Report of Committee on Clarification and Filtration.

By J. RAULT, *Convenor.*

The key problem of the S.A. Sugar Industry is the treatment of the raw juice. The raw juice is a complicated mixture of suspended impurities and chemical compounds in solution and as such involves both a physical and a chemical action for its successful clarification. This is achieved in varying degrees by the processes in vogue at the present time (G. C. Dymond, *S.A. Sugar Journal Annual,* 1925.)

This short extract from a most interesting discourse by one of our practical sugar chemists, will serve as an introduction to this report of the Sub-committee on Clarification and Filtration.

The subject of this report covers a very extensive field in sugar manufacture. Indeed many subdivisions of this field are of sufficient interest to afford the substance of a separate paper, so perforce this our first attempt at a systematic enquiry can be but of a preliminary and very incomplete nature.

The committee thought that the first step was to try and obtain accurate information on the present methods in vogue at the various mills. With this end in view a questionnaire was prepared and sent to all the mills. The answers to the questionnaire will form the basis of this report. It is to be regretted that one or two mills did not send replies, so that the statistics are not as complete as possible.

It was felt that no such information had been placed on record previously and although the mere fact of these records does not throw more light on the solution of our problems, it does however, by the diversity of the replies, create an opportunity for discussion, exchange of ideas and suggestions, all of which constitutes the *"Raison d' etre"* of the Technologists' Association.

A few general remarks are here necessary before entering into detailed statistics.

A superficial observer, judging by the usual criteria of sugar chemists, would not find anything particularly abnormal with the Uba juice, as the average purity of the raw juice sent to clarification is very fair and probably higher than that of the world's average sugar cane juices.

The difficulties met with in the treatment of the Uba juice are to be explained, not so much by the quantity of non-sugars, but rather by the quality of those impurities and possibly the form under which they exist, as it is not uncommon to find canes of high sucrose and purity yielding a very refractory juice.

A certain amount of research work has been done on the nature of the impurities of Uba juice, and the action of different processes of manufacture on them. This class of work demands a special training for the worker, requires time, and an appropriate equipment, and is one of the reasons justifying an Experiment Station.

The present requirements of the sugar laboratory, not only for South Africa, but for the world, in view of efficient clarification control, are on the lines of standard, quick, and simple methods of physical tests, such as discussed by Lindfors or lately described by Paine and Badollet.

It must be confessed that the present methods of chemical control give but an approximate indication of the success or otherwise of clarification which should be judged by physical tests such as viscosity, clarity, colour, surface tension, colloid elimination, etc. These tests would be of considerable value to the practical sugar manufacturer if they could at the same time be co-related in terms of factory language. The practical man judges of a good clarification by rapidity of settling, clarity of settled juice, ease of filtration, speed of boiling and curing, and finally, quality and yield of sugars.

For the time being we must be content with the usual purity, glucose ratio and ash tests, as being an indication of the degree of elimination of non-sugars, of inversion, etc., and wait for other technical results in the factory before judging of any process of clarification.

That the industry has been wide awake to all possibilities of improvements is evident when one considers the number of processes which have been tried with the sole purpose of preparing for the boiling house, a juice of similar physical properties to that of other cane sugar lands, favoured with an easier cane than the Uba.

Carbonatation, Bach, defecation, phosphatation, defecation sulphitation, Norit, modification of Javan methods, Petree, centrifugal processes, have all been tried at some time or other.

The common feature of all clarifying processes consists essentially in first neutralising or changing the impurities into a condition, making possible their removal by mechanical means, and secondly the removal itself of the impurities.

Perusing the statistics of all the mills we see that the first part of the operation is accomplished universally by lime neutralised by some acid and various methods of applying heat. The second part, namely the separation of the impurities is efficiently carried out in one case by immediate filtration of the whole juice, and for all the other mills by a fairly complicated system of settling and partial filtration. How this is done is now to be discussed in detail.

Resumé and Comments on Answers to Questionnaire.

QUALITY OF JUICE SENT TO CLARIFICATION:

This varies according to the history of the cane, whether it has been subjected to drought and frost, left exposed in the fields after burning, etc., which factors are independent of the manufacturer's control.

The milling and maceration system is not, however, without some influence on clarification as hot water and heavy milling may extract increased amounts of impurities connected with the fibre.

