Wöhler, by passing hydrochloric acid gas over red hot iron filings, a method referred to in the various dictionaries. I have not heard of similar deposits having been found in the Deacon plant before.

III. Hexachlorobenzene.—A third deposit, also occurring on the Deacon plant, is of unusual interest since it is organic. It is hexachlorobenzene, C_6Cl_6 , as is shown by its melting point, behaviour towards solvents, and general properties. The present sample recrystallised from chloroform had a melting point of $228^\circ C$. The melting point for hexachlorobenzene is given as $226^\circ C$. It was found in the mains and at the top of the condenser through which the mixture of chlorine and undecomposed hydrochloric acid from the decomposer travels, and its formation is to be ascribed to the action of the chlorine in the gases on the tarry matters in the pipes, hexachlorobenzene being the final product of chlorination of aromatic substances. Confirmation of this view is to be found in the fact that, so far as I can ascertain, the product is mostly found in new ranges of pipes or in repaired lengths where freshly tarred pipes are introduced.

London Section.

Meeting held at Burlington House on Monday, April 6, 1908.

DR. J. LEWKOWITSCH IN THE CHAIR.

MUREXIDE; A ONCE USED DYESTUFF AND PRINTING COLOUR.

BY WATSON SMITH.

A specimen of commercial murexide as put upon the market about 1863 was exhibited, and also a sample of calico printed with it about that period, and before magenta had made its way to the front. The uric acid, necessary for its preparation, was obtained from guano and the first to import Peruvian guano largely for this purpose was the late Robt. Rumney of Manchester. He made about 12 cwt. of murexide weekly, and the cost of it then in the form of paste, was 30s. per lb. The advent of magenta soon destroyed this business. (See Thorpe's Dictionary of Applied Chemistry and Crookes' Dyeing and Calico Printing, 1874, 169.) One of Mr. Rumney's partners gave me these specimens forty years ago, and by keeping the printed calico specimen continually in the dark, I have succeeded in preserving the rose-red tint of the murexide. In the present sample of cloth, exhibited, the murexide pattern has evidently been printed upon a lead mordanted ground.

Purpuric acid is of course the mother substance of murexide, and it was for long of doubtful constitution, but in our Journal 1904, 656 and 818, there are abstracts of papers by Slimmer and Stieglitz (Amer. Chem. J. 1904, 31, 661) and Möhlau (Ber., 1904, 37, 2686) wherein they work out the constitution of purpuric acid as

I may point out that Schorlemmer, in his "Chemistry of the Carbon Compounds" dated 1875 (page 245), states that purpuric acid has probably the identical constitutional formula demonstrated by these chemists. According to Slimmer and Stieglitz, murexide may be represented as follows:—

CONSIDERATIONS AFFECTING THE "STRENGTH" OF WHEAT FLOURS.

BY JULIAN L. BAKER, F.I.C., AND H. F. E. HULTON.

During the last two years a series of interesting and valuable investigations, largely of a pioneer character, has been published by Humphries, Biffen and Wood, in the Journal of Agricultural Science relating to the highly important question of the "Strength of Flours." The present position of our knowledge has been ably summed up by T. B. Wood (J. Agric. Sci., 1907, 2, 140—160 and 267—277; this J., 1907, 1290 and 1908, 175). Not a little confusion attaches to the meaning of the term "strength." Humphries and Biffen have discussed this matter (*ibid.*, 1, 1) and after careful consideration, Humphries defines "strength" as the capacity for making large well-piled loaves.

It is customary to express the "strength" of flours in terms of the above definition by awarding marks, the ideal flour being taken as 100. Since Humphries formulated his conception of "strength," H. B. Wood has made many attempts to find a chemical means of measuring this property, and has correlated his analytical results with the empirical "Bakers' marks." But on reflection it does not seem to us possible that the estimation of one constituent or the determination of one physical property will enable the chemist to affix a baking value to a flour, when this value is the resultant of more than one factor. It appears from T. B. Wood's recent researches (*ibid.*, 1907, 2, 141), that he recognises this, for he points out that no one has succeeded in suggesting a generally satisfactory chemical or physical explanation of "strength," and no one working on chemical or physical lines has used a definition of the term which does not include two distinct properties. Humphries' definition includes two qualities, size and shape of loaf, which are quite likely to be chemically and physically entirely independent, and for each of which a separate explanation must be sought. The definition is obviously not of a scientific character, nor is it a final one, but it has afforded a useful working basis for purposes of comparison, and it sets forth the two factors believed to be of pre-eminent importance.

It seems to us that advances might be made if the baker would apportion marks independently for size and shape of the loaf. If this were done, the results of certain analytical and physical investigations on flours could be compared with the dual system of marking. We believe that the reference of any further analytical data to marks obtained on the present system of expressing the baking value is somewhat futile, and a most necessary reform is the adoption of separate marking for each factor.

Notwithstanding the very considerable amount of work which has been done on this subject, the chemist is not yet in a position to state definitely that one flour is stronger than another, consequently the baking of the dough under more or less standard conditions is the only useful test on which the baker can rely. In this connection may be mentioned a paper by R. W. Thatcher (J. Amer. Chem. Soc., 1907, 29, 910), who has carried out a most elaborate series of experiments comparing the various methods, physical and chemical, of estimating the baking value of flour. This investigator carefully avoids the comparison of his results with any empirical system of marking or definition of "strength," but refers all his determinations to the specific gravity of the loaf baked from each flour under standard conditions. His conclusions, which are mainly negative, are as follows:—"From the results of these comparative tests we must conclude that no single test which was tried is capable of giving conclusive evidence as to the baking quality of flour. Any of the processes which have yet been suggested for testing flour must be supplemented by a baking test if final and accurate conclusions are to be reached."

T. B. Wood in his last paper (J. Agric. Sci., 1907, 2, 267—277), has made some very interesting observations bearing on the effect of acids and salts on the physical character of glutes. Although his results cannot be correlated with

Bakers' marks, we feel sure it is in this direction that further light will be thrown on that gluten-character which, in our opinion, forms one of the two or three essentials concerned in "strength."

