

belonging to the fatty series. The whole molecular complex was broken up when this treatment was carried out hot; but if guncotton was treated with cold caustic soda, then some soluble nitro acids were obtained, which were precipitated by acids from the solution. He was very much interested in Mr. Thomson's experiment with filter paper treated by sulphuric acid. The point had recently been investigated by Heermann, who sought to show that Chardonnnet silk contained combined sulphuric acid. He, personally, did not feel quite satisfied upon the point, that esters did actually exist in a fibre like Chardonnnet silk. He had not put forward the processes described in the paper as actually of commercial value. He had not gone systematically into the question of the best temperature for fixing acid dyes on cotton. In the majority of cases there was a considerably increased affinity for colouring matter, the main cause being the mercerisation. Naphthol Yellow, which could be taken as a typical acid dye, gave a very strong shade. Cotton mercerised with nitric acid showed a much stronger affinity for colouring matters than cotton mercerised with caustic soda. As yet there was no explanation for the increased affinity of ordinary mercerised cotton, and he was equally unable to offer an explanation for the behaviour of cotton mercerised with nitric acid. There was no doubt that combined nitric acid in many cases was a contributory factor to the absorption of colouring matter. This was evidently the case with the basic and the sulphide colours, and particularly with the vat dyes, where the oxidising action of the combined nitric acid made itself evident in fixing the larger proportion. He took it, it was similar to the increased affinity shown by cotton dyed Manganese Bronze for vat dyes. It was known that if cotton were dyed Manganese Bronze, and then dyed with indigo or other vat dyes, it took up a very much larger percentage of colouring matter. He had gone into the question of reducing agents referred to by Dr. Fowler, and had tried all sorts of reducing agents to reduce the nitric acid in cellulose, but had not found anything which would take the place of ammonium sulphide, though perhaps sodium sulphide would act in the same way. He had tried hydrosulphite of soda, both in the presence of a little caustic soda or in the presence of ammonia, with the result that in either case it rotted the fibre and did not denitrate it. This was remarkable as hydrosulphite was known to possess in other respects a far more powerful reducing action than ammonium sulphide. Stannite of soda was without action. He had not gone into the question, but he thought that it would be very interesting to ascertain whether either the nitrated or the denitrated product was capable of undergoing any process of fermentation. The specimen cotton hanks exhibited were treated quite roughly at a boiling temperature, except the vat dyes, which were treated cold. He was somewhat afraid the experiments rather complicated the theory of dyeing for he was quite at a loss to explain certain of the phenomena observed. With regard to comparative washing tests of Acid Violet on nitrated cotton and on wool, it had been shown that the colour was not so fast as in the case of wool. He had not made any test with regard to the fastness to light of the colours, not having thought the process of any technical value. He was, however, very glad the suggestion had been made and would make some trials. He had not made any experiment with regard to eosine and Acid Violet, nor with regard to polarised light, although the latter test was apparently quicker and more reliable than a determination of the nitrogen in the nitrometer. They had made some general tests as to the effect of weak mineral acids on the product, and there was not much difference between the nitrated product and ordinary cotton. He was of opinion that in order to obtain an acid-proof fibre it would be necessary to nitrate very much higher than he had done. The inflammability of the material was not greater than that of ordinary cotton. In reply to Mr. Craig, he had not tried the action of stripping agents on colours dyed on the nitrated cotton; but he imagined it would require a larger amount of stripping agent to strip colours from nitrated cotton than from ordinary cotton.

Scottish Section.

Meeting held at Glasgow on Tuesday, November 25th, 1913.

DR. THOMAS EWAN IN THE CHAIR.

THE COMPOSITION AND AGRICULTURAL VALUE OF CARBONATE OF LIME FROM CAUSTICISING PLANT.

BY JAMES HENDRICK, B.SC., F.I.C.

In the aggregate enormous quantities of carbonate of lime from causticising plant are produced and allowed to go to waste. There are, I understand, about 58 paper mills in Scotland alone, most of which have causticising plant. The production by these of waste carbonate of lime, dry, is probably not less than 20,000 tons per annum. In the case of works known to the writer there are dump heaps containing thousands of tons of this substance, while in other cases expense is incurred in carting it to hollows which are filled up with it and other waste of the works. Occasionally it is got rid of by running it into a river or other watercourse.

