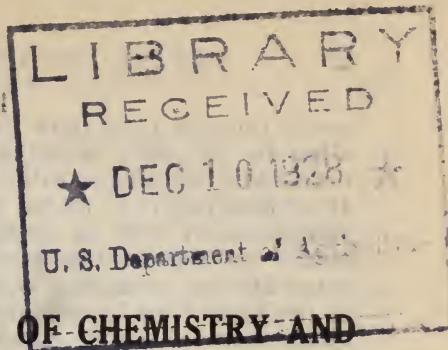


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1927/28

**REPORT OF THE CHIEF OF THE BUREAU OF CHEMISTRY AND SOILS**

UNITED STATES DEPARTMENT OF AGRICULTURE,  
BUREAU OF CHEMISTRY AND SOILS,  
*Washington, D. C., September 1, 1928.*

SIR: I have the honor to submit herewith the report of the work of the Bureau of Chemistry and Soils for the fiscal year ended June 30, 1928.

Respectfully,

HENRY G. KNIGHT,  
*Chief of Bureau.*

Hon. W. M. JARDINE,  
*Secretary of Agriculture.*

**INTRODUCTION**

With the close of the fiscal year 1928 the Bureau of Chemistry and Soils passed its first milestone. The new organization came into existence on July 1, 1927, for the purpose of correlating all of the research work of the Bureau of Chemistry and the Bureau of Soils. The Bureau of Soils included in its field of research not only all investigations relating to soils but also those concerned with fertilizers and the work formerly assigned to the Fixed Nitrogen Research Laboratory. In addition to the work of these two organizations, the new bureau took over from the Bureau of Plant Industry the Division of Soil Fertility and the Division of Soil Bacteriology. Having divorced the regulatory from the research work of the former Bureau of Chemistry, the new bureau became primarily a research and fact-finding institution covering a wide range of subject matter pertaining to land utilization, soil fertility, fertilizer-resource development, and the utilization of agricultural products of various kinds. Within the same organization are now to be found the soil survey, which is laying the foundation for the mapping and study of the Nation's soil resources, soil-fertility studies having for their purpose the better utiliza-

tion of the soil, and, finally, the application of chemical and engineering technology to a study of fertilizer resources and the more economical and diversified utilization of the products of the soil.

The research work now in progress includes investigations on soil chemistry, soil physics, soil erosion, soil microbiology, soil fertility, nitrogen fixation, potash and phosphate resources, crop chemistry, fruit and vegetable chemistry, fermentation methods for the production of organic acids, utilization of farm and industrial wastes, food microbiology, dust explosions and farm fires, and on improved technic for the production of sirups, sugars, vegetable oils, proteins, insecticides, fungicides, tanning materials, and a variety of other products.

For the purpose of administration three large units are recognized within the bureau: (1) Chemical and Technological Research, (2) Soil Investigations, and (3) Fertilizer Resources and Fixed Nitrogen Investigations. Each of the three units is in charge of a chief scientist, who not only directs the work of his unit but also serves as a member of an informal coordinating board within the bureau. By virtue of its broadened field of activities and the coordinated effort within the bureau the new organization is given the opportunity to attack problems along



much broader lines than has been possible in the past under the separate organizations which hitherto existed. It is believed that under the new arrangement it will be possible to give better service to the public for the same amount of money expended, and at the same time to expend more effort along broad lines of fundamental research. In the main the appropriations are made to the bureau for the purpose of attacking specific problems, the solution of which are of interest to the business of agriculture and have, therefore, a utilitarian objective. However, direct attack upon some of these problems in the absence of essential fundamental knowledge is wasteful of funds and energy. The search for this fundamental knowledge frequently leads the scientist into the realms of pure science, where the foundation is laid for the logical attack and final solution of the problem under consideration. Such a method of attack requires careful, thoughtful planning, the development of skilled technic, an intelligent and discriminating analysis of results, and ability of a high order to make the necessary practical applications.

Many of the research problems pertaining to the work of the Bureau of Chemistry and Soils are of such wide scope and national interest that their final solution must of necessity have a wide application. Certain problems of more or less regional interest must also receive consideration, but in most instances these can best be attacked by securing the active cooperation of the States or other local agencies.

The interest of the farmer should not terminate with production of his crops, but he should be in position to follow his products through to the ultimate consumer if he is to be in position to adjust his productions to the demands of the market. To this end the bureau should not only function as a research agency to increase efficient unit production, but should also be in position to follow the products of the farm through the industrial processes that make use of raw agricultural products in the manufacture of articles of commerce. The research activities of the bureau along this line should result in the more economical utilization of farm products and the production of more uniform final products, thus benefiting both the farmer and the ultimate consumer. The widening of markets for farm products through the development of new channels for their industrial utilization is an important function.

Recognition of the close interrelationship between agriculture and the industries that utilize agricultural products has led to the development of plans which will give these industries an opportunity for investigation and analysis of their individual problems under the leadership of the bureau. Under these plans research fellowships are established within the bureau, which will insure careful and conscientious research upon the problems chosen. Such contacts must result in mutual benefit to all concerned.

Results obtained in fertilizer and fixed-nitrogen investigations are being applied by industry as rapidly as conditions appear to warrant, thus reflecting direct benefit to agriculture in the form of cheaper and more satisfactory sources of plant-food materials. Advancement in this field depends largely upon the development of fundamental research and the application of the laws and principles thus discovered or verified to the technic of manufacture. Such researches are primarily functions of the Federal Government, since they are directed to the development of a more efficient national agricultural program.

In the broader aspect, the Bureau of Chemistry and Soils is a research and fact-finding governmental agency, having as its aim the development of an intelligent land-utilization policy and an efficient crop-production and utilization program.

## CHEMICAL AND TECHNOLOGICAL RESEARCH

C. A. BROWNE, *Chief*

### CARBOHYDRATE INVESTIGATIONS

#### CANE SIRUP

Investigations on the more economical utilization of low-purity cane juice were continued. The purpose of this study is to determine whether this juice can be used for sirup rather than for sugar manufacture. The results so far obtained indicate that low-purity juice alone does not yield an acceptable direct-consumption table sirup. It is possible, however, to obtain from such juice a satisfactory blending sirup, which, when mixed with glucose or a sugar sirup, produces a high-quality mixed sirup of its type. If a factory is producing only table sirup, a high extraction of the cane may be employed without injuring materially the quality of the finished product, provided the juice is



divided into two portions, each treated separately. The first portion would consist of the low-extraction juice from the crusher and first mill and may be clarified and concentrated in the usual manner for producing sirup. The second portion, consisting of the lower-purity juice, may be clarified by a special process which has been developed, and may then be concentrated, either separately or after mixing with the first portion. The two portions should preferably be mixed in the same volume ratio that they are extracted from the cane.

The sirup from the low-purity juices may also be utilized in the production of "cane cream," a new product which has recently been developed by this division. The manufacture of "cane cream" has been undertaken on a semicommercial scale, and the results indicate that the cost of manufacturing a high-quality product is moderate. The fabrication of the product is a part of a general plan for the production of specialties which are believed to be of great economic importance for the Louisiana sugar and sirup industry.

At the urgent request of a large Louisiana sirup producer an investigation relating to the cause and remedy of "swells" in canned sirup was undertaken. A peculiar condition exists in that in certain localities the unsulphured type of sirup causes considerable trouble by producing "swells" during storage. This results in a large loss of canned stock. The trouble is caused not by fermentation but by a slow chemical decomposition, the exact nature of which has not yet been determined. A number of samples of Louisiana cane sirup have been examined, but the usual chemical analyses have given no conclusive indication as to the nature of the chemical changes which occur. The theory has been advanced that the reaction between amino acids and reducing sugars, normal constituents of the juice, is responsible. This possibility is being studied in detail with a view to ascertaining the cause and devising a remedy.

#### CANE SUGAR

In recent years the filterability of raw sugars has been receiving considerable attention because of the higher cost of refining a poor-filtering sugar. This has in turn affected the raw-sugar producer, since a poor-filtering sugar is in less demand under present market conditions. An investigation

was undertaken for the purpose of determining the primary cause of this variation in raw sugars, especial attention being given to the colloid content and ash constituents. Different features of factory operation were studied in relation to grades of sugar produced in order to determine to what extent factory control affects the filterability of the resulting sugars.

Observations were made at several factories operating by somewhat varying methods and using cane of different varieties grown under distinctly different climatic conditions. The colloid content of the various sugar end products was determined by means of the dye test and ultrafiltration. The separated colloids were subjected to various types of examination for the purpose of discovering further relations between colloids and filterability. Certain sugars were washed to approximately 99.5 per cent purity and analyzed and filtered in order to ascertain to what extent nonsugar substances embedded in the crystals affect filterability.

The quality of the juice entering the process was found to be of especial significance. The quality may be affected by the conditions under which the cane is harvested, by its maturity, or by the climatic conditions under which it is grown. Variety is probably another factor of importance. The investigation is being continued for the purpose of devising means of control.

