REPORT OF THE CHEMIST.

I have the honor to submit herewith the report of the work done by the Chemical Division for the year 1887.

This work may be classified as follows: First, the continuation of the subject of investigations of food adulteration; second, investigations connected with the manufacture of sugar from sorghum and sugar-canes; third, studies of agricultural products; and, fourth, miscellaneous work. The investigation of adulterations has continued essentially in the same line as was pointed out in the annual report for 1886.

The chief object of investigation has been to determine the character of adulteration practiced and the best methods of detecting it. The work of determining the extent of adulteration is more properly left to the State experiment stations and State municipal boards of health. The results of the investigations are published in Bulletin 13 of the Chemical Division. In the last annual report abstracts of the first and second parts of this bulletin were given. They were devoted to dairy products and to spices and condiments. During the last year one additional part of Bulletin 13 has been issued on the subject of fermented drinks. In this bulletin the subjects of wines, beers, and ciders were considered. Two other parts of Bulletin 13 are now in an advanced state of preparation, viz, baking powders and lards.

The work on the investigation of the sugar-making qualities of sorghum and sugar-canes has been carried on at three different stations, viz, Rio Grande, N. J., Fort Scott, Kans., and Lawrence (Magnolia Plantation), La. The results of these investigations appear in Bulletin 17, already published, and Bulletin 18, now almost ready for the press. Those results mark a successful close of a long series of investigations undertaken by the department, which have been carried on under many difficulties and discouragements. The character of the work which has been accomplished will fully appear in the abstracts which are to follow.

The miscellaneous work of the department has been of a varied character, and it appears to me of little value. This miscellaneous work has consisted in analyses of samples of ores, mineral waters, soils, fertilizers, etc. It is true that quite a number of these investigations have proved of value in themselves, but they do not illustrate any line of methodical research, and thus fail to appear in their proper light. Abstracts of the more valuable work of this kind will follow. In regard to this miscellaneous work I desire to say that, with a limited force at our disposal and the meager laboratory facilities which we have, it does not seem quite appropriate to ask of the division to undertake analyses which are purely for personal advantage or entirely disconnected with agriculture. I desire to plainly state that in my opinion the analyses of ores, mineral waters, and other substances which have no relation whatever to agricultural research are not proper subjects for the employment of the chemists of this division. In the same category should be placed examinations of soils, fertilizers, food stuffs, and other agricultural products sent from States where agricultural colleges and experiment stations have been established. Under the Hatch bill each State has been provided with a fund by Congress for the purpose of carrying on just such investigations as I have mentioned. This fund is in excess of the total amount which is given annually for the support of the distinctively chemical work of this division. In order that the investigations which this division has undertaken in the interest of agricultural chemistry may not be interrupted by such extraneous work it would be well to prohibit, by a clause in the appropriation bill, any work in the chemical division which is purely of a personal nature or not related to agricultural science, or which could be more properly done by the chemists of the several State agricultural colleges and experiment stations. This division would thus be relieved of the labor of examining minerals, ores, mineral waters, potable waters, and other substances of like nature.

There is another reason which leads me to emphasize this statement. We have in our country a large number of professional chemists who devote themselves to private work, and analyses of such samples as I have named naturally belong to this class of chemists. To have this work done by public officials, at public cost, is not only an abuse of official prerogative, but is a positive injury to a legitimate private business which, at best, is poorly supported in the United States. There is no more reason why the chemists employed by the United States to pursue investigations in agricultural science should determine the quantity of gold and silver in a given ore for a private citizen or a member of Congress than there would be for a law clerk of one of the Departments of the Government to devote his time and labor to private practice. This practice of doing private work at public expense it seems to me is of the same nature as that of doing private work during office hours ,and receiving compensation therefor from the individual for whom the work is done. Since I have been in charge of this division I have constantly refused all applications which have been made to have me or my assistants engage in private work of any kind for compensation during the hours devoted to official business. I would even go further than this and require, if possible, that chemists engaged in official work for the Government of the United States should not be allowed to engage in private work even out of official hours. The duties of a chemist engaged in official work are sufficiently onerous to require all his time and energy, and whatsoever is given to work of a private nature is so much taken from what he owes to the public. In short, in my opinion, the line of demarkation between official and private business should be sharply drawn and should never be transgressed. The compensation received by a public analyst or an official chemist should be large enough and his tenure of office sufficiently certain to enable him to devote all his time to the public service without being troubled with anxieties for the future.

Since the establishment of agricultural stations in the various States it may be asked, what is the peculiar function of the Chemical Division of the Department of Agriculture? Is this division only one of the many laboratories established in the several States under the Hatch bill, or has it a work peculiarly its own? I should answer the last question in the affirmative. The work of this division seems to me to be best illustrated by that line of investigation in the work which has been published on food adulteration, and through experimental studies of different methods of analysis and investigations of a more abstract nature intimately connected with the problems of practical agriculture. The study of great problems affecting large industries, like those which have been made in the sugar industry, and the examination of questions affecting proposed legislation on agricultural subjects for the benefit of the agricultural committees of the Senate and the House of Representatives are some further examples of the distinctions of the work of this division from that of the chemical laboratories of the various experiment stations. For a proper prosecution of work of this kind the Congress of the United States should supply a first-class laboratory with first-class appointments. The chemical laboratory of the United States Department of Agriculture should be a model which the various experiment stations might copy instead of being what it is, perhaps the most poorly located and equipped of any chemical laboratory in the country. In a dingy basement, poorly lighted, not ventilated at all, the chemists of this division are compelled to work, in the winter straining their eyes in an all-day twilight, in summer sweltering in a tropical temperature.

I would earnestly request that the bill which is now before Congress for the building and equipment of a new laboratory be pressed to an early passage, so that this division may be furnished with facilities to continue more successfully the line of work which has been marked out.

COMPOSITION OF AMERICAN BEERS, WINES, AND CIDERS, AND THE SUBSTANCES USED IN THEIR ADULTERATION.*

By C. A. CRAMPTON.

MALT LIQUORS.

The production of malt liquors in this country as an industry is second only in importance to the production of breadstuffs. Their consumption is steadily on the increase, as is also the amount consumed in proportion to other kinds of alcoholic beverages. The following tables are taken from recent statistics, compiled by the Bureau of Statistics, U. S. Treasury Department, from figures obtained from official sources: †

*Abstract of Part 3, Bull. No. 13.

† Statements Nos. 32 to 50, inclusive, of the Quarterly Report No. 2, series 1886-'87, of the Chief of the Bureau of Statistics. Government Printing Office, 1887.

Annual consumption of distilled and malt liquors and wines in the United States and the average annual consumption per capita of population during the years 1840, 1850, 1860, and from 1870 to 1886, inclusive.

Year ending June 30—	Distilled spirits consumed.				Wines consumed.		
	Spirits of domestic product.		Imported spirits entered for consumption.	Total.	Wines of domestic product.*	Imported wines entered for consumption.	Total.
	From fruit.	All other.					
	Pr. galls.	*Pr. galls.*	*Pr. galls.*	*Pr. galls.*	*Gallons.*	*Gallons.*	*Gallons.*
1840	(†)	40,378,090	2,682,794	43,060,884	124,734	4,748,3[illegible]	4,873,096
1850	(†)	46,768,083	5,065,390	51,833,473	221,249	6,094,622	6,315,871
1860	(†)	83,904,258	6,064,393	89,968,651	1,860,008	9,199,133	11,059,141
1870	1,223,830	77,266,368	1,405,510	79,895,708	3,059,518	9,165,549	12,225,067
1871	2,472,011	59,842,617	1,745,033	64,059,661	4,980,783	10,853,280	15,834,063
1872	1,039,698	65,145,880	2,186,702	68,422,280	6,968,737	9,713,300	16,682,037
1873	2,965,987	62,945,154	2,125,998	68,037,139	8,953,285	9,893,746	18,847,031
1874	766,687	61,814,875	1,958,528	64,540,090	10,951,859	9,516,855	20,468,714
1875	1,757,202	62,668,709	1,694,647	66,120,558	12,954,961	7,036,369	19,991,330
1876	672,221	57,340,472	1,471,197	59,483,890	14,968,085	5,193,723	20,161,808
1877	1,527,141	57,016,248	1,376,729	59,920,118	16,942,592	4,933,738	21,876,330
1878	1,103,351	49,600,838	1,227,752	51,931,941	17,953,386	4,310,563	22,263,949
1879	1,021,708	52,003,467	1,253,300	54,278,475	19,845,113	4,532,017	24,377,130
1880	1,005,781	61,126,634	1,394,279	63,526,694	23,298,940	5,030,601	28,329,541
1881	1,701,206	67,426,000	1,479,875	70,607,081	18,931,819	5,231,106	24,162,925
1882	1,216,850	70,759,548	1,580,578	73,556,976	19,934,856	5,628,071	25,562,927
1883	1,253,278	75,508,785	1,690,624	78,452,687	17,406,028	8,372,152	25,778,180
1884	1,137,056	78,479,845	1,511,680	81,128,581	17,402,938	3,105,407	20,508,345
1885	1,468,775	67,689,250	1,442,067	70,600,092	17,404,698	4,495,759	21,900,457
1886	1,555,994	69,295,361	1,410,259	72,261,614	17,366,393	4,700,827	22,067,220

Year ending June 30—	Malt liquors consumed.			Total consumption of wines and liquors.	Total consumption per capita of population.			
	Malt liquors of domestic product.*	Imported malt liquors entered for consumption.	Total.		Distilled spirits.	Wines.	Malt liquors.	All wines and liquors.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Pr.galls*	*Galls.*	*Galls.*	*Galls.*
1840	23,162,571	148,272	23,310,843	71,244,817	2.52	0.29	1.36	4.17
1850	36,361,708	201,301	36,563,009	94,712,353	2.23	0.27	1.58	4.08
1860	100,225,879	1,120,790	101,346,699	202,374,461	2.86	0.35	3.22	6.43
1870	203,743,401	1,012,755	204,756,156	296,876,931	2.07	0.32	5.30	7.69
1871	239,838,137	1,299,990	241,138,127	321,031,851	1.62	0.40	6.09	8.11
1872	268,357,983	1,940,933	270,298,916	355,403,233	1.68	0.41	6.65	8.74
1873	298,519,675	2,177,587	300,697,262	387,581,432	1.63	0.45	7.27	9.29
1874	297,519,981	2,001,084	299,521,065	384,529,869	1.51	0.48	6.99	8.98
1875	292,961,047	1,992,110	294,953,157	381,065,045	1.50	0.45	6.71	8.66
1876	306,852,467	1,483,920	308,336,387	387,982,085	1.32	0.45	6.83	8.60
1877	303,854,988	1,072,679	304,926,667	386,723,115	1.29	0.47	6.58	8.34
1878	317,136,597	832,755	317,969,352	392,165,242	1.09	0.47	6.68	8.24
1879	343,724,971	880,514	344,605,485	423,261,090	1.11	0.50	7.05	8.66
1880	413,208,885	1,011,280	414,220,165	506,076,400	1.26	0.56	8.26	10.08
1881	442,947,664	1,164,505	444,112,169	538,882,175	1.37	0.47	8.63	10.47
1882	524,843,379	1,536,601	526,379,980	625,499,883	1.39	0.48	9.97	11.84
1883	549,616,338	1,881,002	551,497,340	655,728,207	1.45	0.48	10.18	12.11
1884	588,005,609	2,010,908	590,016,517	691,653,443	1.46	0.37	10.62	12.45
1885	594,063,095	2,068,771	596,131,866	688,632,415	1.24	0.38	10.44	12.06
1886	640,746,288	2,221,432	642,967,720	737,296,554	1.24	0.38	11.18	12.62

* Product less exports. † Included with "All other."

NOTES.—(1) The data as to product of domestic liquors and wines for 1840, 1850, and 1860 were derived from the Census. (2) The consumption of imported liquors and wines for 1840, 1850, and 1860 is represented by the net imports. (3) The production of domestic wines, from 1870 to 1885, has been estimated by the Department of Agriculture, by Mr. Charles McK. Leoser, president of Wine and Spirit Traders' Society, New York, and other well-informed persons, and the amount stated as consumed represents the production minus the exports. (4) The consumption of domestic spirituous and malt liquors, from 1870 to 1886, was obtained from the reports of the Commissioner of Internal Revenue. (5) In computing the quantity of sparkling and still wines and vermuth in bottles, five so-called quart bottles are reckoned as equivalent to the gallon. (6) The consumption of distilled spirits as a beverage is estimated to be about 90 per cent. of the product consumed for all purposes.

This table shows admirably the rapid increase, especially in the last ten years, of the consumption of malt liquors, and the relative decrease in the consumption of the stronger alcoholic beverages. Thus it will be seen that in 1840 the amount of malt liquor consumed per capita was a little over one-half the amount of distilled liquor consumed; while in 1886 it was *nine times as much.* The amount of distilled liquor consumed per capita has diminished during the twenty-six years to one-half, while the amount of malt liquor consumed has increased very nearly seven times; or, in other words, the malt liquors have been driving out the distilled at the rate of about .05 gallons per capita each year, and supplanting it at the rate of about .38 gallons per capita.

The average quantity consumed annually for the last three years was 609,705,367 gallons, of which 2,100,370 gallons were imported. Taking this as a basis, Mr. F. N. Barrett, in the publication above mentioned, estimates the amount expended for beer per annum at $304,852,683, placing the cost to the consumer at 50 cents per gallon. The cost to the consumer of the total quantity of liquors per annum he places at $700,000,000.

It is hardly necessary, after the above showing, to dwell upon the importance of this article of daily consumption, or the necessity of a thorough acquaintance with its manufacture, composition, and the nature and extent of its adulterations. There is no beverage that compares with it in the amount consumed by the people except water, and possibly milk. But little supervision has been exercised over its manufacture and sale, except the rigorous enforcement by the Government of its demands for a share in the profits of its manufacture.

THE PROCESS OF BREWING.

Brewing, or the art of preparing an alcoholic drink from starchy grains by fermentation, is of very ancient origin. It was practiced by the Egyptians, and the Greeks and Romans learned the art from them. Herodotus speaks of the Egyptians making wine from corn, and it was undoubtedly practiced by the Greeks in the fifth century before Christ, as the use of malt beverages is mentioned in the writings of Æschylus and Sophocles, poets of that period. It is also mentioned by Xenophon, 400 B. C. The Romans are also supposed to have derived a knowledge of the art from the Egyptians, and Pliny and Tacitus both speak of its use among the Gauls and Germans of Spain and France.

It is supposed that the art was introduced into Britain by the Romans and acquired from the natives by the Saxons. According to Verstigan, "this excellent and healthsome liquor, beere, anciently called ale, as of the Danes it yet is, was of the Germans invented and brought into use." Ale-houses are mentioned in the laws of Ina, king of Wessex, A. D. 680. Ale-booths were regulated by law A. D. 728.

The art of producing an alcoholic drink from starchy seeds seems to have been nearly as extensively known and practiced among the various nations of the earth as the less complex operation of preparing a fermented liquor from the juice of fruits and plants containing sugar. Thus the Kaffre races of South Africa are said to have prepared for many years a malt liquor from the seeds of the millet (*Sorghum vulgare*), going through all the processes of germinating the seed, extracting the malt, and fermenting the wort. In the north of Africa another seed is used. The Chinese prepared the drink called sam-shee from rice.

The process of brewing consists of two distinct operations: the malting and the brewing proper. In fact the two operations are frequently separated, many small breweries buying their malt ready prepared. When kept dry it retains its qualities for an indefinite period and is handled as an article of commerce.

MALTING.

The object of this operation is the germination of the grain, and the consequent formation of the ferment diastase, which shall subsequently, under the proper conditions, perform its specific function of converting the starchy portions of the grain into saccharine or fermentable matter. Barley is the grain used almost exclusively for this purpose, its advantages having been recognized even by the Egyptians; they seem to be principally of a physical character, consisting of the firmness of the kernel, and the hard husk, which freely allows the entrance of water, but prevents the passage of starch or insoluble matter.

The operations through which the grain is successively passed are called, technically, steeping, crushing, flooring, and kiln-drying. In the first it is spread out in large vats, covered with water, and allowed to steep several days. When it has become softened, the water is run off and the swollen grain is subjected to a slight degree of heat, which causes it to germinate. This is the second operation. The operation of flooring has for its end the regulation of the germination of the grain, and the time when it has progressed sufficiently is judged by the length which has been attained by the acrospire or plumule. This is variously given as from two-thirds to seven-eighths the length of the grain. The sprouted grain is now spread out in the malt kilns and heat applied, while a current of air circulates about it. After the moisture is driven off, which is done at a low temperature, about 90° F., the heat is raised, and finished at from 125° to 180° F., according to the grade of malt required, the difference between pale, amber, and brown malt being due simply to the temperature at which they are kiln-dried. This last operation serves not only to drive off the moisture, but also stops germination by destroying the vitality of the germ, and fits it for keeping. It also probably develops the flavor by the formation of a minute quantity of empyreumatic oil in the husk.

The rootlets and germs are removed in this process by the turning and stirring of the grain. The water which is used in the process of steeping the grain is an important factor in the production of good malt, and the preference of brewers for hard lime waters for this purpose has been shown by recent experiment to be rational, for it is found that when barley is steeped with distilled water, a very putrescible liquor is obtained charged with albuminous matter, while if a hard water is used these matters remain in an insoluble condition in the grain.

BREWING.

Brewing proper includes a number of distinct operations, such as grinding and mashing the malt, boiling and cooling the wort or infusion, fermenting it, and clearing and racking the beer. In the process of mashing takes place the conversion of the starch into fermentable sugar, mainly maltose, by the action of the diastase. Two methods are used for extracting the soluble matter from the malt, called *infusion* and *decoction*, respectively; the former is the method most in use in England, the latter in Germany and France. The wort prepared by infusion contains less dextrin and more albuminoid matter than that prepared by decoction; the beers from the former are stronger in alcohol, but not so good in keeping qualities.

A good wort should give no blue color with iodine, showing the complete conversion of all the starch, and should contain a large percentage of maltose, which should constitute about 70 per cent. of the extract.

After the mashing process comes the *boiling* of the wort, which is begun as soon as it is drawn off from the exhausted malt and continued for one to two hours. This prevents the formation of acid, and serves to extract the hops, which are added at this stage of the process. The boiling of the wort with hops serves not only to impart to it the desired hop flavor, but also to partially clarify it by precipitating some albuminous matter by means of the tannin in the hops, and to enhance its keeping qualities. To this end larger quantities of hops are used for beers intended for exportation or long keeping.

The wort is now ready to be submitted to the most important operation of all—fermentation—which calls for very careful supervision on the part of the brewer.

FERMENTATION.

After the wort has been boiled with hops it is cooled as rapidly as possible, to prevent the formation of acid, usually effected by means of artificial refrigerating apparatus; it is then ready for the addition of the yeast.

There are two distinct methods of fermentation in use, called by the Germans *Ober- und Untergährung*, and by the French *fermentation haute* (top fermentation) and *basse* (bottom fermentation). The former is carried on at a comparatively high temperature, the action is rapid, and the yeast with the impurities is carried to the surface of the liquid: in the latter method the temperature is kept low, the fermentation goes on slowly, and the yeast and impurities sink to the bottom. The second method is often called the Bavarian method, as it seems to have originated there, and is used exclusively in that country. It is generally preferred in Germany and France, while in England and this country the upward clearing method appears to be more in vogue.

The nature of the fermentation depends greatly upon the character of the yeast used, for Pasteur's experiments have shown that yeast from upward-fermented beer tends to produce the upward fermentation, while yeast from bottom-fermented beer produces the bottom fermentation. The purity of the yeast used is of the very first importance in the production of good beer.

CLARIFYING, STORING, AND PRESERVING.

The treatment of malt liquor after the process of fermentation is complete is very diverse, according to the kind of liquors it is intended to produce, the length of time it is to be kept, etc. The problem of clarifying and preserving the beer is very simple of solution if it has been properly and carefully brewed, for then it is easily cleared and keeps well; but where the reverse is the case it is necessary to make use of various clarifying and preserving agents, and here comes in the delicate question of the proper agents to use, which will perform this duty and still introduce no objectionable constituents into the drink.

The discussion of this question comes properly under the head of adulterations, and will be considered later on. As clarifying agents may be mentioned gelatine, tannin, Iceland moss, and flaxseed, and as mineral coagulating agents phosphate of lime and alum.

Formerly beer was stored in casks or vats in cool cellars for a long period, to allow it to age or ripen, especially in Germany, whence came the name of "lager" beer; but the aim of the brewer at the present day is to produce an article fit for the market in as short a time as possible and thus turn his capital often and keep step with the rapid pace of modern business industry, so that the name of lager beer is rather a misnomer.

COMPOSITION OF MALT LIQUORS.

The composition of malt liquor varies greatly according to the materials used, the method of brewing, the season, and the use for which it is intended.

Malt liquors, properly so called, should be made only of malted barley, hops, yeast, and water, but the use of other materials as substitutes for the first three ingredients has extended so greatly in countries where their use is not prohibited that it is difficult to define what a beer really is.

Modern beer has been defined as a "fermented saccharine infusion to which some wholesome bitter has been added."

Its chemical composition is very complex, the principal constituents being alcohol, various sugars and carbohydrates, nitrogenous matter, carbonic, acetic, succinic, lactic, malic, and tannic acids, bitter and resinous extractive matter from the hops, glycerine, and various mineral constituents, consisting mainly of phosphates of the alkalies and alkali earths.

VARIETIES.

The names given to different kinds of malt liquors relate to various attributes, as the country where they were produced, as English, German, Bavarian beer, etc., or to the peculiarities in the method of brewing, etc. Thus, *porter* is simply a beer of high percentage of alcohol, and made from malt dried at a somewhat high temperature, which gives its dark color; *ale* is a pale beer, likewise of high attenuation and made of pale malt, with more hop extract than porter. *Stout* has less alcohol and more extract and still less hops than porter. These terms are used chiefly with reference to English malt liquors. The terms used for German beers, such as *Erlanger*, *Münchener*, etc., are for the most part names of places and are applied to beers made in imitation of the beers originally brewed in those cities. *Export* beer is beer that is specially prepared with a view to long-keeping qualities.

COMPOSITION OF AMERICAN BEER.

But very little work has been done on American beers; they seem to have shared with other dietary articles the general indifference of the American public to the composition of their food and drink.

A very extensive series of analyses was made in the State of New York in 1885, under the authority of the State Board of Health, by

Dr. F. E. Englehardt, and outside of this I have been able to find very few published analyses of American beers.

Dr. Englehardt's analyses were made upon a very large number of samples, 476 in all, which were collected from all over the State, and were intended to furnish a good average representation of the beer retailed in the State. The samples included various kinds of malt liquor, porters, ales, and a weak beer sold under the name of weiss beer. Unfortunately no arrangement of the analyses was made with a view to showing the composition of various kinds, as the examination was made principally with reference to the adulteration, so all varieties are tabulated together. The following averages I have had compiled from his table by the Statistical Division of this Department, only excepting a few samples which he has indicated as being imported:

Average composition of American malt liquors, as shown by analyses made for New York State Board of Health by F. E. Englehardt, Ph. D.

Kind.	Specific gravity.	Alcohol, by weight.	Extract.	Ash.	Phosphoric acid.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Lager, 172 samples	1.016	3.754	5.864	.259	.0964
Ale, 199 samples.......	1.013	4.622	5.423	.307	.0832
Porter, 70 samples.....	1.015	4.462	6.003	.345	.0942
Weiss, 28 samples	1.006	1.732	2.356	.189	.0491

The maximum and minimum content of alcohol, extract, and ash in the same samples is as follows:

Kind.	Maximum.			Minimum.		
	Alcohol, by weight.	Extract.	Ash.	Alcohol, by weight.	Extract.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lager	7.061	9.647	.412	.677	3.655	.172
Ale	8.994	9.501	.552	2.410	2.703	.197
Porter	6.695	11.783	.557	1.671	2.843	.170
Weiss.....	3.179	4.143	.468	.755	1.277	.069

These analyses show great lack of uniformity of composition in the different varieties of malt liquor, but it should be remembered that the samples were collected with a view to ascertaining the extent of adulteration, and many samples were found to be sophisticated in one way or another. Especially in the case of the content of ash the average of these samples does not give the average composition of American beers, for many of these ashes were found to consist principally of salt.

ANALYSES OF BEERS BY THE UNITED STATES DEPARTMENT OF AGRICULTURE.

The analyses made by this Department comprise 32 samples, this being about all the different brands and varieties of beers of domestic manufacture obtainable in Washington. The investigation was made principally with a view to ascertain the extent and nature of their adulteration, if any, and especially the use of antiseptic and preservative agents. As a basis for determining adulteration, however, it is necessary to know the normal or average composition, so a fairly complete analysis of all samples examined has been made. The intention of the investigation was not so much to make a very extensive series of analyses as to establish definite methods of analysis for the guidance of analysts of State boards of health or similar bodies, whose province it is more especially to investigate the extent of adulteration prevailing in their States by the examination of large numbers of samples.

SAMPLES.

The malt liquors used as samples were all purchased in Washington, D. C., and included the various popular brands made in Milwaukee, Cincinnati, Philadelphia, New York, etc., which are sold all over the country, as well as the product of the few local brewers. Some were obtained from wholesale dealers, but the majority were purchased in retail saloons and groceries, without statement of the purpose for which they were intended. All the draught beers were obtained in this way.

A few English and German beers and ales were analyzed for comparison.

Analyses of malt liquors by United States Department of Agriculture.

Designation.	Manufactured in—	Serial number.	Number of analysis.	Specific gravity.	Alcohol, by weight.	Alcohol, by volume.	Extract.	Original gravity.	Ash.	Reducing sugar as maltose.	Dextrin.	Albuminoids.	Free acids as lactic.	Phosphoric acid.	Carbonic acid.	Remarks.
					Pr.ct.	*Pr.ct.*	*Pr.ct.*		*Pr.ct.*	*Pr.ct.*	*Pr.ct.*	*Pr.ct.*	*Pr.ct.*	*Pr.ct.*	*Pr.ct.*	
Lager beer, bottled	Milwaukee, Wis	4800	1	1.0160	4.28	5.39	4.18	1.0505	.196	1.10	1.57	.511	.057	.065	.411	
Export beer, bottled	....do	4801	2	1.0140	4.12	5.55	5.40	1.0537	.309	1.06	2.63	.465	.057	.056	.369	Salicylated.
Lager beer, bottled	Alexandria, Va	4802	3	1.0171	4.55	5.71	5.71	1.0607	.355	2.04	2.21	.681	.074	.091	.439	Salicylated.
Do	Washington, D. C.	4803	4	1.0143	4.18	5.24	5.05	1.0533	.388	1.25	0.98	.669	.059	.046	.415	
Do	Cincinnati, Ohio	4804	5	1.0100	5.53	6.94	4.55	1.0623	.240	0.94	2.25	.513	.073	.082	.328	
Export beer, bottled	Saint Louis, Mo	4805	6	1.0178	4.40	5.47	6.15	1.0590	.312	2.14	2.51	.463	.067	.074	.471	Salicylated.
Lager beer, bottled	Philadelphia, Pa	4806	7	1.0147	4.29	5.39	5.22	1.0549	.241	1.46	2.30	.538	.078	.071	.717	Salicylated and soured.
Do	....do	4807	8	1.0147	4.35	5.47	5.09	1.0549	.272	1.37	1.80	.738	.080	.104	.219	
"Budweiss" beer, bottled	....do	4808	9	1.0181	4.52	5.63	5.94	1.0609	.241	2.14	2.57	.531	.086	.078	.324	
Lager beer, draught	Buffalo, N. Y	4810	10	1.0241	3.84	4.78	7.05	1.0601	.222	2.81	3.09	.519	.035	.069	.....	
Do	Philadelphia, Pa	4811	11	1.0132	4.36	5.47	4.63	1.0539	.265	1.17	1.82	.636	.046	.095	.....	Substitutes for hops used.
Do	Washington, D. C.	4812	12	1.0146	4.29	5.39	5.18	1.0545	.236	1.22	2.21	.669	.044	.086	.....	
Do	Cincinnati, Ohio	4813	13	1.0169	4.63	5.78	5.86	1.0607	.235	2.37	2.29	.456	.074	.085	.....	
Do	Alexandria, Va	4814	14	1.0137	4.71	5.86	4.91	1.0585	.263	1.10	2.40	.619	.008	.089	.....	Bicarbonate of soda used.
Do	Washington, D. C.	4815	15	1.0140	4.30	5.39	4.83	1.0538	.262	1.49	1.45	.681	.071	.037	.....	Sulphite used.
Do	....do	4816	16	1.0181	3.86	4.85	5.62	....	.312	1.52	2.59	.619	.009	.083	.....	Bicarbonate of soda added.
Pale lager beer, bottled	Saint Louis, Mo	4817	17	1.0178	4.28	5.39	4.61	1.0527	.183	2.17	2.75	.463	.067	.064	.629	Salicylated.
"Erlanger" beer, bottled	....do	4818	18	1.0203	4.68	5.86	6.82	1.0650	.212	2.51	2.58	.675	.046	.093	.344	
Ale, bottled	Philadelphia, Pa	4819	19	1.0059	6.24	7.74	3.46	1.0647	.401	0.59	0.90	.531	.232	.085	.....	
Bass pale ale, bottled	England	4820	20	1.0095	5.66	7.09	4.42	1.0633	.309	0.49	2.20	.500	.117	.056	.503	
English porter, bottled	....do	4821	21	1.0147	6.13	7.66	5.90	1.0728	.371	0.57	2.76	.763	.151	.049	.397	
Lager beer, bottled	Boston, Mass	4822	22	1.0077	5.30	6.63	3.94	1.0587	.328	1.06	1.63	.556	.107	.055	.....	
"Kaiser" beer, bottled	Bremen	4823	23	1.0036	5.38	6.71	3.05	1.0543	.162	0.69	1.36	.263	.089	.045	.....	Salicylated.
"Verzandt" beer, bottled	Bavaria	4824	24	1.0197	3.86	4.85	6.24	1.0553	.190	1.71	3.32	.419	.085	.073	.....	
Export beer, bottled	Milwaukee, Wis	4825	25	1.0150	4.59	5.71	5.33	1.0581	.194	1.87	2.46	.425	.071	.059	.....	Salicylated.
Ale, draught	Philadelphia, Pa	4826	26	1.0171	5.25	6.55	6.02	1.0669	.331	1.19	2.80	.569	.094	.057	.....	
Ale, bottled	Reading, Pa	4827	27	1.0125	6.92	8.63	5.55	1.0781	.472	0.93	1.99	.731	.382	.077	.441	
Porter, bottled	....do	4828	28	1.0269	4.89	6.10	8.19	1.0736	.412	2.67	2.88	.763	.166	.100	.592	
"Select" beer, bottled	Milwaukee, Wis	4842	29	1.0183	4.22	5.32	5.88	1.0570	.193	1.88	2.82	.419	.061	.059	.....	
Export beer, bottled	....do	4843	30	1.0183	4.22	5.32	5.84	1.0567	.222	1.75	3.12	.413	.053	.058	.242	
"Bohemian" beer, bottled	....do	4844	31	1.0133	4.16	5.24	5.88	1.0563	.224	1.82	3.04	.406	.071	.057	.....	
"Bavarian" beer, bottled	....do	4845	32	1.0187	5.06	6.32	6.26	1.0660	.346	1.75	2.87	.556	.074	.077	.265	
Average (27 samples)*	....	......	......	1.0161	4.63	5.79	5.53	1.0597	.279	1.65	2.33	.563	.082	.077	.393	

* In the averages the five samples of foreign beer were omitted.

DETECTION OF ADULTERATION.

Probably there is no one article of daily consumption that has been so often subject to suspicion of adulteration or sophistication as beer. Its complex composition and peculiar nature have deceived people into making all sorts of charges against its purity, but experience has failed to establish the truth of by far the greater majority of these charges, and the facts of many published analyses show that it is as free from adulteration as most other articles of consumption, and more so than some. Here comes in the question, so difficult to answer in this country, of what constitutes adulteration or sophistication of an article of food. The definition of what shall constitute a pure malt liquor is hard to settle. Even in Europe, where a much stricter supervision is kept over food-stuffs than here, the definition varies widely. In Bavaria, where more beer per capita is consumed than in any other country, the laws limit the materials from which it is made to barley, malt, hops, yeast, and water, while in England the comprehensive definition has been given to beer as being "a fermented saccharine infusion to which a wholesome bitter has been added."

SUBSTITUTES FOR MALT.

A great deal has been said, pro and con, on the subject of the propriety of the use of other matter than malted barley as a source of saccharine material for brewing purposes. There may be said to be three ways of substituting saccharine material. First, other grain may be used for malting; second, unmalted starchy matter, that is, whole grain, may be added to the malt before it is mashed, the latter being diluted, as it were, for the diastase in the malt has converting power sufficient for considerably more starch than is contained in itself; third, the saccharine matter may be supplied already converted, as in commercial starch sugar, or glucose, cane sugar, inverted cane sugar, etc. Of these different substitutes the third class is probably the more objectionable, as beer brewed from such saccharine matter is lacking in various constituents derived from the grain, which are important additions to its nutritive power, namely, the phosphatic salts and the nitrogenous bodies.

In much the same way would bread made from starch alone be lacking in nutritive value.

SUBSTITUTES FOR HOPS.

The nature of the bitters used in beer has long been the target towards which public suspicion is directed, and nearly every substance known possessing a bitter taste has been enumerated among the adulterations of beer, from poisonous alkaloids, such as strychnine and picrotoxine, to harmless or quasi-harmless bitter roots and woods, such as quassia, gentian, etc. Complete and exhaustive schemes of analysis have been compiled, such as Dragendorff's, Ender's, etc., for the detection and isolation of such foreign bitters. Either these methods of investigation are faulty or difficult of manipulation, or the use of foreign bitters is very much less prevalent than is generally supposed, for the cases where such bitters have been detected and isolated are very scarce in chemical literature. In fact, Elsner, a German authority on food adulterations, goes so far as to say that there has never been a case where the existence of a foreign bitter in a malt liquor has been proven with certainty. This is going too far, of course, for picrotoxine and picric acid have undoubtedly been found in beers, and probably more cases of such adulteration would occasionally have been discovered were it not for the difficulty of the analysis and the small quantity of matter required for imparting a bitter taste. But there is probably much less of this hop substitution than the space given it in works on the subject would indicate. Hops not only give the bitterness to beer, but also impart to it its peculiar aroma and enhance its keeping qualities, and, unless it were at a time when they were very dear, it would hardly pay the brewer to sacrifice the good flavor and keeping qualities of his beer in order to save a few cents a pound in his bitters.

All the samples analyzed were found to be free from foreign bitters, with one exception, No. 4811, which contained a bitter other than hops, though not in sufficient quantity to admit of its separation and identification. All the samples except Nos. 4801, 4811, and 4815 gave a plainly perceptible odor of hops in the distillate.

PRESERVING AGENTS.

We come now to what I consider the most important sophistication of beer at the present day and the most reprehensible and most deserving of repressive legislation. The use of artificial preserving agents not only introduces foreign matters into the beer which are more or less injurious, according to the nature of the material used, but also serves to cover up and hide the results of unskillful brewing or unfit materials; giving to the public for consumption a liquor that, if left to itself under natural conditions, would have become offensive to the senses and putrid with corruption long before it was offered for sale.

The only means of preservation allowed by the authorities in Germany and France is the process called, from the name of its author, "Pasteurization." This process is entirely rational and commendable, as it conduces to the preservation of the beer by destroying the germs of unhealthy ferments, not by simply paralyzing their activity as antiseptics do, and moreover it introduces no foreign constituents into the beer. Liquid carbonic acid is also coming into use in some of the larger Continental breweries.

Other preservative agents extensively employed at the present day are salicylic acid, bisulphite of lime, and boracic acid.

SALICYLIC ACID.

Salicylic acid ($C_7H_6O_3$) was first prepared by Piria and Ettling by oxidizing salicyl aldehyd, which had previously been obtained from various vegetable sources. It was afterwards obtained from oil of wintergreen, which is nearly pure methyl salicylate, a constituent also of many other essential oils. Its artificial production from phenol (carbolic acid) was discovered by Kolbe and Lautermann in 1860 but was not put into practical use until 1874, when Professor Kolbe succeeded in producing it at a moderate cost. It is now prepared almost exclusively in this way, the cheapness of the method having driven out of the market that which is prepared from oil of wintergreen.

In medicine, besides its use externally as an antiseptic, it is administered very extensively internally, its chief application being as a remedy for acute rheumatic fever. Its physiological action is given as follows in the United States Dispensatory, fifteenth edition, page 101:

When salicylic acid is given to man in doses just sufficient to manifest its presence, symptoms closely resembling those of cinchonism result. These are fullness of the head, with roaring and buzzing in the ears. After larger doses, to these symptoms are added distress in the head or positive headache, disturbances of hearing and vision (deafness, amblyopia, partial blindness), and excessive sweating. According to Reiss (*Berlinger Klin. Wochenschrift*, 1875, p. 674) decided fall of temperature, without alteration of the pulse, also occurs; but this is denied by other observers. The actions upon the system of the acid and of its sodium salts (also ammonium salt, Martenson, *Petersb. Med. Zeitschrift*, 1875, p. 243) appear to be identical, and, as several cases of poisoning with one or other of these agents have occurred, we are able to trace the toxic manifestations. Along with an intensification of the symptoms already mentioned there are ptosis, deafness, strabismus, mydriasis, disturbance of respiration, excessive restlessness passing into delirium, slow laboring pulse, olive-green urine, and involuntary evacuations. In some cases the temperature has remained about normal, but in others has approached that of collapse. The respiration seems to be characteristic, it being both quickened and deepened, often sighing. Sweating is usually very free, and the urine early becomes albuminous. Various local evidences of vaso-motor weakness may supervene, such as rapidly-appearing bed-sores at points subjected to pressure, and transitory dark-colored maculæ on various parts of the body. In several cases death was probably produced by the acid, although there is scarcely one instance which is beyoud doubt.* In certain cases the mental disturbance has been strangely prolonged, lasting for eight days. In some instances it is cheerful, in others melancholic in type. It is stated that upon drunkards the acid acts very unfavorably, violent delirium being an early symptom of its influence.

By the same authority the dose of salicylic acid to be employed in cases of acute rheumatism is given as one dram (3.9 grams) in twenty-four hours. It is excreted chiefly by the kidneys and may be detected in the urine very soon after its ingestion. Authorities in therapeutics warn practitioners of medicine against its administration to patients whose kidneys are known to be diseased, and of late years the opinion has been growing among physicians that it has a very irritating action upon these organs, many preferring the alkaline treatment of rheumatic fever on this account.

USE AS A PRESERVATIVE.

The "salicylic-acid question," as it is called, has received a great deal of attention for several years in Europe, and much has been written, pro and con, on the question of the propriety of its use as a preserving agent in articles of food and drink. In France its use as a preservative in any form of food or drink was forbidden by ministerial decree on the 7th of February, 1881. This decree was based upon a decision of the consulting committee of hygiene that its constant use was dangerous to health.

In Germany its use is prohibited, except in beers intended for export to other countries where its use is allowed.

Its prohibition in France called forth a great deal of opposition, and experiments were made and published which were intended to show that its constant use in small doses exerted no injurious influence upon the system. Kolbe himself made experiments upon himself and his assistants by taking doses of .5 to 1.0 gram daily for

*In the case recorded in the Virginia Medical Monthly, June, 1877, forty-eight grains of the acid were taken in four hours. The symptoms were violent vomiting, headache, total unconsciousness, with stertorous breathing. Death occurred forty hours after the first dose.

several days, and found no appreciable ill effects to follow its use.* Whether such experiments suffice to prove its harmlessness when used for many years and without regard to age, sex, or personal idiosyncrasy is still an open question. A most interesting and exhaustive discussion of the reasons for and against its use can be found in the report of the fourth meeting of the "Independent Union of the Bavarian Representatives of Applied Chemistry, at Nürnberg, 7th and 8th August, 1885,"† when this body refused, with but one dissenting voice, to grant its sanction to the proposed use of salicylic acid in beer in the quantity of .05 grams to the liter. Certainly no one would deny the advisability of at least restricting the amount to be used of so powerful an agent. In an article of daily consumption, and in consideration of the prevalence of kidney disease‡ at the present day, it is a matter worthy of grave consideration whether it would not be more prudent to forbid its use altogether. At all events, beer in which it is used should be sold under its proper designation as "salicylated beer." It would certainly be of interest to the physician who prescribes beer as a tonic to a weak convalescent invalid to know if he were giving at the same time not inconsiderable doses of a strong therapeutic agent, expressly contra-indicated, perhaps, in the case he has on hand.