Much burnt lime and carbonate of lime are used for agricultural purposes, and much more ought to be used. Formerly lime, both in the form of burnt lime and carbonate of lime, was used to a far greater extent than at present. For a variety of reasons the use of lime began to fall off about 40 years ago, and between 1870 and 1900 the practice of liming became almost non-existent over a great part of Scotland. Since 1900 liming has been increasing again, but only to a limited and partial extent, and one may say that over large parts of Scotland farmers have been living, so far as lime is concerned, on the capital laid up in the soil by their predecessors. With the gradual exhaustion of the store of available lime the soil is becoming sour, and various evils, such as weeds which are favoured by sour, lime-deficient soils, and the disease of finger and toe in turnips, are becoming more prevalent.

It has been shown by drainage experiments that every cultivated soil is constantly losing lime. Hall and Miller* have estimated that the loss of lime in the drainage of unmanured plots at the Rothamsted Experiment Station is equal to 1000 lb. of carbonate of lime per acre per annum. The loss is greater from manured plots. Similar results have been obtained on the Continent, where Creydt† and his co-workers estimated from drainage experiments on a cultivated and manured field that the loss of lime in the drainage was 630 kilos. of CaO per hectare, which is almost exactly 1000 lb. of carbonate of lime per acre.

It is estimated that the average loss per acre per annum throughout England and Wales is not less than 500 lb. of carbonate of lime. If we take it at this figure for Scotland also, and for cultivated and manured land, it is probable that this is an under-estimate: at least 500 lb. of carbonate of lime, or 280 lb. of quicklime, per acre per annum should be applied to all cultivated land. In other words, at least 1 ton of commercial burnt lime of good quality or $1\frac{1}{2}$ tons of good quality chalk or ground limestone, should be applied once in seven years merely to maintain the lime of the soil. Only a fraction of this amount is used at present.

For many purposes at any rate it is safer and better to use carbonate of lime than to use burnt lime. Formerly great quantities of soft chalks, marls, shell sands, and other easily friable forms of carbonate of lime were applied to the soil, and in recent years a considerable amount of hard limestone rock has been ground for application to the soil as "ground limestone." While expense is thus being incurred in grinding limestone to a comparatively coarse powder, the very fine precipitated carbonate of lime of causticising plant, which is specially valuable on account of its very great fineness of division, is being thrown away.

* "The Effects of Plant Growth and of Manures upon the Retention of Bases by the Soil." *Proc. Roy. Soc.*, 1905, **77**, 11—32. (This J., 1906, 34.)

† Creydt, C. v. Seelhorst and Wilms, *Jour. Landw.*, 1901, **40**, 251.

Samples of the waste carbonate of lime as it comes from the dump heaps of different paper works were obtained, and analyses of a number of these are shown in Table I.

TABLE I.
Analyses of Wet Waste Carbonate of Lime.

	I.	II.	III.	IV.	V.
	Inverurie.	Inverurie.	Culter.	Culter.	Stoney-wood.
Moisture ...	per cent. 40.64	per cent. 47.84	per cent. 38.29	per cent. 47.07	per cent. 43.78
Carbonate of lime	37.31	44.04	51.93	45.64	40.91
Lime in other forms	9.35	3.30	0.87	0.32	6.80
Alkalinity (as NaOH) ..	8.25	2.80	2.24	1.61	3.65
Silica	0.64	2.15	2.86	2.78	1.70

Nos. I., II. and V.: The alkalinity was due to free lime.

Nos. III. and IV.: The alkalinity was due to carbonate of soda and caustic soda. There was no free alkaline lime.

The amount of moisture in, and the composition of these samples, vary somewhat according to the nature of the process used, and the methods used in removing the carbonate of lime from the caustic lye. In some works the process is comparatively crude and rough, while in others it is carried out with greater precision and with more perfect appliances. In crude samples the moisture is nearly 50 per cent., but in samples which have been well drained or treated in a vacuum filtering apparatus, it is considerably less than 50 per cent.