In view of the negative results so far obtained by the many investigators who have studied the problem, it seemed to us worth while to make an attempt to break fresh ground, and a study of the enzymic activities of flour appeared likely to furnish results of interest. It is well-known that wheat, like other cereals, possesses a starch transforming enzyme which we will discuss later. Gluten in the grain of wheat, apart from its interest to the baker, exists primarily as a reserve of nitrogenous food material for the young embryo, and proteolytic enzymes are consequently secreted to render this reserve available on germination. Such well-known facts as the destruction of wheat for flour making purposes by sprouting, of the presence of sulphurous acid, as in the holds of vessels, the marked improvement by holding over flours, and the grading of flours of different origin to improve their baking value, may alike be due to an alteration of the proteolytic as well as the diastatic enzyme. At the meeting of the British Association, held at Leicester last year, we pointed out that the appearance of white of egg when treated in presence of toluene with an aqueous extract of flour was considerably altered, the albumen being disintegrated and the solution becoming milky. On attempting to measure the amount of nitrogen, if any, rendered soluble, the analytical results showed that there was no increase of soluble nitrogen in aqueous flour extract after digestion for four hours at 36° C. in the presence of white of egg. This was confirmed by the absence of the tryptophane reaction when flour water and egg albumen were kept at 37° C. for sixteen hours. When flour extract was allowed to act on its separated gluten for 18 hours at 37° C., there was practically no evidence of solution and no alteration in the appearance of the gluten. Since these and other experiments demonstrated the absence of a soluble proteolytic enzyme capable of degrading albumen or gluten we directed our attention to the presence of other proteolytic enzymes. Our knowledge of these enzymes in plants is largely due to Vines' work, and prior to his last paper he had shown (*Annal. of Bot.*, 1906, 20, 113) that ungerminated seeds contain (a) a protease that acts at once on Witte peptone, and (b) one or more proteases that act more or less slowly on the reserve proteids of the seed; also that all germinating seeds contain a fibrin dissolving enzyme. In his last paper (*ibid.*, Jan., 1908.) he has succeeded in isolating a protease essentially peptic in character, digesting fibrin to albumose or peptone but without further action on either these products or Witte peptone. This plant pepsin appears always to be associated with an erepsin, that is to say an enzyme capable of degrading still further Witte peptone and the products of pepsin hydrolysis, and characterised by the production of tryptophane among other bodies, and this tryptophane is conveniently identified by the pink-red colour it produces with chlorine or bromine water. It has been shown by Vines (*ibid.*, 1903, 17, 237, 597) that wheat germs contain an erepsin, but since in flour the germs have been removed, it appeared to be of interest to ascertain if the flour itself contains any. Accordingly 10 grms. of flour were digested with 50 c.c. of chloroform water for 20 hours at 37° C., filtered, and the filtrate tested for tryptophane in the usual manner. Nine flours of varying strengths were examined, four showed no reaction, four a slight and one a strong reaction. It was possible that the negative and slight results obtained might be due to the absence in the flour of peptones and albumoses of a character degradable by an erepsin. We, therefore, repeated the previous experiments with the addition of some Witte peptone, and in all cases obtained a distinct reaction. This shows that flour undoubtedly contains an erepsin, but it is apparently in most cases destitute of protein upon which it can act. Since the "strength" of the flour is probably largely dependent on the character of the gluten, and erepsin being without action on insoluble proteins we must look further for the cause of any possible gluten hydrolysis, which if it occurred during the doughing or baking process would almost

certainly affect the size or shape of the loaf. It may be worth noting, in this connection, the great deterioration in baking quality already alluded to of flour made from sprouted wheat, for on germination there is a notable increase of the peptic or gluten-dissolving enzyme.

This leads us to a consideration of the rôle played by the enzymes of the yeast which is used in bread making. Vines (*ibid.*, 1905, 19, 178) has shown that yeast undoubtedly possesses enzymes which can dissolve fibrin and produce the tryptophane reaction. This fibrin-dissolving enzyme, if capable of effecting even the earlier stages of gluten hydrolysis, will probably play an important part as a "strength" factor, since the gluten will be under its influence during doughing for several hours at a favourable temperature. That gluten is attacked by yeast enzymes is shown by the following experiments:—A quantity of flour was made into a dough with its own weight of water containing 5 per cent. of bakers' yeast. The dough was left for four hours at 37° C., and the soluble nitrogen expressed as protein was found to be 2.7 per cent., calculated on the flour after corrections for possible autodigestion of the yeast had been made. The same flour treated as above but without yeast was found to yield only 1.9 per cent. of soluble nitrogen as protein. This increase of nearly 1 per cent. must obviously be due to an enzyme other than erepsin since as we have already shown the latter, although present in yeast is without action on gluten. It is probable that the physical character of the gluten may be much modified during the early stages of enzyme action without the production in large quantity of soluble decomposition products. In this connection may be noted the profound change in the viscosity of a starch paste under the influence of a trace of liquefying diastase before any maltose is produced.

Diastatic enzymes in flours.—The fact that flour contains an amylolytic enzyme, although known, appears to have received but little attention as one of the considerations associated with "strength." It is certain that some of the carbon dioxide concerned in the rise of bread especially in the later stages of doughing and the early period of baking is formed from the fermentation of the maltose produced by the action of the diastase on the flour starch. To prove that maltose is the sugar formed, doughs were prepared (i.) with water and (ii.) with N/50 alkali, to prevent diastatic action. After standing for four hours at 40° C., the masses were extracted with water and alkali respectively, and the difference in the reducing power between the filtrates noted. Usually there is an increase in reducing sugar of $\frac{1}{2}$ to 2 per cent. on the weight of the flour when flour is doughed with water. The filtrates were evaporated to syrups, precipitated with alcohol, the solutions freed from alcohol and submitted to the osazone test. Glucosazone only was found in the alkaline solution, but glucosazone and maltosazone in the aqueous extraction.

Before measuring the amylolytic power in the terms of Lintner's method, it was necessary to investigate the nature of the action of flour diastase on soluble potato starch to determine if Kjeldahl's law of proportionality held good; that is to say whether the amount of maltose produced under certain defined conditions is proportional to the amount of enzyme present. (*Comptes rend. des travaux du laboratoire de Carlsberg*, 1879, 1, 109—157) vide also Ling (*J. Fed. Inst. Brew.*, 1896, 2, 335; this *J.*, 1896, 621). When working with malt diastase Kjeldahl found that, if the production of maltose does not exceed 45 per cent. of the starch used, this maltose may be taken as a measure of the diastatic activity of the solution. Careful work on the validity of this law as regards malt diastase shows that while approximately true it is not absolutely so, and in the case of wheat flour diastase still less so. This is well shown on the accompanying table (Table I.) where the maltose (R) produced by increasing volumes of the flour extract acting on a constant quantity of soluble starch is set against the quotient R/N, N being the number of c.c. of flour extract used. It is obvious that if Kjeldahl's law holds with flour extracts, R/N should be constant up to R=40 to 48. But it is not so.

TABLE I.