SALICYLIC ACID IN SAMPLES EXAMINED BY THIS DIVISION.

Out of thirty-two samples analyzed by this division I found seven to contain salicylic acid in sufficient quantities to admit of qualitative proof, or nearly one-fourth of the entire number analyzed. The serial numbers of these beers corresponding to those in the large table on page 191 are as follows: 4801–3–5–6–17–23–25. These were all bottled beers, one being an imported (Kaiser) beer. None was found in any of the draught beers. Of the nineteen samples of American bottled beers, six contained salicylic acid, or nearly one-third. These included the product of some of the largest breweries in the country, beers that are used to a very large extent all over the United States. Whether the acid is added in the breweries where the beer is made, or whether it is used by the local bottlers, I am unable to decide. In one case I found it in the beer sold here under the brand of a large Western brewery, and sent direct to the same brewery for another sample, which gave no test for the acid. Unfortunately I can not be sure in this case that the firm in question did not know the purpose for which the sample was intended.

SULPHITES.

The use of sulphurous acid as a preservative agent in beer and wine, either in the form of soluble sulphites, liquid sulphite of lime, or sulphur fumes, is not at all recent. It is one of the oldest preservatives known. Together with other chemical preservatives its use is forbidden in France, and the German authorities include it with borax as an agent whose physiological effect is still too little known to allow of its indiscriminate use. It is also sometimes introduced into beers by the hops, which are very generally preserved by means of sulphur fumes. The Bavarian authorities allow its use in sulphur-

*Jour. prak. Chem. 13, 106. Reference may be made to similar experiments, as follows: J. A. Barral, Jour. de l'Agriculture, 1882, 69. M. Blas, Bull. de l'Acad. Royale de Méd. de Belgique. Bd. 12, No. 9.

†Published by Drs. A. Hilger and R. Kayser, Berlin. 1886.

‡The most common form is popularly known as "Bright's disease."

ing barrels and hops. Of course the quantities brought into the beer in this way are very small.

Of the samples examined by the Department, Nos. 4804-6-10-13 and 14 gave slight tests for the presence of sulphurous acid, but only one (No. 4815) gave sufficient evidence to justify the assertion that a sulphite had been added to it. I have not been able to find any recorded instance of sulphurous acid being found in American beers.

BORAX.

This agent, although used very extensively in preserving meats, vegetables, and canned goods, does not seem to have been applied to malt liquors to any great extent, although it has been found in wines. Its use is prohibited in France and Germany. None of the samples examined gave any test for borax.

In conclusion of the work on preservatives, it may be noted that it was done during the cold weather of January, February, and March. It is quite probable that during warm weather the use of preservative agents is still more general than shown by the analyses.

MINERAL ADDITIONS.

The presence of lead, copper, or zinc, sometimes observed in malt liquors, is due usually to the use of brass faucets or lead pipes by the retailer in drawing off the liquor or in filling bottles. The amount of these metals taken up by acid liquors in this way is quite small usually, but may be considerable if they are long left in contact with the metallic surface. Thus the first glass drawn from a faucet in the morning is apt to contain considerable copper and zinc in solution. In Paris the apparatus used for drawing beer is subject to supervision, and a frequent cleansing and proper kind of material is insisted on. The Brooklyn Department of Health issued an order in 1886 prohibiting the use of unprotected brass faucets in drawing beer, but its enforcement has not been insisted on.* Analyses made for the board by Otto Grothe of ales drawn through pumps showed small quantities of copper, zinc, and lead in every case.†

Alum is sometimes used as a clarifying agent in the brewing of beer.

BICARBONATE OF SODA.

This salt is added to beer for the purpose either of correcting an undue acidity of the beer, resulting from improper brewing, or of imparting to it an increased "head" or content of carbonic acid gas, or for both purposes. The salt is decomposed by the free acid of the beer and the gas liberated, lactate and acetate of soda being left dissolved in the beer. This seems to be purely an American practice; at least I have failed to find any mention of it in European authorities. Some of them mention the use of marble dust or magnesia for the correction of acidity, but very little consideration is given to the subject. In this country, however, it seems to be very wide-spread.

It may be necessary to explain to a non-scientific reader that the bicarbonate does not remain in the beer *as bicarbonate*, unless there is an amount added in excess of the quantity of free acid present in the beer. This free acid (mostly acetic in soured beers, but due chiefly to acid phosphates in normal beers) combines with the bicar-

* Annual Report Dept. Health, City of Brooklyn, 1886, p. 87; and 1887, p. 63.
† Ibid.

bonate, setting free carbonic acid, and forming acetate of soda and basic phosphate, which remain in solution. The reaction is very similar to that which takes place in using baking powders for cooking purposes, except that in the latter case tartrate of soda and potash (Rochelle salts) is left instead of acetate and phosphate of soda. Where bitartrate of potash is added to the beer along with the soda the reaction is precisely the same. In these days of the almost universal consumption of baking powders there is doubtless enough alkaline salts thrown into a man's stomach with his food without pumping them in with his drinks as well. At all events there can be but little question of the propriety of prohibiting the use of bicarbonate of soda in beer. It is entirely unnecessary and foreign to the production or preservation of pure beer. Moreover, its use serves to cover up and hide the effects of poor brewing and improper storing or refrigerating, and should be prohibited from this cause alone if there were no other.

Of the samples examined here, Nos. 4814 and 4816 were found to have suffered an addition of bicarbonate of soda.

SALT.

A variable quantity of chloride of sodium is a normal constituent of all beers, being derived principally from the water used in the brewing. Even a slight further addition of salt might be deemed admissible to properly "season" the beer to the taste, just as breadstuffs are treated. Many brewers, however, are in the habit of adding a large quantity, either for the purpose of covering up some objectionable taste or of increasing the thirst of the consumer. The English Government places the limit of chloride of soda which might come from the normal constituents at 50 grains to the gallon, or about .086 per cent., and treats any excess of that amount as evidence of an improper addition. This standard is undoubtedly a very generous one. Dr. Englehardt found quite a large number of the samples examined by him to overstep the limit of 50 grains to the gallon, one sample containing as high as .338 per cent. Of the samples examined here none were beyond it.

CLOUDY BEER.

Cloudiness in beer is sometimes due to the separating out of albuminous matter from changes in temperature, but usually to the presence of yeast, the fermentation not having been complete. This condition of things is best detected by means of the microscope, which shows the presence of quantities of yeast cells, and, in case other fermentations have set in, of their characteristic bacteria. "Yeast-cloudy" (*hefetrübes*) beer is considered unhealthy in Germany, and it is considered one of the qualifications of a good beer that it shall be absolutely bright and clear. An extensive investigation of the unhealthfulness of yeast-cloudy beer, has been lately made by Dr. N. P. Simonowsky* in Pettenkofer's laboratory, who found that such beer had a disturbing effect in both natural and artificial digestion, producing in persons using it obstinate catarrh of the stomach, which persisted for some time. Both Simonowsky and Pettenkofer conclude that the sale of yeast-cloudy beer should be prohibited.

*Zeit. für das gesammte Brauwesen?, 9 Jahrg. 1886, Nos. 7, 8, 9; abstract Bied. Cent., 1887, p. 70.

The Bavarian chemists, at their last meeting at Würzburg, in August, 1886, adopted the following resolution in relation to yeast-cloudy beer:

Beers which are incompletely fermented for use must be entirely free from yeast; that is, must not contain yeast in a cloudy suspension.

WINES.

The statistics in regard to the consumption and production of wines can be observed by referring to the table given under malt liquors (page 186), where it will be seen that in the year 1886, 22,067,220 gallons were consumed, of which 17,366,393 gallons were produced in this country. The consumption per capita has not increased very greatly during the forty-six years since 1840, but the total amount consumed has increased very greatly, it being less than 5,000,000 gallons in 1840. It will be noticed also that the amount produced in this country in proportion to the amount imported has increased to a remarkable degree. In 1840 there was about thirty-eight times as much wine imported as was produced in this country; in 1886 the amount of domestic wine consumed was nearly four times as great as the amount of wine imported. This does not fully represent the production, however, for it does not include the exports, which have increased very greatly of late years, as I am reliably informed, although I have no accurate data upon this point. The largely increased domestic production is principally due to the development of the industry in California.

The following table shows the relative rank of this country among the wine-producing countries of the world; it is taken from the same source as the preceding statistics:

WINE PRODUCTION OF THE WORLD.

Average production of wine in the principal wine-growing countries of the world.

[Estimate by M. Tisserand in 1884, taken from "Journal of the Statistical Society," London, 1885.]

Countries.	Production.	Countries.	Production.
	Imperial gallons.		*Imperial gallons.*
France	765,175,972	Greece	28,600,000
Algeria	722,000,000	United States	18,000,000
Italy	605,000,000	Turkey	22,000,000
Spain	484,000,000	Cape of Good Hope	15,400,000
Austria-Hungary	187,000,000	Roumania	15,400,000
Portugal	88,000,000	Servia	11,000,000
Germany	81,290,000	Australia	1,933,800
Russia	77,000,000		
Cyprus	35,200,000	Total	2,485,599,772
Switzerland	28,600,000		

PREPARATION OF WINE.

The growing of grapes for wine and the proper treatment of the juice for its conversion into wine have formed the subject of numerous treatises, that branch of technology having received a great deal of attention and study in countries where it is carried on. Only a short sketch of the leading features of the process can be given here, necessary to a proper understanding of the product itself.

Wine is properly the pure fermented juice of grapes; its composition is very variable, and the differences in the varieties of grapes used admit of almost endless modifications of the product obtained from them. Moreover, many other conditions affect more or less the composition of wine, as the nature of the soil, the climate, the method of cultivation pursued, the weather during the particular season when the grapes were ripened, etc. Thus the same variety of grapes, when grown under different conditions of soil, climate, etc., produces different wines, and even in the same country the same variety of grape produces wines varying considerably in different seasons.

The most important constituent in the grape is its sugar, from which the alcohol is formed, so as a general rule the grapes are allowed to become fully ripened before they are removed from the vine. The first step is the production of the *must*. To this end the grapes are first bruised and crushed, either by the aid of machinery or by the more primitive but very effective method of trampling them by the feet of men. In some cases, and for very fine wine, the woody stems are removed from the crushed grapes (*dérâpage*). In other cases, especially in white wines, they are left, their contents of tannin making them a desirable addition to the grapes. To obtain the juice the grapes are subjected to pressure. The amount obtained varies with the means employed, the kind of grape, etc., but may be stated at about 60 to 70 per cent. of the weight of the grapes. For red wines the juice is allowed to stand in contact with the skins a variable length of time until it has acquired from them the desired depth of color, and in this case the fermentation commences before the juice is expressed. All musts contain pretty much the same proximate principles, their differences being due solely to the relative proportions of the different constituents. Briefly stated, these constituents are as follows:

(1) Saccharine matter (chiefly dextrose), which may constitute as high as 25 to 30 per cent. of the must.

(2) Albuminoid matter.

(3) Gummy matter, pectin, etc.

(4) Extractive matter, illy-defined substances, comprising the coloring matters, if any, the flavoring matters, etc.

(5) Organic acids and their salts, comprising malic acid (especially in bad seasons), a slight trace of tannic acid derived either from the stems or skins, and tartrates of potassium and calcium.

(6) Mineral matters: Phosphoric, sulphuric, hydrochloric, and silicic acids combined with potassium, sodium, iron, and magnesium.

Water, 70 to 90 per cent.

The must is fermented in suitable vats of wood or stone, according to the usage of the country; the fermentation is produced spontaneously, that is, by germs accidentally introduced into it from the air or on the surface of the grapes themselves. If the fermentation does not take place promptly it is started up by introducing into it a supply of yeast-cells from some must which is already in a state of fermentation. Sometimes a small quantity of must is fermented in anticipation of the vintage season as a "sponge," its fermentation being first induced by a small quantity of well-washed beer yeast. The use of albuminous yeasts, such as bread yeast, etc., is generally avoided as much as possible, however, as tending to produce lactic and acetic or other objectionable fermentations entirely incompatible with the production of a wine with a delicate flavor.

The temperature at which the fermentation is carried on has a very decided influence upon the character of its product, and the practice differs in different countries in this respect. In California, Spain, South of France, Austria, and Hungary fermentation is conducted at a comparatively high temperature, 15° to 20° C., while in Germany a low temperature, 5° to 15° C., is employed. As with beer, the yeast of either variety of fermentation, high or low, reproduces the same kind of fermentation in musts to which it is added, but the subject of the different ferments as applied to wine has not been so carefully studied as with beer. The high fermentation is said to give a wine rich in alcohol but lacking in bouquet, while the reverse is the case with the low fermentation.

The duration of the fermentation varies with the temperature, the amount of sugar to be transformed, etc.; the completion of the process may be known by the cessation of the disengagement of carbonic acid gas and by the diminution of the specific gravity of the liquid, so that the areometer marks zero or less.

After fermentation is complete, the wine is drawn off from any sediment it may contain into casks or barrels, where a second slow fermentation takes place, continuing sometimes several months. When it is over, the wine is "racked off" into fresh casks, which are closely bunged up. The operation of racking off may have to be repeated several times, and it is sometimes necessary to add isinglass or other gelatinous material, which serves to clarify the liquid, acting on the tannin which it contains. This operation is called "fining."

CHANGES PRODUCED BY FERMENTATION.

The principal change in the chemical constitution of the must produced by fermentation is the conversion of the sugar into alcohol and carbonic acid. One hundred parts of sugar produce 50 parts of alcohol, in round numbers. All the sugar, however, is not converted into alcohol and carbonic acid; a small part is converted into glycerine and succinic acid.

The bitartrate of potash, being insoluble in alcohol, is gradually deposited as the content of alcohol in the wine increases, and forms the substance known as "argol" or crude tartar. This distinctive constituent, tartaric acid, constitutes the superiority of grapes over other fruits for wine-making purposes, the comparative insolubility of its acid salts furnishing a means of removing the excess without the addition of other chemical agents.

Other changes take place, especially during the slow second fermentation, not so well defined or so well understood as those mentioned, but of great importance in their relation to the quality of the final product. These changes, which continue after the fermentation has ended, constitute what is called the "ageing" of the wine and produce its "bouquet" or flavor, generally attributed to the etherification produced by a slow action of the acids upon the alcohols. Wine improves with age, but there is a limit after which it degenerates again and loses its flavor.

METHODS FOR "IMPROVING" WINES.

In France and Germany several methods are in use for increasing the yield of wine or improving its quality. These are especially resorted to in unfavorable seasons, when the want of sufficient sun prevents the formation of enough sugar in the grape and the proportion of acid is high.

Chaptalization consists in neutralizing the excess of acidity in the must by the addition of marble dust, and increasing the saccharine content by the addition of a certain quantity of cane sugar, which the vintners sometimes replace by starch sugar. In this process the quantity of the wine is not increased, but it becomes richer in alcohol, poorer in acid, and the bouquet is not injured. It is much used in Burgundy.

Gallization, which was invented by a German, Dr. Ludwig Gall, has for its object the production of a standard must, which shall contain a definite proportion of acid and sugar. This is brought about by the analysis of the must and the addition to it of water and sugar, the quantity to be added being ascertained by reference to tables.

Petiotization.—This process, which takes its name from Petiot, a proprietor in Burgundy, is carried out as follows: The *marc* from which the juice has been separated as usual by pressure is mixed with a solution of sugar and water, and the mixture again fermented, the second steeping containing, like the first, notable quantities of bitartrate of potash, tannic acid, etc., which are far from being exhausted by one extraction. The process may be repeated several times, the different infusions being mixed. This process is very largely used in France, and is said to produce wines rich in alcohol, of as good bouquet as the original wine, and of good keeping qualities. It is not allowed to be sold there, however, as *natural* wine.

To what extent these methods obtain in this country I am unable to state. It is probable, however, that they are but little used, as the principal fault found with American wines is their deficiency in bouquet, not in their content of sugar. The detection of wines made in any of the above-mentioned ways is rather a difficult matter chemically, and requires a knowledge of the composition of the pure product only obtained from large numbers of analyses, extending over many years; which data, although existing in abundance in European countries, are, as yet, lacking here, owing to the comparatively recent development of the industry and the small amount of work done on the subject.

PRESERVATION OF WINE.

The method *par excellence* for the preservation of wines is Pasteurization, already alluded to in this report on malt liquors. The temperature employed is from 50° to 65° C., and serves to completely destroy all vegetable life in the wine. When a process so unobjectionable in every way answers its purpose so admirably, it furnishes an additional argument in favor of the legal suppression of all chemical means of arresting fermentation by the use of antiseptics, etc.

VARIETIES.

The different kinds of wines sold can be numbered by the hundreds. They refer usually either to the country where it is produced, or of whose product it is an imitation, as Port, Sherry, Hochheimer, Madeira, etc., or to the variety of grape from which it is made, as catawba, riesling, zinfandel, etc.

No generally recognized classification is made, except into *white* or *red* wines according to their color, and into *dry* or *sweet* wines according to their content of sugar. The general name of *champagne* is given to effervescing wines.

COMPOSITION OF WINE.

In countries where the production of wine is one of the leading industries, like France and parts of Germany, the composition of the wines made is very well established. Scarcely any article of consumption has been the subject of so much chemical investigation as wine. Thousands of analyses have been published, so that one is at a loss to choose among them for representative figures.

In a general way the normal constituents of a natural wine may be divided into two classes, volatile and fixed.

The volatile matters are as follows: Water, constituting from 80 to 90 per cent. of the weight; alcohol, 5 to 15 per cent.; glycerine, 2 to 8 per cent.; volatile acids, acetic, œnanthic, etc., constituting one-fourth to one-third of the total acidity; aldehyde, compound ethers, together with the other fragrant, indefinite constituents, which give the wine its flavor and bouquet; carbonic acid gas in small quantities in young wines.

The fixed matters are: Glucose or grape sugar in small quantities in most wines; bitartrate of potash, tartaric, malic, and phosphoric acid, partly free and partly combined with potash, lime, soda, aluminum, magnesium, iron, and manganese, of which salts phosphate of lime is the most abundant, constituting from 20 to 60 per cent. of the weight of the ash, the remainder being chiefly carbonate of potash resulting from the calcination of the bitartrate, with a little sulphate and traces of chlorides. Coloring matters: Pectin and analogous gummy matters; tannin, 1 to 2 per cent. in red wines, mere traces only existing in white.

COMPOSITION OF AMERICAN WINES.

The earliest analyses of American wines on record were made by Merrick,* in 1875, comprising six varieties of California wines.

In October of the same year Mallet and Cooper† published analyses of twelve samples of Virginia wines.

The work of Professor Hilgard on California wines began in 1880 and has continued down to the present day, the results being published in the bulletins of the station. These publications include extensive series of analyses, which afford a most valuable index of the composition of California wines, especially as many of the analyses were made on wines manufactured in the laboratory, and hence known to be absolutely pure. A standard of composition could very properly be established from them, and a limit for the amount of each constituent present in pure wines, by which the addition of alcohol, water, sugar, etc., in sophisticated wines could be detected. The number of different determinations made on each sample is not very large, unfortunately, including only the more important constituents.

As this work seems to be very important as establishing the average composition of pure wines made in California, I have prepared from Professor Hilgard's reports a table showing the maximum, minimum, and mean composition of the pure wines analyzed, as well

* Amer. Chemist, 6, 85. † Chem. News, 32, 160.

as of the wines which were made outside and sent in to the laboratory for analysis:

Maximum, minimum, and mean composition of California wines, as shown by the analyses made at the California State Viticultural Laboratory.

	No. of samples analyzed.	Alcohol, by weight.			Body or extract.			Total acids as tartaric.			Ash.		
		Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Pure wines made at laboratory in 1884.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Bordeaux type	10	9.92	7.46	8.81	3.19	2.10	2.57	.633	.381	.510	.447	.252	.352
Burgundy type	6	10.07	6.42	9.01	2.77	1.93	2.36	.765	.450	.624	.425	.200	.319
Southern French and Italian type	18	11.23	7.43	9.26	3.71	1.67	2.56	.585	.393	.506	.511	.234	.343
Dry white wine varieties	13	11.46	7.43	9.71	2.44	1.36	1.90	.600	.428	.516	.342	.157	.219
Sherry and Madeira varieties	10	12.39	7.85	9.68	2.82	1.18	1.85	.660	.217	.498	.390	.160	.288
Port wine varieties	3	10.35	9.05	9.65	3.12	2.36	2.62	.525	.501	.511	.564	.446	.493
Pure wines made at laboratory in 1885.													
Bordeaux type	4	10.54	8.13	9.18	2.99	2.69	2.76	.846	.420	.567	.366	.273	.310
Burgundy type	9	11.46	6.42	8.39	3.07	1.80	2.49	.600	.417	.515	.330	.214	.276
Southern French and Italian type	4	8.84	6.82	7.74	3.07	1.80	2.42	.576	.450	.517	.340	.213	.270
Dry white wine varieties	15	11.23	4.76	9.22	3.82	1.52	2.16	.713	.351	.544	.450	.140	.224
Pure wines made at laboratory in 1886.													
Bordeaux type	15	9.78	6.95	8.28	......	......	......	.810	.420	.620	......	......	......
Burgundy type	16	11.62	7.09	9.21	......	......	......	.940	.350	.540	......	......	......
Southern French and Italian type	15	10.63	6.49	8.48	......	......	......	1.120	.450	.730	......	......	......
Dry white wine varieties	25	9.27	4.14	7.86	......	......	......	.810	.250	.480	......	......	......
Sherry and Madeira varieties	10	11.62	6.35	8.58	......	......	......	.720	.330	.480	......	......	......
American type	3	7.43	6.89	7.14	......	......	......	.740	.500	.620	......	......	......
Wines sent to laboratory for analysis, 1884–'85.													
Reds	20	10.69	7.64	9.63	3.62	2.05	2.87	.750	.395	.563	.534	.219	.340
Whites	5	10.81	8.98	9.80	3.87	2.05	2.67	.527	.397	.473	.367	.255	.303
Wines sent to laboratory for analysis, 1885–'86.													
Reds	55	16.42	7.99	10.48	13.77	2.10	4.30	.879	.225	.554	.470	.230	.324
Whites	16	12.39	8.84	10.82	4.20	1.80	2.66	.750	.210	.473	.300	.170	.261
Zinfandel wines analyzed, 1879–'85	45	12.39	7.43	10.55	8.64	1.46	2.89	.873	.337	.573	.546	.154	.301

In the year 1880 a large number of samples of wine were purchased in the market of Washington and analyzed by the Department of Agriculture. The work was under the charge of the late Henry B. Parsons, one of the most competent analysts ever in the service of the Department. The results are published in the Annual Report for 1880, forming part of the Chemist's report for that year.

The following table gives the averages and extremes of these analyses:

Averages and extremes of American dry wines.

Constituents, etc.	Dry red wines.			Dry white wines.		
	Average (64 analyses).	Highest.	Lowest.	Average (51 analyses).	Highest.	Lowest.
Specific gravity	.9933	1.0011	.9894	.9926	1.0105	.9845
Alcohol, by weight ... per cent	8.92	12.21	5.71	9.35	13.94	7.03
Alcohol, by volume ... do	11.04	15.21	7.17	11.70	17.37	8.80
Total residue ... do	2.28	3.16	1.65	1.75	2.64	1.18
Total ash ... do	0.231	0.532	0.130	0.181	0.335	0.090
Glucose ... do	Traces.	0.450	None.	Traces.	0.300	None.
Total acid as tartaric ... do	0.723	0.997	0.511	0.680	0.855	0.422
Fixed acid as tartaric ... do	0.360	0.646	0.226	0.313	0.561	0.121
Volatile acid as acetic ... do	0.290	0.517	0.138	0.294	0.508	0.068

In the work on wines during the present investigation, 70 samples purchased in the market of Washington were examined. Inasmuch as the analyses made in 1880 included so many samples and represented very fairly the composition of the wine sold here, it was thought inadvisable to make a complete analysis of all the samples, especially as many of them were identical in origin with those examined by Mr. Parsons. Accordingly only about one-half the samples (36) were submitted to a very careful and complete analysis, the rest being examined for adulteration only, especially preservatives. Only those samples were chosen for complete analysis which did not correspond to any of the samples analyzed in 1880. The samples are all wines of American origin, of which by far the greater bulk of the wines consumed here consists. Most of the samples are Californian, a few coming from Virginia and other States. Several of the samples had foreign labels, in imitation of some imported wine of the same general class, but in each case the dealer admitted that the wines were American.

The time and scope allowed to the work did not admit of the extension of the investigation to imported wines.

Analyses of wines made by United States Department of Agriculture in 1887.

Designation.	Made in—	Vintage.	Serial number.	Number of analysis.	Specific gravity.	Alcohol, by weight.	Alcohol, by volume.	Extract.	Total acids as tartaric.	Fixed acids as tartaric.	Volatile acids as acetic.	Bitartrate of potash.	Reducing sugars as dextrose.	Glycerine.	Ash.	Polarization in degrees, cane sugar scale.
Red wines.						*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
American Burgundy	....	.....	4964	1	.9903	11.93	14.74	1.73	.390	.272	.097	.115	.390	....	.176	±0
Charbono	California	1885	4968	2	.9946	9.12	11.35	2.28	.498	.166	.207	....	.302	....	.324	−1.9
Lenoire	....do	1885	4969	3	.9951	10.43	12.96	2.25	.426	.277	.120	....	.354	....	.308	−1.5
Burgundy	....do	1884	4995	4	.9945	10.23	12.68	2.00	.870	.724	.121	.062	.093	.730	.255	−1.0
Claret	....do	1885	4996	5	.9943	10.61	13.15	2.26	.668	.535	.109	.076	.256	.588	.291	−1.6
Zinfandel	....do	1883	5005	6	.9945	9.87	12.22	2.09	.795	.668	.104	.057	.153	.893	.201	+1
Burgundy	....	.....	5084	7	.9951	8.29	10.30	1.39	.383	.113	.216	.057	None.	.552	.236	+0.2
St. Julian Claret	California	1885	5088	8	.9983	10.38	12.87	2.83	.728	.404	.211	.062	.508	.466	.289	±0
Claret	Virginia	.....	5091	9	.9943	9.04	11.20	1.52	.480	.315	.132	.057	.124	.517	.224	±0
Zinfandel	California	.....	5095	10	.9950	8.76	10.87	2.18	.765	.414	.281	.048	.250	.303	.342	−1
Claret	Virginia	.....	5096	11	.9958	8.92	11.08	1.71	.525	.297	.183	.095	Trace.	.382	.396	−0.2
Do	....do	.....	5099	12	.9949	8.43	10.47	1.43	.555	.279	.221	.086	.051	.421	.307	±0
Do	New Jersey	.....	5100	13	.9947	9.94	12.31	1.96	.735	.450	.228	.029	.145	.308	.229	±0
Do	Virginia	.....	5101	14	.9969	7.78	9.68	1.82	.705	.600	.084	.133	None.	.492	.252	±0
Do	California	.....	5103	15	.9923	10.45	12.95	1.71	.668	.443	.180	.029	None.	.370	.453	−0.5
Do	....do	.....	5104	16	.9937	10.01	12.40	1.82	.585	.393	.154	.048	None.	.348	.360	−0.7
Average	....	.....	.....	.....	.9946	9.66	11.95	1.94	.611	.397	.169	.068	.164	.490	.290	
White wines.																
Moselle	California	1884	4997	1	.9911	10.91	13.52	1.44	.735	.593	.118	.094	.073	.394	.247	−2.2
Riesling, gray	... do	1884	4998	2	.9917	9.37	11.61	1.16	.750	.595	.128	.150	.081	.436	.202	−2.4
Riesling, white Johannisburg	....do	1885	4999	3	.9919	10.91	13.52	1.75	.563	.451	.092	.039	.325	.797	.203	−2.0
Sauterne	....do	1885	5000	4	.9882	13.35	16.52	1.74	.488	.385	.082	.062	.394	.835	.181	−3.2
Dry Catawba	....	.....	5081	5	.9913	10.11	12.49	1.16	.683	.448	.156	.198	.147	.370	.240	−1.8
California Riesling	....	.....	5083	6	.9914	9.95	12.31	1.16	.690	.471	.175	.189	.139	.427	.260	−0.8
Riesling	....	.....	5089	7	.9927	9.01	11.17	1.12	.668	.548	.096	.142	.109	.585	.203	−0.5
Do	California	.....	5097	8	.9920	9.64	11.96	1.18	.713	.430	.146	.255	.980	.540	.226	± 0
Berger	....do	.....	5098	9	.9903	10.74	13.32	1.34	.698	.464	.187	.236	None.	.365	.222	−0.4
Average	....	.....	.....	.....	.9912	10.44	12.94	1.35	.665	.498	.131	.152	.250	.328	.220	......

Analyses of wines made by the United States Department of Agriculture in 1887—Continued.

Designation.	Made in—	Vintage.	Serial number.	Number of analysis.	Specific gravity.	Alcohol, by weight.	Alcohol, by volume.	Extract.	Total acids as tartaric.	Fixed acids as tartaric.	Volatile acids as acetic.	Bitartrate of potash.	Reducing sugars as dextrose.	Glycerine.	Ash.	Polarization in degrees, cane-sugar scale.
Sweet wines.						*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Sherry	California	1883	5001	1	.9929	16.16	19.87	3.82	.638	.445	.157	.039	1.850	.606	.312	−12
Do	do	......	5090	2	.9939	15.99	19.68	3.35	.510	.390	.096	.114	2.8 0	.278	.215	− 6.6
Port	do	......	5091	3	1.0432	15.39	18.93	15.38	.683	.431	.202	.076	8.928	.190	.602	−20.2
Sweet Burgundy	do	1884	5002	4	1.0161	15.53	19.08	9.30	.615	.490	.092	.057	6.150	.657	.415	−30.2
Sweet Catawba	....	1886	5087	5	1.0145	14.50	17.87	8.39	.518	.410	.087	.086	6.650	.113	.118	− 8.8
Do	....	......	5102	6	1.0357	10.98	13.60	13.20	.465	.303	.130	.048	....	.417	.384	....
Tokay	California	1884	5004	7	1.0167	14.58	17.92	9.53	.518	.364	.118	.039	6.110	.206	.262	−20.2
Sweet Muscatel	do	1884	5003	8	1.0511	12.99	16.05	17.20	.375	.325	.025	.048	15.050	.192	.256	−30.6
Muscatel	do	......	5092	9	1.0380	15.45	19.00	13.64	.563	.383	.144	.057	11.111	.102	.360	−23.4
Angelica	do	1884	4994	10	1.0492	12.54	15.49	16.27	.375	.330	.030	.132	14.200	.140	.686	−30.0
Do	do	......	5093	11	1.0433	15.37	18.90	13.24	.360	.285	.060	.039	11.873	.052	.249	−29.9
Average					1.0261	14.50	17.85	11.21	.511	.378	.104	.067	8.48	.269	.351	....

Maximum, minimum, and mean composition of the samples examined.

Constituents.	Sixteen samples red wines.			Nine samples white wines.			Eleven samples sweet wines.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Specific gravity	.9983	.9903	.9946	.9918	.9882	.9912	1.0511	.9929	1.0261
Alcohol, by weight .... per cent.	11.93	7.78	9.66	13.35	9.01	10.44	16.16	10.9	14.50
Alcohol, by volume .... do	14.71	9.68	11.95	16.52	11.17	12.91	19.87	13.60	17.85
Extract .... do	2.83	1.39	1.94	1.75	1.16	1.25	17.20	3.38	11.21
Total acids as tartaric .... do	.870	.385	.611	.750	.488	.665	.683	.360	.511
Fixed acids as tartaric .... do	.724	.113	.357	.595	.385	.49	.490	.285	.375
Volatile acids as acetic .... do	.281	.084	.168	.187	.082	.131	.202	.025	.104
Bitartrate of potash .... do	.133	.029	.068	.255	.029	.152	.132	.029	.067
Reducing sugars as dextrose .. do	.508	none.	.161	.980	none.	.250	15.05	1.85	8.48
Glycerine .... do	.893	.303	.490	.835	.365	.528	.657	.052	.260
Ash .... do	.453	.176	.290	.260	.181	.220	.686	.118	.351

THE ADULTERATION OF WINES.

The adulteration of wine has been practiced from a very early date in those countries where the consumption is large. It has increased in amount and in the skillfulness of its practitioners until at the present day it requires for its detection all the knowledge and resources which chemical science can bring to bear upon it, and even then a large part doubtless escapes detection. It must be remembered, however, that in Europe the definition of adulteration has rather a wide scope, including the addition of substances which are simply diluents. The Paris Laboratory considers as a fraud "the addition of any substance for the purpose of gain which changes the composition of the natural wine." In Germany, on account of the northern situation of the country, it is permitted to the wine-growers in bad years, when the grapes contain a relatively high percentage of acid and a low percentage of sugar, to make use of pure sugar as an addition to the must, which addition is not considered as an offense against the adulteration laws, so long as the product is sold as "wine" simply. The amount of water added with the sugar must not be greater than twice the weight of the former, and the product must not be offered for sale as "natural wine."

By far the greater part of the adulteration carried on in the European countries consists of this addition of water (*mouillage*) and sugar (*sucrage*). Such wines result from the methods of manufacture already described—petiotization, gallization, and chaptalization. For the detection of such wines it is necessary to establish maximum and minimum limits for the principal constituents of wines, and the relation in which these constituents stand to one another. To establish these limits is rather difficult, and requires a large series of analyses extending over many years. The constituents most relied on for the establishment of the character of a wine in judging whether it has been diluted or not are, the extract, content of free acid, and the relation between the extract and mineral matters.

The samples which would be considered as watered according to the German standard are as follows: Serial Nos. 5084, 5099, 4997, 4998, 5081, 5083, 5089, 5097, and 5098.

The *plastering* of wines, which is also very extensively carried on in France, consists in adding to the wine or must a large excess of gypsum, or sulphate of lime.

American wines would seem to be quite free from this form of adulteration. In my 70 samples I found none which exceeded the generally adoped standard of .092 gram SO_3 to 100cc., or 2 grams K_2SO_4 to the liter, and only three, Nos. 5100, 5107, and 5115, which contained SO_3 corresponding to over 1 gram K_2SO_4 per liter.

Fortification of wine consists in the addition of alcohol derived from some other source. The alcohol may be added either to the must or the wine. It allows of better incorporation with the wine if it is added to the must before fermentation. In either case, however, it precipitates a part of the constituents originally dissolved, lowers the quantity of extract, deprives the wine of its original bouquet and flavor, and renders it more heady and intoxicating. The least objectionable addition is alcohol distilled from grapes; but the high price of the latter renders it much less likely to be used than corn spirit, which contains considerably more fusel oil. The practice of fortification prevails especially in the more southern wine-growing countries, as Portugal, Spain, and the south of France. Growers in those countries declare it to be a necessary addition in their warm climates for the preservation of the wines, as these latter contain a considerable quantity of unfermented sugar, which would soon produce the souring of the wine if the alcoholic content were not greater than can be obtained by fermentation. In France, for ordinary red wines, the addition of alcohol is decided by the relation of the alcohol to the extract (sugar deducted), exceeding sensibly the relation of 4 to 4.5. In Germany the relation of alcohol to glycerine is relied upon, the maximum proportion allowed being 100 parts by weight of alcohol to 14 of glycerine, and the minimum 100 to 7. Wines going above the maximum are condemned as having suffered an addition of glycerine, those going below the minimum as being fortified with alcohol. With "sweet wines" these figures do not apply, as they are based on natural wines made in Germany.

It is evident that the German standard of 100 parts of alcohol by weight to 7 of glycerine, which is relied upon as a means of detecting the addition of alcohol, can not be applied to American wines. Only three of the samples would pass muster by it, and it seems hardly possible that the practice of adding alcohol could be so wide-spread as would be thus indicated.

Foreign coloring matters are frequently added to red wines, either to brighten and improve the color obtained from the grapes, or, more frequently, to cover up the effects of previous dilution. These colors may be of vegetable origin, obtained from the various vegetable dyes, or by mixing the juice of other highly-colored berries or fruits with the wine; or they may be some of the numerous varieties of aniline dyes obtained from coal-tar. A few examples of the vegetable dyes said to be used may be mentioned as follows: Logwood, cochineal, elderberries, whortleberries, red cabbage, beet-root, mallow, indigo, etc.

All of the samples of *red* wines, about forty, were submitted to a search for aniline coloring matters, which resulted in the demonstration that one sample out of the forty, No. 4996, was colored with an aniline dye-stuff, probably fuchsine.

The *preservative agents* added to wine are entirely similar to those used in malt liquors.

Especial attention has been given in the present investigation to the use of improper preserving agents in fermented drinks. It was thought that such agents were much used; so a considerable number of samples were purchased, and the examination for preservatives, as well as for other adulterations whose detection did not require a complete analysis of the wine, was extended to all. The results show the practice to be even more extensive than was supposed.

The following table shows in what samples salicylic acid and sulphites were detected. In the case of the sulphites, where a "trace" is indicated, there was not sufficient to justify the assertion that a sulphite or sulphurous acid had been added directly to the wine; in such cases it probable came from insufficient cleansing of the casks. Where it is indicated as "present," however, there was sufficient indication of its having been added to the wine.

Examination of wines for preservatives.

Designation.	Made in—	Serial No.	Salicylic acid.	Sulphites.
Champagne	New York	4960	None.	None.
Do	....do	4961	....do.	Do.
Do	Ohio	4962	....do.	Do.
Do		4963	....do.	Present.
Burgundy		4964	....do.	None.
Virginia seedling		4965	....do.	Do.
Catawba	New York	4966	Present	Do.
Sweet Scuppernong	North Carolina	4967	None	Do.
Charbona	California	4968	....do	Do.
Lenoire	....do	4969	....do	Do.
St. Macaire	....do	4970	....do	Do.
Angelica	....do	4994	....do	Do.
Burgundy	....do	4995	....do	Trace.
Claret	....do	4996	....do	None.
Moselle	....do	4997	....do	Present.
Riesling, gray	....do	4998	Present	None.
Riesling, Johannisberg	....do	4999	....do	Present.
Sauterne	....do	5000	None	Do.
Sherry	....do	5001	Present	None.
Sweet Burgundy	....do	5002	None	Do.
Sweet Muscatel	....do	5003	....do	Do.
Tokay	....do	5004	....do	Do.
Zinfandel	....do	5005	....do	Do.
Catawba		5081	....do	Trace.
California Hock		5082	....do	Present.
California Riesling		5083	....do	Trace.
Burgundy		5084	....do	None.
Zinfandel		5085	....do	Do.
St. Julien Claret		5086	....do	Trace.
Sweet Catawba	New York	5087	....do	None.
St. Julien Claret		5088	Present	Trace.
Riesling		5089	None	Present.
Sherry	California	5090	....do	None.
Port	....do	5091	....do	Do.
Muscatel	....do	5092	....do	Do.
Angelica	....do	5093	Present	Do.
Claret	Virginia	5094	None	Do.
Zinfalden	California	5095	....do	Do.
Claret	Virginia	5096	....do	Trace.
Riesling	California	5097	....do	Present.
California Berger	....do	5098	....do	None.
Claret	Virginia	5099	....do	Do.
Do	New Jersey	5100	Present	Do.
Do	Virginia	5101	None	Do.
Catawba		5102	Present	Do.
Claret	California	5103	None	Do.
Do	....do	5104	....do	Do.
Do	Virginia	5105	....do	Do.
Sauterne		5106	....do	Present.
Hock		5107	Present	Do.
California Beaune		5108	....do	None.
Sweet Catawba		5109	....do	Trace.
California Gutedel		5110	....do	Present.
Claret	Virginia	5111	None	Do.
California Zinfalden		5112	....do	Trace.
California Port		5113	....do	None.
Sonoma Port		5114	Present	Do.
California Angelica		5115	....do	Do.

