

the great prosperity of the Society, and they rejoiced that they could still depend upon the benefit of his wisdom and experience upon the Council. He asked them to drink with all heartiness to the general prosperity of the Society and especially to drink to the health of Dr. Messel.

The PRESIDENT, in responding, referred to the election of Sir William Crookes as President of the Royal Society which prevented his continuing to hold the Presidency of the Society of Chemical Industry. The Royal Society knew a good thing when they saw it, and they had come to the Society of Chemical Industry to find it. The Council had come to the decision, with reference to their annual meeting, that some time should be devoted to the consideration of special subjects, but as that would not come into operation until next year they could enjoy themselves this year. He had become so accustomed to the chair that he should be quite sorry when his year of office expired. But to be quite serious, he wished to return them his very sincere and grateful thanks for the support he had received during the years he had had the honour to fill the chair.

Mr. W. F. REID, past President, submitted the toast of "The City and Institutions of Nottingham." He said he felt that he ought to say "My Lord Mayor," because a city of 270,000 inhabitants and which had had a Mayor for 600 years certainly deserved one. At any rate no worthier holder of the position of Mayor was needed than the present occupant of the office. He had been present on the historic occasion when the King had advised England to "wake up," but he felt sure that Nottingham was one of the last places in the world where that admonition was required. They could not fail to be impressed not only by the importance of the industries of this neighbourhood themselves, but by the finished way in which the work was conducted—the organization of the business, the machinery used, etc. In every way Nottingham was absolutely up to date in manufacturing processes. Nottingham lace was worthy of being used and treasured not only because of the way it was made, but because it was beautiful. The lace industry was a very important one, but there might be dangers ahead from lace made without the intervention of spinning or weaving at all—by a simple chemical process. A thick solution made by dissolving old linen was passed over an ingrained, rotating cylinder and the product was peeled off. It had, however, one defect: it was not quite so durable when moist. At the same time, as artificial silk had not diminished the consumption of natural silk, but rather increased it, so an article of this kind might also increase the sale of the genuine article. This artificial lace was used a good deal in Paris, he believed in millinery. There was also an intimate connection between the hosiery trade and chemical industry. Again, some of the leather made in Nottingham was the best that was made in this country: what he had seen in the factories of Nottingham convinced him that the care devoted to the production of leather and in the selection of the material used was a guarantee that leather made in Nottingham was beautiful as well as lasting. Having mentioned also the tobacco industry, Mr. Reid proceeded to say that he did not think there was any city outside Nottingham where there were so many small industries, which meant, moreover, that there was an endeavour on the part of individuals. All these industries employed a large number of people. The preponderance of women, he understood, was a feature of Nottingham: it showed that there was a suitable class of labour for them, and that they felt that they were earning their living in a congenial way.

The MAYOR acknowledged the toast, remarking that the position of the leather industry was largely due to Sir John Turney, of whose works they were very proud. They were also proud of his connection with the public life of the city, no man having filled public offices with greater ability and distinction than he. The business of Boots was established by Sir Jesse Boot not more than 25 or 30 years ago, and it was now a vast concern. The city highly appreciated the work that both Sir Jesse and Lady Boot had done, the benefit of which was felt all over the country.

Professor KIPPING also acknowledged the toast, referring to the connection of University College with the local

Section of the Society of Chemical Industry. The College welcomed the Section and provided it with what accommodation it had at its disposal. A great effort was being made to obtain a full charter for the College and transform it into a University for the City of Nottingham and the East Midlands, and he hoped that when the Society of Chemical Industry met in Nottingham again the University would have some years of successful progress behind it. He would like to mention the name of Dr. Sand, their honorary local secretary, in connection with University College and the local Section, to whose efforts so much of the success of the present meeting was due.

Mr. THOMAS TYRER proposed the toast of "The Sections of the Society." He was convinced that the Sections had a unique opportunity of justifying their existence. There was no reason why the Sections should not become greater centres of activity than they had ever been. Excellent work had been done, and members could show their greater appreciation of the Journal by contributing papers. There was no Section which contributed more useful technological papers, crisp and to the point, than Nottingham. Mr. Tyrer referred to the services of Mr. Archbutt, Mr. Trotman, Mr. Pentecost, Mr. White, and Dr. Sand.

Sir JOHN TURNER responded to the toast.

Dr. RUSSELL W. MOORE proposed the toast of "Our Guests," which was suitably acknowledged by Mr. G. Thornton-Simpson.