C.c. of 5 per cent. aqueous extract of wheat flour added to 50 c.c. of 2 per cent. soluble starch. = N.	Percentage of maltose on solids. = R.	R N.	Amylolytic power, Lintner.
0.5	5.18	10.32	—
1.0	10.06	10.06	24.0°
1.5	14.00	9.33	—
2.0	17.00	8.80	21.5°
2.5	21.00	8.76	—
3.0	24.70	8.23	—
4.0	32.50	8.12	19.5°
5.0	35.3	7.06	—
7.0	40.60	5.80	—
10.0	48.00	4.80	—

The smaller the proportion of maltose formed (R) the more nearly does the resulting diastase figure approach the maximum. Therefore in any work in which the diastatic powers of wheats or flours are recorded the R, at which the experiment was conducted should be defined. Throughout this paper these values were determined in solutions having an R of 17 to 20 per cent.

These curves show by their departure from the horizontal the extent to which the materials employed fail to conform to Kjeldahl's law of proportionality. A typical malt, a wheat, and four flours were experimented with. It is interesting to note how close is the correspondence between the Kurrachee wheat and the flour prepared from it.

The products of the amylolytic action of flour diastase

these determinations were made it was not realised how great was the proportion of enzyme that escaped measurement. It might be supposed that the flour having the higher diastatic capacity would be able to produce more maltose and therefore more carbon dioxide in a given time, and would be the stronger, but no such direct relation can be traced (see Table III.), another proof that gas retention rather than gas production is the more important factor.

TABLE III.

Flour.	Amylolytic power, Degrees Lintner.	Bakers' marks.
*4.	57.0	90
Z.	40.0	90
X.	34.0	40
2.	32.0	78
3.	30.0	80
V.	27.0	90
U.	26.0	91
Y.	25.5	95
T.	25.5	80
W.	25.5	76
1.	25.0	45

* The wheat of Flour 4 in this series was damped and dried before grinding.

It is well-known that wheats and also the flours made from them will often improve in bread making value on keeping. The results recorded in Table IV. show that a marked alteration has been effected by storage in so far as the enzymic activity is concerned.

1. Kurrachee wheat. 2. Flour from Kurrachee Wheat. 3. English malt. 4. Flour No. 1. 5. Flour No. 3. 6. Flour No. 2.

on wheat starch resemble very closely, as might be expected, those which one of us showed were obtained by the action of barley diastase on starch (J. L. Baker, J. Chem. Soc., 1902, 81, 1177; this J., 1902, 1087.) This will have some bearing when the chemical composition of baked bread comes under consideration. We have also observed that the diastase of some flours contains a liquefying enzyme, in others this is either absent or is unable to exert its influence. Attempts to measure the activity of the liquefying enzyme by comparative viscosity tests were not conclusive, all that we can definitely state is that under similar conditions one flour paste loses its viscosity quicker than another. The significance of the presence or absence of a liquefying enzyme will be discussed later. We are aware that in quoting diastatic powers on the Lintner scale we are recording values which by no means represent the total quantity of enzyme, but when

TABLE IV.

Flour.	Date.	Amylolytic power, Lintner.	Date.	Amylolytic power, Lintner.
Flte	1907. Mar.	31.0	1907. July	22
Hard Manitoba	"	35.0	"	21
Kurrachee—				
Dry	May	23.0	"	36
Damped	"	22.0	"	34
Damped and dried	"	17.5	"	30
Flour 1.....	Sept.	20.5	1908. Mar.	32
" 3.....	"	24.5	"	34

In the present state of our knowledge it is not possible to correlate these differences with the behaviour in the

bake house, but they indicate that internal changes take place. It is well-known that enzyme-containing tissues exhibit a greater activity than when extracts from them are used. Ford and Guthrie (J. Fed. Inst. Brew., 1908, 14, 61; this J., 1908, 239) in an extremely suggestive paper, have made use of this fact in studying the diastatic power of barleys. These chemists have announced their intention of reading a paper to this Society on the amylolytic enzymes of wheat flours and their relationship to "baking value."* They state that flours as a rule yield little amylase to solution on aqueous extraction, though the amount present in the "insoluble" condition is very considerable. Not only can we confirm the additional diastatic activity observable when the flour itself is allowed to act on soluble starch but we have made in addition the interesting observation that doughs display even a greater diastatic activity. Our method of experimenting was as follows:—0.4 grms. of a dough made by mixing flour with its own weight of water was at once mixed with 200 c.c. of soluble starch and allowed to stand for 1 hour at 15.5° C. The same determination was repeated after another portion of the original dough had stood for 2 hours in a moist atmosphere. The activity of the dry flour was measured at the same time. The following results were obtained:—

TABLE V.

Flour.	Aqueous extract.	Diastatic power in degrees Lintner.			Bakers' marks.
		Dry flour.	Dough at once.	Dough after 2 hours.	
1.	25	30	44	55	45
2.	32	37	46	54	78
3.	30	36	47	57	80
4.	57	64	75	96	90

On comparing these figures, the increase in diastatic power in the doughs after the stand of 2 hours is very marked. An obvious extension of this experiment was to ascertain if this increase was maintained in the case of dough made with yeast. This was found to be the case. It is remarkable that the diastatic activities of doughs vary in proportion to the amount of water used. The dough immediately after preparation was intimately mixed with soluble starch and the diastatic power determined as in Lintner's method.

	Diastatic power.
Flour doughed with its own weight of water	55
The same flour doughed with 5 times its weight of water	53
" " " 50 " " "	40
" " " 250 " " "	34
" " " 500 " " "	29

The ordinary Lintner figure, using the aqueous extract of the flour, was 29. It would be outside the province of the present communication to discuss more fully the bearing of the above observation.

Signification of gas production and its relation to "strength."—In a paper recently published by T. B. Wood (J. Agric. Sc. 1907, 2, 139—160; this J., 1907, 1290) the whole subject of gas evolution is summarised, and the results of previous workers discussed. He attempts to correlate size of loaf and gas production, and shows that, with a few exceptions, "strength" as measured by bakers' marks is proportional to the volume of gas evolved. He assumes that the size of the loaf depends in the first instance "on the amount of sugar contained in the flour together with that formed in the dough by diastatic action." This inference is, no doubt, substantially correct, but as he did not investigate the amount of diastase present and what proportion of gas

owed its origin to the maltose formed by this diastase, it seemed desirable to ascertain what relation, if any, exists between diastatic capacity, gas production, and bakers' marks. The amount of gas evolved from a flour mixed with water and yeast according to the conditions laid down by Wood was determined for a number of flours. The carbon dioxide was collected over saturated brine, and the volumes recorded at half-hourly intervals for three hours. The accompanying curves illustrate the gas liberation of four typical flours.