Examination of wines for preservatives—Continued.

Designation.	Made in—	Serial No.	Salicylic acid.	Sulphites.
Frontignan	California	5116	None	None.
Old Pale Sherry	do	5117	do	Do.
California Zinfandel		5118	Present	Trace.
Gutedel Hock	California	5119	None	Do.
Berger Hock	do	5120	do	Present.
California Burgundy	do	5121	Present	Trace.
California Madeira	do	5123	do	None.
California Port	do	5124	None	Do.
California Tokay	do	5125	Present	Do.
California Frontignan	do	5126	None	Do.
California Angelica	do	5127	do	Do.
California Berger Hock	do	5128	do	Present.

From an examination of this table it will be seen that of the seventy samples examined, *eighteen*, or over one-fourth, had received an addition of salicylic acid, and *thirteen* had been preserved by the use of sulphurous acid, either as such or in the shape of a sulphite. In two cases both agents had been used. One of the samples which contained salicylic acid and also one containing sulphites were among the samples exhibited at the meeting of the National Viticultural Convention last year in Washington.

CIDER.

Cider is the fermented juice of the apple. It is an article of very general use, especially in those parts of the country where fruit-growing is carried on. Statistics of the amount produced or consumed are rather difficult to obtain, and I am unable to present any definite statement on the subject. It is quite a favorite article of home production, nearly every farmer in regions where apples are grown making his barrel of cider for use through the winter; but a large amount also finds its way into the city markets, finding ready purchasers among people who still retain their taste for the drink, acquired during a childhood on the "old farm." A considerable quantity is also consumed in the shape of bottled cider, "champagne cider," "sparkling cider," and similar substitutes for, or imitations of, champagne wine, large quantities of this clarified cider being produced in some parts of the country, notably New Jersey. Most of the cheaper kinds of champagne (American champagne) are made in this way.

In England and France considerable quantities of cider find their way into the markets, though it is there, as here, largely an article of home consumption. Certain parts of those countries are famous for the quality of their ciders, notably Normandy, in France, and Herefordshire and Devonshire, in England. France produced, in 1883, 23,493,000 hectoliters (620,211,200 gallons) of cider, or over one-half of the quantity of wine produced, and three times as much as the total quantity of malt liquors.

MANUFACTURE OF CIDER.

In the numerous sections of the United States where apples are grown in large quantities the manufacture of cider furnishes a most important means for the utilization of such fruit as is unfit for marketing, either from being too small or sour, or too thoroughly ripened, or bruised from handling. The conversion of these into cider, and perhaps of the cider into vinegar, is a very important branch of apple-growing, and the cider press is an indispensable adjunct to a large orchard. Within the last ten years the manufacture of cider has been greatly aided by improvements, both in the machinery for crushing the fruit and in the presses for extracting the juice, but it is doubtful if the methods of treatment of the juice after extraction have undergone a corresponding development. The methods of fermentation and preserving—operations that are so carefully performed in the manufacture of other fermented liquors—are exceedingly crude, as I can testify from personal experience. The juice, whether containing a relatively large percentage of sugar or not, is drawn into barrels and left to itself, probably exposed to a hot sun and to all the changes of temperature incident to the autumn season; and when the season is over or the cider is in danger of freezing, it is transferred to the cellar in the same barrels in which it was originally run, without any attempt at cleansing it of sediment, or filtering or racking; and when any attempt at improving its keeping quality is made it is by adding some antiseptic instead of freeing it from the matters which conduce to improper fermentations, or so conducting the process as to produce a liquor which can properly be called the "wine of apples." It seems remarkable that with these methods so palatable a drink is produced, a fact which only shows what might be done if a little care and scientific knowledge were applied to the treatment of the juice. There is a great difference between the practice here and in other countries in regard to the treatment of the juice. Here the greater part of the cider produced is treated as indicated above, and is sold to the consumer in the fall or winter of the same year it is produced, without any treatment whatever, except perhaps the addition of a dose of mustard seeds or sulphite of lime or salicylic acid, to arrest or retard the fermentation. This addition serves only to stop the fermentation for a while, probably through the winter, and in the spring whatever has not been consumed has to be thrown away or turned into vinegar. In England and France the juice is treated according to the sweetness of the apples from which it is made, very sweet juice requiring a low temperature for its fermentation, in order that the operation shall not be too rapid. The juice is run into barrels or large vats, which are kept in a barn or cellar where the temperature is more or less constant, and the fermentation allowed to go on until a "chapeau" or head of scum forms on top, containing many of the impurities of the juice. The clear liquid is then "racked off" from between the impurities which have risen to the top and those that have fallen to the bottom. The casks into which it is received are scrupulously clean and are filled nearly full and transferred to a cooler cellar, where a second slow fermentation takes place. The racking-off process may be repeated if necessary, or the juice may be filtered from the first fermentation. Cider fermented and properly racked in this way will keep indefinitely at a low temperature, especially if bottled. For bottling, it generally undergoes the operation called "fining," by the addition of isinglass, which removes most of the albuminous constituents which are so inimical to its proper preservation. Cider made in this way will be much richer in alcohol and contain much less acetic acid than when its first fermentation is allowed to take place at a high temperature and in a rapid, tumultuous manner. It is a true apple wine and will keep indefinitely. The cider of Devonshire has been kept twenty or thirty years.

COMPOSITION OF CIDER.

The amount of chemical work done on cider is not nearly so great as has been done on wine. In fact, the published analyses of cider are very few and are confined almost entirely to other countries. I have not been able to find a single published analysis of American cider.

Various conditions rendered it impossible to extend the present investigation of ciders to a very large number of samples. It is hoped that an opportunity for a more extended study will present itself in the future.

The samples for the investigation were purchased in the city in the same way as the samples of wine and beer.

Analyses of ciders by United States Department of Agriculture.

Designation.	Serial number.	Number of analysis.	Specific gravity.	Alcohol, by weight.	Alcohol, by volume.	Total solids.	Free acids, as malic.	Sugar, as dextrose.	Ash.	Albuminoids.	Carbonic acid.	Polarization, cane-sugar scale.
Well-fermented ciders.				*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P.ct*	°
Draught cider ("extra dry")	4830	1	1.0132	4.18	5.23	3.31	.602	(*)	.396	.038	....	—19.5
Bottled cider, known to be pure	4832	2	1.0003	8.09	10.05	1.88	.456	......	.279	.063	(†)	—7.0
Bottled cider......	4833	3	1.0007	6.28	7.83	1.80	.376	......	.340	.044	....	—6.1
Bottled "extra dry russet" cider	4834	4	1.0261	4.48	5.61	5.52	.339	......	.393	.031	....	—35.2
"Champagne cider," bottled	4835	5	1.0223	4.08	5.10	5.02	.567	......	.310	.050	.161	—23.4
Do												
"Sparkling cider," bottled..	4836	6	1.0143	5.45	6.79	3.69	.361	......	.415	.038	.120	—20.4
	4927	7	1.0306	3.63	4.54	5.92	.113	......	.506	......	(‡)	—33.8
Average	......	....	1.0154	5.17	6.45	3.88	.402	......	.377	.044	....	......
"Sweet" or incompletely-fermented ciders.												
Draught cider......	4829	1	1.0537	0.65	0.81	9.34	.565	......	.315	.069	....	—41.6
"Sweet" cider......	4831	2	1.0516	0.61	0.77	9.59	.302	......	.270	.063	....	—34.2
"Sweet" cider (draught)...	4837	3	1.0567	0.20	0.25	9.53	.375	......	.283	.075	....	—48.4
Do	4838	4	1.0203	3.46	4.33	3.84	.302	......	.374	.044	....	—24.2
Do	4839	5	1.0552	0.55	0.67	9.75	.409	......	.336	.031	....	—48.5
Do	4841	6	1.0355	2.96	3.71	6.98	.478	......	.348	.069	....	—39.1
Average	......	....	1.0455	1.40	1.76	8.17	.405	......	.321	.059	....	......

* A circumstance arising after the samples had been thrown away seemed to throw considerable doubt upon the determinations of sugar, which were made by an assistant, and the entire set had to be thrown out.

† Trace.

‡ Determinations of the carbonic acid in three different bottles gave the following results: .728, .654, .482.

ADULTERATION OF CIDER.

Cider is very little subject to adulteration, according to most of the authorities on foods. Even Hassall, who generally enumerates under each article of food a list of every conceivable adulteration that has ever been found or supposed to have been used in such food, only speaks of the addition of water, of burnt sugar as a coloring matter, and of the use of antacids for the correction of the acidity of spoiled cider. On the other hand, in France, where, as we have seen, it is very largely consumed, its adulteration is by no means uncommon, although principally confined to its watering, together with additions for the purpose of covering up such attenuation, such as foreign coloring matters. In the Paris municipal laboratory, out of 63 samples examined in 1881, 39 were pronounced "bad," among which were 26 artificially colored; in 1882, 59 samples were examined, of which 30 were declared "bad," of which 7 samples were artificially colored; 2 samples contained salicylic acid. The following is considered there as a minimum limit for the composition of a pure cider, and any sample which falls below it in any constituent is considered as watered:

Alcohol, per cent., by volume	3
Extract in grams, per liter	18
Ash	1.7

This is for a completely-fermented cider; in sweet ciders the content of sugar should exceed the limit sufficiently to make up for the deficiency of alcohol, to which it should be calculated.

EXAMINATION OF THE SAMPLES FOR ADULTERATION.

The investigation of the samples was undertaken with the full expectation of finding a considerable number preserved with antiseptics. This supposition failed to be confirmed, however, for no salicylic acid was found, and in but one case was any test obtained for sulphites. None of the samples fell below the standard proposed by the French chemists, given above, and no metallic or other adulteration was discovered.

The single exception, however, No. 4927, was an embodiment in itself of nearly all the adulterations which have been enumerated as possible in cider. It was handsomely put up in neatly-capped bottles, and of a clear, bright color. Its tremendous "head" of gas when uncorked gave rise at once to the suspicion that it had received some addition to produce an artificial pressure of gas, for pure cider does not contain sufficient sugar to produce very much after-fermentation, any more than pure wine. The low content of free acid, together with the large amount of ash and very variable content of carbonic acid in different bottles, established the fact that bicarbonate of soda had been added, probably a varying quantity to each bottle, while the dose of sulphites added was so large that a bottle has stood open in the laboratory all through the summer without souring.

ABSTRACT OF REPORT OF RESULTS OF EXPERIMENTS WITH MANUFACTURE OF SUGAR FROM SORGHUM AND SUGAR CANES.

EXPERIMENTS WITH SORGHUM AT FORT SCOTT.

Report of MAGNUS SWENSON.

PRELIMINARY EXPERIMENTS.

As soon as the earliest of the amber cane approached ripeness a large number of preliminary experiments were made in defecation and filtration of juices. The experiments in filtration were made with a small filter press with a hand pump. The cloth used was the same as that used in the large presses, and every precaution was taken to make the results just as valuable as if made on a larger scale. These experiments were begun on July 29. The filtering materials used were finely-powered lignite, bituminous coal, shale, several kinds of soils, and prepared carbonate of lime. The following conclusions were derived from these experiments:

(1) None of the above materials would filter juice satisfactorily that had an acid reaction.

(2) Neutral juice filtered very slowly and a hard-press cake would not form in the press.

(3) With a decidedly alkaline juice the filtration took place much more readily, but was not entirely satisfactory except with carbonate of lime.

(4) Lignite did not have any apparent decolorizing effect on the juice except when the juice had become highly colored by adding an excess of lime, when a slight decolorization took place. A large number of experiments were made with varying quantities of lignite, but in no case did it show any superiority over fine, sandy loam either as a decolorizer or filtering medium.

Experiments for testing the cutting, cleaning, and elevating machinery were also conducted as early as the condition of the cane would permit.

The method of unloading the cane and getting it onto the carrier was similar to that employed last year. The seed heads, however, were cut off in the field. The cutters were made by the Belle City Manufacturing Company, of Racine, Wis. They did the work well, but the machines were too light to stand the very severe work they were called upon to do.

The cane was cut into pieces about an inch long and then elevated by a drag to the top of the series of four fans standing straight over each other, each fan being furnished with a separate set of shakers. The cleaning apparatus, after considerable adjustment, did fairly good work. The leaves and sheaths were removed by a suction fan. The cleaned pieces of cane were cut by a rapidly-revolving cutter, consisting of a cylinder carrying 30 knives. The cylinder was made up of three separate sections, each with 10 knives. Although no difficulty was encountered in cutting, the work of the cutter was very unsatisfactory. A large portion of the chips consisted of long pieces with the bark on one side. Diffusion in this case could take place but in one direction, and in the largest chips of this kind the extraction of the sugar was very imperfect. The drag for conveying the chips to the cells was rebuilt and placed higher and on one side of the battery so as not to interfere with the packing of the chips in the cells. The exhausted chips were dumped directly into a car running on rails under the battery. This car was run up an incline onto a trestle work about 20 feet from the ground, by the aid of an endless cable. Two friction clutches, running in opposite directions, served to run the car forward or backward, and the car was so arranged that the charge of exhausted chips could be dropped at any point by simply reversing the motion of the cable.

EXPERIMENTS WITH CRUSHER.

It was the opinion of a number of men interested in this industry that a very much larger yield and better quality of juice could be obtained by the crushers if the cane, previously to being pressed, were cleaned and macerated, and it was deemed best to give the matter a thorough trial. For this purpose a 3-foot cane mill was purchased from J. A. Field & Co., of Saint Louis. It consisted of a 3-roller mill and a supplemental 2-roller mill. The principal trouble encountered was in feeding the mill. Even with an arrangement for forcing the chips between the rolls not over 3 tons per hour could be forced through, and the yield of juice was but little if any greater than when whole cane was fed to the mill.

The average yield of sirup was about 10 gallons per ton of cane worked. The same kind of cane yielded by diffusion 25 gallons of sirup per ton of cane. The cane used in this trial was very poor, being mostly lodged. These experiments show conclusively the great superiority of the diffusion process for sirup making, a very good quality of sirup being produced from very poor cane. It was superior in both color and flavor to the sirup from the mill juice. The juices from the mill and battery were treated precisely alike and they were skimmed and evaporated in an open steam evaporator. This is a matter of great importance to all engaged in the sugar business, as both at the beginning and close of the season there will be considerable cane that is not fit for sugar-making, and the fact that 25 gallons of first-class sirup can be made from such cane by diffusion makes it possible to work even such material at a good profit.

The first run for sugar was begun on August 26. The juice was made alkaline with lime, and about 2 per cent. of carbonate of lime was added. It was then filtered. To other portions of juice, instead of carbonate of lime, 3 per cent. of ground shale, bituminous coal, and sandy loam were added respectively. The filtrations were very imperfect except with the carbonate of lime and in every way corresponded with the preliminary experiments. Lignite was not used on a large scale because I had at the time no means of grinding it; but judging from a large number of experiments made in the beginning of the season, it is safe to conclude that it would not have filtered any better than the other materials used.

Satisfactory filtrations were only produced when the juice had been made strongly alkaline, and no material was found which would filter the juice when left slightly acid.

On August 30 the first strike was made, and the yield was a little more than 100 pounds of washed sugar per ton of clean cane.

INVERSION OF CANE SUGAR.

To prevent the inversion of the sugar in battery, about 10 pounds of dry precipitated carbonate of lime was mixed with enough water to produce a thin paste. This was added to the fresh chips while the cell was being filled, and entirely prevented any loss of sugar by inversion.

The carbonate was made by forcing carbonic acid gas by the aid of a pump into thin milk of lime. The injection pipe was perforated and lay along the bottom of a 10 by 10 foot tank containing the milk of lime. The gas was produced by burning coke in a small furnace. When the lime showed but a slight alkaline reaction it was run off into a large hole in the ground where the water soon drained away, leaving the carbonate nearly dry.

EXPERIMENTS WITH DEFECATION.

On September 1 filtration was dispensed with and experiments tried with simple defecation. The defecators were similar to those in ordinary use, being simply round tanks with conical bottoms and furnished with coils for heating the juice. This method of defecation, however, was not satisfactory, and defecation was tried in a shallow pan 16 feet long and 26 inches wide, with a partition running lengthwise in the center, the inlet and outlet for the juice being on the same end of the pan on opposite sides of the partition.

This pan was gotten up very hurriedly and was supplied with iron pipes for heating the juice. The juice, after being previously limed and somewhat heated, was pumped into one side of the long heating pan and run out at the opposite side continuously.

Being compelled by the center partition to flow down one side and back on the other, the juice made a circuit of 32 feet. The steam was so regulated that during the first 16 feet it was gradually brought to the boiling point, while in the opposite side it boiled vigorously. In this way a strong current was produced which carried all the impurities in the form of scum to the quiet portion of the juice, where it was removed and returned to the battery, thus avoiding all waste and annoyance from this source.

EVAPORATION.

The juice was evaporated to from 20° to 30° Baumé, in a double-effect evaporator built by the Pusey & Jones Company, of Wilmington, Del. This apparatus gave perfect satisfaction. All the evaporation was done by exhaust steam of 4 pounds pressure, a small amount of live steam being used only when part of the machinery was stopped.

EXPERIMENTS IN BOILING TO GRAIN.

Every strike was boiled to grain in the pan. Several experiments were made to ascertain the result in boiling "in and in," the juice being enriched by the addition of sugar made from previous strikes. It is very doubtful, however, whether this is to be recommended, excepting when the juice is so poor that a good grain can not be obtained in any other way.

Owing to the fact that we were unable to secure a sufficient supply of cane the work progressed very irregularly. Only twice during the entire season was the battery kept in operation continuously for twenty hours, and during the sugar-making season the diffusion battery was emptied sixty-two times. This entailed no inconsiderable loss, amounting to from 1 to 2 tons of clean cane each time a stoppage occurred.

CANE WORKED FOR SUGAR.

The total amount of cane worked for sugar was 2,610 tons. In this is included all that was used for experiments in filtration and defecation during the first part of the season. I have no record of the exact amount lost in this way. The total amount of first sugar made was 235,476 pounds. This sugar was all washed, and polarized on an average 96 per cent. The total amount of molasses produced was 51,000 gallons.

TRIAL RUNS.

In order to ascertain as nearly as possible the average yield of sugar per ton of cane two trial runs were made.

FIRST TRIAL.

On September 15 a strike was made from 133 tons of clean cane. In order to obtain a better grain 2,600 pounds of sugar were added to the juice after it had been defecated; 2,200 pounds of juice were drawn from each cell.

The following is a record of this experiment:

Sucrose in mill, juice from chips		10
Glucose in mill, juice from chips		3.41
Solids not sugar, juice from chips		3.20
Ratio of sucrose to glucose		2.94
Co-efficient of purity		60.3
Sucrose in diffusion juice		7.91
Glucose in diffusion juice		2.60
Solids no tsugar, diffusion juice		2.59
Ratio of sucrose to glucose		3.04
Co-efficient of purity		60.4
Sucrose in defecated juice		8.34
Glucose in defecated juice		2.4
Solids not sugar, defecated juice		2.46
Ratio of sucrose to glucose		3.47
Co-efficient of purity		63.6
Total weight of first sugar	pounds	17,608
Sugar added to juice	do	2,600
Total yield of first sugar	do	15,008
Total yield of second sugar	do	2,33
Total yield of molasses	gallons	2,22
Yield per ton:		
First sugar	pounds	113
Second sugar	do	17.5
Molasses	gallons	15.5
First sugar polarized		93
Second sugar polarized		88.7

Temperature in battery was between 75° and 80° C.

SECOND TRIAL.

Eighty-six tons of clean cane were worked—54 tons on October 1 and 32 tons on October 2. All was boiled in one strike. No analyses were made on October 2, and unfortunately the complete data can not therefore be given. The juice was not enriched as in the previous trial.

The following are the results:

Yield of first sugar	pounds	9,292
Yield of second sugar	do	1,988
Yield of molasses	gallons	1,462
Yield per ton:		
First sugar	pounds	108
Second sugar	do	23
Molasses	gallons	17
First sugar polarized		97
Second sugar polarized		88

AVERAGE YIELD OF SUGAR.

Making a fair allowance for cane and juice lost in experiments during the first part of the season, the average yield of first sugars will be fully 100 pounds per ton, polarizing 97. A strike of average molasses boiled to string proof yielded 12½ per cent. of the weight of the *masse cuite* in sugar, containing 88 per cent. of sucrose. This is at the rate of 28 pounds per ton of cane. Had the entire crop been boiled for seconds the average yield per ton of cane would not have been less than 128 pounds of sugar and 16 gallons of molasses. From a financial standpoint the advantage of working for seconds depends entirely on the sirup market. In my judgment it would not have paid this season, as the market is better than for years past. The entire product of 51,000 gallons has already been sold at a good price.

AVAILABLE SUGAR.

It is at once apparent that the old method of calculating available sugar must be abandoned. According to this rule there would be but 61.6 pounds available sugar per ton of cane in the diffusion juice of the first trial, when as a matter of fact 130½ pounds were obtained. It would therefore seem that instead of preventing an equal weight of cane sugar from crystallizing, the glucose and other solids not sugar in the juice prevented only two-fifths of their weight of cane sugar from crystallizing. This is also borne out by the data furnished by the analysis of the juices during the entire season.

Average analyses from tables prepared by Dr. Crampton.

For week ending—	Mill juices.			Diffusion juices.			Total sugar (exhaust chips).
	Brix.	Sucrose.	Glucose.	Brix.	Sucrose.	Glucose.	
September 17	16.9	9.99	3.46	12.8	7.74	2.28	.99
September 24	17.3	9.63	3.52	12.2	6.88	2.35	.96
October 1	16.4	9.44	3.24	10.9	6.34	2.21	.63
October 9	16.4	9.96	3.38	11.0	6.60	2.31	.98
October 16	14.8	9.34	2.98	10.1	6.38	1.90	1.10
Average for season	16.3	9.67	3.31	11.4	6.79	2.21	.93

Average ratio of sucrose to glucose in mill juices 2.92
Average co-efficient of purity of mill juices 59.3
Average ratio of sucrose to glucose in diffusion juices 3.07
Average co-efficient of purity of diffusion juices 59.5

The above table discloses two very important facts:

(1) The very uniform condition of the cane throughout the entire season.

(2) By the use of a small quantity of carbonate of lime in the cells the inversion of cane sugar is entirely prevented.

The amount of sugar left in the chips is larger than it ought to be. This is due, as previously stated, to the bad shape of some of the chips. For this reason the juice was also more dilute, as larger charges had to be drawn in order to get a more complete extraction. Up to September 22 the amount drawn was 2,200 pounds. From this to October 4, 2,640 pounds, and from October 4 to the end of the season 2,420 pounds were drawn.

The temperature of the battery was maintained near 80° C.

EFFECT OF HEAT.

In order to determine the amount of inversion taking place when the juice was evaporated to sirup, in an open pan, the following experiments were made. Juice was boiled down in the open pan used for defecating, and samples taken at different intervals.

The following are the analyses:

Brix.	Sucrose.	Glucose.	Ratio of sucrose to glucose.
13.0	8.08	2.39	3.38
21.7	13.49	3.87	3.48
27.7	33.30	9.50	3.50
	37.20	11.36	3.27
	41.10	lost.	

[Trial on Porter's evaporator.]

Sucrose.	Glucose.	Ratio of sucrose to glucose.
6.71	2.04	3.44
39.20	11.80	3.32
50.00	15.26	3.21
51.00	15.88	3.21

The juice in both cases was made as nearly neutral with lime as possible.

It seems from the above that the invertive action of the heat has been greatly overestimated, and that when the juice is not acid no appreciable inversion takes place even when the juice is reduced to a moderately heavy sirup in an open pan.

From Mr. Parkinson's report it will be seen that the loss in leaves and sheaths amounted to about 11 per cent. of the weight of the topped cane. This loss can no doubt be somewhat reduced when the cleaning machines become better adapted to the work.

According to a number of trials with freshly-cut cane the weight of leaves and sheaths amounted to 10 per cent. and the seed tops to 15 per cent. of the weight of the whole plant. Late in the season when the leaves become dry this proportion is of course considerably less.

COST OF A FACTORY.

A very important fact to determine is the capacity and cost of a factory that will work the cane most economically. There can be no doubt but the advantages are greatly on the side of the large factory. The office expenses and cost of management will be but little, if any, greater. All the machinery required in a large factory is equally necessary in a small one, and the proportionate price of this machinery is in favor of the larger factory. In other words, a factory working 200 tons of cane per day will cost much less than double the cost of a factory working 100 tons. Again, the cost of operating a large factory is proportionately much less. It takes no more men to operate a diffusion battery with a capacity of 200 tons of cane than one half as large, and this is true of the larger part of the machinery in the factory. A point may of course be reached where the size of the machinery becomes too large for economical working, and when the amount of cane needed for working will be greater than can be grown within easy reach of the factory.

Judging from our present knowledge, a factory capable of working from 200 to 250 tons of cleaned cane per day seems the most desirable. This would require a diffusion battery of 12 cells, each cell having a capacity of 112 cubic feet. The evaporating apparatus should have a capacity of 250 tons of water per day and a strike pan with a proportionate capacity. The cost of such machinery will, of course, depend largely on its kind and quality, and can be readily obtained from any reliable manufacturer. The cost of a factory is almost always underestimated, owing to many items which are not taken into account. The capital for building a factory of the above capacity should not be less than $100,000 to $125,000, anything below being certainly unsafe. Nothing but the best machinery should be used and every precaution should be taken to prevent breakage of machinery and to be able to make repairs quickly by having duplicate parts of such machinery as are liable to break. There is no manufacture which depends more for its success on the proper working of the machinery than the sugar industry.

COST OF WORKING.

The success of this industry does not depend altogether on how much sugar can be produced per ton of cane, but the cost of this production must also be considered.

There is no doubt but that $2 per ton for working cane are sufficient to cover all legitimate expenses connected with the manufacture.

UTILIZATION OF THE EXHAUST CHIPS.

It will soon become a matter of necessity to dispose in some way of the exhausted chips from the battery.

The great amount of this material accumulating about the factory makes it imperative that they be utilized in some way. Three methods of disposition have been suggested: (1) To return them to the land as a fertilizer; (2) to use them for fuel; (3) to manufacture into paper pulp. One of the last two methods will no doubt be adopted. Some experiments in using for fuel were made during the season. A large portion of the water was pressed out by passing the chips through a 3-foot cane-crusher. The chips dropped from the last roll into a hopper, from which they were taken up by a suction-fan and blown over to the boiler-house. This method of handling the chips has many features to recommend it. It is very simple, and, besides, the chips are dried somewhat by being subjected to the strong current of air. No doubt the making of paper pulp from the chips will become the most profitable disposition to make of them. The cane, after being reduced to fine chips and thoroughly washed in the diffusion battery, is certainly in an excellent condition for this work. No attempts have been made, as far as I know, to make paper pulp on a large scale from this source, but very fine samples of pure white pulp have been made in a small way. This matter is certainly deserving of thorough investigation.

NEEDS OF THE INDUSTRY.

One of the greatest difficulties which will be encountered by those engaged in developing this industry will be the scarcity of men capable of operating factories. This will be the most serious hindrance to rapid development, as nothing but time can produce men of the requisite experience. The establishment of a school for training young men in this work would be of inestimable value. Here they should receive thorough technical training, which should be supplemented with a drill in the factories while they are in operation. This would in a short time develop a number of men capable not only of taking charge of a factory, but also qualified to conduct independent research, which, in so fruitful a field, could not but result in great good to the industry.

The improvement of the sorghum cane is also one of the subjects which should receive immediate attention.

Although very little has been attempted in this line, enough has been done to show that the cane sugar is greatly increased by good culture, and that it is susceptible of very great improvement by the various methods known to scientific agriculture there can be no doubt. The idea that sorghum cane will grow anywhere and do well with any kind of treatment is one of the main causes of poor cane. Instead of receiving thorough culture, it generally gets only such attention as can be spared from the other crops. If the price paid for cane could be regulated by the actual amount of sugar it contained, the farmer would soon find it to his advantage to devote more time to his cane-field.

The establishment of a sugar refinery within easy reach of the sorghum-sugar factories will be one of the imperative needs in the near future. The demand for any kind of sugar but white granulated is comparatively limited. The sugar produced at Fort Scott averaged within 2½ per cent. of being as pure as the best granulated, while the selling price has been about 1½ cents per pound less, or a difference of about 25 per cent. The most feasible manner of conducting the refinery, at least in the near future, will be to supply one or more factories with the additional appliances needed, and when the season's work is over the sugar from a number of factories could be refined there during the balance of the year.

CONCLUSIONS.

In reviewing the work the most important point suggested is the complete success of the experiments in demonstrating the commercial practicability of manufacturing sugar from sorghum cane.

(2) That sugar was produced uniformly throughout the entire season.

(3) That this was not due to any extraordinary content of sugar in the cane, but, on the contrary, the cane was much injured by severe drought and chinch-bugs.

(4) That the value of the sugar and molasses obtained this year per ton of sorghum cane will compare favorably with that of the highest yields obtained in Louisiana from sugar-cane; and, taking into consideration the much greater cost of the sugar-cane, and that it has no equivalent to the 2 bushels of seed yielded per ton of sorghum cane, also our much cheaper fuel, I say without hesitancy that sugar can be produced fully as cheaply in Kansas as in Louisiana.

M. SWENSON.

SUMMARY OF CHEMICAL WORK DONE AT FORT SCOTT, 1887, *UNDER DIRECTION OF THE CHEMIST OF THE DEPARTMENT.*

[By C. A. CRAMPTON and N. J. FAKE.]

Analyses were begun on the 3d of September, but a full chemical control of the work was not established until the 8th.

Samples of the fresh chips, diffusion juices, and exhausted chips were taken in the usual way, great care being taken to have them represent as accurately as possible the mean properties of the several substances mentioned.

TABLE 1.—*Analyses of juices of fresh chips.*

Number of analyses	55
Sucrose:	Per cent.
Mean	9.54
Maximum	11.51
Minimum	1.39
Glucose:	
Mean	3.40
Maximum	6.49
Minimum	6.20
Total solids (spindle):	
Mean	16.14
Maximum	17.18
Minimum	13.09

TABLE 2.—*Diffusion juices.*

Number of analyses	51
Sucrose:	Per cent.
Mean	6.68
Maximum	8.79
Minimum	5.05
Glucose:	
Mean	2.26
Maximum	3.07
Minimum	1.75
Total solids (spindle):	
Mean	11.08
Maximum	13.10
Minimum	8.64

TABLE 3.—*Exhausted chips.*

Number of analyses	29
Both sugars:	Per cent.
Mean	1.03
Maximum	1.83
Minimum	.49

TABLE 4.—*Clarified juices.*

Number of analyses	25
Sucrose:	Per cent.
Mean	6.91
Maximum	8.25
Minimum	5.11
Glucose:	
Mean	2.19
Maximum	2.85
Minimum	1.69
Total solids (spindle):	
Mean	11.31
Maximum	13.35
Minimum	8.94

TABLE 5.—*Sirups.*

Number of analyses	14
Sucrose:	Per cent.
Mean	29.90
Maximum	41.90
Minimum	16.10
Glucose:	
Mean	10.06
Maximum	16.26
Minimum	7.52

Total solids (spindle):	Per cent.
Mean	46.02
Maximum	60.40
Minimum	36.20

TABLE 6.—*First sugars.*

Number of analyses	28
Sucrose:	Per cent.
Mean	95.64
Maximum	98.10
Minimum	92.40

TABLE 7.—*Second sugars.*

Number of analyses	3
Sucrose:	Per cent.
Mean	85.80
Maximum	88.70
Minimum	82.30

The analyses of the molasses, masse cuites, and some other products are not yet complete, but will be given in full in Bulletin No. 18.

The ratio of sucrose to glucose in the fresh chips and diffusion juices for the season was as follows:

Mill juice	1 : 2.80
Diffusion juice	1 : 2.95

This would seem to show one of two things, either that there was absolutely no inversion in the battery or that the glucose in the cane was not so readily diffused as the sucrose. The latter hypothesis seems to be borne out by the analyses of the exhausted chips, as shown in the following table of analyses:

Sucrose and glucose in juice from exhausted chips and corresponding diffusion juices.

Date.	Exhausted chips.			Diffusion juices.		
	No.	Sucrose.	Glucose.	No.	Sucrose.	Glucose.
		Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Oct. 8	248	.78	.57	247	5.90	3.06
Oct. 11	260	.87	.51	259	6.58	2.09
Oct. 12	267	.63	.29	266	6.17	2.03
Oct. 13	280	.95	.48	279	5.97	1.89
Oct. 14	289	.52	.24	288	6.02	1.80
Oct. 15	294	.75	.27	293	5.66	1.75
Oct. 18	313	.99	.43	312	5.66	2.02
Average	......	.78	.40	......	5.99	2.09

ABSTRACT OF REPORT OF E. B. COWGILL.

HISTORICAL SKETCH.

The sorghum plant was introduced into the United States in 1853–'54 by the Patent Office, which then embraced all there was of the United States Department of Agriculture. Its juice was known to be sweet, and chemists were not long in discovering that it contained a considerable percentage of some substance giving the reactions of cane sugar. The opinion that the reactions were due to cane sugar received repeated confirmations in the formation of true cane-sugar crystals in sirups made from sorghum. Yet the small amounts that were crystallized, compared with the amounts present in the juices as shown by the analyses, led many to believe that the reactions were largely due to some other substance than cane sugar.

EARLY INVESTIGATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

During the years 1878 to 1882, inclusive, while Dr. Peter Collier was chief chemist of the Department of Agriculture, much attention was given to the study of sorghum juices from canes cultivated in the gardens of the Department, at Washington. Dr. Collier became an enthusiastic believer in the future greatness of sorghum as a sugar-producing plant, and the extensive series of analyses published by him attracted much attention from sugar-makers in the South and students of the chemistry of sugar throughout the country.

SUGAR FACTORIES ERECTED IN KANSAS.

Stimulated by the analytical results published by Dr. Collier, interested parties erected large sugar factories and provided them with costly appliances. Hon. John Bennyworth erected one of these at Larned, in this State. S. A. Liebold & Co. subsequently erected one at Great Bend. Both of these factories made some sugar, both lost money, and both quit the business.

Sterling and Hutchinson followed with factories which made considerable amounts of merchantable sugar at no profit.

INFORMATION GAINED.

Much valuable information was developed by the experience in these several factories, but the most important of all was the fact that, with the best crushers, the average extraction did not exceed half of the sugar contained in the cane.

FURTHER WORK OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

In 1883, Prof. H. W. Wiley, chief chemist of the Department of Agriculture, made an exhaustive series of practical experiments in the laboratories of the Department on the extraction of the sugars from sorghum by the diffusion process. His report sums up the results of his experiments as follows:

(1) The extraction of at least 85 per cent. of the total sugars present was secured. In many of the experiments, as will be seen by consulting the table, scarcely a trace of sugar could be detected in the exhausted chips.

(2) The production of a quantity of melada represented by from 10.9 to 12.28 per cent. of the weight of the cane diffused.

This was secured with a cane in which the total sugars did not excede 11.68 per cent. The percentage of melada by this process will be found just about equal to the per cent. of total sugars in the cane.

It ought to be greater with a more perfect extraction, but I am speaking only of results actually obtained.

This yield is just about double that obtained by the large factories at Rio Grande, Champaign, and other places.

(3) The production of a juice of great purity, which lends itself easily to processes of depuration.

I consider the experiments, however, to have their chief value in the fact that they will call the attention of cane-growers to the advantages which a rational system of diffusion will have over pressure in the extraction of the saccharine matter.

I hope to be able at the end of another season to report further progress in this interesting problem.

In the present condition of the sorghum-sugar industry, in which it has alike to be protected from the overzeal of its friends and the opposition of its enemies, the process of diffusion offers the most promising outlook for success. It therefore seems the duty of this division to make a more practical test of this process and on a larger scale.

To make the necessary further experiments with diffusion required the expenditure of large sums of money. As already shown, the private companies had lost heavily. They were utterly unable to complete the experiments so hopefully begun by the Department of Agriculture.

ANOTHER APPROPRIATION.

In 1885, Senator Plumb again labored for an appropriation for experiments with diffusion. Fifty thousand dollars for this purpose was again added to the agricultural appropriation bill, on the amendment of Senator Plumb. This was expended at Ottawa, Kans., and in Louisiana. The report of the work at Ottawa closes as follows:

(1) By the process of diffusion 98 per cent. of the sugar in the cane was extracted, and the yield was fully double that obtained in the ordinary way.

(2) The difficulties to be overcome in the application of diffusion are wholly mechanical. With the apparatus on hand the following changes are necessary in order to be able to work 120 tons per day: (*a*) The diffusion cells should be made twice as large as they now are; that is, of 130 cubic feet capacity. (*b*) The opening through which the chips are discharged should be made as nearly as possible of the same area as a horizontal cross-section of the cell. (*c*) The forced feed of the cutters requires a few minor changes in order to prevent choking. (*d*) The apparatus for delivering the chips to the cells should be remodeled so as to dispense with the labor of one man.

(3) The process of carbonatation for the purification of the juice is the only method which will give a limpid juice with a minimum of waste and a maximum of purity.

(4) By a proper combination of diffusion and carbonatation the experiments have demonstrated that fully 95 per cent. of the sugar in the cane can be placed on the market either as dry sugar or molasses.

(5) It is highly important that the Department complete the experiments so successfully inaugurated by making the changes in the machinery mentioned above and by the erection of a complete carbonatation outfit.

Respectfully,

H. W. WILEY, *Chemist.*

The report of 1885 showed such favorable results that in 1886 the House made an appropriation of $94,000, to be used in Louisiana, New Jersey, and Kansas. A new battery and complete carbonatation apparatus were erected at Fort Scott. About $60,000 of the appropriation was expended here in experiments in diffusion and carbonatation.

In his report Dr. Wiley arrived at the following conclusions:

In a general review of the work the most important point suggested is the absolute failure of the experiments to demonstrate the commercial practicability of manufacturing sorghum sugar. The causes of this failure have been pointed out in the preceding pages, and it will only be necessary here to recapitulate them. They were:

(1) Defective machinery for cutting the canes and for elevating and cleaning the chips and for removing the exhausted chips.

(2) The deterioration of the cane due to much of it becoming overripe, but chiefly to the fact that much time would generally elapse after the canes were cut before they reached the diffusion battery. The heavy frost which came the first of October also injured the cane somewhat, but not until ten days or two weeks after it occurred.

(3) The deteriorated cane caused a considerable inversion of the sucrose in the battery, an inversion which was increased by the delay in furnishing chips, thus causing the chips in the battery to remain exposed under pressure for a much longer

time than was necessary. The mean time required for diffusing one cell was twenty-one minutes, three times as long as it should have been.

(4) The process of carbonatation, as employed, secured a maximum yield of sugar, but failed to make a molasses which was marketable. This trouble arose from the small quantity of lime remaining in the filtered juices, causing a blackening of the sirup on concentration, and the failure of the cleaning apparatus to properly prepare the chips for diffusion.

THE PRESENT STATE OF THE INDUSTRY.

The experiments in making sugar from sorghum, which, as above shown, have been in progress for several years at the expense of private capital and the United States Department of Agriculture, have this year reached so favorable results as to place the manufacture of sorghum sugar on the basis of a profitable business.

The success has been due to, first, the almost complete extraction of the sugars from the cane by the diffusion process; second, the prompt and proper treatment of the juice in defecating and evaporating; third, the efficient manner in which the sugar was boiled to grain in the strike-pan. That these results may be duplicated and improved upon will be readily understood from the showing made in Mr. Parkinson's report, and the descriptions of methods and processes used, and the discussion of the same as they appear in the subsequent pages of this paper.

[Abstract of report of W. L. Parkinson.]