Some of the members availed themselves of the privilege of honorary membership conferred on them by the Notts Golf Club at Hollinwell. The Constitutional and Reform Clubs also opened their houses to members.

THIRD DAY.

EXCURSION TO THE DUKERIES.

Members and ladies left early by motor. The route was past Rufford Park, through Edwinstowe to Welbeck Abbey, where, by kind permission of the Duke of Portland, the stables, gardens, underground rooms, chapel and library were visited. Luncheon was taken in the riding school, at which the President acknowledged the obligations of the Society to the Duke for his courtesy, extended to the Society not for the first time. The President also took the opportunity to offer a special welcome to Mr. John Hargreaves, one of the founders of the Society, who was present.

In the afternoon Clumber Church was visited by permission of the Duke of Newcastle, and the homeward way was through the Lime Tree Avenue and Normanton, past Thoresby House to Ollerton, where tea was taken.

RECEPTION AT "PLAISANCE."

Sir Jesse and Lady Boot received the members and ladies at "Plaisance," their summer house at West Bridgford, and offered them a charming entertainment.

London Section.

Meeting held at Burlington House, on Monday, June 8th, 1914.

PROF. W. R. HODGKINSON IN THE CHAIR.

BLEACHING EFFICIENCY CONSIDERED IN CONNECTION WITH SUGGESTED STANDARD FOR TESTING BLEACHING QUALITIES OF CHEMICAL WOOD PULP.

BY CLAYTON BEADLE AND HENRY P. STEVENS, M.A., PH.D.

We regret very much that we were not able to be present at the reading of Messrs. Baker and Jennison's paper, but our experience so far as it goes appears to fall in with several of the observations and conclusions arrived at by these authors.

We have had a good deal of experience in bleaching at different temperatures in paper mills, and one of us devised a circulating bleaching system for rags which was in use for many years, whereby the liquor in course of circulation was continuously drawn from the bottom and sprinkled upon the top of the material. The liquor was maintained at a constant temperature by means of live steam. By studying the temperature and observing the conditions of the bleached material, we came to the conclusion that the result was as good in point of strength of fibre, yield, etc., at 100° F. as at any lower temperature, but that immediately we raised it to say 110° F. or over, we noticed weakening and deterioration of the material as well as increased consumption of chlorine. We therefore maintained the circulating liquor at 100° F. and the bleaching was done in about one-eighth the time of that required at an ordinary atmospheric temperature. This seems to confirm Messrs. Baker and Jennison's statements for wood pulp.

Then, as regards the use of spent liquors, if liquor is drawn from a material which is in course of bleaching and periodically titrated for chlorine strength, it will be found that the chlorine strength diminishes after the liquor is out of contact with the material to be bleached, and diminishes fairly rapidly.

Another factor in bleaching is the question of agitation, which is a very important one. It is a common practice in some mills to add bleach during the process of beating, especially in rag mills. One of us has made determinations of the rate of exhaustion of bleach during the process of beating and compared the chlorine consumption with that of material bleached, say in the form of half stuff, but without undergoing the beating operation, and discovered that for the same amount of bleaching effect, the material which is undergoing beating consumes only about 40% of the amount of chlorine as compared with that in the form of half stuff which is not being circulated or beaten.* With electrolytic bleaching for linen half stuff a saving of 30% was effected, and for cotton half stuff, 47%, by circulating in comparison with non-circulating of liquor. No doubt the circulation and the rapid agitation in contact with air, and possibly with the assistance of carbonic acid of the air, enormously accelerates the action, as well as making it more economical. Although concentration is a very important factor in the economy of bleaching, agitation is also important, particularly if the beating operation is proceeding at the same time. We have found that, when comparing bleaching efficiencies of different hypochlorites solutions such as by making a comparison between (a) bleaching powder solution in its normal condition, (b) the same on the addition of sufficient acid to combine with the base, (c) sodium hypochlorite, and (d) calcium hypochlorite produced by bubbling chlorine into milk of lime, as well as (e) hypochlorites in the presence of salt, a certain relationship of efficiencies is obtained with any one particular material at a given concentration, temperature, etc., but if several materials are compared with one another, these various solutions behave relatively differently both in regard to efficiencies, i.e., chlorine consumption and rapidity of action, so that it cannot be said that one particular form of hypochlorite is more efficient than another except in relationship to one given material to be bleached, and under given conditions. For instance, we have compared chemical wood pulps with different forms of cotton half stuff and we have found these different hypochlorite solutions to behave relatively very differently.