Several paper works known to the writer have for years offered this substance free of charge to farmers who will take it away, but in no case has any substantial quantity been taken. The objection seems to be that it is sticky and difficult to spread when wet. Further, farmers are unfamiliar with it, and are very doubtful if it is of any value at all. It is quite possible to use it in the undried state, and much of it might be used in this way by farmers in the neighbourhood of paper works, for if it is scattered about in lumps and left exposed for a short time to dry weather or to frost, it readily falls to powder and can then be spread. Where it has to be carried any considerable distance before use it will probably be found better to dry it.

It is easily dried by artificial means, and at the suggestion of the writer some paper works have experimented on drying it, and one at least is now drying it on a large scale and is selling it to farmers in this state at a price sufficient to cover the costs of drying and marketing. Even if nothing more is obtained, this is a saving as compared with incurring expense merely to dispose of it as a waste product. When dried, it is more easily disposed of to farmers, and the firm in question has got rid of hundreds of tons during the past few years.

Table II. gives analyses of a number of dried samples obtained from different sources.

TABLE II.
Analyses of Dried Waste Limes.

	I.	II.	III.	IV.	V.
	per cent.	per cent.	per cent.	per cent.	per cent.
Moisture	4.02	1.23	12.27	9.51	13.48
Carbonate of lime	66.50	88.33	68.06	60.84	74.20
Lime in other forms	13.89	3.46	3.74	11.60	1.45
Alkalinity (as NaOH)	16.08	0.63	4.37	6.76	0.02
Silica	2.40	1.65	3.48	2.48	4.97

No. I. contained alkaline lime equal to 11.26 per cent. CaO; equal to 14.87 per cent. Ca(OH)₂, and practically no soda.

No. II. contained no free alkaline lime, and very little soda.

Nos. III. and V.: The alkalinity was due to soda and carbonate of soda.

No. IV.: Like No. I., contained much alkaline lime.

In addition to carbonate of lime, which is the chief substance present, and which may constitute upwards of 90 per cent. of a well-dried sample, there are smaller quantities of other substances present. The material is sometimes very alkaline, in other cases very little alkalinity is exhibited (Nos. II. and V., Table II.). In some cases the alkalinity is due to alkaline lime (Nos. I., II., and V., Table I.; and Nos. I and IV., Table II.), which shows that considerable excess of lime had been added in the causticising tanks. In other cases the alkalinity is due to the presence of sodium hydroxide and sodium carbonate (Nos. III. and IV., Table I.; and No. III., Table II.), which indicates that the soda lye had not been efficiently drained from the precipitated lime. There is always a small quantity of silica present, chiefly as silicate of lime, and some organic matter. On the whole, however, the dried samples contain as much available lime, as carbonate of lime and hydrate of lime, as is contained in ordinary commercial ground limestone, and they contain more than half as much available lime as is contained in ordinary commercial burnt lime. By "available lime" is meant lime available to neutralise acids, and therefore in a form which will be of use for the purposes for which lime is needed in the soil.

Field Experiments.—The field experiments carried out by the writer with paper works waste lime were not undertaken primarily to determine the value of this substance for field use. Their main object was to demonstrate the value of lime as a remedial agent in combating the disease of finger and toe in turnips. At the outset the writer was inclined to the common view that burnt lime is far more effective for the object in view than carbonate of lime. The paper works carbonate of lime was included among the different kinds of lime used, as it was a waste product extensively produced locally, the value of which it was thought it might be worth while to test in comparison with other forms of lime more generally used by farmers. Further study of the subject has shown that one of the principal reasons which led to the general use of burnt lime in agriculture was that such lime can readily be brought into a fine state of division by slaking and can thus be thoroughly incorporated with the soil. Another important reason for the use of burnt lime was that carriage was saved by its use. In former days, before means of transport were developed to the present extent, this was a consideration of even more importance than at present. In course of time it has been forgotten that these were the main reasons for the adoption of the use of burnt lime in agriculture and not any essential superiority for most agricultural purposes of calcium oxide or calcium hydrate over calcium carbonate. If we look back to the agricultural records of the first half of the nineteenth century we find that wherever soft chalks, marls, or shell sands could be obtained, they were used extensively in the surrounding districts without being burnt to quicklime, but on the other hand, where only hard limestone rock could be obtained or where lime had to be carried from a distance, burnt lime was used. There is little doubt that for nearly all purposes carbonate of lime is, weight for weight of lime, as valuable as burnt lime, and that on certain soils and under certain conditions carbonate of lime is a safer and better substance to apply to the soil than quicklime. The results of the four experiments described below are in favour of this view.

