With respect to Mr. Clifford's observations he might say that whilst it was true that some of the valuable constituents of the sludge were destroyed by this process, the analysis of the final product showed that a little over one-third of the fatty matter and about one-fourth of the nitrogen were lost. The phosphoric acid would be very little altered. It was therefore far from the fact to say that the digested sludge resulting from the process was useless. In view of the possibilities of this sludge and the large amount of promising investigation going on just now he (the author) considered it a very desirable thing to accumulate the sludge on a tip. This process made such storage possible by eliminating the nauseous character of the sludge.

The merits of small versus large outfall works were chiefly engineering and financial ones, which usually told in favour of the large installation.

The means for utilising the sludge had yet to be worked out, and if the claims of the inventors of some recent processes were realised when tried on a large scale, then this means would be very shortly at hand. In the meantime the processes like the one described in this paper relieved the community of a serious nuisance.

The difficulty in connection with the manurial value of sludge was exemplified by the small proportion of the nitrogenous matter destroyed by the above process. This provided independent evidence of the extreme slowness with which the nitrogen became available for the nourishment of plant life.

As to the cost of the process, the costs given above were working costs, and included maintenance and repairs of working parts of machinery. From a mechanical point of view the process was simple and the wear and tear very small. The interest on capital and sinking fund charges were in this case very intricate, and so involved that it was almost impossible to assess them accurately. Their net contribution to the figure for cost was however probably small.

NOTE ON GRU-GRU OIL.

BY A. W. KNAPP, B.Sc., F.I.C.

Gru-gru is the Trinidad name for *Acrocomia sclerocarpa*. I saw trees of the same species (*Acrocomia lasiocarpa*) in Grenada, and they are said to grow in many parts of S. America. They will grow in the poorest of soils. The trunk has at intervals circles of sharp spines, so that it is almost impossible to climb. The tree belongs to the same tribe as the coconut palm—the leaflets are thinner and the trunk is generally swollen in the middle. The leaves are said to yield a very delicate fibre. The fruits are oblate spheroid in shape, about the size of a large plum, and dark green in colour. The skin is very tough, but if the fruits are allowed to fall to the ground this rots off leaving the nuts behind, the kernels remaining sweet. The shell of the nut is about $\frac{1}{4}$ -inch thick and hard, the kernel ($\frac{1}{2}$ -inch across) has the appearance and flavour of coconut, but is tougher and more transparent.

Fruit: length $1\frac{1}{2}$ inch, breadth $1\frac{1}{4}$ inch, weight 30 grammes.

	Per cent.
Pericarp	59.73
Shell	31.30
Kernel	8.97
	100.00

Dry ether extracts 2.44 per cent. from the pulp of the pericarp. The kernel contains:—

	Per cent.
Fat (petroleum ether extract)	49.13
Water	8.14
Albuminoids	13.70
Fibre and unestimated	29.03
	100.00

One tree I examined had on it 9 large bunches, each bunch containing about 400 fruits, that is, in all 3,600. The kernels were collected in March. The oil, which was

obtained from the kernels by pressing them when hot, gave the following figures:—

	Oil.	Insoluble fatty acids.
Colour	Very pale yellow	White
Odour	Like coconut oil	Like coconut fatty acids
Taste	Ditto	Ditto
Sp. gr. (90° C. water at 15.5° C.)	0.861	0.838
Melting point	26.0° C.	24.0° C.
Titer	—	23.05° C.
Iodine value (Wijs)	10.4	20.3
Refraction at 40° C.	36.95	10.7
Saponification value	243.5	—
Reichert-Meissl value	7.2	—
Polenske value	13.0	—
Shrewsbury and Knapp	163.0	—
Neutralisation value	—	261.0
Mean molecular weight	—	214
Free fatty acids (as oleic)....	0.62%	—

From the above properties I conclude that this is the same oil as Mocaya oil of Paraguay and the oil from the maccasuba palm of Surinam (see De Nigri and Fabris, Chem. Rev., 1897, 82; and Sack "Inspectie van den Landbouw in West Indie," Bulletin 5, 1906).

It is evident both from the organoleptic and analytical tests that the oil is very similar to coconut and palm-kernel oils, so that it consists chiefly of laurin and myristin. It contains about 12 per cent. more olein than coconut oil, and hence should have about the same value as palm-kernel oil.

The soap produced from this oil is almost white and has excellent lathering properties, and the "stearine" from the oil would make a good edible fat.