Quite a number of papers have recently been published on the subject of relative bleaching efficiencies of the hypochlorites. The conclusions arrived at in most cases are in our opinion most erroneous. First of all there has only been one kind of raw material experimented upon, such as boiled linen, and another material might have led to quite a different order of so-called efficiencies. We have an instance in the above-cited comparison of cotton and linen half stuff and wood pulp compared with cotton half stuff. Secondly, the relative efficiencies have been expressed as chlorine consumption per unit weight of raw material on the assumption that the same bleaching

effect is always accompanied by the same chlorine consumption, the higher the figure in unit time, the greater the so-called efficiency. As a fact, the reverse is the case. The relative efficiencies of all hypochlorite solutions should be judged by the amount of chlorine consumed per unit of bleaching effect, and the smaller the chlorine consumption the greater the efficiency. Thus the Hermite solution was found to be much more effective than the ordinary bleaching powder solution because the chlorine consumption per unit of bleaching effect was so much less than with ordinary bleaching powder. This, from the fact that a large amount of unelectrolysed salt is present, may be accounted for by the influence of the undecomposed salt and not by any special qualities of the electrolysed hypochlorite, as it is now found that salt, when added in different quantities to solutions of hypochlorites, has a marked effect upon their efficiency.

In many cases, certainly, the addition of the spent liquor is a doubtful economy, as Messrs. Baker and Jennison clearly show in their paper, but we know cases in practice where the bleaching liquor which would otherwise have to go to waste is usefully expended by using it as a wash water in the breaker, the unbleached material in a very few moments completely exhausting the chlorine, after which, it is slightly further washed and then fresh bleach is added. In this manner the spent liquor is taken out of the sphere of action before the fresh liquor is added.

We have often found that bleaching is much more effective if followed by an acid treatment or by washing and then again bleach added. Many materials seem to come to a full stop unless the bleaching products are removed. Furthermore, the addition of acid after the hypochlorite bleaching very materially improves the colour in many cases. The "more water more bleach" maxim is fully borne out in the results obtained by the Dobson process where the material is bleached with the maximum concentration, the amount of total liquor being only enough to make the material wet, and furthermore, in the old-fashioned method of tumbler bleaching, as was employed in the early days for rags. We have recently drawn attention to the fact that, with some lignified fibres, chlorination is produced in acid solution of hypochlorites (i.e., by hypochlorous acid) but in alkaline solution the ordinary bleaching effect is produced. Either one or the other effect is brought about according to whether the solution is rendered basic or acid, but the behaviour is largely controlled by the amount of boiling to which these lignified fibres have been previously subjected.

The use of carbon dioxide as an accelerator to bleaching powder was patented by Thompson in 1883, B.P. 959. One of us tested this process at the time that it was under investigation by Cross and Bevan, and subsequently suggested in a publication the use of carbonic acid gas by discharging same under the roll of a potcher or hollander in which the bleaching operation was going on. On visiting a German mill many years afterwards we saw this very operation. It is quite evident that a relatively small amount of carbon dioxide is sufficient to produce a marked acceleration which rather suggests that carbon dioxide acts catalytically. Very good commercial results are got and it is well worth while following up, but so far no relative figures are available for comparing the bleaching efficiency of such a solution with that of ordinary bleaching powder without carbon dioxide as an accelerator.

We have tested a process which involves the use of liquefied chlorine in steel cylinders. This has been in use for some years on the Continent. This bleaching process in some mills shows a considerable economy, in point of bleaching value and also in actual cost, over ordinary bleaching powder. For this purpose the chlorine is supplied in cylinders under a pressure of 5 atmospheres at 15° C. The process is conducted in the following manner:—

The half stuff is run off on an ordinary wet end machine and delivered in rolls containing from 40—50% moisture. These rolls are packed through a manhole door into a large rectangular cement-lined chamber. The chamber is then hermetically sealed. The cylinder containing chlorine is placed on a weighing machine and connected up with the

* Beadle, *Chapters on Papermaking*, Vol. 1 p. 57.