#### SUGAR DETERIORATION

Considerable progress was made in the study of means for preventing the deterioration of raw cane sugar during storage. This work is being conducted along two lines, one of which relates to the hygroscopicity of sugars and sugar products and the means of controlling it, and the other to a study of the efficiency of fumigants in destroying microbiological activity in raw sugar. The problem of sugar storage is a very important one, inasmuch as every year a very large loss of sugar occurs. The best conditions for storage and the possibility of the use of fumigants for destroying microorganisms have not yet been satisfactorily determined.

#### BEET SUGAR

In continuing the investigation relating to beet-sugar manufacture, a study of the possibility of an automatic control of the carbonation and sulphitation processes in the clarification of beet juices was successfully made. An accurate control of these



processes, particularly the second carbonation and sulphitation of the thin juice, is very desirable. At these stages a delicate adjustment in alkalinity must be made in order to obtain the maximum elimination of impurities, including lime salts, which, if present in excessive quantity, cause considerable trouble by scaling the heating surfaces of the evaporators and vacuum pans as well as preventing the maximum recovery of sugar from the juices.

An automatic pH control of the second carbonation station in beet-sugar manufacture was installed experimentally during the past season to determine the practicability of this method of obtaining a closer control and also a permanent record of the pH of the juice over a 24-hour period. Tungsten electrodes were used with good results in carbonated juice and also functioned satisfactorily in sulphured thin juice.

#### IMPURITIES PRODUCING COLOR

Further progress has been made in determining the character of substances present in various grades of sugar which cause the production of objectionable color in commercial products made therefrom. Several inorganic compounds produce this effect, but the substances which are most objectionable are organic and colloidal in nature. All of these substances are present in very small proportions, but have quite pronounced effects in lowering the caramelization point of sugar and producing dark color, especially at the higher temperatures to which sugar is subjected in preparing certain food products. Under certain conditions decolorizing carbons will overcome the difficulty, but a satisfactory process for commercial application has not yet been found.

#### HONEY

A revision of Bureau of Chemistry Bulletin 110, Chemical Analysis and Composition of American Honeys, has been undertaken. For this revision new analytical data are desired, since some of the official methods have been changed during recent years. The analysis of numerous typical honeys was therefore undertaken, and the work is partially completed.

#### STARCH

At the urgent demand of a number of sweet-potato producers' associations, an investigation has been started pertaining to the economical utilization of excess and cull sweet pota-

toes, of which there is available an enormous quantity throughout the Southern States. Various means of utilizing these waste potatoes have been suggested in the past, but no satisfactory method has yet been found. Owing to the relatively high starch content of sweet potatoes, there is a possibility that the waste portion of this crop can be utilized in the production of starch. In order to investigate this possibility a starch plant having a daily capacity of approximately 100 pounds of dry starch was erected, and trial runs were made. Starch of good quality was obtained, but further investigation must be made to determine such factors as the cost of commercial production, yield, and most economical size of factory. Study of the properties of the starch must also be undertaken in order to determine its commercial uses and value.

#### MISCELLANEOUS INVESTIGATIONS

The efficiency of filtration and other clarification processes is frequently judged by the degree of turbidity of the clarified juice or other liquor, but the operator has been handicapped by having no equipment available for measuring turbidity accurately in numerical terms. An instrument was, therefore, developed for this purpose. It is rugged in construction and is capable of measuring turbidity in numerical values and in detecting differences invisible to the naked eye.

In view of the fact that considerable discrepancy exists between the results of various investigators on the 100° point of the Ventzke sugar scale for saccharimeters, a redetermination of this important constant was made. This work was done in cooperation with the New York sugar trade laboratory. The results from the two laboratories agree with the value found by the Bureau of Standards rather than with the values of European investigators.

#### DUST EXPLOSIONS

Studies were continued to determine the causes of dust explosions in various types of industrial plants and to develop methods for their control and prevention. The work already done indicates very definitely that practically all types of combustible dusts, when mixed with air in proper proportions, are explosive and that at least 28,000 industrial plants in the United States are subject to this hazard. These plants employ approxi-



mately 1,324,000 people and manufacture products having an annual value in excess of \$10,000,000,000. The Bureau of Chemistry and Soils is the only governmental agency conducting research studies relating to industrial plant dust-explosion prevention. The bureau is recognized as a leader in this undertaking in the United States and is frequently called upon for assistance by foreign countries.

#### ORGANIZATION OF WORK

Research on the subject is organized along two definite lines: (1) Engineering investigations relating to the determination of the causes of explosions and to the design and development of mechanical equipment and appliances for their control and prevention; (2) chemical investigations in connection with the determination of the relative degree of explosibility of industrial plant dusts. This work includes research to determine the factors contributing to the explosibility of the dusts, ignition temperature, rate of flame propagation, pressures developed, and similar important factors.

#### INERT GAS

During the year attention was given to the development of methods for the use of inert gases for the prevention of dust explosions and fires. A large number of demonstrations was given at the Arlington experimental plant, and the results of the work have been published in Technical Bulletin No. 74, entitled "The Value of Inert Gas as a Preventive of Dust Explosions in Grinding Equipment." The engineers working on this problem have cooperated with a large number of industrial companies in arranging for the installation of equipment for the utilization of boiler-flue gas. As a result of this work one of the largest feed-grinding companies in the country has planned an installation of this character sufficiently large to provide inert gas for all the grinding equipment, conveyors, and elevators where the dust-explosion hazard is recognized. This apparatus has been designed to handle approximately 150,000 cubic feet of boiler-flue gas per hour.

Special attention was given to solving the problem of sulphur-fume elimination in connection with the use of flue gases in installations of this character, and tests to develop a satisfactory type of scrubber for this purpose are under way.

#### DUST EXPLOSIONS HAZARDS COMMITTEE

In its work on dust-explosion hazards the bureau enjoys close cooperation with industrial companies, State commissions, insurance organizations, fire-prevention associations, and practically all agencies interested in explosion and fire prevention. Among the important contacts is that with the National Fire Protection Association through the work of the dust explosion hazards committee. The engineer in charge of the dust explosion work in the bureau is chairman of this committee, which is composed of representatives of industries and agencies directly interested. The dust explosion hazards committee has prepared regulations for explosion control for the following lines of industry: Flour and feed mills, sugar and coco-pulverizing systems, terminal grain elevators, pulverized fuel installations, and starch factories. These regulations have been approved by the American engineering standards committee and are used as a basis by insurance underwriters, State and municipal officials, and safety organizations.

A digest of State health and labor laws, and also safety codes, was made during this year with a view to preparing an adequate dust-explosion-prevention code which would be of service to State commissions in connection with their factory-inspection work. Special attention was given to the results of a survey of dust explosions in foreign countries and the methods that had been introduced for their control.

The more important dust explosions investigated during the past year include pyroxylin lacquer dust, sugar dust, wood dust, cork dust, feed dust, and fertilizer dust. These explosions involved a property loss of over \$4,000,000, with 67 persons killed or injured.

#### CHEMICAL INVESTIGATIONS

Progress was made in the chemical laboratory investigations in determining the oxygen dilution necessary to prevent dust explosions. Values for oxygen dilution were determined for ground cork, ground pyrethrum flowers, ground oat hulls, and powdered aluminum. It was found that with aluminum the concentration of the dust cloud affected the oxygen dilution required, while none of the other dusts tested exhibited this phenomenon in such a pronounced manner. Different



types of ground pyrethrum flowers exhibited a variation in explosibility. Some samples gave very little pressure, whereas others produced pressures comparable with the more explosive dusts. Microscopical examinations showed that explosibility is largely dependent on the pollen content of the flowers. Ground cork produced the highest pressure with normal air, but the pressure was reduced very rapidly with the introduction of carbon dioxide. Ground oat hulls did not produce as high pressure with normal air as did cork, but the same oxygen dilution did not have the same quenching effect on the oat hulls as it did with the cork. Lower limits of concentration for explosion of ground cork, pyrethrum flowers, and oat hulls were established, and the flame-propagation temperatures of several types of dusts were determined.

During the year the bureau was called upon to conduct tests and to determine relative flammability, ignition temperatures, particle size, moisture, and ash for alfalfa dust, corn dust, ground antimony, cocoa dust, carbon black, fertilizer dust, wood dust, pecan-shell dust, wood flour, and peat. Special attention was given to the development of methods for determining the explosive density of dust clouds, and studies were made of various types of equipment designed for this purpose.

#### FARM FIRES

According to a conservative estimate, farm fires annually take a toll of 3,500 lives and destroy \$150,000,000 worth of property.

The bureau has undertaken a study of the causes of farm fires, with a view to devising new and improving existing methods and equipment for fire prevention and protection. Research is planned along engineering, chemical, bacteriological, statistical, and educational lines.

The principal known causes of farm fires, in order of their importance, are: Spontaneous ignition of hay, grain, feeds, and other agricultural products; lightning; defective chimneys and heating apparatus; sparks on combustible roofs; careless use of matches in smoking; careless handling and storage of gasoline and kerosene; and faulty wiring and improper use of electrical appliances.