These experiments are only part of a series which is at present in progress, and they are very incomplete. Such experiments should be carried out not for one or two years only but over a considerable period of years, so as to cover more than one rotation of crops on the same land. But it is very difficult to arrange this except on an experimental farm, and till now this has not been available to the writer. When carried out on the lands of private persons, and especially of tenant farmers, for obvious reasons it is generally impossible to have the experiment continued for more than a short period.

In some of the experiments mentioned below the lime was applied only a few months before the turnips were drilled. It would have been better had it been possible to commence the liming at least a year or two before the land came into turnips. Also had one had complete control of the land and been able to keep in view merely

the experiment without considering the natural wish of the farmer not to risk the loss of a crop, much larger quantities of lime would have been applied to some of the plots than were applied. Experiments covering all these points are at present in progress; meantime the results already obtained are quoted because they illustrate the value of paper works waste lime.

Field experiments suffer from the disadvantage that the probable error of a single experiment is very great. In measuring differences, therefore, which are not very great it is necessary to repeat the experiment over and over again on a large number of plots in order to obtain significant figures. In the experiments here described the differences found in the incidence of disease and also in the weight of crop obtained are so great that the figures may safely be regarded as significant.

The experiments were carried out on soils which were known to be badly infected with finger and toe, and on which the turnip crop had been seriously injured by the ravages of the disease the last time the land was under turnips. In all four cases samples of the soil were taken for analysis, and in every case it was found that the soil was distinctly acid in its reaction to litmus paper. Analyses of the soils were made, and among other things the percentages of lime were determined which could be extracted from each by digestion with strong hydrochloric acid, and by treatment with cold 1 per cent.

In the case of all four soils no appreciable amount of carbonate could be detected. The titration never differed from the blank, which was always carried on alongside, by more than 0.1 c.c. of the N/10 HCl used. This is well within the probable error of experiment for the method.

The first experiment was carried out at Kinmundy where the soil is a good rich loam and carries heavy crops, but when previously in turnips the crop was almost completely destroyed by disease. Two varieties of turnips were grown on the plots; Challenger Green Top Yellow, and a Purple Top Yellow. The purple top variety was known to be very liable to disease.

Waste carbonate of lime from two different paper works, marked I. and II. in the table, was used. It was applied at the rate of 4 tons per acre. To another plot "shell lime" was applied at the rate of 2 tons per acre. All the lime was applied in January about 5 months before the turnips were sown. Four tons of paper works lime was taken as a standard dressing in these experiments, while 2 tons of shell lime of good quality, which contains about the same amount of available CaO as 4 tons of paper works lime, was taken as the standard dressing of this substance for purposes of comparison.

The weights of turnips per acre obtained on the different plots are shown in Table IV.

TABLE IV.

Finger and Toe Experiment: Kinmundy.

Variety (A) Challenger Green Top Yellow. Variety (B) Purple Top Yellow.

		No lime.	Waste carbonate of lime. 4 tons per acre.				Shell lime. 2 tons per acre.		
			I.		II.				
			tons	cwt.	tons	cwt.	tons	cwt.	tons
Weight of turnips per acre	(A)	20	10	22	10	22	10	21	10
	(B)	10	11	13	1	13	1	13	1
Increase over no lime	(A)	—	—	2	0	2	0	1	0
	(B)	—	—	2	10	2	10	2	10

citric acid, according to Dyer's method, respectively. The results are shown in the table below.

TABLE III.

Amount of Lime (CaO) found in the Soils.