It is not at present cultivated in the West Indies, and hence, although widely distributed is only thinly scattered, so that the gathering of sufficiently large quantities presents considerable difficulty. Further, the nuts are very hard. The shells when cracked are heavy enough to be separated from the kernels by immersion in brine. Last June, as an experiment, copra was prepared from gru-gru nuts in St. Vincent.

In conclusion I wish to thank Mr. S. B. Phillips for his assistance.

DISCUSSION.

Mr. SILVESTER asked if the author had any knowledge of gru-gru oil being used, for cocoanut oil, in the manufacture of margarine.

Mr. KNAPP replied that he was not aware that such a practice was followed, though there was no reason why it should not be pursued.

Newcastle Section.

Meeting held at Armstrong College on Wednesday, December 10th, 1913.

MR. T. W. LOVIBOND IN THE CHAIR.

THE SOLUBILITY OF MINERAL PHOSPHATES IN CITRIC ACID.

BY G. S. ROBERTSON, B.Sc.

Quite recently artificial manure manufacturers have placed on the market large quantities of mineral rock phosphates as a suitable phosphatic manure. These mineral phosphates, in spite of the fact that they are very finely ground, are only slightly soluble in 2 per cent. citric

acid.* They were therefore assumed to be of little use as an available manure compared with basic slag and bone meal, in which 80 to 95 per cent. of the phosphates are soluble in 2 per cent. citric acid.

With the object of testing mineral phosphates a series of experiments were laid down at Cockle Park, the results of which are given in the following tables :—

TABLE I.*
Upper Brick Field.

Plots 1/20th acre.	Three years' ley.	Average yield of hay for 3 years, per acre.
1.	10.85 cwt. of basic slag, 35.80 % phosphate of lime, 95% citric soluble	cwt. 38½
2.	9.1 cwt. basic slag, 42.7% phosphate of lime, 75% citric soluble	39½
3.	9.75 cwt. basic slag, 39.97% phosphate of lime, 88.6 % citric soluble	39½
5.	8.5 cwt. bone meal, 40.64% phosphate of lime, mostly citric soluble, and also contained 4.78% nitrogen	40½
6.	6.6 cwt. Tunisian phosphate, 59.09% phosphate of lime, trace citric soluble ..	37½
7.	No dressing	33½
8.	10.5 cwt. Belgian rock phosphate (calcined) 37.16% phosphate of lime, trace citric soluble	40½

* See Guide to Cockle Park for 1913, page 39, also Guide for 1914.

TABLE II.*
Tower Hill Field.

Plots 1/20th acre.	Three years' ley.	Average yield of hay for 2 years per acre.
1.	9.5 cwt. basic slag, 41.3% phosphate of lime, 80% citric soluble	cwt. 41½
2.	19.7 cwt. basic slag, 19.82 % phosphate of lime, 66% citric soluble	44½
3.	8.5 cwt. bone meal, 40.64% phosphate of lime, mostly citric soluble, also contained 4.78% nitrogen	38½
4.	No dressing	38
5.	8.6 cwt. Tunisian rock phosphate (ground) 45.3% phosphate of lime, trace citric soluble	42½
6.	8.25 cwt. Belgian rock phosphate (ground) 47.2% phosphate of lime, trace citric soluble	42½
7.	16.25 cwt. Belgian rock phosphate (calcined), 24% phosphate of lime, trace citric soluble	44½
8.	4.12 cwt. Belgian rock phosphate (ground) 47.2% phosphate of lime, and 6.5 cwt. superphosphate, 29.9% soluble phosphate of lime	45½

* See Guide to Cockle Park for 1913, page 40. Also Guide for 1914

The cost of a unit of phosphate in rock phosphates is only about 9d., whilst in basic slag it is about 1s. 4d. It will therefore be readily understood that the use of rock phosphates might prove of considerable economical importance.

With the object of finding a satisfactory explanation of the successful results obtained by the use of rock phosphates, the following short investigation was carried out.

At the commencement of the investigation a Belgian rock phosphate and a calcined Belgian rock phosphate were submitted to two consecutive extractions with 2 per cent. citric acid. The Belgian phosphate showed three times as much phosphate soluble in the second extraction as in the first, while the calcined sample showed ten times as much soluble in the second as in the first extract.

* To perform this test 5 grms. of the phosphate are placed in a litre flask containing 500 c.c. of 2% citric acid solution. The flask is shaken end over end for 30 minutes in an apparatus making 30 revolutions per minute.

These results led to five consecutive extractions being made of each of four rock phosphates. The results of these extractions are given in the following table :—

TABLE III.
Belgian Rock Phosphate.