TABLE VI.

Flour.	Bakers' marks.	Diastatic power in degrees Lintner.	Volume of carbon dioxide in cub. cen. after 3 hours at 40° C.	Ratio of diastase to carbon dioxide.
X.	40	34.0	84	1:2.4
1.	45	25.0	78	1:3.1
W.	76	25.5	145	1:5.6
2.	78	32.0	175	1:5.4
3.	80	30.0	155	1:5.1
T.	80	25.5	220	1:8.6
V.	90	27.0	217	1:8.0
4.*	90	57.0	193	1:3.4*
Z.	90	40.0	270	1:6.7
U.	91	26.0	230	1:8.9
Y.	95	25.5	184	1:0.4

* NOTE.—It should be borne in mind that Flour 4 was submitted to a special treatment of dampening and drying before milling, the result being to accentuate its saccharifying capacity out of proportion to the volume of gas evolved.

Roughly, the total volumes of gas increase as the bakers' marks, but a weak flour may have a diastatic power as high as or even higher than a strong flour. Thus it appears that gas production is not a function of diastase, as is obvious from the last column; but, as the following figures show, there is a connection between the gas volume and the additional matter rendered soluble during the process of doughing. The cold water soluble extract in a series of flours was estimated and also the soluble matter in their doughs, which had been kept at 40° C. for three hours. Both sets of estimations were corrected for soluble nitrogenous substances present. The increase, measured by subtracting one from the other, can only be due to maltose formed by the action of diastase.

* This paper appears at p. 389 of this issue.

TABLE VII.

Flour.	Per cent. of matter soluble in water at 15-5° C.	Per cent. of matter soluble in dough when kept at 40° C. for 3 hours.	Difference = maltose formed during doughing.	Volume of gas obtained from dough in 3 hours.	Bakers' marks.
1.	2.12	3.00	1.48	78	45
X.	2.03	4.41	1.38	84	40
W.	2.83	5.38	2.53	145	76
3.	2.40	5.53	3.04	155	80
Y.	2.60	6.57	3.88	104	95
2.	3.19	6.60	3.45	175	78
4.	4.10	10.95	0.75	193	90
V.	2.83	8.26	5.42	217	90
T.	2.84	7.66	4.82	220	80
U.	2.65	7.68	5.02	230	91
Z.	3.54	11.65	8.11	270	90

A study of this table shows that gas production follows fairly closely the maltose formed during doughing. In

0.25 per cent. of malt on the 20 grms. of flour used is only 50 mgrms., an amount which does not materially increase the saccharifying diastase present and supplies no fresh sugar. The results indicate, we think, most conclusively that the low gas production of this flour arises from an inadequate supply of starch liquefying enzyme. We have already shown (Table VI.) that the gas : diastase ratio is higher on the whole in strong flours, and it seemed probable, in view of the last experiment, that we might establish a connection between strength and the relative amount of a starch liquefying enzyme in a flour. If the gas production from weak flours (which is usually smaller than in strong ones) were relatively increased in a greater proportion by the addition of a trace of liquefying diastase, than in the case of flours with large gas productions, then we should have established the point that gas : diastase ratio, total volume of gas, and, incidentally therefore, to some extent strength were functions of this liquefying enzyme. The following results justify this conclusion :—

TABLE IX.

Flour.	Bakers' marks.	Diastatic power.	Gas : diastase ratio.	Gas production in 3 hours. c.c. of carbon dioxide.	Gas production in 3 hours in presence of 0.25 per cent. malt. c.c. of carbon dioxide.	Percentage increase due to added malt.
X.	40	34.0	1 : 2.4	84	158	88.0
1.	45	25.0	1 : 3.1	78	145	86.0
W.	76	25.5	1 : 5.6	145	194	34.0
2.	78	32.0	1 : 5.4	175	207	18.0
Z.	80	25.5	1 : 8.6	220	230	4.5
T.	90	40.0	1 : 6.7	270	250	nil.
U.	91	20.0	1 : 8.9	230	248	8.0
Y.	95	25.5	1 : 6.4	104	235	49.0

some cases the maltose formed is an appreciable figure, and this fact, in conjunction with the observation, made in an earlier portion of the paper, that some flours have a liquefying enzyme, would naturally suggest that low strength flours were deficient in the latter. It should not be forgotten that diastase, estimated in degrees Lintner, is solely saccharifying diastase, since soluble starch is the material acted upon, and the figure so obtained provides no measure of any liquefying enzyme. Flours with the diastatic powers recorded in this paper are comparable with brewing malts in so far as their saccharifying action on soluble starch is concerned. This being so, there is an ample amount of saccharifying diastase present to deal with any material rendered soluble had more liquefying diastase been present.

It is well known that malt extract is frequently employed by bakers, presumably with the object of increasing the amount of sugar available for gas production. This, in our opinion, it does by providing a starch liquefying enzyme, the flours' own diastase being adequate for saccharification. This is supported by the following evidence. A weak flour (bakers' marks, 45) was tested for gas production by itself, and with the addition of a trace of liquefying enzyme, powdered malt being added for this purpose.

TABLE VIII.

Time	Flour alone.	0.25 per cent. of malt.	1 per cent. of malt.
Hours.	c.c. carbon dioxide.	c.c. carbon dioxide.	c.c. carbon dioxide.
1	28	30	32
1 1/4	47	66	69
1 1/2	55	101	115
1 3/4	113	245	362

This table shows that the percentage increase in gas volume due to the presence of liquefying diastase follows inversely the amount of gas originally liberated by the dough *per se*. The percentage increase is also inversely proportional to the bakers' marks, with the exception of Y. This flour, although highly marked, yields little gas, and it is of especial interest to note that, as might have been expected, its capacity for increase in presence of malt is considerable, thereby bringing it into line with other flours yielding small volumes of gas. In the case of Z, a flour giving the largest gas production of all, there is no increase in the volume of gas obtained by the addition of malt, and presumably, therefore, there is already present liquefying enzyme in such quantity as not to be capable of serious augmentation by such a trace of malt as we have used.

Lange (this J., 1907, 1104) has shown that wheat flour and aqueous extracts prepared from it under certain conditions are poisonous to top fermentation, distillery and pressed yeasts. This poisonous action is only exhibited in the presence of fermentable sugar and in the absence of certain salts; it manifests itself in the form of decreased fermentative power and the drying off of the cells. Lange's work appeared to us to possess some importance in our enquiry, for under the conditions of doughing and early baking, the toxic effect of different flours on yeast might be a factor influencing strength. We find that the number of dead cells of *saccharomyces cerevisia* is apparently increased in presence of aqueous flour extracts but as the following experiments show the toxic action if exerted does not influence strength.