#### SPONTANEOUS IGNITION OF AGRICULTURAL PRODUCTS

One of the first problems to be studied will be that of the spontaneous

ignition of hay and other agricultural products. It is generally known that improperly cured or damp hay, grain, and feed, when stored in large piles, are subject to spontaneous heating. If conditions are favorable, this heating will progress until ignition occurs. This phenomenon is believed to be due to both microorganic and chemical action. Even though the heating should abate before the ignition temperature is reached, the resulting deterioration of the products represents a staggering loss.

Studies by the engineers and bacteriologists of the bureau are being continued to find a means to store hay so as to prevent its spontaneous ignition. Attempts at isolation in pure cultures of thermophilic organisms capable of decomposing cellulose with the liberation of inflammable gas have been made with moderate success.

It is planned to conduct several large experiments on the spontaneous ignition of agricultural products during the harvest season of 1929 and to correlate the bacteriological, chemical, and engineering phases of the problem. Special studies will be made of the effect of modern haying machinery and methods upon the spontaneous heating and ignition of hay.

#### VERMONT FLOOD INVESTIGATIONS

The spontaneous heating of wet hay stored in barns following the Vermont flood of 1927 offered an unusual opportunity to study a new phase of this phenomenon. An investigation of conditions was conducted by an engineer and a bacteriologist of the bureau. During the flood the high waters of the Winooski, Missisquoi, and Lamoille Rivers entered many barns and rose to a height of 17 feet in the stored hay. When the waters receded the spontaneous heating of the wet hay was so severe that the barns and their contents were endangered, and in order to save the barns from fire the steaming hay was removed. A barn near Middlesex, Vt., housing 50 tons of hay and standing in several feet of water, burned three days after the flood receded. On a second visit made to the affected sections five months after the flood it was found that the stored hay in some barns was still heating, and in one instance it had become so hot during the winter that it was removed from the barn in January. Very little of the wet hay had dried during the winter months, and most of it was a total loss, as it could not be fed to



animals and little could be used for bedding.

#### FLORIDA PEAT-SOIL FIRES

The bureau was also called upon for assistance in studying fires in the peat soils in the Everglades of Florida during the past winter and spring, and specialists made a preliminary survey of the situation. It was found that approximately 1,250,000 acres of peat soil had been burned over, the burning ranging from mere surface burning in some sections to a depth of several feet in others. It has been estimated that the monetary loss as a result of soil damage is approximately \$60,000,000. While news reports assigned spontaneous ignition as a cause of these fires, the survey did not afford confirmatory evidence. Whether or not peat soil or peat in storage is capable of spontaneous heating and ignition, however, is a question that can be settled only by actual experiment. It appears that the majority of the peat fires were caused indirectly by drought and overdrainage and directly by "clearing off" operations and by careless hunters, trappers, and smokers.

#### FARM FIRE-PROTECTION COMMITTEE

The bureau has leadership in the work of the farm fire-protection committee of the National Fire Protection Association, the chairman and the secretary of this committee both being members of this bureau. Three meetings were held during the year—one in Boston, one in Chicago, and one in Atlantic City. In addition to the Bureau of Chemistry and Soils, Agricultural Economics, and Public Roads, of the Department of Agriculture, and the Bureau of Standards, of the Department of Commerce, the committee membership represents 14 nationally known organizations. The Bureau of Chemistry and Soils is also cooperating with the National Fire Waste Council, the American Society of Agricultural Engineers, and others in the study of the farm fire problem.

#### OTHER PROPOSED RESEARCH

Proposed research work also calls for the devising of a practicable way of storing and handling gasoline and kerosene on the farm; the development of a simple, inexpensive, effective first-aid extinguisher for farm use; and studies on lightning protection, construction and location of buildings,

farmstead wiring for electricity, and rural fire-fighting apparatus.

#### VISUAL EDUCATION, EXHIBITS, AND PUBLIC INFORMATION

The work of the bureau on visual education, exhibits, and public information is being conducted under the direction of this division. During the year considerable time was devoted to the preparation and installation of the exhibit of the Department of Agriculture at the New York Chemical Exposition. This exhibit attracted considerable attention from the industries.

Special exhibits were prepared and installed at the annual meeting of the Association of Official Agricultural Chemists in Washington and at the industrial exposition held under the auspices of the Washington Chamber of Commerce.

#### COLOR INVESTIGATIONS

#### INDUSTRIAL WASTES

Research on the high-boiling coal-tar acids has been concluded, and samples of the materials sought were sent to a commercial firm for testing in the making of resins. The report was quite satisfactory and was accompanied by a request for larger samples for further tests. These samples are now being prepared.

In an effort to make a suitable resin from furfural and other well-known resin-forming materials a number of articles were molded from a resin made by the furfural-phenol-hydrochloric acid combination. One article, made by combining furfural with the phenols obtained by the destructive distillation of corncobs, indicates some of the possibilities of utilizing farm wastes.

#### DYE INTERMEDIATES

A study of the production of 2-aminoanthraquinone, an important vat dye intermediate, has been satisfactorily concluded. This investigation was undertaken at the suggestion of the industries because of the need of a cheaper and better method of production. The problem was solved by preparing pure chloranthraquinone from chlorobenzene by the Friedel-Crafts reaction, with a net yield of over 90 per cent. The halide was then treated either with 40 per cent aqueous ammonia or with a nitrobenzene ammonia solution to obtain the beta-aminoanthraquinone. A method of purification was perfected to give a product of 98 to 99 per cent purity. It is expected



that the technic developed in this process will be of great value to the American dye industry because (1) the method is shorter and cheaper than the present operating procedure utilizing anthraquinone-B-sulphonic acid, (2) high yields are obtained in each step of the processes, (3) a very pure product is obtained, and (4) no organic solvents or costly recrystallizations are necessary.

The production of alizarin from O-dichlorobenzene and phthalic anhydride by means of the Friedel-Crafts synthesis and the subsequent fusion of the dichloroanthraquinone with caustic soda has been almost completed. Data have been obtained from which it is believed a commercial process may be developed to prepare alizarin from O-dichlorobenzene, a waste product from the manufacture of chlorobenzene, thus removing our dependence on foreign sources for this material and at the same time utilizing an industrial waste.

An exhaustive study of the nature and application of the Friedel-Crafts synthesis work on the preparation of naphthanthraquinone with a view to the further utilization of phthalic anhydride in the manufacture of vat dyes is progressing. It is planned to continue this phase of the investigation until the process is susceptible of commercial exploitation. Further work relates to the condensation of phthalic anhydride with diphenyl, dibenzyl, starch, glucose, and alcohol.

#### FARM-WASTE INVESTIGATIONS

##### AGRICULTURAL WASTES

Experiments to find means to utilize peanut shells have resulted in the production of a good white pulp that meets the published specifications for rayon pulp. Two commercial firms are interested in this product and samples will be tested.

The possibility of making insulating briquettes from corncobs was investigated during the year, and two plans were evolved which give promise of satisfactory results. One method is to add 10 per cent of asphaltum binder to the corncobs and then compress the whole mass in a hot mold. The other requires softening of the cellulose material in the corncobs with a very small quantity of dilute caustic and then compressing the mass at a high temperature. It is believed that corncobs may be used in briquettes as a substitute for cork and may be espe-

cially valuable in small refrigerating units.

An investigation of the production of gluconic acid from glucose by means of the fermenting action of molds has been completed. Optimum conditions have been determined on a laboratory scale, and these results have been carried to a semiplant scale and applied there in an apparatus which may be used as a model for industrial development of this process. A number of commercial firms are cooperating with the bureau in its effort to find a use for this acid.

#### LIGNIN INVESTIGATIONS

Various sources of lignin have been studied during the year. It has been found that sulphonated lignin can be combined with aromatic bases to make dyes. Lignin has also been destructively distilled, and the products of distillation include acetone, methanol, acetic acid, guaicol, and eugenol. Further development of this phase of the work may be of commercial interest. The metabolism of lignin in the animal body has been studied and also its rôle in the production of humus in the soil. Certain valuable resins have also been made by the combination of lignin with aromatic amines.

#### CROP CHEMISTRY LABORATORY

The crop chemistry laboratory was created for the purpose of making a scientific study of the factors, both natural and artificial, which affect the quality of our crops, with the idea that when the interrelation of these factors is more fully understood it will be possible to modify existing agricultural practice so as to produce improvements in the quality of our food supply. Some of the specific problems being studied include improvement in the quality of wheat, especially with reference to the protein content; increasing the content in crops of minor chemical elements such as iron, manganese, and iodine, which may be of great significance in nutrition; and the effect of soil acidity on the yield of crops and crop plants.