To the Board of Directors Parkinson Sugar Company:

GENTLEMEN: I respectfully submit for your consideration the following report of the operations of the works of your company for the season just closing:

It is provided in our contract with the United States Department of Agriculture that certain experiments in sugar-making shall be made by the Department with certain machinery of its own and at its own expense, using the company's plant and machinery. * * *

As you are aware, the crop of cane contracted for last spring was very much less than the capacity of our works to consume. It was considered prudent to limit our danger from loss, by reason of the experimental nature of the work, and at the same time to have sufficient cane to determine thoroughly the value of the work on a practical manufacturing basis. This has been done, though it is now apparent that had the crop been twice as large, the expenses for working it would have been relatively much less. Indeed, a crop double the size of the one just finished could have been worked in about the same time, and at a comparatively trifling additional expense. The plans, methods, and processes which have made the work of the season successful beyond our most sanguine expectations, were adopted early in the season, so that the risks incident to experiments taken into account when contracting for a crop were reduced to the minimum. The fact that at least a portion of these highly successful processes were not tried and adopted last season was no fault of your company, nor of any one connected with this season's work.

To arrive at the cost per ton of cane worked, let us take the working of a single average day, when in full operation, and apart from the cost of experiments referred to.

The capacity of our factory, aside from deficient centrifugals, is limited to the capacity of the diffusion battery. Working twenty-two hours per day, this battery can comfortably handle 135 tons of chips or cleaned cane. This represents a capacity of field cane, or cane with seed tops and blades, of about 170 tons. To handle this, aside from curing and handling seed, cost us per day of twenty-two hours, when running regularly, as follows:

1 weighmaster, at $2	$2.00
1 team, pulling cane onto storage racks, at $2.50	2.50
5 men, unloading and getting cane to cutters, 22 hours, at 12½ cents	13.75
1 man, cutting machine, at 15 cents	3.30
1 man, cleaning machine, at 12½ cents	2.75
1 man, grinder, etc., at 15 cents	3.30
1 man, oiler, at 15 cents	3.30

3 men, diffusion battery, 1 on car and 2 above, at 12½ cents	$8.25
1 man, diffusion battery, director of battery, at 20 cents	4.40
2 men, defecating, at 15 cents	6.60
2 men, double effects, at 15 cents	6.60
1 man, strike-pan, at $5	5.00
1 man, hot room, at 12½ cents	2.75
1 man, barreler, at 12½ cents	2.75
2 men, centrifugals, at 15 cents	6.60
1 man, machinist, at $3	3.00
2 men, engineers, at 20 cents	4.40
5 men, firemen, at 15 cents	16.50
2 men, roustabouts, at 12½ cents	5.50
1 man, water-boy	2.00
1 man, night watch	1.50
2 men, foremen, at $2.50	5.00
Total cost of labor	111.75
Oil, etc	2.50
Coal, 23 tons slack, at 90 cents	20.70
Total	134.75

This makes the cost of working a ton of cleaned cane, with a factory of the capacity of ours, about $1 per ton for labor and fuel, or 90 cents per ton of field cane. The cost per ton for salaries, insurance, wear and tear, etc., must depend, of course, not only upon the size of the salaries and other general expenses, but the number of tons worked. This plant, rated as above, is capable, in seventy days, of working 9,450 tons of chips, or 11,900 tons of field cane. There is necessarily considerable expense in preparing for the season's work, and again in closing up. Allowing liberally for this and for the proper management and control of the works, we may still bring our total expenses, outside the cost of labor and fuel, at $1 per ton upon the above basis. Add to this the cost of labor and fuel, and we have $2 per ton as the total cost per ton of working cleaned cane. These figures are fully verified by our pay-rolls, coal bills, and other expenses while working to our capacity during the season, separated from expenditures in the completion and changing of machinery directly connected with experiments made. And to work a factory with a capacity at least one-half greater than this one would require very little additional expense except in the matter of fuel, and that would be relatively less. It seems to me a very conservative basis, with a factory of the capacity of ours, to place the actual cost of manufacture at $2 per ton of cane ; and with such a factory as I have indicated, and with a season of, say, seventy days, it is safe to place the cost of manufacture at considerably less than that sum. It requires but little figuring upon this basis, and with the cost of cane at $2 per ton, and the yield of cane and product secured this year, to show that we have here developed a business of great interest and profit to our State and nation.

To run a factory at the maximum profit it must be operated constantly during the working season. The loss this season by reason of the irregular operation of the factory for want of sufficient cane was very considerable. During the whole season the factory was operated but three whole days of twenty-two hours each. Some idea of the loss from this source may be gathered from the fact that not less than 2 tons of chips were lost at each break in the operation of the diffusion battery. Sixty-five such breaks or stoppages were made while running for sugar. With a larger crop of cane and better arrangements for delivery upon the part of the larger contractors, but little or no difficulty from this source need be apprehended in the future.

	Tons.
Total cane bought	3,840
Total seed tops bought	437
Total field cane	4,277

This represents the crop, less about 30 tons of seed tops yet to come in, from about 450 acres of land. There were something over 500 acres planted. Some of it failed to come at all, some "fell upon the rocky places, where they had not much earth, and when the sun was risen they were scorched;" so that, as nearly as we can estimate, about 450 acres of cane were actually harvested and delivered at the works. This would make the average yield of cane 9½ tons per acre, or $19 per acre in dollars and cents. * * *

Of the total cane worked, 162 tons were consumed in experiments with our cutters and cleaning machinery before the cane was ripe enough for use for either sirup or sugar. No product whatever, not even seed, was saved from this, nor from 10 tons additional brought in since the factory closed down. About 300 tons of mostly down and inferior cane was worked in the early part of the season on the crushers, and without diffusion. The only product from this was molasses, and of that but a small quantity. About 375 tons were also worked for molasses only on the diffusion battery. This, with the exception of 50 tons at the close of the season, and which came in too irregularly to be worked for sugar, was worked before the sugar season began, and comprised such down patches and poorer quality of cane as could be gathered, mainly on the lands belonging to the company. It was an open question whether very poor cane could be worked successfully, even for sirups, on a diffusion battery. Nothing in this direction had hitherto been attempted. The total yield of molasses from this source, and from which no sugar has been taken, is 4,157 gallons. From this are sold 3,157 gallons, for $726.71 net. The remaining 1,000 gallons are still on hand, and are worth 25 cents per gallon.

	Tons.
Deducting from total tonnage, less seed	3,840
Amount not worked for sugar	897
We have total cane and leaves for sugar	2,943

The total number of diffusion cells worked for sugar is 2,643. The weight of a cell of chips is 1,975 pounds. With this as a basis there was worked by diffusion for sugar 2,610 tons of clean cane as it entered the cells. Deducting this from 2,943 tons of cane, with leaves and blades, and we have 333 tons of leaves and blades, The latter are to us a dead loss. A small portion has been hauled away by farmers for feed, but the bulk of this large tonnage is now fit only for manure. This waste was considerably increased by the failure of our separating machines, especially in the early part of the season, to properly discharge their duties. This whole subject was new; machines had to be devised, and their adjustment, which is not yet perfect, caused considerable loss of cane. The weight of blades and leaves will not be far from 10 per cent. of field cane. For either feed or fuel, especially where the latter is much of an object, the blades can be utilized so as to at least cover their own cost. At present we figure the loss from this source to seed account.

SEED.

There have been delivered of seed tops 437 tons. As nearly as we can estimate, there are yet to be delivered 30 tons, making in all 467 tons. From the best calculations we can make, and judging from our experience in former years, seed yields about 70 per cent. of the weight of heads, as bought in over the scales, in cleaned seed. Putting it at 60 per cent., and with 56 pounds to the bushel, we shall have 10,000 bushels of cleaned seed. A portion of this, estimated at 1,000 bushels, has, at considerable additional expense, been picked over by hand, head by head, tied into small bundles, and hung up in the dry. This has been done to provide ourselves with pure seed of the different varieties for planting, and to supply a probable want in the same direction from others. For this hand-picked seed we expect to get not less than $2 per bushel. The cost of handling the seed has not been kept separate from the cost of running the factory. The total cost of curing, stacking, and hand-picking will not be far from $700, fully $200 of which has been expended in securing pure and perfectly cured seed for ourselves and others willing to pay the extra price. To thrash and prepare the seed for market the seed will cost about 6 cents per bushel additional. I estimate that we shall get for our seed crop $7,000 net. There will be left of seed tops, after thrashing, fully 100 tons. These are good for feed or fuel.

SIRUPS.

The bulk of our sirups are stored in the large cistern or cellar under the warehouse. The amount on hand we estimate at 50,000 gallons. This includes the whole crop, except the 3,157 gallons sold in early part of season. Of this we have sold, to be delivered within thirty days, and one car-load of which has already gone, 250 barrels, or about 12,500 gallons, at a price that will net us here 20 cents. This sale includes the bulk of our poorest sirups. I think we can safely estimate our sirup product, exclusive of packages, at $10,000. Considering the condition of our factory for work in cold weather, and the limited capacity of our centrifugal machinery, I recommend their sale, without boiling for seconds.

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W. L. PARKINSON.

OUTLINE OF THE PROCESSES OF SUGAR-MAKING.

As now developed, the processes of making sugar from sorghum are as follows:

(1) The topped cane is delivered at the factory by the farmers who grow it.

(2) The cane is cut by a machine into pieces about 1¼ inches long.

(3) The leaves and sheaths are separated from the cut cane by fanning mills.

(4) The cleaned cane is cut into fine bits called chips.

(5) The chips are placed in iron tanks, and the sugar "diffused"—soaked out with hot water.

(6) The juice obtained by diffusion has its acids nearly or quite neutralized with milk of lime, and is heated and skimmed.

(7) The defecated or clarified juice is boiled to a semi-sirup in vacuum pans.

(8) The semi-sirup is boiled "to grain" in a high vacuum in the strike-pan.

(9) The mixture of sugar and molasses from the strike-pan is passed through a mixing machine into centrifugal machines, which throw out the molasses and and retain the sugar.

DETAILS OF THE PROCESSES OF SUGAR-MAKING.

An account of the processes of sugar-making ought, doubtless, to begin with the planting and cultivation, growth, and ripening of the cane, for it is here that the sugar is made. No known processes of science or art, save those of plant growth, produce the peculiar combination of carbon with the elements of water which we call sugar. Not only is this true, but the chemist utterly fails in every attempt to so modify existing similar combinations of these elements as to produce cane sugar. It will be interesting here to note three substances of nearly the same composition, viz, starch, sucrose or cane sugar, and glucose or grape sugar. Their compositions are much alike, and may be stated as follows:

	Carbon.	Water.
Starch*	12	10
Cane sugar	12	11
Grape sugar	12	12

* The chemical formulas for these compounds are: Starch, $C_6H_{10}O_5$; cane sugar, $C_{12}H_{22}O_{11}$; grape sugar, $C_6H_{12}O_6$; in which C represents an equivalent of carbon, H of hydrogen, and O of oxygen, or H_2O an equivalent of water.

The chemist produces glucose, or grape sugar, from either starch or sugar by treatment with acid, but all attempts have failed to produce cane sugar from either starch or grape sugar.

THE FARMER THE REAL SUGAR-MAKER.

The farmer, then, or perhaps more accurately the power which impels the plant to select and combine in proper form and proportions the three elements, carbon, hydrogen, and oxygen, is the real sugar-maker. All after processes are merely devices for separating the sugar from the other substances with which it grows.

HOW IS THE SUGAR FORMED IN THE CANE?

The process of the formation of sugar in the cane is not fully determined; but analyses of canes made at different stages of growth show that the sap of growing cane contains a soluble substance having a composition and giving reaction similar to starch. As maturity approaches, grape sugar is also found in the juice. A further advance towards maturity discloses cane sugar with the other substances, and at full maturity perfect canes contain much cane sugar and little grape sugar and starchy matter.

In sweet fruits the change from grape sugar to cane sugar does not take place, or takes place but sparingly. The grape sugar is very sweet, however.

INVERSION OR CHANGE OF CANE SUGAR INTO GRAPE SUGAR.

Cane sugar, called also sucrose or crystallizable sugar, when in dilute solution, is changed very readily into grape sugar or glucose, a substance which is much more difficult than cane sugar to crystallize. This change, called inversion, takes place in overripe canes; it sets in very soon after cutting in any cane during warm weather; it occurs in cane which has been injured by blowing down or by insects or by frost, and it probably occurs in cane which takes a second growth after nearly or quite reaching maturity.

Inversion will be further considered in another place.

THE FARMER'S PART MOST IMPORTANT OF ALL.

Since sugar is produced only by nature's processes of growth and is easily lost through inversion, it is evident that the farmer's part in the process of sugar-making is first and most important of all. It is a subject which invites most careful, scientific, and practical attention, and will be further considered under the subject "Improving the cane."

It is apparent from what has already been said that to insure a successful outcome from the operations of the factory the cane must be so planted, cultivated, and matured as to make the sugar in its juice; that it must be delivered to the factory very soon after cutting; and that it must be taken care of before the season of heavy frosts.

THE WORK AT THE FACTORY.

THE FIRST CUTTING.

The operations of the factory are illustrated in the large drawing, to which the reader is referred in tracing the successive steps. The first cutting is accomplished in the ensilage or feed-cutter. This cutter is provided with three knives, fastened to the three spokes of a cast-iron wheel, which makes about 250 revolutions per minute, carrying the knives with a shearing motion past a dead knife. By a forced feed the cane is so fed as to be cut into pieces about 1¼ inches long. This cutting frees the leaves and nearly the entire sheaths from the pieces of cane. By a suitable elevator the pieces of cane, leaves, and sheaths are carried to the second floor.

THE CLEANING.

The elevator empties into a hopper, below which a series of four or five fans is arranged one below the other. By passing down through these fans the cane is separated from the lighter leaves much as grain is separated from chaff. The leaves are blown away, and finally taken from the building by an exhaust fan. This separation of the leaves and other refuse is essential to the success of the sugar-making, for in them the largest part of the coloring and other deleterious matters are contained. If carried into the diffusion battery these matters are extracted (see reports of Chemical Division, U. S. Department of Agriculture), and go into the juice with the sugar. As already stated, the process of manufacturing sugar is essentially one of separation. The mechanical elimination of these deleterious substances at the outset at once obviates the necessity of separating them later and by more difficult methods, and relieves the juice of their harmful influences. From the fans the pieces of cane are delivered by a screw carrier to an elevator, which discharges into

THE FINAL CUTTING-MACHINE

on the third floor. This machine consists of an 8-inch cast-iron cylinder with knives like those of a planing-machine. It is really three cylinders placed end to end on the same shaft, making the entire length 18 inches. The knives are inserted in slots and held in place with set-screws. The cylinder revolves at the rate of about 1,200 per minute, carrying the knives past an iron dead knife, which is set so close that no cane can pass without being cut into fine chips.* From this cutter the chips of cane are taken by an elevator and a conveyor to the cells of the diffusion battery. The conveyor passes above and at one side of the battery, and is provided with an opening and a spout opposite each cell of the battery. The openings are closed at pleasure by a slide. A movable spout completes the connection with any cell which it is desired to fill with chips.

WHAT IS DIFFUSION?

The condition in which the sugars and other soluble substances exist in the cane is that of solution in water. This sweetish liquid is contained, like the juices of plants generally, in cells. The walls of these cells are porous. It has long been known that if a solution of sugar in water be placed in a porous or membranous sack and the sack placed in water, an action called osmose takes place, whereby the water from the outside and the sugar solution from the inside of the sack each pass through until the liquids on the two sides of the membrane are equally sweet. Other substances soluble in water behave similarly, but sugar and other readily crystallizable substances pass through much more readily than uncrystallizable or difficultly crystallizable bodies. To apply this property to the extraction of sugar the cane is first cut into fine chips, as already described, and put into the diffusion cells, where water is applied and the sugar is displaced.

WHAT HAS TAKEN PLACE IN THE DIFFUSION CELLS.

For the purpose of illustration, let us assume that when a cell has been filled with chips just as much water is passed into the cell as there was juice in the chips. The process of osmose or diffusion sets in, and in a few minutes there is as much sugar in the liquid outside of the cane cells as in the juice in these cane cells; *i. e.*, the water and the juice have divided the sugar, each taking half. Again, assume that as much liquid can be drawn from one as there was water

*This machine is the device of Mr. H. A. Hughes.

added. It is plain that if the osmotic action is complete the liquid drawn off will be half as sweet as cane juice. It has now reached fresh chips in two, and again equalization takes place. Half of the sugar from one was brought into two, so that it now contains $1\frac{1}{2}$ portions of sugar, dissolved in 2 portions of liquid, or the liquid has risen to $\frac{3}{4}$ of the strength of cane juice. This liquid having $\frac{3}{4}$ strength passes to three, and we have in three $1\frac{3}{4}$ portions of liquid, or after the action has taken place the liquid in three is $\frac{7}{8}$ strength. One portion of this liquid passes to four, and we have $1\frac{7}{8}$ portions of sugar in 2 portions of liquid, or the liquid becomes $\frac{15}{16}$ strength. One portion of this liquid passes to five, and we have in five $1\frac{15}{16}$ portions of sugar in 2 portions of liquid, or the liquid is $\frac{31}{32}$ strength. It is now called *juice*, and is drawn off and subjected to the processes of the subsequent operations of the factory. From this time forward a cell is drawn for every one filled.

a	1	2	3	4	5	6	7	8	9	10	11	12
1	w											
2	w	l										
3	w	l	l									
4	w	l	l	l								
5	w	l	l	l	l							
6	w	l	l	l	l	j						
7	w	l	l	l	l	l	j					
8	w	l	l	l	l	l	l	j				
9	w	l	l	l	l	l	l	l	j			
10		w	l	l	l	l	l	l	l	j		
11			w	l	l	l	l	l	l	l	j	
12				w	l	l	l	l	l	l	l	j
13	j				w	l	l	l	l	l	l	l
14	l	j				w	l	l	l	l	l	l
15	l	l	j				w	l	l	l	l	l
16	l	l	l	j				w	l	l	l	l
17	l	l	l	l	j				w	l	l	l
18	l	l	l	l	l	j				w	l	l
19	l	l	l	l	l	l	j				w	l
20	l	l	l	l	l	l	l	j				w
21	w	l	l	l	l	l	l	l	j			
22		w	l	l	l	l	l	l	l	j		
23			w	l	l	l	l	l	l	l	j	
24				w	l	l	l	l	l	l	l	j
25	j				w	l	l	l	l	l	l	l
26	l	j				w	l	l	l	l	l	l
27	l	l	j				w	l	l	l	l	l
28	l	l	l	j				w	l	l	l	l
29	l	l	l	l	j				w	l	l	l

Throughout the operation the temperature is kept as near the boiling point as can be done conveniently without danger of filling some of the battery cells with steam. Diffusion takes place more rapidly, at high than at low temperatures, and the danger of fermentation, with the consequent loss of sugar, is avoided. The process will be readily understood from the above diagram, in which the columns represent the cells of the battery, the numbers at the left the number of diffusions; *w*, water; *l*, liquid in the cells, or passing through them, and *j*, juice to be drawn.

INVERSION OF SUGAR IN THE DIFFUSION CELLS.

In the experiments at Fort Scott in 1886 much difficulty was experienced on account of inversion of the sugar in the diffusion battery. The report shows that this resulted from the use of soured cane and from delays in the operation of the battery on account of the imperfect working of the cutting and elevating machinery, much of which was then experimental. Under the circumstances, however, it became a matter of the gravest importance to find a method of preventing this inversion without in any manner interfering with the other processes. On the suggestion of Professor Swenson a portion of freshly precipitated carbonate of lime was placed with the chips in each cell. In the case of soured cane this took up the acid which otherwise produced inversion. In case no harmful acids were present this chalk was entirely inactive. Soured canes are not desirable to work under any circumstances, and should be rejected by the chemist and not allowed to enter the factory. So, also, delays on account of imperfect machinery are disastrous to profitable manufacturing and must be avoided. But for those who desire to experiment with deteriorated canes and untried cutting machines, the addition of the calcium carbonate provides against disastrous results which would otherwise be inevitable.

CLARIFYING OR DEFECATING THE JUICE.

Immediately after it is drawn from the diffusion battery the juice is taken from the measuring tanks into the defecating tanks or pans. These are large, deep vessels, provided with copper steam coils in the bottom for the purpose of heating the juice. Sufficient milk of lime is added here to nearly or quite neutralize the acids in the juice, the test being made with litmus paper. The juice is brought to the boiling point, and as much of the scum is removed as can be taken quickly. The scum is returned to the diffusion cells, and the juice is sent by a pump to the top of the building, where it is boiled and thoroughly skimmed. These skimmings are also returned to the diffusion cells.

This method of disposing of the skimmings was suggested by Mr. Parkinson. It is better than the old plan of throwing them away to decompose and create a strench about the factory. Probably a better method would be to pass these skimmings through some sort of filter, or, perhaps better still, to filter the juice and avoid all skimming. After this last skimming the juice is ready to be boiled down to a thin sirup, in

THE DOUBLE-EFFECT EVAPORATORS.

These consist of two large closed pans provided within with steam pipes of copper, whereby the liquid is heated. They are also connected with each other and with pumps in such a way as to reduce the pressure in the first to about three-fifths and in the second to about one-fifth the normal atmospheric pressure.

The juice boils rapidly in the first at somewhat below the temperature of boiling water, and in the second at a still lower temperature. The exhaust steam from the engines is used for heating the first pan, and the vapor from the boiling juice in the first pan is hot enough to do all the boiling in the second, and is taken into the copper pipes of the second for this purpose. In this way the evaporation is effected without so great expenditure of fuel as is necessary in open pans or in single-effect vacuum pans, and the deleterious influences of long-continued high temperature on the crystallizing powers of the sugar are avoided.

From the double effects the sirup is stored in tanks ready to be taken into the strike-pan, where the sugar is crystallized.

THE FIRST CHANCE TO PAUSE.

At this point the juice has just reached a condition in which it will keep. From the moment the cane is cut in the fields until now every delay is liable to entail loss of sugar by inversion. After the water is put into the cells of the battery with the chips, the temperature is carefully kept above that at which fermentation takes place most readily, and the danger of inversion is thereby reduced. But with all the precautions known to science up to this point the utmost celerity is necessary to secure the best results. There is here, however, a natural division in the process of sugar-making, which will be further considered under the heading of "auxiliary factories." Any part of the process heretofore described may be learned in a few days by workmen of intelligence and observation who will give careful attention to their respective duties.

BOILING THE SIRUP TO GRAIN THE SUGAR.

This operation is the next in course, and is performed in what is known at the sugar factory as the strike-pan, a large air-tight vessel from which the air and vapor are almost exhausted by means of a suitable pump and condensing apparatus. As is the case with the saccharine juices of other plants, the sugar from sorghum crystallizes most readily at medium temperature. There are two ways of proceeding. The simplest is to boil the sirup in the vacuum pan until it has reached about the density at which crystallization begins, then draw it off into suitable vessels and set it away in a hot room (about 110° to 120° F.) to crystallize slowly. The proper density is usually judged by the boiler, by observing the length to which a sample of the hot liquid from the pan can be drawn. This is called the "string-proof" test. A far better method is to "boil to grain" in the pan. This is better because it gives the operator control of the size of the grain within certain limits, because it gives a better appearing sugar, and more important still, because with proper skill it gives a better yield. Several descriptions of this delicate operation have been published. After reading some of the best of these, the writer found, on attempting to boil to grain, that more definite instruction was necessary; and after obtaining the instruction it became apparent that while almost any one can learn to "boil to grain," yet to obtain the best yield requires personal skill and powers of observation and comparison which will be obtained in widely different degrees by different persons. To become a good sugar-boiler one must be an enthusiastic specialist. The Department of Agriculture was fortunate in securing for this important work the services of Mr. Frederick Hinze, a native of Hanover, Germany, and a graduate of the "Sugar Industry School" at Braunschweig.

The process of boiling to grain may be described as follows: A portion of the sirup is taken into the pan and boiled rapidly *in vacuo* to the crystallizing density. If in a sirup the molecules of sugar are brought sufficiently near to each other through concentration—the removal of the dissolving liquid—these molecules attract each other so strongly as to overcome the separating power of the solvent, and they unite to form crystals. Sugar is much more soluble at high than at low temperatures, the heat acting in this as in almost all cases as a repulsive force among the molecules. It is therefore necessary to maintain a high vacuum in order to boil at a low pressure in boiling to grain. When the proper density is reached the crystals sometimes fail to appear, and a fresh portion of cold sirup is allowed to enter the pan. This must not be sufficient in amount to reduce the density of the contents of the pan below that at which crystallization may take place. This cold sirup causes a sudden though slight reduction of temperature, which may so reduce the repulsive forces as to allow the attraction among the molecules to prevail, resulting in the inception of crystallization. To discover this requires the keenest observation. When beginning to form, the crystals are too minute to show either form or size, even when viewed through a strong magnifying glass. There is to be seen simply a very delicate cloud. The inexperienced observer would entirely overlook this cloud, his attention probably being directed to some curious globular and annular objects, which I have nowhere seen explained. Very soon after the sample from the pan is placed upon glass for observation the surface becomes cooled and somewhat hardened. As the cooling proceeds below the surface contraction ensues, and consequently a wrinkling of the surface, causing a shimmer of the light in a very attractive manner. This, too, is likely to attract more attention than the delicate, thin cloud of crystals, and may be even confounded with the reflection and refraction of light, by which alone the minute crystals are determined. The practical operator learns to disregard all other attractions, and to look for the cloud and its peculiarities. When the contents of the pan have again reached the proper density another portion of sirup is added. The sugar which this contains is attracted to the crystals already formed, and goes to enlarge these rather than to form new crystals, provided the first are sufficiently numerous to receive the sugar as rapidly as it can crystallize.

The contents of the pan are repeatedly brought to the proper density, and fresh sirup added, as above described, until the desired size of grain is obtained, or until the pan is full. Good management should bring about these two conditions at the same time. If a sufficient number of crystals has not been started at the beginning of the operation to receive the sugar from the sirup added, a fresh crop of crystals will be started at such time as the crystallization becomes too rapid to be accommodated on the surfaces of the grain already formed. The older and larger crystals grow more rapidly, by reason of their greater attractive force, than the newer and smaller ones on succeeding additions of sirup, so that the disparity in size will increase as the work proceeds. This condition is by all means to be avoided, since it entails serious difficulties on the process of separating the sugar from the molasses. In case this second crop of crystals, called "false grain" or "mush sugar," has appeared, the sugar-boiler must act upon his judgment, guided by his experience, as to what is to be done. He may take enough thin sirup into the pan to dissolve all of the crystals, and begin again, or, if very skillful, he may so force the growth of the false grain as to bring it up to a size that can be worked.

No attempt will be made here to describe the methods of "boiling for yield," nor to point out the methods by which many special difficulties are to be overcome. Not only does the limited experience of the writer make him hesitate to enter upon these intricate subjects, but their discussion would unduly extend this report. It may be remarked that the handling of the cane, the treatment of the juice, and the preparation of the sirup, have much to do with the difficulties and success of this, the most intricate of all.

THE FINAL SEPARATION OF THE SUGAR FROM THE MOLASSES.

The completion of the work in the strike-pan leaves the sugar mixed with molasses. The mixture is called *melada* or *masse cuite*. It may be drawn off into iron sugar wagons and set in the hot room above mentioned, in which case still more of the sugar which remains in the uncrystallized state generally joins the crystals, somewhat increasing the yield of "first sugar." At the proper time these sugar wagons are emptied into a mixing machine, where the mass is brought to a uniform consistency. If the sugar wagons are not used, the strike-pan is emptied directly into the mixer.

THE CENTRIFUGAL MACHINES.

From the mixer the melada is drawn into the centrifugal machines. These consist, first, of an iron case resembling in form the husk of mill-stones. A spout at the bottom of the husk connects with a molasses tank. Within this husk is placed a metallic vessel with perforated sides. This vessel is either mounted or hung on a vertical axis, and is lined with wire cloth. Having taken a proper portion of the melada into the centrifugal, the operator starts it to revolving, and by means of a friction clutch makes such connection with the engine as gives it about 1,500 revolutions a minute. The centrifugal force developed drives the liquid molasses through the meshes of the wire cloth, and out against the husk, from which it flows off into a tank. The sugar, being solid, is retained by the wire cloth. If there is in the melada the "false grain" already mentioned, it passes into the meshes of the wire cloth, and prevents the passage of the molasses. After the molasses has been nearly all thrown out, a small quantity of water is sprayed over the sugar while the centrifugal is in motion. This is forced through the sugar, and carries with it much of the molasses which would otherwise adhere to the sugar, and discolor it. If the sugar is to be refined, this washing with water is omitted. When the sugar has been sufficiently dried, the machine is stopped, the sugar taken out, and put into barrels for market.

Simple as the operation of the centrifugals is, the direction of the sugar-boiler as to the special treatment of each strike is necessary, since he, better than any one else, knows what difficulties are to be expected on account of the condition in which the melada left the strike-pan.

CAPACITY OF THE SUGAR FACTORY.

It has already been shown that the operation of the diffusion battery should be continuous. The experience so far had in diffusing sorghum indicates eight minutes as the proper time for filling a cell; or one cell should be filled and another emptied every eight minutes. This, with a battery of 12 cells, 9 of which are under pressure, gives seventy-two minutes as the time during which the chips are subject to the action of the water. If the chips are cut sufficiently fine, the time may be reduced to seven or even to six minutes to the cell without probable loss from poor extraction. The time may be extended to ten minutes per cell without danger of damage when working sound canes.

Taking eight minutes as the mean, we shall have 180 as the number of cells diffused in a day. To secure the best results, all other parts of the factory must be adjusted to work as rapidly as the diffusion battery, so that the capacity of the battery will determine the capacity of the factory.

A plant having a battery like that at Fort Scott, in which the cells are each capable of containing a ton of cane chips, should then have a capacity of 180 tons of cleaned cane, or 200 tons of cane with leaves, or 240 tons of cane as it grows in the field, per day of twenty-four hours. Those who have given most attention to the subject think that a battery composed of $1\frac{1}{2}$-ton cells may be operated quite as successfully as a battery of 1-ton cells. Such a battery would have a capacity of 360 tons of field cane per day.

THE CUTTING AND CLEANING APPARATUS.

This consists of modifications of appliances which have long been used for other purposes. Simple as it is, and presenting only mechanical problems, the cutting, cleaning, and elevating apparatus is likely to be the source of more delays and perplexities in the operation of the sugar factory than any other part.

The diffusion battery in good hands works perfectly; the clarification of the juice causes no delays; the concentration to the condition of semi-sirup may be readily, rapidly, and surely effected in apparatus which has been brought to great perfection by long experience, and in many forms; the work at the strike-pan requires only to be placed in the hands of an expert; the mixer never fails to do its duty. There are various forms of centrifugal machines on the market, some of which are nearly perfect. If, then, the mechanical work of delivering, cutting, cleaning, and elevating the cane can be accomplished with regularity and rapidity, the operation of a well-adjusted sugar factory should proceed without interruption or delay from Monday morning to Saturday night.

The machines used at Fort Scott for these purposes have not been described in detail. They need only to be made stronger and simpler. Their general plan is not far from that which is likely to be in general use in the near future.

The methods of handling cane need some modifications as to details. The arrangement for making the factory engine unload the cane from the farmers' wagons will probably never be abandoned, since it is much more rapid and leaves the cane in better shape than it can be left by hand.

THE SCIENTIFIC WORK.

The present favorable condition of the sorghum-sugar industry, like the immense development of the beet-sugar industry of Europe, is indebted for its existence largely to long-continued scientific work; and while much of the scientific manipulation which it was once feared would be necessary to success has been eliminated in practice, yet the scientist has not been able to so far simplify the subject as to enable the manufacturer to dispense with his services. I shall try here to make a plain statement of the scientific work necessary in a sugar factory under developments so far made.

WHERE THE SCIENTIFIC WORK IS NEEDED.

It has already been shown that it is only on reaching maturity that sorghum is a profitable sugar plant. To determine when most farm products are ripe is a simple matter of inspection. But it is astonishing to note how greatly different will be the views of, say, a dozen practical farmers as to when a given field of wheat is ripe. Experience in judging of the ripeness of sorghum is far less extended than in the case of wheat. Indeed, the varying conditions of the weather so greatly affect the appearance of ripeness, *i. e.*, the hardness of the seed, the condition of the leaves, etc., that the manufacturer, who must know before he uses cane whether it is ripe or green, is left no other than the test of chemical analysis. This determines the one point of interest to him, namely, whether the cane has reached such a degree of maturity as to have made its sugar.

Again, although the cane may have reached full maturity, if it shall have been cut and exposed to the atmospheric influences of the earlier part of the season for any considerable time, the sugar may have been changed to glucose. In moist weather this change may take place without any accompanying change in the appearance of the cane. A notable instance illustrating this kind of depreciation occurred at the Parkinson works during the season just closed. A farmer brought in a sample of excellent-looking cane. The book-keeper, who has had considerable experience about sugar factories, examined it, and after ascertaining by the hydrometer that the juice contained about 13 per cent. of dissolved solids, was about to direct the farmer to bring in the cane. An analysis showed that about 8 of this 13 per cent. was glucose, 3 per cent. sugar, and 2 per cent. other substances not more valuable than glucose. Inquiry disclosed the fact that the cane had been cut for three days. The weather had been moist, so that no change in appearance had taken place. To have worked such cane for sugar would have been worse than useless, since the glucose and other substances its juice contained would have held from crystallization not only the 3 per cent. of sugar which this cane contained, but a considerable amount more had it been worked with better juice.

Instances might be multiplied to show the perplexities and disappointments which are liable to result unless a most careful supervision be had of the condition of the cane when it enters the factory. Certainly no field of cane should be cut until the development of its sugar has been reached and determined by the best means available.

In the early part of the season, while the weather is warm, all cane cut in the forenoon should be worked the same day, and that cut in the afternoon should be worked by noon the next day. During the cooler weather of the latter part of the season it is not necessary to be quite so prompt. The delays which will be admissible can be determined by analysis of the cane.

Not only is it necessary to know that the cane enters the factory with its sugar intact, but it is important to see that it does not suffer inversion during the process of manufacture. To prevent this all delays must be avoided. The cane must go promptly and regularly through the cutters and cleaners as rapidly as it can be thoroughly diffused. In a pile of cane chips inversion of the sugar very soon begins, and is soon followed, if not accompanied, by acetic fermentation. If acetic or other active acid be present in the diffusion cells it causes rapid inversion of the sugar under the high temperature of the battery. After leaving the battery the treatment of the juice must be prompt to guard against inversion. Indeed, as has been remarked above, every part of the factory in which the work is done until the juice has been reduced to a sirup should be of such a capacity that it can surely do its work at all times as rapidly as the battery can be operated. It is a matter of great importance to the manufacturer to know whether, at any stage of the process, inversion is taking place. To determine this, analysis of the average samples of freshly-cut chips may be compared with analysis of the product at other stages. For example: To determine whether inversion is taking place in the battery, crush out and analyze the juice from samples of chips as they enter; then analyze samples of the diffusion juice as it comes from the battery. If the relation of sugar to glucose is the same in these analyses it may be concluded that no inversion is taking place. If, however, the proportion of sugar to glucose is smaller in the diffusion juice than in that obtained directly from the chips by crushing, inversion is probably taking place, and its cause must be sought and remedied.

The subsequent processes of manufacture give little occasion for inversion, unless from delay before the juice has been reduced to sirup. The safest plan is to not let it cool until it is ready for the strike-pan. If unavoidable delays lead to a suspicion that inversion may have taken place, the matter may be determined by analysis. Inversion is not the only cause of loss to be guarded against in the battery. As shown by the report of the Chemist of the United States Department of Agriculture, the average extraction of the battery at the Parkinson factory this season was 92.04 per cent. of all the sugars the cane contained. A closer average extraction than 95 per cent. is scarcely to be expected, and an extraction of less than 90 per cent. should be considered inadmissible. Poor extraction may result from overhurrying the battery, from allowing the temperature to run too low, from raising the temperature too high, thereby filling the upper parts of the cells with steam instead of water, or from improper manipulation of the valves, or from failure of the cutting machines to properly prepare the chips. The perfection of the extraction may be determined by analysis of the exhausted chips from the battery, and if not found satisfactory, the cause is of course to be sought out and remedied.

It is desirable for the manufacturer to know how much sugar he is leaving in the molasses, and also how much molasses he is leaving in the sugar; *i. e.*, the purity of the sugar. These points are readily determined by analysis.

WHO CAN DO THIS SCIENTIFIC WORK?

It is doubtless desirable, though not essential, that the superintendent of a sugar factory be also a chemist. The analyses indicated in the above pages are not intricate. To make them all, however, will require considerable time, and whether the superintendent be capable or incapable of making them, he will scarcely be able to spare the time which ought to be devoted to them.

Any of the graduates of our agricultural or other colleges who have taken a good course of chemistry, with laboratory practice, can by a few months' special training in sugar chemistry and practice in sugar analysis become entirely competent to do the work required in the ordinary operation of a factory, under the direction of the superintendent.

THE YIELD OBTAINED AT FORT SCOTT.

The actual yield obtained was 234,607 pounds of first sugar, from 2,501 cells. If, now, the cell be taken as a ton, the yield of first sugar was 234,607÷2,501=93.8 pounds. Enough of the molasses was reboiled for a second crop of crystals, and the sugar separated, to ascertain that 15 to 20 pounds per ton of cane represented could be obtained. Calling it 15, we have for the entire yield 93.8+15=108.8 pounds per ton of cleaned cane. This is a larger yield than is obtainable according to the heretofore accepted theory. There is some uncertainty about the weight of a cell, which may account for the discrepancy between the theoretical and the actual results. It is possible, however, that the theory may need reconstruction. In any case the yield actually obtained is most gratifying.

I have made no mention in the above of the exceptionally large yields of some special strikes made during the season. One strike gave 109 pounds of merchantable sugar for each cellful of chips. The seconds from this would doubtless have brought the yield up to 130 pounds. But the general reader and the prospective manufacturer are more interested in average than in special results. It seems safe to assume that a mean of 100 pounds of sugar and 12 gallons of molasses can be made from each ton of cleaned sorghum cane of average richness.

Science suggests several methods for the complete separation of the cane sugar from the grape sugar and the "not sugar," and further experiments in this direction should be the work of the near future. As yet almost nothing has been done towards the development of methods of separating the grape sugar from the not sugar. This subject presents a most inviting field for the chemist.

THE FUTURE OF THE SORGHUM-SUGAR INDUSTRY.

The sorghum-sugar industry now seems to have an assured future. The quantities of sugar and molasses and other valuable products obtained from each ton of the cane and from each acre of land, well renumerate the farmer for his crop and the manufacturer for his investment and the labor and skill required to operate the factory.

An acre of land cultivated in sorghum yields a greater tonnage of valuable products than in any other crop, with the possible exception of hay. Under ordinary methods of cultivation, 10 tons of cleaned cane per acre is somewhat above the average, but the larger varieties often exceed 12, while the small Early Amber sometimes goes below 8 tons per acre. Let 7½ tons of cleaned cane per acre be assumed for the illustration. This corresponds to a gross yield of 10 tons for the farmer, and at $2 per ton gives him $20 per acre for his crop. These 7½ tons of clean cane will yield—

	Pounds.
Sugar	750
Molasses	1,000
Seed	900
Fodder (green leaves)	1,500
Exhausted chips (dried)	1,500
Total	5,650

The first three items, which are as likely to be transported as wheat or corn, aggregate 2,650 pounds per acre.

Sorghum will yield 7½ tons of cleaned cane per acre more surely than corn will yield 30 bushels or wheat 15 bushels per acre.

In the comparison, then, of products which bear transportation, these crops stand as follows:

Sorghum, at 7½ tons, 2,650 pounds per acre.

Corn, at 30 bushels, 1,680 pounds per acre.

Wheat, at 15 bushels, 900 pounds per acre.

The sugar from the sorghum is worth, say, 5 cents per pound; the molasses, 1¾ cents per pound; the seed. ½ cent per pound.

The products give market values as follows:

750 pounds sugar, at, say, 5 cents*	$37.50
1,000 pounds molasses, at, say, 1¾ cents*	17.50
900 pounds seed, at, say, ½ cent*	4.50
Total value of sorghum, less fodder	59.50
The corn crop gives 1,680 pounds, at ½ cent	7.40
The wheat crop gives 900 pounds, at 1 cent	9.00

Thus it will be seen that the sorghum yields to the farmer more than twice as much per acre as either of the leading cereals, and as a gross product of agriculture and manufacture on our own soil more than six times as much per acre as is usually realized from either of these standard crops.

LENGTH OF THE SEASON FOR WORKING SORGHUM.

