cloudy juices and this was thought to be associated with the increased sucrose loss in molasses with accompanying increase in True Purity and decrease in B.H.R. Cold limed juices appeared to ferment more easily than fractionally limed juices and it was noted that the juice in contact with subsider mud was always acidic for the former (6.8—6.9) and alkaline (7.1—7.4) for the latter.

I will conclude by saying that these results show the importance of having a filter station which is efficient and having pH control which is reliable. When these two conditions are realised it is then possible to make an accurate assessment between two techniques of clarification. All figures given are for purely local conditions at Tongaat and may not be representative of the industry.

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(For joint discussion on this and the following paper turn to page 88)

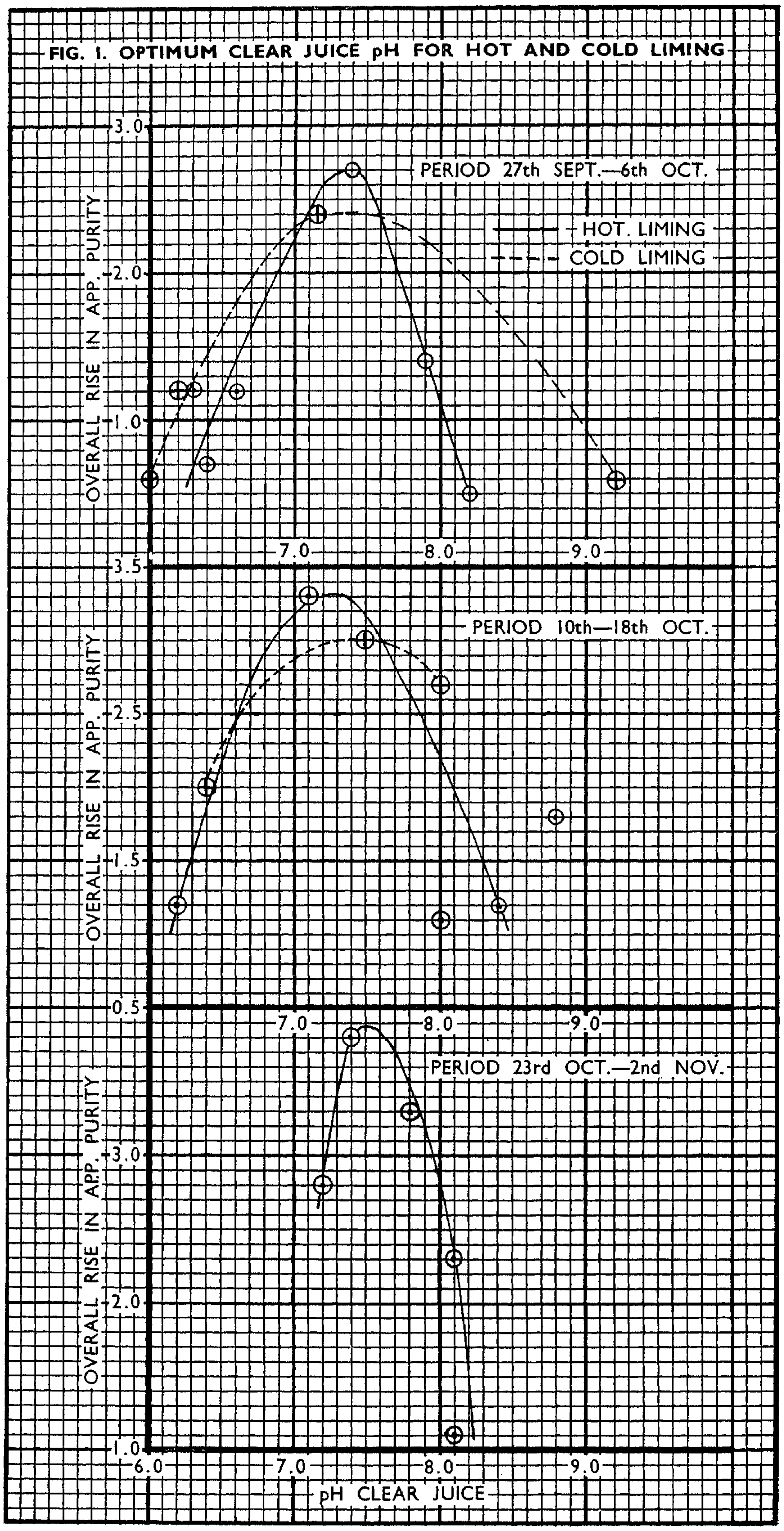


FIG. 1. OPTIMUM CLEAR JUICE pH FOR HOT AND COLD LIMING
PERIOD 27th SEPT.—6th OCT.
HOT. LIMING
COLD LIMING
PERIOD 10th—18th OCT.
PERIOD 23rd OCT.—2nd NOV.
OVERALL RISE IN APP. PURITY
pH CLEAR JUICE
3.0
2.0
1.0
3.5
2.5
1.5
0.5
3.0
2.0
1.0
6.0
7.0
8.0
9.0

FIG. II. LIME CONSUMPTION WITH P_2O_5 REMOVAL AND CLEAR JUICE pH

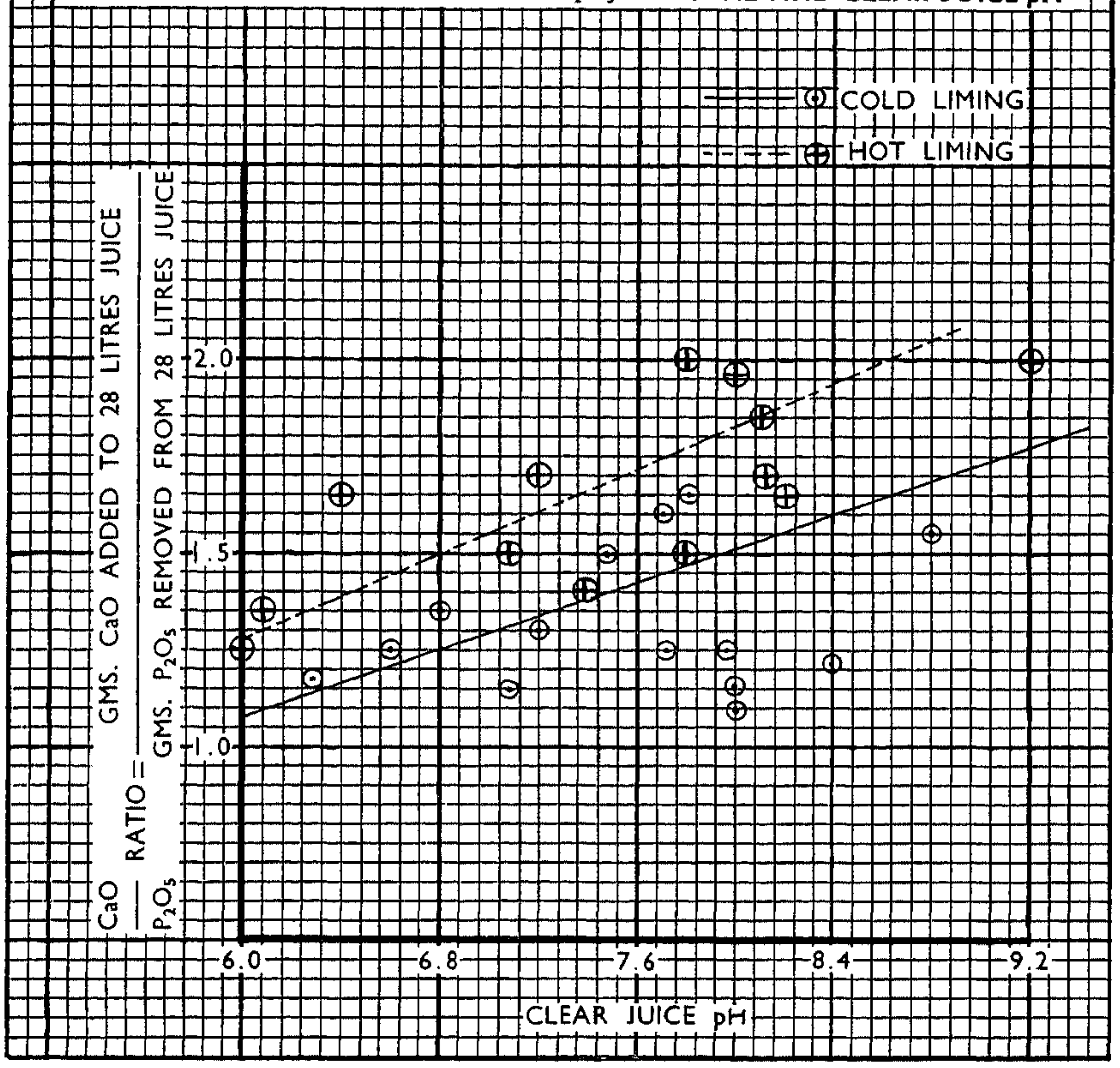
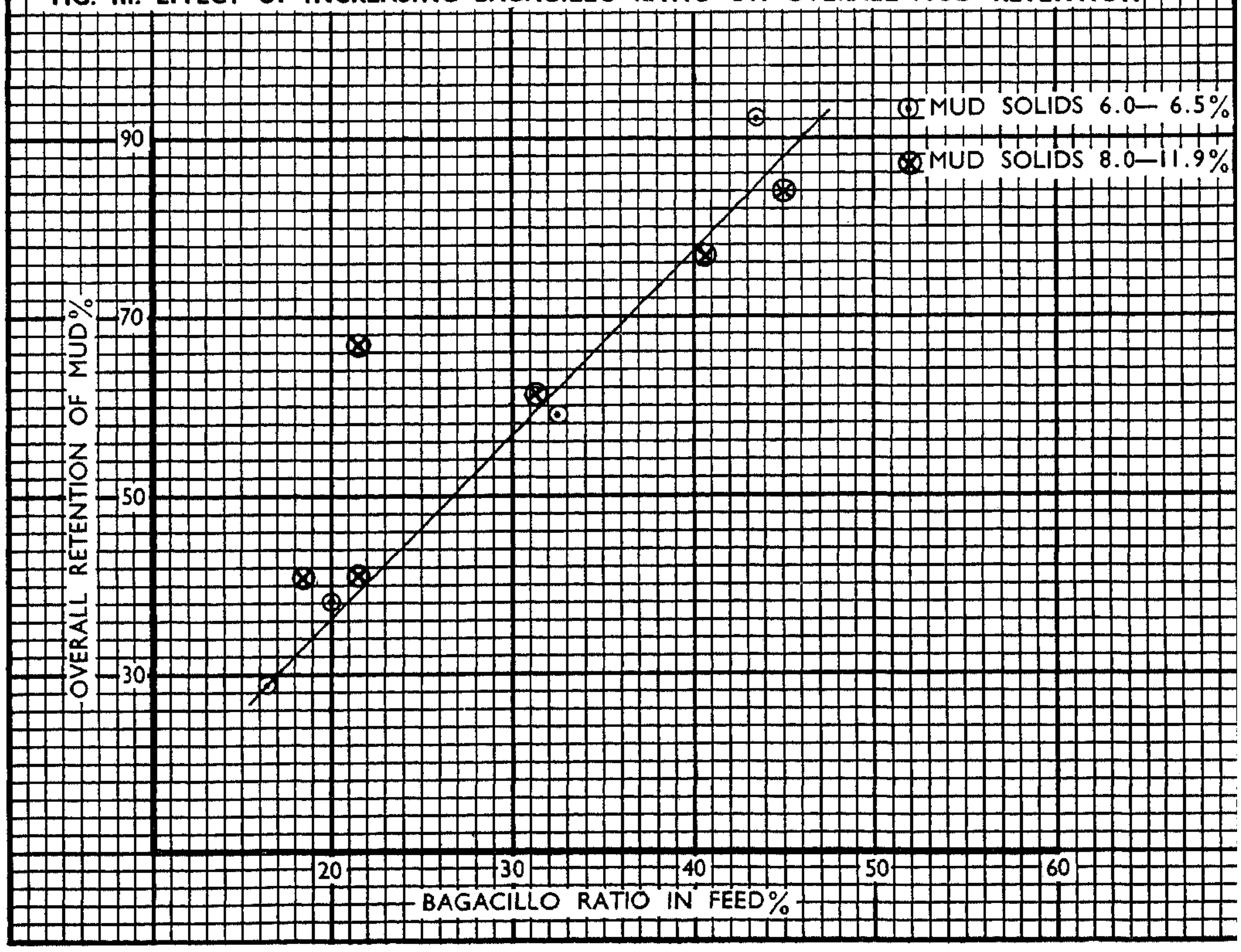


FIG. III. EFFECT OF INCREASING BAGACILLO RATIO ON OVERALL MUD RETENTION



SOME FURTHER REMARKS ON RESULTS OBTAINED WITH THE DEFECATION PROCESS IN NATAL

By C. VAN DER POL

In the past crushing season a further four mills (Amatikulu, Darnall, Felixton and Umfolozi) have followed Illovo and Tongaat in abandoning the use of sulphur for the production of raw sugars. Hence at the close of the 1955-56 crushing season, 42.48 per cent, of all government grade and raw sugars produced in Natal were obtained from juices clarified by the defecation process.

The advantages of the defecation process over the sulpho-defecation process are many and can briefly be enumerated as follows:

A. Lower production costs due to:
   1. Saving in chemicals.
   2. Saving in labour.
   3. Saving on maintenance of equipment.
   4. Increase in capacity of evaporators.

B. Simplicity of the process lending itself to automatic control.

It speaks for itself that, if the above advantages are accompanied by a reduction in efficiency, they will not compensate for a financial loss due to a lower recovery of sucrose from the juice. It is a comparatively simple matter to calculate the amount saved due to lower production costs, but to estimate the magnitude of a gain or loss in efficiency of sucrose recovery due to a change in clarification technique, is not so straight forward.

Factory Performance

The boiling house performance figure is undoubtedly the best figure on which to judge the effect of a change in clarification efficiency, if it can be assumed that the performance of the boiling house as such is only dependent on clarification efficiency. Unfortunately, this is not the case from week to

Factory		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Final to Date 1955-1956	Final to Date 1953-1954	Final to Date 1954-1955
			SULPHO-DEFECATION					DEFECATION						
AK ...	B.H.P.	98.3	100.1	100.9	99.5	98.0	98.5	98.2	99.1	99.0	—	99.4	97.7	98.7
	Purity Final Molasses...	37.3	38.3	37.6	38.5	38.4	41.6	42.6	40.7	39.0	—	39.3	37.7	38.9
	Brix Final Molasses ...	87.4	88.1	88.9	89.2	90.0	87.3	86.8	87.9	87.2	—	88.2	89.6	88.1
DL ...	B.H.P.	97.2	99.8	98.8	98.5	97.3	96.5	98.5	99.6	99.6	100.4	98.5	96.8	97.3
	Purity Final Molasses...	37.4	36.9	37.4	38.6	40.7	43.0	41.4	39.9	40.0	39.2	39.4	37.5	37.3
	Brix Final Molasses ...	89.6	91 2	91.8	91.8	90.21	89.7	89.7	89.2	88.6	89.5	90.2	89.4	90.3
FX ...	B.H.P.	96.9	98.2	98.7	98.7	99.4	98.9	97.7	97.6	98.1	97.5	98.3	97.9	98.2
	Purity Final Molasses...	39.6	38.7	38.5	39.2	39.2	38.6	41.4	40.3	40.4	40.3	39.7	38.5	38.8
	Brix Final Molasses ...	89.1	91.4	93.2	92.7	92.9	92.5	92.4	92.2	91.9	90.5	92.0	90.3	88.4
UF ...	B.H.P.	—	97.1	99.0	96.8	98.0	97.6	97.4	96.4	95.1	—	97.2	96.9	97.1
	Purity Final Molasses...	—	38.5	36.9	38.8	38.2	41.4	42.2	41.3	40.2	—	39.7	39.5	38.9
	Brix Final Molasses ...	—	91.7	93.6	92.8	93.5	91.6	91.2	90.7	90.6	—	91.9	96.5	94.0
							SULPHO-DEFECATION							
ZM ...	B.H.P.	98.2	99.0	98.4	97.3	97.1	98.0	97.9	98.0	97.5	95.5	97.8	97.5	97.6
	Purity Final Molasses...	36.6	37.4	37.5	39.1	38.3	38.8	39.0	37.9	38.5	39.8	38.2	37.1	37.8
	Brix Final Molasses ...	94.1	94.5	94.7	93.3	93.2	93.8	93.3	94.0	93.7	92.0	93.7	93.8	95.0
MV ...	B.H.P.	91.5	98.5	99.9	99.2	97.3	96.8	98.0	97.5	96.9	97.1	97.8	96.1	97.9
	Purity Final Molasses...	40.5	38.5	37.5	38.0	41.3	43.3	41.2	40.7	40.2	40.6	40.2	42.0	39.7
	Brix Final Molasses ...	87.7	87.2	87.6	88.0	85.9	85.4	86.8	87.0	86.9	87.9	86.9	85.5	88.2
UK ...	B.H.P.	—	97.0	98.0	98.0	98.9	97.5	95.0	—	—	—	98.0	97.5	99.2
	Purity Final Molasses...	—	38.0	37.3	36.0	38.1	41.1	41.2	—	—	—	38.3	40.2	38.5
	Brix Final Molasses ...	—	92.1	91.0	92.1	91.4	89.9	90.3	—	—	—	91.1	91.2	92.7

week due to varying undetermined losses, occasional mishaps, etc., but over a relatively long period of time the boiling house performance can be assumed to be a direct function of clarification efficiency.

The purity of final molasses, although being influenced by variables other than clarification efficiency to an even greater extent than the boiling house performance figure, is also a valuable guide to factory performance.

In the above table the boiling house performance, final molasses purity and brix of final molasses for the four "new" defecation factories as well as for the three remaining sulpho-defecation raw sugar factories, are collected. The monthly figures have been taken in an attempt to even out fluctuation due to factors not dependent on clarification efficiency and the sulpho-defecation factories have been included in case there is a natural seasonal variation in performance efficiency. The vertical dark lines separate the periods sulpho-defecation from defecaion and in the case of the factories still on sulpho-defecation, are intended to indicate the approximate time at which the change from sulpho-defecation to defecation occurred at the other factories.

A statistical study of the boiling house performance data in the table above shows that there is no significant difference between values obtained before and after the change-over to the defecation process.

The molasses purity figures, on the other hand, do show a significant difference when comparing the periods before and after the change-over to defecation. However, the sulpho-defecation factories also show a small rise in final molasses purity over the latter part of the season and this rise can only be due to a seasonal variation independent of the nature of the clarification process.

Further, there is a significant drop in brix of the final molasses produced after the change-over to defecation in the factories concerned. This, naturally, has an important bearing on the purity of the final molasses. The brix of molasses produced by the sulpho-defecation process did not drop significantly.

Since the increase in defecation molasses purity was not accompanied by a drop in boiling house performance it must be assumed that either the quantity of molasses produced had decreased, due to a better removal of non-sugars from mixed juice, or the nature of the non-sugars in clarified juice changed, affecting the brix as determined by Brix spindle. There is no evidence for a suggestion that the defecation process removes more non-sugars than the sulpho-defecation process. However, there is evidence to show that, for the same dry substance, a sulphitation molasses has a higher brix than a defecation molasses, when measured with a Brix spindle at the same dilution.

This phenomenon has been observed repeatedly in our laboratories when analysing molasses produced by a factory just before and just after the change to the defecation process.

Hence for the same true purity (sucrose per cent, dry substance), a defecation molasses will have a higher gravity purity than a sulphitation molasses. Whereas this fact is somewhat confusing, it affords no evidence for any suggestion that a defecation molasses is less easily exhausted than a sulphitation molasses.*

A complete survey of molasses produced by all factories is at present being carried out at the S.M.R.I. and it is hoped that some empirical formula can be established whereby the efficiency of exhaustion of a molasses can be judged, completely independently of its source.

There is hence no evidence to suggest that lower production costs with the defecation process are partly or wholly nullified by a decrease in sucrose recovery from the juices.

Quality of Raw Sugar

The question has been raised recently whether the quality of raw sugars produced by the defecation process is inferior to that produced by the sulphitation process. An answer to this question is somewhat dependent on how one defines the quality of a raw sugar. From the refiners' point of view the following criteria, not necessarily in order of merit, are usually considered to be of importance:

(1) Keeping quality of the sugar on storage.

(2) Average grain size and regularity of the grain.

(3) Filterability of the affined sugar melt.

(4) Colour of the affined sugar melt.

(5) Composition of the sugar.

Whereas the above points are, to a certain extent, inter-related, this can be ignored when discussing the difference between sulphitation and defecation raws.

Both points (1) and (2) mentioned above are not dependent on the clarification process used to produce the sugar and will not be discussed further.

(3) *Filterability*

A number of filtration tests have recently been carried out in the S.M.R.L laboratories on raw sugars produced by all the factories. Since these tests were not made for the purpose of detecting a possible change in filterability of sugars due to a change in clarification process, no evidence is available to suggest that defecation sugars have poorer filtration properties than sulphitation sugars of the same factory. It is a fact that of the samples analysed, the defecation sugars did on the whole have a somewhat lower filtration rate than sulphitation sugars. Since this is not in agreement with previous results and also since very large variations in filtration rate of sulphitation sugars from the same factory have been observed for different samples, no conclusion can as yet be reached.

Factory experience at Illovo, when this factory was still refining, did not give any evidence for a deterioration in filtration rate after the change-over to defecation. Hulsar too, although upset by the change in colour of the defecation sugars, were not troubled by a decrease in filtration rate.

Good and bad filtering sugars can apparently result from both the sulpho-defecation process and the defecation process.

(4) *Colour*

On the whole the colour of raw sugars produced by the sulpho-defecation process is lighter than that of sugars produced by the defecation progress, as is evident from the monthly analysis carried out on raw sugars by the S.M.R.I. This is as expected in view of the well-recognised inhibiting action of sulphur dioxide on colour formation in sugar products. However, the concentration of coloured substance in a refinery melt is of less importance than the presence of certain specific coloured com-

Illovo succeeded in producing a mill white sugar of quality better than average, by straight remelting of affinated defecation sugars without any refining operation whatsoever. This affords considerable proof that the specific colouring matter harmful to the refining process is not necessarily present in defecation raws.

(5) *Composition*

Ash, and in particular calcium salts, are considered to be undesirable components of a raw sugar, since they affect the colour of refinery products and reduce the recovery of sucrose.

Starch, phosphates and silica are suspected of being responsible for at least part of poor filtration properties of some sugars.

The arithmetical averages of the analysis on raw sugars, as recorded monthly in the communications of the S.M.R.I., are recorded here for the months October to January inclusive for the factories indicated.

are recorded here for the months October to January inclusive indicated.

Factory	Pol.	Moisture per cent.	S.F.	R.S.	Ash per cent.	CaO per cent. Ash	SO_3 per cent. Ash	A_c* 505	A_c* 560
Defecation Raw Sugars									
UF	98.7	0.468	0.36	0.240	0.438	9.8	21.0	753	524
FX	98.7	0.391	0.30	0.376	0.375	16.2	27.0	676	471
AK	98.8	0.336	0.29	0.307	0.326	15.2	29.1	879	636
DL	98.3	0.544	0.32	0.364	0.472	12.1	22.8	1,144	816
Average	98.6	0.439	0.32	0.365	0.396	13.7	25.5	877	623
Sulphitation Raw Sugars									
ZM	98.7	0.441	0.33	0.262	0.398	15.2	26.0	495	343
MV	98.2	0.626	0.33	0.566	0.445	18.2	28.9	609	459
UK	98.4	0.519	0.32	0.593	0.393	17.3	24.0	555	443
Average	98.4	0.528	0.33	0.474	0.412	16.9	26.3	553	415

Whereas the average composition of the defecation sugars is better than the average composition of the sulphitation sugars considered, this has no statistical significance due to the relatively large variation in composition within the two groups. It can hence only be concluded that the composition (as analysed for) of defecation sugars is no different from sulphitation sugars, except for colouring matter.