The work to improve the quality of wheat has been continued. To obtain further data on the effect of spacing the rows and of applying varying amounts of sodium nitrate at time of heading, 2 acres of wheat were planted at the Arlington Experimental Farm, Arlington, Va. Previous experiments with small plots showed that spacing rows 2 feet apart did not materially diminish the yield and that sodium



nitrate applied at heading time increased the protein content of the grain by as much as 50 per cent. In order to ascertain whether these results could be expected over larger areas, 5 acres were planted to wheat on a farm near Wheaton, Md., half having the rows spaced 2 feet apart instead of the customary 8 inches.

Crop-chemistry problems under consideration include the effect of soil reaction on the yield and composition of green vegetables, with special reference to the iron content, an investigation of the absorption of phosphorus and potassium by seedling plants, and an analytical study of the manganese content of a large number of widely used cereals.

#### FOOD RESEARCH INVESTIGATIONS

##### PHYTOCHEMICAL INVESTIGATIONS

The phytochemical research has for its aims the isolation of definite organic compounds and their characterization, the determination of their constitution, the study of their formation and progressive changes in the living plant, and, if possible, the means for their synthetic production.

During the year problems on the biochemistry of the apple were transferred from the Bureau of Plant Industry, and a varietal comparison of apples with respect to waxy coating and cutin was undertaken with the object of determining if the quantity of waxlike constituents on different varieties is definitely associated with degree of wilting or related in some way to the susceptibility to storage scald. A study of the apple surface compounds is also of importance because of a possible bearing on work dealing with the removal of arsenical spray residues from apples, which is being undertaken in the Northwest. Samples of 12 commercially important varieties grown at Arlington farm, representing three stages of growth, and a final storage sample for a number of varieties will be examined.

A chemical study of the waxlike constituents of the apple surface is also under way, the work being confined to a study of malol, one of the chief constituents of so-called apple wax, and a comparison of it with similar compounds from other sources is being made. Considerable quantities of chemically pure substances have been isolated, malol from apples, urson from bearberry leaves, prunol from wild-cherry leaves, oleanol from olive leaves, caryophyllin from clove buds,

and unidentified materials from grape pomace and dogwood bracts. Malol was subjected to ultra-violet light with the thought that it might possibly exhibit antirachitic activity, but no such change was noted.

##### FROTH FERMENTATION OF MOLASSES

One of the problems of the sugar house is the spontaneous decomposition of molasses, a condition known as froth fermentation. An extensive research is under way on the acids, nonsugars, and unfermentable sugars of molasses to determine, if possible, the cause of such fermentation. Considerable progress has been made in the investigation. The chief acid of natural origin in molasses was found to be aconitic acid, a constituent of sugar-cane juice. It is accompanied by very small amounts of malic and citric acids. The volatile acids of molasses were identified as formic and acetic acids. The study of the unstable acids of molasses, such as the more or less hypothetical "glucic" acid, is not yet complete.

##### CANNED SIRUP AND MOLASSES

Work is in progress to determine the biological and chemical causes for the production of gas in canned sirup and molasses. All the samples examined contained living spore-forming aerobic bacteria, and other samples contained living sugar-tolerant yeasts. It is known that yeasts can develop in mixtures of carbohydrates having a density of 61 per cent total solids. This study is as yet incomplete, but its successful conclusion should lead to a reduction of swells in canned sirup and molasses.

##### SPOILAGE OF CANNED VEGETABLES

Data resulting from an investigation of canned vegetables demonstrate the significance of the thermophilic spoilage organisms of the "flat sour," "sulphur," and "hard-swell" types as factors producing spoilage of canned goods. Studies made at pea and corn canneries showed that when a focus of heavy infection of the spoilage thermophiles existed within a factory, a large percentage of the canned product was also contaminated and liable to thermophilic spoilage. In determining the sources of the organisms it was noted that the "sulphur" and "hard-swell" types were present in fertilized soils and natural fertilizers and that the "flat-sour" type was



demonstrable only in the sugar used for making the sirup. Study of a large number of sugar samples showed that spoilage thermophiles entered the refineries in the raw sugar, increased in number in the refining processes, and were only partially eliminated from the granulated market sugars. Granulated cane sugars contained spoilage thermophiles more often than did the granulated beet sugars. Putrefactive anaerobes were found in a high percentage of the samples.

#### FUNGI COLLECTION

A collection of fungi and sugar-tolerant microorganisms of economic importance to food-deterioration studies obtained from the Japanese shoyu industry and industrial fermentation processes has been developed. This collection was selected from hundreds of cultures isolated over a long period of years. The maintenance of such a collection is of value to chemical, biological, and technical studies in this department and other institutions.

#### FIG INVESTIGATION

During the last few years diseases and insect pests have become more and more serious in the production of figs in California, so that a large amount of the 1926 crop was condemned by food-control officials. In an attempt to understand more fully the various details of the situation, and to seek methods for eliminating the loss which had become so great as to threaten the very industry itself, a study was made during the year in cooperation with the Bureau of Entomology, the Food, Drug, and Insecticide Administration, and California State officials. Orchard and factory conditions were investigated to gain a comprehensive understanding of the various phases of the problem, both theoretical and practical. In this study it was found that the problem is a most complex one, involving closely interlocking questions of entomology, plant disease, horticulture, and practices as to harvesting, curing, and handling in the packing houses. It has been variously estimated that the loss from the combined causes in 1927 was from 25 per cent to 40 per cent of the crop.

Growers and packers were instructed in the characteristics of the diseases and insect infestation and in methods of testing and sorting to produce a more acceptable product.

#### FRUIT AND VEGETABLE CHEMISTRY LABORATORY

The fruit and vegetable chemistry laboratory, at Los Angeles, Calif., is engaged in the development of new and improved by-products from cull or surplus fruits and vegetables and is studying the composition of fruits and vegetables with reference to their maturity and the influence of chemical and other agents on their composition and ripening, as well as the inheritance of composition through vegetative propagation. It is actively interested in investigations of dehydration and sun-drying of fruits and vegetables, with special reference to the sulphuring of apricots, peaches, and pears. Another active field of work is a study of the effect of freezing on the composition of fruits and vegetables.

#### ETHYLENE METHOD OF COLORING CITRUS FRUITS

A method devised by the laboratory for the use of ethylene in coloring mature citrus fruits is in general use. Emphasis is placed on the need to conform to the proper conditions of temperature, humidity, and ventilation in the coloring rooms in order to secure satisfactory results when this method is used to color mature oranges and lemons. Investigation of complaints regarding lack of uniformity of color when this method was used revealed improper conditions in the coloring rooms, such as stacking the boxes of fruit too closely together on the floor, lack of proper ventilation, etc.

All chemical and physical data compiled on the effect of ethylene on the composition and color of fruits show that this gas has for practical purposes no effect on the composition of the fruit, but acts as a stimulus to the coloring processes.

#### PERSIMMONS

Two problems facing the persimmon industry are the determination of the proper stage of maturity and the removal of astringency. Related to the maturity problem is the effect of ethylene on the ripening processes naturally taking place in the fruit. Studies were undertaken of the effect of ethylene on the Hachiya and Fuyu varieties of fruit from the time when it was almost entirely green but well sized to the period when it was considered commercially mature. Data have been accumulated on the composition of the fruit, before and after the ethylene



treatment, and on the respiration of the treated and untreated fruit. Progressive increase in color, weight, and total sugars was noted, with decrease in moisture, insoluble solids, and total acidity as the season advanced. Changes due to the ethylene treatment were increased color in the Hachiya variety; increased soluble solids and decreased insoluble solids in the Fuyu; decrease in hardness of both varieties; and decreased astringency in the Hachiya variety.

#### FROZEN ORANGES

Enormous losses sometimes occur from the freezing of oranges and lemons, and as the frozen fruit can not be detected by visible inspection there is great need for the development of methods to separate it from fruit of marketable quality. The chemical changes taking place in oranges during freezing are being studied with the hope that the extent of damage may be predicted within a few days after the occurrence of a freeze, as it is very desirable to have a quick and accurate estimate of the extent of the injury.

Experimental work conducted during the year on the acidity of the juice of frozen oranges indicates greater variability in the frozen than in the unfrozen fruit.

#### SULPHURING OF DRIED FRUITS

Experiments to ascertain the retention of sulphur dioxide by dried peaches were undertaken in collaboration with the California Dried Fruit Association. Sulphur dioxide and moisture determinations were made on the samples collected, and the effect of heat and pressure on sulphuring was studied. The data obtained from this work will form the basis of plans for more extensive experiments for next season.

In order to obtain basic data on the sulphuring of apricots, two field stations were established at the beginning of the apricot season of 1928, one at Hanford and the other at Davis, Calif., where samples of the fruit were obtained. Determinations of sulphur dioxide and sulphur trioxide in the sulphur-house atmosphere have been made and records kept of the temperatures of the houses.