	Kinmundy.	Greenhowe.	Barra.	Blackhills.
Extraction with hydrochloric acid	0.70	0.61	1.72	0.62
Extraction with 1 per cent. citric acid	0.163	0.225	0.125	0.246

Although all these soils were found to contain an appreciable quantity of lime soluble even in weak citric acid, it does not follow that they contained any carbonate of lime. As they were all found to be acid in reaction the presumption is that they contained little, if any, carbonate of lime. They were therefore tested by a modification of the method of Amor and Marr.* In this modification the soil is not heated with acid, but air freed from carbon dioxide is drawn through it for several hours after addition of an excess of hydrochloric acid and the carbon dioxide estimated by Brown and Escombe's double titration method after absorption in a Reiset Tower. This method when used with suitable precautions is capable of estimating carbonate equal to less than 0.05 per cent. stated as carbonate of lime in 20 grams of soil. It does not of course follow that if carbonate is found it is necessarily present as carbonate of lime, but it is usual to estimate it as such.

As the table shows considerable increases of crop were obtained from the use of each kind of lime and on each variety of turnips.

It was found that in spite of the liming the purple top turnips were very badly diseased on all the plots, while the green tops were affected to only a comparatively slight extent. This accounts for the great differences in weight between the two varieties. Up to a certain point they seemed to be equally vigorous. Had they been weighed early in the season instead of in December, it is probable that the purple tops would have given weights quite as great as the green tops, but after a certain point they went down rapidly with disease, and at the time of weighing there was hardly a turnip of this variety on any of the plots which was not more or less attacked. At the same time there was a great difference between the disease on the limed and on the unlimed plots. There were far more turnips which were only slightly diseased on the limed than on the unlimed plots.

An attempt was made to estimate the incidence of the disease, but the methods adopted were too crude to give results of value except in so far as they taught us that better but more laborious methods would have to be adopted in succeeding experiments. In the experiments which follow the incidence of disease was estimated by the extremely laborious method of lifting individually and at once examining on the field a large number of bulbs from each plot, and dividing these into three classes:—

- (A) *Badly diseased*, or those in which the bulb was either completely or badly rotted by the disease;
- (B) *Slightly diseased*, where either the bulb was not touched by the disease which was confined to the roots, or where the bulb, if attacked, was not rotted by the disease;
- (C) *Sound*, where no disease was noticed.

* Jour. of Agr. Science, 1905, I., 322, and 1909 III., 155.

It does not follow that bulbs classed as "sound" were quite free from disease. In pulling the bulbs many of the roots were left in the ground, and if the disease was confined to these it would not be noticed. The number of bulbs examined on each plot always amounted to several hundreds. These were taken up in lots of one hundred each along one drill, and the lots were systematically distributed over the plot so as to give as fair an average as possible.

In this method the disease is estimated not by weighing but by counting. Many of the bulbs in the badly diseased class were so far gone with disease that they were not fit to be weighed at all in estimating the crop by weight.

The result of this first experiment showed that the amount of lime applied was not sufficient on this soil to control the disease in the case of a susceptible variety like the purple tops, though in the case of both varieties it certainly diminished disease and increased the weight of crop.

The second experiment was carried out at Greenhowe on a poor, shallow, mossy loam, with pan beneath. The soil was distinctly acid, and infested with such weeds as are found on sour soils. The crop suffered considerably from drought as well as from the bad condition of the land. Gas lime at the rate of 2 tons per acre was used in this experiment as well as paper works carbonate of lime and shell lime. The lime was not applied directly to the turnip crop but early in the previous year before a crop of oats. Table V. shows the weight of crop per acre, and the incidence of disease on the different plots.

In every case the liming greatly increased the weight of crop, and in the case of paper works lime and shell lime, greatly diminished the amount of disease. The plot which was dressed with paper works lime was almost free from badly diseased roots, while that which received shell lime had the badly diseased reduced from over 20 per cent. to under 5 per cent. This plot was perhaps hardly fairly treated with regard to weight of crop per acre. The crop on it suffered most from drought and probably it was the thinnest soil. The dressing of gas lime, though it increased the weight of crop considerably, did not diminish the disease very much.