chamber, and chlorine gas passed in equal in weight to 2% of the dry weight of the material under treatment. At the beginning there is considerable pressure in the chamber. After a few hours the whole of the chlorine is absorbed, there being no trace of chlorine when the workman enters for the removal of the rolls. The rolls are penetrated to the interior and uniformly bleached. There are no lime salts but of course a slight hydrochloric acidity, which is sufficient to dissolve any basic salts already present in the half-stuff. The bleached stuff, which is now placed in the beater, generally receives a slight further treatment with bleaching powder solution. In a case of cotton rag half stuff, which under normal circumstances requires 12% of bleaching powder, the consumption by the above treatment was 2% of chlorine + 2% bleaching powder, and with a better colour produced than can be obtained by bleaching powder alone. The point here is that, apart from a better colour, 2% of chlorine as gas replaces 10% of bleaching powder and therefore 2% of chlorine as gas is equal to 3.5% chlorine as bleaching powder; that is, the bleaching efficiency of chlorine as gas in this case is nearly double that of bleaching powder. In fact, for equal colours it is probably more than double but in point of fact it shows quite as great an increase in bleaching efficiency as an electrolysed solution of magnesium chloride + sodium chloride does over that of ordinary bleaching powder. Besides seeing it operated as a regular process in Germany we have tried it in this country. The only difficulty here is the question of transport of the compressed chlorine in cylinders, which is not an easy matter to arrange with the railways.

With iron mordanted rags, bleaching powder sets the iron in a more insoluble condition. In such cases, when bleaching powder is used, it is preferable to acidify for the removal of the iron before adding the bleaching powder solution. Otherwise the iron salts frequently refuse to dissolve by subsequent acid treatment, but in the case of chlorine, the iron is chlorinated and consequently easily removed by subsequent washing. In Germany the Badische Co. are able to supply to some mills chlorine in this form at a rate that renders the process cheaper than using bleaching powder. They generally supply the gas in cylinders for use by bubbling into caustic soda, 12.87 kilos. of chlorine being required to transfer 100 kilos. of lye of 14.5% NaOH into bleaching liquid (sodium hypochlorite).

Some years ago one of us made trials in a paper mill on a commercial scale with potassium permanganate in comparison with bleaching powder, and found that 1 lb. of bleaching oxygen as contained in permanganate did just as much bleaching as 5½ lbs. of bleaching powder oxygen when reckoned from the available chlorine equivalent of ordinary bleaching powder. The rapidity of attack in the case of permanganate is infinitely greater. Generally speaking, the rapidity of attack and bleaching efficiency seem to go together.

The foregoing examples, which might be multiplied, merely serve to show that there is a range of bleaching efficiency varying with the bleaching agents and the materials operated upon, as well as with the conditions employed.

In spite of all the work that has been done upon the subject, the economic problems involved in such operations offer one of the most promising fields for industrial research. To arrive at practical conclusions it is most important that the work should be done under mill conditions, or at least having due regard to mill conditions.

It is perfectly clear, therefore, that in the case of disputes as to the bleaching qualities of pulps, etc., a great difference of opinion might exist between the two parties, and it is a most desirable thing that a uniform and standard method should be agreed upon not only in case of dispute, but also on the question of making contracts. Messrs. Baker and Jennison have made out a very excellent case for their own standard which could easily be worked out in an ordinary laboratory, and the proposal to use standard colours in the form of porcelain is far more workable than recording the colours by means of the Lovibond Tintometer, and would appeal to the practical man. We would suggest, however, that instead of specifying that a pulp should exactly correspond with any particular one standard, it

should be specified that it should fall between two of the standard colours, on account of the fact that there might sometimes be a dispute as to which of the particular standards it most closely corresponded with, but, if it falls between two, then there can be no question, and it gives a slight latitude to the manufacturer.

DISCUSSION.

Mr. A. BAKER thought that the treatment of rags for the production of high priced rag papers could almost be regarded as a specialised branch of paper manufacture, because in rags the fibres were spun, whereas in chemical wood pulp they were dealing with ultimate fibres. In the former case, no doubt, it was more economical from a chlorine point of view, certainly from a power point of view, to do a portion of the bleaching during the breaking and possibly during the actual beating operation. He thought, however, that it was far better to make the bleaching of chemical wood pulp a separate process.

They were inclined to think that the effect of agitation was somewhat over-estimated, and were firmly of the opinion that concentration was even more important than agitation. In actual manufacturing practice when bleaching large quantities of pulp, complete chlorine exhaustion on a large scale could be obtained with about 8—10% concentration in reasonable time, whereas if the concentration was neglected it was very difficult to get complete exhaustion by a considerable amount of agitation in 6 or 8 hours, and certainly not within two hours.