#### HIDES, TANNING MATERIALS, AND LEATHER

##### HIDES AND SKINS

**Improving practices in skinning and curing.**—As a part of the department's

broad program on the conservation of hides and skins, field work was started during the year on better practices in skinning and curing. So far the work has been carried on principally in Pennsylvania and largely on the handling of calfskins, interviewing producers and dealers in hides and skins, studying their practices in skinning and curing, and introducing better procedures wherever advisable. Much room for improvement is being found, particularly in regard to the composition and size of the salt used for curing. The variation in the latter factor is wide, some operators using salt that is entirely too coarse and others salt that is too fine. The reuse of unwashed, dirty, bloody salt is also frequent, and often but little attention is given to the need of prompt salting and of proper conditions of drainage, temperature, and ventilation for storage of the hides and skins during curing.

**Salt stains.**—Salt stain is one of the most serious and prevalent damages resulting from the curing of domestic calfskins. It is an old cause of complaint, having been recognized over 40 years ago and, although it has been the subject of much study and research, it is not thoroughly understood, and its origin is still a debatable subject. Certainly means for preventing salt stains have either not been discovered or not been applied, as is evidenced by their prevalence to-day. The study of the causes of salt stains on hides and skins and the development and application of practical means to prevent them is one of the problems on which active work has been started and will be continued during the coming year.

**Hide-skinning devices.**—In connection with the above work, machines and safety devices and better means for removing hides and skins without scoring or cutting them are being studied and submitted to trial in large-scale experiments.

**Hide "poisons."**—Assistance has been given hide dealers and tanners in supplying them with information on hide "poisons" for protecting hides and skins against insect damage during storage.

#### TANNING MATERIALS

Because of a continually decreasing supply of domestic tanning materials from inroads by man and diseases upon the forests, and particularly because of the doom of the American chestnut tree by the blight, attention is being given to the matter of new



sources of tannin. The development of new supplies through the cultivation of either domestic or introduced foreign tannin-bearing plants and trees or both should be actively pursued now and not postponed until the tanning industry is confronted with an acute shortage. Such studies offer the possibility of relief to the leather industry and diversity to agriculture in the form of annual or periodic supplies and crops.

**Canaigre.**—In this connection some attention has been given to the resurrection of the idea of growing canaigre in this country as a source of tannin. About 30 years ago this venture almost proved a success. A study of the causes of its failure and of what bearing economic and industrial developments since then might have in overcoming these causes is the first step in a resurvey of this project. Cooperative work with several firms on canaigre is in progress.

**Chestnut studies.**—Collaboration has been continued with the Office of Forest Pathology of the Bureau of Plant Industry in connection with studies of foreign chestnut trees as a substitute for American chestnut wood as a tanning material. Two samples of wood from Japanese chestnut trees grown in North Carolina were found to contain, on a moisture-free basis, 10 and 10.7 per cent of tannin, respectively. American chestnut wood runs from 8 to 11 per cent of tannin.

**Waste hemlock bark.**—Samples of hemlock bark, occurring as a waste from lumbering operations in the Northwest and exposed to salt water, have been examined. One bark had been in salt water for two years and showed 10.7 per cent of tannin; the other bark had been in salt water for but two months and showed 10.8 per cent of tannin. No conclusions with reference to the effect of immersion on tannin content can be drawn from the work so far done.

**Barks from Honduras.**—Several barks from Honduras, Central America, have been examined with reference to a proposal to import them into this country. Mangrove bark from this source was found to contain, on a moisture-free basis, from 34 to 37 per cent of tannin; nance bark, 27.5 per cent of tannin; and an oak bark, 22.7 per cent of tannin. These figures indicate an attractive tannin content. The tannin in our domestic barks ranges from about 11 to 16 per cent.

**Ferrochrome.**—In cooperation with a tanner, a few large-scale tanning experiments have been made with ferro-

chrome as a tanning agent, and plans for additional experiments are now being worked out.

**Sugars in tanning materials.**—Methods for the determination of sugar in tanning materials have not been satisfactory. A critical study has been made of this determination. From this work, the results of which have been published, methods have been developed and proposed for the determination of total sugars, reducing sugars, non-fermentable sugars, and fermentable sugars in tanning materials.

**New extractor for tanning materials.**—The metal extractors used in the laboratory are defective in that the extraction can not be watched and its completeness judged. A practical glass extractor of novel and simple construction has been designed in collaboration with a commercial firm of New York for the extraction of tanning materials and other products and is being rapidly introduced into tannery laboratories.

#### LEATHER

**Leathers for public binding.**—Active cooperation has been continued with the Government Printing Office in an effort to obtain durable bookbinding leathers. Chemical and physical examination of the leathers received during the past year by the Printing Office shows a trend toward improvement in quality since this move was started several years ago. While in general domestic-tanned bookbinding leathers do not meet the essential requirements for durability or long life, increasing interest is being shown in this subject by several tanners, to whom helpful suggestions have been given as the result of examination and analysis of their leathers.

**Foreign-tanned bookbinding leathers.**—In collaboration with the division of tests of the Government Printing Office, physical examination and chemical analysis of a collection of 25 foreign-tanned bookbinding leathers have been completed and the data are being assembled for publication. One of the outstanding findings of this work is the general absence of harmful or mineral acidity. Another is the use of pyrogallol tanning materials. These are two of the essential requirements for durable bookbinding leathers.

**Deterioration of leather bindings.**—A note on the deterioration of bookbinding leather, based on data from the examination of some old bindings from the Library of the Royal Archives, of England, has been published. These



bindings, which dated from 1480 to 1880, had been filed under very favorable conditions, especially as regards freedom from exposure to an atmosphere polluted with acidic gases and other harmful constituents, such as the air of cities and industrial centers, and were in a relatively good state of preservation. Examination of the bindings showed the leathers to be practically acid free, indicating both freedom from acidity originally or when tanned and no absorption of acids from the atmosphere during their existence. The tannages were also found to be, in general, of a pyrogallol nature. These findings offer sufficient explanation for the long life of these bindings.

**Leather dressings.**—Supplementing our work on old leather bindings, which indicated absorption of acid from polluted atmosphere as an important factor in their deterioration, experiments have been inaugurated on the development of dressings to help to preserve the leather through the prevention of absorption and also through the neutralization of the acids the leather may contain. Several preparations have been devised and applied to test sets of bookbinding leather. One-half of this set is being used as a control; the other half is being exposed to an atmosphere containing a known quantity of sulphur-dioxide gas. After sufficient exposure, the pieces will be examined chemically and physically and compared with the controls for a measure of the relative efficacy of the different treatments in counteracting the acidity of the sulphur dioxide and its oxidation product, sulphuric acid.

**Vegetable and chrome-retanned sole leathers.**—Experiments on a comparison of the properties of vegetable-tanned and chrome-retanned sole leathers are under way. A particularly interesting and valuable feature of this work is the direct comparison afforded by using alternate right and left sides of the same lot of hides in making the two types of leather. Data have been obtained in regard to these leathers on weight yields, area yields, thickness, density, tensile strength, stretch, and chemical composition. Actual wear tests are now being made to determine the wearing quality of these two leathers.

**Effect of acids and alkalis on leather.**—Many of the preliminary details of an elaborate experiment to show the deteriorating influence of acids and alkalis upon vegetable-tanned and chrome-tanned leathers have been worked out, including particularly the

procedure and equipment necessary to introduce into the leather known and controlled quantities of acid or alkali with a minimum resulting "edge effect," or uneven distribution, an obviously important matter in such work. Another serious difficulty in this work to which much attention has been given, with as yet but little success, is the prevention of mold growth, which will be necessary, as a part of these experiments requires storage of the leather for five years or more in high relative humidities.

**Effect of oils and greases on leather.**—An equally extensive experiment is under way on the merits of different oils and greases in prolonging the life and serviceability of leather and leather goods. Authentic lots of many oils and greases for this work have been obtained and analyzed, and the preliminary details of laboratory manipulation are being worked out.

**Preparation of leather for analysis.**—Comparison has been made of four machines in the preparation of leather samples for analyses. This is an important problem of the leather analyst because of the tough, compact nature of leather and its susceptibility to modification from heat or friction often developed in preparing the sample for analysis, especially in machines of the old, familiar coffee-mill type. The data show that not one of the machines tried seriously modifies the leather, as reflected by chemical analysis. They also suggest the possibility of using a certain recently designed mill for the preparation of all types of leather. Machines used heretofore have been designed primarily for the preparation of what are known as the heavy leathers, as distinct from the thin, pliable, light leather.

**Footprint paper.**—To supply a need for a practical or generally available means of registering the size of the foot, a treated paper has been developed which gives a contrasting print when the foot is rubbed over with a wet cake of soap and placed on the paper. Considerable interest has been shown in this procedure by several firms doing a mail-order business in shoes and also by clinics and hospitals in making foot records.

#### NAVAL STORES

Naval stores are among the major farm and forest products of the South and are valued at about \$60,000,000 annually. They are essential as raw materials of the paint, varnish, paper-size, soap, printing-ink, polish, and



other industries of the Northern and Central States. They are also largely exported.