1. Thus, if a yeast is subjected to the toxic action of different flour extracts, the fermentative energy would be lessened in proportion to the toxicity of the flour employed. To establish this point, some yeast was kept for three hours in presence of the under-mentioned flours and water, and a known volume of the mixture was then used to ferment a saccharine solution.

TABLE X.

Time.	Bakers' marks, 40.	Baker's marks, 95.
Hours.	Volume of gas. c.c.	Volume of gas. c.c.
1.	9	14
3.	65	76
5.	125	146
19.	472	486

The weaker flour has thus proved no more deadly to the yeast than the stronger.

2. Should a toxic action be exerted on a yeast by flour, a dough at the end of its four hours' fermentation would contain its yeast in a weakened form. That this is not so we proved by adding a further quantity of flour to the dough at this stage, and noted that the gas production was vigorously continued.

Relation of gluten to "strength."—It is obvious that the strength of a flour must be closely connected with the gluten, although, no doubt, the presence of enzymes, soluble carbohydrates, and mineral constituents all play a part.

Gluten as isolated from flour consists of a mixture of proteins of which glutenin and gliadin are the principal constituents. T. B. Wood (*loc. cit.*, p. 139) has proved that the chemical composition of the gliadin and glutenin of strong and weak flours is identical. It has long been thought that the "strength" of a flour depends upon the ratio in which these two substances, gliadin and glutenin, are combined. The fact that the former can be separated from gluten or flour by treatment with 70 per cent. alcohol served as a basis for the estimation of the gliadin: glutenin ratio. The results of individual workers have been contradictory, and A. D. Hall (Report of the Home Grown Wheat Committee 1906, 2) states that the gliadin-glutenin ratio fails to indicate whether a flour is weak or strong. Continental and American chemists still attach importance to this ratio, and it is not improbable that the English idea of "strength" would require modification in countries where the loaves have a shape different from ours, and where this factor would consequently differ.

The formation of gluten.—Gluten itself having a physical character so different from either of its constituents suggests the idea that it is most likely some kind of loose compound whose formation is due either to enzymic activity analogous to a coagulase, or to hydration. If gluten could be washed out from a flour which had been made into dough with water containing a substance inhibiting enzymic activity, the first possibility would be eliminated. Portions of a flour were doughed with water containing 1 per cent. of copper sulphate, 0.25 per cent. of mercuric chloride, and N/10 hydrochloric acid, each piece of dough being allowed to stand 36 hours. At the expiration of this time the gluten was easily obtained, and it did not materially differ in physical properties from the gluten separated from an untreated dough. There is thus a strong presumption that gluten is formed by the combination of glutenin and gliadin in the presence of water. Gluten is not a definite hydrate, since the water content of glutes from different flours varies considerably. We have found in a series of determinations that dry gluten will absorb from 1.5 to 2.0 times its weight of water. Thatcher (J. Amer. Chem. Soc. 1907, 29, 910) has recorded values lying between 1.69 and 2.38. The water absorbed by dry gluten appears to bear no relation to "strength."

We thought it would be of interest to try and build up gluten from its constituents. A sample of flour was thoroughly extracted with 70 per cent. alcohol. The residue, consisting of starch and glutenin, after being washed out with 70 per cent. alcohol, was drained and dried. The alcohol was removed from the solution of gliadin by distilling under diminished pressure at a temperature not exceeding 40° C. The gliadin was then thoroughly incorporated with the glutenin and starch, dried *in vacuo*, powdered and made into dough. From this dough gluten could be separated although it

was not so coherent and elastic, or in such quantity as the gluten prepared from the flour in the ordinary way. We were able to repeat this experiment with several flours. The weakening of the gluten formed in this manner was, no doubt, due to the alcohol, for if a flour be doughed with even 10 per cent. alcohol, the gluten yielded has a less degree of elasticity than if it were prepared in the ordinary way.

Diastase in gluten.—Reychler (Ber., 1889, 22, 414; this J., 1889, 407) showed that by treating wheat gluten with dilute acids and salts he obtained solutions which possessed diastatic power. This statement has been contradicted by other workers, but Ford (J. Fed. Inst. Brewing 1908, 14, 77; this J., 1908, 239) points out that the failure to obtain an active enzyme was due either to a difference in the method of preparing gluten or to the use of an excessive amount of acid. Reychler's conditions were so arranged that the amount of acid he used was probably completely neutralised. We have examined several specimens of gluten and have invariably found that they readily hydrolysed soluble starch with the formation of reducing sugar. We next studied the distribution of diastase in gluten after thoroughly extracting a sample of flour with 70 per cent. alcohol, and to remove the gliadin the alcoholic solution was evaporated under diminished pressure at a temperature of 35° to 40° C., to remove the alcohol, but the matter which was in solution was without effect on soluble starch. The residue, consisting of glutenin and starch, possessed a relatively strong diastatic power. Having proved that the amylolytic enzymes will resist alcohol of 70 per cent. strength by digesting flour with such alcohol and then finding that its diastatic power was unaffected, there is strong presumptive evidence that the glutenin portion of the gluten molecule is that which possesses enzymic activity.

We desire to thank Mr. A. E. Humphries for his kind assistance in supplying the samples of flours mentioned in this investigation and for information relating to their milling and origin, also to Mr. F. Day for analytical assistance.

DISCUSSION.