Compound maceration with its circulation and exposure of raw juices, although economical on the score of juice extraction is always fraught with the risk of inversion.

Hot water is used in two mills, the others use cold water.

Nine mills use compound maceration and five do not return the thin juices.

Strict sanitation round the mill bed plates, juice gutters and cush-cush tanks, is always desirable in order to avoid heavy undetermined losses which may occur in the raw juice. These losses may not be accounted for in the usual system of control which starts from the juice scales, but nevertheless affect the bagging returns. An abnormally low Java Ratio is often an indication of decomposition during milling.

A constant source of souring will be found in stagnant particles of cush-cush that accumulate in inaccessible corners of the milling plant or under the cush-cush sieves.

The replies to the questionnaire show that lime, formalin, sodium fluoride, steam, wash water, are all used against souring, but it seems that some mills do not realise yet the necessity of regular and frequent cleanings, as "weekly" or "occasional" is still the ruling condition.

Flushing with a fine jet of hot water under high pressure has been found a very successful method of cleaning.

STRAINING OF THE RAW JUICE:

All mills use the common mechanical scraper and sieve for "cush-cush" removal from the juice. The openings of the sieve vary from 200 to 640 holes to the square inch. Three mills have lately supplemented this preliminary straining by the help of the "Peck" strainer, with cloth of 80 to 100 mesh.

The effect of "cush-cush" or "Bagacillo" on clarification has been extensively studied by different observers, and especially in Hawaii. The general opinion is that its complete removal previous to clarification, should be of great advantage especially where lime and heat are applied previous to neutralisation.

HEATING OF JUICE:

Apart from the mill using the carbonatation process where the raw juice is heated to 140°F. previous to liming, the usual practice up to two years ago has been to follow along the lines of Louisiana and Mauritius, *i.e.*, sulphur and lime in the cold. Lately methods similar to those of Java have taken favour, 5 mills , Nos. 7, 12, 13, 16, 19, heat to 140-150°F. before liming, whilst mill No. 10 brings the raw juice to boiling point previous to tempering.

It would be interesting to compare the results obtained by the various methods of heating on the elimination of gums, waxes and colloids.

TREATMENT WITH CHEMICALS:

Five mills add lime first and then acid, 2 mills add lime and acid simultaneously and 7 mills add acid first and lime after.

So far no factory has been able to clarify by the simple defecation with lime only, 2 mills use lime and phosphoric acid (for raw sugar), 1 mill uses lime and sulphurous acid only (white sugar). Lime, sulphurous acid and phosphoric acid are used in 10 mills producing white or raw sugar and 1 mill uses lime, carbonic acid, and sulphurous acid (white sugar).

It is evident that the tendency in clarification is to create in the juice a precipitate as voluminous as possible with the idea of maximum absorption of impurities, and that economy on the chemical bill is not considered justifiable when balanced against the trouble experienced by the want of clarifying material.

FINAL REACTION OF TEMPERED JUICE AND TEMPERATURE OF JUICE LEAVING HEATERS:

Three mills report slightly acid to litmus paper, 1 mill reports acidity 1.00 cc. to N/10, another mill reports neutral to phenolphthalein, and 7 mills report as pH.

There is here a want of uniformity in the methods of expressing the reaction of the juice. As the majority of mills have found the hydrogen ion concentration method very practicable, it is advisable in the future that this should be the standard method for S.A. mills. The Chemical Control Sub-committe is putting a recommendation to that effect in its report.

It is interesting to note that Farnell in 1924 found the average pH of tempered juice to be 6.9 and that of clarified juice 6.5.

The temperature of juice leaving the heaters varies from 190° to 212°F. In 4 mills a further heating to cracking point in open defecators follows the juice heater treatment, while in the carbonatation mill the final heating to boiling point is carried out in 3 stages, with filtration between each stage.

SETTLING:

Three mills report the use of continuous settlers of the Dorr and Petree type, the other mills, except for the carbonatation mill which filters, use the old intermittent methods with a great number of units.

The time of settling varies widely from mill to mill. One mill reports half hour to one hour, and another 7 to 8 hours. The average settling time under normal conditions seems to be about 1½ hours. The total settling capacity (in gallons per ton cane hour) fluctuates from 466 to 1218 gallons so that the factories are equipped to take a supply of juice equivalent to 3 to 8 hours crushing, provided the available space is not taken up by returns of scum juice, filter press juice, or syrup bottoms.