For many years the bureau has recognized the necessity of investigations to improve the equipment and methods of cleaning and distilling gum in the production of rosin and turpentine, as well as to make an economic study of the industry. Users of naval stores stand in need of helpful work on production quite as much as the producers. Every improvement in process or product made by the producers gives the users a better material or one less difficult to work with.

#### GUM CLEANING

Laboratory experiments on the removal of fine dirt from crude turpentine gum by filtering both the gum alone and the gum diluted with turpentine through various materials, with and without pressure, at a temperature of 95° C. have been continued and indicate that cotton batting, even when two thicknesses of the heavier weights are used, will not hold back all the fine dirt. Cotton felt and a filter made of cellulose pulp were more satisfactory than batting. A mixture of four parts gum to one part turpentine was found to filter much more readily than straight gum, and the addition of fuller's earth to the extent of about 5 per cent was found in a number of instances to facilitate filtration. A working model of an apparatus for cleaning gum that might be tried out at a commercial still was designed and built on the basis of the laboratory experiments. Experiments so far conducted with this apparatus indicate that this process of cleaning gum will prove to be practical. Considerable interest has been shown by the industry in this line of work, and requests have already been made by leading men in the industry to have the first gum-filtration plant erected at their establishments.

#### STEAM STILL

Excellent progress has been made in developing the steam turpentine still designed by the bureau in 1927. While only 1 of these stills was in operation at the beginning of the year, 7 more have been installed, 3 in Louisiana, 1 in Mississippi, 2 in Florida, and 1 in Georgia. All are giving satisfactory service. From the numerous requests for plans and specifications, it is expected that many others

will be erected before the opening of the next turpentine season.

Extensive experiments have been made under the direction of bureau representatives to determine the performance of the steam still in comparison with the fire still and to establish its practicability. In these experiments an effort was made to secure gum of exactly the same nature from similar woods for comparable charges in the fire and steam stills, and everything was carefully weighed or measured. With the steam still, the yield of turpentine averaged about 1 per cent more than with the fire still. The yield of rosin was about the same for both kinds of stills, but the rosin from the steam still was lighter colored than that from the fire still. Out of 91 barrels produced in the steam still and 89 barrels produced in the fire still, the quantity of water-white rosin was 10 per cent and 5½ per cent, respectively, and the quantity of window-glass rosin was 37 per cent from the steam still, as compared with 10 per cent from the fire still. In lower grades the quantity of N rosin was 47 per cent from the steam still and 65½ per cent from the fire still, and the quantity of M rosin was only 6 per cent from the steam still, as compared with 19 per cent from the fire still. While experiments were made on all classes of gum, the outstanding showing was in the case of third-year gum, which consistently yielded N rosin on the steam still and M rosin on the fire still. In the distillation of selected scrape, the steam still produced on the average over one-half gallon more turpentine per 300-pound barrel than did the fire still. It also yielded lighter-colored rosin, that from one charge being close to window glass. The time for running a charge so as to get the best possible grade of rosin was only one and three-fourths hours for the steam still, and at least three hours for the fire still. In experiments on the use of superheated steam in the steam still, it was found that the time required for distilling scrape was greatly reduced, and the method of operating the still was simplified thereby. The steam was superheated but 75° F.

Complete detailed drawings, with specifications, were prepared for steam stills of 25-barrel and 35-barrel capacities, and for a modified steam sparger, plant layout, and still setting. Blue prints and specifications have been supplied to a large number of interested persons. A special type of



superheater that will not burn up during periods when steam is not flowing through the coils has been designed and found to be very satisfactory. A detailed drawing of this superheater will be prepared and furnished to boiler makers for the benefit of turpentine operators requiring such equipment. It is needed particularly in the distillation of scrape. Thorough tests with weighed gum of different grades showed that the steam stills have an advantage over the fire stills as regards yields, grades of rosin made, and time required for distillation. A public-service patent on the steam still has been granted.

#### FIELD TECHNOLOGICAL WORK

Continued interest is manifested in the educational work carried on among naval-stores producers. The bulk of the naval stores produced in this country is made at smaller places, owned in many instances by farmers in the Southern States. The possibilities for financial loss through wasteful methods of operation, insufficient and incorrectly designed equipment, and faulty handling of the finished products are numerous. The field work is performed by an experienced naval-stores man, who studies the conditions at the stills, installs better methods of production, suggests improvement in equipment, and offers suggestions for the elimination of waste. The demand for this work is far more than can be met with the force and funds available. The naval-stores technologist, because of lack of funds, was able to investigate and help only about 30 naval-stores works during the year. He delivered addresses on technological subjects before 20 meetings and associations of naval-stores interests.

#### TURPENTINE DETERIORATION

Spirits of turpentine has a tendency to become viscous, turbid, discolored, and rancid on aging, as do some products containing turpentine. These products, as a consequence, should be used within a few months after production. These changes often result in serious losses to producers and users. In some instances they develop with unexpected and unexplained rapidity. Experiments have been started to find a means for preventing the deterioration of turpentine during storage and in manufactured products such as shoe polishes, prepared waxes, etc. While the tests have not run

long enough for the untreated turpentine to show pronounced deterioration, the results have already developed promising and practical retardants of deterioration. The work is being continued on a laboratory scale, and at the proper time will be put to practical application.

#### VISCOSITY OF ROSIN

The cooperative work with producers and users of rosin has continued and has resulted in the working out of acceptable tentative methods for the determination of this property of rosin, which is becoming more and more important.

#### BLEACHING OF ROSIN

Experiments both in the laboratory and in the field on the bleaching of rosin have been continued during the year with promising results but have not been completed.

#### STATISTICS

Statistics to show the total rosin and turpentine used annually and on hand in each of the using industries, at the primary ports and the chief distributing centers at the close of the naval-stores season, March 31, 1927, and also reports on the number of new cups sold for use during the year 1927 were published during the year. These figures, which are the bureau's compilation of those voluntarily supplied it by individual users and manufacturers, are the only source of this information and serve to keep the naval-stores trade informed as to conditions. They are calculated to be between 90 and 95 per cent accurate.

#### MODELS

Models of the steam still, the fire still, and its setting, and of rosin strainers have been constructed and used to acquaint producers with this equipment and the best methods of installing and operating it.

#### NAVAL-STORES HANDBOOK

Progress has been made on the handbook to contain technical and industrial, agricultural, and general information useful to the producers. This handbook, which has been in mind for several years, is being prepared in cooperation with other interested bureaus of the department.

#### PAPER AND BOARD

#### CORNSTALKS AND STRAW

The recrudescence of general interest in the utilization of cornstalks, ba-



gasse, straw, and other farm products for paper and board making has required careful attention and much correspondence.

The work that has been done on these materials (of which there is grown annually enough to make three or four times the paper produced in this country) during the past hundred years, on two occasions by the department itself, has shown clearly that it is entirely possible to make paper and board from them. However, it has not so far been profitable to make anything but what is known as "strawboard" and "strawpaper," which have been made from wheat straw for a century in this country. It should be borne in mind, however, the making of these boards from the waste wood of the lumber and paper mills is increasing rapidly and that this raw material can probably be gathered, transported, and processed at lower cost than cornstalks. Intimate contact with industrial work along these lines has been maintained during the year. The plants engaged in the work have been visited and such cooperation as practicable extended, especially to inquirers who have been interested in these developments from the investment point of view.

In the light of our present knowledge, it is conservatively estimated that it may take as long as five years' mill-scale work, at a cost of about \$150,000 annually, to establish the practicability or rather profitability of making white paper or of separating cellulose from such raw materials. The evidence available indicates that at prevailing prices white paper can not be made profitably.

Investigations have been started on the deterioration out of doors of piled baled cornstalks, since such deterioration is likely to play a large part in the utilization of cornstalks. Small-scale laboratory experiments have been conducted with some success in making structural boards out of such farm wastes as sledged cotton burs, cornstalks, corncobs, and wild sunflower.

#### PAPER DETERIORATION AND PAPER SPECIFICATIONS

Work on paper deterioration and paper specifications, which have long engaged the attention of the bureau, has been continued during the year, independently and in cooperation with the Government Printing Office and the Federal Specification Board. The specifications upon which the papers for Government use are bought have

been further strengthened during the year and interest in deterioration and specification has increased. Several striking instances of the astonishingly rapid deterioration of the paper in valuable publications and documents are but confirmation of the evidence which necessitates a vigorous continuation of the work along these and related lines.

#### FARM FABRICS

##### TOBACCO SHADE CLOTH

In collaboration with the tobacco substation of the Connecticut Agricultural Experiment Station and with tobacco growers in the Connecticut Valley the bureau arranged to have about 7,000 square yards of tobacco shade cloth treated with lead chromate by a commercial treating plant to get further information concerning the value of the treatment as a light-proofing agent and concerning its commercial practicability. The treated cloth, which was sufficient to cover 1¼ acres, was put up for practical tests over growing tobacco during the 1928 season. Small-scale exposure tests are in progress to determine also the preservative effects of lighter treatments with lead chromate.

