PURIFICATION OF SUGAR MILL WASTE WATERS

By Dr. E. P. HEDLEY

At this conference last year there was a good deal of discussion about the disposal of waste waters from Sugar Mills and Distilleries, and complaints were made about the nuisance these waters caused those living in the neighbourhood of such places. In order to explore the problem of overcoming such nuisance, as far as we are concerned, my company gave me instructions last September to carry out an experimental investigation of the subject and the following is a brief resumé of the experiments undertaken with that object.

Before undertaking the work a definition was sought as to what constituted a satisfactory effluent. None could be found, only a very general remark by Dr. Park Ross recorded in the proceedings of last year's conference, viz. "that solid or fermentable matter would not be allowed to go into the river . . . He could not even promise that the purified effluent would be allowed to flow into the streams." That was a very vague definition to work upon. It seemed to mean, however, that should all the fermentable solids be removed from the waste waters and a clear effluent result we would be well on the way to getting what was required.

Two types of water were experimented on, one contained the sludgy filter-press washings and the other was a similar water which had fermented for some days. In the former case on allowing the bottle containing the water to stand for two or three hours a great deal of mud settled out, leaving a turbid supernatant liquid wholly devoid of smell. In the case of the fermenting effluent nothing settled out and the water of course had a very objectionable smell.

The first precipitant tried was alumina ferric. 0.8 parts by weight of Alumina ferric were dissolved in 1,000 parts by weight of both types of water, sufficient lime to set free the hydroxides of aluminium and iron was then added and the whole allowed to stand two hours, by the end of which time if precipitation were going to result the reaction should have been completed. It was found even after 72 hours standing precipitation was far from being completed.

Four parts by weight in 1,000 of water of alumina ferric were then tried with a somewhat better result, but still far from satisfactory.

Six parts by weight of the reagent were finally tried in 1,000 of water to see whether complete precipitation could be brought about and this time the waters cleared completely. The use of such a quantity of alumina ferric would, however, be too costly. It is, therefore, to be concluded that this reagent is useless for these waters. Ferrous Sulphate behaved in a similar way. Other agents were also tried and lime proved to be the most satisfactory.

Four parts by weight of lime per 1,000 of the effluent produced a satisfactory precipitation, but it was evident that this quantity would have to be increased should we have to deal with a specially sludgy water. It was also found that when the waters contained fermented matter, lime, while removing the suspended impurities, would not remove the smell. This is a condition it should never obtain, but it seemed of interest to find a reagent which would remove the smell in the event of such waters having to be treated. Several reagents were tried and the best and cheapest proved to be bleaching powder. It was, however, found that if lime and bleaching powder were added simultaneously no clarification resulted. If, however, lime were first added and precipitation were allowed to take place, and the clear water decanted and then treated with bleaching powder the smell was removed in half an hour and the water remained free from odour. The amount of bleaching powder required to produce this condition varies naturally with the extent of the purification. In the experiments tried in the case mentioned it was found that two parts by weight per 1,000 proved adequate to bring about a satisfactory result.

In the experiments recorded it was found that before treatment there were 1,227 parts of solids per 100,000 of water. After treatment with lime only 198 parts of solids per 100,000 were left. The solids consisted of free lime and lime salts. The albuminoids, the decomposition products which gave rise to the nuisance, were quite removed. On keeping the water thus treated for ten days at atmospheric temperature no smell developed and it was felt that the objectionable constituents could be considered as removed. To put this water into a river should, therefore, give rise to no complaints.

Based on these conclusions my company are putting down plant to deal with the effluent from Felixton Mill. The waste waters consisting of filter-press waters and washings of the mill are to be treated with milk of lime and pumped into settling tanks. After settlement the clear water will be decanted off through a floating syphon and run away to the river. The mud which has settled out will be pumped through the filter-press and the resulting cake disposed of with the mill cake. The tanks are three in number, 17ft. by 23ft. and 5ft. high and can deal easily with 24,000 to 48,000 gallons per day.

At this point I should like to make a few remarks about Dr. Park Ross's and Mr. de Froberville's paper. It will be noticed that we found that alumina ferric would be required in very large quantities to precipitate the impurities in our waste waters. At Froyères we are told that 1lb. of ferrous sulphate is added every quarter of an hour to the 2,203,000 gallons of the waste waters from that factory. This means that 1lb. is added to every 22,925 gallons. Is there not something wrong here? Messrs. Kynochs use 1lb. of alumina ferric to every 2,000 gallons of river water, approximately ten times as much chemical as Froyères use to purify a waste which surely must be much more contaminated than even the water from a river in flood.