Mr. A. E. HUMPHRIES said there was no standard marking of flours, but the marks used in the Reports of the Home Grown Wheat Committee, by Mr. A. D. Hall of Rothamsted, by Prof. Wood, by the authors of to-night's paper, and by Messrs. Ford and Guthrie in their recent work, had all emanated from him; which at any rate meant that the results recorded by them were comparable. This marking was a convenient method of expressing an opinion on the relative values of flours when many were being tested, but it was empirical. The authors wanted marks for shape as well as for size, but he was not at all sure that was necessary. Baking was not a precise science, and the most careful operator was sometimes in doubt as to whether he had used the right temperatures and followed the right process, or whether certain flours wanted some form of "yeast food" or not. He had in some fifty or sixty cases awarded marks in the usual method, and then measured the loaves. He found that the marks indicated volume within a small percentage of error. Almost all the flours referred to in the paper were well known and thoroughly tested, and the bakers' marks awarded indicated with reasonable accuracy the opinions which capable bakers, working on commercial lines, would entertain as to their relative strengths. As regarded shape, that was largely in the control of the baker, provided he had the advantage of repeated bakings to find out the best method possible, or if he could make laboratory experiments to ascertain beforehand the proper method of treating the flours in the bakehouse. In the paper which he read before the British Association at Leicester last year, he said that of the two points gas making and gas retention the latter was by far the more important. He was inclined now to say that it was all-important. He had, by water displacement, measured 2 lbs. 3 ozs. of fermented dough, moulded into the shape of a loaf as it entered the oven, and a piece of unfermented dough of the same weight, made from the same proportion of flour and water,

similarly moulded; and had found, on the supposition that the difference in size represented the gas contained in the dough, that it was less than one per cent. of the total gas that the flour was capable of evolving by fermentation in the laboratory under standard conditions, reproducing bakehouse conditions. Not long ago he conceived the notion that, instead of taking either the total nitrogen, or the nitrogen less the soluble nitrogen, or the percentage of dry gluten, or the gas-making capacity, a true index of a flour's strength might be obtained by multiplying total nitrogen by c.e.'s of gas evolved under standard conditions; the idea being that the total nitrogen might represent roughly the gas-retaining power of the flour. He found that this worked fairly well but with a very big "if." The methods adopted by the authors were open to criticism so long as they wanted to make their results comparable with bakers' marks, thus:—If 5 per cent. of yeast, no salt, and a temperature of 40° C. were employed, a totally different result would be obtained as compared with bakehouse practice, viz.:— $\frac{1}{2}$ per cent. yeast, say 1 per cent. salt, and a temperature of say 25° to 30° C. He had taken a series of eight flours and fermented them under standard conditions at 30° C. and then at a temperature of 24° C. Two cases would illustrate his point. A flour, which in the first case was 3 in order of gas-making capacity, became 7; and, alternatively, a flour which, was No. 7 at 30° C., became No. 4 at 24° C. He had asked himself why, if gas were of so little importance, he should not try to make bread in an hour. A baker knew perfectly well that the maximum sized loaf could not be made in one or two hours, but for experiment he had tried to do so, using a flour which had yielded a maximum sized loaf only after about 12 hours' fermentation. At the end of 2 hours, much more gas had been evolved than was required to blow it up to its full size, but when the loaf came out of the oven it was quite small. To sum up, the gluten had to be got ready for distension, gas was needed at every stage of the fermentation, and the regularity with which it was given off was more important than the quantity. With the exception of one class of wheat, he believed that flour made from any wheat which millers handled, would give more than sufficient gas for all practical purposes, and weak flours evolved as much gas as strong ones; so that they were driven to consider more than ever the question of gas retention. His idea as to obtaining an index of strength by multiplying nitrogen by gas worked very fairly well for some time, but he came across a flour which made a most extraordinary quantity of gas and the percentage of nitrogen was good. The gluten extracted before fermentation was not bad, yet that loaf was a miserable loaf in all respects. Mr. J. S. Ford, who had recently read a paper before the Scottish Section of the Society, discovered that some flours contain a proteolytic enzyme which shows a distinct effect when used in the ordinary gelatine test. He would like to emphasise the point that nature, in making wheat, was more concerned with the reproduction of its kind than in feeding human beings. Man had discovered that wheat yielded a particularly good food, but, in so using it, he perverted it from its original use. One heard a great deal about wholemeal bread, but in that bread one ate the husk, an indigestible woody fibrous material, which nature provided as a protection for the food of the baby plant underground. So these ferments were there to make the kernel of the wheat available as food for the young plant. They might do good for that purpose, but they might be bad in the hands of the baker.

Dr. J. A. VOELCKER pointed out the importance of the subject to agriculturists, as well as to millers. It was well known that certain wheats, grown under particular conditions, produced grain which was of decidedly glutenous nature and were generally termed "strong" wheats; whilst other kinds were more starchy in character and produced "weak" flours. The object of the agriculturist was to combine with the production of a "strong" wheat a sufficiently large yield to be remunerative to the grower, and in this lay the real difficulty. It might be, as the authors had stated, that a kind of wheat had been found which retained, when grown in this country,

its characteristics of strength; but it had not yet been shown that the yield was sufficiently large to enable the crop to pay the farmer to grow.

The paper contributed by the authors covered a wide field, and contained the record of much work upon the chemistry of this intricate subject. Notwithstanding this, and also the excellent work done by Prof. Wood, of Cambridge, he (Dr. Voelcker) could not help feeling that they were still a considerable way from the real solution of the question.

When they examined the tables put before them, he thought they could not come to a satisfactory conclusion as to the points on which the "strength" of flour really depended. It did not seem that either in the "diastatic power" or in the "maltose-yielding capacity" was the full explanation found.

The truth was that the authors, as also Prof. Wood, had dealt, in their contributions, with the flour after it had been produced, rather than with the conditions which caused it to be what it was. In dealing with the differences produced by keeping the flour, by the relative amounts of water used in the doughing, by the presence of salts, and by the use of yeast, one was inclined to ask whether the varying results obtained were not the outcome of different ways of manipulation rather than the consequence of original and inherent differences in the grain itself, according as whether it was "hard" or "soft."

He (Dr. Voelcker) was more inclined to go further back and to lay emphasis upon those external conditions which were known to exercise an influence on the grain, and to, in great measure, determine its characteristics. He proceeded to instance these, illustrating them by the results of experiments at the Woburn Experimental Farm. Among these conditions were those of soil, maturity, season, climate, and, to a certain extent, manuring. He instanced, in particular, the effect of a hot, dry climate as seen in the universally "hard" character of Indian wheat, and asked, in view of the authors' researches, whether one was to conclude that Indian wheat contained more of the desirable enzymes than did English wheat, or if there was in it more of those constituents which gave a high "diastatic power" or produced much maltose. He argued that the real differences were in the grain itself and had been impressed upon it, probably from the early period of germination, by varying soil constituents and modified subsequently by external conditions.

In conclusion, he instanced a recent experiment at the Woburn Experimental Farm, in which he had shown that the addition of magnesium oxide (MgO) in increasing quantities to the ordinary soil of the farm (a light sandy loam, poor in lime) was able to gradually change the character of the wheat grain from starchy to quite glutenous. This did not, however, happen with all compounds of magnesium, the sulphate, for instance, producing no such effect.