To check on the possibility of a significant effect of the change in clarification technique on the quality of the sugars for individual factories, the data on ash per cent, sugar, CaO per cent, ash and SO_3 per cent, ash were analysed for the period before and after the change in clarification process. In the following table the results are summarised for the factories indicated. The data listed under the sulpho-defecation factories pertain to the periods before and after the end of September and are included to check on seasonal variations.

Factories	Defecation UF	DL	FX	AK	Sulpho-Defecation ZM	MV	UK
Average Ash per cent. Sugar							
Before Change	0.523	0.402	0.383	0.363	0.433	0.395	0.339
After Change	0.438	0.467	0.348	0.326	0.429	0.428	0.355
Difference	+0.085	−0.065	+0.035	+0.037	+0.004	−0.033	+0.016
Average CaO per cent. Ash							
Before Change	10.8	16.9	21.3	17.5	13.0	14.0	15.8
After Change	9.8	12.4	15.9	15.2	14.2	17.7	16.5
Difference	+1.0	+4.5	+5.4	+2.3	−1.2	−3.7	−0.7
Average SO_3 per cent. Ash							
Before Change	16.9	27.1	33.3	26.5	24.2	26.3	23.7
After Change	21.0	22.2	27.8	29.1	24.3	27.7	24.2
Difference	−4.1	+4.9	+5.5	−2.6	−0.1	−1.4	−0.5

A statistical analysis of the significance of the difference showed that the change in ash per cent, sugar is in all cases not significant for the factories that changed to the defecation process.

The reduction in CaO per cent, ash is significant for DL and FX, and the increase in CaO per cent, ash for MV during the period in question is also significant. If one can conclude from the data on the sulpho-defecation factories that there is a tendency for the CaO per cent, ash to increase in the latter half of the season, the decrease in CaO per cent, ash as observed after the change-over to the defecation process becomes even more significant.

Both the increase in SO_3 per cent, ash at UF and the decrease in SO_3 per cent ash at DL are statistically significant. Since no additional SO_3 could have been introduced in juices at UF during the defecation period, the increse in SO_3 per cent. ash in their defecation sugars is difficult to explain, and is most probably due to factors not associated with the clarification process.

Unfortunately, neither starch, phosphate nor silica were part of the routine analysis of raw sugars during the past season. A number of sugar samples have lately been analysed for these constituents at the S.M.R.I., in connection with filtration work. Results obtained so far do not indicate that either the starch content or the silica content of defecation sugars is necessarily higher than that of sulphitation sugars. There is a tendency for the phosphate content to be higher, i.e. 20 ppm. for defecation sugars and 5 ppm. for sulphitation sugars are average values obtained for the samples analysed.

Particular attention has been given to starch in sugars since South African sugars contain such a high proportion of this impurity. Laboratory investigations have shown a somewhat better removal of starch from mixed juice by the defecation process. Factory investigations have shown that 80 per cent, of the starch in mixed juice enters the clarified mice with the sulpho-defecation process. Unfortunately similar results are not available for the defecation process, but it is clear that if the defecation process permitted even more starch to enter the clarified juice (for which no theoretical or practical evidence exists) that this could have but little effect on the starch content of sugar.

Some idea of the large variation in starch content of the different raw sugars from various factories can be obtained from the following table in which the average starch content, as well as the upper and lower limit between which the average occurred, are collected for the 1954-55 season.

Starch Content of 1954-55 Raw Sugars

Factory	Average	Upper Limit	Lower Limit
UF ...	457 ppm.	570 ppm.	330 ppm.
ZM ...	386 ,,	790 ,,	230 ,,
FX ...	274 ,,	390 ,,	190 ,,
EN ...	819 ,,	1,100 ,,	540 ,,
AK ...	361 ,,	490 ,,	230 ,,
DK ...	420 ,,	520 ,,	370 ,,
DL ...	364 ,,	480 ,,	230 ,,
GL ...	632 ,,	850 ,,	480 ,,
MV ...	414 ,,	590 ,,	190 ,,
CK ...	440 ,,	One Sample Only	
TS ...	755 ,,	1,050 ppm.	300 ppm.
NE ...	390 ,,	One Sample Only	
IL ...	378 ,,	580 ppm.	290 ppm.
RN ...	641 ,,	740 ,,	540 ,,
SZ ...	560 ,,	700 ,,	440 ,,
UK ...	450 ,,	600 ,,	260 ,,

It can hence be concluded that, from the point of view of raw sugar quality also, there is little difference between the two clarification processes, except for the colour of the raw sugars. It must, however, be remembered that the sulpho-defecation process is essentially a white sugar process, in which the colour of the product is of greater importance than in the production of raw[r] sugars.

General

It is indeed very gratifying that the results obtained after a very short experience with the defecation process already compare favourably with the results obtained by the sulpho-defecation process, which has been in use in Natal for many years.

It would be erroneous to conclude from this that there is no room for improvements in the defecation process as applied in many factories. pH control in particular is open to serious criticism in a number ol cases. It has been noticed by a number of factories that a serious descrepancy exists between the pH of the various juices as measured by the glass electrode pH meter and by a certain brand of indicator paper. The paper reading is invariably lower than the meter reading, the difference sometimes being as much as one pH unit. Since this difference is not constant, it becomes rather a difficult task for the juice preparer to know to which colour he has to lime to obtain the desired pH value. There is no doubt that continuous operation with automatic liming by electrometric pH control is a far more satisfactory way of controlling the clarification process.

Liming of the muds before filtration has found favour in a number of factories. Since the chemical reactions involved in the precipitation of calcium phosphate are not instantaneous, the pH of juices containing the phosphate precipitate, i.e. the muds, will drop when such juices are kept in contact with the precipitate for a prolonged time at an elevated temperature. On further liming of the muds it is quite possible that further non-sugars can be precipitated. Provided the liming of muds is not carried to above pH8, little harm can be done. However, if the pH is allowed to reach values of 9 or higher, two very undesirable reactions take place:

(1) Destruction of reducing sugars.

(2) Irreversible re-solution of some precipitated non-sugars.

Although maximum removal of non-sugars at the filters is of great importance in efficient clarification, it is extremely doubtful whether the supposed small advantage gained by liming muds is balanced by the above-mentioned serious disadvantages.

In conclusion it may be mentioned that one factory in particular, i.e. Darnall, has benefited considerably from the defecation process in an indirect way. Increased capacity of the evaporator station, due to reduced scaling of evaporator tubes, has enabled Darnall to increase the maceration from about 200 per cent, on fibre to nearly 300 per cent, on fibre. Whereas it is not suggested that this is the only factor responsible for raising its extraction from being one of the lowest in the industry to one of the highest, it cannot be denied that the benefits of the defecation process have been exploited to the full at this factory.

Summary

Results obtained by the factories that changed from the sulpho-defecation process to the defecation process during the past season, have been studied from two aspects:

(1) Sucrose recovery.

(2) Quality of raw sugar.

It is concluded that sucrose recovery did not suffer by the change and that the quality of defecation raw sugars is comparable to sulphitation raws.

Acknowledgment

The author wishes to express his gratitude to Mr. J. B. Alexander of the S.M.R.I., for permitting him to quote freely from his unpublished work on factors influencing the quality of raw sugars.

Mr. J. Rault, in the Chair, stated that Mr. Boyes was Research Chemist to the Tongaat Sugar Co., a new position marking a progressive step in the appreciation of technical control in our leading sugar farms.

The works chemist fully engaged in the day to clay production control could hardly spare the time and the staff for research. He was now being helped by a very precious collaborator, with more leasure and training to solve on the spot local problems, more slowly investigated by research stations.

The paper referred to a very topical subject, i.e. the successful working of the simple defecation process adapted to our South African conditions and at one specific factory.

Dr. van der Pol's contributionon the same subject, covered more ground, and was a study of the average results of six factories, lately gone over to the simple and more economical liming process, after years of previous experience with the more exacting sulphitation process. One notable improvement was claimed for the defecation treatment, namely the decrease of evaporation scaling—a feature which should allow for heavier water application at the mills and the filters, with a consequent rise in overall recovery.

Mr. Boyes having been asked to explain the meaning of fractional liming double heating, said that this was a technique first introduced in 1936 by Mr. J. Davies, then a lecturer at the Imperial College of Tropical Agriculture. The idea was to add an initial dose of lime to the cold mixed juice to give a pH of about 6.2. This was sufficient to prevent inversion and also near to the isoelectric point of the juice facilitating colloid removal. The juice was then heated to 200° F followed by the addition of the balance of the lime. A second heating was necessary to bring the temperature to 220° F. Thus the lime was added in two fractions and the heating carried out in two stages.

Mr. A. D. Elysee said that changing from sulphitation to simple defecation led to no decrease in boiling house recovery, although the juice looked very poor. There was a considerable amount of work still to be done to improve results obtained from simple defecation. The colour of the juice was not satisfactory. Amatikulu factory had just started, and he had never seen such dirty looking juice come out of clarification.

Mr. **Boyes** stated that he had visited 15 overseas factories recently and in every case they used the simple defecation process. The processes used were either cold liming or double liming with single heating. The juices obtained in these factories were brilliant, and probably better than sulphitation juices in South Africa. He considered one reason for their getting such satisfactory juices was the cleanliness of the cane. These overseas factories seemed to have to deal with much less mud than we did in South Africa. He said that overseas they had made a study of the subject and took into account all departments of the clarification process. It took a long time to develop the sulpho-defecation process in South Africa, and he considered we still had a lot to learn about the defecation process. Possibly, when we knew more about this process, we might one day be able to produce juices comparable with those obtained overseas.

Mr. **Elysee** said that here quite a lot of work was done on the quantity and quality of bagacillo used in the filters, but he thought that if one could get 90 per cent retention of mud we would get clear juices. In his opinion, the Oliver filter was a machine which took in thick mud and finally delivered thin mud.

Mr. Alexander said that he was not quite sure what Davies meant by "organic silica," but that at the S.M.R.I. they had been unable to find evidence of silica organically combined. The silica in a clear clarified juice was entirely of a soluble form originating from three sources namely: that from chemicals used (i.e. lime), that silica which was originally insoluble in the mixed juice and that which was soluble in the mixed juice. The mixed juice was usually nearly saturated with respect to soluble silica but with increase of temperature and pH silica deposited as silic acid on cell walls etc. was made soluble.

Mr. Thumann said that in past years he obtained, as a general rule, very good juice with the sulpho-defecation process. At the beginning of the last season they had experienced difficulty, presumably due to the mud on the cane, and also to lack of bagacillo available.

With extensive experimentation as far as temperatures were concerned, no improvement was found.

With the change-over to simple defecation, there appeared to be no difference in clarity of juice.

He though that as far as Umfolozi factory was concerned, until they got a normal season, it would be difficult to reach any conclusion as to the best method of treating juice.

Mr. **Boyes** considered that by studying the best methods of applying simple defecation in this country, a big improvement in the clarity of the juices would be obtained, although they would not probably be equal to those in other countries. He thought we should follow the basic principles of the processes used elsewhere.

Mr. Thumanm said that in India, when they crushed one variety of cane, Co.419, and used simple defecation, the clarity of the juice there was as good as that obtained with sulpho-defecation in South

Africa. At one factory in India, however, very dark clarified juices were obtained in the 1950 Season. He considered that this was due to very high pH of juice following liming and prior to sulphitation. By reducing the high pH at this tage, an immediate improvement in clarity of juice was observed. He found that testing the pH by means of colour paper was not at all reliable when preliming to a high pH. The reason for production of the poor juice at that factory, therefore, would appear to be too high an alkalinity and too high temperatures for too long a time.

Mr. Phipson said that on comparing colour papers with the pH meter, he found that in the case of sulphitation test papers gave a much better comparable figure than they did with simple defecation. He found big differences between the pH shown by the test papers and the pH meter and he also found similar differences on water,

Mr. Antonowitz was of the opinion that if one wanted to get good results from test papers, one would have to make sure that they were treated at the particular pH range required.

Mr. Elysee said that the performance of the test papers in sulpho-defecation and simple defecation was different, due to the different buffer action in the juice itself.

As far as P_20_5 tests were concerned, he found a big difference between results obtained on hourly tests, as compared with eight-hourly periods. He found that if the solution was left for a long time before testing, a very much higher figure for P_20_5 resulted. He wondered if there should be a specified time limit for these tests.

Mr. Boyes replied that he had found a very great variation in P_20_5 content hour by hour. This he attributed to variation in the cane. He quoted figures from his paper to illustrate this. He had not found that on standing, juice P_20_5 tests changed. He had noticed however that the diluted stannous chloride reducing agent was only stable for four hours and wondered if this was causing the trouble.

Dr. **van der Pol** said that as far as test papers were concerned, he thought that colloidal matter might affect the pH indicated. It had been suggested that the colour of the juice might affect the colour given by the paper.

He asked Mr. Boyes if, from his experience overseas, he would tell the Meeting the method of determining pH and to what extent automatic pH control was used.

Mr. **Boyes** replied that he had observed pH control in a number of factories. In two factories, one using a Kent pH recorder-controller, the other a Bristol, very fluctuating results were being obtained. Both these factories were cold liming and attempted to control the pH at about 8.6. In the first it fluctuated 8.0 and 9.5 and in the second between 6.0 and 9.0. These unsatisfactory results may not have been due to the pH meters concerned and may have been the result of a faulty hook-up. In a third factory a pH recorder was working very satisfactorily. This was a Beckman pH meter with Foxboro recorder, recording the pH of limed juice prior to entering the subsiclers. Special glass electrodes recording at a temperature of 100° C and giving three months' service were being used. The chart shewed a straight line.

The Chairman asked what was the experience at Illovo with automatic liming by pH control for the defecation process.

Mr. C. L. Wagner stated that, provided the flow of juice remained constant, one could get good results, working to 8.5 pH.

Mr. **Rault** stated that with reference to scaling and the rate of heat transmission, he considered that very useful data could be published in the Annual Summary by the S.M.R.L, i.e. "the lbs. of water evaporated per sq. ft. per hr."

He wondered why so few factories brought the thick syrup to a Brix density of 60° and over, specially after being told of the improvement in incrustation through the defecation process.

In his factory working with the carbonatation process and realising an evaporative rate of 8.2 to 8.5 lbs. per sq. ft. per hr., the least amount of cloudy liquor from the filters going to the evaporator caused an immediate drop in evaporation rate, prejudicial to the subsequent rate of pan boiling speed—a department which was always overloaded by remelting and refining operations.

Dr. **van der Pol** considered that the figure suggested by Mr. Rault was not a very useful one, as evaporation depended upon a number of factors, such as Brix of the syrup, etc.

As far as scaling of evaporators was concerned, he said that Dr. Honig had found that the suspended matter in the juice had led to cleaner evaporators. Apart from this, the big reason why one could expect less scaling when using simple defecation was because there were fewer lime salts in the clarified juice.

As far as the dirtiness of the juice was concerned, he was careful to avoid saying that a dirty juice could produce a very good sugar.

Tests done at the S.M.R.L, removing starch and silica, had indicated that quite a lot of the silica was bound up with the fine particles of fibre and also as the starch in the mixed juice was insoluble, they had found that by centrifuging juices prior to clarification they obtained clearer juices.

He also remarked upon the fact that even in the past, using sulpho-defecation, when the appearance of the juice was very good as compared with simple defecation, the filter-ability of the sugar was not necessarily of a high standard. Indeed, there appeared to have been no deterioration by using simple defecation.

Mr. D. C. Ross remarked that experience in the West Indies showed that when clarification was poor, overall recovery was not appreciably effected, and raw sugars polarised at about 97.5°. However, after these sugars had been stored in the sugar store for about two months, and then shipped to the U.K., test results received back, showed a fall in polarisation to somewhere in the region of 93.5°-94°. Could, therefore this be traced back to bad. clarification?

Mr. Antonowitz said that in East Africa there were periods where the sugar was of very poor quality due to poor clarification and this sugar deteriorated readily.

Mr. Carter enquired as to what type of pump was used overseas in handling treated juice so as to preserve the floc.

Mr. Boyes said that in the procedure of double liming single heating, the juice first received the initial lime and was then pumped by a centrifugal pump through the heaters and into the flash tank. The flash tank was so situated above the subsiders that the juice was able to gravitate through the liming device, fluctuating tanks and into the subsiders.

In one factory a reciprocating pump was used. This was of such a capacity as to give a very slow operating speed. The juice was pumped slowly through the heaters and only heated to 212° F so that little turbulence occurred in the flash tank. In this way floc break-up was reduced.

Mr. Hardy enquired what efforts were made overseas to avoid choking the filter screens when liming muds.

Mr. Boyes replied that he found overseas that liming was very common practice. Towards the end of last Season they did find a falling off in filtration at Tongaat. On opening up the screens he found a white deposit which could have been lime. However a black deposit, which he took to be wax, was far more predominant. A modification of practice might avoid this.

Mr. du Toit asked what was the P_2O_5 content of mixed juice overseas, and how it compared with ours here.

Mr. Boyes stated that he considered the figures here to be higher than those he had seen overseas.

The Chairman asked Mr. Perk or Dr. van der Pol for the reason why factories on going over to simple defecation shewed a higher purity of final molasses. Could this be an indication of inability to exhaust through the presence of some refractory non-sugar, and was this a real increase of sucrose lost in molasses?

He considered that the sucrose lost per cent of the sucrose in juice, was more important than the mere expression of the degree of purity of molasses, a figure affected by the influence of certain non-sugars on the Brix hydrometer, as well as the method of dilution for analysis.

The loss in molasses was as much affected by the quantity of molasses produced.

Dr. van der Pol said that every Chemist, where simple defecation had been introduced, was worried about the purity of molasses, for otherwise the only method of judging the loss was to wait until the end of the week.

Mr. Antonowitz said that he had tested Brix by distillation and he found a big difference as compared with the Brix hydrometer. He had tried this out with both sulphitation molasses and simple defecation molasses and he found the same results in each case.

Dr. van der Pol said that similar tests had been carried out at the S.M.R.I., where it was found that the difference in purity between true purity and apparent purity was less in the case of simple defecation molasses.

Mr. Thumann enquired that since the purity of simple defecation molasses was apparently higher, what would be the effect on the boiling house performance? Was the value of the boiling house performance figure affected by the higher purities found?

Mr. Perk replying to the query by Mr. Thumann about the effect of the final molasses purity on the boiling house performance figure, said that the molasses purity only affected the calculation of the crystal content of the sugar. In the case of white sugar the influence was therefore negligible. The same could be said in the case of raw sugar when the difference in purity of the final molasses was small For example, in the case of a raw sugar of 98.50° (Safety Factor 0.25) the crystal content would be 97.90, when the molasses purity was 40.0 and 97.92 when the purity is 39.0. The B.H.P. changed proportionally to the crystal percentage or as 97.90 to 97.92 which was not significant.

Mr. Alexander asked Mr. Boyes if he had actually analysed the deposit on the screens or if he had just assumed it was wax.

Mr. Boyes replied that no analysis was made.

Mr. Hardy said he had tried to steam the screens, without success.

Mr. Elysee said that for years they had found that when the reducing sugars in the juice rose, the quantity of molasses increased, and, at the same time, the purity of the molasses decreased.

He remarked that if there were a higher amount of salts in the molasses, they would increase the Brix unduly. With simple defecation and less salts being present, the Brix spindle gave a nearer assessment of the total solids.

Dr. van der Pol agreed with Mr. Elysee's point.

The Chairman stated that with further study of the various impurities in the juice, a great advance in clarification could be expected.

Visual judgment of the quality of the juice was obviously not an infallible criterion. He however admitted that the raw juice of much cleaner appearance that he had observed in other countries, and even in South Africa, when cleaner canes were sent to the factories, did give a superior clarified juice, easier to process in the factory.

i

WEIGHING THE SYRUP—A TIGHTER CONTROL OF THE SUGAR FACTORY

By J. ANTONOWITZ

On drawing up the Annual Summaries of Chemical Laboratory Reports for several years past, Mr. Chas. M. Perk has repeatedly stressed the importance of drawing up a complete Sucrose Balance. As some factories do not weigh their Final Molasses, a factor (Non-Sucrose Ratio = 0.83) was estimated for all factories. With the help of this factor the Tons of Sucrose lost in Molasses and the approximate undetermined losses can be calculated.

This factor is based upon the assumption that a constant 17 per cent, of the non-sugars is eliminated by the clarification at the filter station.

Examination of Table L—Thirtieth Annual Summary of Chem. Lab. Reports, 1954-55 season, which reviews the non-sucrose ratios of several factories during recent years—discloses the fact that rather abrupt deviations from the mean are prone to occur. A striking deviation was that calculated for the AK factory for the 1954-55 season, the values being 0.82, 0.81, 0.84, 0.86 and 0.74. Values reported for UF were regular at 0.82, 0.89, 0.83, 0.85, 0.82. For no immediately apparent reason, this, 1955-56 season> this average ratio has dropped to 0.74. From consideration of the comment given by Mr. Perk on Table L, it was concluded that this drop is due to a greater elimination of non-sugars at the filter station.

The non-sucrose ratio has been calculated on a weekly basis and graphed together with the B.H. Recovery to shew the dependance of good factory recoveries on better clarification, or rather, on better non-sucrose elimination. The greater overall elimination of non-sucrose at the filter station at UF this season could be attributed to the very high percentage of muddy cane

This is by the way, but illustrates how apparently reliable factors can be rendered misleading by unsuspected occurrences. It also emphasises the value of a sucrose balance computed on properly weighed constituents. Even if the molasses are weighed, a reliable sucrose balance can not be secured if the weight of filter cake produced is estimated by expedients. The utility of carefully weighed filter cake is still dubious, if no allowance is made for the sucrose reintroduced into the process by the bagacillio added at the filter station. Mr. W. A. Powe, of the Oliver Filter Corporation, clearly describes a method for the estimation of this reintroduced sucrose, in an article in the "Proceedings of the Sixth Annual Congress of the I.S.S.C.T., 1938."

article in the "Proceedings of the Sixth Annual Congress of the I.S.S.C.T., 1938."

It is contended by many that a great deal of lattitude can be allowed when computing the tonnage of filter cake discarded—because, after all, the amount of sucrose involved (expressed as sucrose per cent, sucrose in cane) rarely exceeds 1.0 per cent.; a big error in the calculated weight would have to occur before a significant increase or decrease of this parameter would become evident. This lattitude becomes an acute embarrassment when exceptionally high undetermined losses are disclosed by the calculation of the sucrose balance, particularly if the molasses per cent, cane figure shews a relatively marked increase.

If the weight of sucrose in filter cake discarded at the filter station is accurately known, the undetermined losses can be calculated in a perectly straightforward manner.

To avoid the weighing of trucks of filter cake, or the use of expedients of a doubtful nature to secure the approximate weight of sucrose lost at the filters, it is contended that a most precise and almost foolproof chemical control could be instituted if the syrup was weighed. The difference between the weight of sucrose in mixed juice and the weight of sucrose in syrup could then be allocated to sucrose lost in clarification and filtration. In this way losses due to entrainment, and/or inversion, and/or negligence at the filter station could be pinpointed. Attention is drawn to Mr. Rault's paper (S.A.S.T.A., 1939) on the calculation of sucrose balances, and to Mr. M. Viger's paper entitled "High Unknown Losses caused by Entrainment during Evaporation and Boiling of Sugar Cane Juice," S.A.S.T.A., 1933; wherein reference is made to the desirability for weighing the syrup.