In their recommendations Dr. Park Ross and Mr. de Froberville put forward a scheme whereby milk of lime is added to the extent of 10% of the bulk of the water to be treated. Taking milk of lime as 10° Beaume and the amount of water to be treated at Felixton as up to 48,000 gallons per day, the lime required per day works out at more than that required daily to make our sugar. That is, that it would cost more in lime to treat our effluent than to make our sugar, a rather expensive suggestion. Further they suggest heating the water with the flue gases. This is unnecessary as in the cold, lime in lesser quantities than they propose, is perfectly effective.

The utilisation of the carbon dioxide from the flue to precipitate the lime might be used should it ultimately be found necessary to get rid of the lime completely, but it would be interesting and useful to hear some additional details as to the manner in which it is proposed to apply these gases. How are they to be conveyed to the flue? How are the flue gases to be purified from unburnt bagasse, etc.? Flue gases are used in certain industries as a source of carbon dioxide, such as the preparation of solid carbon dioxide for refrigeration purposes, but the source is a coke furnace where little dust results from combustion.

Chairman: In view of the nuisance that has occurred in certain parts of the coast regarding the disposal of waste waters from mills, it is very likely that legislation will be introduced to deal with it, and so it is a very important matter for the factories to arrive at some suitable and practical method of treatment. Leaving Dr. Park Ross's and Mr. de Froberville's paper over for the present and referring to Dr. Hedley's paper I would like to ask him whether he found that using alumina ferric with rather more lime than was necessary to precipitate the hydroxides was used. So far as I remember we found at Umbogintwini 15 years ago that we got the maximum precipitation of suspended matter from raw river water by adding a slight excess of lime, as we know now we had to arrive at a certain hydrogen ion concentration, but we did not look at it in that way in those days.

As regards the application of flue gasses, we might get some information from the Carbonatation factory regarding the way carbon dioxide could be utilised in that way.

Mr. Rault: In a Carbonatation mill there is always a large excess of carbonic acid gas wasted, as the quantity required to neutralise the lime is provided for by the decomposition of the limestone, the CO_2 coming from the burning of coke represents an excess of about 40% over, theoretical requirements. The use of flue gasses of low CO_2 content and high amount of unburnt particles in suspension will entail a special installation of scrubber and large pump in order to gas the enormous volume of water usually coming out of a sugar mill. A carbonatation factory may probably be able to do so fairly easily and this is why the French factories who all use the carbonatation process have given the lead in this direction.

Dr. Hedley: I tried alumina ferric alone and I tried it with lime and it seemed to me that in the end it was the lime that was doing the work and not the alumina ferric, consequently the alumina ferric was cut out.

Mr. Blacklock: We have made experiments at the Refinery recently in co-operation with Mr. de Froberville of Darnall. Following on pressure brought to bear by the Medical Officer of Health, the question of purification of effluent waters has been again taken up by the Refinery during the past two weeks. The report issued by Dr. Park Ross and Mr. de Froberville embodying the experiences gained in their recent trip to Europe is very interesting and has helped us in indicating the lines along which we might proceed in the making of experiments. In 1927 I did some work in this connection and submitted the results in a short paper read at the last Annual General Meeting of this Association. A simple lime treatment followed by decantation in sedimentation tanks was indicated. In the report just read, it appears that the process of purification which impressed the authors most was that in use at Froyères in France. This was also substantially a simple lime treatment, but with the added effect of minute additions of ferrous sulphate as coagulant. In our experiment of the past few days we have again proceeded on these lines. The coagulants used have been either ferrous sulphate, alumina ferric or soluble phosphate of lime.

A small experimental plant was erected, consisting of a flume 60ft. long conducting the waters to be treated into a mixing vessel of 77 gallons capacity. In here the main precipitation or coagulation took place and the treated water overflowed through a 3in. pipe into a chain of five sedimentation vessels of sixty gallons capacity each. The discharge from each of these vessels was an accurately levelled sill 2 feet long, which acted as a weir and over which the water at considerably diminished speed flowed in a stream apprixımately 1/16in. deep on the sill. The fifth sedimentation tank proper discharged into a square tank of 4 feet side and one foot deep which acted as a final save-all for stray flocks of the precipitate carried forward. It was found necessary to fit a baffle plate into each of these tanks to break the current and prevent the hotter water flowing straight across the surface.