TREATMENT OF MUDDY JUICE AFTER FIRST SETTLING:

The volume of muddy juice left after subsidence represents 10 to 30% of the juice from the mills. In every case this is treated by lime (No. 2 mill sulphurs also), diluted 10 to 20% in the case of 7 mills, heated up to near 200°F. and resettled.

Mills Nos. 13, 17 and 18 do not dilute, Mills No. 18 and 10 do not heat, whilst No. 12. 16 and 19 mills filter immediately without attempting to draw off some clear juice.

This second settling is done continuously in 2 mills by Dorr clarifiers.

As for the first settling, the time factor varies from mill to mill. half an hour in mill 9, and 10 hours in mill No. 17.

The capacity for subsiding the muddy juice represents from 16 to 66% of the volume of 1st subsiders.

Four mills send the clear juice from the secondary subsiders straight to the evaporator, and 4 mills return it to the raw juice or to the hot-tempered juice going to the heaters. The mud from the second settling has a further lime addition, in one case is also treated with kieselguhr and is sent to the presses.

FILTRATION:

With the exception of mill No. 4 (Petree Process) all factories use the common "plate and frame" presses. Automatic rotary vacuum filters are now being tried, but there is not enough information available to express any opinion as to their suitability.

The industry does not use one standard size filter press, the dimensions of the plates vary from 24 ins. to 40 ins. square, some having centre feed and others side feed, some provided with washing arrangements, and others with no special arrangement.

In the carbonatation process the most sensitive part is usually the filter press department as the clarification problem is primarily a filtration problem. In a lesser degree this is also a problem of sulphitation and defecation mills. "Making room" in a sulphitation mill consists more often in sending as little muddy juice as possible to the press department.

It is generally recognised that the filtration department is the least satisfactory station of the mill, and any process which can economically solve this problem brings with it potentialities of improvement in many directions.

Although a defecation process sends to the filters about 15% at the most of its juice, it is remarkable to find from the statistics that the carbonatation mill which filters the whole output of juice from the mills, is not the one that carries the maximum filtering area per ton of cane hour.

On account of the permeable nature of the cake obtained in this process, the sucrose in cake is washed down to 1%, but all the other mills show by their sucrose per cent cake record of 6 to 11% that washing is not a practical proposition.

Five mills are using the Monte-jus, 7 mills are using a reciprocating pump, and the carbonatation mill uses the centrifugal for forcing the muddy juice into the presses. The average working pressure is about 40 lbs. per square inch. The filtering cloth material varies according to the fancy or experience of every individual mill and 4 mills use double sacks.

The general practice is to send the alkaline filtrate from the presses back to the raw juice except in two cases, namely No. 9 that sends it straight to the evaporator, and No. 11 that neutralises with phosphoric acid and sends the clear juice after settling to the evaporator.

SYRUP:

Four mills, Nos. 17, 12, 4, and 7 do not settle the syrup, 1 mill (carbonatation) filters, 6 mills Nos. 13, 18, 10, 8, 16 and 19 settle for 2 to 8 hours, and 3 mills, Nos. 2, 11 and 9. settle from 8 to 36 hours. The subsider capacity varies from 2 to 21 hours of syrup supply from the mill.

Two mills, Nos. 4 and 5 making raw sugar, boil a syrup of pH 6.8 to 7.0. Mills Nos. 9 and 10 (white sugar) work at pH 6.4 and 6.6. Mill No. 7 sulphurs the syrup to 1.5-2.0 sulphur dioxide per litre, and the carbonatation mill occassionally sulphurs or phosphates to a pH 6.4-6.6. Mill No. 19 phosphates to pH 6.4 to 6.6

Syrup bottoms are generally returned to the raw juice except in Mill No. 19 where the mud is sent to the 2nd Massecuite.

INCRUSTATION:

Mills Nos. 17, 12, 10, 4, and 16 report freeness from evaporator incrustation; Mill No. 13 notes that incrustation has increased since the use of phosphoric acid in conjunction with lime and sulphurous acid, whilst numbers 18, 4, 1, 8, 7 and 19 report frequent incrustation of the evaporator.

All mills have to clean the evaporator heating surface at least once per week.