If one calculates the "sucrose available" in mixed juice by the S.J.M. Formula and compares this figure with the "sucrose available" as calculated on the purity of the syrup, it will be noted that the sucrose actually recovered in the sugar corresponds much closer to that indicated by the calculation using the syrup purity. That is, as is evident, the S.J.M. calculation is made after allowing for the *actual* and not an arbitrariaUy assumed non-existent clarification effect. This is illustrated by the following calculation made on the figures of the UF 1954-55 crop.

Purity of Sucrose	100.00
Purity of Molasses	38.86
Purity of Mixed Juice	84.84
Purity of Syrup	86.46
Tons of Sucrose in Mixed Juice ...	90394.347
Tons of Sucrose in Filter Cake ...	710.970
Tons of Sucrose in Syrup	89683.377
S.J.M. Retention Factor calculated on Mixed Juice purity	88.645
S.J.M. Retention Factor calculated on Syrup purity	90.049
Tons sucrose available in sugar calculated on Mx. Ju. Purity: $\frac{90394.347 \times 88.645}{100.00}$ ... ... =	80130.069
Tons sucrose available in sugar calculated on Syrup purity: $\frac{89683.377 \times 90.049}{100.00}$ ... ... =	80758.984
Tons sucrose in Sugar actually produced	80768.802
Shortfall on Mx. Ju. purity calculation...	638.733
Shortfall on Syrup purity calculation...	9.818

In the above calculation the average F/S Ratio of the filter cake produced during the season was available, therefore the tons of sucrose returned into process by the bagacillio was calculated. This amounted to 173.245 tons. This tonnage was deducted from the total tons of sucrose in filter cake, so that the proper weight of sucrose in syrup could be found. The difference of only 9.818 tons of sucrose between the calculated value and the amount actually recovered in the sugar made during the season, shews a remarkably close agreement, and appears to be the most convincing illustration of the utility of the proposed positive refinement in the chemical control. It is also one very substantial reason why the weighing of syrup and not clear juice is insisted upon.

Examination of the graph (attached), which shews the almost absolute dependence of recovery on non-sucrose elimination, evokes the conviction that, if the syrup is weighed, a quantitative daily determination of the non-sucrose elimination effected by the clarification procedure will be established. In other words a positive control on clarification, filtration, and boiling will become a reality. It will no longer be necessary to wait until the end of the week to discover from the B.H. Recovery or from the B.H. Performance figures whether the filtration or clarification was operating properly.

In a paper entitled "One Year of Weekly Factory Report Data," S.A.S.T.A., 1951, Dr. Douwes-Dekker points out that the amount of non-sucrose in clarified juice, which in normal cases is nearly equal to the amount of non-sucrose in final molasses, largely determines the weight of final molasses which will be produced. It is therefore contended that the ratio of non-sucrose in syrup to non-sucrose in mixed juice, if determined quantitatively, will give a daily and a positive quantitative estimation of the amount of molasses being made, as well as providing a measure of the amount of molasses formers in the juice, which have been removed by the filters.

The weekly calculation of the non-sucrose in molasses/non-sucrose in mixed juice ratio at UF shews a marked variation from the mean of 0.74 (0.83 for all factories, as calculated by the S.M.R.L). Values as low as 0.60 and as high as 0.90 have been found. As the low ratios consistently coincide with high recoveries and the high ratios coincide with low recoveries, while the mixed juice purities remain fairly constant, it is felt that a definite proof has been established that the removal of non-sugars in the current clarification and filtration procedure occurs in a most erratic manner. The mixed juice purities do not vary widely week by week, or even day by day for that matter, hence, if the clarification procedure is conducted at its optimum efficiency, with the help of the daily non-sucrose ratio determined by the weighing of the syrup, the fluctuation in the efficiency of the removal of non-sugars would be eliminated and a fairly regular and constant optimum weekly recovery figure would be secured.


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
NON-SUCROSE IN MOLASSES/NON-SUCROSE IN MIXED JUICE RATIO
BOILING HOUSE RECOVERY
92.0
91.0
90.0
89.0
88.0
87.0
86.0
0.60
0.70
0.80
0.90

Mr. Rault, in the Chair, said that we were grateful to Mr, Antonowitz for his bringing forward again the idea of such a further refinement in chemical control. Some years ago at Natal Estates, it was customary to weigh syrup but in recent years owing to remelted sugars and other liquids returned back to clarification, it had been abandoned, much to his regret. Without weighing the syrup the correct location of undetermined losses became very obscure, can be heavy by entrainment at the evaporation stage and at other times, later in the boiling house. It was no longer possible to determine the amount of sucrose entering the boiling house before and after evaporation.

Mr. Perk said he wanted to draw attention in particular to the statement made where Mr. Antonowitz says: "The greater overall elimination of non-sucrose at Umfolosi could be attributed to the very high percentage of muddy

The high amount of finely suspended clay would have affected the determination of brix per cent mixed juice and in this manner the ratio figure. Regarding this ratio he wished once more to draw attention to last year's discussion on this subject (Proc. 29th Annual Congress, page 27) which reads:

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

Mr. Perk pointed out that the ratio of 83 was only a mathematical form. Naturally these factors depended upon how they were calculated and in this case it was meant just as a means of calculating the amount of molasses/'

He could not agree with Mr. Antonowitz's statement that the ratio assumes that 17 per cent of the non-sugars had been eliminated by the clarifiction and he could not possibly agree that it was *based* on 17 per cent removal of non-sugars. In this respect he pointed to Mr. Bax's remark. Moreover during the manufacturing process not only were non-sugars eliminated but also non-sugais were formed.

Regarding the weighing of syrup, he had previous experience when at ten of the factories at which he was consultant, syrup weighing was introduced.

It appeared that it was more difficult than anticipated to obtain a representative sample of the syrup weighed. The weighing of syrup showed that 1/4—1/3 of the undetermined losses occurred between mixed juice and syrup weighing; the balance occurred between syrup and sugar weighing.

We must not overlook the fact that weighing of syrup did not reduce undetermined or other losses. To reduce undetermined losses, they had to be tracked down first and appropriate measures had to be taken to reduce or eliminate them. For example, syrup weighing would not tell which of the vacuum pans entrained; this had to be detected by other means. The same had to be said about the prevention of the entrainment by the evaporator.

Mr. Elysee pointed out that Mr. Viger's paper was written because he had found an enormous difference between sucrose entering the factory with the mixed juice and that received in the syrup, clue to very heavy entrainment. There was no doubt that there was a big loss between mixed juice and syrup, most of it loss in the evaporator.

Mr. **Antonowitz** replied that one reason for weighing syrup at Umfolosi factory was the fact that they were considering introducing a belt conveyor to take away the filter cake, which made it impossible to assess the loss in this substance. Lack of weighing syrup reduced the efficiency of the chemical control.

Mr. Carter stated that unless the sucrose introduced at the filters in the bagacillo used were taken into consideration losses could not be determined accurately.

Mr. E. H. Phipson considered that the weighing of syrup would be an advantage at the factory in which he was employed. There they had no idea of what the loss was in filter cake. The difficulties consequent on weighing the syrup however would be brought about by sampling and also the necessity of having to carry out the Jackson & Gillis test. He said that a manually operated scale would he more successful than an automatic one.

Mr. Rault asked Mr. Perk to explain why he considered the sampling of syrup so difficult, against the common practice of weighing thick exhaust molasses.

Mr. Perk replied that in the case of final molasses the variations in per cent brix were small compared with the big variations especially encountered when weighing syrup. These variations in density made it difficult to collect a sample representative of the quantity of syrup weighed. Moreover the molasses quantity was 21/2 per cent on cane only, compared with 30 per cent on cane in case of syrup; the sucrose content of the latter being about 55 per cent. This made really representative sampling of syrup of the greatest importance.

Mr. **Elysee** considered that weighing of molasses was of far greater importance than weighing syrup. As far as loss in filter cake was concerned, this was a very small amount, and not of very great importance.

The Chairman considered that weighing of molasses was an essential part of chemical control and that all factories should weigh their molasses. He stated that even at Tate & Lyle's refinery where the chemical control was a very strict one, they were still not able to trace separately all undetermined losses, three quarters of which were not located.

Mr. Antonowitz stated that provided one knew the loss in filter cake one could definitely say one knew the actual undetermined loss in the factory. Without the knowledge of this loss, it was impossible to do so.

Dr. van der Pol said that there were alternative means of calculating the quantity of filter cake and he quoted those used in Australia.

Mr. Antonowitz said that which ever way one looked at it one had to carry out a certain number of operations even if one used alternative methods determining loss in filter cake, and as a certain number of operations had to be carried out, why not weigh the syrup?

Mr. **Elysee** pointed out that the loss in filter cake was so small that unless this rose to an inconceivable amount it could not affect the sucrose balance. As the Amatikulu factory weighed the molasses it was able to determine the loss in molasses. The undetermined losses could thus be isolated.

Mr. Phipson said that he had considered trying to arrive at the weight of filter cake by recording the number of revolutions of the filter and taking samples from different areas, but he found that the variation in the thickness of the cake was so great that the figures would be quite unreliable.

SOME NOTES ON THE DETERMINATION OF THE GRIST OF SUGARS WITH REFERENCE TO THE MEAN APERTURE--CO-EFFICIENT OF VARIATION CONCEPT

By DENNIS HASTILOW

It is possible to obtain most substances in the form of discrete particles, but whether these particles are grown from a small neucleus, as in the case of sugar, or reduced to this small size from larger particles, it is only under the most carefully controlled conditions that all the ultimate particles will be of the same size. Even the shapes of these ultimate particles are not readily made to conform exactly to any predetermined configuration, and for a long time, efforts have been made to find a simple and easily comprehended method of expressing the overall picture of the variations in sizes and shapes of the particles in a given mass of material.

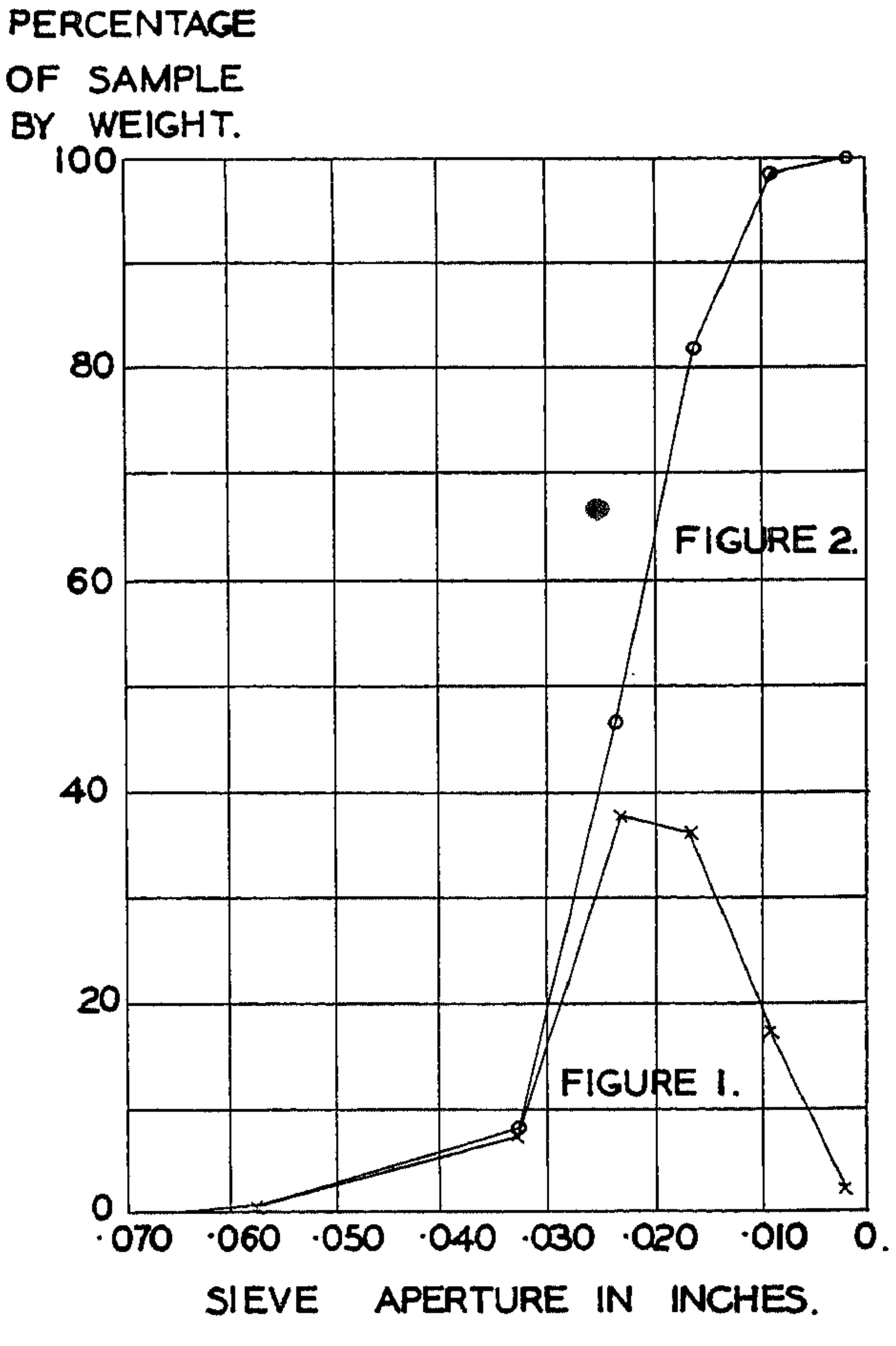
In case these efforts may be thought of as just another manner in which a scientist or technologist can justify his spending (some would even be unkind enough to say wasting) a lot of time, there are many instances of the practical use of a close appreciation of the variation in shapes in sizes from the desired or average value.

To take two examples only from our own industry, in the case of raw sugar manufacture, it is important that the magma used for seeding should be of as uniform a size as possible and without conglomerates, so that the final product will also have crystals of uniform size and shape, since this facilitates the spinning and drying of the massecuite. At the moment, this procedure of magma seeding lies within the province of the sugar miller, but it is quite possible that in the not too far distant future, some form of magma seeding may be used in the refinery. In the case of refined sugar, it is the variations in size and shape of crystals which are responsible for the attractive or otherwise appearance of the finished product.

At a previous S.A.S.T.A. Congress, Dr. Douwes Dekker[1] read a paper connected with the properties of raw sugar, in which he stressed the desirability of obtaining raw sugar in the form of single crystals without conglomerates and of as regular a size as possible. The reason for this, he pointed out, was that the improved purging, washing and drying would reduce the molasses film to as small an amount as possible, the advantage of this being that most deterioration problems find their source in this unwanted substance.

The actual irregularities of grain size also have an effect on deterioration from the physical standpoint, as opposed to the chemical factors usually considered, since the small grain readily fills up the spaces between the large grains, and this process continues with every small vibration until the pile of sugar would eventually consolidate even with a minimum of chemical deterioration.

In this same paper, Dr. Douwes Dekker introduced, I believe, to Natal the concept of Specific Grain Size, which is one of the methods mentioned earlier of reducing to a description in simple terms the variations in size of the particles of any material.



Without wishing to become involved in arguments concerning the merits and demerits of this idea, I should now like to place before you another concept, that of Mean Aperture and Co-efficient of Variation which was evolved by Philip Lyle, and is in common use in the Tate & Lyle refineries, both in the laboratory, and in the pan house.

This concept is described in the *International Sugar Journal* in an article by Powers,[2] and it is extremely simple in use since only two sieves are necessary once certain prerequisites have been determined.

The first requisite concerns these sieves, and it is the fairly obvious one that they should have a high standard of accuracy and their aperature sizes should so be chosen that the one of larger aperture should retain about 10 per cent. of sugar, and the one of smaller aperture should allow about 10 per cent, of the sugar to pass, when the sieving operation has been allowed to proceed for such a time that any sieve has passed all the sugar that it is capable of passing.

The second requirement concerns the sugar itself and is more easily understood if one considers mathematically and graphically a complete gristing with a full range of sieves. Fig. 1 represents a typical grist analysis of Hulett's refined Sugar, plotted with the sieve aperatures as abscissae and the percentages remaining on each sieve as ordinates. This- shows a rather wide peak with a spread each side into coarse and fine fractions, and the aim of a sugar refiinery is to produce refined sugar which has as high a peak as possible with a narrow but symmetrical spread on each side.

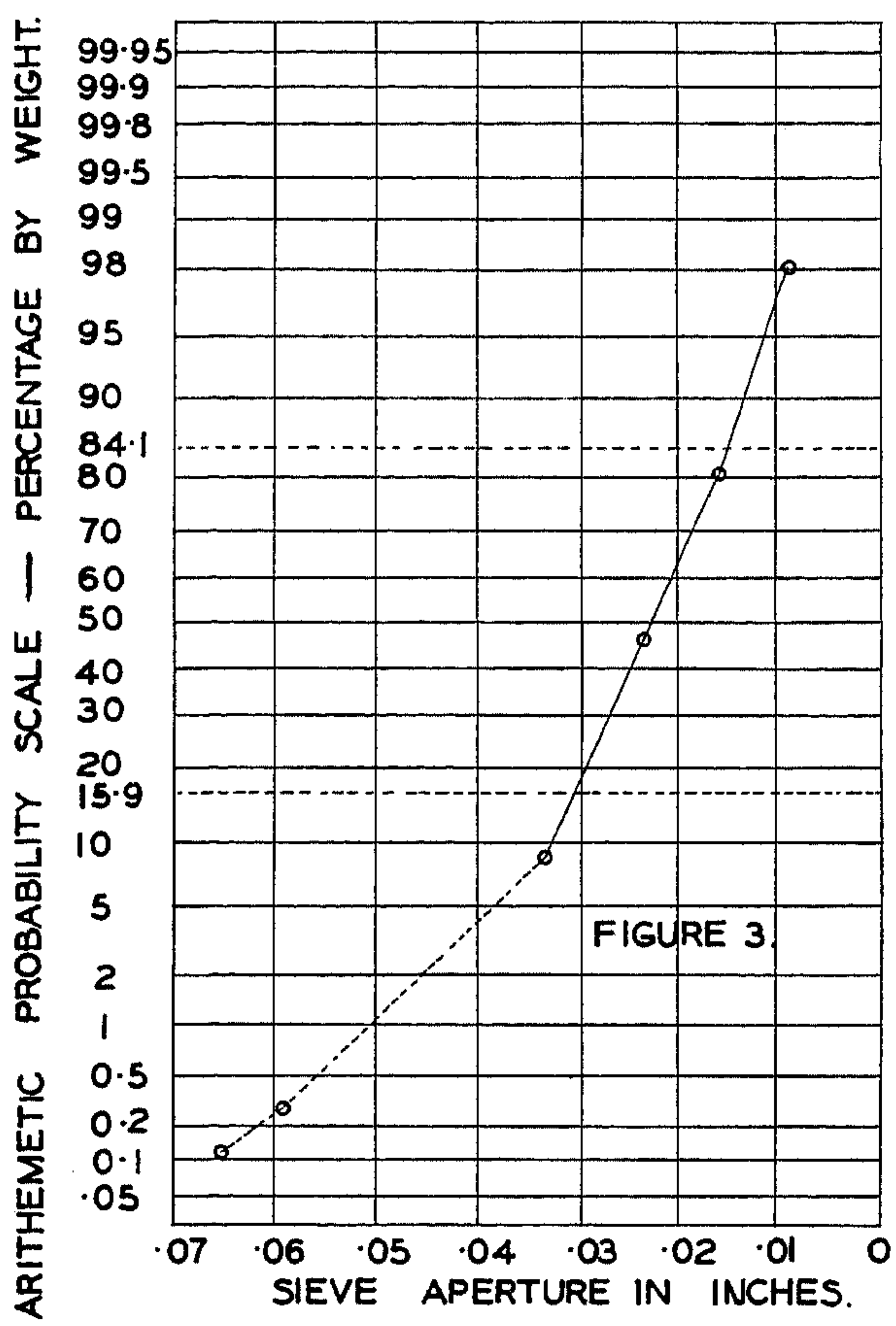
If, instead of plotting the actual percentages retained by each sieve as ordinates, one plots the cumulative percentages, that is, the percentage retained by each sieve, plus the percentages retained by aU sieves having a bigger aperture than the particular one in question, the graph assumes the from of Fig. 2, which is seen to resemble a straight line, with a certain amount of fading-away at each end, i.e. in the 0 to 10 per cent, and the 90 to 100 per cent, regions.

If the sieving results used for Fig, 2 are further plotted on arithmetic probability graph paper, the line becomes much more closely a straight line, and within the region 10 to 90 per cent., it can be assumed to be straight within the limits of the experimental errors involved in the actual sieving determinations. This gives the graph in Fig. 3.

This is the second requirement of this present concept and it leads to the simple mathematical fact that only two points on the graph are required to fix completely the straight line, and this is the explanation for the sieving determination only being carried out with two sieves as detailedin the first requisite.

Once the two sieving results have been obtained, and the graph has been drawn, the Mean Aperture can be read directly from the graph, since it is defined as the size of sieve aperture which would retain 50 per cent, by weight of the sample and would permit 50 per cent, by weight to pass.

The mathematical theory of statistics is now brought into use, and this states that in a normal distribution, there are two sizes, one larger than, and one smaller than, the Mean, each of which differs from the mean by a certain amount, and this certain amount is called the Standard Deviation. Furthermore, 15.9 per cent, of the sample will be bigger than this standard deviation above the mean size, and 15.9 per cent, will be smaller than the standard deviation below the mean size. It is an easy matter



therefore, to see that the Standard Deviation can be found from Fig. 3 by reading off the sieve apertures corresponding to 15.9 per cent. retained, and 84.1 per cent. retained, and the difference between these two sieve sizes will be twice the Standard Deviation.

In actual use in Tate & Lyle's refineries, and in Hulett's South African refineries, off the Means and drawing the graph and reading off the Means and Standard Deviations, has been obviated by the working out of a set of tables which relate the required results directly to the percentages remaining on the two sieves.

Tate & Lyle consider that the characteristics of the grain size distribution of a sugar are better described by the ratio of the Standard Deviation to the Mean Aperture rather than the Standard Deviation itself, and it is this ratio expressed as a percentage which is termed the Co-efficient of Variation.

Thus the present concept can be summarised as follows: The Mean Aperture is the calculated aperture which would retain 50 per cent, by weight of the sample and allow the other 50 per cent, to pass, and the Co-efficient of Variation is the difference between the two calculated aperture sizes, which would retain 15.9 per cent, and 84.1 per cent, respectively divided by twice the Mean Aperture and multiplied by 100.

In the actual example taken for Figs. 1, 2 and 3, the Mean Aperture is read from the graph to be 0.022 inches. The aperture retaining 15.9 per cent, is read off as 0.029 inches and the aperture retaining 84.1 per cent, is read off as 0.014 inches. Thus the Co-efficient of Variation is calculated as:

$$\frac{0.029'' - 0.014''}{0.022'' \times 2} \times 100 = 34$$

Hence the sugar taken for this example would be described as having the following grist analysis: M.A. 0.022", C.V. 34.

Tate & Lyle have fixed specifications for their several sorts of refined and castor sugars, and without going into details, it is sufficient to say that the pansmen are fully aware of this simple method of expressing the appearance of the sugar they have boiled, and they also know whether it is necessary for them to make any adjustments to their boiling technique to improve their next pan.

Acknowledgements

I should like to express my thanks to the management of Hulett's South African Refineries for permission to publish this short paper and to my colleagues for their encouragement.

I should also like to place on record my delight at being the means of bringing to an end a long series of sustained silences by the staff of Hulett's South African Refineries in so far as the reading of papers is concerned, and I would like to express the earnest hope that more regular contributions will be made at future Congresses of the S.A. Sugar Technologists' Association.

Summary

A discussion is entered into concerning sizes and shapes of particles, with particular reference to sugar, and mention is made of the concept of Specific Grain Size.