The actual effluent of the factory could not be treated in this plant, unfortunately, owing to the fact that the different waste waters do not merge into common discharge until a point some quarter of a mile from the works. The trial plant was erected actually in the Refinery buildings for convenience, and some attempt was made to lead waters to the flume which would approximate, after mixing, the composition of the usual average effluent. These mixtures were subject, however, to sudden changes in sugar content—acidity—matter in suspension, etc., in a way which could not happen in the case of the final large body of waste water—and these changes militated against the smooth working of the trials to some extent. A certain measure of success was attained, however, in that no matter how dirty in appearance the original water, the overflow from the end tank of the small plant was clear and colourless, odourless and tasteless except for the faint sweetness due to the sugar from which the water is never free. The water treated was a variable mixture of char washings and pulp washings carrying the suspended matter separated from the sugar stations by the pulp cakes of the mechanical filters. Both waters unavoidably carry traces of sugar. The former is responsible for the slight acidity of the final effluent through lactic, formic, and other acids, and carries also colouring matters from the sugar albuminoids and mineral salts as phosphates, sulphates, sulphites, etc. The waters treated had an initial temperature of 130/180° F. and this assisted greatly in the formation and agglomeration of the precipitates formed. It was found that the higher the alkalinity reached the bulkier and heavier the precipitate formed and the more rapid the subsidation, and apparently the better the result. At a certain point, however, the cost of chemicals became prohibitive and the economic limit was decided upon with an addition of .05% of slaked lime and .001% of Iron or Aluminium Sulphate, or .0005% of phosphate. There seemed to be very little difference in the result whatever coagulant was used, and in occasional cases treatment with lime only was only slightly inferior to that with coagulants. The small plant described above was found to be capable of dealing effectively with 200 gallons of water per hour—and this was probably its maximum capacity. Analysis of the waters before and after treatment do not reveal the improvement which might be expected from their appearance. The total solids in each case is only slightly lowered—owing to the solution of soluble salts formed by the lime more than compensating for the deposition of all suspended matters along with the precipitates. The sugar remains unaltered and apparently unaffected. The weight of mineral salts in solution remains practically constant for the reason given above, while the organic matter other than sugar is reduced by about 50% due to the floculation of the colloids.

The oxygen absorbtion test cannot be taken as a reliable indication of the amount of organic matter other than sugar—by reason of the comparatively large amounts of sugar present.

The treated effluent yields a clear bright water containing practically nothing in suspension. This water is non-putrescible on standing at 25/30° C. for a period of ten days or more, the initial alkalinity being about .08 grams CaO per 1,000 c.c. To test the effect of the treated water upon fish life a mixture was made of river water containing a quarter effluent and a small fish placed therein. Being alive and unaffected after four days, another mixture containing equal parts effluent and river water was substituted, and in this the fish has been living now for about seven days and to-day seems as lively as ever. It is intended to make further investigations on the above lines on the actual effluent, but with a much bigger experimental plant capable of dealing with 50,000 gallons per day in order to try out the process more thoroughly and to obtain reliable working figures regarding capacities of tanks, quantities, and cost of chemicals and operation.

I have noticed that an article on the effluent problem is published in the current issue of the International Sugar Journal by Mr. B. J. Owen. The author deals with effluent from Beet factories and his experiments were conducted on the same lines as those described above, differing in detail only. His procedure consisted in screening off the rougher matter in suspension and then treating the screened water with lime and alumina ferric and filtering the treated water upward through coarse gravel, using an adaption of the Pennell Wyllie filter. In this manner only the non-settling portion of the precipitation was separated by the filters—the settling part being drawn off from below at intervals in the form of thick sludge. The particularly interesting feature is the replacement of a series of bulky mixing and sedimentation tanks by one filter of about 600 gallons capacity. A filter of this size, however, only dealt efficiently with some 100 gallons per hour. Owen's results confirm what has been done here, but he apparently obtains a much better "oxygen absorption" figure by again filtering through finer gravel and sand.

Chairman: With reference to the report by Dr. Park Ross and Mr. de Froberville, and the figures given as to the standard for effluents, it has been asked whether it is likely that those standards would be introduced here; they were regarded as impracticable for mill wastes, having been laid down for sewerage effluents.

Mr. de Froberville: They speak about three parts per 100,000 suspended matter. The suspended matter is really a very small thing in our mill residues.

Chairman: Three parts in 100,000 is a very high standard.