They agreed that the only legitimate use of bleach residual liquors when containing available chlorine was to wash material which had been boiled previously by alkaline treatment, and which received a thorough washing before the actual bleaching was carried out.

The Dobson process was really the revival of an old process. Whilst the concentration was brought to the extreme limit there were grave objections to be urged against that process, one of the chief being that all the residual chemicals had been left in the bleached pulp and all the chlorinated organic compounds, resinous matter, etc., removed from the pulp, which really demanded another process in order to wash them completely out. In the making of high class papers there would be danger of sizing troubles, and generally speaking he thought it was enough to condemn the process in many cases. The use of potassium permanganate presented other difficulties, because the brown oxide of manganese formed required removal by sulphurous acid or some other treatment.

The use of oxygen, in addition to the ordinary hypochlorites, was out of the question on account of cost. He did not see how, at any rate in the paper industry, the erection of electrolytic bleach liquor plant in a paper mill could compete with the ordinary bleaching powder at the price the latter could be bought, because in England they had a highly organised and successful alkali industry and obtained their bleaching powder very cheaply.

R. L. TAYLOR (this J., 1914, 308) had found that linen did not bleach very well with chlorine water, and that there must be present hypochlorites, and also that there was difficulty with ordinary bleach powder solution, principally due to the presence of free lime; by neutralising the free lime completely or almost completely a very much better result was obtained. In the paper industry where large quantities of linen, cotton, as well as wood pulp were bleached, the matter might be worth further investigation, and at the present time Mr. Jennison and himself were engaged in carrying out some investigations on a manufacturing scale which might possibly be of interest.

He thought Mr. Beadle's suggestion about colour standards was useful. Possibly if the number of standards were increased say from 4 to 6, one could, in specifying a contract, say the pulp should fall within two colours.

DR. L. T. THORNE said that the exact reproduction of conditions in the experiments was of great importance, especially in heating and circulating, because there was present in all these tests an additional influence that was generally neglected, namely, that of atmospheric oxygen. He had carried out extensive experiments on a large manufacturing scale both in cotton and wood pulps of all

sorts, by introducing oxygen into the potcher at the same time that the action of the bleaching powder was going on. In some cases 50 tons of paper pulp were experimented on at the time. By introducing oxygen in a fine state of division in the same potcher one could reduce the amount of bleach required by 30% and in some cases nearly 50%, by the use of the oxygen in conjunction with the bleaching powder. Whether it was that nascent chlorine, being liberated from the bleaching powder, rendered the oxygen active, or whether the oxygen was able to oxidise intermediate unstable compounds produced by the bleach from the colouring matters present, it was difficult to say; but there was undoubtedly the fact that if the oxygen were passed into the pulp in the potcher without bleaching powder, there was practically no effect, but if it was passed in whilst the bleaching solution was there and the action was going on, the amount of chlorine or bleaching powder could be enormously reduced. To his mind that was a reason that caused a great deal of difference of opinion where experiments were made on the efficiency of the different bleaches. If experiments were carried out in different potchers the results might be affected owing to the different amount of aeration due to difference in the speeds and the character of the beaters, and so on. The possible action of oxygen should certainly be taken into account in all tests, where comparisons of efficiency of different bleaching materials were being made.

Dr. ERIC RIDEAL asked whether atmospheric oxygen had any effect. They had found that the carbon dioxide had a marked action, but it had been suggested that the oxygen also had an influence. He thought that the question of bleaching fibre had, to a certain extent, been looked at from the wrong point of view. It was not the fibre they wanted to bleach, but the colour of the fibre. These colours were acidic or basic, and in the case of basic colours, one would at least expect the bleach to be slightly acid, while for acid colouring one might reasonably suppose that the bleach should be a little more basic or less acid. He thought it would be rather interesting if, in the case of the coloured fibres used in commerce, the addition of small quantities of alkali or acid would be shown to have any dependence on that fact.

When using liquid chlorine, he had noticed that the corrosion of the reducing valve was a very serious problem, and he did not know of any valve for chlorine which would stand continuous work without giving trouble.