It is then concerned with the Mean Aperture-Co-efficient of Variation concept, as evolved and used by Tate & Lyle, with definitions of the terms, and a description of the method of obtaining these values by a single sieving using two carefully chosen accurate sieves.

[1] Douwes Dekker, K. (1952): Some Notes on the Properties of Raw Sugar in connection with Deterioration during Storage, Proc. S.A. Sugar Tech. Ass. 26, p. 40.

[2] Powers, H. E. C. (1948): Determination of the Grist of Sugars. Int. Sugar Journal. Vol. L, No. 594 (June, 1948), p. 149

The Chairman, Mr. Rault, said that the subject of this paper was of some importance in standardising our final product.

Sugar sales are, and would continue to be, on appearance, and laboratory tests should in some measure agree with the superficial judgement of the buyer. Colour determinations are now standardised by the I.C.U.M.S.A., and it is hoped that figures referring to crystal size and its regularity would also be accepted by the consuming public.

He hoped Mr. Hastilow would be successful in educating buyers to appreciate figures expressing the grain-size of sugar, rather than the visual appearance.

Mr. Hastilow said he was not quite sure that the public really knew what they wanted as far as grain size was concerned. He found that some people who asked for a smaller grain-size, when confronted with a more regular grain which was even bigger than before, were completely nonplussed.

Mr. Boyes asked Mr. Hastilow what application this method would have to raw sugars. At Tongaat they prefer to measure crystal sizes under a microscope. He also thought that the actual sieving operations might break up the grain.

Mr. Hastilow replied that the sieves did tend to break up the grain to a slight extent but were more likely to break up congolmerates.

He stated that even by washing raw sugar with 70 per cent alcohol saturated with sucrose, it was difficult to keep the crystal size at its original level.

If, however, the sugar could be sieved, this would be much easier to do than to try and measure large quantities of sugar under a microscope.

Dr. **van der Pol** enquired of Mr. Hastilow what the average mean variation would be in a raw sugar which would be of good affination properties.

Mr. **Hastilow** replied that even though the Refinery was interested in the crystal properties of raw sugar from the point of view of good affination it was much more concerned at the moment with the factors causing deterioration and consolidation.

Mr. **Beesley** said that the two methods of determining grain size (sieve test and photomicrographic) both had their own advantages and disadvantages. For instance, the sieve test was very much quicker than the photomicrographic method and hence was more applicable to good dry sugars. However it was practically impossible to apply it to a C sugar and hence the micrographic method was the best to use

A vast number of photomicrographic analyses had been carried out at the S.M.R.I, and had clearly shown that this method, where the basis was number of crystals (in the sieve method the basis is weight of fractions), also gave a normal distribution of sizes and that the Mean Crystal Length and Co-efficient of Variation best described the properties of the crystals.

It therefore appeared that the two methods could possibly be correlated by some formula, such that it would be possible to express crystal properties by the M.A.—C.V. concept no matter how the analyses had been carried out.

This would be of immense value would cover the complete range from dry refined to sticky C sugars.

The Chairman said that possibly through slower growth, it was common experience that graining from a comparatively low purity liquor, produced a very uniform size crystal, whilst the product crystallised from the purer refinery liquors, contained more

A quick method of determining the size and proportion of crystals, specially in a viscous massecuite, would be very valuable, as regularity of grain was an advantage in the purging of massecuites.

He had observed some very regular, although small crystals, in beet factories, but this regularity was obtained by sieving installations at the bagging department, and was not due to more efficient methods of pan boiling.

Mr. **Hastilow** said he considered the explanation for poor crystal sizes of refined sugar was that the sucrose liquor was so highly super-saturated that sucrose had to be deposited on any face of the crystals, so they did not grow regularly, whereas, with low purity material, where the deposition of sucrose was slower, it was easier to obtain regularly shaped crystals. He considered that the specific grain size could not give a reasonable description of the sugar, whereas the co-efficient of variation could do so.

Mr. Perk replying to Mr. Hastilow drew attention to the fact that the specific grain size was never used alone, where description of a sugar was concerned, but always together with two other characteristics.

In the paper read by Dr. Douwes Dekker at the 26th Annual Congress when discussing "Size and Regularity of Sugar Crystals," Dr. Douwes Dekker mentioned as ultimate characteristics:

(i) the specific grain size of the sugar (s.g.s.), which was calculated from the weights of the fractions by a method described in Appendix II;

(ii) the weight of the main fraction;

(iii) the weight of the finest fraction(s).

(see Proc. 26th Congress; p. 40.)

These three characteristics give a complete picture of the size and the regularity of the sugar concerned.

The Chairman said he was glad to have such a paper because it was high time we departed in the sugar industry from mere subjective opinion, and were able to express conditions and standards by figures.

REPORT ON TESTS ON THE ESCHER WYSS CONTINUOUS CENTRIFUGAL AT ILLOVO DURING NOVEMBER, 1955

By E. BEESLEY

INTRODUCTION

In the 1955 Proceedings of this Congress we were given an excellent paper on the performance of one of these machines (Escher Wyss Continuous Sugar Centrifugal, Model C 4/4) in Mauritius by Mr. P. E. Bouvet of that country.

In the discussion on this paper Mr. Farquharson mentioned that he had always been led to believe that Natal sugars were more "difficult" to process than elsewhere in the world and, for this reason, he wondered if the performance of such a machine could be repeated in Natal.

This, the author thinks, expressed the feelings of quite a number of the technologists present, hence the results of the tests at Illovo have added interest.

The answer appears to be that the machine can handle Natal massecuites equally well as those of Mauritius.

DESCRIPTION OF THE MACHINE

Bouvet in the aforementioned paper[1] gave a very good description of the C 4/4 Type Escher Wyss Continuous Sugar Centrifugal and hence it seems redundant to redescribe it here.

The Illovo machine was equipped with the more powerful oil pump (allowing up to 48 strokes per minute) for all the tests.

The screen slot width was 0.30 mm.

The set-up of the machine was such that the A massecuites to be tested, were struck into B crystallizers and hence transferred by screw conveyor and pump to a large mixer above the centrifugal.

B massecuites were transferred to this mixer in the same way, and white strikes were struck directly into it from No. 1 pan.

The discharge from this mixer was manually controlled into a small, hot-water-jacketed, stirred vessel in which the massecuite level was maintained at a constant head and then discharged *via* a variable head weir into the centrifugal feed pipe, the variable head weir being used to regulate the rate of feed to the machine.

TESTS AND RESULTS

As there were two distinct types of massecuite to be tested, that is, Mill White massecuites and Raw Sugar massecuites, the results and comments are best divided into three sections:

1. Mill White
2. Raw Sugar
3. General

1. Mill White Tests

The main objects of the tests on Mill White massecuites were to determine -

(a) the capacity of the machine, both input of massecuite and output of sugar;

(h) the quality of sugar;

(c) the quantity of wash water required to achieve this quality.

The results are tabulated in Tables I, II and III.

TABLE I

General Results Obtained with the Mill White Massecuite Tests

Product	White	White	White	White
Massecuite Type	First	First	Second	Third
Test No.	1	12	2	3
Date	1 Nov. 1955	24 Nov. 1955	3 Nov. 1955	3 Nov. 1955
Masse. Bx.	89.0	89.5	89.9	89.75
Masse. Apparent Pty. .	99.8	99.8	99.7	99.4
Run-off Bx	76.25	75.5	78.25	79.0
Run-off Apparent Pty.	98.1	99.4	98.6	97.6
Sugar Moisture per cent	1.13	1.77	1.60	2.08
Sugar Reducing Sugar per cent	Nil	—	Nil	0.006
Sugar Ash per cent ...	0.004	0.006	0.008	0.019
Sugar Col. Index	31	N.D.	59	110
Sugar SGS (Sieve Test)	0.53	N.D.	0.48	0.43
Masse. Temp. °C... ...	65.0	68.5	69.0	72.0
Wash Water Temp. °C.	87.5	89.0	96.0	95.0
Run-off Temp. °C ...	64.0	64.8	66.3	69.1
Wash Water Flow Rate 1/m...	5.15	3.80	5.55	6.66
Wash Water Flow Rate gall./cu. ft. Masse. ...	N.D.	0.19	0.30	0.24
Revs. per minute	870±	877	870±	870±
Strokes per minute ...	38±	37.8	38±	38±
Current amp	35–39	35–39	35–39	35–39
Masse. Curing Rate cu. ft./min.	N.D.	4.38	4.05	6.08
Masse. Curing Rate tons /hour	N.D.	12.16	11.20	13.60
Sugar Output tons/hr.	N.D.	5.06	4.48±	5.44±
Sugar per cent Masse. Output	N.D.	41.6	40±	40±
Visc. Run-off at Run-off Temp. cp...	85.0	N.D.	N.D.	N.D.

TABLE II

Comparison of Sugars produced from the same Massecuite by the Continuous Centrifuge and the 36″ × 1000 rpm Vertical Machines

Massecuite—First White Test—No. 1 Date—1/11/55

Centrifugal	Moisture per cent.	Red Sug. per cent.	Ash per cent.	Colour Index	S.G.S. (Sieve Test)
Escher Wyss ...	1.13	Nil	0.004	31	0.53
36″ Vertical ...	1.12	Nil	0.006	47	0.70

Table showing the Percentage of Lumps returned to Process from the Finished Sugar from the Continuous Centrifugal and from the 36" X 1000 rpm Vertical Machines

Masse. Type	First White	Second White	First White	First White	Second White
Test No. ...	12	—	—	—	—
Date	24 Nov.	22 Nov.	15 Nov.	24 Nov.	24 Nov.
Escher Wyss	1.85	2.43	—	—	—
36″ Vertical	—	—	1.32	1.28	0.82

Comments

(a) Massecuite Quality

The massecuite quality, as indicated by both analyses and appearance, was normal for all the massecuites used in the tests. The massecuites were all spun as soon as they were struck from the pan, as this is normal practice.

In the case of Test No. 1 the massecuite was split, half into the continuous centrifugal mixer and half into the mixer feeding the normal white sugar battery for sugar quality comparison. This latter battery consists of 7 X 36" X 1,000 r.p.m. belt - driven machines, which have fixed steam supply and manual washing (hose) and discharge.

(b) Sugar Quality

The quality of the sugar is assessed from the figures given in Tables I, II and III.

It will be seen from the figures in Table II, which were determined for the "split" strike mentioned above, that the sugar from the continuous centrifugal was highly comparable to that from the verticals in moisture, reducing sugars and ash content, somewhat better on colour index and gave a considerably smaller specific grain size by sieve test.

The latter two points require further comment.

Firstly, at the time that these tests were conducted the spectrophotometer normally used for colour determination at the S.M.R.I, was out of order and hence all the colour determinations recorded for these tests were carried out on the stand-by instrument, which is not as accurate and which does not give results comparable to the standard machine.

However, the figures (Tables I and II) do indicate that the colour index of the continuous centrifugal sugars, was better than that of the conventional machines, which in turn indicates better washing.

Secondly, the sugar samples were collected prior to the sugar drier and hence had to be dried in the laboratory before determining the specific grain size. This *is* an unsatisfactory operation due to the likelihood of crystals sticking together while drying, so giving an inflated value to the S.G.S. Hence the most that can be said about the specific grain size figures is that the sugar from the continuous centrifugal was finer than from the conventional machines. This could be caused by a grinding or crushing action on the crystals, mainly in the layer adjacent to the basket wall, as the sugar is pushed through the machine.

Further evidence that crystals were being crushed is that the appearance of the sugar from the continuous machine was duller than is normal. Unfortunately, brightness figures cannot be quoted due to the spectrophotometer at the S.M.R.I, being out of order as mentioned previously.

Table III gives confirmation to the observation by the Illovo staff that a higher percentage of lumps of sugar rejected by the final screen (before bagging), resulted from the massecuites processed in the continuous centrifugal. However, the increase does not appear to be more than about 1 per cent. on sugar produced.

(c) Wash Water Requirements

The figures shown in Table I and wash water requirements determined for seven strikes processed by the 36-in. conventional machines, show that the continuous centrifugal required only half the quantity of water (0.25 gall./cu.ft. massecuite compared to 0.5 gall./cu.ft.) and no steam, to achieve the same degree of washing. This is presumably because of the tumbling action of the sugar as it passes from basket to basket.

(d) Capacity

All the tests were conducted such that the output of sugar was at the normal rate required by Illovo, which appeared to leave the machine with ample capacity in hand.

The sugar per cent, massecuite figure for Mill Whites at Illovo is normally rather low (of the order of 40 to 45 per cent.) and hence the figures for massecuite curing rate rather than sugar output give a better idea of the machine's capacity under easy conditions.

2. Raw Sugar Tests

The Raw Sugar tests were complicated by the fact that both A and B massecuites had to be tested; the former for the production of both raw sugar and affinated sugar for mill white production, and the latter (B massecuites) for the production of raw sugar only.

Again, the main object of the tests were to determine:

(a) the capacity of the machine, both input of massecuite and output of sugar;

(b) the quality of the sugar;

(c) the quantity of wash water required to achieve trus quality.

The results of the tests are shown in Table IV.

TABLE IV

General Results Obtained with the Raw Sugar Massecuites

Product...	AFF.	AFF.	RAW	RAW	RAW	RAW		RAW
Massecuite Type...	A	A	A	A	A	A		B
Test No.	8	10	4	5	6	11A	11B	9
Date	15 Nov. 1955	17 Nov. 1955	10 Nov. 1955	11 Nov. 1955	14 Nov. 1955	18 Nov. 1955		16 Nov. 1955
Massecuite Brix	91.75	90.50	91.75	92.75	91.50	91.00		93.25
Massecuite Apparent Purity	86.9	87.5	89.6	87.5	87.4	87.9		76.6
Mother Liquor Brix	82.25	81.25	N.D.	N.D.	N.D.	81.5		88.25
Mother Liquor Apparent Purity	70.5	75.1	N.D.	N.D.	N.D.	75.0		59.5
Molasses Brix	79.79	78.75	83.0	84.25	82.5	80.0	79.25	84.5
Molasses Apparent Purity	73.2	77.0	74.7	70.9	70.6	75.3	75.4	60.9
Purity Rise	2.7	1.9	N.D.	N.D.	N.D.	0.3	0.4	1.4
Sugar Pol	97.4	97.65	97.9	97.75	97.4	96.5	95.7	97.8
Sugar Moisture	1.75	1.95	1.23	1.01	1.35	2.08	2.83	1.07
Sugar Purity	99.14	99.59	99.12	98.75	98.73	98.55	98.49	98.86
Lumps Pol	95.0	94.7	N.D.	92.8	93.0	92.7	92.5	93.8
Lumps Moisture	3.57	3.71	N.D.	3.76	3.80	4.37	4.62	3.67
Lumps Purity	98.5	98.3	N.D.	96.4	96.7	96.9	97.0	97.4
Percentage Lumps	2.55	2.79	N.D.	N.D.	4.73	2.44	4.11	6.88
Massecuite Temperature °C	55.6	58.7	56.5	59.9	54.9	56.6	56.9	63.9
Wash Water Temperature °C	96.7	88.5	—	—	—	—	—	92.0
Molasses Temperature °C	51.9	56.45	56.5	56.6	50.2	51.5	51.4	55.8
Steam Press p.s.i.g.	16.6	16.5	—	16.0	16.8	—	16.4	16.4
Wash Water Flow Rate l/m	5.10	2.57	—	—	—	—	—	3.415
Wash Water Flow Rate gall./cu.ft.Masse.	0.245	0.113	—	—	—	—	—	0.384
Revs. per minute	942	951	840±	950±	954	871	825	988
Strokes per minute	36.2	35.6	35.5	36.0	34.9	35.6	36.4	40.7
Current amps	36–40	36–40	N.D.	39.6	36–40	36–40	36–40	36–40
Massecuite Curing Rate cu. ft./min.	4.58	4.99	4.08	4.52	3.67	4.33	4.33	1.96
Massecuite Curing Rate tons/hour	12.82	13.87	11.39	12.68	10.22	12.06	12.06	5.51
Sugar Output tons/hour	6.50	6.19	6.48	7.34	5.58	6.39	6.39	2.14
Sugar per cent. Massecuite Output	50.76	44.63	56.87	57.90	54.58	52.92	52.95	38.81
Viscosity Molasses at Molasses Temp. cp	395	246	635	1020	835	400	420	1130
Average Xal. Length of Massecuite mm.*	1.0±	0.508	1.0±	1.137	1.002	0.568		0.935
Average Xal. Breadth of Massecuite mm.*	0.7±	0.498	0.7±	0.733	0.707	0.537		0.678
Ratio Breadth/Length	0.7±	0.981	0.7±	0.645	0.706	0.946		0.725

* *Determined from photo-micrographs.*

Comments

(a) Massecuite Quality

On the whole, the quality of the massecuites was of the high standard normally associated with Illovo—that is a very large (1.0 mm.) even grain with negligible conglomerate or twins. There were two exceptions to this, for the massecuites for Tests 10 and 11 were grained on syrup as against the normal practice of using molasses grained C sugar as footing. This resulted in the crystals being less regular in shape, considerably smaller, and containing something like 10 per cent. conglomerate.

The effect of this poorer grain quality on the operation of the centrifugal was masked by the lower viscosity of the molasses at spinning temperature.

The lower viscosity was *definitely not due* to the fact that the strikes were syrup-grained as against boiled on a C sugar magma footing. This will be discussed further under "General."

In all cases, curing of the massecuites was commenced immediately after they were struck. As it is normal practice at Illovo to allow the A massecuite to stand approximately three hours before curing and the B massecuite about twelve hours, the mother liquor and molasses purities were somewhat higher than usual. Unfortunately, this procedure had to be adopted due to the necessity of curing the massecuites as hot as possible (that is, at as low a viscosity as possible), the small jacketed vessel feeding the machine being unable to reheat a massecuite.

(b) Sugar Quality

A Massecuites—In both raw sugar and affiliated sugar production the quality of the sugar was quite satisfactory except for two things:

Firstly, the high moisture content of the sugars. This, of course, is of no consequence when affiliated sugar is being produced as it is remelted long before any decomposition can take place. However, in the case of raw sugar it makes it essential to pass the sugar through a drier before bagging, otherwise the safety factor is far too high and severe deterioration on storage is inevitable.

Secondly, the formation of lumps. As mentioned under the mill white tests, it appears that the layer of sugar in contact with the basket undergoes a grinding action which results in some of the crushed crystal passing into the molasses whilst the remainder passes out with the sugar. Now, as this crushed crystal is very fine compared to the normal crystals, drainage is poor and so the moisture content is high, hence when it leaves the last basket it would tend to cling together and form lumps of damp sugar chips of somewhat lower purity than the rest of the sugar.

Again, in the case of affination this production of lumps is of no major consequence, as remelting takes place immediately and the quantity is so small that the slightly lower purity has no material effect.

However, in the case of raw sugar the lumps are a disadvantage, as due to their fine structure (crystal chips), and high moisture content, it is possible that a normal sugar drier would not dry them sufficiently to prevent their being initial points for decomposition to set in and, therefore, appears as though it may be necessary to screen the sugar after drying and return the lumps to process.

It is extremely unlikely that the returns to process would be as high as the percentage lumps figure quoted in Table IV due to break-up in the drier.

B Massecuite—The raw sugar produced from B massecuite suffered from the same defects as for A raw sugar. Further, its quality varied considerably due to the machine being very sensitive to feed rate on B massecuite, which in turn was probably due to the high viscosity of the massecuite mother liquor as it *entered* the machine. (Actually, this figure was 8,000 ± cp compared to 1,000 ± cp for the most viscous of the A massecuites.)

(c) Wash Water Requirements

A Massecuite (Affination)—For the affination tests on A massecuite, both steam and wash water were used, however, from the raw sugar tests the indications are that the only effect of the steam was to increase the moisture content of the sugar.

The wash water requirements were very satisfactory. The rate of application when affinating in 40" X 30" X 1,450 r.p.m. machines normally varies between 0.28 and 0.38 gall./cu.ft. massecuite, whereas the continuous centrifugal used only 0.245 and 0.113 gall./cu.ft. for the two tests respectively.

A Massecuite (Raw Sugar)—No wash water was required to produce raw sugar and Test 11 was conducted especially to determine whether steam was necessary or not.

The results of this test indicate that the only effect of the steam was adverse, in that the moisture content of the sugar and the quantity of lumps produced are both much higher with steam than without.

It must be pointed out, however, that the steam used was in all probability quite wet and it is quite possible that superheated steam would have the opposite effect.

B Massecuite—A considerable quantity of wash water was required to produce raw sugar from B massecuite, i.e. 0.384 gall./cu. ft. massecuite. This does not compare too well with the 40" X 30" x 1,450 r.p.m. vertical machines, where 0.43 to 0.52 gall./cu. ft. is all that is required to *affinate* B massecuite even after 12 ± hours in the crystallizers.

Steam was also used for the B massecuite test.

(d) Capacity

The average capacity of the machine when treating A massecuites (both affination and raw) was 12.2 tons per hour massecuite and 6.41 tons per hour sugar output, and it appeared certain that it could give a sugar output of 7.0 tons per hour quite satisfactorily.

On the other hand, the capacity when working on B massecuite was very low (5.51 and 2.14 tons/hour massecuite and sugar respectively).

It is felt that the low throughput of B massecuite combined with the high wash water rate and high initial mother liquor viscosity, accounts for the machine being so sensitive to feed rate on B massecuite, hence giving marked variation in sugar quality.

3. General

The following comments apply equally well to all the types of massecuite tested:

(a) Power Demand

It is inherent to any continuous process that the power demand should be steadier than a similar batch process and in very few instances is this more marked than with centrifugals, especially when the comparison is against high capacity, short cycle, individually-driven modern machines.

Hence it is only natural that the power demand of the Escher Wyss Continuous Centrifugal varies only with the rate of feed.

The actual power consumption for the two centrifugal drive motors and the molasses pumps for all the tests, varied between 35 and 41 amps on a 500-volt three-phase supply (i.e. 30 to 40 h.p.).

(b) Handling Characteristics

Apart from the trouble experienced with feed variations when curing B massecuite as mentioned earlier in the report, the machine was very easy to control. The operator adjusted the feed rate by the appearance and quantity of the sugar issuing from the machine.

(c) *Viscosities*

Viscosity determinations were carried out on most of the molasses resulting from these tests.

The determinations were carried out with the Hoeppler falling ball viscometer on deaerated composite samples of the undiluted molasses, which had been heated until all the crystal had dissolved.

The results obtained are set out in Table V.

Table V

Table showing Viscosity (Centipoises), Temperature (°C) Relationships for Most of the Molasses Obtained during the Tests

Test No.	*Massecuite Type*	*Molasses Purity*	*Molasses Brix*	TEMPERATURE °C 30	40	50	60	70
1	1st White	98.1	76.25	970	388	188	104	64
10	A	77.0	78.75	2160	790	370	197	116
4	A	74.7	83.00	7550	2500	1050	525	290
5	A	70.9	84.25	14100	4300	1710	800	422
6	A	70.6	82.50	5950	1970	860	426	240
11A	A	75.3	80.00	2380	920	440	240	144
11B	A	75.4	79.75	2600	970	460	245	144
9	B	60.9	84.50	14100	4350	1740	815	450

Taking these results and plotting Viscosity to Brix at constant temperature the family of curves shown in Figure I is obtained.

Examination of these curves leads to the rather interesting conclusion that, although the mill white run-off does not fit the curves, all the values for the raw house A and B molasses fit extremely well, even though the purity range covered is 60 to 78 and some of the strikes were boiled on magma grain whilst others were boiled on virgin syrup grain.

The "fit" of the points on the curves was considered to be so good, in fact, that the curves were used to determine the Viscosity of Molasses at Molasses Temperature for Test No. 8 which, unfortunately, could not be determined directly.