The third experiment was carried out on a good, fairly deep loam at Barra. This soil yields good crops, but was rotten with disease when previously in turnips. The lime was applied in February, only three months before the turnips were sown. Waste lime from two different paper works was used as well as shell lime and gas lime. The results, both as to weight per acre and incidence of disease, are shown in Table V.

shell lime or gas lime, especially in diminishing disease. One sample of waste lime gave a better result both as to weight of crop and as to diminution of disease than the other. While the differences are not great enough to be treated as significant in the case of single plots, it is interesting to notice that the plot which gave the better result was treated with a waste lime containing a distinct amount of soda (Analysis III., Table II.). This indicates, at least, that the presence of soda was not injurious in the quantity here used. There was at first some hesitation in using this lime as it was feared that the soda might be injurious to the crop.

The fourth experiment was carried out on a somewhat peaty loam at Blackhills. The soil was considered a fairly good one, but was not in very good condition, and the previous turnip crop had been very badly diseased. The soil was quite acid in reaction and badly infested with such weeds as rejoice in a sour soil. Paper works waste lime, lime shells, and gas lime were all used as before. All these forms of lime were applied only two months before the turnip seed was sown. The results in this case were very curious, as none of the dressings of lime had any distinct effect in diminishing the disease or increasing the crop. The results tabulated in the usual form are shown in Table VI.

The differences in weight of crop and in amount of disease shown in this table from the use of lime, are of a quite different order from those shown in Tables V. and VI. In order to find the reason for this anomalous result, the soil from the limed plots was examined, and it was found that on this peaty soil the amount of lime used was not sufficient to neutralise the acidity. The limed soils were still acid to litmus paper. A representative sample taken from the plot which had been dressed with paper works lime was analysed. It yielded to extraction by strong hydrochloric acid 0.78 per cent. of CaO, and to extraction by 1 per cent. citric acid 0.34 per cent. of CaO. As might be expected, these figures are both somewhat greater than those given by the untreated soil (Table III.), but the lime was not present as carbonate of lime. When tested by the method described above no carbonate of lime was found: 20 grams of soil yielded the same result as the blank determination.

The soil sample was taken to a depth of 9 inches. There are roughly speaking about 1000 tons of soil on an acre to a depth of 9 inches. The paper works lime used contained 74.2 per cent. of calcium carbonate (V., Table II.), therefore about 0.3 per cent. of calcium carbonate had been added to the soil. As none was found the whole of this had been neutralised by the soil acids, and the soil still

TABLE V.
Finger and Toe Experiment: Greenhowe and Barra.

	No lime.	Waste carbonate of lime.		Shell lime.		Gas lime.	
		4 tons per acre. I.	4 tons per acre. II.	1 ton per acre.	2 tons per acre.	2 tons per acre.	4 tons per acre.
GREENHOWE:—	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.
Weight of bulbs	7 5	12 16	—	9 2	—	11 19	—
Increase over no lime	—	5 11	—	1 17	—	4 14	—
Sound turnips	42.5	70.0	—	61.5	—	47.0	—
Slightly diseased	37.0	29.0	—	34.0	—	30.8	—
Badly diseased	20.5	1.0	—	4.5	—	13.2	—
BARRA:—	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.
Weight of bulbs	12 8	15 5	17 5	—	13 6	15 15	16 10
Increase over no lime	—	2 17	4 17	—	0 18	3 7	4 2
Sound turnips	41.8	72.2	82.6	—	60.6	59.1	58.6
Slightly diseased	36.0	18.5	14.4	—	24.6	28.0	24.0
Badly diseased	22.2	9.3	3.0	—	14.8	12.9	17.4

As in the last experiment any form of lime increases the crop and diminishes the disease, but, just as at Greenhowe, waste lime from paper works does better than either

remained sour to litmus paper. It is evident that on this soil much more lime was needed to produce a result. It is proposed to make further investigations on this soil.

TABLE VI.
Finger and Toe Experiment: Blackhills.