Mr. CLAYTON BEADLE, in reply, said he thought that the beating effect which Dr. Thorne had mentioned must be distinguished from the effect of agitation, because the process of disintegration, which went on all the time during the process of beating, had a very marked effect in accelerating the action of the bleach. Quite apart from the question of more agitation, *i.e.*, the churning effect, the fibre was being reduced and bruised, and that no doubt very much accelerated the process of bleaching. There was a tremendous amount of agitation in the ordinary beater. The roll revolved at a very rapid rate, it was half immersed in the liquid mass of pulp, and it brought a large quantity of air into close contact with the pulp as it travelled round. He thought himself, the oxygen of the air played a very considerable part in the economy as well as the rapidity of the bleach when it was admitted during the process of beating. They had found somewhere between 50 and 60% economy. Inasmuch as every kind of raw material behaved differently, and different kinds of wood pulp also behaved differently, each material might be said to be specialised and required to be studied independently in comparison with other materials. When bleaching, varying bleaching efficiencies had been found for different kinds of chemical pulp, distinguishing sulphides from sulphates and so forth. There was a variation in the rate of bleach and the order in which the various solutions behaved relatively, so it was a very complex problem. He quite agreed with Mr. Baker with regard to the Dobson process. Subsequent treatment was necessary to remove the products. Permanganate bleach had not been mentioned in the paper with the view to suggesting it as a commercial proposition, although it might be on account of the much smaller quantity required in comparison with hypochlorite, but merely as showing that what they called oxygen

equivalent varied so enormously in the case of hypochlorites and other oxidising agents which were used for the purpose of bleaching.

Apart from the work Dr. Thorne had done, he did not think any work had been done on the subject of the distinct effect of oxygen as compared with the effect of carbon dioxide. The bleaching process was not entirely a matter of removing the colouring matter; with some materials it was a purification process as well. In most cases when the solution was basic, it was inclined to be sluggish, and when it was acid there was considerable acceleration.

He had visited a mill in Germany where liquid chlorine had altogether taken the place of the hypochlorite bleach: there appeared to be no trouble with regard to the valve, and considerable economy was obtained in point of cost as well as in increased efficiency in comparison with bleaching powder.

APPARATUS FOR THE DRYING OF PAPER FOR TEST PURPOSES.

BY CLAYTON BEADLE AND HENRY P. STEVENS.

As the qualities of paper are largely affected by the method of drying, it is important to imitate in the laboratory as far as possible the methods of drying employed in practice. All papers contract in the course of drying from 5 to 15 per cent., if not kept stretched. If tension is put upon the web, the paper may in some cases actually elongate as in the case of the production of fast running news, where the tension is so great as to render it necessary to run the drying cylinders at a considerably greater speed than the machine wire. If sheets liable to considerable contraction are dried by merely placing in an oven, they become cockled and quite useless.

The air drying or loft drying of paper which only slightly contracts is easily imitated on a small scale by hanging the sheets upon a line stretched across the room, but in the majority of tests it is necessary to ascertain what qualities are likely to be obtained by drying under tension in contact with a felt to keep the sheets taut, so as to prevent cockling, this being the method employed in the manufacture of machine-made paper.

To imitate the action of drying cylinders we have employed a hot plate made by fixing a full-sized billiard table-iron in an inverted position over an atmospheric burner consisting of a row of very small gas jets placed at some distance from the plate. With a mercury lute and a thermometer laid down in a convenient position upon the iron, it is possible to record the temperature with a sufficient degree of accuracy to imitate the temperature of the surface of a steam cylinder under any given steam pressure. The sheets of paper are pressed upon the surface of the iron by means of the same kind of felt as is used for the manufacture of the drying felts of the paper machine. By such means the conditions of the machine drying are fairly well imitated but this method entails considerable care and attention to detail, and moreover each sheet has to be dried separately.

We have recently devised a simple apparatus which makes it possible to dry under tension 50 small sheets at a time. When finished they are in much the same condition as they would be if dried over a steam-heated cylinder of a paper machine. This apparatus consists of a cylinder of tin plate, blocked at the top end but with a flange hole at the lower end, and stands upon a tripod. Beneath it is a small Bunsen burner and resting upon the flange is a baffle (see sketch). The heat strikes the baffle and travels upwards to the top and passes downwards along the sides and escapes at the bottom, rising again around the outside. The baffle is so designed as to produce a uniform temperature at top and bottom of the cylinder. Without a baffle the top half is much hotter than the bottom half.

To economise heat, the top of the cylinder can be covered either externally or internally with a sheet of asbestos.

For filling, the cylinder is placed horizontally upon a table and tightly wound with cloth for one and a half revolutions. The sheets of paper are then laid upon the unrolled cloth whilst the cylinder is revolved, keeping the cloth as taut as possible. Finally, the cloth is kept taut by tying tape round near each end of the cylinder. The