The season for harvesting sorghum is limited to the months during which it may be worked. At present this dates in our southern counties from about the last of July to the middle or last of October, if a proper selection of varieties of cane has been made. Without doubt this season may and will be lengthened. On this point I can do no better than quote from my report to this Department in 1884:

> As shown by the reports of the sugar factories of Kansas for the last two years, the working season is confined almost exclusively to the months of September and October. When the great cost of sugar-works, the expense of keeping them in repair, and the salaries of the specialists are considered the importance of lengthening the working season becomes painfully apparent. That a $100,000 factory should lie idle for ten months every year implies that it must be run at an enormous profit during the two months or fail to pay interest on the investment.
>
> Several plans have been proposed for extending the time during which the works may run. One of these is the development of earlier varieties of cane by systematic selection of seed, cultivation, and breeding. The researches of modern physiological botanists give reason to hope for good results in this direction.
>
> Another plan proposed is to reduce the juice to a semi-sirup in small auxiliary factories, store the semi-sirup, and make it into sugar during the winter months. This has much to commend it.

CENTRAL AND AUXILIARY FACTORIES—SIZE OF FACTORIES.

The complete sugar factory is an expensive establishment, and while most of the work of operating it can be performed by laboring men of ordinary intelligence, there will be required in each of such factories, whether large or small, at least two men whose attainments will command liberal compensation. These are the chemist, or the superintendent, with a cheaper chemist for an assistant, and the sugar-boiler. Good business management is of course also necessary to success. The chemist and the sugar-boiler can preside over a large as well as over a small factory. Moreover, many of the labors of the factory can be performed with no fewer men in a small than in a large factory. It will therefore be cheaper to work a given amount of cane and to turn out a given amount of product in large than in small factories. The limit, however, beyond which experience so far does not warrant manufacturers to go is believed to be at a capacity of about 270 tons of cleaned cane per day.

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*The sugar sold this year at 5¾ cents per pound, the molasses at 20 cents per gallon, and the seed at —— per bushel of 56 pounds. The seed is of about equal value with corn for feeding stock.

In order to use to the best advantage the services of the specialists of the business, it has been proposed to establish at convenient places auxiliary factories which shall carry the processes so far as to prepare sirup for the strike-pan. This sirup will be stored in suitable tanks or cisterns and worked for sugar after the close of the season for handling cane. In this way the working season for the central factory may be prolonged to occupy almost the entire year. The auxiliary factories will cost about half or two-thirds as much as the complete factory, capable of taking care of the same amount of cane. As thus arranged, the central factory will, in addition to its own regular season's work, take care of the sirup from two or three of these sirup factories.

LETTERS PATENT GRANTED TO M. SWENSON.

UNITED STATES DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., December 10, 1887.

SIR: In response to the resolution of the Senate of the 7th instant, directing me to inform the Senate whether any person in the employ of this Department has applied for or obtained a patent on any process connected with certain experiments in the manufacture of sugar from sorghum, conducted under the auspices of the Government, I have the honor to make the following statement of facts:

For the fiscal year 1886–'87 Congress made an appropriation of $94,000 for "continuing and concluding experiments in the manufacture of sugar by the diffusion and saturation process, from sorghum and sugar-cane." By virtue of this appropriation the Commissioner appointed, under date of July 19, 1886, Mr. Magnus Swenson "an agent of this Department to superintend, under the direction of the Chemist, the experiments in the manufacture of sugar from sorghum at Fort Scott, Kans."

In his report to me, under date of December 21, 1886, Professor Wiley, the Chief Chemist of this Department, in detailing the experiments above alluded to, stated that an acidity existed in the diffusion bath, causing a conversion of a portion of sucrose (sugar) into glucose, and that several experiments had been made to correct this acidity. Among those experiments was one in which he added "freshly precipitated carbonate of lime to the extraction bottle," a method which he states was suggested by Professor Swenson. At the close of these experiments, November 15, 1886, Mr. Swenson's service ceased. On April 27, 1887, he was again appointed "superintendent of sugar experiments at Fort Scott, Kans.," which position he now holds. On October 21, 1887, I was informed that Professor Swenson was seeking a patent for the process which he had suggested as above stated, and while in the line of his duty, and which had been tried in a public experiment with the people's money and for the benefit of the country. On that date I filed with the Commissioner of Patents my protest against any action on the part of his office by which Professor Swenson, as an individual, should reap the benefit of this experiment. In answer to that letter I received a communication from the Commissioner of Patents, under date of October 26, stating that Professor Swenson had been allowed letters patent on the process, under date of October 11, 1887. In that patent the following claims were allowed to Professor Swenson:

(1) As an improvement in the diffusion process of making sugar, the mode herein described of preventing the invertive action of the organic acids in the cane chips upon the sugar during the process of extraction, said mode consisting in adding to the diffusion bath a carbonate of the alkaline earths, substantially as set forth.

(2) As an improvement in the diffusion process of making sugar, the mode herein described of preventing the invertive action of the organic acids in the cane chips upon the sugar during the process of extraction, said mode consisting in adding to the diffusion bath calcium carbonate, substantially as set forth.

The application for this patent was filed on December 29, 1886, after Professor Swenson's employment by the Government had ceased, but the nature of the claims is so closely allied to the experiment made with carbonate of lime, heretofore alluded to, that it seems to leave no doubt that Professor Swenson intended to cover in his patent the suggestion which he made in the line of his duty, which was adopted during his employment, and which amounted only to an improvement in a process which had been conceived, planned, and was then being perfected by the Government of the United States.

I deem it proper to add that I have had an exhaustive search made of judicial decisions and legal opinions bearing upon the validity of a patent granted under these circumstances, and that I have become convinced th t the state of the art, and the fact of Mr. Swenson's appointment and employment by this Department, will affect the validity of his claim, and that I have therefore called the attention of the Attorney-General to all the facts in the case and suggested to him the institution of a suit looking to a perpetual injunction to restrain Professor Swenson from making any use of this patent.

As bearing upon this case, I beg respectfully to inclose, as an appendix to this communication, certain citations and memoranda for the information of the Senate, and in this connection I beg also to recommend such immediate action on the part of the legislative branch of the Government as will enable the Attorney-General, if he has not now sufficient authority, to institute a suit looking to the cancellation of the patent in question.

Very respectfully, your obedient servant,

NORMAN J. COLMAN,
Commissioner of Agriculture.

Hon. JOHN J. INGALLS,
President pro tempore United States Senate.

[Copy of statement of facts submitted to the Attorney-General for his information by the Commissioner of Agriculture.]

Letters Patent, No. 371528, issued to Magnus Swenson. Manufacture of sugar.

STATEMENT OF FACTS.

The Department of Agriculture directed its attention to the manufacture of sugar from maize and sorghum cane in the year 1877, and since that time has continuously been engaged in investigations and experiments for the purpose of discovering a process that would extract the sugar from these canes in a commercially successful manner. These experiments have been carried on by direct authorization of Congress.

The first session of the Forty-seventh Congress appropriated: "for experiments in the manufacture of sugar from sorghum, beets, and other sugar-producing plants, twenty-five thousand dollars" (Stat. L., vol. 22, p. 91).

The same Congress at its second session appropriated $16,000 (vol. 22, p. 410); the Forty-eighth Congress at its first session appropriated $50,000 (vol. 23, p. 38), and at its second session, $40,000 (vol. 23, p. 354), for the same purpose. In 1883 the Chemist of the Department conceived the idea of adapting the "diffusion process," successfully used in Europe in the manufacture of beet sugar, to the extraction of sugar from sorghum and maize cane. The results of the experiments carried on in this direction during the year 1883 are contained in special Bulletins Nos. 2 and 3, issued by the Chemical Division of the Department in 1884.

Further investigations were made during the year 1884, and a chemist from the Chemical Division was sent to Europe to study the "diffusion process" as practiced there and the machinery used in its application. The results of the work for this year are fully set out in Bulletin No. 5. Bulletin No. 6 contains a record of the work for the year 1885.

In the fall of 1885 Professor Wiley, Chemist of the Department, was directed to proceed to Europe to study the "diffusion process." Bulletin No. 8 gives the result of his visit there and conclusions reached as to the proper adaptation of process and machinery to manufacture sugar in this country from sorghum cane by the "diffusion process."

As a result of the investigations and experiments brought down to 1886, this Department felt convinced that it had reached a satisfactory solution of sugar manufacture as applied to sorghum, and that it had secured a successful method and devised suitable machinery to establish this work as one of the commercial industries of the country. To test the process and the machinery devised on a commercial scale, and for the purpose of perfecting by experiments any defect that might arise either in the chemical progress of the process or mechanical arrangement of the machinery, the Department received from Congress an appropriation for these purposes.

On June 30, 1886, there was appropriated as follows: "For purchase, erection, transportation, and operation of machinery, and necessary traveling within the United States, and other expenses in continuing and concluding experiments in the manufacture of sugar, by the 'diffusion and saturation processes,' from sorghum and sugar cane, so much thereof as may be necessary, to be immediately available, $94,000" (Stat. L., vol. 23, p. 101).

Under this act of Congress the Commissioner of Agriculture, on the 19th of July, 1886, employed and appointed one Magnus Swenson to "superintend, under the direction of the Chemist, the experiments in the manufacture of sugar from sorghum at Fort Scott, Kans.," at a salary of $2,400 per annum, during the continuance of the experiments. A copy of this appointment is hereto appended (Exhibit A).

The experiments carried on under the foregoing act of Congress last mentioned are set out in detail in Bulletin No. 14, a copy of which is appended (Exhibit B).

In the course of these experiments a difficulty was met with, described on page 28 of Exhibit B, namely, an acidity in the diffusion battery, which caused an inversion of a portion of sucrose into glucose, thereby diminishing the amount of sugar that should be obtained. On the same page are detailed the experiments made to overcome this defect. Experiment No. 4, "the addition of freshly precipitated carbonate of lime to the 'extraction bottle,'" was suggested by Mr. Swenson, the superintendent of the experiments under the foregoing employment. Comments on the result of this experiment will be found on pages 32 and 33 of Bulletin 16.

Experiments at Fort Scott, Kans., were discontinued on November 15, 1886, and the service of Mr. Swenson as agent of this Department ceased on that day.

On December 29, 1886, Mr. Swenson filed an application for letters patent for an improvement in the manufacture of sugar, and on October 11, 1887, letters patent No. 371528 were issued to him.

This patent is for the use of carbonate of lime and carbonates of other alkaline earths in the diffusion bath to prevent the invertive action of organic acids during the process of extraction. It is simply a patent for experiment No. 4, as made at Fort Scott, Kans., by this Department, and set out on page 28 of Bulletin 16.

I am informed that Mr. Swenson is now threatening to prosecute all persons who shall use the method described and covered by his patent, and this Department, still being engaged in experimentation for the manufacture of sugar, will be liable to Mr. Swenson in damages for using a process discovered by itself if the patent aforesaid is rightfully the property of Mr. Swenson.

II.

CONDITION OF THE ART.

The aforesaid patent is for the use of carbonate of the alkaline earths to neutralize organic acids present in saccharine solutions, and thus prevent inversion of sucrose into glucose. This is not new, and has been known to those engaged in the art of manufacture of sugar for years, and allusions are to be met with to its use in works describing this art, and patents have been issued for this same means for neutralizing acidity in saccharine solutions in England. A brief reference to some of these will be made.

In a work entitled "Sugar Growing and Refining," by Wigner and Harland, published in London in 1882, the following allusions are made pertinent to this part of the art.

On page 185, in describing the diffusion process, it says:

"In order to insure the solidification in the tissues of the soluble substance injurious to the sugar, especially of pectine, which is not coagulated by hot water alone, *lime or some other suitable agent* may be added to the water or liquor."

On page 504 of the same work, in speaking of the alum process, it says:

"After the separation of the alum it is possible to *neutralize* the *acid liquor* with *chalk* (carbonate of lime) only, and this has been done on a large scale for a considerable time. The use of chalk has an advantage over lime in that should an *excess* be added it does no harm to the sirup beyond simply *increasing the insoluble deposit in the filters*."

A description of the identical advantage claimed by Mr. Swenson in his patent, lines 52 to 58: " * * * it is possible to neutralize the acid liquor with some other alkaline body instead of lime; among other substances which have been tried for this purpose are ammonia, carbonate of ammonia, baryta, carbonate of baryta, strontia, carbonate of strontia, magnesia, carbonate of magnesia." These are the carbonates of alkaline earths mentioned in the patent, lines 58 to 63.

In a pamphlet published in Cincinnati in 1876, entitled "Extraction du Jus Sucré des Plantes sacchariféres, par Diffusion," the author of which is G. Bouscaren, is found, on page 2, a description of the alleged improvement patented by Swenson, and it speaks of the addition of chalk (carbonate of lime) to either the water of the diffusion battery or to the pulp of the cane itself before it goes into the battery.

The following is a translation of the paragraph referred to:

"The solidification of the albumen, pectine, and other elements injurious to the sugar being made in the tissue of the pulp itself by the *addition* of a *proper* quantity of *chalk*, either to the water of alimentation or to the pulp itself before its introduction into the macerators."

Of the English patents that have been issued may be noted the following:

In 1813, No. 3754, to one Howard, the use of alum, lime, and chalk.

In 1874, No. 1736, to Johnson, the use of alkaline carbonates prior to treatment of the sugar with alcohol.

In 1874, No. 1989, to James Duncan, the neutralization of the free acids arising in saccharine solutions by means of carbonate of lime.

III.

From the foregoing statements the following conclusions may be drawn:

(1) That the above patent is held by Mr. Swenson in trust for the use and benefit of the Government and its citizens, the discovery patented having been made by him while specially employed in experimentation, and under an implied contract granting to the Government all property in the results of such experimentation.

(2) That the thing patented was a suggestion made by an employé specially employed for the purpose, and which only amounted to the curing of a defect in a part of a process already planned in its entirety by another, and which of itself was not a complete invention, and which suggestion would belong to the inventor of the process under whom he was working.

(3) The patent is invalid in that the thing patented is not *new*.

Under the first head it is sufficient to say that Congress having authorized the making of these sugar experiments at public expense, they are made for the benefit of the public at large, and the results that spring from them become the property of the Government, to the free use of which all citizens are equally entitled. Persons employed in the carrying on of such experiments, so authorized, by the acceptance of the employment waive all personal right to any discoveries they may make in the course of their employment, and by implication contract that such discoveries shall become the property of the Government. It would be incompatible with the object of the act of Congress authorizing the making of experiments, that any personal property to discoveries made by persons employed under the law should be retained by them, for, if so, then the end had in view, the general benefit of the public, would be destroyed, and public moneys would be expended merely to enable private persons to make discoveries for their own personal use and advantage, and not for the general welfare of the people. Congress would be granting public moneys for private use, and this it can not constitutionally do.

While there are no adjudicated cases bearing upon the right of a person employed by the Government to make experiments to discoveries made by him in the course of experiments, there is a dictum by Justice Field, in the case of the United States *v.* Burns, 12 Wallace, page 246, where he says: "If an officer in the military service, *not specially employed to make experiments with a view to suggested* improvements, devises a valuable improvement, he is entitled to the benefit of it, and to letters patent," etc.

This may be held to imply the *converse*, that where such officer was employed to experiment he would *not* be entitled to patent his improvement.

Under the second head, it is sufficient to state that the suggestion made by Mr. Swenson makes a case on all fours with the general doctrine laid down in the leading case of Agawam *v.* Woolen Company (7 Wallace, 583), on the relations between employers and employés, and that such improvement as he suggested would be for the use and benefit of his employer.

The doctrine is thus stated in the opinion by Justice Clifford:

"Persons employed, as much as employers, are entitled to their own independent inventions, but where the employer has conceived the plan of an invention and is engaged in experiments to perfect it, no suggestions from an *employé*, not amounting to a new method or arrangement, which in itself is a complete invention, is sufficient to deprive the employer of the exclusive property in the perfected improvements. But where the suggestions go to make up a perfect and complete machine, embracing the substance of all that is embodied in the patent subsequently issued to the party to whom the suggestions were made, the patent is invalid, because the real invention or discovery belongs to another," and cases cited.

Under the third head it is unnecessary to comment, for the thing patented not being new, the patent is invalid.

IV.

REMEDY.

The possession by Mr. Swenson of this patent has a serious and damaging effect on the progress of the manufacture of sugar from sorghum cane in this country. It is a cloud on the title of the people of this country to make use of a discovery which the Government has at public expense made. Congress, in authorizing the expending of $225,000 to promote this manufacture, was mindful of its great importance and the benefits to arise from utilizing sorghum cane, which could be grown over an immense area of this country and make valuable thousands of acres of land, and and at the same time cause the production of the home supply of sugar.

This new enterprise has received a damaging blow, and it is desirable that the law department of the Government should take all necessary steps to protect this enterprise, to remove the cloud that to-day prevents the free use of this manufacture as perfected by the Department of Agriculture, and secure to the people the full benefit of all its works.

It is suggested that where a patent has been improperly obtained by a person employed by the Government to carry on experiment for discoveries made in the course of the experiments, the patentee may be *restrained* by injunction from appropriating to his own use any of the rights granted by the patent. This is the view as held by Attorney-General Cushing in an opinion to be found in volume 7, Opinions Attorneys-General, page 656.

EXPERIMENTS AT RIO GRANDE, N. J.

Report of H. A. Hughes.

SIR: I have the honor to present herewith my report, as superintendent of the experiments conducted at Rio Grande the past season, on the manufacture of sugar from sorghum.

The Hughes Sugar House Company is located at Rio Grande, Cape May County, N. J. The building of this company is constructed of brick and iron, 30 feet square, and fully equipped with machinery for extracting and working into merchantable products all of the sugar from 15 tons of cane per day.

The machinery consists of a cleaning and shreding apparatus, a diffusion battery, an open evaporator, vacuum pan, hot room, wagons, and centrifugal.

The cane is cut into sections, freed from leaves, sheaths, and seed tops, and passed in at once to the shreding knives. The leaves and seed tops are also separated and collected into different receptacles. All this machinery is automatic, and the capacity of the cleaning apparatus was proved to be equal to the cleaning of 44 tons in twenty-two hours. It worked without delay or repairs of any description, and the wear and tear was so slight that at the close of the season its condition appeared to be as good as when first started. All this apparatus had been thoroughly tested during the season of 1886.

The shreded cane is packed into perforated baskets and it is then ready for the diffusion battery.

This battery differs radically from those in ordinary use, and was planned in 1886. During this season its work was not perfectly satisfactory, concentration of juice being gained only at a serious loss of sugar in the waste products; but after the close of the season and when the battery was properly managed it was proven and the tests recorded, which have shown that it can extract practically all of the sugar in the cane at an expense for evaporation of 10 per cent. only in excess of that for mill juice; this result is satisfactory, and is believed to be better than that given by any other battery. The diffusion juice from this battery was evaporated in an open pan until one-half of its water was removed; it was then drawn into the vacuum, still further concentrated, grained into the same pan, and struck into sugar wagons in the hot room. The centrifugal machine separated the crude molasses from the raw sugar, leaving it in a condition suitable for refiners' uses. Storage tanks, settling tanks, filter presses, defecators, clarifiers, and chemicals of any kind were not used. The vacuum pan and centrifugal machine do not differ from well-known forms.

THE CROP.

Eighty acres of cane were planted for the use of the mill, and of this 7 acres were grown by neighboring farmers and the balance by the company. Varieties planted were Amber, White African, Kansas Orange, and Late Orange, from which 910 pounds of sugar and 80 gallons of molasses per acre were made. In this account is included the unripe cane used in breaking in the house and all damaged cane. The tonnage far exceeded our greatest expectations. This was occasioned by carefully planting the hills closer and giving it good attention, together with favorable rains. The cost of raising the cane was $11.62 per acre. This includes the hauling out of fertilizers and placing them upon the land, which consisted of 150 pounds muriate of potash per acre, and rotten chips from previous seasons, together with a little stable manure in spots. The cost of potash and chips are not included in the above. The cost of cutting the cane and bringing it to the factory was 45 cents per ton. We paid $3 per day for the use of teams and farm hands, and laborers were paid $1.25 per day.

The average yield was 16½ tons per acre. All the farmers' cane was worked and 27.38 acres of that raised by the company. Over 47 acres were left in the fields. One tract (8.43 acres) averaged 25 tons of cane per acre, from which 1,400 pounds of raw sugar and 120 gallons of molasses per acre were extracted.

Part of the field was used in breaking in the house.

The yields of the farmers' crops varied widely, the maximum being 1,970 pounds of raw sugar and 120 gallons of molasses per acre. This was made from 17 tons and 675 pounds of field cane. The term "field cane" means neither stripped nor topped. The minimum was 540 pounds of sugar and 60 gallons of molasses. All the seed used by the farmers was the same. The variations in yield were caused by the difference in cultivation. Other yields were as follows per acre:

	First.	Second.	Third.	Fourth.
Sugar........pounds..	1,970	1,560	1,444	1,254
Molasses........gallons..	120	120	80	116

The company grew this cane on shares, giving the farmers one-half the products, viz, sugar, molasses, and seed. The basis of settlement was for raw sugar 4 cents per pound and molasses at 25 cents per gallon. Consequently the four best acres yielded (reduced to a cash basis) as follows:

	Quantity.	Amount.	Total.
Ephraim Hildrith:			
Sugar, at 4 cents........pounds..	1,970	$78.80	$108.80
Molasses, at 25 cents........gallons..	120	30.00	
Joseph Richardson:			
Sugar, at 4 cents........pounds..	1,560	62.40	92.40
Molasses, at 25 cents........gallons..	120	30.00	
William Hollingshead:			
Sugar, at 4 cents........pounds..	1,444	57.76	77.76
Molasses, at 25 cents........gallons..	80	20.00	
John Brown:			
Sugar, at 4 cents........pounds..	1,254	50.16	79.16
Molasses, at 25 cents........gallons..	116	29.00	

This does not include the seed, which has not been thrashed.

WORKING SEASON.

The company commenced breaking in its machinery on September 5 and closed on November 8, making fifty-two days. Twelve days in the commencement of the season were consumed in training men to manage the new machinery. The working season was the most unfavorable since 1880. Frost occurred in the last week in September, but did little damage. Ice one-half inch thick was found on October 15. The crop at that time was growing beautifully and the sugar tests rising rapidly, and the day following this freeze the leaves turned white and died.

At that time we were working on the Kansas Orange fields. This variety did not deteriorate for several days, but at the expiration of this time it gradually declined until October 28, when the purity of the juice was reduced so low that it did not warrant our working any longer for sugar. During this period there were several frosts.

Another effect of the ice on this variety of cane was to make it unable to withstand the repeated heavy gales of wind, which finally blew it down and broke it badly.

It was especially our desire to study the effects of frost on the different varieties, and we were fully aware that we could at any time increase our average sugar per acre by leaving this variety and working the Late Orange. After October 28 we commenced cutting on the Late Orange fields, which had withstood frost and ice in marked contrast with the other cane. This variety stood the freezes and thaws with very little change, and at the time of the closing of the house it was still up to the average of the season in purity.

The cane was worked after this date at intervals in the diffusion battery until November 22. The cane brought in at this time was frozen solidly, but the juice was in good condition. Warm weather having intervened from the 22d to the 26th, the cane was sampled and tested on November 26 with the intention of making a run for sugar on December 1. Other matters having interfered this was not carried out. There is not the slightest doubt that good sugar crystals could have been obtained until December 1.

This cane has at last been weakened by the unusually severe weather during the past week. It is falling down badly and is only fit for sirup on this date, December 7.

The sugar per acre could have been increased fully 23 per cent. on this season's work by good extraction. It must not be overlooked that the raw sugar made this season would have to be reduced from 20 to 25 per cent. in order to make it chemically pure.

Another source of loss to which I desire to call your attention is in the harvesting of the seed. The seed tops are cut off, spread on the fields to dry, stacked up, and afterwards thrashed. By this method we rarely obtain more than 1½ bushels of seed from a ton of field cane. There is a constant loss in the field during the drying by the seed shelling out and the ravaging of birds. Field mice and rats also attack the stacks. Samples of seed tops carefully saved from these same fields show an average yield, on well-developed canes, of 3 bushels per ton. If this seed could be saved it would be of sufficient value to pay the coal bill for working up the crop in this place.

In making the above statements I wish it to be distinctly understood that neither time nor expense was spared in order to make these records accurate, the house being frequently delayed in order that the records might be secured.

I believe that a ton of field cane is too uncertain a factor to be used as a standard for calculation, as it varies considerably in wet and dry weather. Wagons containing 3,000 pounds of cane, as it comes from the field, will increase to 3,400 pounds and more by being rained on. There is a variation in the weight of the cane before and after frost; also in the percentage of leaves of the large and small canes. For these reasons it is better to use clean chips prepared for the battery or an acre of ground.

It might be worth while to state that this sugar-house, with slight alteration, could be made to work 25 tons per day, having frequently worked at this rate from six to eight hours.

Believing that sorghum-sugar manufacture is to be an established industry and that reports of this nature will have an attraction for the general public, I have written in this simple style and tried to avoid technicalities. Those who wish the details I refer to the reports of your chemists, Messrs. Broadbent and Edson, who, I believe, have faithfully recorded the workings of the house; also to the report of the experimental station of New Jersey, soon to be issued.

Respectfully,

H. A. HUGHES,
Superintendent.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture, Washington, D. C.

NOTE.—For further information concerning the sorghum-sugar industry in New Jersey see Dr. Neale's Bulletin No. 44 of the New Jersey Experiment Station.

SUMMARY OF CHEMICAL WORK AT RIO GRANDE, UNDER DIRECTION OF THE CHEMIST OF THE DEPARTMENT.

[Abstract of report of Hubert Edson.]

The manufacturing season at Rio Grande commenced September 5 and closed November 8. The analyses of juices were begun September 8 and continued throughout the season.

On October 15 there fell a heavy frost, one of the earliest known in Rio Grande, which completely killed all the leaves on the cane and stopped the growth of all the unripe fields. The Late Orange was the only variety which was not seriously injured by the frost and the cold weather following it. This hardy cane, although the frost touched it before it was matured, held its sucrose to the end of the season, even notwithstanding two slight freezes.

It will be noticed from Table III that the extraction of sugar by the battery was very poor. This arose from improper management of the battery by the men employed in the diffusion room, much sugar being thrown out with the exhausted chips from this cause.

EXPERIMENTS IN CRYSTALLIZING SUGARS.

All the sugars as first run from the centrifugal were full of "smear," and after the regular season had closed experiments were made as to the advisability of recrystallizing the sugar, but it was found that the loss in weight was too great to make it profitable, only 8,329 pounds of recrystallized sugars being obtained from nearly double that amount of smear sugar.

In Table VIII are found the analyses of the recrystallized sugars.

On November 19 and 22 experiments were made with the diffusion battery to see if it was possible to obtain a better extraction than the season's work had given.

An extra cell was made and placed outside the battery. Then, instead of emptying one cell of diffusion juice at a time, the two heaviest juices were drawn into the outside cell. By drawing off two cells at a time two baskets of fresh chips could be immersed each time in the outside cell, and the diffusion juice be brought up within 1° Brix of the mill juice, and at the same time an excellent extraction obtained. Both the days in which these experiments were made were very cold. This, of course, made it difficult to keep the battery at a sufficiently high temperature for a proper diffusion.

In the appended table the degree Brix is all that is given, as the juices were not used:

	Chip juice.	Diffusion juice.	Exhausted chip juice.
Average degree Brix:			
November 19	15.50	14.65	1.30
November 22, a. m	13.42	12.66	1.48
November 22, p. m	15.18	13.79	.88

These experiments were conducted by Mr. Hughes and Dr. Neale, chemists of the New Jersey experimental station. The degrees Brix were taken by Dr. Neale and myself.

A sample of chip juice was polarized and found to contain 8.98 per cent. sucrose, with a purity of 59.27.

RESULTS OF ANALYSES.

TABLE 1.—*Analyses of juice from fresh chips.*

Number of analyses	61
	Per cent.
Mean sucrose	8.98
Mean glucose	3.24
Mean total solids (by spindle)	14.02
Sucrose:	
Maximum	12.28
Minimum	4.71

	Per cent.
Glucose:	
Maximum	4.45
Minimum	2.07
Total solids:	
Maximum	17.80
Minimum	10.45

TABLE 2.—*Analyses of diffusion juices*

Number of analyses	63
	Per cent.
Mean sucrose	6.93
Mean glucose	2.86
Mean total solids (spindle)	11.18
Sucrose:	
Maximum	10.02
Minimum	3.89
Glucose:	
Maximum	3.97
Minimum	1.32
Total solids:	
Maximum	14.40
Minimum	8.38

TABLE 3.—*Sirups.*

Number of analyses	55
	Per cent.
Mean sucrose	18.68
Mean glucose	8.67
Mean total solids (spindle)	32.40
Sucrose:	
Maximum	25.26
Minimum	10.78
Glucose:	
Maximum	15.70
Minimum	3.81
Total solids:	
Maximum	43.16
Minimum	19.88

TABLE 4.—*Exhausted chips.*

Number of analyses	58
	Per cent.
Mean sucrose	2.46
Mean glucose	.98
Mean total solids (spindle)	4.03
Sucrose:	
Maximum	4.23
Minimum	.81
Glucose:	
Maximum	1.62
Minimum	.30
Total solids:	
Maximum	6.64
Minimum	1.33

TABLE 5.—*Masse cuites.*

Number of analyses	6
	Per cent.
Mean sucrose	55.76
Mean glucose	23.44
Mean water	18.50
Mean ash	4.44

TABLE 6.—*Raw sugars.*

Number of analyses	14
	Per cent.
Mean sucrose	73.80
Mean glucose	13.63
Mean water	5.89
Mean ash	2.56

TABLE 7.—*Molasses.*

Number of analyses	14
	Per cent.
Mean sucrose	35.48
Mean glucose	32.20
Mean water	34.72
Mean ash	5.45

TABLE 8.—*Recrystallized sugars.*

Number of analyses	9
	Per cent.
Mean sucrose	90.73
Mean glucose	4.63
Mean water	4.19
Mean ash	.71

(NOTE.—The analyses of *masse cuites* sugars and molasses are only partial. The complete analyses will be given in Bulletin 18.)

ESTIMATES OF COST OF SUGAR FACTORIES, MADE BY MR. H. A. HUGHES.

SMALL CENTRAL SUGAR HOUSE.

Cost and summary of machinery.

One vacuum pan. 4 feet	$850.00
One vacuum pump	500.00
Thirty sugar wagons, at $14	720.00
Two Weston centrifugals, complete, with mixer, at $850	1,700.00
Four tanks, water, sirup, dumps, and extra, at $25	100.00
One 50 horse-power boiler	600.00
One engine, 15 horse power	400.00
Pipe-fittings	800.00
Two boiler feed pumps, at $90	180.00
One water pump	200.00
Two sirup pumps, at $90	180.00
Extra work, machinist, two months, and labor	520.00
Buildings	3,000.00
Freights, lights, and extras	250.00
Total	9,000.00

Capacity of house per day.

Six wagons on 1,080 gallons molasses worked into *masse cuite* for an average, say, 4 pounds sugar to a gallon, or	pounds..	4.320
And 45 per cent. sirup	gallons..	488
For 260 days, from September 1 to July 1	pounds..	1,123,200
For 260 days, from September 1 to July 1	gallons..	126,880

Crew, cost of manning, and cost per gallon.

	Per day.
Day shift:	
One fireman	$1.50
One centrifugal	1.50
One sirup and coopering	2.50
One sugar boiler	3.00

	Per day.
Night shift:	
One fireman	$1.50
One pan man	1.50
	11.50
Three tons soft coal, at $2.50	7.50
	19.00
Cost per gallon	1.77
Twenty-five gallons for 1 ton field cane ......cents	44½

SMALL AUXILIARY PLANTATION HOUSE.

One diffusion battery, 50 to 75 tons, complete	$5,000.00
Cutting and cleaning apparatus	800.00
One double effect	2,500.00
Two juice pumps, at $90	180.00
Seven small tanks	100.00
One large tank	25.00
Engine, 8 horse-power	200.00
Boilers, 100 horse-power	1,000.00
Two boiler feed pumps, at $125	250.00
One water pump	250.00
One hot-water pump	125.00
Pipe-fittings	500.00
Building one-story shed	1,000.00
Labor, freight, and incidentals	800.00
Total	13,330.00

Capacity per day.

Lowest estimate, 50 tons field cane; 25 gallons molasses, 45 to 56 per cent. test for each ton field cane worked; 25 gallons for each ton × 50=1,250 per day for eighty days = 100,000 gallons, or 4 acres of ordinary cane per acre for each day; or 320 acres per season of eighty days.

Three such plants would supply 300,000 gallons in a working season.

Crew, cost of manufacture, and cost per ton.

One man throwing cane on carrier	$1.25	
One man on seed topper	1.25	
One man filling baskets	1.25	
One man on eleventh cell	1.25	
One man hanging on baskets	1.25	
One man center	1.25	
One man bagasse	1.25	
One man double effect	1.50	
One man firing	1.50	
One man driving away seed and leaves	1.25	
Total, 10 men	13.00	
One horse on cart	1.00	
	14.00×2 =	$28.00
Labor		28.00
Coal, 5 tons, at $2.50		12.50
		40.50

Or 80.1 cents per ton for labor, etc.

RECAPITULATION.

Capital invested, small central house	$9,000
Capital invested, three small auxiliaries, $13,330	39,990
Total	48,990
	Tons.
Amount of cane worked, 150 tons for eighty days	12,000

Product.

12,000 tons, yielding 25 gallons molasses each	gallons..	300,000
300,000 gallons molasses, yielding 4 pounds sugar each	pounds..	1,200,000
And 45 per cent. molasses	gallons..	135,000
1,200,000 pounds, at 4 cents		$48,000
135,000 gallons, at 20 cents		27,000
18,000 bushels seed, at 40 cents		7,200
Total		82,200

Cost of production.

	Cents.
Auxiliary house, per ton	80.01
Central house, per ton	44.25
	124.26
Cost of packages, per ton	30.00
	154.26×12,000=$18,511

Farmers' half, $41,100 or $3.43 per ton; the company's half, $41,100, less $18,511, $22,589 for interest, insurance, superintendence, etc.

In working 1,000 tons a day there should be ten 100 to 175 ton batteries and a large central house. Auxiliary houses of this size would cost complete about $20,000 each and the central house would cost without bone-black $90,000. There would also be a corresponding reduction in working expenses.

EXPERIMENTS AT LAWRENCE, LA.

CANE-SLICER.

In order to secure a multiple feed for a single cutter it was determined to adopt the horizontal disk system. Cutters of this kind not being made in this country, it was necessary to purchase one in Europe.

The cutter built by the Sangerhauser Company, of Sangerhausen, Germany, was selected. This cutter was guarantied to give from 200 to 250 tons of chips per twenty-four hours, suitable for diffusion.

This slicing machine, having been tried in Demerara in the early summer, proved inefficient. To guard against failure from lack of a proper cutter another machine, which had already proved successful in Java, was ordered from the Sudenburg Company of Magdeburg.

The small cutter with a horizontal disk, tried at Fort Scott last year, was also sent to New York for certain alterations, and thence to Magnolia. Unfortunately the new knives sent with the machine had not been properly tempered, and this prevented the use of this cutter for the preliminary experiments.

Mr. R. Sieg, of New Orleans, who had had large experience in working cane-cutters in Louisiana in 1874 and the following years, was also instructed to build a cutter with vertical disk and multiple feed. We found, however, that the time at his disposal was too short to permit the building of such a machine as he desired.

On October 6 I received the following instructions:

You are hereby instructed to go to Fort Scott, Kans., and after inspecting the work of the Department there in the manufacture of sugar, you will proceed to Lawrence, La., to conduct the work of the Department at that place in the application of diffusion to the extraction of sugar from sugar-cane.

You are also authorized to travel between Magnolia Station and New Orleans as often as may be necessary to secure the proper conduct of public business.

Very respectfully,

NORMAN J. COLMAN,
Commissioner.

In obedience to the above instructions I reached Magnolia on the evening of October 17, 1887. The experimental work was conducted without being complicated by the use of any process or machinery in which any one in the employment of the Department had any patented or financial interest whatever. The sole object in view was to benefit those engaged in the manufacture of sugar in all parts of the country. Experiments conducted at public expense should, in my opinion, be for the public good, and not for the benefit of a private individual or corporation.

On the morning of the 19th the diffusion building was badly injured by a cyclone. The water-tank to supply the battery, together with the tower supporting it, was blown on to Governor Warmoth's sugar-house, causing great damage. Nearly a month was required to repair the damage and restore the building and apparatus to the condition in which it was before the storm.

The delays incident to the working of new machinery were numerous. The original plan contemplated having all the machinery ready by the 1st of October, thus permitting a series of preliminary trials extending over a month before the regular season began.

Instead of this, however, unavoidable delays, incident to the imperfections of the machinery and the damage of the storm, postponed even the preliminary experiments until the beginning of December.

A recital of the details of these delays would only lengthen the report without adding anything to its value. It must be said, however, in this connection that the gentlemen associated with me worked earnestly and faithfuly through all the discouragements attending the preparation of the machinery.

Mr. Ernest Schulze, representing the Sangerhauser Company, was also present, and rendered valuable assistance in putting his cane-slicer in working order.

The numerous defects in the battery and the cutter having been remedied, the apparatus of the Colwell Company was accepted on December 11, 1887.

Mr. A. W. Colwell, the president of the company, was present during the final trials of the battery, and rendered valuable assistance in putting it into working order. The defects in both cutter and battery were of a minor character, but were such as to greatly delay the use of new machinery for new purposes. The final working of all the machinery was excellent and satisfactory. The season's experiments, however, disclosed many improvements of a seemingly trivial nature, but by the adoption of which a more economical working of the diffusion process can be secured. These improvements will be discussed in another place.

The first results from the experiments were obtained from the run of December 3, 1887.

The juice was treated with .3 per cent. its weight of lime, and after the precipitation of the lime with carbonic dioxide, an amount of lignite equal to 10 per cent. of the weight of the sugar present was added.

The juice filtered readily through the presses, forming firm, hard cakes. The filtered juice was treated with phosphate of soda, 15 pounds of this salt being added for each 5,000 pounds of juice.

The phosphate produced an abundant flocculent precipitate, which filtered easily through the twin filter presses, giving a juice of remarkable limpidity. The *masse cuite*, however, was dark, and the molasses much inferior in color to that made by the use of bone-black and ordinary clarification.

The phosphate of soda did not produce as favorable results as had been expected, and its further use was discontinued.

Following are the data obtained in the first run:

First diffusion run, December 3, 1887.

	Total solids.	Sucrose.	Glucose.
Juice from chips:		*Per cent.*	*Per cent.*
First	15.20	12.01	.96
Second	14.45	11.92	1.00
Third	15.45	12.84	1.02
Average	15.03	12.26	.99
Diffusion juice:			
First	10.88	8.88	.83
Second	10.40	8.65	.74
Average	10.64	8.76	.78
Exhausted chips:			
First sample	....	.51	....
Second sample	....	.76	....
Third sample	....	.91	....
Average	....	.73	....
Carbonated juice	11.09	9.20	.70
Waste water	....	....	.12
Semi-sirup	51.80	42.20	3.39
First sugar	....	97.50	....
Molasses from first sugar	76.30	45.00	11.11
Second sugar	....	91.60	....

Cane used ...tons..	80.3
First sugar per ton ...pounds..	146.1
Second sugar per ton ...do....	40.1
Total first and second sugars	186.2
Third sugar	15
The total sugar in the cane at 90 per cent. juice was ...pounds..	220.6
Of this there was obtained 146.1 pounds at 97.50 ...do....	144.4
And 40.1 pounds at 91.6 ...do....	36.7
Total pure sucrose obtained ...do....	181.1
Left in chips ...do....	14.6
Total left in molasses and lost in manufacturing ...do....	24.9

(NOTE.—The third sugar will not be dried until in May or June, 1888. The estimates of third sugar have been made by Mr. E. C. Barthelemy.

EXTRACTION.

The percentage of sucrose left in the spent chips was .73. Sucrose in cane was 11.03 per cent. The per cent. of extraction is therefore $11.03 - .73 = 10.30 \div 11.03 \times 100 = 93.4$.

SECOND TRIAL.