Also the above curves led to the statement earlier in the report that it was merely the low brix that gave the low viscosity figures to Tests 10 and 11, not the fact that they were boiled on virgin syrup grain.

Figures taken from Figure I are tabulated in Table VI to show the Viscosity, Brix, Temperature relationship for the A and B molasses tested.

TABLE VI

Table showing Viscosity (Centipoises), Brix Relationships derived from Table V and Figure I for the A and B Molasses Tested

Temp. °C	BRIX 79	81	83	85
30	2060	3620	7400	19500
40	800	1330	2450	5900
50	377	585	1030	2200
60	201	302	506	1030
70	121	174	284	555

SUMMARY OF CONCLUSIONS

1. That the centrifugal handles Mill White massecuites very well with very small wash water requirements. A slight increase in the quantity of lumps returned from the sieve to remelt is, however, apparent.

2. That the machine is not satisfactory from the point of view of sugar quality and capacity on Illovo B massecuite.

3. That the centrifugal handles A massecuite for raw sugar production at a satisfactory rate, but that the quality of the sugar would definitely call for a sugar drier possibly followed by a coarse mesh screen.

4. That the machine handles A massecuite for affination and remelt at a satisfactory rate, producing sugar of good quality for remelting with very small wash water requirements.

A sugar affination is definitely the most valuable role for this centrifugal in Natal, where raw sugar driers are not used.

5. That the power demand of the machine is most pleasingly small and steady, no matter what massecuite is being cured.

SUMMARY OF THE REPORT

The report covers tests carried out on an Escher Wyss Continuous Centrifugal (Type C 4/4) at Illovo Sugar Mill during November 1955.

Massecuites handled were:

First, Second and Third Mill White Massecuites with purities of the order 98 to 99+.

A Raw Sugar massecuites for both affination and raw sugar production.

B Raw Sugar massecuite for raw sugar production.

Further, there are some general remarks on the operation of the machine and Viscosity, Brix, Temperature relationship for the molasses are given.

Special Note

In fairness to Escher Wyss Limited, it must be emphasized that not only was the above machine the first continuous centrifugal in the Natal sugar industry, but that the tests reported in this paper were carried out on practically the first massecuites to be processed in the machine (actually a few Mill White massecuites only had been processed prior to Test No. 1) hence the makers had no opportunity to adjust the machine to best suit local conditions prior to the above tests being carried out. This rather unfair state of affairs was due to the approach of the end of the crushing season.

It may be mentioned that Escher Wyss' experience in other parts of the world indicate that modifications or adjustments such as altering the length of the baskets, using different screens, changing the rotor speed, etc., can reduce to a large extent the disadvantages brought to light in the above test. Further, it appears that the makers have developed an efficient automatic feed device as uniform feed rate is naturally most important to the satisfactory operation of a continuous process.

It is quite likely that the results reported for the B massecuite in this paper (Test No. 9) would have been far more satisfactory had this device been available at Illovo.

Acknowledgments

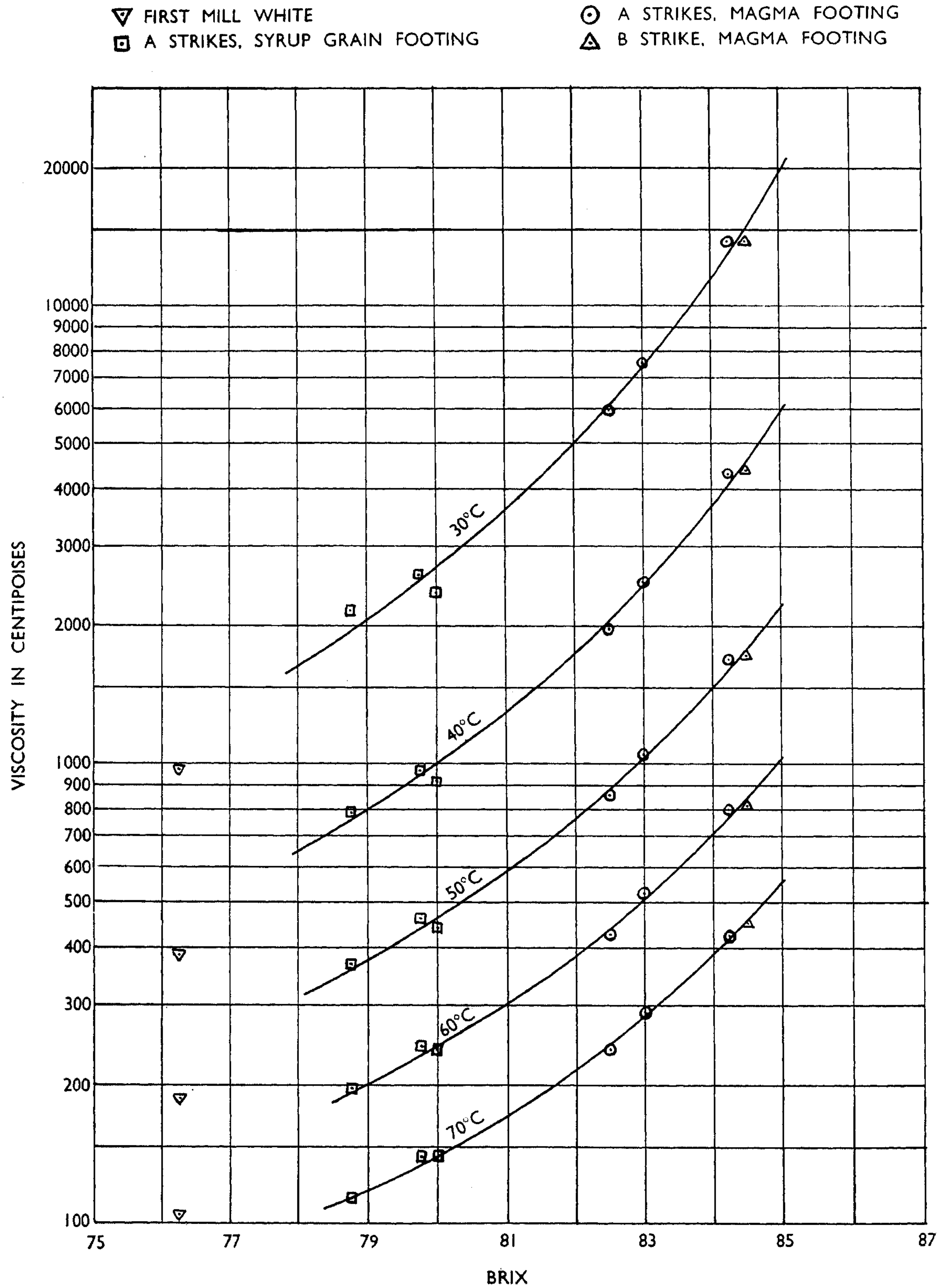
Thanks are due to the Illovo Sugar Estates Ltd., and Escher Wyss Ltd. of Switzerland, for enabling these tests to be carried out; to the staff at Illovo for their usual cheerful co-operation; to Mr. Matossi of Escher Wyss Ltd., who was in charge of the machine and who assisted greatly in carrying out the tests; and to the laboratory staff of the S.M.R.I, for carrying out the analyses.

REFERENCES

[1] **Bouvet,** P. E. (1954): Report on the Performance of a Continuous Sugar Centrifugal, Manufactured by the Escher Wyss Co. of Switzerland. Proc. S.A. Sug. Tech Assoc, 29, 88.

FIGURE I

VISCOSITY TO BRIX CURVES AT CONSTANT TEMPERATURE FOR FIRST MILL WHITE RUN-OFF AND A AND B MOLASSES



The Chairman, Mr. Rank, said we should all be interested in this type of machine for the sugar industry, in common with other industries, was tending towards continuous operation, in all factory processes. With labour difficulties appearing on the horizon it was imperative that new labour-saving devices should be thoroughly tested.

Mr. D. Hastilow asked Mr, Beesley what his experience was as far as increasing the speed of the machine was concerned. With a similar type of machine at the Refinery it was found that with the increase of speed a large quantity of small sugar crystals was produced in the syrup. He gave run-off purities comparing the continuous machine with the conventional type of high-speed centrifugal.

Mr. Beesley replied that the continuous centrifugal at the Refinery was vastly different in design and operation from that at Illovo and that although two speeds were used on the Illovo machine the results were inconclusive.

In view of the fact that no wash water or steam was applied to the refinery machine, the purity figures quoted by Mr. Hastilow made it appear obvious that sugar was passing through the screen.

Mr. Hastilow mentioned that even with the high-speed conventional centrifugal the smaller crystals were sometimes evident but not to a serious extent.

Mr. Beesley pointed out that in the case of the conventional type centrifugal, the sugar was more or less static against the sieve, hence the slots were soon covered by a layer of large crystals which prevented the smaller ones passing through into the molasses. Invariably a few of the finer crystals escaped before this static condition arose but only in negligible quantities.

In the case of a continuous machine however, a new layer of crystals was continuously being presented to the slots hence crystals of smaller size than the slots could pass into the molasses.

Also due to the continual movement of the crystals a certain amount of grinding was inevitable (the higher the gravity factor the worse this would be) and this would give rise to crystal chips in the molasses.

The Chairman enquired about the size of the screens.

Mr. Beesley in reply to the Chairman stated that in the case of C sugars say, the slot width was normally 0.35 to 0.4 mm. this would successfully retain sugar with an average length of 0.35 m.m. In fact in the case of a certain mill circular perforations of 0.8 m.m. diameter were being used for C massecuites of average crystal length 0.45 m.m., without loss of crystal.

The Chairman commented favourably on the low ash content of Illovo "mill whites," which was at a level not always reached by some refined sugars.

He also asked Mr. Beesley if he considered the amount of wash water reasonably small for the colour of sugar produced.

Mr. Beesley replied that under Illovo conditions where the conventional machines required 0.5 gall, per cubic foot of mill white massecuite, the figure of 0.25 gall, per cubic foot was low.

The Chairman stated that for 8 cubic foot massecuite and refined sugar they used only 2½ gallons of wash water in the conventional type of machine.

Mr. **Camden-Smith** said that he had had the privilege of witnessing the functioning of this machine last year and he considered that from the mechanical point of view and from the point of view of labour-saving it worked very well. He certainly gained the impression, however, that the pushing action in the basket tended not only to push the crystals forward but also through the screen. This was the only point which he considered should be improved upon to ensure the efficient operation of the machine.

Mr. Beesley stated that crystal chips were definitely present in the molasses from the continuous machine, and that it appeared as though they derived from the layer of crystal next to the basket. However, he pointed out that the quantity of chips must be very small as in Test II, which was spun dry (i.e. no steam or wash water was used), the purity rise from massecuite mother liquor to molasses was only 0.3 of a unit even though the crystal quality for this test was not nearly as good as normal.

He thought that there were possibilities that this disadvantage could be overcome to a great extent.

Mr. Bentley asked Mr. Beesley to enlarge upon the fact that apparently the conventional type belt-driven machines were handling only half the massecuites they would normally do, and that the comparison was between 3-4 conventional type against the continuous one. He wondered if the installation of such continuous machines would be economical from the capital cost point of view.

Mr. Beesley replied that the continuous machine was handling mill white massecuite at the same rate as the 7 conventional belt driven machines. The comparison would therefore be between 7 x 36 in. x 100 r.p.m. belt driven machines and the continuous centrifugal.

The Chairman drew attention to the low yield of sugar per cubic foot of the first massecuite, as shown in the paper. He thought this probably meant that slack massecuite was cured which undoubtedly helped the machine.

Mr. **Beesley** replied that apparently 40 to 45 per cent was the normal crystal content of Illovo mill white massecuites. However, from the point of view of its assisting capacity, he pointed out that the Raw Sugar A Massecuites were handled at a similar massecuite rate even though the crystal content and viscosity were much higher.

The Chairman complimented the Escher Wyss Co. and the Illovo Sugar Estates on their pioneer work in exploring the field of continuous curing of sugar under South African conditions.

COPPER DEFICIENCY DISCOVERED IN THE SUGAR BELT

By J. L. DU TOIT

With a few minor exceptions, trace element deficiency has not been of much importance in sugarcane production, but it is possible that the position may alter with continuous cropping. Sugarcane may not be quite so sensitive to trace element deficiencies as some other crops, but where severe deficiencies do exist the crop can be very greatly affected.

Thus in peat soils of the Florida Everglades sugarcane production was severely restricted before the discovery of copper deficiency and the fact that copper sulphate could correct this deficiency. Bourne[1] found that the application of 20 lbs. per acre of copper sulphate gave an enormous stimulation to the crop and this discovery led to the rapid expansion of the industry. Allison[2] described both copper and manganese deficiency in sugarcane in Florida. In Queensland[3] restricted areas of copper deficiency are found and the cane responds very well to about 55 lbs. of copper sulphate per acre in these areas.[4]

During 1953, the writer visited Florida and found that manganese deficiency symptoms were now far more common than copper deficiency symptoms, but some of the latter were seen. It is, however, common practice to apply copper sulphate at the rate of 20 lbs. CuO per acre, manganese sulphate at the rate of 60 lbs. MnO per acre and zinc sulphate at the rate of 4½ lbs. ZnO per acre, at the time of planting on these deficient soils.

During March 1955, Mr. D. A. Routledge, Advisory Officer of the Experiment Station, brought in a cane stool showing decided green islands on the leaf laminae. The field in question on Glebe Section, Mission Reserve, between Sezela and Esperanza, on the South Coast was in a granitic area and the soil was probably dervied from a para-gneiss. The field was considered good cane land and had grown normal, to better than normal, cane crops for the past thirty years. At the beginning of 1955, however, Mr. Brickhill, the section manager, noticed that there were patches of chlorotic and very stunted cane in the field and he drew Mr. Routledge's attention to them.

On visiting the area the following typical copper deficiency symptoms were found. The cane in affected areas was extremely stunted. The leaves drooped down and this was most abnormal for the variety Co.331. There were numerous green islands, or green blotches, on the somewhat chlorotic leaves. It was also noticed that there were several cases of cane stools in which the leaves failed to unroll as described by Allison. In this case, however, it was thought quite possible that the failing of the leaves to unroll might have been the result of injury during cultivation and this symptom was not taken as necessarily indicating copper deficiency. The other abovementioned symptoms were, however, definite enough to suggest a copper treatment. In addition many leaves were characterised by yellow and green stripes and it was decided also to try out a manganese treatment.

It may be mentioned that this five-months-old affected plant Co.331 was in appearance quite different from what this variety normally looks like. Not only were the leaves drooping, but they were exceptionally broad. In the surrounding unaffected cane, which was normal in growth and appearance, there were definite signs of potash deficiency, but these were not apparent in the depressed copper deficient areas. Soil analyses showed a low potash content, a medium phosphate content with a pH of 5.6 and 3.2 per cent, organic matter content. Leaf analyses (third leaf mid-laminae samples) done on the affected and unaffected areas were as follows:

	Percentage Composition on Dry Basis		
	N	P_2O_5	K_2O
Affected area	2.17	0.71	1.53
Unaffected area ...	1.77	0.48	0.70

At the end of March the following treatments were applied:

(1) a copper sulphate top dressing at the rate of 50 lbs. per acre;

(2) a copper sulphate spray application at the rate of 30 galls, per acre of a 0.4 per cent, solution;

(3) a manganese sulphate top dressing at the rate of 50 lbs. per acre;

(4) a manganese sulphate spray application at the rate of 30 galls, per acre of a 0.4 per cent, solution.

A month after these applications were made the copper sulphate sprayed lines appeared much improved with no green islands, or yellow and green stripes visible, and much the same applied to the copper sulphate top-dressed lines. The manganese treated lines were, however, unchanged and the islands and stripes were as common here as in the control lines.

Towards the middle of May a similar copper spray application was applied in another patch of badly affected cane.

Towards the end of June the cane in the first copper treated lines, both spray and soil applications, had responded remarkably well and was a couple of feet taller than the untreated affected cane.

Deficiency symptoms had disappeared completely whereas they persisted in the untreated cane. In the treated area the cane once more looked typically like Co.331 with mainly upright and narrow leaves, while in the affected area the leaves were still broad and drooping. It was also interesting to note that the treated cane which had apparently thrown off all copper deficiency symptoms now started to show potash deficiency symptoms similar to those of the originally unaffected cane in this field.

By this time, too, the lines sprayed with copper sulphate during May had recovered completely as far as visible symptoms were concerned but they did not show any better growth than the surrounding cane. This was probably due to the severe drought experienced during that period, whereas the earlier treated cane could take advantage of the earlier rains and it was also situated in a more moist area.

It was at first thought that the discovery of this copper deficiency in our sugar belt may only be of academic interest and this may still be the case, but since then several leaf samples showing some resemblance to copper deficiency have been brought in and in one area on a recent sand at Flanders Estate of Natal Estates Ltd. the symptoms appears to be definite. Here the first leaf samples were brought in by Mr. V. Frances, Government cane inspector, and the worst affected area was found by Mr. K. E. F. Alexander of the Chemical Department. The area is at present under investigation, but indications are that it is a comparatively mild case of copper deficiency and although a copper treatment appears to benefit the cane the untreated cane seems to recover too.

In this particular case the pH of the top soil is about 8 as a result of heavy applications of carbonatation filter cake. The soil is high in phosphate but low in potash with an organic matter content of 1.5 per cent.

Summary

Copper deficiency has been discovered in a granitic area on the South Coast. Some leaf samples brought in from the North Coast show a resemblance to copper deficiency symptoms and one area of suspected mild copper deficiency is under investigation.

Acknowledgments

The writer acknowledges with thanks the co-operation received from members of the Experiment Station staff, Messrs. Reynolds Bros. Ltd., Natal Estates Ltd., Mr. Frances, and particularly Mr. K. E. F. Alexander who was associated with the writer in all aspects of this investigation.

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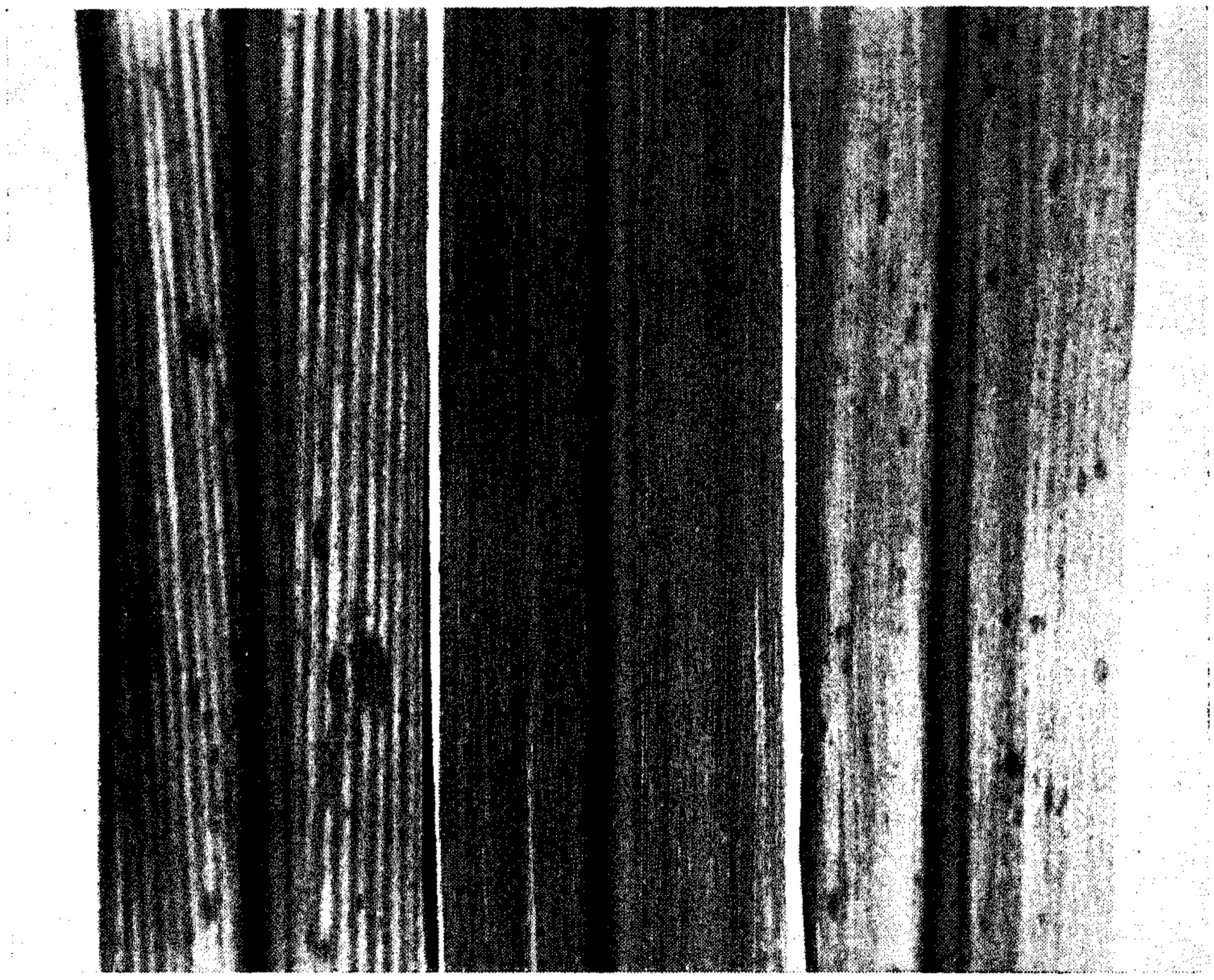


Copper deficiency symptoms on the left and right of a normal cane leaf.

Photograph : K. E. F. ALEXANDER.

Dr. J. Dick, in the Chair, said that his was a very interesting piece of investigation. Deficiency symptoms in sugar cane in South Africa had not been remarked upon much in the past and what had been found had been mainly due to the work of Mr. du Toit.

Dr. H. H. Dodds related that some years ago the chemist at Umfolosi, reported that he had found a cure for streak disease by applying manganese salts to the cane. This was tried out at the Experiment Station and it seemed that manganese treated cane did not show symptons so early as untreated cane. However it did not cure the disease but merely delayed the appearance of the symptoms, and the treatment did not affect the yield in any way.

Mr. du Toit, replying to the Chairman, said that the reason for his being able to detect copper deficiency was the fact that he had seen copper deficiency overseas. This was a very good reason for sending men to overseas countries. He assured Dr. Dodds that by treating this cane with copper sulphate did not only make the symptoms disappear but the cane responded tremendously in yield and the pathologist found no evidence of a disease.

Mr. Twinch inquired of Mr. du Toit what would be the residual effects of copper treatment. Would it persist throughout the crop and would it be necessary to reapply it to the ratoons.

Mr. du Toit stated that in Florida *it* had been found that the application of about 50 lbs. of copper sulphate to plant cane was sufficient for all the ratoons. He did not think that the light spray application would persist in its beneficial effect to the ratoons. He said this matter would be followed up.

Mr. Barnes said it was a practice in Florida to apply copper, manganese and zinc at the time of planting and no further treatment was necessary until the field was replanted. He suggested that it be pointed out that this was not a very serious state of affairs as it was something that could easily and cheaply be corrected. He pointed out that up to now these copper deficiency symptoms had been found in the extreme ranges of pH variation, and it was possible that cane growing under these conditions might not be able to take up the required copper. He asked if Mr. du Toit had as yet tested for copper in the soil.

Mr. du Toil replied that the determination of copper both in the leaves and in the soil was under consideration and arrangements had been made to have a general survey of the sugar industry carried out with the aid of the Imperial College, Trinidad. If this could be done for other countries as well, we should be able to get an idea of our relative status as compared with such countries.

Mr. Coignet suggested that it would be a good idea to return ash from the factories into the fields.

Mr. du. Toit replied that trace elements should be traced throughout the plant and in its final products.