Mr. de Froberville: This proportion seems rather high but according to what Mr. Blacklock has said in the tests made at the Refinery there is practically nothing in the pure effluent. As to the non-putrefaction in four to five days, Mr. Blacklock has said that after twelve days there is not the slightest trace of fermentation or putrefaction, and treated even with a small dose of lime. Therefore, as to the non-putrescibility after five days this period is very small if it is to be made law. Most of the waters when treated with a small percentage of lime will not ferment after five days at 18° C. We kept the water about 35° for about twelve days and there was no sign of putrefaction.

Chairman: It would be better to have a standard in this country at a temperature nearer our average air temperature.

Mr. de Froberville: As far as the absorption of oxygen is concerned, we cannot give any definite information because as Mr. Blacklock has informed you the sugar present in the effluent produces an enormous absorption of oxygen, therefore we cannot say what is the proportion in the effluent itself. As soon as the crushing season starts, although we have to deal with products containing sugar yet the proportion of sugar will not be so high and we may be able to trace something and give an opinion regarding the absorbtion of oxygen.

Mr. Blacklock: On page 4 of the paper by Dr. Park Ross and Mr. de Froberville, about half way down it says "under no circumstances whatever can a waste water which contains fermentable matter, even in small amount, be discharged to a river or stream no matter what the volume of the latter may be." Our experience has been that we could not remove the sugar; the sugar was always left. Therefore, that cuts out our water and the effluent from all sugar factories. If you can't remove sugar from the water you can't discharge it into the rivers according to that. The fact that the water is non-putrescible after standing for so many days is due to its alkalinity; once it loses that by absorption of carbon dioxide, fermentation and putrefaction will begin.

Chairman: The suggestion underlying this paper of Dr. Park Ross and Mr. de Froberville, seems to be that the factories should produce an effluent that they should use in manufacture and not return to the stream at all. Is that not the intention?

M. de Froberville: In those factories where the quantity of water is very small, the same as is done at Froyères; where they have a very small quantity of water to work with so they are bound to use the same water and purify it as best they can. Even this water after the season is over is kept in tanks and used again afterwards. We saw this water and it had no smell whatever.

Mr. Rault: Is this in actual contact with the sugar?

Mr. de Froberville: It serves to wash the sugars in the process. We have seen it done. It is used in every part of the mill as well as for condensing purposes. It is the same water which is constantly returned and which is aerated in the different passages, in flumes and tanks and so on. There is no sign of putrefaction.

Dr. Hedley: Refinery effluents and mill effluents are two different things. Mill effluent is a much dirtier thing than the refinery effluent. They take notice of that on page 8 when they say "The carbonatation process is almost universally adopted, and the filter press waters are not particularly foul as in the sugar cane manufacture." The filter press waters from the mill even if settled by decantation have been found very difficult to get down to three parts to 100,000. It would be extraordinarily difficult without filtration through sand or something like that to get it down to that figure. Mr. Blacklock is right in that the waters contain sugar. We are going to find that very difficult if we are going to be bound down to waters containing no fermentable matter because sugar cannot be removed except by fermentation. I could not get it out by treating with lime and it seems to me that at Froyères they were using a diluted alcoholic solution. If we are going to return this continuously to the mill we are going to accumulate an acid effluent. At Felixton we don't need to do that; we send it straight away to the river and encourage these little fish!—(Laughter.)

Mr. de Froberville: It must be borne in mind that the water used at Froyères is kept during the off season. It ferments only after three months because during that time the alkalinity disappears. Therefore it is highly limed. The water cannot be acid to the point of fermentation unless time be given to it. They keep adding lime to it. When the next crop starts the same water is used again. We did not taste the water but there was no smell at all.

Mr. Rault: Speaking about our experience at

Mt. Edgecombe, I must say that having no river near the mill, we are very short of water and have to use over and over again the same water for condensing purposes. This water which is kept in large ponds contains entrained sugar and acids from the evaporation. To improve its physical quality we treat it with lime and test it regularly for alkalinity or acidity or sugar traces. Our daily tests show that sugar will keep a long time in them, at least a week—before decomposing. In the off season we overlime these ponds, but I must admit that although the waters may be alkaline and very clear to the eye, yet they smell and we have never been able to get rid completely of the bad odour and the sugar goes very slowly out of that water.

Mr. Watson: That does not seem to get us any further with regard to the point referred to on page 4 that under no circumstances can we discharge waters which contain any fermentable matter into rivers. Therefore, we must get some means of sending all the water back to the factories.