Another trial was made of the diffusion machinery beginning December 9. Carbonatation was again used, but without lignite or any further treatment. The juice passed directly from the filter presses to the double-effect pan.

The quantity of lime employed was .6 per cent. the weight of the juice. The filtration was perfect. The experiment was remarkable in showing that a perfect defecation can be made with carbonatation with a much smaller percentage of lime than had been supposed necessary.

The *masse cuite* was dark, but the sugar a fair yellow.

Following are the data of the run:

Second diffusion run, December 9, 1887.

	Total solids.	Sucrose.	Glucose.
		Per cent.	*Per cent.*
Fresh chips:			
First sample	14.06	11.70	1.04
Second sample	15.65	13.64	.76
Third sample	15.70	13.52	.75
Fourth sample	15.50	13.02	.51
Fifth sample	14.00	11.18	1.02
Average	14.93	12.61	.83
Diffusion juice:			
First sample	9.36	7.83	.67
Second sample	8.67	7.25	.58
Third sample	9.68	7.61	.55
Fourth sample	10.40	8.69	.91
Fifth sample	10.20	8.45	.78
Average	9.66	7.96	.69
Carbonated juice:			
First sample	9.12	7.73	.65
Second sample	8.74	7.35	.57
Third sample	10.20	8.55	.50
Fourth sample	11.40	9.00	.73
Average	9.86	8.16	.61
Exhausted chips:			
First sample	....	1.53	....
Second sample	....	1.69	....
Third sample	....	.48	....
Fourth sample	....	.33	....
Fifth sample	....	.43	....
Average	....	.89	....
Semi-sirup	47.70	38.90	2.96
First sugar	....	96.60	....
Molasses from firsts	72.20	42.40	10.50
Second sugar	....	87.30	....

Yield of first sugar per ton	pounds..	128
Yield of second sugar per ton	do....	43
Cane used	tons..	90
The total sugar in the cane at 90 per cent. juice was, per ton	pounds..	226.98
Of these there was obtained 128 pounds at 96.6	do....	123.6
And 43 pounds at 87.3	do....	37.5
Total pure sucrose obtained, per ton	do....	161.1
Pure sucrose left in chips, per ton	do....	17.8
Pure sucrose left in molasses and lost in manufacture, per ton	do....	41.1
Third sugar estimated, per ton	do....	17
Percentage sugar in cane extracted		92.16

The poor yield was due to use of thick chips during the first part of the run, causing a loss of 1.6 per cent. sucrose in the chips.

THIRD TRIAL.

In this run the use of carbonatation and lignite was discontinued. The diffusion juices were treated with sulphur fumes until well saturaised. They were then treated with lime and clarified in the usual way.

The clarification took place readily. The quantity of scums was very small, and the sediment subsided rapidly, forming a thin layer on the bottom of the tank, permitting the clear liquor to be easily and completely drawn off. The juice passed at once from the clarifiers to the double-effect pan and subsequently received no further purification.

Following are the analytical data obtained:

Third diffusion run, December 10 *and* 11, 1887.

	Total solids.	Sucrose.	Glucose.
Fresh chips:		*Per cent.*	*Per cent.*
First sample	14.39	11.89	.79
Second sample	12.77	10.63	.77
Third sample	14.49	12.06	.80
Average	13.88	11.53	.78
Diffusion juice:			
First sample	9.42	7.82	.62
Second sample	9.41	7.87	.59
Third sample	9.55	7.86	.67
Average	9.46	7.85	.63
Sulphured juice:			
First sample	9.69	8.17	.66
Second sample	9.12	7.53	.58
Average	9.40	7.85	.62
Clarified juice:			
First sample	9.95	8.21	.67
Second sample	9.89	8.06	.63
Third sample	10.32	8.39	.71
Average	10.05	8.22	.67
Exhausted chips:			
First sample	....	.80	....
Second sample	....	.50	....
Third sample	....	.77	....
Fourth sample	....	.93	....
Average	....	.75	....
Semi-sirup	44.70	34.60	2.87
First sugar	....	96.30	....
Molasses from first sugar	72.90	36.70	12.07

First sugar per ton ....pounds..	143
Number tons cane used	110

The molasses from the first sugar was boiled to string proof and put in wagons. A good crystallization of second sugar was secured, but the molasses having been left too acid, a good separation was not secured. Mr. Barthelemy therefore decided to reboil the molasses with some of the product of the mill process, and therefore no statement of the quantity of second sugar can be given. It was estimated at 30 pounds per ton.

The cane from which this run was made was grown on new back land and was the poorest of the whole season.

The percentage of sugar extracted of total sugar in cane was 92.80.

FOURTH TRIAL.

In this run the diffusion juice was treated with lime until almost neutral. It was then boiled, skimmed, and allowed to settle. The scums and sediments were of small volume and were all returned to the battery.

The juice received no other treatment whatever for clarification. It was converted to sirup in a double-effect vacuum pan. The capacity of this pan was not quite great enough to evaporate the juice as fast as furnished by the battery. For this reason the run, which might have been finished in two days, occupied a part of a third day. The quantity of cane worked was 200 tons.

Following is a record of the analytical data obtained:

Fourth diffusion run, December 29, 30, and 31, 1887.

	Total solids.	Sucrose.	Glucose.
Juices from fresh chips:		*Per cent.*	*Per cent.*
A. M., first day	16.46	14.23	.49
P. M., first day	17.27	15.33	.43
Midnight, first day	17.26	15.12	.43
A. M., second day	17.13	14.84	.45
Midnight, second day	16.97	14.93	.54
A. M., third day	16.19	13.90	.61
P. M., third day	16.26	14.05	.50
Average fresh chip juice for run	16.79	14.60	.49
Diffusion juices:			
First sample, first day	9.72	8.71	.32
Second sample, first day	10.09	9.01	.29
Third sample, first day	11.38	10.16	.30
Fourth sample, first day	11.60	9.31	.53
First sample, second day	11.10	9.87	.32
Second sample, second day	10.92	9.69	.33
Third sample, second day	10.94	9.77	.44
First sample, third day	10.45	9.31	.35
Second sample, third day	10.87	9.69	.38
Average diffusion juice for run	10.78	9.50	.36
Clarified juices:			
Average for first day	10.75	9.34	.32
Average for second day	11.77	10.36	.32
First sample, third day	12.01	10.36	.41
Second sample, third day	11.61	9.78	.38
Third sample, third day	11.25	9.51	.36
Average clarified juice for run	11.48	9.87	.36
Juices from exhausted chips:			
First sample, first day	....	.52	....
Second sample, first day	....	.61	....
Third sample, first day	....	.83	....
First sample, second day	....	1.12	....
Second sample, second day	....	.72	....
Third sample, second day	....	.95	....
First sample, third day	....	1.09	....
Second sample, third day	....	1.30	....
Third sample, third day	....	1.10	....
Average exhausted chip juice for run	....	.91	....
Semi-sirup for first strike	37.37	33.10	.99
Masse cuite first strike	....	81.20	....
First sugar from first strike	....	98.40	....
First molasses from first strike	76.22	51.80	7.76
Semi-sirup for second strike	40.00	35.10	1.19
Masse cuite	....	80.60	....
First sugar	....	98.90	....
Molasses from second strike	79.00	55.60	....
Average extraction	....	93.80	....
Pounds first sugar per ton	....	165.50	....
Per cent. sugar extracted obtained in firsts	....	66.20	......

Second sugar per ton	pounds	45.9
Third sugar per ton (estimated)	do	*18.0
Cane used	tons	200

* On February 29 I was informed by letter from Governor Warmoth that the third sugars from the fourth run had been dried and weighed, yielding 3,723 pounds, or 18.6 pounds per ton.

FIFTH TRIAL.

The fifth and last run of the diffusion battery was begun on January 14 and finished on the 18th. This trial was made after the milling work had been completed. The diffusion juices were treated precisely the same way as the mill juices had been, and after passing over bone-black were concentrated to sirup in a Yaryan quadruple effect, which had been in use with the mill juices during the manufacturing season.

The working of all the machinery during this final trial was admirable, and the even march of the whole work promoted the efficiency of the machinery and the successful manipulation of the juice.

Analytical data of fifth run.

No.	Brix.	Sucrose.	Glucose.	No.	Brix.	Sucrose.	Glucose.
Fresh chips:		*Per cent.*	*Per cent.*	Diffusion juices—Continued.		*Per cent.*	*Per cent.*
397	16.87	14.23	.74	450	9.88	8.12	.43
400	16.39	13.45	.87	453	10.87	9.09	.3[illegible]
403	16.39	13.79	.89	460	9.89	....	.45
405	17.09	14.73	.68	466	10.67	8.41	.61
408	16.86	12.11	.75	469	10.47	8.01	.72
411	17.16	14.73	.64	473	10.17	8.09	.48
414	16.93	14.06	.70	476	10.15	7.86	.45
417	17.00	14.50	.61	479	10.31	7.92	.47
420	16.70	13.93	.73	485	10.59	8.26	.52
423	16.79	14.11	.74	491	9.69	7.53	.61
426	17.19	14.17	.61				
429	16.73	14.19	.59	Maximum	....	9.28	.72
437	17.11	14.55	.61	Minimum	....	7.53	.34
440	16.17	13.48	.75	Mean	....	8.41	.47
443	16.17	13.43	.76				
446	16.60	13.99	.62	Exhausted chips:			
449	16.63	14.39	.65	399	....	.52	....
452	16.77	14.23	.73	402	....	.21	....
459	16.23	13.29	.77	407	....	.52	....
465	16.93	13.79	.76	410	....	.32	....
468	16.07	13.35	.85	413	....	.52	....
472	16.84	14.34	.64	416	....	.41	....
475	16.37	13.54	.82	419	....	.33	....
478	15.51	14.17	.70	422	....	.42	....
484	16.94	14.35	.65	425	....	.42	....
490	16.57	14.52	.62	428	....	.55	....
Maximum	....	14.73	.89	431	....	.42	....
Minimum	....	12.11	.59	439	....	.50	....
Mean	....	13.98	.70	442	....	.50	....
				445	....	.42	....
Diffusion juices:				448	....	.46	....
398	11.37	9.28	.60	451	....	.69	....
401	10.67	8.66	.64	454	....	.55	....
404	10.61	8.92	.40	461	....	.51	....
409	10.38	8.53	.41	467	....	.42	....
412	11.01	9.10	.45	470	....	.39	....
415	10.91	8.60	.45	474	....	.43	....
418	10.71	8.76	.49	477	....	.54	....
421	10.65	8.77	.40	480	....	.34	....
424	10.57	8.51	.44	486	....	.22	....
427	10.52	8.90	.45	492	....	.43	....
430	10.65	9.05	.32				
438	10.27	8.46	.35	Maximum	....	.69	....
441	10.73	8.94	.45	Minimum	....	.21	....
444	10.88	8.99	.42	Mean	....	.44	....
447	49.50	7.68	.34				

The molasses from the first sugars being very rich, the method of reboiling to grain was employed. To this end the molasses of the first strike, having been reduced to 55 to 60 per cent. of total solids, was boiled on a nucleus of first sugar left in the pan from the second strike. In this way all the molasses was boiled to grain with most gratifying results except that from the last strike of the first sugars.

The attempt to boil this to grain did not succeed in giving a *masse cuite* which could be dried with ease. The molasses running from the machines was so thick that it clogged them up. Seven large sugar wagons were filled with this material and set in the hot room.

The sugars made were equal in every respect to those obtained by milling in similar instances. Without counting the second sugar above named, the grained sugar per ton amounted to 181.5 pounds. The grained sugars in wagons will yield not less than 7,500 pounds, or 18 pounds per ton.*

The third sugars are estimated by Mr. Barthelemy at not less than 16 pounds per ton.

The total yield per ton of the fifth run will reach, therefore, 215.5. The number of tons of cane used was 417.

Summary of results.

Number of run.	Cane.	Mean sucrose in juice.	Mean glucose in juice.	Sugar grained in pan per ton. First sugar.	Wagon sugar per ton. Second sugar.	Wagon sugar per ton. Third sugar (estimated).	Total sugars per ton.
	Tons.	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1	80.3	12.26	.99	146.1	40.1	15	201.2
2	90.0	12.61	.88	128.0	43.0	18	189.0
3	110.0	11.53	.78	143.0	*30.0	12	185.0
4	200.0	14.60	.49	165.5	45.9	18	229.4
5	417.0	13.98	.70	181.5	*18.0	16	†215.5

*Estimated.

†Actual weight, 16.3 pounds per ton, and 213.8 pounds total sugars per ton. The third sugars from this run were mixed with molasses from the mill products, and no separate return of it will be made.

COMPARATIVE YIELDS BY MILLING AND DIFFUSION.

The yield in first or grained sugars affords the best comparison of the two systems of manufacture. Judged by this standard the diffusion process had given a yield of sugar fully 30 pounds per ton greater than was afforded by milling. For further data on this point see the report of Governor Warmoth farther on.

CHARACTERISTICS OF DIFFUSION JUICE.

The juice of diffusion differs from the mill juice chiefly in its content of water. In addition to this, also, must be noted a slight increase in the ratio of glucose to sucrose. This is due doubtless to a slight inversion of the sucrose during the process of diffusion. From a commercial point of view the loss is insignificant. Further, it may be said that there appeared to be in the diffusion juice treated in the

* The actual yield reported to me February 23, by Governor Warmoth, was 6,805 pounds, or 16.3 pounds per ton.

ordinary way a slightly increased amount of gummy matter. This was noticed only in filtering the sirup through bone-black. In the strike-pan and the centrifugal the products of diffusion worked fully as well as those from the mill.

DISPOSITION OF CHIPS.

An attempt was made to pass the chips through the five-roll mill, but it was found impracticable. The first rolls would not take them easily, and the second set of rolls had to be opened somewhat to secure the proper feed. The bagasse issuing from the mill contained still 65 per cent. water and made a poor fuel.

It would probably not be a difficult problem to so adjust the mill as to secure a proper drying of the chips. To return the chips to the soil, however, appears to be the most rational method of disposing of them.

It is true that if spread too thickly on the soil the chips may prove highly injurious, but if distributed in a thin layer, covering almost if not quite the original acreage of the cane furnishing them, they would certainly prove advantageous. The chips would not only furnish organic matter to the soil, and thus increase its porosity, but they also contain still a considerable part of nitrogenous matter, which would afford a valuable plant food. Even the richest land should be treated fairly, and the cane-field should receive as nearly as possible as much as it gives. The additional cost of replacing the chips on the field is a matter which should receive attention here, but the benefit will apparently be greater than the expense. During the manufacturing season the chips can be deposited in large beds, which subsequently can be transferred to the field. If time for the partial decay of the chips should be desired, the accumulation of one season need not be moved until the following year.

DISPOSITION OF SCUMS AND SEDIMENTS.

The scums and sediments were successfully treated by the process of carbonatation. The expense of a lime-kiln is not necessary for this work. It was satisfactorily done by drawing the carbonic dioxide gas directly from the stack of the boilers. As high as 11 per cent. of CO_2 was found in the gases from this source.

The scums, etc., treated with 2 to 3 per cent. of lime, are subjected to the action of the gas until the lime is precipitated. They then can be easily and rapidly filtered.

By means of a cheap and convenient *monte jus* the scums and sediments were also returned to the battery. The method of operating was as follows:

The scums and sediments from the clarifiers were collected in a tank furnished with a steam coil to keep them at the boiling temperature. This tank was connected with a *monte jus* of 50 liters capacity. This apparatus was connected with the compressed-air service used in operating the battery. It was so arranged that the master of diffusion, or his assistant, could operate it directly from the central column of the battery.

After each cell was filled with chips, 50 liters of the scums were run into the *monte jus* from the storage tank, and, by means of compressed air, poured into the full cell. The process of diffusion was then continued in the usual way. The quantity of liquid drawn from each cell was increased by the amount of scums added. For instance, if 900 liters were the amount regularly drawn, 950 would be taken from a cell to which the scums had been added, as above indicated.

No deterioration of the diffusion juice could be detected in using this method.

This procedure was also used during the progress of the work conducted by the Department at Fort Scott during the season of 1887. I have been told that a patent has been applied for to cover this process, and have therefore placed on record the experiments made at Lawrence for the public benefit.

THE USE OF LIGNITE.

In order to get lignite of the best possible variety and in the best form for use, a few tons of the ground article were purchased from the inventor of the process of filtering with brown coal, Mr. Fritz Kleeman, of Schönigen, Germany.

I have already alluded to the successful use of lignite in conjunction with lime and carbonic acid.

This experiment, however, did not show that any beneficial effects were produced by the introduction of the lignite.

Afterwards experiments were made by Mr. Kleeman himself, using lignite alone. Mr. Kleeman said the arrangement of the clarifying tanks was not suitable to the process. The filter cloths were soon clogged and the attempt at filtration had to be abandoned.

Later in the season I received a letter from Mr. W. J. Thompson, of Calumet Plantation, in which he said that he would make a trial of the process under more favorable conditions than obtained at Magnolia, and requesting me to send him enough of the Kleeman lignite for that purpose. This I gladly did. Mr. Thompson made a run of nineteen clarifiers with lignite, but found so many difficulties attending the work that its further progress was abandoned.* On the other hand, Professor Stubbs, at Kenner, working with a small press, secured results that were highly satisfactory.

The results of the work with lignite show—

(1) That on a large scale the filtration takes place with great difficulty, unless a very great quantity of the lignite be used and the juice be neutral or slightly alkaline.

(2) That with a slight excess of lime, precipitated with carbonic acid, lignite can be successfully used to increase the filtering surface.

(3) The decolorizing power of lignite varies with the nature of the sample. In some cases this property is present in a high degree; in others, entirely absent.

(4) The successful working of the process on a small scale would indicate that it might be worked commercially.

(5) In juices as pure as those of sugar-canes, filtration through lignite, even if easily done, does not seem to be necessary.

I had expected to have Mr. Thompson's complete report on the experiments with lignite before this time, but it has not yet been received.†

COMPARATIVE YIELD FROM MILL AND DIFFUSION BATTERY.

The comparative yield from the cane-mill and the diffusion battery is given by Governor Warmoth in a paper read before the Planters' Association at the February meeting, viz:

> The first cane worked was from second year stubble, and it gave us 146 pounds of first sugar to the ton and 40 pounds of seconds.

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*See Report of Mr. Thompson, *post*.

†Mr. Thompson's report was received March 5.

The molasses was put into the cisterns with the other, and we can not give any estimate of the thirds. Our mill gave us 145 pounds first and second sugars from this cane.

The next test was from some green cane, grown on new land, yielding 28 tons of cane per acre, considerably blown down and sprouted in a small degree. This had much less sugar in it than the first cane. Yet we got 128 pounds of first sugar and 43 pounds second sugar per ton from it.

Our mill gave us 140 pounds of first and second sugar per ton from this cane.

The next run gave us 165.5 pounds firsts, 45.9 of seconds; total, 211.4 pounds, with thirds in the wagons, which we estimate will give us 15 pounds more, a total of 226.4 pounds.

The next run was on 450 tons of cane, beginning on the 13th of January, ending on the 18th. This cane was rich and fine. It had been killed on the 26th of December, was not windrowed, but was in fine condition. From this cane diffusion gave us 181 pounds of first sugar and grained seconds, with enough left in the wagons to bring it up to 223 pounds. From this cane we got 193 pounds of first and second sugar by our mill.*

All of this shows about the same difference between diffusion and our mill-work of about 35 pounds of sugar per ton of cane. I do not mean to be invidious when I say that I think we got a little better extraction by our mill than any of our neighbors. My friend, Mr. Dan Thompson, got more sugar to the ton of cane in 1886 than we did, but this result was obtained not so much by his extraction as by the skillful work in the balance of his house, in which I firmly believe the equal does not exist in Louisiana.

It is safe to say that the average yield per ton of cane in the State is not over 110 pounds. I believe diffusion will bring the average up to within the neighborhood of 200 pounds, a gain of certainly 75 pounds, and perhaps 90 pounds, per ton of cane.

My nearest neighbor, Mr. Bradish Johnson, obtained the past season 136 pounds of sugar per ton of cane. We are within 3 miles of each other; our land is much the same; our cultivation is substantially the same. It is fair to assume his cane was as rich as mine, yet we had about 175 pounds of all sugar per ton, a difference of 39 pounds of sugar per ton on our mill-work, and about 71 pounds difference on the diffusion work. Take his estate for illustration:

His 10,000 tons of cane gave him 1,390,000 pounds of sugar. Had he worked his crop by diffusion he would certainly have had 70 pounds more sugar to the ton of cane. This would have increased his yield 700,000 pounds of sugar, which, at 5½ cents per pound, would have given him $38,500 more for his crop than he received.

Take my own crop of 13,300 tons of cane. Had I worked it by diffusion I would have had 35 pounds more sugar per ton. This would have given me 465,000 pounds more sugar than I obtained, an aggregate of 2,865,000 pounds of sugar from about 600 acres, or 4,750 pounds per acre. The cash increase of my crop would have been, at 5½ cents per pound, $25,592.50, a difference to Mr. Johnson of $3.85 per ton of cane, and to me, on my crop, of $1.82½ per ton of cane.

QUANTITY OF JUICE DRAWN FROM EACH CELL.

The cane used for diffusion was weighed and delivered, chiefly on cars, to the cutter. The trash which becomes detached in handling the cane was collected in carts and weighed, and its weight deducted from the total. No account was taken of the trash which entered the cutter.

It was found that the average weight of chips in each cell, when filled in the ordinary manner, was 1,757 pounds. One cell filled with extra care was weighed, and the weight found to be 1,860 pounds. It was thus seen that by careful packing it was easy to get 100 pounds extra weight of chips into each cell.

The quantity of juice drawn from each cell varied from 900 to 1,000 liters, or from 2,059 to 2,288 pounds.

The mean quantity of juice drawn for the first four runs was nearly 2,170 pounds. Assuming that in each 100 pounds of chips there is

*In respect of the last run, the analytical data show that the cane worked by the mill during its last run, from which 193 pounds per ton were made, was richer in sucrose by nearly 1 per cent. than that worked at the last diffusion run.

90 per cent. of juice, we have in 1,757 pounds of chips 1,581.3 pounds of normal juice.

The quantity of diffusion juice from this was 2,170 pounds. The increase over normal juice is therefore 589 pounds, or 37.2 per cent.

In the last run a much greater dilution was secured. In order to get a slow current of the juice through the calorisators the master of diffusion was instructed to begin filling the cell with juice when it was about half full of chips. At the end of the run it was found that the introduction of liquid had caused a floating of the chips, and that the weight of chips in each cell had been greatly diminished. Thus a higher dilution of the diffusion juice was secured than was intended. The very perfect exhaustion of the chips during the last run was partially secured by this means.

The mean weight of chips in each cell during the last run was 1,500 pounds; the weight of normal juice 1,350 pounds, giving an increase of 60 per cent. This dilution is greater than is necessary for diffusion work. With a battery of sixteen cells I think the dilution could be easily reduced to 30 per cent. and the extraction be satisfactory.

COAL CONSUMED.

The quantity of coal consumed depends, first, on the efficiency of the boilers and evaporators employed; second, on the quality of the coal, and, third, on the dilution of the juice.

In beet-sugar factories the method of computation is generally based on the dilution arising from drawing 180 pounds of diffusion juice from each 100 pounds of beet cuttings. In respect of evaporation what is found to be true of beet juices will also apply to cane juices of the same density.

From the arrangement of the machinery at Magnolia it was found impossible to measure the quantity of coal consumed by the diffusion work. In the last run, when the milling work was over, the centrifugals were run drying seconds and the vacuum pan boiling thirds during the process of the work.

In addition to this, a part of the steam used was furnished by the bagasse boilers, using wood and coal as a fuel—not an economical method of making steam.

As nearly as could be estimated, the quantity of coal required to make a pound of sugar was 2 pounds. The actual quantity of coal which would be required with the best boilers and evaporators may be found by consulting Dr. Karl Stammer's latest edition of "Textbook of Sugar Making," pages 873 *et seq.*

When 180 pounds juice are taken for each 100 pounds beets the consumption of coal to reduce the juice to a sirup of 60 per cent. total solids is as follows:

	Pounds.
With double-effect pan	13.50
With triple-effect pan	9.10
With quadruple-effect pan	6.76

To reduce the sirup to *masse cuite* requires 4.44 pounds.

We find, therefore, the following quantities of coal necessary for each 100 pounds raw material giving 180 pounds of juice:

	Pounds.
For a double effect	17.94
For a triple effect	13.54
For a quadruple effect	11.20

If, now, we take the ordinary dilution for sugar-cane, the following numbers are found:

In evaporating 180 pounds of diffusion juice from 100 pounds cuttings to 60 per cent. sirup, 156 pounds of water are evaporated. In evaporating 125 pounds of diffusion juice to same density, only 101 pounds of water are driven off. To evaporate 156 pounds of water 13.26, 9.10, and 6.76 pounds of coal are used for double, triple, and quadruple effects, respectively. For the same weight of cane chips, giving 125 pounds of diffusion juice, the quantities of coal consumed would be 8.58, 5.89, and 4.44 pounds, respectively. To reduce this to *masse cuite* would require the same consumption as before, viz, 4.44 pounds. One hundred pounds of cane chips will yield by diffusion an average of 10 pounds of sugar for the whole State of Louisiana. The coal consumed in evaporation, therefore, would be:

	Pounds.
For a double effect	13.02
For a triple effect	10.33
For a quadruple effect	8.88

The above computation includes the exhaust steam from the pumps, centrifugal engine, etc. The quantity of steam required to run the battery must be added to the above. It certainly would not amount to more than 2 pounds per 100 of cane used.

With the best apparatus most economically arranged the total consumption of coal per 100 pounds of cane would be:

	Pounds.
For a double effect	15.02
For a triple effect	12.33
For a quadruple effect	10.88

Reduced to 1,000 pounds of sugar from cane yielding an average of 10 per cent. of all sugars, the figures become:

	Pounds.
For 1,000 pounds sugar—	
With double effect	1,502
With triple effect	1,233
With quadruple effect	1,088

In all these calculations the coal is assumed to be of fair average quality, and to be able to convert 6 pounds of water into steam at usual boiler pressure for each 1 pound of coal. In general, then, it may be said the quantity of coal required to make 1,000 pounds of sugar by diffusion varies from 1,000 to 1,500 pounds, according to the system of evaporation employed.

Diffusion can only be made an economical success when the best machinery and the most economical methods are employed. The great objection which has been urged against it, viz, the increased consumption of fuel required, is entirely removed when the process is carried on under the economical conditions which have been mentioned.

To attempt to introduce diffusion with old and worn-out apparatus, defective boilers, and open pans would simply be disastrous. It can only succeed when the highest mechanical skill, associated with the best scientific control, directs all the operations of the sugar-house.

In the one experiment where actual weighings have been completed of the whole product, viz, the fourth run, the quantity of sugar made per ton is:

	Pounds.
Firsts	165.5
Seconds	45.9
Thirds	18.6
Total	230.0

I do not think, therefore, that it is extravagant to believe that with the best culture and most economical method of manufacture the yield per ton of cane in Louisiana may be brought up to 200 pounds. The introduction of diffusion means almost a complete rehabilitation of the average sugar-house. It would be unreasonable to expect that planters will have the money and the desire to undertake such a radical change, or at least to make it rapidly.

But it seems to me that the gradual introduction of diffusion, with its concomitant machinery, will work a great change in the sugar industry of the South, bringing success and prosperity where for years a hard struggle for existence has been going on.

The final result, I sincerely hope, will bring into cultivation the extensive areas of rich sugar lands now lying idle and increase the production of the State of Louisiana to 500,000 tons annually.

I can not close this report without expressing my hearty appreciation of the support I have received from the sugar-planters. The great majority of them were skeptical in respect of the process, but all were anxious that a thorough trial should be made.

Particularly I desire to thank Governor Warmoth for his constant and enthusiastic support and for generously giving $5,000 and more to continue experiments when the funds appropriated for them had been exhausted by the expensive delays caused by the cyclone and imperfections in the machinery. Without this timely aid the whole work would have been stopped on the very threshold of success.

The advice and encouragement of Messrs. Dymond and McCall, members of the advisory committee, helped me greatly during the most trying days of the work, when it seemed an almost hopeless task to wrestle further with difficulties of a purely mechanical nature.

The active co-operation of Mr. J. B. Wilkinson, jr., was a source of constant assistance during the whole progress of the work, which is but inadequately recognized by a simple sentence of thanks.

Of my own assistants, Messrs. Barthelemy and Spencer had charge of the erection of the building and of the apparatus, except that put up by the Colwell Company.

Mr. Barthelemy took charge of the sugar-making during the various trials, and Mr. Spencer had the general supervision of the diffusion process and particularly of the lime-kiln and carbonatation apparatus. Messrs. Crampton and Fake took charge of the chemical work. Mr. John Dugan was master of diffusion. Mr. R. Sieg, as consulting engineer, rendered much assistance. His long experience and thorough knowledge of the literature of diffusion rendered his services particularly valuable.

Finally, I will say that no one recognizes more fully than myself the many imperfections noticed during the progress of the experiments in the machinery and methods employed. I have endeavored not to conceal these, believing that in pointing them out a service is rendered the public only less valuable than that secured by complete success.

The success of the work at all three stations has been most gratifying, and the diffusion process for the manufacture of sugar has been advanced beyond the experimental stage by the labors of this Department, beginning in 1883, and it is now offered to the sugar-growers of the country with the confident assurance that it is the best, most simple, and most economical method of extracting sugar both from sorghum and sugar canes.

BROWN COAL AND WOOD CHAR IN THE FILTRATION OF CANE JUICES AND SIRUPS.

Report of W. J. THOMPSON.

CALUMET SUGAR-HOUSE, BAYOU TECHE, LA.,
Wednesday, February 29, 1888.

DEAR SIR: Pursuant to the conditions attaching 9 tons of German lignite furnished him by the U. S. Department of Agriculture for experimentation in cane-juice filtration at this factory, I am instructed by Mr. Daniel Thompson, its proprietor, under whose exclusive patronage the experiments have otherwise been conducted, to make you the following report concerning the same:

A miniature apparatus, comprising mill, steam defecators, open steam evaporators, subsiders, and a laboratory frame filter-press from Wegelin and Hübner, center-feed, executed in bronze, of one-half square foot filtering area, arranged for complete displacement, offered reasonable facilities at all times to small work. Four Kroog presses of thirty frames, 220 square feet filtering surface each, so mounted with respect to receiving vessels, juice, and lixiviating pumps, safety-valves, and like appurtenances as to have operated upon scums throughout the season without suggesting alteration, besides eliciting the eulogiums of the inventor of the so-called Brown coal process, served during industrial trials. All pipes were of copper or brass, pumps of bronze, and the plates, perforated sheets, frames, and other iron parts of the apparatus in contact with juice all thoroughly painted, as insurance against discoloration of products. A well-arranged chemical laboratory, unusually well equipped for investigations connected with sugar, was also provided.

Mr. B. Remmers, an English expert in mechanical filtration and sugar refining, well known to readers of the Sugar Cane Magazine, assumed technical control of the experiments, assisted by Mr. R. A. Williams, chemist from the Louisiana Sugar Experiment Station, Mr. J. P. Baldwin, a local adept in defecation, and two long-time employés of the factory.

A preliminary study was made of cake formation. For this purpose Spanish whiting, variously colored, as with aniline dyes and alizarine, kept mechanically suspended in water by vigorous agitation, was pumped into the chambers, the cakes being finished off at high pressures to insure extreme solidity, which, after removal, were cut into sections, longitudinal and transverse. It was found that, with constant or very gradually increased pressures maintained within the chambers, and a liquid kept under unaltered conditions, the cakes formed by extremely uniform accretions, beginning with a thin and even coating of the entire filtering area, over which the various colors used deposited one upon the other, as fed in succession to the press, in likewise thin and equable layers, until the chambers were quite filled and filtration ceased. With oscillatory pressures and with substances of widely differing specific gravities, such as whiting, brown coal, red lead, wood char, and ultramarine, one following upon the other, the various laminæ proved most irregular in their deposition upon the filter-bed, being comparatively of excessive thickness in parts while running out altogether in others, the plane of contact being besides often obliterated or scarcely defined, because of partial intermingling between the different substances employed. The same effects, also, found their cause in the use of any given substance fed alternately in fine and coarse division, or at first in high followed by low percents of the matrix.

There can be little doubt that for the best results in general filter-press work, this indicates, as afterwards substantiated, for sugar liquors by the use of hydrostatic columns on the one hand and intermittency secured through means of a by-pass valve on the other, the first importance of constant pressures, freed especially from the vibratory pulsations of ordinary pumps, and a liquid so agitated while awaiting the process as to carry to the press, at all stages of this, a reasonably uniform percentage of whatever matrix is employed, the laws of hydraulics, as illustrated in silt-bearing streams, here again exhibiting themselves in complete application.

Satisfied that the mechanical arrangement of the large apparatus was appropriate to the intervention of a matrix and that the small answered to all the essential conditions of the large, systematic work with brown coal, under what is known as the Kleemann process, began on November 29. Five long tons of this article had been imported by Mr. Daniel Thompson, through the Sangerhausen Maschinenfabrik, Germany, which, however, was so superlatively unfit for its destined duty, by reason of uneven and inadequate pulverization, as to have required previous and, of course, laborious hand-sifting.

It was first sought to learn what relation varying quantities of this article bore to speed in the filtration of defecated but unskimmed juices. With this intent different percentages, based upon the estimated weight of the contained sucrose, as the most convenient, although not assuredly the most rational standard of reference, were employed with the results which follow:

Lignite, per cent. on contained sucrose.	Juice filtered per operation; 30-frame Kroog press. (Approximate gallons.)		Average time of one operation (Approximate hours.)		Average juice per press, per 24 hours. (Approximate gallons.)	Average juice per square foot; filtering area per 24 hours. (Approximate gallons.)
	Maxima.	Minima.	Filtering.	Lixiviating and emptying.		
7.5	2,800	2,900	8	3	6,220	28.3
15	2,600	2,100	6	3	5,466	24.6
22.5	1,500	1,600	4.5	2.5	5,296	24.1
30	1,200	1,300	3	2	6,000	27.2
45	950	1,050	1.5	1.5	8,000	36.3
60	700	800	.75	1	10,275	46.7

The average juice per press and per square foot of filtering surface, per twenty-four hours, stand calculated on the basis of a sixty-day continuous run. Here, taking the average weight of the juice at 8.85 pounds per gallon and its sucrose at 13⅓ per cent., for percents of lignite upon sucrose contained may be substituted percents of the same on the weight of juice or pounds of the former per 100 gallons of the latter, as exhibited in the annexed scheme:

Lignite, per cent. on weight of sucrose in juice	7.5	15	22.5	30	45	60
Lignite, per cent. on weight of juice	1	2	3	4	6	8
Lignite in pounds per 100 gallons of juice	8.85	17.7	26.55	35.4	53.1	70.8

The juices treated during the interval of this work remained, so far as could be ascertained, essentially uniform as respected adaptability to filtration, as, indeed, they have done up to present writing, being referred in this regard occasionally to an arbitrarily selected standard by careful weighings of defecated juice, brown coal, and products operated upon in observed times on tarred-paper filters. The analyses of raw juices for those dates which cover this series of determinations, as made in the course of diurnal routine work, are presented below.

While they may serve for general comparison with the like as observed in other portions of our tropical cane belt, no relation has yet been noted to exist between the amounts of sucrose, reducing sugars, or other known constituents of the juice, and the difficulties exhibited by this in filtration. In the latter regard it is not possible to say if that which has here been experimented upon fairly represents Louisiana's average. It would seem, indeed, to be otherwise, since, in the treatment of scums, great difficulty is reported to have been experienced in almost if not every other local factory possessing filter-presses, while at this no other process of manufacture was throughout so satisfactorily performed.

Date.	9 a.m.				3 p.m.				9 p.m.			
	Solids.	Sucrose.	Glucose.	Exponent.	Solids.	Sucrose.	Glucose.	Exponent.	Solids.	Sucrose.	Glucose.	Exponent.
1887.												
Nov. 30	15.96	13.5	1.45	84.58	......	......	......	......	......	......	......	......
Dec. 1	15.03	12.0	1.31	79.84	15.23	11.6	1.25	76.16	15.43	12.0	1.14	77.77
2	15.30	12.1	1.27	79.08	14.78	11.0	1.09	74.42	14.43	11.7	1.33	81.08
3	15.27	12.3	1.52	80.55	14.07	11.2	1.47	79.60	13.78	9.7	1.56	70.39
5	14.09	10.4	1.62	73.81	14.69	10.7	1.50	72.83	14.91	11.5	1.36	77.12
6	14.18	10.1	1.50	71.22	14.03	11.0	1.43	78.40	14.23	11.2	1.36	78.70
7	14.06	10.8	1.45	76.81	14.58	10.7	1.50	73.38	......	......	......	......
8	14.43	11.5	1.66	79.69	14.77	11.5	1.51	77.86	......	......	......	......
9	14.63	11.7	1.56	79.97	14.69	11.3	1.38	76.92	......	......	......	......
10	13.96	11.3	1.48	80.94	14.69	11.5	1.47	78.28	14.96	11.4	......	76.20
12	15.09	11.7	1.64	77.53	15.63	12.1	......	77.41	14.00	11.6	......	82.85
14	14.17	12.1	1.61	85.39	14.93	12.1	1.66	81.04	14.20	11.3	......	79.57
15	15.03	11.9	1.47	79.17	15.09	11.8	......	78.19	......	......	......	......
16	14.63	12.5	1.66	85.44	14.69	12.9	1.43	87.81	......	......	......	......
17	14.97	12.0	1.64	80.16	14.69	13.4	1.45	91.21	......	......	......	......
19	15.16	12.3	1.35	81.13	15.43	12.6	1.34	81.65	15.29	13.6	1.22	88.94

Average solids 14.72
Average sucrose 11.68
Average reducing sugars (glucose) 1.44
Average co-efficient of purity (exponent) 79.34

Plant cane, 27.5 tons (*circa*) per acre, blown prostrate September 16.

From these trials the resulting extremes, in round numbers, have alone been given. Variations in temperatures and in pressures, both with juice and displacement water; in density and completeness of defecation with the former; in perfection of cake and lixiviation sought, as in other similar variables, some premeditated, others at times uncontrollable, render, as will be understood by a trained experimentalist like yourself, absolutely definite and thoroughly iron-clad figures quite out of the question. The average amounts of juice put through given filtering areas in fixed times have, however, in fact, most nearly corresponded with those presented as minima.

In general, it may be safely said, the most satisfactory filtrations were uniformly of juices slightly acid only, 180° F. (*circa*), under pressures which, initially low, were most gradually increased until, at finishing off, 60 pounds per square inch had been attained. Neither reasonable increase of pressure nor higher temperatures than these availed perceptibly. Boiling after the addition of the lignite produced no good result later in filtration, when intimate admixture of matrix and liquid had been maintained. Of displacement, or the depletion in sugar of the cake, more will be said hereafter.

Utterly at variance as the coal percentages and time volumes indicated are with promises which had preceded the process to this country, they proved as persistent as they are disappointing. From 30 to 45 per cent. on the estimated crystallizable product present were shown over and over again to be the smallest of coal consistent with reasonable amounts of work done in given times, with given filtering areas, whether by the experimental or the working apparatus. Upon this last from one to three consecutive defecators, of exceeding 1,300 gallons each, were repeatedly essayed. Separate treatment of skimmed liquors and their scums did no better in the aggregate. Those substances which peculiarly interfere with filtration appear to be removed only in minimum degree with the skimmings and sediments. Were this otherwise, separation and recovery of juice from the latter by filter pressing, as now practiced, would scarcely be feasible. It was the same whether with a lime, a sulphurous acid and lime, a lime and phosphoric acid, an acid sulphite of alumina, or an acid albumen defecation, under the Willcox patent, and with these re-agents in all proportions. Tannic acid extracted coloring matter from the brown coal, as did phosphoric and some other chemicals, without facilitating filtration. The use of lignite in alkaline solution is forbidden by its solubility in such. Basic lead acetate showed no better effects with the small press than the rest. Carbonatation alone succeeds, and this, as you told me, requires no lignite. Repetition, later repeated, with foreign lignite prepared under Mr. Kleemann's individual supervision and furnished by your Department, as also with native coals obtained from the Louisiana Sugar Experiment Station and other sources, comminuted at home, aggravated the disappointment. All degrees of pulverization were tried. The amounts filtered seemed tolerably constant for stubble and plant-cane juices and for juices from freshly-cut canes, and from those many weeks windrowed. From old-land cane they did doubtfully better than from new; those deteriorated as a frost effect not altogether so well, perhaps, as those not so injured. With cane freed from its adhering *cerosin*, by sandpapering prior to crushing, it went no better. Butts showed no decided superiority to middles and tops.