Dr. Brett suggested that the low potash content of the cane in some parts of the field might have masked the copper deficiency.

Mr. du Toit replied that it might be possible for limiting elements to so affect the growth of the cane that it might mask deficiency symptoms of other elements; but he thought this would only happen in extreme cases of deficiency.

Mr. King suggested that the fact that Co.331 leaves in copper deficient areas appeared broad might merely be an optical illusion. He wondered if this was really the case or if measurements had been made.

Mr. du Toit stated that no measurements were made but the appearance of this cane was most striking as far as the broadness of the leaves was concerned.

A STUDY OF THE GROWTH, SUCROSE ACCUMULATION AND PLANT FOOD UPTAKE OF SUGARCANE DURING SUCCESSIVE MONTHS

By J. L. DU TOIT

Introduction

As a result of a relatively short active growing season and cold dry winters the sugarcane crop, in South Africa, remains a predominantly two-year crop. Fertiliser applications normally take place at planting and soon after, or at harvesting and soon after, and very seldom in the second year of growth or even at the end of the first year's growth. It was, therefore, decided to test out experimentally the nutrient absorption by the sugarcane plant at successive stages of growth, under our conditions, and at the same time to assess its growth rate, sucrose accumulation, purity and fibre fluctuations and do such other analyses as may be of interest.

The Experiment

The experiment was situated on a black doleritic soil on the Experiment Station, Mount Edgecombe, and consisted of three fertiliser treatments each replicated six times. The fertiliser treatments were:-

(a) control;

(b) 100 lbs. per acre each of N, P_2O_5 and K_2O; and

(c) 200 lbs. per acre each of N, P_2O_5 and K_2O.

All the phosphate was applied in the furrow as superphosphate. A quarter of the nitrogen and potash as ammonium sulphate and muriate of potash respectively were applied at planting on the 30th of September, 1953, to the heat-treated N:Co.310 setts, and the rest in two equal top dressings on 21st December, 1953, and 18th November, 1954. The four rows of cane to be harvested in each plot were sub-divided by four-foot breaks to give a total of twenty-four lines. One of these short lines per plot was harvested each month for twenty-four months.

For the first three months when the cane was very small the setts were dug up and the total shoots removed for weighing and analysis and thereafter the above-ground cane was cut off and used. These short lines were only seven and a half feet long and there was considerable variation between lines with the response to fertiliser small to moderate. The results reported will therefore be, unless otherwise stated, the average of all eighteen lines harvested per month irrespective of treatment.

Growth

It is known that under dry land conditions the growth made by sugarcane is at a minimum during our cold dry winter months of June, July and August. It is severely restricted during May and September and to a lesser extent during April and October, with generally good growing conditions prevailing from November to the end of March and probably the maximum growth being made during the wet hot month of February.

Some years ago growth measurements done at the Experiment Station on the varieties Co.281, Co.331 and Co.301 gave the following results in inches of growth per stick of cane per month.

Month	Growth in inches per stick	Rainfall in inches	Mean Temperature in °F
January	6.7	3.05	75.6
February ...	7.6	6.59	73.2
March	7.2	2.22	72.8
April	5.3	3.90	71.1
May	3.7	0.49	66.2
June	2.6	0.56	64.0
July	1.5	0.10	62.3
August	0.9	0.21	64.3
September ...	1.3	2.45	67.8
October	5.3	4.72	68.0
November ...	4.7	6.53	70.2
December ...	5.5	5.79	73.5

In this case the elongation during January to March amounted to 41 per cent. of the total for the year and that occurring from October to December was 30 per cent., with April to June equalling 22 per cent. and July to September only 7 per cent.

Graph I illustrates the data and shows clearly how the growth curve follows those of rainfall and mean temperature.

In the experiment now completed on N:Co.310 plant cane, the weights of the total cane plant including leaves and trash, are available for the whole of the twenty-four months, growth period and the amount of millable cane was weighed separately from the end of the eighth month. The results obtained were as follows:

Date Sampled	Month used for rainfall etc.	Approx. age in months	Tons Cane per Acre Whole plant	Millable cane	Moisture in whole plant	Monthly rainfall in inches moisture	Monthly mean temp. in °F
30/10/53	Oct.	1	0.1	—	0.08	2.02	69.2
1/12/53	Nov.	2	0.5	—	0.4	4.92	70.7
4/ 1/54	Dec.	3	3.0	—	2.5	6.10	73.2
1/ 2/54	Jan.	4	8	—	7	3.31	73.1
1/ 3/54	Feb.	5	16	—	13	4.23	74.6
31/ 3/54	March	6	27	—	22	3.39	72.9
29/ 4/54	April	7	29	—	22	0.95	69.4
28/ 5/54	May	8	29	18	22	2.02	66.4
30/ 6/54	June	9	29	19	21	0.55	62.5
31/ 7/54	July	10	27	18	18	0.41	61.4
30/ 8/54	August	11	30	21	20	1.52	63.1
30/ 9/54	Sept.	12	29	20	19	5.42	66.3
1/11/54	Oct.	13	34	24	24	10.78	67.7
1/12/54	Nov.	14	37	25	27	3.67	69.9
5/ 1/55	Dec.	15	43	30	30	1.08	73.2
2/ 2/55	Jan.	16	46	30	32	7.64	73.1
7/ 3/55	Feb.	17	57	42	41	1.44	74.0
4/ 4/55	March	18	63	49	44	6.50	72.1
3/ 5/55	April	19	70	53	49	3.22	69.6
1/ 6/55	May	20	68	55	48	0.61	66.2
4/ 7/55	June	21	72	59	49	0.60	62.5
2/ 8/55	July	22	76	62	50	0.17	62.9
31/ 8/55	August	23	67	55	43	0.87	62.4
6/10/55	Sept.	24	79	67	50	3.71	63 9

The above Table and Graph No. II shows that the weight of whole cane remained practically unaltered from April to September in 1954 and there was only a slight increase for the same period in 1955. In both cases the increase in tons millable cane was somewhat better but stiU very small. Growth as reflected in both total plant weight and tons millable cane was excellent from December to March and here it is interesting to note that rate of increase in 1953-54 when the cane was three to six months was very similar to that for the same period in 1954-55 when the cane was fifteen to eighteen months old. It can also be seen that the unseasonable drought of December 1954 made itself felt and is reflected in a flattening'of the cane per acre curve in January 1955. The exceptionally heavy rains of October 1954 and to a lesser extent September and November 1954 resulted in good growing conditions from October to December 1954 and it is difficult to compare this period with that of the year before when the cane was either germinating or very young. It is the difference in growth between these two periods, however, which accounted largely for the fact that considerably more cane was obtained during the second year's growth than the first.

Sucrose Accumulation

From the end of May 1954 when the cane was about eight months old to the end of the experiment when the cane was twenty-four months, sucrose, purity, fibre, etc., were regularly determined.

As a result of increased crops to be handled our normal crushing season has now been considerably extended. The first factories often start as early as April and some do not close down until sometime in February. This experiment enabled us to follow the percentage fluctuations of sucrose of a crop from the same field for seventeen consecutive months and also to assess the total amount of sucrose per acre obtainable from the field each month. The results are given in the following table:

Date Sampled	Sucrose per cent. Cane	Tons Sucrose per acre	Date Sampled	Sucrose per cent. Cane	Tons Sucrose per acre
28/ 5/54	12 31	2 2	7/ 3/55	12 94	5.4
30/ 6/54	15.11	2.9	4/ 4/55	12.08	5.9
31/ 7/54	16.92	3.0	3/ 5/55	12.53	6.6
30/ 8/54	17.72	3.7	1/ 6/55	13.23	7.3
30/ 9/54	18.74	3.7	4/ 7/55	16.16	9.5
1/11/54	15.32	3.7	2/ 8/55	16.65	10.3
1/12/54	14.06	3.5	31/ 8/55	16.92	9.3
5/ 1/55	13.96	4.2	1/10/55	17.80	11.9
2/ 2/55	14.43	4.3			

Normally sucrose per cent. cane reaches a peak about September or October and then declines gradually to November and December with a further fall in later months if crushing is continued. The above table and Graph No. III show an excessive fall in sucrose per cent. cane during October and November, a somewhat unexpected rise in January and an expected absolute low during March or April. The rapid fall of sucrose per cent. cane during October to November was undoubtedly the result of the exceptionally heavy rainfall of October 1954 which has already been referred to. In fact this fall in sucrose content was so great that in spite of renewed excellent growth there was no accumulation of sucrose per acre and actually a downward tendency was evident. It would appear that the cane which was at a very high sucrose level just before the rain used some of the stored energy in the form of sucrose to make the extra growth when extremely moist and cloudy conditions suddenly developed.

The rise in sucrose per cent. cane during January may possibly be the result of the December drought.

On the average, fertiliser seems to have had a slightly depressing effect on sucrose per cent. cane. Thus the average of fifteen sucrose determinations gave 15.27 per cent. on the control plots, 15.01 and 15.09 per cent. on the medium and heavily fertilised plots respectively.

Yield of cane was, however, increased as a result of fertiliser application, the medium fertilised plots as millable cane averaged 104 per cent. of the controls over sixteen successive months and the heavily fertilised plots 111 per cent. of controls over the same period. The heavily fertilised plots only once averaged slightly less than the controls and then it was 99.6 per cent. of the control.

Cane Quality and Cane Tops

Juice purity, reducing sugars, reducing sugar ratio and fibre per cent. cane were determined on all cane samples. Purity and reducing sugars bear the expected relationship to sucrose per cent. cane and will not be commented on further. Fibre per cent. cane can be expected to rise with the desiccation of cane. During this experiment the crop went through dry winters but this did not seem to affect the fibre per cent. cane in this way as will be seen from the following table.

Date	Fibre % cane	Date	Fibre % cane	Date	Fibre % cane
28/5/54	9.93	1/12/54	11.99	1/ 6/55	12.99
30/6/54	11.60	5/ 1/55	12.57	4/ 7/55	12.42
31/7/54	11.15	2/ 2/55	12.31	2/ 8/55	13.72
30/8/54	10.85	7/ 3/55	12.35	31/ 8/55	13.27
30/9/54	11.25	4/ 4/55	12.86	6/10/55	12.98
1/11/54	11.58	3/ 5/55	11.99		

The tendency here appears to be for the fibre per cent. cane to increase with the age of the crop rather than during the dry winter period. The average results from our factories also show that fibre per cent. cane in general decreases from May to September or October and thereafter rises again. The conclusion must therefore be drawn that the loss of moisture is compensated for, or more than compensated for, by the rise of sucrose in cane during our winter months. The result is that the ratio of sucrose to fibre rises steeply during the winter to early spring months. It is also interesting to note that the sucrose to fibre ratio is appreciably higher in one-year-old cane than in two-year-old cane. Thus for the months of May to September when comparable figures were available, the eight- to twelve-months-old cane had a percentage sucrose to fibre ratio of 147.2 and the twenty- to twenty-four-months-old cane a percentage ratio of 123.6.

During the visit to this country of the eminent sugar technologist, Dr. Pieter Honig, surprise was expressed at the amount of top left on our cane for the mills. It was then decided, whilst busy on this experiment, once again to test out the juice quality of cane tops during different periods of growth. For this purpose the cane was divided into four parts, i.e. the first two inches from the breaking point at the top, the next four inches, the next six inches, and the rest of the cane. Sucrose and purity were determined and the percentage ash content of the juice was also done. The results are given in the table shown at the foot of this page.

It will be seen from this table that the sucrose content and purity of the top of the cane stalk are extremely variable. When the cane is fully mature, purities of over 60 or 70 can be obtained from the cane top two to six inches from the breaking point, but when the cane is still in active growth or has not had time to ripen, this same part may have juice purities as low as 15 to 20 or much lower than that of the juice from the upper two inches in winter. The upper part of the cane stalk invariably contains large amounts of ash and at times as much ash as sucrose may be introduced into the factory in the upper two inches of cane. These higher parts of the cane stalk are also very rich in plant nutrients, which were regularly determined. Thus the analyses of these parts of the cane harvested on the 1st June 1955 were as follows:

	2 inches from Top	Next 4 inches	Next 6 inches	Rest of cane
N % cane ...	0.270	0.184	0.121	0.067
P_2O_5 % cane	0.126	0.066	0.041	0.026
K_2O % cane ...	0.538	0.329	0.226	0.092

The last two inches of cane is therefore about five times as rich, on a percentage basis, in plant nutrient as the mature stick of cane. It is obviously in the interest of all concerned to keep this immature cane top in the field. It is of no value in the factory where the sucrose is not recoverable and the ash constituents can only cause trouble and it is of decided value in the cane field where its return will mean the recirculation of valuable plant nutrients while transport and handling costs are eliminated.

Date Sampled	2 inches from Top: Sucrose per cent. Cane	Purity	Ash per cent. Juice	Next 4 inches: Sucrose per cent. Cane	Purity	Ash per cent. Juice	Next 6 inches: Sucrose per cent. Cane	Purity	Ash per cent. Juice	Rest of Cane: Sucrose per cent. Cane	Purity	Ash per cent. Juice
30/9/54 ...	5.08	38.0	1.31	12.11	79.8	0.74	17.44	92.4	0.56	19.18	94.5	0.28
2/2/55 ...	1.17	10.8	1.26	2.10	20.0	0.78	8.17	71.4	0.51	15.92	93.7	0.32
3/5/55 ...	1.57	17.4	1.37	1.36	16.2	0.85	2.95	34.5	0.57	13.22	89.5	0.35
1/6/55 ...	1.62	16.3	1.32	1.76	15.4	0.82	4.41	41.7	0.57	13.87	89.8	0.30
4/7/55 ...	4.09	31.2	1.19	6.09	46.3	0.78	9.82	67.6	0.61	15.61	90.3	0.35
2/8/55 ...	7.41	37.7	1.09	9.67	66.0	0.66	12.54	77.2	0.55	16.97	94.8	0.31
31/8/55 ...	8.07	48.5	—	10.64	63.8	—	13.43	76.4	—	17.34	90.2	—
6/10/55 ...	8.90	58.4	—	12.16	74.5	—	14.91	84.5	—	18.28	93.7	—

Plant Food Uptake

Mineral nutrients were regularly determined in the total cane plant so as to get an idea of the uptake of plant foods with time. The percentage composition on a dry basis was as follows:

Date Sampled	Approx. Age in months	Per cent. N	Per cent. P_2O_5	Per cent. K_2O	Per cent. CaO	Per cent MgO
30/10/53	1	1.99	0.81	4.21	0.41	0.48
1/12/53	2	1.81	0.56	2.89	.45	.45
4/ 1/54	3	1.76	0.50	3.14	.34	.43
1/ 2/54	4	1.42	0.40	2.59	.35	.46
1/ 3/54	5	1.20	0.45	2.41	.36	.38
31/ 3/54	6	0.87	0.23	1.56	.31	.35
29/ 4/54	7	0.78	0.19	1.12	.32	.37
28/ 5/54	8	0.70	0.15	0.98	.31	.35
30/ 6/54	9	0.61	0.16	0.89	.35	.33
31/ 7/54	10	0.63	0.15	0.78	.30	.30
30/ 8/54	11	0.56	0.13	0.61	.21	.28
30/ 9/54	12	0.48	0.12	0.55	.23	.26
1/11/54	13	0.49	0.12	0.56	.21	.29
1/12/54	14	0.55	0.13	0.57	.26	.30
5/ 1/55	15	0.48	0.12	0.51	.27	.29
2/ 2/55	16	0.39	0.12	0.42	.24	.29
7/ 3/55	17	0.48	0.13	0.49	.22	.24
4/ 4/55	18	0.48	0.13	0.47	.21	.22
3/ 5/55	19	0.42	0.13	0.41	.19	.24
1/ 6/55	20	0.39	0.12	0.50	.18	.21
4/ 7/55	21	0.36	0.11	0.37	.18	.22
2/ 8/55	22	0.35	0.11	0.35	.18	.24
31/ 8/55	23	0.37	0.10	0.39	.16	.23
6/10/55	24	0.35	0.10	0.30	.14	.23

Fertiliser application did have an effect on the percentage composition of the samples. Thus the high level of fertiliser application resulted in an average increase in the percentage composition of N, P_2O_5 and K_2O of 10, 25 and 8 per cent. respectively for the first three months of growth. For the three months period nineteen to twenty-one months, the increase in phosphate had fallen to 12 per cent. and the other two remained more or less the same as they were.

The quantities of plant foods taken up by the crop during its growth are given by the following table:

Date Sampled	Approx. Age in months	Lbs. per Acre N	P_2O_5	K_2O	CaO	MgO
30/10/53	1	.56	.23	1.19	.10	.12
1/12/53	2	3.47	1.09	5.67	.85	.85
4/ 1/54	3	17.59	5.07	32.32	3.41	4.31
1/ 2/54	4	38	11	69	9	13
1/ 3/54	5	68	26	122	20	21
31/ 3/54	6	89	23	159	32	36
29/ 4/54	7	102	25	148	43	49
28/ 5/54	8	102	22	144	42	47
30/ 6/54	9	103	26	150	59	56
30/ 7/54	10	107	26	133	52	52
30/ 8/54	10	111	25	120	42	55
30/ 9/54	12	91	23	104	44	50
1/11/54	13	98	25	113	42	58
1/12/54	14	113	26	117	55	63
5/ 1/55	15	123	32	132	69	74
2/ 2/55	16	108	33	116	65	79
7/ 3/55	17	158	44	161	72	78
4/ 4/55	18	179	49	181	78	82
3/ 5/55	19	179	56	181	81	102
1/ 6/55	20	162	51	207	74	86
4/ 7/55	21	166	49	171	83	102
2/ 8/55	22	179	56	179	95	127
31/ 8/55	23	178	46	184	76	110
6/10/55	24	200	57	172	80	135

In this experiment an attempt was made to weigh and analyse the total aerial portion of the cane plant including dry leaves. It was inevitable, however, that a certain amount of dead leaves got lost and consequently the total uptake of plant food might have been a little higher than given.

The nitrogen status of the crop was evidently better than the potash status and the ratio of nitrogen to potash in the plant is somewhat higher than normal, but on the whole the crop did take up appreciably more potash than nitrogen, particularly so during the first year of growth. The phosphate uptake is as expected, much lower. Somewhat more MgO than CaO was absorbed.

Ignoring minor fluctuations, which must be expected in data of this nature, it is clear as shown in Graph No. IV that plant foods are mainly taken up during the maximum growing periods of the first and second year. During the winter months nitrogen and phosphate uptake comes practically to a standstill, whereas in the case of potash the indications are very strong that the aerial part of the plant actually looses potash during the winter months.

It is interesting to note that the plant food uptake during the second year of growth is comparable in quantity to that of the first year and that this applies equally to phosphate, which is generally considered so important for the early development of the plant. It further seems obvious that whatever is done to stimulate growth during the early stages of development, conditions must not arise during the second year that will retard further development, and for this reason adequacy of mineral nutrients is essential for the second year's active growth period. In this experiment it was found, however, that the plant does take up relatively more of its total plant nutrients from the applied fertiliser in its early stages of growth. Thus the plants with the high rate of fertiliser had 56, 37 and 31 per cent. more P_2O_5, N and K_2O respectively than controls for the first three months, whereas the corresponding average increases at the nineteen- to twenty-one-months-old cane were 26, 23 and 23 per cent., some of which was due to the heavier uptake in the earlier months.

Although leaf analyses were done regularly on both mid-laminae samples and total third leaf as well as on leaf sheaths, it is not intended to discuss these here, except to point out the potash level became rather low during the second year of growth and that it reached a peak in May-June with a minimum value about January. Nitrogen and phosphate levels were of course very low during the dry winter months when whole cane composition remained relatively constant and dropped rapidly during the early stages of growth.

Summary

A study was made of the growth, sucrose accumulation and plant food absorption of N:Co.310 at the Experiment Station, Mount Edgecombe. For this purpose monthly harvestings were made and analyses done. From the end of the eighth month sucrose, purity, fibre, etc., analyses were also done on the millable cane. Separate analyses were done on portions of the top foot of the cane stalk to examine the quality of the juice and the mineral nutrients contained in it.

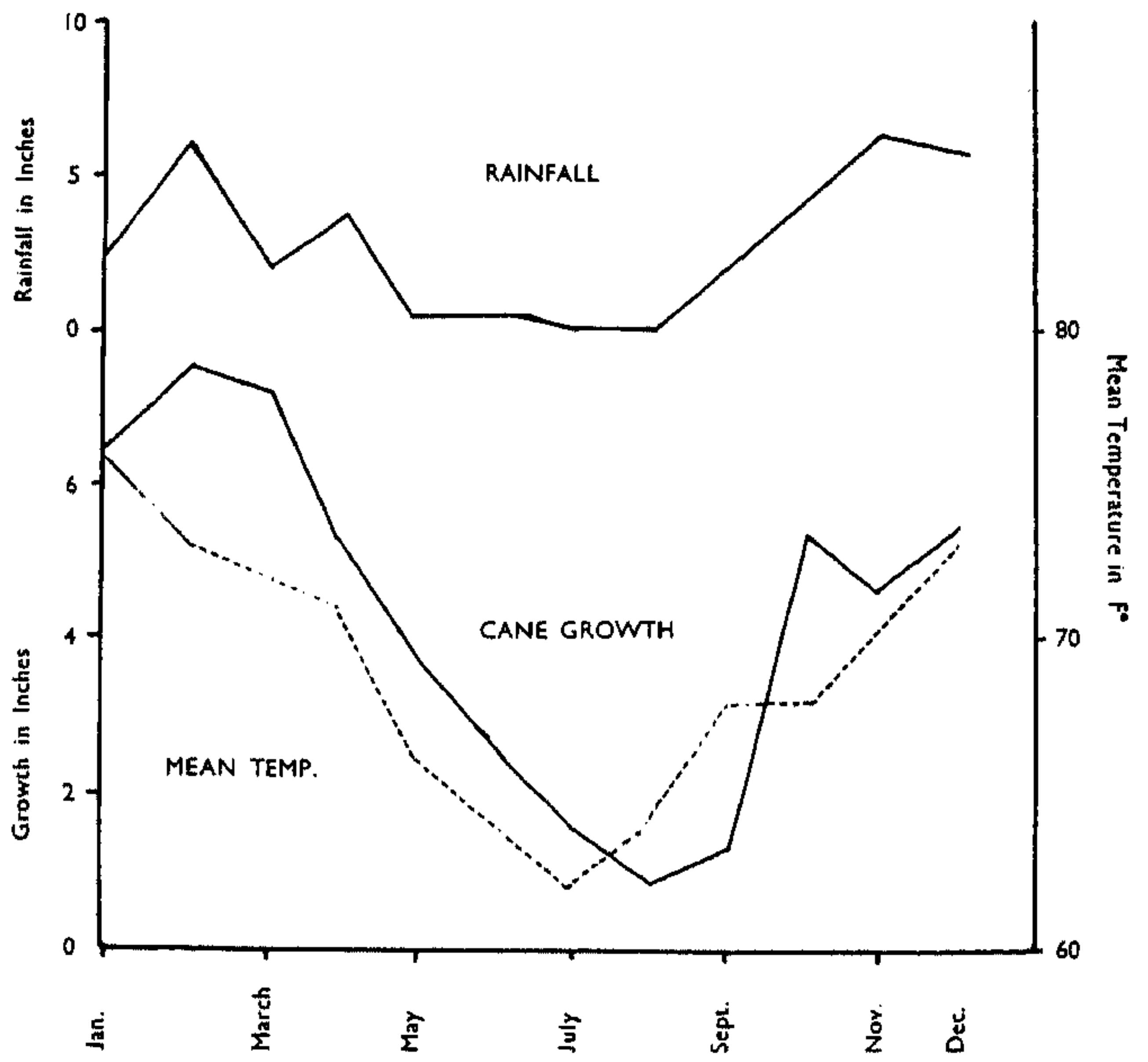
It was found that the total weight of the cane plant comes virtually to a standstill during our cold dry winter months but there is a small gain in millable cane during these periods and a very considerable gain in sucrose per acre because sucrose per cent. cane is rapidly increasing during this period to a maximum in about September. The accumulation of sucrose proceeded fairly steadily throughout the period tested with the exception of the period following heavy rams in October 1954.