	No lime.	Waste carbonate of lime. 4 tons per acre.	Shell lime. 2 tons per acre.	Gas lime. 4 tons per acre.
	tons cwt.	tons cwt.	tons cwt.	tons cwt.
Weight of bulbs per acre	18 — 8	19 12	19 5	18 — 6
Increase over no lime	—	1 4	0 17	—
Sound turnips per cent.	26.1	19.1	25.3	36.6
Slightly diseased per cent.	69.7	75.5	72.6	58.7
Badly diseased per cent.	4.2	5.4	2.1	4.7

The foregoing results are, as already indicated, incomplete, but so far as they go they show that for, at any rate, certain soils paper works waste carbonate of lime is at least as effective as the other forms of lime in ordinary use. As great quantities of this by-product are at present being

wasted, it seemed to be desirable to publish these early results, for it will be to the interests both of agriculture and of the paper makers if this waste lime is used for application to the soil.

Journal and Patent Literature.

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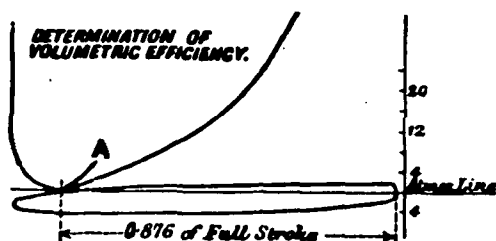
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I.—GENERAL PLANT; MACHINERY.

Internal-combustion engines; Commercial tests of.—
W. A. Tookey. Engineering, 1914, 97, 129–132.

THE author has made 763 tests of gas engines of various makes and sizes as found in actual use by consumers. In 66 per cent. of the cases, the working was improved by



adjusting the gas and air supplies, the ignition and the valve-setting. The average increase in the power obtained at each impulse was 27 per cent., and the average reduction in the consumption of gas per indicated horse-power per hour was 13.3 per cent. The method of testing recommended consists in taking indicator diagrams, including diagrams with light spring, and observing the number of impulses and the gas consumption per min. On the light-spring diagram (see Fig.), the point, A, where the compression line crosses the atmospheric line, gives the "volumetric efficiency," which is multiplied by the piston displacement in order to find the "effective piston displacement." It is assumed that the compression curve follows the law $\frac{P_1}{P_2} = \left(\frac{V_1}{V_2}\right)^{1.3}$, and from the observed compression

pressure P_2 , the ratio of V_1 (the cylinder volume corresponding to point, A, in the figure) to V_2 , the clearance volume, is at once obtained. The clearance volume, V_2 , is then equal to the effective piston displacement divided by $\left(\frac{V_1}{V_2} - 1\right)$, and the total cylinder volume at the point, A,

is equal to the clearance volume added to the effective

piston displacement. This volume, divided into the volume of gas used per impulse, as shown by the meter, and multiplied by the calorific value of the gas, gives the "mixture strength," i.e., the number of British thermal units per cu. ft. of the actual mixture of gas, air, and exhaust gases which is present in the cylinder at the point, A. The factor $\frac{\text{mean pressure of diagram}}{\text{mixture strength}}$ affords a valuable test of the working of an engine. A factor of 2.4 is considered very satisfactory.—A. T. L.

PATENTS.

Mills for grinding, crushing, pulverizing, separating, or mixing materials. E. Allen and Co., Ltd., Sheffield, H. Grey, Rotherham, and L. D Parker, Sheffield. Eng. Pat. 5069, Feb. 28, 1913.

A SERIES of large and small balls are arranged in a revolving circular track and are kept in position by an overhanging segmental stationary track which carries a series of scoops. The material is fed into the track and the finely-ground material is forced outwards and upwards by centrifugal force and directed upwards under the guidance of the scoops, to a fan driven by the same shaft as the track, but at a higher speed. The fan, the indraught to which is regulated by an adjustable circumferential damper, discharges the finely ground portion of the material through annular discharge openings and allows the coarser portions to return to the grinding channel.

—W. H. C.

Evaporating apparatus for liquids. Farbenfabr. vorm. F. Bayer und Co., Leverkusen, Germany. Eng. Pat. 15,624, July 7, 1913. Under Int. Conv., Feb. 18, 1913.

IN evaporating apparatus working under a high vacuum, the boiling points of the upper and lower layers of liquid differ greatly if the depth of liquid is considerable. This defect is avoided in the apparatus claimed, in which a number of slightly inclined boiling tubes pass across a steam space and are provided at the ends with small chambers or pockets having vapour-escape openings at