Juice heaters are cleaned once a week in mills Nos. 12 and 10 where no sulphur is used. Mill No. 18 is the only mill using sulphur dioxide that cleans only once a week. Mill No. 13 cleans the primary juice heater once per week and the secondary heater every 12 hours.

Mill No. 1 cleans twice a week, mills Nos. 17, 7 and 2 every 2 days, and mills Nos. 4, 9, 8 and 11, clean every day.

The juice heater, heating surface (per ton cane hour) varies from 33 to 94 square feet.

SULPHUR PLANT:

The most common type of sulphur plant is the tower 16 to 35 feet high, coolers being used for the hot sulphur gas, but scrubbers are not found in any mill.

QUALITY OF LIME USED:

The Taungs lime has practically the monopoly of use in South African mills although two mills report the use of Umzimkulu lime in conjunction with Taungs.

The Chairman said the report was extremely interesting and it was very remarkable to see that nearly every mill had its own way of working. He certainly did not wish to criticise anything, but the only regret about it was that, from the paper, they did not know which was the best method to use. (Hear, hear). He hoped anyhow that this was a beginning and that later on they would arrive at the most satisfactory method in order to obtain the best results.

Mr. Dodds thought that Mr. Rault and his committee were to be heartily congratulated on the excellent report. (Hear, hear). The questionnaire which had been drawn up appeared to him to be particularly skilfully compiled and certainly gave a very complete view of the clarification and filtration process of all the factories which had sent in returns. It was collective information of that kind which he thought had been most seriously lacking in the South African industry in the past, and the more they had of such material available for discussion and comparison the sooner would they arrive at uniform standard practices which could be considered the best for their conditions. He hoped that would form the basis of one or two suitable and efficient processes, one or other of which could be confidently recommended for our varied local conditions.

Mr. Rault said he would like to make a remark regarding the compiling of the statistics on the question of incrustation. Five or six mills reported that they were not having frequent incrustation; but yet he noticed that all the mills had to clean their evaporators at least once a week, whilst he understood that in some countries they could run for two or three weeks or more without having to clean.

Mr. Dodds thought that in some cases it had been found possible to run juice heaters efficiently longer than a week without cleaning, but he thought the best practice was to clean juice heaters weekly; but if they were not suffering from incrustation he did not see the necessity for cleaning the evaporators at the end of each week.

Mr. Pearce pointed out that the numbers of this report were different to those of the report given by Mr. Dodds. Was it not possible to make them all the same, so that it would be possible to see which were the best, and which not ?

Mr. Dodds remarked that Mr. Rault and himself had discussed this question. The difficulty was that some of the mills had sent in replies to the clarification questionnaire which had not sent in replies to the chemical questionnaire, and *vice versa*. Consequently there would be several gaps in the sequence of the clarification report if they were correlated, as there were already in the chemical one. The omissions in the sequence of the chemical report were due to the fact that there were one or two factories which had sent in returns last year, but had not done so this year.

The Chairman said it was a pity that the numbers did not correspond with the other numbers because if they did it would be possible to study what was the best way to work. There was another thing. Many of the mills did not want to have their workings disclosed.

Mr. Dodds stated that if it was the general wish of the meeting and a recommendation from it, they could perhaps correlate the two reports and change the numbers to correspond.

The Chairman said he had no doubt that the wish of everybody present would be that the best methods of working should be indicated.

Mr. Rault remarked that when the report was written the idea was not to give a pronouncement as to which was the best way or not, but to give statistics.

The Chairman said he was not speaking about the paper. It was, of course, extremely valuable and good as it was, but if they could make it more valuable by giving certain indications, he did not see why they should not do so. They all knew that carbonatation was the best.

Mr. Dodds pointed out that the same position had arisen in connection with the chemical report presented last year. They would remember that they gave the methods of laboratory procedure of each of the different mills, and the question was asked at the Congress, which was the best of those methods. It was, of course, impossible to say at that time; not until the various methods had been fully discussed.

The Chairman remarked that the report involved a great amount of work, and certainly it had been well carried out. No doubt it was a very clever questionnaire in every way.

Mr. Pearce proposed that the numbers be changed to suit the chemical control numbers.

The Chairman said he would like to know whether there would be any objection to doing so.

Mr. Dodds replied that there would not be any objection, so far as he was aware, from the Chemical Control Committee. It merely depended on conditions under which the answers were sent to the Clarification and Filtration Committee.