In all cases the filtered juices, whether from skimmed liquors or scums, or the two treated without previous separation, whether from high or low percentages of brown coal, and with whatever defecating agent employed, were exceedingly bright and clear from the first until running had quite ceased altogether. Another disappointment, however, awaited inquiry into the actual improvement as to purity secured. The exponent, on the average, was raised not materially to exceed 1 per cent. of total solids attributable to the coal, exclusive even of sweet waters. A few analyses, taken at random from the laboratory records, sufficiently illustrate this. In every case the non-filtered and filtered samples represent, as nearly as practicable, the same juice. For the large presses these were taken in equal volumes at the discharge openings of defecators and presses, respectively, at intervals of three minutes, always so as to represent by pairs identical defecators of juice and identical defecations, before and after filtration, which, following adequate admixture of each series, as obtained from individual defecators, were resampled. This was permitted by the admirable arrangement of the coal-mixing receivers, which contained each precisely the amount from one defecator, and which were filled and emptied alternately in rotation. The effect of a thorough cake washing, the sweet water being mixed back proportionately with the filtered juice, of which it was the after-product, is shown in the last two analyses.

Date.	Defecated, not filtered.					Filtered, 30 to 40 per cent. brown coal.					Improvement in exponent.	Remarks.
	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.		
1887.												
Dec. 28	16.44	13.0	1.84	79.08	14.15	16.43	13.3	1.80	80.95	14.15	1.87	Frosted cane.
28	16.44	13.0	1.84	79.08	14.15	16.03	12.9	1.78	80.47	13.79	1.39	Cake from the above used.
29	16.44	13.6	1.46	82.72	10.70	16.44	13.8	1.38	83.94	10.00	1.22	
30	17.05	13.9	1.25	81.52	8.99	16.48	13.6	1.19	82.52	8.75	1.00	Willcox albumen defecation.
31	15.00	11.7	1.44	78.00	12.30	14.70	11.6	1.40	78.91	12.07	.91	
1888.												
Jan. 2	15.00	12.6	1.20	84.00	9.52	15.30	13.0	1.30	84.97	10.00	.97	
3	15.17	12.3	1.07	81.09	8.69	15.20	12.6	1.10	82.89	8.00	1.81	
4	15.11	12.3	1.10	81.40	9.67	14.56	12.0	1.13	82.41	9.41	1.01	
10	16.46	13.5	1.00	82.01	7.41	15.96	13.3	1.01	83.33	7.52	1.32	Large presses, Willcox defecation.
17	16.44	13.5	1.10	82.11	8.17	15.12	12.6	1.02	83.33	8.09	1.22	Large presses, lime defecation.
17	16.63	13.6	.96	81.77	7.06	15.67	12.9	.83	82.32	6.46	.55	Large presses.
17	16.47	13.7	1.06	81.96	7.40	15.57	12.8	.89	82.21	6.95	.25	Large presses, pro rata of sweet H_2O included.
17	16.36	13.6	1.06	83.12	7.79	15.29	12.9	.94	84.37	7.28	1.25	Large presses.
17	16.35	13.0	.91	79.46	7.00	15.34	12.2	.83	79.53	6.80	.07	Large presses, pro rata of sweet H_2O included.
17	15.90	13.4	.98	84.27	7.35	14.78	12.5	.90	84.57	7.20	.30	Do.
Means.	16.03	13.1	1.22	81.46	.31	15.52	12.8	1.16	82.47	9.06	1.01	

After that, due to the use of 10 or 15 per cent. of lignite on the weight of sugar present, no commensurate effect was observed to be produced in the direction of increased purity by the addition of further quantities. This fell off very slightly or not at all, however, as filtration proceeded towards its finishing point, as also more or less in lixiviation, depending, as seemed shown, upon a lower or higher percentage of coal employed. Believing the application of the process to Louisiana juice condemned by the excessive quantities of lignite found essential to sufficiently rapid filtration and by its failure to realize a higher gain in purity, before reaching conclusive knowledge of these minutæ it should be said these have not since been accorded that systematic inquiry which otherwise they would have deserved.

As decolorizers of saccharine liquors, either dilute or concentrated, certain brown coals are, on the other hand, surprisingly effective. In the table annexed are given to the nearest per cent. the color repeatedly removed from defecated juices, by varying percentages of the article furnished by your Department, referred in each series to standard samples prepared from the defecated juice dealt with by mere passage through filter paper. This paper filtration is a necessity, since suspended matter, lighter in color than the mother liquor, partly by preventing the transmission of light through this last and partly by itself reflecting light, gives invariably, in simply subsided juices, a tint too light by a number of degrees. The percentages of color removed were uniformly measured by the relative length of columns made to give the same tint as the untreated standard when contained in tubes of like glass, of caliber such as to avoid a decided meniscus, and with light of equal intensities transmitted from below in lines parallel to the columns' longitudinal axes.

Lignite, per cent. on weight of sucrose.	Length of columns, mm.	Per cent. color removed.
Unfiltered	10	....
5	28	64
10	36	72
15	50	80
20	64	84
25	80	88
30	92	89
40	100	90
50	112	91

In the foregoing the juices were treated nearly to neutrality with lime alone. With sulphurous and phosphoric acids, acid albumen, acid sulphite of alumina, or even a decidedly acid lime defecation, the percents removed were, of course, reduced, there being a less intense primary tint. No other lignite gave such high effects as that furnished by your Department. This will be seen from the accompanying approximations, obtained with from 22.5 per cent. to 25 per cent. of lignite on the weight of sucrose filtered, expressed in maxima and minima to the nearest 10, sulphur fumes having been used on the juices, the sirups not having been treated with coal prior to concentration:

Lignite, where obtained.	Per cent. color removed.			
	Juice.		Sirup.	
	Maxima.	Minima.	Maxima.	Minima.
Sangerhausen Machine Works, Germany	60	40	45	35
United States Department of Agriculture, prepared by F. Kleemann, Germany	80	60	50	40
Louisiana Sugar Experiment Station, mined in Alabama	70	50	45	35
J. B. Friedheim, Camden, Ark	60	40	40	30
B. F. Read & Co., Mineola, Tex	60	40	40	30

The higher effect of your article is perhaps attributable, in considerable measure, to a more perfect pulverization than that secured in other samples, the degree of this exercising an undoubted influence. As was noticed in the matter of purity co-efficient, after the use of some 15 per cent. further amounts added were out of all proportion to the increase in effect. The power of lignite to absorb or otherwise destroy or remove is apparently confined to those contained substances producing particular color effects only. For these its affinity is certainly very great, animal char or bone-black, in the lower percentages, being found altogether out of comparison with it in this regard. These colors suppressed, however, by a relatively small quantity of the lignite, additional quantities produce but little useful effect, the remaining coloring matters being those for which it possesses little or no affinity. This hypothesis explains the fact that, having used so much as 30 to 45 per cent. to secure rapidity of filtration, the cake from one operation was found to have lost none of its decolorizing power upon a second application, though it no longer filtered with the same efficiency. Its influence upon the exponent, also, seemed to have diminished little by like previous use upon juice, although considerably more so after the filtration of dense sirups not first treated as juice, a fact possibly finding its explanation on the same lines. Except for the Texas sample, all the coals examined gave up a slight amount of greenish coloring matter, whether boiled in distilled water, juice, or sirup, all showing likewise an acid reaction, your own being most pronounced in the latter particular.

A hard and apparently very dry cake was obtained with whatever variety of lignite, if employed in amounts above 15 per cent. of the contained sugar, provided only ample time was accorded its formation. It was, however, in all instances of high percents, exceedingly porous as compared with scum cake finished off at corresponding pressures, weighing per press always in close proximity to the ascertained average of 670 pounds at a final pressure of 60 pounds, of which, after lixiviation at 40 pounds pressure, 49 per cent., a little more or less, was moisture.

Since with a juice polarizing 13 per cent. sucrose some 46 pounds of the latter would be otherwise lost from each pressing, equal to nearly 3 per cent. of the entire amount treated, supposing 1,300 gallons of juice to be put through, with 30 per cent. of the brown coal, at each operation, the importance of lixiviation can scarcely be overstated. No press except arranged for this supplementary process in its most complete attainment would, of course, be admissible. This work is too uniformly accomplished by steam, by reason of channels at once cut on lines of least resistance, which, besides, leaves the press too hot for immediate manipulation and severely taxes the cloths. Hot water results in too rapid and too great a reduction of the purity co-efficient, possibly because of the action of heat upon the solubility of some among the retained impurities. Cold water certainly performed best, all things considered.

The theoretical amount of so-called displacement water was found altogether inadequate. For a 30-frame Kroog press 200 liters are, for reasons not necessary to state, supposed to be the extreme limit of requirement. This amount when passed in one hour—already a serious loss of time compared with the filtration itself, which consumes but three with 30 per cent. of coal—gave at finishing off a sweet water still running at an average analysis of: Solids, 6.77; sucrose, 5.0; reducing sugars, 0.52; exponent, 73.87. Assuming the

49 per cent. of retained moisture on the 670 pounds of cake to be juice diluted to the same figures, we should have:

	Pounds.
As water	328.30
As contained solids	23.83
As dilute juice	352.13

equal to 25.5 per cent. of the cakes' weight, which would mean the loss per operation of $670 \times 0.525 \times 0.05 = 17.58$ pounds sucrose, or $352 \times 0.05 = 17.60$ pounds sucrose, or to $17.60 \times 46.1 = 811.36$ pounds sucroseper day's work of 60,000 gallons of juice, using 30 per cent. of lignite.

As a matter of fact, analysis of the cake showed this to contain 2.8 per cent. sucrose, or 18.76 pounds of the latter per pressing—a seeming paradox, dispelled by physical examination. This sufficed to reveal how the water, first finding its way past the cake on its line of contact with the iron frame, thoroughly lixiviated the extreme peripheral portions of this, afterwards to pass here in important volumes without effecting any good purpose, while yet having accomplished only a very partial depletion of more central parts. Here was met the third and last serious technical objection to lignite; one which, since it is multiplied by the number of pressings required for given volumes of juice filtered, must apply to the use of any matrix just in proportion as larger or smaller amounts of this are essential to the results sought.

There appeared to offer two methods of escape from this difficulty, each, however, involving a dilemma. Lower lixiviating pressures, while producing much better effects, prolonged the time required for the operation so far beyond the reasonable as would need double or treble the filter-press plant. Increased quantities of water employed reduced the exponent, prolonged the time, and increased the evaporation correspondingly. A third expedient was less effective, but offered some collateral advantages, to wit, more perfect pulverization of the matrix. There can be no reasonable doubt that the finer the state of division to which brown coal is reduced the more rapid becomes filtration, the more complete the decolorization effected, the more solid its cake, and the lower its final per cent. of retained juice. Sifted through the finest of millers' silk bolting-cloth, it performs better duty in every respect than otherwise. It is advisedly stated, and with positiveness, after repeated experiment, that lignite can not be too finely prepared, on a large scale at least, for cane-juice filtration, by any mechanical means at present command. Dissolved even in strong alkalis and reprecipitated as an impalpable powder, its efficiency is yet further enhanced.

As a last recourse higher juice pressures, even up to 300 pounds per square inch on the small press, were used. This, though it unquestionably left remaining a cake charged likewise with less juice and so uniformly compact as to be better adapted to displacement, again was attended with too serious a loss of time, both in finishing off and in subsequent lixiviation, to compensate the advantage in sugar redeemed or evaporation avoided. Pressures in excess of 100 pounds per square inch are, besides, not feasible in industrial practice.

A single industrial run of twenty-four hours was finally made January 16 and 17 with brown coal, with intent primarily to develop and locate any unforeseen mechanical difficulties incident to continuous work. Numerous such arose, of course, each happily, however, suggesting at once its own certain remedy. If, technically, this large effort was not as satisfactory as might have been anticipated from the painstaking arrangements made for and well-organized and precise management accorded it, it was yet successful beyond all expectation in solving those problems which must ever attach in cane-juice work to the application in filter presses on a considerable manufacturing basis of any matrix whatever. It removed at a stroke all necessity for the yet more extensive operations which, as you know, had previously been proposed.

It is needless here to weary you with the details of this day's run, which, with its antecedents rather than with its consequents, demonstrated conclusively, as is believed, that while the filtration of the entire body of defecated juice thus, with brown coal, stands well among the mechanical possibilities, its application can by no means now conceived with us be rendered remunerative to the Louisiana industry. This your discernment will already have made quite as clear to you by what precedes as it can by any present comparison between the weights and polarizations of its resulting products and those customary to the establishment in its treatment of like raw materials. Such data, indeed, await your command, but indicate to me no variation in *rendement* beyond that attributable to the accidents and incidents common with every-day factory experience. There occurred nothing of the oft and persistently predicted clogging, either of pumps, conduits, presses, or cloths. The cloths at the end of twenty-four hours showed no loss of transmitting power, and were washed with surprising ease.

In quality of products, no doubt, some advantage was recognized to accrue, bone-coal not being employed in the factory. Notwithstanding, in this particular also disappointment was felt. In no other respect than this, surely, did the results of this experiment compare even favorably with those secured by Mr. G. L. Spencer, in 1886, with the Remmers and Williamson wood-char process, under the patronage of your Department at its Magnolia Station, as these stand officially reported in your Bulletin No. 15 (pp. 20–25, inclusive). So much more effective has vegetable char than brown coal been shown also in our own work, both as a filtering and as a defecating agent, that, having abandoned the latter altogether, experimentation since several weeks with the former, in a laboratory way, with seed-cane, has now been in seemingly successful progress here. The following is not an unfair comparison, so far as experience yet teaches, between the two articles applied to juices somewhat deteriorated by long storage of canes:

	Matrix required on weight of sucrose.	Improvement of purity co-efficient.	Decolorization sulphured.
	Per cent.		*Per cent.*
Brown coal	30 to 45	0.30 to 1.90	60 to 80
Wood char	6 to 12	1.50 to 4.30	6 to 12

Lignite presents other disadvantages, as well, in comparison with wood charcoal. Upon concentration to sirup, juice filtered with whatever percentage of it, whether reduced with the low temperatures of vacuum evaporation or under atmospheric pressure, gives invariably an additional precipitate of matter probably rendered insoluble solely by the increase of density. No such precipitate has at any time, with any defecating agent, been observed after filtration with wood coal. How weak is its absorptive power, beyond that for coloring matters, is shown by the fact that, after filtration through paper alone, an improvement of but 0.03 in the exponent was secured to sirups from the ordinary lime defecation by subsequent treatment with 30 per cent. of the lignite. Below are the averages:

[Concentrated in double effect.]

Sirup.	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.
After primary filtration through paper............	57.60	47.2	4.55	81.94	9.64
After subsequent treatment with 30 per cent. lignite...	62.70	51.4	4.76	81.97	9.58
Rise in purity co-efficient with lignite...............	....	....	....	0.03	....

Although when freshly ground, and yet containing from 30 to 35 per cent. of hyroscopic moisture, it can be readily brought to mix intimately by mechanical means with the juices, this is scarcely to be accomplished in the large and regular quantities required if, having been long prepared, desiccation to 15 or 20 per cent. has not somehow been prevented; in which state, if sufficiently comminuted, it excels not only the kneading requirements of patent flour fourfold, but becomes even dangerous from liability to spontaneous combustion. This infers the necessity for a grinder on the premises, with engine, foundations, sifters, elevators, mixers, shafting, belting, and their like *ad libitum,* in a structure apart from the factory building proper, which last would needs be protected from the attendant dust, as another serious sugar-making complication and care. Such a plant has been estimated, by a probably competent European engineer, to cost, for a 60,000-pound diurnal output, erected upon this property, exclusive of the presses and their immediate appurtenances, but inclusive of building, not less than $10,000. Wood coal can, on the other hand, safely be prepared during the leisure of idle months, at home or elsewhere, and be mixed in the greatly reduced amounts called for, as wanted, with the most simple and inexpensive devices, or be stored without injury or danger from season to season. Even wood char, however, for satisfactory filtration, should also contain a considerable percentage of moisture when ground. Otherwise the first run of liquor is likely to come charged with the char, requiring refiltration. It appears that this, unlike lignite, may be rendered in part too pulverulent, which last the enforced presence of sufficient moisture at the time of its reduction is believed to prevent.

Brown coal, again, is not known to exert even a favorable mechanical action on the soil's productiveness; that wood char exercises valuable functions in this regard is well understood among agronomists. If in the ordinary filter-pressing of scums and sediments well-nigh the entire fertilizing content of the juice itself is already secured, leaving no credit for such properly to be conceded to either, for this mechanical advantage of charcoal something may well be deducted from its estimated first cost to manufacture. It presumably absorbs from the juice, also, fertilizing material in excess of the brown coal, equivalent to the additional rise it secures in the exponent of this. The aggregate bulk of brown coal required would be such as might well preclude economic distribution over the fields.

Considering the quality of the native brown coals as yet examined, the cost of transportation, and, if imported, the duty upon such enormous quantities of these as are demanded, the price of vegetable char, it appears, should compare most favorably with them throughout the Louisiana sugar belt. Brown coal, in sugar work, demands also a royalty under letters patent; the patents upon wood char, in this application, have been permitted to lapse. Brown coal can not be revivified. Wood char, it is believed, can be reburned by superheated steam in any state of comminution, if found desirable. It remains to be known from the distillation of which variety of wood, however, the best quality of the last-named article for the purpose proposed is to be obtained. As saw-dust, oak is known to perform best, probably because of its excess in tannic acid.

As of application with whatever matrix employed it is pertinent only to add, as a further result of our experience in the matter, a few convictions touching the appliances best suited to the treatment of juice in considerable volumes.

The advantage of duplex, double-acting plunger pumps, extra large for their duty and operated at low-piston speeds, with exceedingly capacious air vessels and sensitive safety valves placed close to the pumps, the last of equal conducting capacity with the feed-pipes, was fully indicated. To thus insure, by every means, against sudden variations of pressure, such, especially, as the vibratory pulsations inseparable from ordinary pumping plants, seemed essential to a cake of maximum uniformity and uniformly well adapted to lixiviation in all its parts, as before insisted. With the lixiviating apparatus itself this completeness in erection is even more prominently to be indorsed, except that, as no grit is here to be encountered, piston pumps should suffice. A continuous stream of liquid running from the safety valves, both juice and lixiviating, should be maintained during operation. In the most perfect practice no approach to theoretical displacement has been found to occur. This supplementary process is, unfortunately, at the most we have been able to make it, little more than has been expressed with the word lixiviation. Whiting and highly colored liquids render its study facile.

The absolute necessity to the process of chamber presses, whether top, bottom, or central feed, and, conversely, the total unsuitability of frame presses in general to it, was left in no doubt. Each operation consumes so short an interval that a large percentage of total time is spent in emptying. A chamber press can be emptied readily in one-half the period consumed by one of the frame variety for the same number of cakes. As the cloths need be removed not oftener than twice a week, the loss from this source, in employing such, is negligible. It is not true that cloths wear most rapidly from use in chamber presses, except these be ill constructed. The tendency during lixiviation which the water exhibits, however this be fed and no matter how superlatively perfect the cake is, to cut of itself a ready and continuous channel about the cake's peripheral joint with the iron frame, has been mentioned. This results in a sludge formed along the cake's feather edges which, upon opening the press, runs more or less, despite the best effort, down the frame's sides, especially along its bottom portions, compromising the joint which this afterwards makes with its adjoining cloth. Following three rounds with brown coal, such a press can not be made tight, and after four or five may even refuse to close, except the surfaces be laboriously cleansed with iron scrapers. In chamber presses the peripheral joint is made between cake and cloth and not between cake and iron. From this fact alone it is far more perfect. Its form, however, if properly designed, is of yet greater importance and, presenting no longer necessarily a line of least resistance, reduces the chance of sludge, besides insuring, other things equal, a more uniform and complete displacement with reduced quantities of water by preventing the formation of such water channels as those before described. If by any chance a small amount of semi-liquid material here runs in like manner, notwithstanding, this interferes in but half degree with a press joint now made between two thicknesses of the fabric instead of between iron and one such. Although in top and bottom fed chamber presses the liquor inter-ports of the individual chambers may be of greater diameter than those possible with frames, yet from liability to obstruction the center feed is to be preferred.

Any filter press constructed for the use of brown coal or any of its congeners should be recessed for $1\frac{1}{4}$ instead of for 1-inch cakes. This statement will not remain true except that in all cases the wisdom of employing the matrix in excess is confirmed. A yet greater thickness in these might then perhaps prove still more advantageous were it not the limit at which, in such presses, the cloths have been made to stand. Without attempting an explanation of the fact, it remains that, with chambers of increased thickness, higher results per square foot of filtering area are attained, this dimension even doubled, curiously enough as it would seem, requiring but a very small fraction more of time for cake completion than before, so long as a slight excess only of matrix is in each instance employed. This is best illustrated in starch manufacture. Speed in filtration is, then, increased by this innovation, except for deficiency of matrix; a relative reduction in the amount of sweet water to be dealt with is secured and proportionate time is saved in emptying.

Since it consumes no more time to empty thirty chambers presenting 400 square feet of filtering area than thirty aggregating but 220, presses of the former size should alone be used for the purpose under consideration. Such are decidedly cheaper in first cost per square foot of filtering surface; are as readily handled and kept tight, and require, proportionately to the work done, fewer laborers. They occupy scarcely more space.

The presses should be worked in batteries after the English plan, instead of by rotation, as practiced in Germany. This avoids a fall of pressure, with consequent loss of time and a cake ill suited to lixiviation in the other active presses, when one freshly prepared is set in operation. It also permits, which is of much consequence, low pressures at the start, which are gradually increased to high at the finish, a practice precluding all attempt at governing the pressure at the pump's throttle by an attached pressure regulator.

A precipitate invariably following evaporation, by whatever means accomplished, of juice filtered through brown coal, the filtration of sirup was accorded some study. For this purpose from 12 to 15 per cent. of lignite on the weight of sugar operated upon was found necessary to satisfactorily rapid work, previous treatment notwithstanding. Again the improvement in purity was not marked, averaging 0.82; that in color being the more conspicuous result, at about 40 per cent. of this removed.

For sirups from unfiltered juices the ratio of lignite had, of course, to be increased until percentages approaching those employed with juice had been attained. Equal amounts would probably have been necessary, in terms of sugar, except for scums removed and some 8 to 10 per cent. of the juice itself already filtered with these, decantation of clear liquor from skimmings not having been practiced. Mere bulk, thus, in the filtrate, was seen to exercise no perceptible influence in this work. The dilution of sirup by the addition of water in any amount can, of course, in no wise reduce the quantity of coal required, which is determined alone by the quantity and quality of non-sugar dealt with. Neither the net result in purity nor in color was equivalent in filtered sirup from unfiltered juice to that secured in unfiltered sirups from filtered juice. The glucose ratios of sirups first filtered as such were always considerably higher than those of unfiltered sirups derived from filtered juices of like quality. It is supposed that by the filtration of juice, though this is left in all cases more acid by the process, certain active inverting agents are removed, thus reducing the losses otherwise sustained in concentration. The brown coal also removed an amount of reducing sugars relatively larger than that of sucrose lost in the operation, the glucose ratio being almost uniformly lower after than before filtration, whether of juice or sirup. The ash is also reduced.

Not above 550 gallons of sirup from unfiltered juice could be put through a 30-frame Kroog press with 25 per cent. of brown coal on the weight of its sucrose at one operation, this, complete, occupying about four hours. A $\frac{7}{8}$-inch frame or chamber was found ample in the treatment of sirups, but even for this work 400-foot presses, it is thought, would be preferred. Thinner frames would be necessary with reduced percentages of lignite. Lower pressures than those mentioned for juice gave the more satisfactory results, which also should be extremely steady.

The cake from sirup filtrations following that of the juice, with or without lixiviation, when mixed with the amount of fresh coal necessary to bring the total of this to the usual standard, was found to perform about as well on a fresh supply of juice as an equal total of fresh coal, the amount of the latter being thus proportionately reduced. In practice this would obviate the difficulty of sweet water from the sirup filters. Wood char was given no trial in connection with concentrated liquors. The whole subject of sirup filtration in filter presses merits more thorough investigation than circumstances have yet permitted at this factory, although success with such can scarcely supplant the far greater necessity for previous treatment of the juices.

Experiments, by no means exhaustive, were also made with the Bauer process. This failed from the first. The mucilaginous impurities, passing through the interstices of the bone char, reached and occluded at once the pores of the cloth, thus bringing operations to a speedy termination with every trial. The cloths were washed with great difficulty. To fully meet every prejudice the entirely inutile use of various fabrics was resorted to. With bone-black, from coarse to finest, the result was always the same. Indeed, as is well known, animal char in sugar work is an extremely poor filtering medium, no matter how skillfully revivified, and except for the preliminary Taylor or bag filtration could scarcely be used after the manner or in the percents at present common except upon the highest centrifugal goods, even in the refining of sugars from which the major portion of non-sugar has already been removed, upon the plantation, in scums, sediments, and molasses—substances which are yet left remaining with us in our treatment of juices. It is imperative with this article, in our work at least, that it be used in quantities quite beyond the utmost ability of filter presses to accommodate.

Notwithstanding the meager results as yet secured, eventual success in the economic mechanical filtration of the entire body of defecated juice is not altogether despaired of. Its difficulties have been greatly underrated. All the juices thus far dealt with have been the product of milling under pressures attaining from 65 to 78 per cent. of these upon the weight of canes crushed. So successful throughout has been the routine work in this establishment with skimmings and settlings from all manner of canes and with many modes of defecation, and so small has been at any time the immediate improvement in the purity co-efficient attributable to it, and yet, by comparison, so easy and rapid a second filtration, as to have forced a conviction that in but an exceedingly small part of the total non-sugar resides well nigh the whole difficulty. This probably minute portion of especially refractory material has been traced as an insoluble, suspended impurity to raw juice direct from the rolls, which presents in the filter practically all the perplexities encountered after defecation and may be followed thence quite to the molasses. The microscope has not identified it at 100 diameters. Fermentation fails to remove it. Although itself probably inert and harmless, it suffices to render most difficult or altogether impossible a process which, in effecting an immediate improvement, if only of several points in the exponent, would yet suffice before the by-product was reached to add directly or indirectly a decided increment to the otherwise possible *rendement*. Your success in filter-pressing carbonated diffusion juices this season of 1887–'88 at the Magnolia Station leads to the hope that this small part, whatever it may be, is either in great measure eliminated from the artificial juice by diffusion, or else is amenable to chemical treatment (other than carbonation), such as it is reasonable to suppose will not escape adequate research. In either case the benefit to accrue would become important to the local industry, the substitution of osmosis for pressure in juice extraction by large central factories now seeming as if eventually inevitable.

It is proposed by the proprietor that the investigation of this subject shall continue at this place uninterruptedly throughout another season. At his desire I express the hope that it may not be impossible with you to detail a chemist from your department to aid in this search for an improved defecation. It is not to be overlooked how, to the present, your Department, in pursuing its inquiries with respect of sugar manufacture, has neglected altogether the sulphur regimen universally found in Louisiana's practice, excepting only at its previously chosen station.

With much respect, sir, I am yours, very truly,

W. J. THOMPSON.

Dr. H. W. WILEY,

Chemist, U. S. Department of Agriculture,

Washington, D. C.

INVESTIGATION OF FOOD PRODUCTS.

CERTAIN PLANTS OF ECONOMIC VALUE AS FOOD FOR MAN AND STOCK IN TEXAS AND NEW MEXICO.

By Clifford Richardson.

During the past few years several plants have been brought to my attention which are in use for forage purposes or as food for man in Texas and New Mexico. They belong to the genera *Opuntia*, *Dasylirion*, and *Agave*. One of the *Agave* species has been superficially examined from a chemical point of view by O. Loew in his reports to the Wheeler survey.* It is not of agricultural importance, that I am aware, but it is of interest because of its chemical relations to the others. The *Dasylirion* species, known as Sotol, I have already noticed in the Annual Report of the Department of Agriculture for 1883, pages 242–244. It belongs to the family *Liliaceæ*. Generally described it consists of a caudex 2 to 5 feet high, bearing a rosette of light-green leaves 3 or 4 feet long and $\frac{4}{10}$ to $\frac{5}{10}$ inch broad, expanding into a fleshy base 1 to 2 inches broad, and a flowering stem 8 to 10 feet long.† It is the fleshy bases of the leaves, forming a dense cabbage-like head, which are used for feeding purposes. The outer are black and hard, while the inner are yellowish-white and succulent. The heads weigh 6 or 7 pounds, of which the soft edible portion forms one-third. The shepherd splits the head open with a knife, after which the sheep or cattle readily get at the succulent interior, and in time become accustomed to pull off the outer leaves. Sheep living on it can exist without water in winter for four or five months. It is eaten by man, when prepared by roasting in pits, after the manner of the *Agave*. It is also fermented into a mescal or highly intoxicating liquor, known from the name of the plant as "*Sotol mesal.*"

The plant grows abundantly in western Texas and Mexico on rocky and gravelly soil, and flourishes in the driest seasons. An investigation of the soft interior showed that about 40 per cent. of juice may be expressed from it, which is sirupy, and consists of over 30 per cent. of solid matter, corresponding to sugars, equivalent to—

	Per cent.
Reducing sugar, as dextrose	.66
Sugar, reducing after inversion, as sucrose	26.44

An examination of the whole head showed the presence of between 15 and 16 per cent. of sugars. The reducing sugar resembles dextrose, but the principal sugar is not sucrose, since the juice polarizes 30° to the left before inversion, marking it at once as new, since no non-reducing sugar of such rotatory power is known. It is readily inverted, even on boiling, with production of a substance other than sugar, besides the reducing matter. The plant is therefore distinguished by the presence of a large amount of a glucoside readily decomposed, and which could be further investigated with interest.

The agave examined by Dr. Loew was also found to contain a large amount of a similar substance. It was a species related to

*Reports of the Surveys West of the 100th Meridian. Lieut. G. M. Wheeler in charge. Vol. III. Geology, 610, 611.

†Watson, Proc. Amer. Acad., xiv., 249.

Agave decipiens called *Maguey* or *Mescal*, and used by the Indians as food. Of it he says:

The undeveloped leaves are folded into each other like a bud, and are perfectly white and soft as long as no sunlight reaches them. The taste is sweet, afterwards somewhat biting. These heart leaves when exposed to heat assume a very sweet, at the same time sour taste. When roasted several hours, they become soft enough to remove the fibrous portions.

There is no peculiar smell, and the change is like that of no known substance. No starch or similar matter is present, and a reducing sugar is formed without the aid of acid, although none is originally present. Mere boiling with water is sufficient. The products of the inversion were proved to be dextrose or a similar reducing sugar and citric acid. The peculiar substance is therefore a glucoside. The sugar in *Dasylirion* and that of *Agave* are so much alike that, being derived from such similar plants, their relation is of interest.

The *Opuntia* species, which was next examined, it was thought might resemble the two preceding plants. The specimens which were forwarded to Washington were sent through the courtesy of Hon. A. J. Dull, of Harrisburg, Pa., with the request that an analysis be made, as the plant was of importance for forage purposes and was attracting some attention in southern Texas. The species was not identified with certainty, but was either *Opuntia tuna* or one closely allied. It is known by the Mexicans as *Cacannapo*, and in this country as cactus or Prickly Pear, the succulent joints, not properly the leaves, being the portion of value for fodder. The results of the ordinary fodder analysis were sent to Mr. Dull with the comment that the material showed a deficiency in albuminoids, and should be combined for feeding purposes with substances rich in nitrogen. At the close of the season a reply was received in regard to the results of the use of the plant from Dr. A. G. Carrothers as follows, which explains the peculiarities and uses of the different *Opuntia* species.

In compliance with your request of July 27, I send to-day by mail specimens of the thick cactus known by the Mexicans as *Napal de Buey*, or the "Cactus of the Ox," together with specimens of its fruit, the flowers being unattainable at this season, collected at Iuka Ranch, La Salle County, Tex., 28 miles north of Mr. Dull's ranch. As to practical information in regard to the application of the plant as fodder in Texas and Mexico, I will state that I have studied this matter for a couple of years, believing that it possessed a considerable food value.

While living in Mexico I saw that the Mexican teamsters, who did the freighting of the country with oxen, were able to work their steers all winter and keep them in good condition by collecting the pear leaves, burning the thorns off them, and feeding them to the oxen. I found the Mexican freighters in Texas doing freighting on the same food, alongside of the Americans who were feeding high priced corn to their animals, and maintaining their animals in as good or better condition than their competitors. From this I concluded that the Prickly Pear was rich in growth producing elements.

About 1878 or 1879, while on a visit to the Leona Ranch Company in Zarella County, Tex., the foreman told me that he had just received a consignment of 52 thoroughbred and high grade Durham bulls from Kentucky, late in the fall, and did not know how to feed them. They cost about $150 each. I advised him to scorch the thorns off the pear leaves, chop them up, put them into troughs, and sprinkle them with corn-meal and salt, and feed them to his bulls at night, allowing them to graze on the Mesquite grass (*Buchloë dactyloides*) during the day. He did so, and next year he assured me that his bulls wintered in good style, and were fat and vigorous the next spring. His wife also volunteered the information that she thanked me for the suggestion, as she had fed some of her milch cows on the same food and that she had made as fine butter all through the winter as she had ever made in Illinois. Since that I have fed my milch cows at the ranch on the scorched pear alone, with marked benefit to their milk and butter-producing qualities. Several of my friends have done so with like results. My foreman tells me that his father, as an experiment, shut up some hogs and sheep in a pen in July, and gave them no food or water for six weeks except what they derived from the scorched pear leaves, and that they greatly improved in flesh during the time. About sixteen months ago (April, 1885) I asked the pastor of 3,000 sheep grazing on some of my land when he watered his sheep. He replied that he gave them no water except what they got from the pear, and that they had not seen water since the previous October, for six months, at shearing time. I have since verified his statement, and it is well known that sheep and cattle can subsist indefinitely upon the pear in the winter months. During the severe drought of last winter and the previous one many thousands of cattle were fed upon the scorched pear leaves, but it was the universal experience that it was necessary to give some species of "roughness" with it: that if fed alone it would not be assimilated, and would cause "scouring" or diarrhea. On the Nueces River, below my ranch, thousands of trees covered with Spanish moss were cut down for the moss as a food for the cattle in conjunction with the scorched pear leaves. The moss is not regarded as possessing much nutritive value, but rather as the diluent and bond of union to the pear, to enable the animal to properly ruminate it. Colonel Miller, member of Congress from Gonzales district of Texas, who owns the finest herd of Holstein cattle in the State, tells me that he has fed his entire Holstein herd of about 80 head for the past five years on the leaves of the Prickly Pear thoroughly cooked with cotton-seed. He covers the bottom of a large sheet-iron box with the scorched and chopped pear leaves, filling it about two-thirds full of pear, then fills the box with cotton-seed, throws a few bucketsful of water into the box, builds a fire under it, and cooks the cotton-seed with the steam which arises. He assures me that his cattle keep fat all winter upon a small pasture which could not otherwise support them. Judge Blackburn, of Burnett, Tex., gives me substantially the same statement, from feeding it to a herd of imported cattle. The Dolores Land and Cattle Company, composed of my brother, W. S. Carothers, and my cousin, G. A. Searight, of Austin, have fed it for the last three years to some three or four car-loads of Hereford cattle which they have brought to Texas from Iowa, and find it a valuable food, and also believe it to be almost a specific in the prevention of the impaction of the third stomach and hemo-albuminuria, called Texas fever, from which animals brought from the North are apt to suffer. I imported 41 head of Hereford bulls last January, and found the cooked pear of great utility in preventing the same trouble. I could multiply instances of its supposed utility, but these are the principal ones that have come under my direct observation.

My conclusions are: (1) That it is not a perfect food. It must be supplemented or complemented with other articles, especially with hay or grass. (2) That while your chemist found no starch present, he found the metamorphic stage of starch, glucose, which is most readily assimilable in the stomach of all animals, and the condition to which starch must be reduced by the action of the salivary and pancreatic secretions before it can be assimilated. (3) That it is deficient in the nitrogenized albuminoids, contrary to my preconceived opinion. (4) That whatever its food value may be, it undoubtedly aids in the assimilation of more highly nutritious foods, possibly by some catalytic action or by emulsifying the fats that they contain. Colonel Miller is very positive in his conclusions upon this point. Gum and glucose make a perfect emulsion with all fats.

The presence of the "glucoside body" explains two facts that have lately come to my knowledge: (1) That a neighbor of mine, a Frenchman, has succeeded in making a palatable and intoxicating wine from the fruit of this cactus. (2) That alcohol has been distilled by a chemist in San Antonio from the bruised and fermented leaves of this plant to such a degree that it has been discussed as a possible source of alcohol. There are several points upon which scientific information, such as you can give, would be of great value to Texans.

First. The substances with which this cactus can be combined to make it a perfect food for the purpose of fattening beef. We have available in our section the following articles:

(*a*) Mesquite grass (*Buchloë unioloides*).
(*b*) Grama grass (*Bouteloua oligostachya*).
(*c*) Johnson grass (*Sorghum halapense*).
(*d*) *Sorghum—saccharatum* and other varieties.
(*e*) Cotton-seed oil meal.
(*f*) Corn-meal.
(*g*) Our pasture grasses, annuals, as the varieties of *Andropogon*, *Paspalum*, and *Panicum*, especially *P. texanum*.

Now, if we can make a combination of the above enumerated articles and the Prickly Pear, we can mature our beef on our own ranges. I send specimens as follows:

No. 1. A leaf of last year's growth.

No. 2. A leaf of this year's growth.

No. 3. An old leaf cut from near the main stalk. This is supposed to be more nutritious than the others, and is the part that horses will eat if cut up fine for them. I regard this as of interest.

No. 4. Specimens of the fruit, the last of the season.

I have been unable to procure specimens of the thin-leafed cactus, the *Cacanapo* of the Mexicans that Mr. Dull sent you, as it only grows upon thin black land, whereas my land is a rich, sandy, red loam. I shall, however, procure the *Cacanapo* as soon as possible, and send it to you. It may be well to note what may be, and probably is, a popular superstition in relation to the fruit of these two varieties. It is believed that the fruit of the *Nopal de Buey* which I send you will cause, if eaten, chills and fever (*Febris intermittens*), while that of the *Cacanapo*, a smaller and lighter colored fruit, is innocuous, and is used by the Mexicans as an article of diet, while they will not eat the other. It may also be worthy of attention that the cochineal insect is only found upon the *Nopel de Buey*, of which I send a specimen, and never upon the *Cacanapo*. I would also like to correct a misapprehension in your letter. It is not an "arid" region in which this cactus exists. We have an annual rain-fall of from 24 to 26 inches, and usually raise good crops of cotton, corn, and nearly all the cereals. I have raised stalks of Johnson grass 9 feet high, within 100 yards of where I cut the samples of pear that I send you.

I fear that I have extended this report to such a length as to weary you in reading it, but what I believe to be the importance of the subject must be my apology. I am secretary of the Southern Texas Live Stock Association, own a large ranch, and have my entire capital embarked in stock-raising, hence I am greatly interested in the matter and in everything pertaining to it. I would regard it as important if you would have an analysis made of the different parts of the cactus before and after cooking the same. Congressman Miller is quite positive from his experience that cooking greatly increases the food value of this substance, and I think it not improbable. We have familiar examples in the process of panification, in the making of "*pinole*" by toasting the kernels of corn and rice, in the roasting of peanuts, and other similar cases. In all of these the quantity of sugar or its congeners is increased.

Could you give me the quantitative analysis of the glucose in same specimen before and after cooking? I am at your command for any further information you may require, and should this investigation be attended with any expense I will cheerfully meet it.