Mr. de Froberville: In this report it is dealing with distillation in Scotland and there is no sugar in it. By fermentable matter it must be understood that it must be no fermentable matter other than sugar. Whatever we may do here there will always be sugar present. It is impossible to say our waters are free from sugar. That is why certain corrections should be made to that. I am sorry Dr. Park Ross is not here just now.

Chairman: I seem to remember that Dr. Park Ross said last year that they would not allow any fermentable matter to go into the streams, and that seems to be the impression of the paper also.

At this stage Dr. Park Ross arrived and the Chairman explained to him what had just taken place.

Chairman: We would like to know whether it is the intention of the Public Works Department to prohibit waters containing traces of sugar entering streams. It would appear to be the case judging from your remarks last year that all fermentable matter would be prohibited in effluent waters.

Dr. Park Ross: The Public Health Department has not yet formulated its exact definition of what is to be determined polluted waters. This report is in the nature of a Parliamentary statement of the position as we saw it in Europe, together with certain suggestions which are placed before the Industry, not with the intention of asking the industry to adopt these suggestions, but merely of indicating to the industry that the Public Health Department believes that this pollution question is soluble, and our paper gives some of the grounds on which we have arrived at this belief; that is to say that as long as the industry makes a solution of the problem we don't care how they do it, but we believe it can be done, and we have asked the industry officially to get on with the business and to do it either in the way we suggest or some way of their own. With regard to the standard of effluent which is to be admitted to a river, I have stated in that report the standards which are enforced in the Home country. And I would be very interested to see, especially with regard to this test plant at the Refinery, as to what standard of effluent that plant is capable of producing. I have not got the analysis yet of the effluent but seeing the fish which were placed in it are all bright and lively I consider it would be a fairly high standard. As to the traces of sugar in an effluent, we pointed out that so long as there is a trace of sugar in a fluid delivered to a river that trace of sugar is going to ferment. And within limits it does not matter whether it is a small river or a large river you are going to get the same amount of fermentation, but whether the amount of damage is measurable or not will depend on other factors, and the Public Health Department will preserve an open mind as to what amount of sugar, if any, is going to be allowed into the river. Personally I think in a moderate size river a trace of sugar is not going to produce any measure of damage at all. In such cases the Public Health Department would not be prepared to do anything drastic, but we are convinced that the time has come when the effluent discharged to rivers—if they are to be discharged at all—must do no measurable damage to such streams. We believe that the adoption of processes, possibly some of the processes we recommend or others, will reduce the quantity of sugar being discharged into the streams to such a minimnm quantity that it will not produce any measurable damage. I am not prepared to state the exact amount of sugar, if any, which will be permitted by the Health Department.

Dr. Hedley: I should like to point out to Dr. Park Ross that he must not take the effluent from a refinery as a standard. As I said before he came in, the effluent from a sugar mill is one thing and from a refinery is another. As you point out in your own paper the effluent from a sugar mill filter press is far worse than any you get in the beet industry. These words are "The carbonatation process is almost universally adopted, and the filter press waters are not particularly foul as in sugar cane manufacture." Now it is a very difficult matter to completely get this filter press stuff out of even decanted liquor and they have less trouble in getting a decent effluent from the refinery than we shall have in getting it out of the mills, and they may even find it harder still in the Distilleries which are on the South Coast, although you say they are not as putrid as at Home.

Dr. Park Ross: The wash here is not as putrid as the Scotch whisky distilleries.

Dr. Hedley: But they may still find it extraordinarily difficult to get a good effluent. I think the people who would find it easiest would be the Refinery so that when the Health Department are laying down the standard, for goodness sake don't take the Refinery as the one you are going to work on.

Dr. Park Ross: My friend has put up a plea for an effluent which is not necessarily a good effluent, and he indicates that there will be very great difficulty in getting a good effluent from the sugar mills. I admit that there may be considerable difficulty but the purity of effluent which the sugar industry are to get after the adoption of a certain process will greatly depend on the effort that the sugar industry puts in to a perfection of the process to get a good effluent. Dr. Hedley has indicated that it is very difficult to get a good effluent, but since this report has been written I have found out that they are getting very fine results on the Nile from a process very much on the lines of the process at Froyères, and I am at present awaiting results. It will be quite interesting to see what Natal can do when proper plants are put down. All I have been able to find out so far from Egypt is that they are producing an effluent which is not producing any harmful effect on the waters of the Nile. The Health Department is not prepared to let the sugar industry sit down until the Health Department collects information from other centres. We look to the sugar industry to make a real effort to test out either their own processes or our processes, or both, and see if some solution of this thing cannot be arrived at.