In laboratory experiments on treating tobacco shade cloth with lead chromate as a light-proofing agent it was found that a short preliminary treatment with a 0.5 per cent solution of a wetting-out agent of the naphthalene-sulphonic acid ester type facilitated impregnation to such an extent that the combined time of impregnation with lead acetate and potassium bichromate at room temperature could be reduced from about 1 hour to 5 minutes. Tests are under way to determine if there are any injurious effects from traces of the wetting-out agent left on the fabric.

##### GLASS SUBSTITUTES

Weather-exposure tests for five months on glass substitutes over cold-frames indicated that wire-screen cloth coated with cellulose acetate was in fairly good condition after this period; wire-screen cloth coated with cellulose nitrate was worthless, all meshes being open; two makes of paraffined cloth were worthless after exposure, being very dirty and torn through weakening of the fabric; and the same cloths with paraffin removed were comparatively clean and not torn.



## SHOCK COVERS

In order to meet the need for low-priced and lightweight shock covers to protect hay and grain in the field, covers made of sheeting and drill have been subjected to waterproofing, and preservative treatments and tests are under way to determine their serviceability in comparison with canvas.

## MILDEW-PROOFING MATERIALS

Mildew-proofing materials have continued to receive attention during the year. Those that have come to our attention have been subjected to laboratory tests and on their promising showing are being subjected to practical tests in the field on canvas treated therewith.

## INSECTICIDE AND FUNGICIDE INVESTIGATIONS

## INSECTICIDES

Injurious insects cause a loss of not less than \$2,000,000,000 annually in the United States, and their control is therefore a matter of tremendous economic significance. For a number of years chemists have been investigating some of the most important insecticides in order to devise methods for reducing the costs of manufacture and for improving their insecticidal efficacy, to ascertain with what other insecticides they are compatible, to determine the changes in their chemical composition during storage, to increase their spreading and sticking properties, and to study other problems of a physical nature.

Nicotine is one of the most valuable insecticides for controlling plant lice and certain injurious insects. It is prepared from the stems of tobacco and the sweepings from cigar factories, the better parts of the tobacco leaf being consumed in the manufacture of cigars, cigarettes, pipe tobacco, snuff, and chewing tobacco. The supply of nicotine is therefore limited and its price high. The bureau has been engaged for some time in researches looking toward the synthesis of an effective nicotine substitute, and some promising compounds have been prepared and are being tested. A compound that is even more deadly to insects than is nicotine has been isolated from crude dipyrindyl and has been designated as "neonicotine." A commercial firm has manufactured several hundred pounds of crude dipyrindyl containing "neonicotine," both as a solution and as a dust, and tests

with it against a variety of insects are being made by several entomologists in different parts of the country. The preparation and properties of "neonicotine" are described in a paper prepared for publication.

Among the nonarsenical insecticides certain fluorine compounds appear to be most promising. In order to explore the field of fluorine insecticides a number of inorganic fluorides have been prepared during the past year and are being tested against chewing insects. Samples of all fluorine compounds that are offered for sale as insecticides were analyzed, and a paper recording the results was read at the annual meeting of the Association of Economic Entomologists.

## ARSENICAL SPRAY RESIDUES

The removal of arsenical residue from sprayed fruit is a matter of extreme importance as the metallic residues caused by the overspraying or late spraying of the fruit constitute a definite health hazard. In certain parts of the country the codling moth is more resistant than in other parts to arsenical sprays. For this reason it is necessary to make heavier or more frequent applications of the spray than has been customary in the past. The removal of the spray has been difficult, and in many cases apples which have been shipped, not only in interstate trade in the United States but to England and other foreign countries, upon analysis have shown an excessive arsenic residue. As a result of this the whole export apple industry, amounting in 1927 to over \$30,000,000, was jeopardized. A cooperative investigation will be undertaken during the year by the Bureau of Entomology, the Bureau of Plant Industry, and the Bureau of Chemistry and Soils to devise effective means of removing arsenical spray residue without injuring the apples. Effective substitutes for lead arsenate will also be sought. Certain oil emulsions are among the most promising of substitutes for lead arsenate for the control of the codling moth, and a thorough study is being made of these materials. A paper outlining a method for sampling apples for the determination of arsenical spray residue has been prepared for publication.

## FUMIGANTS

A number of new fumigants have been developed during the past year. One of these, a mixture of ethylene



dichloride with carbon tetrachloride, which has proved to be effective against clothes moths, was brought to the attention of the public in September, and by December it was being sold at the rate of 10,000 pounds a month. This substance has never before been used as a fumigant. A manufacturer of fumigant equipment for warehouses has adopted this fumigant for use in his apparatus.

Following the announcement that the esters of formic acid were efficacious as fumigants, the production of ethyl and isopropyl formates was begun on a large scale by a manufacturer of chemicals. These substances are now being used in California to fumigate raisins.

Methyl chloracetate and ethylene oxide have been found to be very toxic to insects, and it is planned to carry on extensive tests in fumigating grain in railway cars and in bins with these compounds.

The results of investigations to find repellents for blowflies infesting domestic animals have been published.

During the year the title of "The Review of United States Patents Relating to Insecticides and Fungicides" was changed to "Review of United States Patents Relating to Pest Control." This review is now being sent to over 500 entomologists, chemists, plant pathologists, and bacteriologists in this country and abroad.

#### OIL, FAT, AND WAX INVESTIGATIONS

The oil, fat, and wax laboratory is studying the composition of fats and oils with a view to gaining a more accurate and intimate knowledge of them, so that they may be produced and utilized to better advantage. Fats and oils are an essential part of our diet, and many of them play an important rôle in the industries. Fats and oils from new sources are examined to discover the purpose they may serve and to determine whether or not it is feasible to produce them commercially. Investigations are also made of the more important domestic commercial oils to determine the effect of climate and soils upon the character of these products. In addition to these studies, research methods and procedures for testing the purity of fats and oils are developed.

#### AVOCADO OIL

The possibility of using cull avocados as a source of oil has led to a study of their composition. The oil which was obtained both by solvent

extraction and expression from the dehydrated fruit had a deep-green color, which laboratory refining and bleaching experiments failed to remove altogether. The oil had a slight fruity avocado flavor and showed good keeping qualities. It produced a pale-green hard soap somewhat similar to castile soap. Avocado oil, which belongs to the nondrying class, is similar in composition to olive oil and is characterized by its small percentage of saturated acids.

#### ERGOT OIL

Determinations have been made of the chemical and physical characteristics, as well as the composition, of the oil obtained by extracting a large composite sample of Austrian, Russian, and Spanish ergot with petroleum ether. Ergot oil is nondrying and is characterized by containing over 26 per cent of saturated acids as glycerides. The oil is reported to be used for the extraction of the ergosterol (which constitutes a portion of the unsaponifiable matter, amounting in this sample to about 1 per cent), the reputed parent substance of vitamin D. After the removal of the unsaponifiable matter the oil can be used in making soap.

#### CHIA SEED OIL

Chia, an herb of the mint family, grows wild in considerable quantity in California and is cultivated to some extent in Mexico for its seed. The latter contains an oil which, in drying power, is similar but slightly superior to that of linseed and which can be employed in the manufacture of paints and varnishes. In view of the tests made here and abroad, it appears that the oil has commercial possibilities. Also, it is probable that suitable localities for the cultivation of chia seed could be found in some of our Southern States. The investigation upon the composition of the oil, which has been in progress for several months, is approaching completion. The identity and quantity of the saturated acids, as well as of the unsaturated linolenic acid, have been determined.

#### METHODS

The parachloro, parabromo, and bromo-parachloro phenacyl esters of lauric, myristic, palmitic, stearic, arachidic, and lignoceric acids have been made, and their solubility in 95 per cent alcohol has been determined. The results indicate that several of



these compounds could be used for the separation of the higher from the lower members of the fatty acid series. Likewise, similar derivatives of chaulmoogric acid have been prepared, but it remains to determine their solubility. Owing to the biological interest attached to this acid in connection with the treatment of leprosy, it is desired to find some reagent that will permit its ready separation, in a quantitative manner, from the saturated and unsaturated acids with which it is associated.

An extensive study is being made of the Crismer dissolution method in connection with its further application to testing the purity of cod-liver and various vegetable oils.

#### NUTRITIONAL INVESTIGATIONS

##### PROTEIN INVESTIGATIONS

Investigations started several years ago to determine the amino acids in a number of the proteins of various foodstuffs have been completed. Formerly little was known of the chemical composition of proteins, and one protein was considered to be of equal value with another in supplying the necessary nitrogenous matter of the diet. Research has shown, however, that proteins vary materially and that the nutritive value of the proteins of foodstuffs depends chiefly upon their content of the nutritionally essential amino acids. It has shown that some of our most important foodstuffs are deficient or lacking in one or more of the amino acids necessary for animal growth. This deficiency, however, may be remedied, for feeding experiments with small animals have established the fact that when rations containing proteins of little value are supplemented by feeds having proteins rich in the necessary amino acids the mixture will produce normal growth and development.