Extraction.	P ₂ O ₅	Ca ₃ P ₂ O ₈	CaO
1st	1.58	3.45	13.84
2nd	4.81	10.49	10.80
3rd	4.81	10.49	9.02
4th	4.30	9.39	7.73
5th	3.20	6.98	—
Total for 5 extractions	18.70	40.80	41.39
Actual totals	21.24	46.36	49.28

Calcined Belgian Rock Phosphate.

Extraction.	P ₂ O ₅	Ca ₃ P ₂ O ₈	CaO
1st	.40	.86	47.63
2nd	3.76	8.21	8.01
3rd	3.72	8.12	5.82
4th	1.96	4.28	3.32
5th	0.70	1.53	1.13
Total for 5 extractions	10.54	23.00	65.91
Actual totals	11.16	24.34	67.50

Tunisian Phosphate.

Extraction.	P ₂ O ₅	Ca ₃ P ₂ O ₈	CaO
1st	3.86	8.44	17.23
2nd	7.72	16.88	12.54
3rd	5.78	12.62	9.42
4th	3.86	8.44	6.00
5th	1.48	3.25	2.24
Total for 5 extractions*	22.70	49.63	47.43
Actual totals	22.61	49.46	46.50

Calcined Tunisian Phosphate.

Extraction.	P ₂ O ₅	Ca ₃ P ₂ O ₈	CaO
1st	1.22	2.65	19.06
2nd	4.90	10.68	9.05
3rd	4.26	9.28	6.48
4th	4.12	8.09	5.84
5th	3.15	6.90	4.42
Total for 5 extractions	17.65	38.50	45.75
Actual totals	24.20	53.01	55.70

In the case of the calcined Belgian phosphate it is probable that the large amount of free lime present did by neutralising the citric acid interfere with the solubility of the phosphates in the first extract. These results undoubtedly show that these rock phosphates are completely soluble in citric acid, if enough citric acid is used, and enough time is spent in the extraction. Further, if we take into consideration the fact that the process of solution in the soil rendering phosphates soluble is a continuous one, then the reasons why these so-called "citric insoluble phosphates" give just as good results as the high citric soluble slags is readily understood. It is worthy of note that the second and third extractions give the bulk of the phosphates soluble in citric acid, but the first extract contains more lime than any other extract. In other words, the citric acid test as commonly performed is a test for lime rather than a test for phosphates.

Conclusions.—This investigation demonstrates the worthlessness of the citric acid test as a means of judging the relative value to the plant of phosphatic manures. The original purpose of the citric acid test was to detect adulterations, against which purpose nothing is urged.

It is the subsequent interpretations which have been put on this test that the author considers unreliable.

Summary of Field Experiments on Three Years' Ley.

Manure.	Number of experiments.	Total number of years.	Average yield of hay per acre.
Slag (200 lb. P_2O_5 per acre) ..	5	13	cwt. 40.3
Bone meal (200 lb. P_2O_5 per acre)	2	5	39.7
Mineral phosphates (200 lb. P_2O_5 per acre)	5	12	41.0
No manure.....	2	5	35.2

The author wishes to express his sincere thanks to Mr. S. Hoare Collins for his invaluable advice and suggestions, and to Professor Gilchrist for permission to publish the figures in Tables I. and II.

ON THE DIFFERENCE BETWEEN THE CALCULATED AND DETERMINED CALORIFIC VALUES OF COAL GAS.

BY G. WEYMAN, M.Sc.

In the course of the examination of the gas manufactured at the Elswick and Redheugh Works of the Newcastle and Gateshead Gas Company, some interesting points were observed. It was noticed that the difference between the calculated and actually determined calorific values was about 28 B.T.U. per cub. ft. for the gas manufactured in the horizontal retort plants, and this difference—provided no great change was made in the method of working—was remarkably constant. When the vertical retort plant was started at Elswick, it was evident that no less than about 43 B.T.U. would have to be added to the calculated value to bring it up to the determined. When, some months later, a tar circulation was introduced to keep the cross-collecting mains free from thick tar, the difference between the two values considerably decreased. The tar for the circulation, which at first was taken back to the wells as soon as it entered the large main, was subsequently allowed to run with the gas right along to the condensers. A further decrease in the difference between the two calorific values was noticed. Suspicious as to stripping of the gas by the tar were aroused, and the following experiments were made to solve the point.