Yours, truly,

A. G. CAROTHERS, M. D.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., October, 1887.

Later Dr. Carothers wrote:

In pursuance of the correspondence of last summer, begun by Mr, A. J. Dull, I have fed 400 beeves and am now feeding 800 more on this food. From the analysis furnished I found the cactus was deficient in the nitrogenous albuminoids, and from the well-known richness of the cotton-seed oil cake in these elements, I selected it to supply the deficiency, which it did very satisfactorily.

I first burned the thorns off the cactus, then cut it up by a machine which I devised, and spread it in large troughs, scattering the cotton-seed meal over it, when the cattle ate it with great avidity. I soon found, however, that the burning was injurious, as it was impossible to conduct it without cooking the cactus to a greater or less extent, which caused purging in the animals. To remedy this, *i. e.*, to destroy the thorns without scorching, I took advantage of the botanical fact that the thorns of *O. Engelmanni*, the only one I use, are set at about an angle of 60° backward to the plane of the leaf, and that a cut of one-half inch in width would strike every one of them and destroy them. I therefore set the knives of my machine to a one-half inch cut, and find that the cattle eat it fully as well as when scorched, with none of the unpleasant results referred to. I have fed about 60 pounds of the cactus and an average of about 6 pounds of the meal per capita for ninety days. A train load of 330 head of these cattle sold last week in Chicago at 4¼ cents. The meat is singularly juicy and tender, the fat well distributed among the muscles. I have sold it at 1 cent gross over grass cattle in San Antonio.

A. G. CAROTHERS.

Others have more recently expressed, at the request of Dr. Vasey, their opinions in regard to the use of Opuntia, which have been published in Bulletin No. 3 of the Botanical Division of the U.

S. Department of Agriculture. The experience of nine or ten observers has been varied. It is fed especially in winter, cattle, sheep, hogs, and goats living upon it. At times it is fed as found upon the range, but difficulties, as Dr. Carothers remarks, have been met with by most cattlemen on account of the spines and with their removal by burning and the consequent purging, although others have never experienced the latter defect. As a whole, however, the success met with in its use has been marked, and as it grows in such large amounts and so readily in those portions of the country where corn can not be obtained, it must become of considerable value.

With a view to throw some light upon its rational use as a forage plant, its analysis was undertaken for Mr. Dull and carried rather further, for the purpose of comparing it with *Dasylirion* and *Agave*, and as being a representative of a class of plants of which little is known.

The results obtained from an ordinary fodder analysis of two specimens of the *Cacanapo* or thin-leaved Prickly Pear, probably *Opuntia tuna*, from Waugh's Ranch, La Salle County, Tex., was as follows:

	Old thick specimen.		Young thin specimen.	
	Fresh.	Dry.	Fresh.	Dry.
Water	85.93	....	86.88	....
Ash	2.94	20.84	2.40	18.36
Fat	.13	.98	.11	.82
Crude fiber	.90	6.37	.53	4.04
Albuminoids	.51	3.63	.78	5.91
Nitrogen-free extract	9.59	68.18	9.30	70.87
	100.00	100.00	100.00	100.00
Per cent. of N. as non-albuminoid	....	30.0	....	22.6

As has been remarked, it is deficient in nitrogen, and should be fed together with cotton-seed meal and the grasses which fortunately are common and cheap in the country where the Opuntia grows, and supplies the deficiency in oil and albuminoids.

With the view of determining the proximate principles of the plant, and discovering the character of the non-nitrogenous extract and the causes of purging in the roasted specimens, a more thorough analysis was undertaken. A microscopic examination showed that the structure of the joints consisted of an outer, thin cuticle, growing thicker in older specimens, followed by a row of round, longitudinal cells running lengthwise of the joints, and then a row of shorter cells running crosswise, delicate in the young plants, but quite woody in the older ones. Below these there is a series of long, round cells running through the joints till the parenchyma, which forms the main body, is reached. Through the latter run fibro-vascular bundles, and near its juncture with the outer coats are scattered starch grains. The largest portion of the nitrogenous substance is in the fibro-vascular bundles, which form the frame-work of the plant, and probably give, with the outer coats, the fiber mentioned in the analysis. The cellular structure of the interior is small and delicate.

The joints weighed—

	Grams.
Old and thick specimens	731
Young and thin specimens	650

The results of the more detailed proximate analyses were as follows:

Approximate analyses of Opuntia species, Cacanapo.

	Older and thicker specimen.			Younger specimen.		
	Original substance.	Dry substance.		Original substance.	Dry substance.	
Water	85.93	.....		86.88	.....	
Ash:						
Insoluble	1.76	12.48	20.84	.90	6.88	18.36
Soluble in water	.80	5.66		1.22	9.32	
Soluble in 80 per cent. alcohol	.38	2.70		.28	2.16	
Volatile oil, ether extract	.01	.08		.01	.06	
Solid soft fat, ether extract	.12	.90		.10	.76	
Aromatic bitter resin, 80 per cent. alcohol extract	.13	.98		.11	.84	
Organic acid, 80 per cent. alcohol extract	.53	3.74	25.43	.68	5.19	20.01
Glucoside, etc., 80 per cent. alcohol extract	3.05	21.69		1.94	14.82	
Vegetable mucilage and organic salts containing ash, water extract	1.59 [.80]	11.31 [5.66]	16.97	3.03 [1.22]	23.08 [9.32]	32.40
Soluble in acid, pararabin, starch, and oxalate of lime	2.84	20.17		3.09	23.57	
Soluble in alkali	1.45	10.34		.44	3.37	
Crude fiber	.90	6.37		.53	4.04	
Crude albuminoids	.51	3.63		.78	5.91	
Nitrogen	.....	.58		.....	.86	
In alcohol extract	.....	.084		.....	.....	
In water extract	.....	.056		.....	.....	
In lactic acid	.....	.174		.....	.195	

It will be seen that, as in the *Dasylirion* and *Agave*, a glucoside was found. This also rotates the ray to the left, and is readily inverted with the formation of an acid. It was obtained in small amount in crystalline form, but not sufficient for extended examination. Owing to its partial decomposition the alcohol extract of the plant has an acid reaction. The other prominent constituent of the nitrogen-free extract is a vegetable mucilage which is present as a magnesia compound, the latter being a prominent ash constituent. The value of this as a nutrient is uncertain, and the presence of so much magnesia may cause the purging, which would then be greater with the younger plants, which agrees with the opinion that the plant is more so when the sap is in it. The mucilage polarizes left-handed, but less so after treatment with acid. It is precipitated by one volume of alcohol from water, but not by lime-water.

There seems to be some relation between the glucose and mucilage in the plant, for where one becomes abundant the other diminishes proportionally, the younger portions containing more mucilage and less glucoside.

Of other constituents it was observed that the alkalinity of the ash of the leaves corresponded to the following amounts of organic matter in the plant, calculated as oxalic acid:

	Per cent.
Older leaves	11.05
Younger leaves	29.54

An examination showed that the acid present was not largely oxalic, but some other forming a soluble lime but insoluble lead salt; in fact probably a mixture of several.

The fat was of a nature solid at ordinary temperatures, but small in amount, and accompanied by a trace of volatile oil.

The substance insoluble in water but soluble in dilute acid was in part nearly related to pararabin, together with a little starch and some oxalate of lime. The alkali extract was not identified, but was much larger in the older specimen, and is probably of a nature allied to cellulose or the material forming the cells.

The alcohol extract gives a heavy precipitate with basic lead acetate, organic salts, a cloudiness with mercuric nitrate, and a slight brown with copper acetate on boiling. The resin insoluble in water but soluble in alcohol is soluble in ammonia and precipitated by acid. To what to attribute the purging is uncertain. It may be due to the acid produced by the inversion of the glucoside, to the large amount of mucilage and magnesia, or to the organic acids present in such large amounts. Dr. Carothers's specimens, which, as he states, were different from Mr. Dull's, were identified as *Opuntia Engelmanni*. Being supplied in several stages of development of the joints and fruit, they furnished material for a more thorough study of the variations in the composition at intervals in the growth of the plant, as well as for comparison of the two species and the effect of cooking.

The joints varied in dimension and weight, in accordance with their age. The specimens were weighed and measured, with the following results:

	Thickness.	Length.	Width.	Weight of one.
	Inches.	*Inches.*	*Inches.*	*Grams.*
Growth of the year	1.25	....	....	1500
Growth of previous years	.75	12	9	1311
Old stem joint	2.00	....	5	2093
Old fruit	....	....	....	66
Younger fruit	....	....	....	49
Youngest fruit	....	....	....	28

The growth of the year was much thicker and narrower than that of the previous year, and in consequence, as appears from the analysis, more succulent. These two samples appear not to be strictly comparable as representing these two stages of development. It would have been more desirable to have selected joints developed more on the same plan. The oldest fruit was ripe and purple, the younger just tinged, and the youngest quite green.

The analyses resulted as follows:

Analyses of the joints and fruit of Opuntia Engelmanni at various stages of growth.

JOINTS.

	Growth of the year.				Growth of previous year.				Old stem joints.	
	Natural condition.		Steamed.		Natural condition.		Steamed.		Natural condition.	
	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.
Water	86.00	....	88.00	....	93.50	....	90.00	....	86.00	....
Total ash	3.27	23.38	2.18	18.21	1.18	18.09	1.60	15.98	1.77	12.64
Oil	.88	6.26	.76	6.30	.48	7.31	.66	6.63	.27	3.27
Resin, etc	.33	2.39	.24	2.00	.14	2.12	.30	2.95	.46	1.89
Glucoside and organic acid	1.05	7.48	1.10	9.19	.90	13.88	1.04	10.39	2.01	14.40
Ash soluble in alcohol	....	[2.61]	....	[3.36]	....	[6.00]	....	[3.98]	....	[4.29]
Mucilage	1.92	13.69	1.45	12.14	.60	9.27	1.11	11.10	.58	4.14
Ash	....	[7.13]	....	[6.16]	....	[4.19]	....	[5.46]	....	[1.75]
Crude fiber	1.11	7.90	1.09	9.01	.80	12.27	1.39	13.96	1.97	14.07
Albuminoids	1.16	8.29	1.02	8.46	.50	7.81	.80	7.95	.79	5.66
Undetermined	4.28	30.61	4.16	34.69	1.90	29.25	3.10	31.04	6.15	43.93
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen	....	1.33	....	1.35	....	1.25	....	1.27	....	.91
Non-albuminoid nitrogen	....	.31	....	.34	....	.48	....	.64	....	.42
Per cent. of nitrogen as non-albuminoid	....	23.3	....	25.2	....	38.01	....	50.0	....	46.4

Analyses of the joints and fruit of Opuntia Engelmanni, etc.—Continued.

FRUIT.

	Last of season.		Younger.		Youngest.	
	Steamed.		Natural condition.		Steamed.	
	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.
Water	86.00	....	85.00	....	85.00	....
Total ash	1.60	11.44	1.89	12.58	2.22	14.79
Oil	1.58	11.25	1.87	12.45	1.72	11.48
Resin, etc	1.77	12.66	1.08	7.21	} 3.14	20.96
Glucoside and organic acid	1.27	9.16	2.01	13.41		
Ash soluble in alcohol	....	[3.23]	....	[4.02]	....	[4.25]
Mucilage	1.00	7.10	.75	5.00	.71	4.75
Ash	....	[2.79]	....	[3.09]	....	[3.46]
Crude fiber	2.70	19.29	2.81	18.73	3.08	20.54
Albuminoids	.74	5.20	.88	5.86	.93	6.17
Undetermined	3.34	23.90	3.71	24.76	3.20	21.31
	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen	....	.83	....	.94	....	.99
Non-albuminoid nitrogen	....	.17	....	.10	....	.15
Per cent. of nitrogen as non-albuminoid	....	21.1	....	10.3	....	14.7

The determinations show considerable difference between the two species. The *Opuntia Engelmanni* has much more oil or fat and albuminoids, but less glucoside or gum than that previously analyzed, and in the old joints the mucilage largely disappears. The percentage of crude fiber is also slightly greater in the *O. Engelmanni*. When calculated to the original percentage of water as mere fodder analyses, the results appear thus:

	Growth of the year.				Growth of previous year.				Old stem joints.	
	Natural condition.		Steamed.		Natural condition.		Steamed.		Natural condition.	
	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.
Water	86.00	....	88.00	....	93.50	....	90.00	....	86.00	....
Ash	3.27	23.38	2.18	18.21	1.18	18.09	1.60	15.98	1.77	12.64
Oil	.88	6.26	.76	6.30	.48	7.31	.66	6.63	.27	3.27
Crude fiber	1.11	7.90	1.09	9.01	.80	12.27	1.39	13.96	1.97	14.07
Albuminoids	1.16	8.29	1.02	8.46	.50	7.81	.80	7.95	.79	5.66
Nitrogen-free extract	7.58	54.17	6.95	58.02	3.54	54.52	5.55	55.48	9.20	64.36
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Per cent. of N. as non-alb	....	23.3	....	25.2	....	38.1	....	50.0	....	46.4

The amount of nitrogen-free extract is decidedly smaller, and the nutritive ratio a more nearly normal one than in Mr. Dull's species, undoubtedly making it of greater value and necessitating perhaps only the amelioration of its physical consistency to make it by itself a suitable cattle food. The larger amount of water in the growth of the previous year is due to its greater thickness, which, however, in the old stem joints is neutralized by their more woody nature.

In the *O. Engelmanni*, as in the other species, the glucoside increases with the age of the plant, accompanied by a corresponding diminution of the mucilage. The albuminoids, as would be expected, diminish in the older joints, but the percentage of non-albuminoid nitrogen increases. In the same way the ash, oil, fat, or resin decrease, and the fiber increases, all in the same manner as in other plants. In the fruit also the changes are those to have been expected.

The results obtained by steaming do not explain the purging effect, and without a more thorough study of the products it must be attributed to the increased acidity. The changes make the constituents of a joint of the previous year's growth less soluble in alcohol, but the reverse is the case with the growth of the first season; there is reason, however, to believe that this may merely be apparent and due to the difficulty of selecting exactly comparable specimens for analysis in the natural and cooked condition, and changes produced in drying the moist material.

The entire investigation can make no claim to completeness, having been undertaken at moments when no other official work interfered, but will serve to call attention to a plant which is of considerable economic importance and scientific interest from its relations to others of the same region, without entering into a thorough discussion of the possibilities and best methods of its use.

MISCELLANEOUS WORK.

The miscellaneous work done by this division during the past year has been of an exceedingly varied character.

Many samples of minerals, ores, clays, etc., were received for identification and valuation, and in most cases proved to be of little or no value. For example, persons finding a piece of rock with a few particles of pyrites embedded in it frequently would imagine they had found an ore containing a precious metal owing to the metallic luster and color of the pyrites; and the specimen would be forwarded to this Department for assay.

The following is a partial list of such samples as were analyzed, mere inspection, in very many cases, being sufficient to ascertain their value:

(1) Mineral sent by Burrel Laseter, Rule, Ark.: Calcite and pyrites; of no value.

(2) Mineral sent by James Randolph, Neverfail, Tenn.: Granitic rock with pyrites; no value.

(3) Mineral sent by Joseph Watson, Nelsonville, Tex.: Limestone; tested for phosphoric acid with negative results.

(4) Mineral sent by John Osborne, Flag Pond, Va.: Limonite, an iron ore of little commercial value.

(5) Sent by George Dugan, Kansas City, Mo.: Blue sandstone; unfit for building purposes owing to the presence of pyrites.

(6) Sent by G. W. Robinett, Flag Pond, Va.: Galena and limestone.

(7) Sent by J. A. G. Blackburn, War Eagle Mills, Ark.: Limestone.

(8) Sent by Frank Long, Fayetteville, Ark.: Pyrites in sandstone.

(9) Sent by Frank Long, Fayetteville, Ark.: Iron ore (Hematite).

(10) Sent by Frank Long, Fayetteville, Ark.: Manganese ore (Wad.).

(11) Sent by Frank Long, Fayetteville, Ark.: Pyrites.

(12) Sent by Frank Long, Fayetteville, Ark.: Epidote in quartz.

(13) Sent by Frank Long, Fayetteville, Ark.: Limestone.

(14) Sent by Frank Long, Fayetteville, Ark.: Pyrites partly oxidized.

(15) Sent by Frank Long, Fayetteville, Ark.: Limestone.

(16) Sent by Frank Long, Fayetteville, Ark.: Silicified wood.

(17) Sent by Lee Breeding, Springdale, Tenn.: Pyrites.

(18) Sent by Alex. Moseley, Buckingham Court-House, Va.: Gneiss, epidote, and biotite.

(19) Sent by William B. Stark, Meridian, Tex.: Pyrites.
(20) Sent by B. D. Carter, Flag Pond, Va.: Calcite.
(21) Sent by G. W. Buiter, Knapp, Pa.: Quartz.
(22) Sent by G. W. Kile, Upper Tract, W. Va.: Ferruginous clay.
(23) Sent by Frank P. Bond, Brownsville, Tenn.: A good quality of pottery clay, or suitable for the manufacture of brick.
(24) Sent by G. W. Merk, San Francisco, Cal.: Carbonate of lime and a trace of phosphoric acid.
(25) Sent by George W. Robinett, Flag Pond, Va.: Gypsum.
(26) Sent by George W. Robinett, Flag Pond, Va.: Oxide of iron.
(27) Sent by Daniel Bond, Brownsville, Tenn.: A clay of good quality for pottery and brick making, but not suitable for fire-brick.
(28) Sent by D. L. Chamberlin, Clearwater Harbor, Fla.: An inferior article of clay, containing a large amount of iron, sand, and gravel.
(29) Sent by J. A. Frogs, Harrison, Ark.: Iron ore (Hematite).
(30) Sent by J. A. Ragsdale, Gainesville, Tex.: A horseshoe incrusted with carbonate of lime and oxide of iron, caused by lying in water containing carbonates of lime.
(31, 32, 33, and 34) Sent by Henry W. Sturmer, Richlandtown, Pa.: Samples of rocks, none of which had any value.
(35) Sent by S. H. Hemmenway, Washington, D. C.: Manganese ore, containing also iron and phosphoric acid.
(36) Sent by W. W. Brown, Clinton County, Pa.: Mineral paint, ochre.
(37) Sent by E. E. Rope, Lake View, Fla.: Sulphate of lime (gypsum).
(38) Sent by O. W. Longan, Washington, D. C.: Sample of impure limestone.
(39) Sent by H. Rosenfeldt, Mimbres, Grant County, N. Mex.: Mountain cork; a variety of asbestos.
(40) Sent by C. S. Sterner, Cooperstown, Pa.: Supposed to contain lead or coal, but contained neither.
(41) Sent by H. Shrout, Menifee County, Ky.: Contained 14.84 per cent. phosphoric acid, and would make a valuable fertilizer when finely ground.
(42) Sent by G. S. Allen, Harrison, Ark.: Contains traces of copper and phosphoric acid.
(43, 44, 45, 46, 47, and 48) Sent by Hon. C. T. O'Ferrall, M. C.: Minerals composed of quartz and pyrites, the latter having been mistaken for gold. None of the samples are of any value.
(49) Sent by A. Y. Simpson, Elliott, Miss.: A sample of clay very free from iron, but containing too much soda and potash to make good fire-brick.
(50) Sent by J. Milton Moore, Richlandtown, Pa.: A mineral supposed to contain lead or tin, but found to contain neither.
(51) Sent by W. F. Combe, Hillam, Ind.: A mineral consisting largely of sulphide of zinc, and valuable as a zinc ore.
(52) Sent by A. M. Sloan, Valley Spring, Ark.: Contains particles of pyrites which were mistaken for gold.
(53) Sent by B. F. Reed, Mineola, Tex.: Galena, which might prove valuable as a source of lead.
(54) Sent by Hon. F. M. Cockrell, U. S. Senate: Minerals supposed to contain manganese, but none was found.
(55) Sent by Hon. F. G. Barry, M. C.: Supposed to contain silver. No silver was found, but some galena and sulphide of zinc.
(56) Sent by James W. Warne: Minerals consisting of silicates of iron, alumina, etc., and of no value.
(57) Sent by J. D. Tillett: Mineral supposed to contain tin: contains no tin, but consists largely of binoxide of manganese.
(58) Sent by W. S. Pridgeon: Supposed to be diamonds; found to be small crystals of quartz.
(59) Sent by Henry A. Bathurst, Cheyenne, Wyo.: A lump of slag, which sender thought contained tin; consists almost entirely of iron.

SAMPLES OF FERTILIZERS, FERTILIZING MATERIALS, MARLS, ETC.

(60) Sent by E. G. Watson, Baltimore, Md.: A marl, containing a small amount of phosphoric acid and a trace of potash, but not sufficient of either to make it a valuable fertilizer.
(61) Sent by Mrs. E. C. Joins, Madisonville, Tenn.: Brown earth, containing a large quantity of organic matter, but not enough to make it very valuabl eas a fertilizer.
(62) Sent from Van Opstal's vineyard, Spottsylvania, Va.: A fertilizer containing 2.63 per cent. phosphoric acid, and 4.94 per cent. of nitrogen.

(63) Sent by W. N. Reed: Green sand; contains a trace of lime and phosphoric acid; no value.

(64) Sent by Charles Metzner, Kewaunee, Wis.: Sample consisting of shell marl with a trace of phosphoric acid.

(65) Sent by Frank Banney, Farmdale, Ohio: A marl containing no phosphoric acid.

(66) Sent by Ohio State Board of Agriculture, Columbus, Ohio: Two samples of commercial fertilizer, serial Nos. 4958 and 4959: analyses as follows:

	4958.	4959.
	Per cent.	*Per cent.*
Total phosphoric acid	19.64	18.03
Soluble phosphoric acid	9.76	9.92
Reverted phosphoric acid	3.32	2.81
Insoluble phosphoric acid	3.34	2.15

(67) Sent by Fred. Sassur, jr., Marlborough, Md.: A marl containing a trace of phosphoric acid.

(68) Sent by S. H. Griffin, Saint Stephens, S. C.: Sample described as "bone;" contains only a trace of phosphoric acid.

(69) Sent by Louis Schade, Washington, D. C.: A clay supposed to contain phosphoric acid, but none was found.

(70) Samples sent by G. W. Knapp, Limona, Fla.: Serial Nos. 4983, 4984, and 4985. 4984 is a coprolite and a very valuable fertilizer:

No.	Phosphoric acid.
	Per cent.
4983	.2
4984	34.4
4985	1.6

(71) Sent by Daniel Moler, Moler, W. Va.: A blue slate supposed to contain phosphoric acid, only a trace of which was found.

(72) Sent by N. C. Nutting, Oswego, N. Y.: A marl containing no phosphoric acid.

(73) Sent by W. P. Hill, Lake George, Fla.: A marl containing a considerable quantity of phosphoric acid.

(74) Sent by S. H. Hemmengway, Wsahington, D. C.: A marl containing a trace of phosphoric acid.

(75) Sent by J. R. Dodge, Washington, D. C.: A marl tested for phosphoric acid.

(76) Sent by C. E. Pearson, Beach, Miss.: A shell marl tested for phosphoric acid.

(77) Sent by F. R. Evans, Washington, D. C.: A muck containing a large quantity of organic matter, but no phosphoric acid.

(78) Sent by Alonzo Thompson, Baltimore, Md.: Samples of phosphoric acid and phosphate of soda, serial Nos. 5297 and 5298:

No.	Phosphoric acid.
	Per cent.
5297	10.61
5298	18.25

(79) Sent by L. J. Kimbell, Gatesville, Tex.: Samples of bat guano, serial Nos 5193 and 5194; analyses as follows:

	5193.	5194.
	Per cent.	*Per cent.*
Phosphoric acid	.97	4.98
Ammonia	4.69	11.15

(80) Sent by D. A. Beard, Martinsburgh, W. Va.: Two samples commercial fertilizer, serial Nos. 5293 and 5296; analyses as follows:

No.	Sample.	Phosphoric acid.
		Per cent.
5293	S. C. dissolved rock	16.20
5296	Patapsco Company fertilizer	17.24

(81) Sent by C. E. Pearson, Beach, Miss.: A marl containing a trace of phosphoric acid.

(82) Sent by W. W. Cobey, Cross Roads, Md.: Three samples of marl, each containing a small amount of phosphoric acid.

(83) Sent by W. W. Watts, Collegeville, Ark.: A shell marl containing a trace of phosphoric acid.

(84) Sent by James D. Sherer, DeLand, Fla.: A fertilizer suspected of causing a diseased condition of orange trees. It contained 8.45 per cent. of phosphoric acid and 1.46 per cent. of nitrogen. This fertilizer does not appear to be of a nature to produce any deleterious effect upon orange trees, and the disease complained of is doubtless due to some other cause.

(85) Sent by committee on nitrogen of the Association of Official Agricultural Chemists: Six samples, in which the nitrogen was determined as indicated by the following table:

Number.	Soda lime method.	Kjeldahl method.	Ruffle method.	New Ruffle method.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	13.49	13.86	13.44	13.83
2	2.97	2.82	2.57	3.24
3	3.08	3.20	3.05	3.16
4			3.30	2.70
5			3.14	2.91
6			2.52	2.57

(86) Sent by committee on phosphoric acid of the Association of Official Agricultural Chemists: Five samples for the determination of phosphoric acid:

Number.	Moisture.	Total phosphoric acid.	Soluble phosphoric acid.	Insoluble phosphoric acid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	.76	28.16		
2	6.44	14.23		
3	14.06	9.63	6.74	1.30
4	9.33	15.22	10.68	1.28
5	8.25	18.06	6.78	3.34

(87) Sent by committee on dairy products of the Association of Official Agricultural Chemists: Four samples of butter and butter substitutes:

Number.	Specific gravity.	Melting point.	Volatile acids, cubic centimeters, one-tenth alkali.	Saponification equivalent.	Water.	Salt.	Curd.
		°C.			*Per cent.*	*Per cent.*	*Per cent.*
1	.9060	31.8	.40	281.0	6.49	1.99	.34
2	.9046	40.1	.40	288.7	6.64	2.11	.58
3	.9091	34.5	13.06	244.0	8.97	4.56	.78
4	.9109	33.0	15.49	248.0	8.44	.79	.64

(88) Sent by the Commissioner of Internal Revenue: Two samples of butter suspected of being adulterated. The analyses show that these butters are genuine. A microscopic examination showed that they had been artificially melted:

Number.	Specific gravity.	Melting point.	Saponification equivalent.	Cubic centimeters, one-tenth normal alkali.	Salt.
1		°C.			*Per cent.*
2	.91195	33.70	245.3	17.1	5.58
	.91087	32.00	249.4	15.8	8.41

(89) Sent by E. M. Nesbit, Maythorpe Farm, College Station, Md.: Five samples of milk. The analyses showed that these milks contain about 1 per cent. more fat in proportion to the total solids than the ordinary milks of commerce:

Number.	Milk.	Fat.	Total Solids.
		Per cent.	*Per cent.*
1	Morning	4.14	12.71
2	Evening	4.16	12.25
3	Morning	4.22	11.55
4	Evening		11.89
5		4.87	12.80

(90) Sent by J. D. Johnson, Washington, D. C.: Sample of butter from Tennessee:

Specific gravity at 40° C	.908
Saponification equivalent	248.00
Cubic centimeters one-tenth normal alkali	15.12
Per cent. salt	1.42
Per cent. of moisture	10.25
Per cent of curd	.44

EXAMINATION OF LIGNITES, ETC., SUBMITTED AS SUITABLE MATERIALS FOR FILTERING SUGAR SOLUTIONS.

(91) Sent by R. A. Amdorf, Van Buren Furnacè, Va.: Sample supposed to be coal or lignite, but which proved to be only a black shale.

(92) Sent by Courier-Journal Company, of Louisville, Ky.: A sample of lignite. This sample possessed but little decolorizing power on a solution of molasses:

	Per cent.
Loss on ignition	92.70
Ash	7.30

(93) Sent from Avery's Island, La.: A sample of lignite. This sample possessed but little decolorizing power:

	Per cent.
Moisture	11.73
Volatile and combustible matter	49.50
Ash	38.74
Sulphur	.75

(94) Sent by Charles E. Pearson, Beach, Miss.: Sample of lignite. The soluble extract possessed an acid reaction, and the decolorizing power of the sample was very slight:

	Per cent.
Moisture	17.14
Ash	9.25
Soluble in water	4.56

(95) Sent by J. B. Friedheim, Camden, Ark.: Sample of lignite. This sample possessed a high decolorizing power:

	Per cent.
Moisture	30.18
Ash	6.89
Soluble in water	.34

(96) Sent by B. F. Reed, Mineola, Tex.: Sample of lignite. The aqueous extract had a very faint acid reaction. The filtration was rapid, but the decolorizing power not strongly marked:

	Per cent.
Moisture	24.76
Ash	5.65
Soluble in water	.36

(97) Sent by M. Swenson, Fort Scott, Kans.: Two samples of lignite. The aqueous extracts were faintly acid and the decolorizing power very slight:

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Moisture	8.29	13.71
Ash	30.25	5.04
Soluble in water	.52	.40

(98) Sent by the Hon. Commissioner of Agriculture: Sample of bituminous coal:

	Per cent.
Volatile matter	31.51
Coke	68.49
Ash	4.10

(99) Sent by Hon. Benton McMillin, of Tennessee: A sample from Carthage, Tenn., which proved to be graphite.

EXAMINATION OF SAMPLES OF WATER.

A large number of samples of water have been sent to this division for examination within the past year. As has already been intimated, the analysis of waters is not a work which falls within the legitimate scope of agricultural chemistry except in cases where its fitness or unfitness for the use of stock might be called in question. Nearly all the samples of water which have been received were sent on the supposition that they contained medicinal principles. Wherever it has been possible to do so the analysis of these samples has been declined. When an examination has been made it has been of the simplest nature possible. The force of chemists employed in the division was so small as to render it impossible to make complete analyses of the samples examined.

(100) Sent by F. P. Bishof, Washington, D. C.: A mineral water containing large quantities of solid matter:

Grains of solid matter per gallon 391.3

(101) Sent by F. P. Bishof, Washington, D. C.: Mineral water containing a very large quantity of solid matter:

Grains of solid matter per gallon 1,184.6

(102) Sent by Philip Walker, Washington, D. C.: A sample of water from Newton, Kans., water-works:

Grains of solid matter per gallon 47.587

This is too large a quantity for good potable water.

(103) Sent by H. S. Alexander, Culpeper, Va.:

Grains solid matter per gallon 26.243

(104) Sent by J. C. Rounds, Manassas, Va.: Two samples of potable water:

No. 1, well water, grains solid matter per gallon 14.580
No. 2, spring water, grains solid matter per gallon 4.665

Sample of spring water is very good. The well water is rather hard.

(105) Sent by Stephen Gill, Washington, D. C.: Sample of pump water from city pump.

Grains solid matter	per gallon	56.918
Grains chlorine	do	29.936
Free ammonia	parts per 100,000	115
Albuminoid ammonia	do	66

This water is totally unfit for domestic purposes, and shows how easily well waters in a city become contaminated.

(106) Sent by James P. Stabler, Sandy Springs, Md.: Sample of potable water:

Grains solid matter	per gallon	4.899
Free ammonia	parts per 100,000	1.2
Albuminoid ammonia	do	6.6

This is a very pure water.

(107) Sent by O. Hendricks, Marshall, Tex.: Two samples of supposed mineral water:

No. 1, grains solid matter	per gallon	11.664
No. 2, grains solid matter	do	6.415

Sample No. 1 contains slight amount of iron, and sample No. 2 gave indications of having contained hydro-sulphuric acid when fresh.

(108) Sent by S. H. Hemenway, Chicago, Ill.: Sample of supposed mineral water:

Grains solid matter per gallon 6.943

This sample contains no constituents of a medicinal nature.

(109) Sent by John P. Horan, Shreveport, La.: A sample of mineral water:

Grains solid matter	per gallon	312.44
Free ammonia	parts per 1,000,000	.67
Albuminoid ammonia	do	3.24

(110) Sent by William M. Gatewood, Carrizo Springs, Tex.:

Grains solid matter .... per gallon .. 1,396.3

The solid matter consists of lime, magnesia, alumina, soda, potash, and traces of iron combined as sulphates, chlorides, and carbonates. It also contains free ammonia, parts per million, .026; albuminoid ammonia, parts per million, .320.

(111) Sent by Peter Morong, Virginia: Three samples of potable water:

No. 1, grains solid matter	per gallon	7.581
No. 2, grains solid matter	do	6.377
No. 3, grains solid matter	do	7.420

These are all good waters.

MISCELLANEOUS EXAMINATIONS OF FOOD PRODUCTS.

(112) Sent by M. J. Martinez, New York City: Three samples of Cuban sugar-cane:

No.	Cane.	Sucrose.	Sucrose by inversion.	Glucose.
		Per cent.	*Per cent.*	*Per cent.*
1....	Ten months old............	20.6	20.75	.98
2....	Eleven months old	13.0	16.9	3.39
3....	Fourth year stubble........	18.3	18.4	.93

The above percentages are given for the juice. The first and second sets of numbers should be diminished by 10 per cent. and the third by 12 per cent. when calculated for the cane itself.

(113) Sent by Col. F. E. Boyd, Delta, Colo.: A sample of sorghum sirup:

Specific gravity		1.417
Sucrose	per cent..	39.30
Glucose	do	28.73
Ash	do	3.94
Other solids not sugar	do	3.97
Co-efficient of purity		49.50

(114) Sent by James M. Hart, Oswego, N. Y.: Sample of sugar beets:

In whole beet:		
Moisture	per cent..	76.90
Ash	do	.92
In the juice:		
Specific gravity		1.070
Total solid matter	per cent..	16.76
Sucrose	do	12.63
Glucose	do	.30
Co-efficient of purity		75.40

Presence of glucose in the juice of the beet is probably due to the fact that a considerable time elapsed after the beet was harvested before the analysis was made.

(115) Sent by Seth H. Kenney, Morristown, Minn.: A sample of sorghum sirup:

Specific gravity		1.3965
Sucrose	per cent..	40.45
Glucose	do	23.43
Co-efficient of purity		52.53

(116) Sent by Densmore Brothers, Red Wing, Minn.: Sample of sorghum *masse cuite*:

Sucrose	per cent..	46.30
Sucrose by inversion	do....	49.16
Glucose	do....	30.40

(117) Sent by Henry McCall, Donaldsonville, La.: Sample of sugar-cane molasses from second crystallization:

Sucrose	per cent..	29.00
Glucose	do....	22.00

(118) Sent by Capt. S. S. Blackford, Washington, D. C.: Sample of maple sirup from Ohio:

Sucrose	per cent..	60.10
Sucrose by inversion	do....	61.30
Moisture	do....	35.24
Glucose	do....	.96
Ash	do....	4.03
Acidity as acetic acid	do....	.11

(119) Sent by Lewis F. Ware, Philadelphia, Pa.: Two samples of dates:

No.	Sucrose.	Glucose.
	Per cent.	*Per cent.*
1	5.05	41.8
2	4.68	42.4

(120) Sent by Sheldon E. Elderkin, Cooperstown, N. Y.: A sample of maple sugar:

Sucrose	per cent	77.60
Sucrose by inversion	do	79.76
Moisture	do	15.33
Glucose	do	3.92
Ash	do	.85

(121) Sent by W. J. Thompson, Pattersonville, La.: Sample of sugar-cane molasses from second crystallization:

Sucrose	per cent	33.70
Sucrose by inversion	do	41.00
Glucose	do	27.00

(122) Sent by Springer Harbaugh, Saint Paul, Minn.: One sample of wheat and one of barley:

	Wheat.	Barley.
Weight per bushel ....pounds	62.7	65.4
Weight of 100 grains ....grams	2.233	3.755
Moisture ....per cent	6.52	7.52
Ash ....do	1.48	1.44
Fat ....do	2.52	3.55
Carbohydrates ....do	71.93	72.77
Crude fiber ....do	2.06	2.12
Albuminoids ....do	15.49	12.60

(123) Sent by A. Chandler, Fargo, Dak.: A sample of Polish wheat:

Moisture	per cent	8.82
Ash	do	1.89
Oil	do	2.60
Carbohydrates	do	67.92
Crude fiber	do	1.33
Albuminoids	do	17.42

(124) Sent by W. T. Kelso, Hallock, Minn.: A sample of wheat:

Weight per bushel	pounds	67.00
Weight of 100 grains	grams	2.925
Moisture	per cent	7.58
Ash	do	1.45
Oil	do	3.65
Carbohydrates	do	70.59
Crude fiber	do	1.68
Albuminoids	do	15.05

(125) Sent by L. H. Haines, Fargo, Dak.: A sample of wheat:

Moisture	per cent	7.80
Ash	do	1.77
Crude fiber	do	1.70
Albuminoids	do	15.93
Carbohydrates	do	72.80

(126) Sent by W. H. Reed, Walla Walla, Wash.: A sample of wheat:

Moisture	per cent	7.42
Ash	do	1.95
Oil	do	1.98
Crude fiber	do	2.13
Albuminoids	do	9.89
Carbohydrates	do	76.63

(127) Sent by Alex. McBeth, Georgetown, D. C.: Sample of rice husks and ash from same:

Organic matter in husks	per cent	81.72
Moisture in husks	do	4.15
Ash in husks	do	14.13
Silica in ash	do	89.13

The ash also contains a trace of manganese.

(128) Sent by J. H. Watkins, Palmetto, Ga.: A sample of Kaffir corn:

Moisture	per cent	11.18
Ash	do	1.22
Oil	do	3.58
Dextrine	do	3.37
Sugars	do	1.85
Starch	do	67.62
Albuminoids	do	9.73
Crude fiber	do	.85

(129) Sent by W. M. King, superintendent Seed Division.: A sample of Kaffir corn for the determination of nitrogen only:

Nitrogen	per cent	1.43
Equal to albuminoids	do	8.93

(130) Sent by William M. Singerly, Philadelphia, Pa.: A sample of brewer's grain:

Moisture	per cent	7.86
Ash	do	4.33
Oil	do	5.66
Carbohydrates	do	51.37
Crude fiber	do	8.81
Albuminoids	do	21.97

(131) Sent by John A. Baker, Washington, D. C.: A sample of pea-meal:

Moisture	per cent	8.21
Ash	do	3.73
Oil	do	1.89
Carbohydrates	do	62.16
Crude fiber	do	2.19
Albuminoids	do	21.82

This meal would make an excellent cattle food, having a very high percentage of nitrogenous matters, with a good proportion of phosphoric acid in the ash.

(132) Sent by Dr. W. M. Mew, Washington, D. C.: A sample of food material for the determination of nitrogen only:

Nitrogen	per cent	4.75
Equal to albuminoids	do	29.75

(133) Sent by J. Sears, Chicago, Ill.: A sample of cotton-seed hulls for the determination of nitrogen only:

Nitrogen	per cent	.77
Equal to ammonia	do	.93

(134) Sent by J. Sears, Chicago, Ill.: A sample of powdered olive stones for the determination of nitrogen only:

Nitrogen	per cent	.25
Equal to albuminoids	do	1.56

(135) Sent by J. Sears, Chicago, Ill.: Powdered cocoa-nut shells for the determination of nitrogen only:

Nitrogen	per cent	.20
Equal to albuminoids	do	1.25

(136) Sent by the Hon. Secretary of the Treasury: A sample of opium from the collector of customs at San Francisco:

Moisture	per cent	21.10
Morphia	do	6.38

(137) Sent by Ernest T. Gennert, Berlin, Germany: Two samples of cotton-seed meal, in one of which the oil had been extracted by hydraulic pressure and the other by petroleum:

	Hydraulic pressure.	Petroleum.
	Per cent.	*Per cent.*
Moisture	6.10	7.52
Ash	7.50	6.35
Crude fiber	2.99	12.01
Nitrogen	7.47	5.29
Equal to albuminoids	46.69	33.06
Oil	13.26	3.27

(138) Sent by Dr. George Vasey, botanist: A sample of tiquila, a fermented liquor made from fermented agaves:

Alcohol	per cent.	41.58
Dry residue	do	.012
Aromatic oil	do	.020

This liquor has a slight acid reaction and contains no fusel oil.

H. W. WILEY,
Chemist.

HON. NORMAN J. COLMAN,
Commissioner of Agriculture.