Chairman: There is a minor chemical point arising out of the paper. There is a comparison of waste waters between cane and beet sugar factories, to the disadvantage of the cane sugar factories. I should have thought in view of the much greater content of nitrogenous matter in the bye-products from beet that their waste waters would have been much more objectionable than cane sugar waste, even though containing a small amount of sulphur.

Mr. de Froberville: These fermentable waters from the beet factories have a lot of albuminous matters and others which are eliminated by the lime treatment and by the ferric solution. If we adopt the same treatment here are we certain we are going to eliminate all these sulphites which are the worst things to be dealt with? They are found specially in the filter press cakes and in the washings. Will the sulphites have any influence on the machinery to be employed? We are not in a position to state yet as no experiments have been made in this line. It may be that we have a far more foul liquid here than in Europe, but it is only time which will prove if it is so. We have not the faintest idea yet of what these residual matters may be. No proper tests have been made yet. What can be done in the laboratory can be done in bulk.

Mr. Watson: At Tinley Manor the sedimentation tanks have been in use the whole of last season, the sludge having been passed through a filter press. I wonder if Mr. de Froberville has any idea of the result at Tinley Manor.

Mr. de Froberville: I was away during the last crushing season and cannot say anything about it.

Dr. Hedley: When I was doing this work I referred to in this paper I went and saw Tinley Manor and their effluent had no smell. It certainly had sugar in it; you can't get rid of sugar once you have it in solution. The conditions we are adopting at Felixton really amount to what they are doing at Tinley Manor. Tinley Manor were using alumina ferric and I consider alumina ferric is quite useless from my experience. Lime is quite sufficient by itself. We have decided at Felixton to put down this plant for the coming season. I have had Dr. Park Ross' paper for some weeks and have discussed it with others who are interested. There is one thing on page 6 where the authors are discussing the amount of evaporation which one pound of Scotch coal will do (reads). It strikes me that it is a jolly good work because one pound of coal is usually taken to evaporate nine pounds of water. I don't think there is much to grouse about if a pound of coal is going to evaporate two gallons of wash.

Dr. Park Ross: I had the advantage of going through this evaporation plant at Rothes Distillery with the Consulting Engineer, getting all his results, and finally going on those results with the Ministry of Health people who keep a very careful watch on this matter in Scotland. At the same time I was able to visit the other group of distilleries using the biological method of filtration. It struck me that comparing one with the other there was no possible comparison between the evaporation plant and biological filtration, but you will notice when we come to consider the treatment of sugar effluent I have been very cautious on the subject of biological purification because I don't know what the effect would be. We would be on new ground altogether. I know that there is a considerable amount of carbon dioxide given off in the biological process but at the same time they deal with a minimum of sulphur in their effluent liquor, and knowing from laboratory experience what happens with sulphur compounds in anaerobic fermentation, I could not give an opinion as to how biological purification would work out including with effluents containing a fair amount of sulphur.

Mr. de Froberville: In connection with the figures mentioned on page 2 of Dr. Hedley's paper, he speaks of Kynochs using one pound of alumina ferric to 2,000 gallons, which is about ten times the quantity used at Froyères using as they do a quarter of a pound of sulphate of iron; it produced a very fine precipitation with a great clarity of water. I wonder whether in the case of these beet waters at Froyères whether the alumina ferric would do the same. At the Refinery we used the same proportion, but Mr. Blacklock preferred to have a more apparent subsidation so we used double the quantity and we found results which were fine. Had we used the quantity of one pound to every 2,000 gallons it would have cost us a few pounds a day.

Chairman: Can you say why they used ferrous sulphate rather than alumina ferric? I know in certain parts of the world ferrous sulphate is the cheaper. I was wondering what were their conditions, whether they chose it because it was cheaper or because it was more effective.

Mr. de Froberville: I think they found it more effective.

Dr. Park Ross: They were very particular about one thing. They said they must get their alkalinity definitely .6. We are not going to say the effluent from the sugar mills would have to be brought to the same, but it was very carefully balanced at Froyères.

Mr. de Froberville: Furthermore, the lime they used at Froyères was scrap, it was kiln scrap which did not cost them a farthing, whereas if we were to have lime which we buy at 58/- or 60/- a ton, it would be rather expensive. It would be an utter impossibility, it would mean ten to twelve tons of lime for the Refinery itself.

At 4.45 p.m. the Conference was adjourned to 10 a.m. the next day, Wednesday the 21st March, 1928.