1. A twenty cubic-foot holder was filled with gas from the vertical plant, mixed, and allowed to attain a constant temperature. The calorific value was determined and an analysis made. The gas was then passed through a sample of the tar at $10^{\circ}C$, which had been taken from the tar outlet beside the works' condensers and again examined. From the results shown in Table No. 1 it is evident that the calorific value of the gas had been depreciated by 11.7 B.T.U. by passing through the tar. The tar has stripped the gas of some hydrocarbons. The calculated calorific value (the constants used are taken from the table in Coste's *Calorific Power of Gases*), however, is practically the same. One would imagine then that

TABLE 1.—Gas and tar separated at $72^{\circ}C$.

	Without tar.	Tar at $10^{\circ}C$.	
Cal. val. gross detd.	550.3	547.0	Note.—In all the analyses which were made in the Sodeau Apparatus the $CuHm$ were absorbed in bromine water, the CH_4 and H_2 determined by explosion, and the N_2 by difference. All the calorific values are in gross B.T.U. pr. c. ft.
Cal. val. calc. gross	542.5	543.1	
CO_2	0.0	0.0	
O_2	0.8	0.8	
$CuHm$	2.1	2.2	
CO	8.6	7.8	
CH_4	20.0	20.5	
H_2	53.2	54.7	
N_2	5.4	5.0	
	100.0	100.0	

the hydrocarbons removed by the tar are such as are not estimated in the analysis. In fact the olefines show a slight increase; while the carbon monoxide has suffered to the extent of nearly 1 per cent. The methane and hydrogen also show a change which is more than warranted by experimental error.

A fresh series of experiments was made in which the tar was heated to different temperatures. It should be noted that the gas and tar were separated in the works at $72^{\circ}C$. and in the results given in Table 2, the calorific value at $75^{\circ}C$. is slightly higher than the original sample of gas, while below this temperature it gradually decreases in value.

TABLE 2.—Tar and gas separated at $72^{\circ}C$.

	With-out tar.	Tar at $60^{\circ}C$.	Tar at $64^{\circ}C$.	Tar at $70^{\circ}C$.	Tar at $75^{\circ}C$.
Cal. val. detd. gross	555.0	542.0	544.5	553.1	558.8

An additional series of experiments gave confirmatory results which are shown in Table 3:—

TABLE 3.—Tar and gas separated at $72^{\circ}C$.

	With-out tar.	Tar at $85^{\circ}C$.	Tar at $87^{\circ}C$.	Tar at $92^{\circ}C$.	Tar at $86^{\circ}C$.	Tar at $75^{\circ}C$.	Tar at $60^{\circ}C$.
Cal. val. detd. gross	543.0	549.6	551.1	554.7	555.2	548.0	535.5
Cal. val. calc. gross	545.7			544.4			
CO_2	0.0			0.0			
O_2	0.4			0.3			
$CuHm$	2.4			2.4			
CO	9.1			8.8			
CH_4	20.4			20.2			
H_2	53.1			53.0			
N_2	5.0			5.7			
	100.0			100.0			

In this series the tar was gradually heated and then slowly cooled, the calorific value and samples for analysis being taken at intervals. The calculated value for the original gas is higher than the determined, but falls below as the temperature at which it passes through the tar is raised above $70^{\circ}C$. Considering these results as a whole it is quite clear that there are present in the gas some hydro-carbon vapours, which are not estimated in the analysis and therefore, while they contribute towards the determined calorific value, are not included in the calculated figure. These hydrocarbon vapours, unlike the hydro-carbons estimated by bromine are easily removed by tar, in fact a state of equilibrium exists between tar, gas and hydro-carbon vapour, which depends on the temperature at which they are in contact. The higher the temperature, the greater will be the amount of vapour in the gas, and if the gas is then removed, it will of course carry the vapour with it. Also it is evidently these vapours which make the difference between the calculated and determined values, rather than any difference in composition of the olefines determined by absorption in bromine water. The variation in the difference between the calculated and determined values shown in connection with the vertical plant is clearly due to the lower temperature of separation of tar and gas when the tar circulation was introduced, with consequent reduction in the amount of hydro-carbon vapour present. These considerations led me to find a way of estimating these hydro-carbon vapours, and I soon found that Bunsen had distinguished between the permanent unsaturated gases, ethylene, propylene, etc. (the olefines) and the vapours of volatile saturated hydro-carbons. Bunsen found that the vapours could be dissolved out in absolute alcohol, while the excess of alcoholic vapour could be afterwards removed by water. The estimation must be made before any treatment of the gas, since benzene and other vapours, are soluble