The sucrose and purity of juice from cane tops vary a great deal with season. These juices are, however, always very high in ash and plant foods, and at least a portion of them are always more economically left in the field.

In this experiment leaf analyses pointed to possible potash deficiency during the second year's growth, and the total potash uptake was low compared with that of nitrogen although on the whole more potash than nitrogen was taken up. Second season's uptake of nutrients was comparable with that of the first year but during the cold dry winter months nutrient absorption virtually ceased as far as nitrogen, phosphate, calcium and magnesium are concerned and there were indications that the aerial part of the plant actually lost potash.

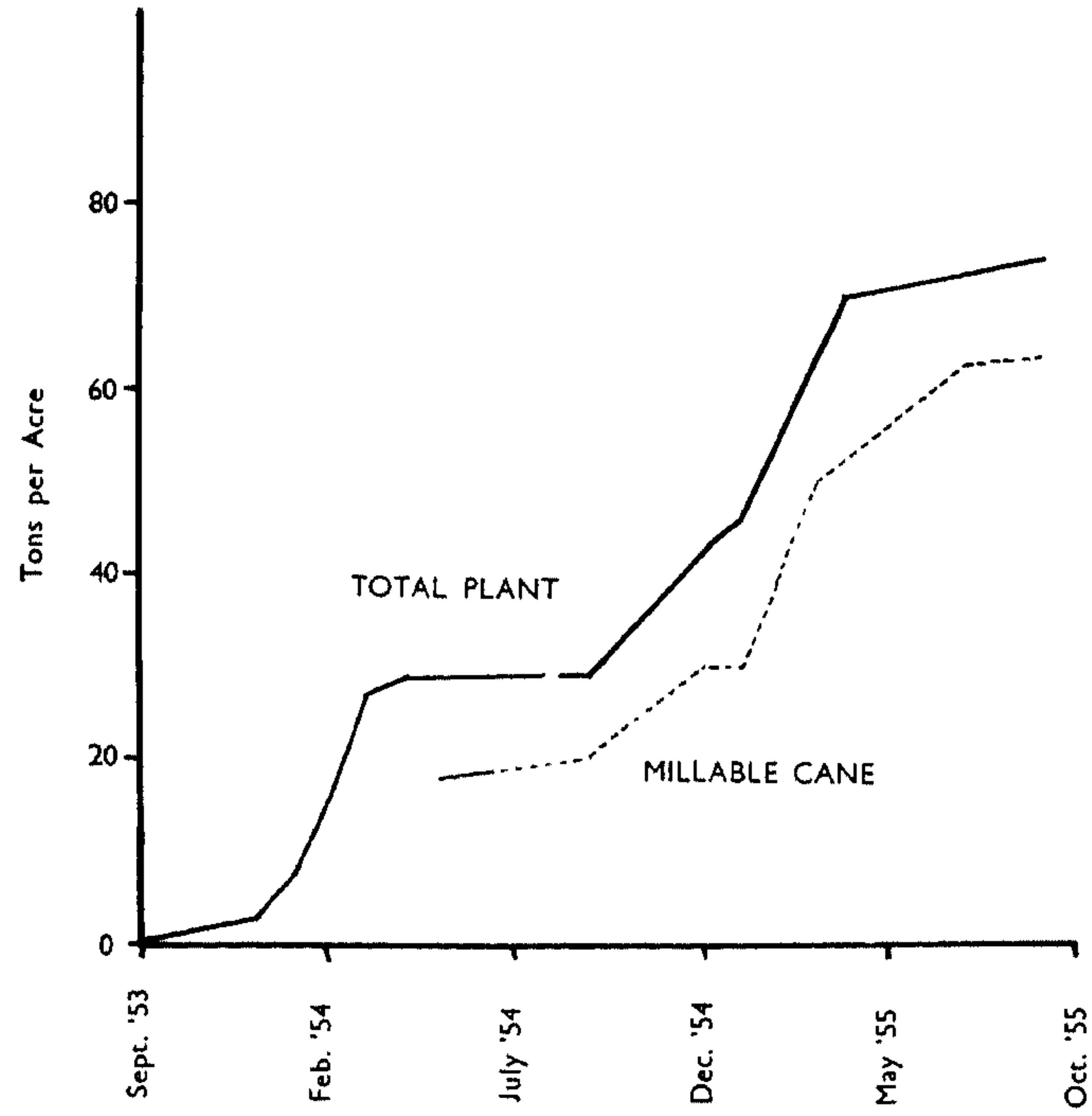
These tests were done on plant cane only, but it is hoped to continue work on ratoon cane later.

GRAPH No. I



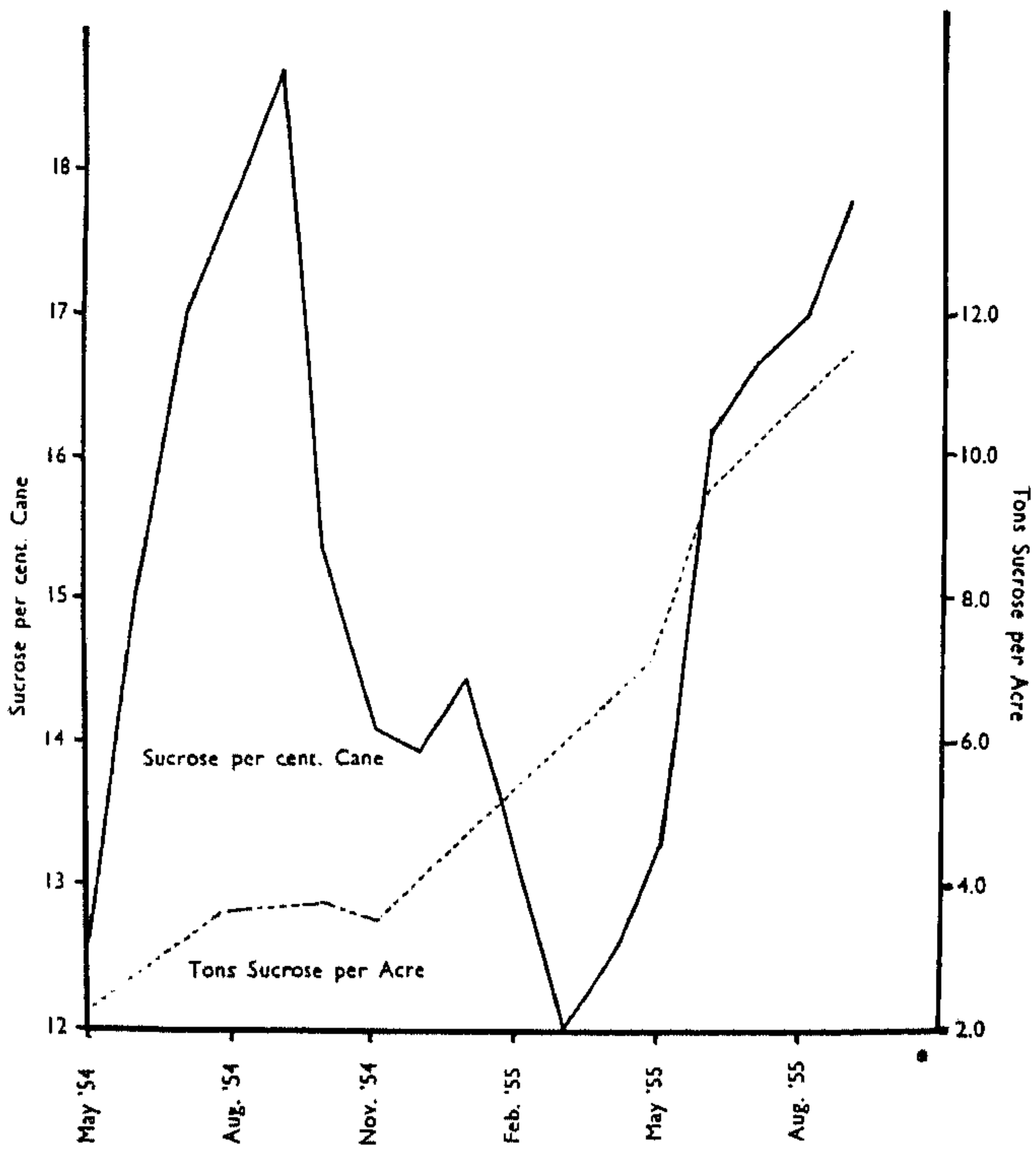
MONTHLY INCREMENTS OF CANE LENGTH, RAINFALL AND MEAN TEMPERATURE

GRAPH No. II



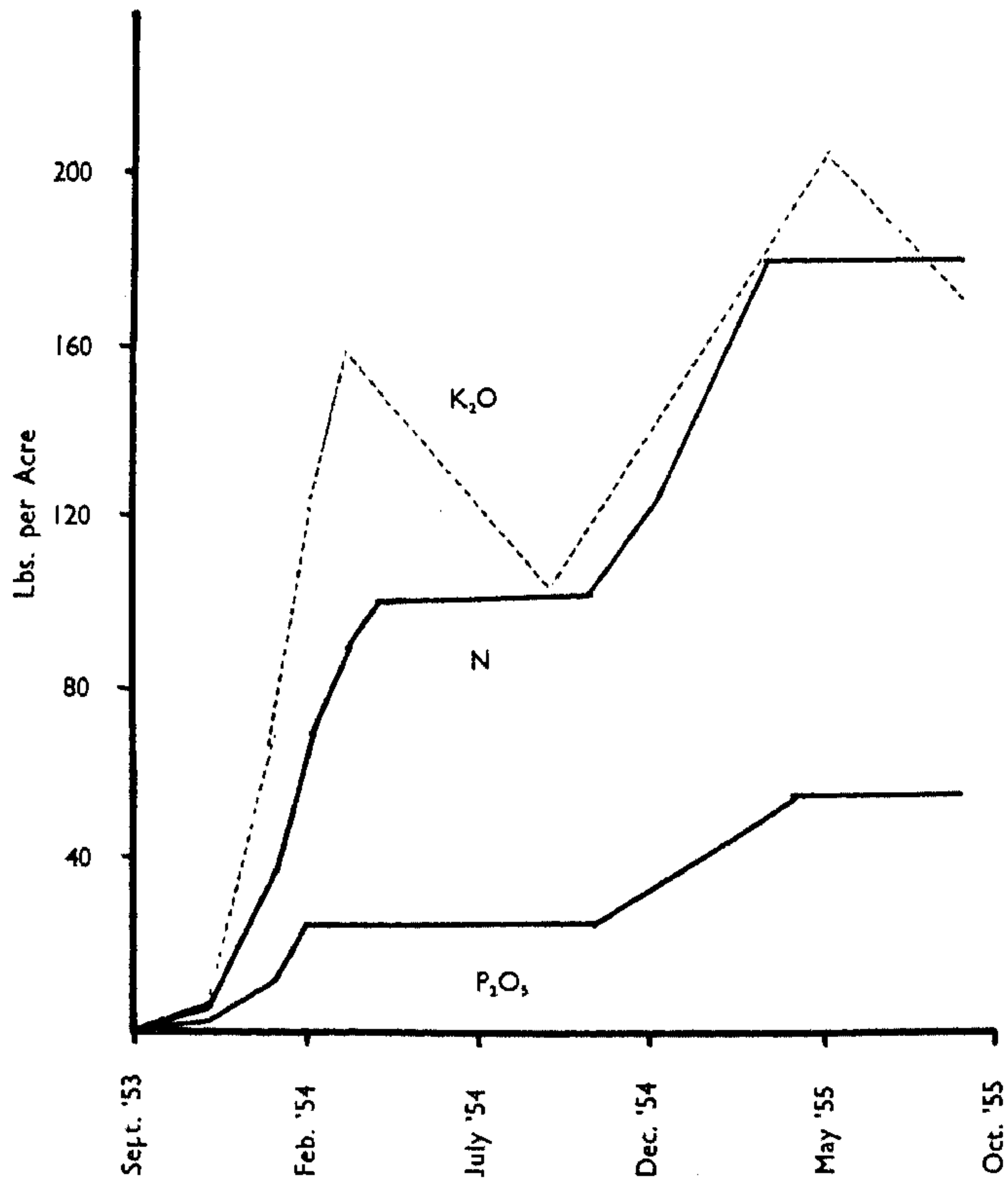
TONS TOTAL CANE AND TONS MILLABLE CANE

GRAPH No. III



SUCROSE PER CENT. CANE AND TONS SUCROSE PER ACRE

GRAPH No. IV



LBS. N, P_2O_5 AND K_2O PER ACRE

Dr. Dick, in the Chair, referred to his own observations on the effect of defoliation on the length of internode of cane and asked whether Mr. du Toit had considered using measurements of internodes as an index of rate of growth. He wondered if Mr. du Toit had been able to shew any relationship between leaf area and length of internode.

Mr. du Toit replied that it was well known that conditions of poor growth gave rise to the formation of very short internodes. He did not, however, use the length of internode as a quantitative measure in this experiment.

Dr. Dick asked if Dr. Brett could indicate if the number of internodes was more a matter of time than of growing conditions.

Dr. Brett said that work at the Experiment Station had indicated that prevailing conditions had little effect upon the number of internodes formed within a given time. Work in Formosa had suggested that the supply of food substances from a particular leaf had a great influence upon the length of the corresponding internode.

Mr. Barnes said an interesting point was the delayed growth following changed weather conditions. He said that on a certain estate overseas where the rainfall was about 90 inches per annum, the sucrose held for a longer period than on another estate which was irrigated. Here the effect of rain on sucrose and juice purity was apparent in a very much shorter time.

Mr. Main said that it was well known that after heavy rainfall the sucrose and purity of cut cane fell considerably. This was understandable, but the same also applied to growing cane. He would like an explanation for this and why recovery took some time after the rainfall occurred.

Mr. du Toit agreed that under certain circumstances rainfall might have an immediate adverse effect on sucrose and purity of cane as was shown in this experiment. Recovery would necessarily take some time as it was dependent on further sucrose formation.

Dr. Dodds said that he noticed from the figures in the paper that more magnesia than lime was taken up. Lime was applied to the soils in various forms but magnesia was seldom applied. He wished to know if there were any indication of magnesium deficiencies in the cane belt. He noted that experiments shown in the paper were carried out only on N:Co.310 and he enquired if there was any intention to carry out similar experiments on other varieties.

Mr. du Toit stated that the ratio of magnesium to calcium was higher in millable cane than in leaves and consequently the magnesium drain from our fields was considerable. Magnesium deficiency was therefore a distinct possibility in future and even more so where more potash was likely to be applied in future.

It was not his intention to repeat this type of experiment on all new varieties but the nutrient content of different varieties was now determined.

Mr. Pearson considered that this type of experiment might be helpful to agriculturists by providing a guide as to when to apply various plant foods. He was aware that dressings of nitrogen were applied in the furrow in this experiment but because of the s,allness of the sample the treatments were combined. He asked Mr. du Toit if he had any figures reflecting the differential amount of fertiliser applied.

Mr. du Toit said that some results showing the effect of treatment on cane composition were given. He hoped, however, to continue this experiment as a ratoon and hoped then to find bigger responses and bigger differences in composition due to fertiliser application.

Dr. van der Pol referred to graph 3 and said that if one looked at the peak of sucrose in cane it would be seen that this was narrow. He assumed that it was the same in the second year. He noticed that Mr. du Toit had not intended carrying out this experiment on other varieties. He asked if Mr. du Toit did not think that if this type of experiment was applied to other varieties it might be possible to establish early maturing varieties and late maturing varieties.

Mr. du Toit reminded the meeting that the sudden fall in sucrose per cent cane shown in the graph was the result of exceptionally heavy rains. Normally the deterioration of N:Co.310 would not be as rapid. Past tests had indicated that we had no variety which reached a peak sucrose content either early or late in the season. All our varieties reached their peaks much the same time although the steepness of the curve varied on either side of the peak and consequently some varieties can be cut more profitably early or late in the season. Varietal comparisons of this nature will be done in future but he pointed out once again that all varieties would not be submitted to such an exhaustive test as reported here.

Mr. Rault said that a few years ago, he had carried out a complete per cent analysis of the mineral constituents of cane juice, from the average sample of ash collected by calcining the mixed and clarified juices during the whole of the crushing season.

He was not so much interested in the plant food taken by the cane, but on the effect of clarification, and elimination of mineral non-sugars, and had found that the carbonatation process eliminated practicallv the whole of the magnesia content of raw juice.

At that time the ash of cane juice contained more magnesia than lime.

Mr. du Toit was welcome to the samples of cane juice ash he had collected and was still collecting for a number of seasons, for future reference.

Dr. Dodds said that in many agricultural industries a certain uniform lime-magnesia ratio in the soil was considered of importance. Possibly Mr. Sexton had now gained some information in this matter under local conditions.

Mr. du Toit said he had no information as to the optimum quantities of calcium and magnesium which should be present in the soil.

Mr. Sexton in reply to a query by Dr. Dodds said he could not tell how important was the ratio of calcium to magnesium or what it should be, but he had found in soil, calcium was about twice the quantity of magnesium and this applied similarly to cane leaves where the ratio was l 1/2 to 1.

RECENT MEALYBUG INVESTIGATIONS

By J. DICK

In a paper read to this Association in 1953,[3] the results were given of a number of experiments on the effects of infestation by the sugarcane mealybug, *Saccharicoccus (Trionymus) sacchari* (Ckll.). It was shown that the presence of mealybugs on setts at the time of planting had a detrimental effect on germination and early growth, and that some part of this effect might persist even if the insects were removed before planting. This led to the hypothesis that the removal of juice during feeding was not the only mechanism through which mealybugs were able to affect the plant. The object of the present note is to discuss the results of more recent investigations in which this hypothesis has been further examined by studying the germination and early growth of cuttings inoculated with an extract prepared by grinding the bodies of mealybugs.

Preliminary trials, of which an example was quoted in the above-mentioned paper, showed that, when cuttings were inoculated with this extract, germination was significantly reduced. Of three varieties tested, Co.301 was the most severely affected and this variety was therefore used in subsequent trials.

In the next experiment, setts were inoculated with untreated extract; with extract prepared from mealybugs which had been dipped in formaldehyde solution in order to destroy any fungi or bacteria which might be present on their surface; and with extract autoclaved after preparation in order to destroy all organisms which might be present. Four replications, each consisting of ten single-budded cuttings, were planted for each treatment and for the control, in which the cuttings were inoculated with distilled water. Figures, indicating the numbers of buds which had germinated after fourteen days, are shown in Table I,

TABLE I

Numbers of Buds Germinating

Control	Un-treated Extract	Auto-day ed	Formal-dehyde Extract
9	2	9	9
7	2	9	7
7	1	8	4
10	4	7	9
33	9	33	29

Significant differences between totals: 10 at 19 : 1, 14 at 99 : 1.

This result suggested that the depression in germination might be due to some type of infection, presumably fungal or bacterial, introduced in the mealybug extract. Setts of cane were therefore surface-sterilised with alcohol and were then inoculated by dipping the cut ends in the extract. A control series was surface-sterilised and dipped in distilled water. Both series were then kept in glass jars for four days at 30°C. At the end of this period, both buds and root primordia in the control series had sprouted, while those in the inoculated series, after starting to develop, had apparently died. The cut ends in this series were covered with a luxuriant growth of fungi, apparently mainly saprophytic. It was considered that, if infection had caused failure to germinate, the causal organism should have grown into the stick and should have been present at the base of the bud. Pieces of tissue from this region, where some discoloration was evident, were removed, surface-sterilised, planted in maltose-peptone liquid medium and incubated for two days at 30°C. At the end of this period, the only organism growing in the culture medium was apparently a species of yeast.

To discover whether this yeast might be responsible for depression in germination, setts were planted after inoculation with yeast, mealybug extract or distilled water. Results for one such test are given in Table II.

TABLE II

Numbers of Buds Germinating

Water	Yeast	Mealybug
10	8	3
10	9	5
9	8	2
10	8	7
39	33	17

Significant differences between totals: 11 at 19 : 1, 17 at 99 : 1.

These figures would appear to indicate that the yeast was of no significant importance as a cause of poor germination. However, two factors might have influenced the result, namely concentration, which might have been lower in the yeast culture than in the extract, and the length of the cuttings, which might have had some bearing on the time required for infection to travel from the cut ends of the sticks to the base of the buds.

Consequently, single-budded cuttings two, four or six inches in lenght were inoculated by dipping the ends in a culture of the yeast which had been allowed to grow for a week at 30°C, or in the mealybug extract, undiluted or diluted with three or fifteen parts of distilled water. For completeness, a control, dipped in distilled water, was inserted for each length and dilution. Ten cuttings were planted for each treatment and two repetitions of the entire experiment were carried out. In Table III, which shows the numbers of buds which had germinated after a fortnight, the sum of the two repetitions for each treatment is given.

TABLH III

Germination of Setts 6", 4" *or* 2" *long, After Dipping in Water (W), Yeast (Y) or Mealybug Extract (M), Undiluted* (1), *or Diluted* 1/4 (2) *or* 1/16 (3)

6" W	19	6" Y 3	17	6" M 3	17
6" W	19	6" Y 2	18	6" M 2	18
6" W	19	6" Y 1	18	6"M 1	10
4" W	17	4" Y 3	15	4"M 3	16
4" W	17	4" Y 2	14	4"M 2	12
4"W	18	4" Y 1	14	4"M 1	9
2" W	16	2" Y 3	16	2" M 3	7
2" W	14	2" Y 2	9	2"M 2	3
2" W	14	2" Y 1	8	2"M 1	1

Analysis of these figures indicated significant effects for all three factors: treatment, length and dilution. There was a significant interaction between length and treatment, particularly in the mealybug series. The effect of dilution was less than that of treatment or length. Mealybug extract had, moreover, produced a significantly greater effect than was estimated that, in the yeast culture used, there could not be fewer spores than in the mealybug extract. It was therefore concluded that, although the yeast might under certain conditions cause some reduction in germination, it could not be responsible for the whole effect observed after inoculation with the mealybug extract.

In attempting to explain the mechanism by which mealybugs affect the germination and early growth of cane, some four possibilities are apparent: the direct effect of removal of juice during feeding; the existence of some unknown disease of a virus nature; infection by organisms, such as fungi or bacteria, carried on or within the bodies of the insects; or the presence of some chemical toxin produced either by the insects themselves or by organisms associated with them.

Although the direct effect of feeding undoubtedly has some bearing on observed results, it is presumably not the only factor involved since inoculation with mealybug extract affects germination and early growth. Against the existence of some unknown virus it might be argued that, since practically every stick of cane is attacked by mealybugs at some period of its life, all cane in Natal should be infected with this hypothetical virus and it should not be possible to produce further symptoms by inoculation. As far as infection is concerned, the only organism found at the base ot the Duels in inoculated sticks was a yeast which, although it could be shown to occasion some reduction in germination, was not as potent in this respect as the mealybug extract itself. The possibility therefore still exists that some form of chemical toxin, produced by the mealybug or by some organism associated with it, is inoculated into the cane when the insect feeds and is, at least in part, responsible for the symptoms observed. The fact that the extract is inactivated by heat or by treatment with formaldehyde does not preclude the existence of such a toxin, since many chemical substances of this nature are precipitated by either heat or formaldehyde. The existence in mealybugs of toxins capable of affecting the growth of plants is not without precedent, since Carter,[1,2] m a number of papers, has demonstrated that wilt of pineapples is caused by just such a material. As far as sugarcane mealybug is concerned, it is therefore proposed to investigate the matter further.