The Chairman asked whether there would be any objection from the millers.

Mr. Rault answered that there was nothing said about it.

Mr. Dodds said he took it that the proposal was not to disclose the identity of the individual mills, but merely to correllate the numbers.

The Chairman did not think it would matter much if they made the numbers correspond.

Mr. Dodds said he would be glad if Mr. Rault could give them a little more information regarding the methods of Lindfors and of Paine and Badollet of testing the physical properties of juices and sugar house products, that he had mentioned.

Mr. Rault said so far as he remembered from read-

ing the article, that Lindfors suggested the use of a small instrument (Dunouy's) for determining quantitatively the surface tension of any liquid. As the percentage of gum in juices was closely related to the surface tension value, a rapid test by Dunouy's apparatus would give an approximation of the quantity of gums in any juice.

Regarding the Badollet and Paine method of colloid determination this was on the principle of flocculation of colloids by basic dyes in definite ratios. The flocculating point of the colloids in the liquids tested was determined by a rapid optical test.

(Adjourned until 10 a.m. on Wednesday the 9th. March).

Wednesday the 9th March, the Congress continued at 10 a.m.

The first paper taken was that by Mr. J. Pullar on "THE USES OF ELECTRICITY IN THE SUGAR INDUSTRY."

Report of the Uses of Electricity in the Sugar Industry.

By J. PULLAR, *Convenor.*

Since our report of last year, which dealt principally with the advantages of electrified mills, electrical development in the Natal sugar industry has been negligible.

One complete new mill has been designed and ordered, which includes partially electrified auxiliary equipment only. One mill has been completely reconstructed and the electrical plant increased to provide for pumping and other electrically driven auxiliaries. One large mill extension has been ordered, but includes high pressure superheated steam engine for power, instead of the ideal electrical drive, which could have been applied. One mill has ordered power equipment for partially converting auxiliaries to electric drive, and only one concern has extended it's electrical plant for use outside the factory itself.

From this summary it would appear that the industry as a whole has not yet wakened up to the advantages to be obtained from an abundance of electric power, and that the subject matter of our last year's report has not convinced the millers that the advantages in conserving their fuel or at least converting it into useful electric power, are worthwhile.

Nevertheless we feel sure that in due course the advantages will be understood and realised, and we, therefore, proceed with a few notes on the uses of electricity outside the mill itself.

The uses to which electricity can be put in the vicinity of a sugar mill depend to a large extent on the nature of the fields, ownership, available water, and population. They can be classified under principal headings as follows:—

Transportation.
Irrigation.
Cultivation.
Rural and Domestic Uses.

We shall broadly review the possibilities for these uses in the Natal sugar belt.

TRANSPORTATION:

The handling of cane from the field to the factory is being considered by a separate committee, and we do not intend to trespass unduly on the subject matter under this heading, but will rather contribute to the discussion on the subject.

The cane when cut has to be collected and conveyed as a rule to a narrow gauge cane truck or ox-wagon, from which it is drawn by mules, oxen, or locomotive either direct to the mills, or to stations for reloading into S.A.R. Trucks. The expenditure of labour in these operations is very considerable, partly due to the nature of the material handled and partly due to the contour of the country.

It is our considered opinion that electricity can be brought to effective use in this field by the use of electric mules and haulages in the cane fields for collecting and loading the cane, and for marshalling the trucks at the permanent tracks.

The use of trolley, battery, or other equipment for this purpose depends solely upon individual requirements. Conditions differ so much that no general rule can be laid down.

From the marshalling stations at the termini of the portable tracks, the question of steam *versus* electric haulage to the mill again resolves itself into the consideration of individual economic and technical conditions. In some cases trolley electric locomotives can be shown to be a commercial proposition. In some cases battery locomotives have a claim for preference, and sometimes steam must hold its own.

A supply of electricity extended throughout the fields would be of inestimable advantage for some of the purposes described above, and also for mechanical handling of the cane at the various transloading stations.

The advantages offered by the electric locomotive as compared with steam or oil, are the very greatly reduced cost of maintenance, operation and depreciation, and the quick acceleration, ease of handling, reduced wear on track, and absence of the principal cause of cane fires.

It is not our intention to go into the merits of various systems of electric traction, but we expect