Mr. A. C. CHAPMAN said that there could be very little doubt that the physical condition of the gluten was an important, if not the most important, factor connection with the "strength" of flour, and that this was largely affected by the nature of the soluble matters present in the wheat. Prof. Wood had studied the question from this point of view, and it would probably be found, as Dr. Voelcker had hinted, that the influence of soil on the strength of wheat was referable to the influence which certain mineral constituents, taken up by the grain, exerted on the physical character of the gluten. The effect which salts in solution exerted on gliadin was extraordinary, and the same was true of certain other proteins. The bearing of this on the important question of gas retention was obvious, and in his opinion, the question of "strength" was much more closely connected with gas retention, than with gas production. Mr. Humphreys had referred to the important question of the regularity of gas production. The authors had made considerable reference in their paper to the question of diastatic activity and to the formation of maltose during doughing, but no reference had been made to the specific character of the yeast employed. It was known that this had a very marked

influence on the character of panary fermentation; he was engaged in the investigation of a number of different species and races of yeast from that point of view. In some cases the fermentation started almost immediately and proceeded regularly, whilst in others the commencement of fermentation was relatively very slow, but of a very vigorous and rapid character when once it had started. He hoped at a later date to be able to bring before the Society some information on this aspect of the matter.

Mr. GRANT HOOPER said that the paper presented a comparison of analytical results with what might be called a practical or empirical standard, and he should like to know what degree of uniformity in bakers' marks would be attained by different workers, or in other words, what was the margin of error as regards these marks? It would probably be agreed that, close as able practical men might get in such a valuation of a particular loaf, yet there must be appreciable variations in the time and temperature of baking, the activity of the yeast, etc. These variations would result in differences in the production of gas which would largely influence the result. Turning to the question of "strength," he suggested that the modification of the albumenoid constituents of the grain which determined whether the flour would be strong or weak depended on the history of the wheat. If grown in a hot climate and harvested under favourable circumstances, it seemed to him that the grain would not have been in a condition in which any modification of the albumenoid constituents would be likely to occur, but in other cases at a comparatively early stage and perhaps throughout the history of the harvested grain the moisture might be such as permitted changes in the character of the albumenoids; and so, as such changes occurred or were precluded by the conditions, might it be expected that, other things being equal, a strong or weak flour resulted.

Dr. E. F. ARMSTRONG remarked that some of Prof. Wood's conclusions and possibly his numerical results were invalidated, because the conditions under which he worked were not the same as those which the baker used in practice. The degree of strength as determined by baking test was not a factor of such accuracy as they could wish when comparing it with chemical results. So far, workers in this field had had the advantage of Mr. Humphries' judgment to obtain baking marks; it was to be feared that if the flours were tested by anyone else different results might be obtained. An important point, which the authors recognised, was that some flours changed very much with age. Their experiments had extended over a considerable period, and he should like to ask if the bakers' marks quoted were arrived at within three months of the time of the experiment, because if the authors had relied on the baking figure supplied by Mr. Humphries six months before, the present baking figures might be very different, and invalidate the accuracy of some of their conclusions. In bread-making a series of enzymes were at work which symbiotically acted and gradually degraded wheat starch down to the glucose which was fermented to gas by the yeast. The novel point in the authors' paper was to draw attention to the presence of a liquefying enzyme. There was always a large excess of gas produced during fermentation and it was the gas retention which was of greatest importance. Prof. Wood, basing his work on Prof. Hardy's well-known investigation of colloids, pointed out the enormous influence that small quantities of salts and acids had on gluten. Long before, it had been known to workers in the field of enzymes that small quantities of acids and salts had an extraordinary effect on enzymic action. The point was such a difficult one practically that it had been taken as one of the burdens which workers in this field had to bear, and was more or less silently passed over in the published work. Now, enzymes were to be regarded as colloids, and if that was the case, their activity might be modified by the presence of salts and acids. Accordingly, the quantity and nature of the crystalloid bodies present in flour would very materially modify the character of the gluten, and the activity of the enzymes, and bring about variations in the gas production, also in the structure of the gluten, and in its power to retain gas.

Mr. W. H. RAWLES said that, so far as "strength" was concerned, flour had to be valued by the practical baker's method of baking a loaf, no chemical method at present known being reliable.

The hypothesis advanced by the authors in their paper, in which only single flours were considered, that variations in strength were due to differences in enzymic activity did not appear to him to agree with the results obtained by blending flours. If it were so, the product obtained by mixing equal quantities of a weak with a strong flour would have the mean strength of its two components, since diastatic activity apparently only varied in degree, not kind; whereas he had always found both in the laboratory and in the factory, in connection with biscuit-manufacture that the "strength" of a blend was far greater than the mean of its components, and in some cases practically as strong as the strongest flour in the mixture. This did not seem to be accounted for by this enzymic hypothesis, but to be due more to a chemical combination of the gluten constituents. Had the authors investigated blends of flour, having due regard to the values obtained with their individual components?

Dr. L. T. THORNE said that in carrying out experiments on this subject he had noticed, as Mr. Chapman said, the influence of the different races of yeast, but he also noticed very markedly the effect of the state of activity of the yeast and especially of its state of aeration. Where yeasts were properly active and sufficiently aerated there was a more regular evolution of gas, accompanied at the same time with a more efficient result from the bakers' point of view.

Mr. A. GORDON SALAMON wrote that he had made a number of experiments which proved that the fatty matter of the flour exercised an enormous influence upon the size of the loaf. Also that the viscosity of the fatty matter varied within very wide limits with the age and the variety of the wheat flour. The fatty matter of wheat flour was very uniformly diffused throughout, and, although it amounted to so small a proportion by weight, its presence materially affected the process of panification. He had treated large samples of flour with ether in order to extract this fatty matter, and if a loaf from wheat flour free from the fatty matter were made in the same manner as a similar loaf containing the fatty matter, the one from which the fatty matter had been extracted was very much larger, and the vesicles also were very much larger than the fat-containing flour loaf. It was easy to understand the resistance offered to the passage of gas by a fatty menstruum. This resistance would, of course, vary with the viscosity of the fatty matter.

The Authors, in reply to Mr. Humphries, said that the method for measuring the gas formed during doughing was substantially the same as that described by Professor Wood. The yeast rate was $2\frac{1}{2}$ per cent.; not 5 per cent. It would be impossible to reproduce bakehouse conditions in the laboratory. Temperature and the amount of yeast added would obviously influence gas production, but the authors' object was to obtain results that compared with one another, and upon which they could base conclusions. If the marks assigned by Mr. Humphries were based on the behaviour of each flour under its own optimum conditions as to temperature and yeast rate, etc., etc., then no laboratory experiments could ever be comparable with these marks when a series of flours were treated side by side under standardised conditions as must necessarily be the case in work of this kind. Their experimental results showed that they by no means claimed that gas production followed bakers' marks.