Summary

A description is given of some experiments which demonstrated that inoculation with the body fluid of mealybugs adversely affected germination and early growth of sugarcane. Investigation of this phenomenon showed the presence of a yeast, associated with the insects, which had some effect but was not as potent as the body fluid itself. The existence of some toxin associated with the insects is suggested as a possible cause of observed symptoms.

REFERENCES

[1] Carter, W. (1933): The Pineapple Mealybug, *Pseudococcus brevipes*, and Wilt of Pineapples. Phytopath. 23, 207-242.

[2] Carter, W. (1937): The Toxic Dose of Mealybug Wilt of Pineapple. Phytopath. 27, 971-981.

[3] Dick, J, (1953): Mealybug and Its Effect on Sugarcane. Proc. **27th.** Congr. S.A.S.T.A., 113-118.

Experiment Station,
South African Sugar Association,
Mount Edgecombe.
March, 1956.

The Chairman said that we had heard with much interest Dr. Dick's paper on the effects of the mealybug, and he hoped that chemists in the audience would be able to supply further data on this subject.

Dr. Dick stated that from his latest experiments it would appear that the effect on the cane sett might be due to an organism associated with the mealybug and not to the mealybug itself.

Dr. Dodds mentioned that Australians were surprised that so much time was spent in South Africa on mosaic disease which in Australia was regarded as being of no importance while in this country it is a serious threat. **Dr. Dick,** in reply to a question from Mr. W. J. Hempson, explained that the mealybug was a small soft-bodied insect found under the leaf sheaths of the cane.

Mr. Rault stated that two new varieties, i.e. N:Co.339, and N:Co.293 planted on the eighteen different sections constituting the Natal Estates had yielded the excellent returns of 8.8 and 9.9 tons of sucrose per acre respectively. The acreage cut represented a total of 48 and 79 acres.

As one of them was a carrier of mosaic and the other of "smut," the field management had decided as a precautionary measure, to restrict their propogation on account of the possible damage to the not so resistant already established varieties.

This anomalous position indicated that as in the case of Australia, carriers of mosaic under certain forms, could still be profilic yielders, very profitable *to* the industry for the time being.

Dr. Dick said that it had been hoped to grow only varieties which were immune to mosaic, but now all that could be hoped for was that we might be able to propagate resistant varieties. The danger was that if tolerant varieties were allowed to be planted they might act as a source of infection to less tolerant varieties.

The Chairman, Mr. du Toit, asked Mr. King to comment upon the remarks by Mr. Rault that N:Co.339 had been condemned although its yield was very high, simply because it contracted mosaic disease.

Mr. **King** said that there was a great danger of strain mutations taking place when there was a large number of mosaic infected plants about. These strains may be more or less virulent than the common strain now present in the industry. If a more virulent strain arose there was the possibility that N:Co. 339 would no longer be a tolerant variety.

Mr. **Pearson** commented on Mr. Buzzacott's remark that mosaic was not important whereas Mr. Henzel from Jamaica had stressed the importance of it in the West Indies.

Mr. **Main** enquired what the effect of mosaic on Co:339 would be over a certain period.

Mr. King said that experiments had shown, when carried up to the 3rd ratoon, that there was no particular loss in N:Co.339. In N:Co.310 it had been found that after about the 2nd or 3rd ratoon the variety recovered from the disease.

Dr. Brett asked Dr. Dick if he did not think that the effect of wilt in pineapple could not be entirely accounted for by a simple toxin.

Dr. Dick said that Mr. Carter was apparently satisfied that it was the effect of a toxin.

, **Dr. Dodds** asked if there were not more than one species of mealybug in this country. Apparently the one in Louisiana that attacked cane was very different from the principal one here.

Dr. Dick replied that for a long time *it* was thought that there was only one species of mealybug but he himself had some time ago found another species. This however was more susceptible to the attacks of parasites, and would not develop to the same extent as the one mentioned in the paper.

The Chairman said that we had long known of the existence of mealybug in this country but no great importance was attached to it. Dr. Dick had now opened up a wide field of investigation, and had draw attention to the harmful effects of the mealybug. This field of investigation would embrace the work not only of the entomologist but also that of the botanist and chemist.

THE CONTROL OF WEEDS IN PLANT CANE BY CHEMICAL SPRAY

Introduction

In presenting these observations on the application of chemical sprays for the control of weeds in plant cane and of the results obtained, it is not intended to express dogmatic ideas or to cross swords with the experts. This paper is merely a record of what has been done at Kearsney recently with chemicals to eradicate weeds, with different methods of application and with various mixtures and concentrates. The facts are given in the hope that they may assist planters in selecting some method of chemical weed control which might be sufficiently economical for use on their own farms. As will be shown, the cost of the various methods varies considerably. Generally speaking, the more expensive the mixture and the greater the number of applications the better are the results which are obtained, and the main consideration is to find that point where the expense involved justifies the control obtained.

Methods of Application and Cost

There are at present two methods used for applying the spray. Firstly by means of a knapsack pump fitted with a boom with four or six nozzles. Using this method with a six-nozzle boom, one boy is able to spray two-and-a-half acres per day putting on emulsion at the rate of forty gallons per acre. For every two pumps, an additional boy is required to prepare the mixture, supply the pumps and generally assist the spray boys. Thus it takes three boys to cover five acres per day. Putting the cost of one boy at 5s., to cover wages, rations, etc., the total cost by this method is 3s. per acre for application. It is essential that a good type of knapsack sprayer be used—a suitable one costs about £12. Du Toit[1] states that at the Kekaha Sugar Co., in Hawaii, one boy with a hand-spray, applying solution at the rate of twenty-five gallons per acre, will do three to four acres per day.

The second method is application by means of a wheel tractor fitted with a fifty-gallon drum, a pump to maintain a pressure of 70 lb. and a hinged boom on which there are twenty-four nozzles or spraying jets. The cost of the drum, pump and boom is approximately £100; £25 for the pump and £75 for the rest of the equipment. This outfit can spray twenty acres per day comfortably, provided water for the solution is available alongside the field. If the tractor has to travel to the source of the water supply each time the drum is empty, the acreage done per day will naturally be reduced according to the distance travelled to fetch water. Assuming that the area covered is twenty acres per day, then the cost of application is calculated thus:

		s.	d.
1 tractor driver (including rations, etc.) ...		10	0
1 assistant		5	0
10 gals., Power Paraffin @ Is. 4d. per gallon		13	4
Oil and grease ... ••• ...		1	0
Depreciation on tractor @ £100 per 300 days		6	8
	£1	16	0

That is £1 16s 0d for twenty acres or, say, 1s. 10d. per acre, as against 3s. per acre by the knapsack method as shown above. It will be noticed that no allowance has been made in the above figures for depreciation of the spraying equipment. The tractor boom sprays four lines 4 ft. 6 in. apart, or 18 ft. at a time, and one filling of the fifty-gallon drum completes one-and-a-half acres, thus giving a cover of thirty-three gallons per acre.

The area covered daily by a tractor can be increased greatly by using a larger tractor and more elaborate equipment. Du Toit[1] shows that in Hawaii, by use of a D4 tractor with two tanks each containing two hundred gallons of solution, and with twenty-nine nozzles doing nine lines at a time, sixty-five acres per day are accomplished. With the success that is being achieved in Natal by chemical spray the day cannot be too far distant when these larger spraying units must come into operation.

Chemicals Used, Cost and Effect

Let us now consider the chemicals at present being used and their cost. Firstly there is weed-killer D-Concentrate, a description of which by the manufacturers[2] XO CLO follows:

"Weedkiller D-Concentrate is a selective hormone-type herbicide containing 4 lb. of 2, 4D acid equivalent per gallon. It is toxic to broad-leaved weeds and sedges, but generally not to grasses once they have emerged. Its mode of action is to induce a systematic physiological disorder. When it is applied to moist soil before weeds have appeared it will prevent the germination not only of broad-leaved weeds and sedges, but many annual grasses." (The *Oxford Dictionary* describes sedges as "Water-side plants resembling coarse grass growing together in a mass. ") The price of D-Concentrate is 26s. 6d. per gallon or 3s, 3 3/4d. per pint.

The second type of chemical is designated as "Q" and is described as "A non-selective herbicide containing 4.5 per cent, pentachlorophenol in phytotoxic oils. It is primarily used to control seedling weeds which are resistant to D-Concentrate and its mode of action is one of burning aerial growth on contact/' The price of "Q" is 4s. 5d. per gallon.

All spraying done so far has been with D-Concentrate alone or with a mixture of "D" and "Q." Satisfactory results have been obtained m areas that have little or no water grass, by applying five pints of D-Concentrate two or three days after planting. This keeps the broad-leaved weeds under control for approximately two months. That is to say it is about two months before the field begins to look "dirty. A second application of five pints of D-Concentrate is then applied which keeps the weeds in check, so that the first-hand weeding will not be necessary until the cane is four or five months old. The cost of five pints of D-Concentrate at 3s. 3 3/4d. per pint is, say, 16s. 7d., plus cost of application by knapsack pump gives a total cost of 19s. 7d. per acre. If the spraying is done by tractor the cost is reduced to 18s. 5d. per acre per application. It must be emphasised that treatment with D-Concentrate alone will not be satisfactory in water grass areas. Where there is both water grass, other grasses and weeds, as is usually the case, it has been found that a mixture of four pints of D-Concentrate and six gallons of "Q" in the fifty-gallon drum mounted on the tractor gives good results. As has been mentioned above the fifty gallons of mixture when sprayed by tractor covers one-and-a-half acres, giving an application of two and two-thirds pints of D-Concentrate and four gallons of "Q" per acre in thirty-three gallons of emulsion. The cost of this is 8s. lOd. for the D-Concentrate, plus 17s. 8d. for the "Q," plus Is. lOd. for application—a total of 28s. 4d. per acre.

When using a knapsack sprayer a convenient mixture is three pints of D-Concentrate plus four gallons of "Q" in a forty-gallon drum which must be all sprayed on to one acre. The greater the dilution of the emulsion the better, provided the correct amount of chemical is applied per acre, because the weeds and the soil get a better soaking and a more uniform distribution is assured.

The mixture of D-Concentrate and "Q" as described abovemay be used as a pre-emergence spray or the application may be delayed until there is a fair growth of weeds and water grass. The second procedure has the advantage of carrying the crop longer before the second application is required, and thus longer before the first hand weeding is necessary. Water grass up to four inches in height will be killed if the first application is delayed until then. One disadvantage, however, of allowing weed growth to develop before treatment, is that any weeds must take up a certain amount of plant food. Owing to the presence of the contact herbicide "Q" in the mixture the leaves of the young cane, with a late first application and with a second application, will all turn brown. Although this presents rather an alarming picture we have found that the heart of the cane plant is not effected and continues to grow, so that in ten days or a fortnight the field is green again and does not appear to have been set back to any noticeable extent. As it is easier to keep the spray off the cane with knapsack sprayers, this method should be used if a second application is done.

A Practical Example

The photograph shows a field of young plant N:Co.310 where an area was sprayed with two and two-thirds pints of D-Concentrate plus four gallons of "Q" at the rate of thirty-three gallons of solution

per acre. This cane was planted on 10th October, 1955, and sprayed for the first time exactly four weeks later, on 7th November, by which time the majority of the cane had germinated and was showing above ground in spikes and flags. The weed population consisted of well-established water grass between four and six inches in height, and other small miscellaneous weeds. All this growth was totally destroyed within six days of spraying as can be clearly seen in the photograph, in contrast to the

were taken twelve days after spraying and forty days after planting. Some water grass grew again after two weeks, but there was no appearance of other weeds for a month. The field was then scarified, which kept the water grass and weeds under control. The first hand-

was not done until 5th March, seventeen weeks after spraying; this was a very light weeding, taking only four Togt women per acre at a cost of

10s. This field will now require only one more weeding in approximately three months' time. Before the cane gets too big it will have been cultivated, by means of a scarifier drawn by a mule, six times, Scarifying costs 2s. per acre at three acres per day per unit. The total cultivation cost per acre of bringing this field to maturity is therefore:

		s.	d.
1 spraying by tractor with two and two-thirds pints "D" and 4 gallons "Q"		18	5
2 light weedings, 4 Togt units per acre @ 2s 6d	1	0	**0**
6 scarifyings @ 2s. per acre		12	0
	£ 2	10	5

If no spraying is done an average field of plant cane needs three hand-weeding which, if only the most expensive type of labour is available, contracted men at an overall rate of 5s. per day, would cost at five units per acre, 25s. per weeding, or 75s. for the three weedings. Add to this scarifying six times, 12 s. per acre, gives a total cost of £4 7s. 0d. per acre. If the cheaper Togt labour is obtainable this cost is reduced to £2 9s. 6d. per acre, which is practically the shown above when combining spraying and hand-weeding. Thus the whole question of whether to spray or **not,** rests on the supply and type of labour available. The reason for Natal not being advanced as are other sugar-producing countries in the use of chemicals is that, until fairly recently, an abundant supply of cheap labour has been obtainable. The fact that this is no longer the case **makes it essential that chemical** weed **control methods will** have to be adopted to a greater extent.

So far we have used only the two: 4-D and "Q" as described. The use of other chemical sprays is, however, under consideration and the details of an experiment recently laid down are shown below. All information is as given by the manufacturers.

Weedkiller Experiment

Object; Chemical control of all weeds (especially water grass) using pre-emergence technique.

Location; Alluvial flats of Tugela River. Soil—alluvial clay.

Equipment Used: Knapsack sprayer with full cover boom delivering 25

Date of Application: 16th February, 1956.

Conditions at Time of Application: Weather extremely hot and overcast. Soil very dry. Seed-bed in parts very rough (cloddy). Negligible wind.

Replications: All treatments replicated four times

Treatment of costs

Treat-ment	*Application per Acre*	*Cost per Acre* s.	d.
T.1	Fernimine 4—8 pints	33	6
T.2	Fernimine 4—16 pints	67	0
T.3	Fernesta 8 pints	30	0
T.4	Fernesta 16 pints	60	0
T.5	Fernimine 4—8 pints + 20 lb. T.C.A.	86	10
T.6	Fernimine 4—16 pints + 20 lb. T.C.A.	120	4
T.7	Fernesta 8 pints+20 lb. T.C.A.	83	4
T *8.*	Fernimine 16 pints + 20 lb. T.C.A.	113	4

It will be noticed that the cost per acre is considerably higher than for the procedures employed by us. This may, or may not, be justified by the results obtained, but as yet the experiment is in too early a stage for any opinion to be expressed.

General

There are several important things to remember when using herbicides. Firstly, no cultivation of any description must be done for several weeks after spraying, as this disturbs the layer of herbicide which has been spread over the soil, with a consequent loss of effect. If desired, cultivators may be used just before spraying, but not just after. Secondly, the chemicals must be thoroughly mixed with the water—it is advisable to put the chemicals in the container first and then add the water while constantly stirring the mixture. It is important to keep the solution free from foreign matter by means of sieves, as otherwise the spraying jets become clogged and much time can be wasted freeing them. After each day's work all jets and pumps should be dismantled and cleaned, so as to ensure efficient operation the following day. To obtain the best results, spraying should be carried out under suitable weather conditions. The soil should be damp, and the less wind there is the more even the application. For contact weedkiller best results are obtained on a hot sunny day, after rain.

Further Information

Anybody requiring more detailed information, particularly regarding the chemicals available for weed control, is advised to study the very informative papers presented at last year's Congress. One of these papers is by M. J. Stewart and the other by N. C. King and F. L. Almond. They are published in the Proceedings of the Twenty-Ninth

Annual Congress of the South African Sugar Technologists' Association on pages 126 and 122 respectively.

Conclusions

The chemical control of weeds has now been established as a practical and economical factor in sugar agricultural practice in Natal and will be used to a greater extent by the average farmer in the future. As Altona and Mentz[3] say: "The use of weedkillers is worldwide and each year a new crop of weedkillers emerges from the chemist's laboratory. In the United States the total consumption of weed-killers in 1951 was estimated to be 122,000,0001b. There was little doubt that weedkillers had established themselves in agriculture. As an aid to good farming practices they could play a big part in crop production, but their limitations must be realised. They are not a panacea to all farming operations.'

Acknowledgements

The writer would like to thank those members of the field staff of Messrs. Sir J. L. Hulett & Sons Ltd., who have carried out the work outlined in this paper and supplied much of the data.

REFERENCES

[1] du Toit, J. L. (1953), Report on Visit to Hawaii, Louisiana, Florida, Puerto Rica, and the Eighth I.S.S.C.T. Congress in B.W.I. S.A. Sugar Association, p. 37.

[2] Shell Bulletin No, 513 (1954), "Chemical Weed Control in Sugar Cane with Shell Weedkillers," p. 1.

[3] Altona. Dr. R. E., and Mentz, N. J., "Wide Range of Chemical Weedkillers," *S.A. Farmers' Weekly,* 8th September, 1955.

Mr. Twinch regretted that there were not more planters present because the subject was so practical and valuable information was given which might never get to their ears.

He said that seed-bed preparation was extremely-important. The seed-bed should not be prepared and treated too long before the cane was planted.

The tilth was also important as it was difficult to spray cloddy ground.

He asked Mr. Steward about the quantities of spray employed. These high rates, he thought, might be cut down with advantage,

He wanted to know from Mr. Steward if he always applied weed-killer at the rate of 40 gallons per acre as he had found 25 gallons quite sufficient.

Mr. Steward said that he had tried using only 25 gallons per acre but found that water grass, the weed it was especially necessary to destroy, was not killed satisfactorily unless it received a thorough soaking which could be done only by applying a minimum of 40 gallons per acie. He had found that, provided the correct amount of chemical was applied per acre, the more water used in doing so the better the results obtained.

He considered that the reason for their originally not getting good control of water grass was due to putting on too little water with the chemical. The reason that 33 1/3 gallons per acre, instead of 40, was applied when using the tractor was simply because that was the maximum amount that could be sprayed with the particular type of boom fitted at present. When using nanci pumps, however, it was a simple matter to apply the required 40 gallons per acre.

Mr. Pearson said that thispaper should be brought to the attention of the farmers.

He asked Mr. Steward if he did not find that by using small quantities of solution the jet blocked up more readily. With heavy applications of liquid, the jets could be bigger and less blocking would occur.

Mr. Steward replied that obviously a larger jet would give less trouble than a smaller one but, in any case, he had stressed that all jets should be kept scrupulously clean.

Mr. King was grateful that Mr. Steward had given costs of weeding, etc.

As far as application by tractor was concerned, he thought this would be better for post-emergent spray rather than pre-emergent spray, as even big estates only planted a small acreage per day, which could easily be covered by knapsack spray.

He felt that not sufficient stress had been placed upon the possible spread to gardens of these commercial weed-killers. He felt that a warning should be given about the possible effects on other crops, and that the dangers inherent in the use of weed-killers had not been stressed enough.

Mr. Rank also remarked upon his experience with garden plants and fruit trees being affected by weed-killers, probably wind-borne, as such plants were at some distance from the cane fields.

Mr. Twinch, commenting upon a statement in the paper that water grass up to 4 inches in height had been killed, wished to have further clarification. He wondered if it was not merely a case of it being controlled but not being killed..

Mr. Steward said that what he had meant was that full grown water grass starting to seed, was, after spraying, completely burned down. He did not mean that the plant was completely killed as some of the roots would grow again. However, the water grass was set back in its harmful effects for a couple of months or longer, and by the time it re-grew, the cane was very much higher and the water grass could be easily controlled by scarifiers.

Dr. Dodds stated that this paper was very valuable at this stage. It had been proved conclusively by scientists that chemicals could control weeds, but the next question was—did it pay?

This paper by Mr. Steward, giving costs, was, therefore, especially welcome. He considered it only a matter of time before the application of chemicals for controlling weeds would become economical everywhere. As the materials for the manufacture of these chemicals were considered that before long the cost of their manufacture would be considerably reduced.

Mr. Stewart remarked upon
and considered this fixed the amount of liquid which was applied.

Mr. Steward replied that six nozzles were used because they wanted 40 gallons to be applied per acre. If it was required to reduce quantity some removed.

Mr. Stewart said that there was more than one type of water grass, one being more easily controlled than the other.

Mr. King said that from the paper, they were using 5 pints of 'D' Concentrate, which was equal to 2J lbs. of 2, 4D per acre. Some years ago at Illovo, they claimed to control weeds by using only 1 lb. of 2, 4D per acre, but this had not been the experience at the Experiment Station. It would appear that we are now increasing the quantity of 2, 4D used. He wondered if the more resistant type of plants were now left, or whether there was an increase in the number of organisms which broke down the 2, 4D. There was also the possibility that we were now expecting better control than previously.

Mr. Steward said that he had tried using smalleri quantities, but he found the amounts now given were the minimum that were required to control the weeds. He said it was their practice only to spray plant cane so a period of up to 9 years would pass before more spraying would be done on the same land, when it had been replanted.

Mr. Twinch did not agree tnat it was now necessary to use heavier applications than before, because application of these weed-killers in the cane belt was quite recent. He related that even 1 lb. per acre would assure some control. In his own experiments he has applied up to 8 lbs. per acre, which gave complete control from planting to complete canopy.

He asked for some information about very heavy applications, up to 150 lbs. of 2, 4d per acre.

Mr. **King** replied that cane was still growing on tnat land.

chemical was due to the fact that to begin with the more easily killed weeds were destroyed and now the tougher varieties were in evidence.

Mr. Steward replied that, as far as he could see, there was no change in the weed population. Except for water grass, of which some areas were free, the weed varieties appeared to be similar in any location.

Dr. Dick reminded the Meeting that when synthetic organic insecticides were first used, they were more effective than they are now. He wondered if the same might not apply to weed-killers.

Mr. Twinch pointed out that the number of types of weed-killers was increasing far quicker than the types of weed, and that if one chemical proved to be no longer effective, another could be used to take its place.

Mr. Stewart said that the heavy applications of weed-killers were directed against the nut grasses. Ordinary weeds could be controlled at the rate of 2 lbs. of 2, 4D per acre, whereas nut grass required at least 8 lbs. per acre to control it. Such heavier applications, however, also affected the cane.

The Chairman, Mr. du **Toit,** said that the Association was grateful for such a very practical paper, and the Meeting could be assured that it would receive adequate publicity amongst the cane growing section of the industry.

INSTRUCTIONS TO AUTHORS

I. All papers for the Congress **must** be in the hands of the Technical Secretary fourteen days before the meeting. It is requested that authors will endeavour to send their papers earlier than this date so as to facilitate the work of printing.

2. Where possible the manuscript should be typewritten; when not possible the paper should be submitted in a form easily read.

3. References at the end of the paper should be arranged as follows : Name and initial(s) of author; year of publication in brackets; **exact** title of paper; contracted title of periodical; volume number; beginning page number of article. Thus:—
Brown, S. J. (1933): Study of Streak Disease. Proc. S.A. Sugar Tech. Assoc, 7, 101.

4. All the authors referred to should be arranged in alphabetical order.

5. Illustrations and diagrams accompanying the papers must be carefully drawn on **smooth, white drawing paper in Indian ink** so as to be suitable for reproduction. Any lettering on margins should be in pencil so as to allow of easy replacement by printer's type. The size of the largest diagram, curve, etc., should not be greater than 10 by 15 inches. Curves should be drawn on black graph paper, which can be obtained from the Technical Secretary.

6. Careful correction of typographical and other errors should be carried out by authors; this would save time on the parts of the Editor and Printers.

7. A **summary** of the main features described in the paper should be given at the end of the paper, immediately before the REFERENCES.

8. Authors may have 25 copies of their papers on application to the Technical Secretary. Any additional copies required by the author will be charged for.

9. Papers read at the Congress will not necessarily be published in the Proceedings.