Dr. Voeleker raised several points of interest. As an agricultural chemist he would naturally attach great importance to soil and climatic conditions. He asked whether such conditions were not connected with those differences which constitute the distinction between weak and strong flours. This was not within the scope of the authors' investigation; all they had attempted was to take certain flours which had specific characteristics and to find data which could be correlated with their behaviour in the bake-house. Before, however, that

could be done it was necessary to ascertain what chemical and physical properties of flours were capable of measurement. Whilst fully aware that different races of yeasts possess varying fermentative energies, the authors thought it desirable to use the ordinary baker's yeast. The same yeast had been used in all their experiments and its constancy of fermentative energy had been checked and verified. The baking marks were apportioned by Mr. Humphries some time before the gas production experiments were carried out. It had not been possible to have them redetermined except in one case and in this the value was unaltered. This point would be borne in mind in the continuation of their work. The laboratory behaviour of blends of flours had not been studied although the authors were quite aware that the bakehouse results when working with mixtures did not agree with the mean values that might be expected. They submitted that so far from this being against the enzyme theory, it was a result that was only explicable by assuming the truth of that theory. Mere physical qualities of mixed flours would average out to a mean resultant, but, taking into consideration the characteristic nature of enzymes, what was to be expected would be the great modification of one flour by a mere trace of a suitable enzyme contained in another.

New York Section.

Meeting held at Chemists' Club on March 20, 1908.

MR. GEORGE O. STONE IN THE CHAIR.

CITY REFUSE AND ITS DISPOSAL.

BY H. DE B. PARSONS.

City-waste materials may be divided into three parts: sewage; city refuse; and trade refuse. These may be further subdivided as in Table I.

TABLE I.
Classification of city wastes.

City Refuse	Sewage	Liquid and Semi-liquid Refuse	Household Refuse	House sewage.
				Street, roof, and area drainage.
	Garbage	Ashes	Rubbish	Night-soil.
				Animal matter.
Trade Refuse	Street Refuse	Dead Animals	Snow	Vegetable matter.
				Meat and bones.
	Street Sweepings	Dead Animals	Snow	Fruit.
				Steam ashes.
Trade Refuse	Street Sweepings	Dead Animals	Snow	Household ashes.
				Paper.
	Street Sweepings	Dead Animals	Snow	Wood.
				Rags and bedding.
Trade Refuse	Street Sweepings	Dead Animals	Snow	Leather and rubber.
				Metals.
	Street Sweepings	Dead Animals	Snow	Bottles, glass, and crockery.
				Sweepings from buildings.
Trade Refuse	Street Sweepings	Dead Animals	Snow	Animal manure.
				Pavement dirt.
	Street Sweepings	Dead Animals	Snow	Droppings from carts.
				Materials from building construction.
Trade Refuse	Street Sweepings	Dead Animals	Snow	Rubbish and leaves.
				Cellar excavations.
	Street Sweepings	Dead Animals	Snow	Materials from building construction.
				Stable manure.
Trade Refuse	Street Sweepings	Dead Animals	Snow	Market offal.
				Slaughter-house offal.
	Street Sweepings	Dead Animals	Snow	Dead animals.

The total refuse, excluding snow and dead animals, collected in the year 1906 by city and permit carts from the five boroughs of Greater New York amounted to 3,159,182 tons. The average quantities of refuse collected yearly per capita in Greater New York are given in Table II.

TABLE II.
Average yearly collection of refuse per capita.

	Pounds.	Yards.	Percentages.	
			By weight.	By volume.
Garbage	181	0.163	12.31	8.45
Ashes	936	0.862	63.68	44.64
Rubbish	93	0.650	6.33	33.65
Street-sweepings ..	260	0.256	17.68	13.26
Total refuse .	1470	1.931	100.00	100.00

The average weights of the different classes of refuse, as collected in the Boroughs of Manhattan and the Bronx, City of New York, are: Garbage, 1110 lb. per cubic yard; ashes, 1086 lb. per cubic yard; rubbish, 143 lb. per cubic yard; street-sweepings, 1016 lb. per cubic yard. The weights per cubic yard of these materials as collected in the other boroughs vary to some extent. The greatest difference is noted in the unit weight of street-sweepings, which from macadam roads are heavier than those from asphalt or stone block pavements.

Methods of disposal.—There are six generally recognised ways for disposal of refuse, some of which are limited to one or more of the subdivisions of Table I. These are:—

Methods.	Applicable to
1. Dumping on land.	All subdivisions.
2. Dumping into water.	All subdivisions.
3. Ploughing into soil.	Garbage and street-sweepings.
4. Feeding to swine.	Garbage.
5. Reduction process.	Garbage.
6. Incineration.	All subdivisions (except steam ashes).

1. *Dumping on land.*—Where primary separation is in force, ashes, with or without street-sweepings, can be used to reclaim land where a combined collection would be decidedly objectionable. In such case, the garbage, rubbish, and sweepings have to be dealt with separately.

2. *Dumping into water.*—All classes of refuse could be dumped into water provided that the water is large enough in volume to dilute and scatter those portions which float, and deep enough to permit the heavier portions to sink without interfering with channels or navigation. Unless there be an almost uniform current away from the neighbouring shores, this method cannot be recommended, and, where in use, efforts are made to abandon it in favour of some other.

3. *Ploughing into soil.*—This method is only applicable to garbage, and possibly to street-sweepings. The soil should be sandy and the farm area large. The hauls will be necessarily long, and it requires the primary separation system for collection. It is inapplicable to cold climates where the ground freezes.

4. *Feeding to swine.*—This is a method only applicable to fresh garbage, unmixed with other refuse. It is seldom considered for large cities.

5. *Reduction.*—These processes consist of some method of "rendering" the garbage, by which the oil and grease are extracted, leaving a residue called "tankage." It is only applicable to garbage practically freed from rubbish, and can only be adopted by large cities, for, unless there be sufficient garbage, the first cost is prohibitive. Furthermore, it is only profitable when the garbage is rich in grease, which is one reason why it has not been more generally adopted by the southern cities of the United States. The best known systems are the Arnold, using live steam for melting and cooking; the Merz and the Simonin, using a solvent like naphtha and benzene.

The oil and grease are sold at a price varying from 2 to 4½ cents per pound. The crude oil is refined by the purchasers and used for commercial purposes. Its chief constituents are glycerin, stearine, and red oil.

The tankage, when dried and ground, is odourless and dark brown in colour. It is sold as a base for the