The world production of sesame seed is approximately 700,000 tons. Sesame seed contains about 50 per cent of oil, and the press cake remaining after the expression of the oil contains about 40 per cent of protein. Practically all of the press cake is used for cattle feeding, but little information as to the value of its proteins was available until the bureau began its studies along this line several years ago. Examination of the proteins of sesame seed have been completed and two globulins isolated. One of them was obtained in the form of octahedral crystals.

Analyses of these proteins showed that they contained the nutritionally essential amino acids in sufficient quantities so that sesame press cake can be classified with protein feedstuffs that have high feeding value, and on account of its high percentage of protein of good quality it can probably be most economically utilized as a concentrate for supplementing other feedstuffs containing less protein and of poorer quality.

As compared with the proteins of other cereals those of rice have been studied but little, notwithstanding the importance of rice as an article of food. Studies of rice conducted during the past year showed that most of its proteins belong to the class known as glutelins—that is, proteins that are insoluble in water, salt solution, and alcohol. From white rice or rice from which the bran and germs have been removed, two different salt-soluble proteins (globulins) have been isolated and characterized and the percentages of the nutritionally essential amino acids determined. Polished rice contains only one glutelin.

The new method developed for the separation of the class of proteins called glutelins, by means of which it was shown that wheat glutelin consists of two separate glutelin fractions, has been further applied to a study of other cereals, including corn, oats, barley, rye, rice, and buckwheat. Two glutelins were obtained from several of these cereals, and their properties and composition are being studied.

A study of the proteins of the growing wheat plant is being made to find out in what order the different proteins present in the ripe kernel are formed and originate. The work thus far shows that the nitrogenous material in the green wheat plant is not extractable by the methods applied at present for the extraction of proteins from seeds. The nitrogen content of the press juice of the green plant at the stage approaching heading is only one-fifth of the total nitrogen present in the whole plant. After heading, but before the kernel is formed, the proportion of the nitrogen in the juice to that of the whole plant remains practically the same—one-fifth. From the salt extract of the green wheat kernel (milky stage) two protein fractions have been separated.

##### LIGNIN

Lignin is a substance that enters largely into the composition of plants and consequently constitutes a not in-



considerable part of the diet of herbivorous animals. Comparatively little is known regarding its structure or the part that it may play in the metabolism of animals. Herbivorous animals usually eliminate relatively large quantities of hippuric acid, the source of which is yet unknown. Lignin present in such large quantities in their food has been long suspected as the source of this acid, but no conclusive proof of this has been presented. Experiments are being conducted in which lignin is fed to animals in order to find out what part, if any, it plays in animal metabolism. Results thus far obtained indicate that lignin is metabolized and that it contributes to the formation of hippuric acid in animals.

#### GOSSYPOL

Feeding experiments with small animals are being conducted to test the toxicity of gossypol. Two-tenths of 1 per cent or more of pure gossypol in a satisfactory diet produced decline in weight and caused death. One-tenth of 1 per cent in the diet permitted growth at a subnormal rate, but no other visible deleterious effects on the animal over a period of more than four months. Five-hundredths per cent of gossypol in the diet produced a noticeable retardation of the growth rate. This information is of fundamental importance in connection with further work related to cottonseed poisoning in the feeding of farm animals.

#### VITAMINS

Experiments are being conducted to estimate the quantity of vitamins in different foodstuffs, to extend our knowledge concerning the properties of vitamins, and to develop more satisfactory methods for their assay. The determination of vitamins in oysters collected at different seasons and a comparative study of the vitamin content of certain citrus fruits with reference to genetic relationships are in progress.

Studies on the vitamin content of fresh sugar-cane juice showed that juice from the upper portion of the stalks has a higher content of vitamin B than that from the lower portion, and that juice expressed from the stalks at a high pressure has more vitamin B than juice obtained at a low pressure. Whole-cane juice contains no vitamin A or vitamin D, and the quantity of vitamin B present is too low to furnish growth at a normal rate.

Avocados were found to contain an abundance of vitamin B, but no vitamin A or D.

The bureau uses a number of young rats in its nutrition experiments. Some of the difficulties that have been met with in raising rats satisfactorily for vitamin A determination have been overcome as a result of studies carried on for the past two years. A diet regimen has been established, whereby the storage of vitamin A in young rats may be controlled and maintained at a comparatively uniform level. By means of this method the time and labor required for the determination of vitamin A in foods and commercial preparations can be materially decreased.

The general recognition of the importance of vitamins in nutrition has brought before the public a large number of so-called vitamin preparations. The realization of the value of cod-liver oil as one of the best sources of vitamins A and D has greatly increased the demand for this product, and special attention has been given to this and similar preparations on the market for the guidance of the Food, Drug, and Insecticide Administration.

#### SOIL INVESTIGATIONS

A. G. MCCALL, *Chief*

##### THE SOIL SURVEY

During the fiscal year soil-survey work was in progress in 29 States on 74 different projects. On some of these projects the work had been inaugurated the previous year; on others it was begun in 1928 and was incomplete at the close of the year.

During the progress of the soil survey approximately half of the arable land of the United States has been surveyed and mapped.

A high degree of accuracy has been reached in making soil maps. Soil surveying represents the mechanics of a new science, and it has been necessary to work out methods step by step. The geological relations, the great variety of materials of different composition from which soils have developed, the various modes of soil formation, all of which have a bearing on the final characteristics of the soil, had to be worked out as these problems were met with in the field, and the whole system of soil classification gradually had to be perfected.

Each year has seen progress, and in recent years a stage of development has been reached which combines fun-



damental scientific principles with accuracy in soil classification.

In the application of the soil survey the individual is usually interested in a particular locality of limited extent. The States are interested primarily in the lands within their borders, whereas the National Government is interested in the whole country. For the sake of uniformity and in order that all interested parties may think of soils in the same terms the bureau has worked out and put into effect a system of soil classification and naming broad enough to embrace the entire country and inclusive enough to allow the differentiation of minor details.

To insure continuous adherence to the idea of uniformity in classifying soils throughout the United States and at the same time to provide for proper consideration of local conditions, it has been found desirable that Federal and State agencies should work together in making soil surveys in any particular State, with the former acting as the coordinating agency.

It is also recognized that the soils departments of the State experiment stations are best qualified to do the State's part of the work, because of their special knowledge of the soils of the State and because of the fact that all soil-fertility investigations should be closely correlated with soil classification.

For these reasons the Federal Bureau of Soils and the State experiment stations have in most cases entered into cooperative agreements for carrying on soil-survey work. In such agreements the expenses are divided equally between the two cooperating agencies.

The soil survey is of value to the individual farmer because it classifies the agricultural and the nonagricultural land and indicates soils which are best adapted to special crops and areas best suited to intensive cropping systems. It is of particular value to farmers who are seeking new locations and to city dwellers who are interested in buying farm land, and in general, for locating suburban developments or in seeking land suitable for parks or golf courses.

State agricultural experiment stations utilize the information in the reports to aid them in locating outlying experimental fields; agricultural high schools and colleges and the county agents make extensive use of the soil maps and reports in dealing with cropping systems and soil-management problems; and road engineers and factory managers use the maps in locat-

ing roads, road-building materials, and deposits of clay and other raw materials.

Another unusual but very important use which is being made of the soil-survey reports is in connection with public health and sanitary surveys made by large life-insurance companies and by banks in connection with loans made on farm lands.

The total expense of making a detailed survey of a county is less than the cost of a quarter of a mile of a modern concrete road. The actual average cost, including both Federal and State expenses, is only a fraction over 2 cents per acre. It is doubtful if there is any other line of public work of such great economic value that can be done at so low a cost to the taxpayer.

Since 1899 more than 1,100 areas have been surveyed, aggregating over 800,000,000 acres. This does not include surveys made for the Forest, Indian, and Reclamation Services and special service rendered the Department of Commerce in its rubber investigations.

Much scientific data have been collected. The characteristics of soils have been determined and evaluated, their course of development traced, and fundamental facts have been determined to make possible a scientific classification of the soils of the United States and broaden the foundation of a rational soil science.

With the reorganization of the work incident to the setting up of the new Bureau of Chemistry and Soils, it is planned to extend and more fully coordinate the work of the soil survey division with the other activities of the Federal Government and with those of the State colleges and experiment stations.

The soil survey division has been engaged in the determination of soil characteristics, in the isolation of soil types, and in mapping their distribution for many years. The work has been distributed widely over the country. Through this wide distribution an important knowledge regarding the characteristics of the soils in all parts of the country has been obtained. Very little work has been done, however, in the evaluation of the soils that have been mapped. The characteristics of these soils are known. Except for such knowledge as has been gained incidentally, the value of these types in terms of agriculture is not known. One of the necessary lines of work in order to determine this is to carry on studies in various parts of



the country, organized for the purpose of obtaining this evaluation data. Study should be carried on in each of the great soil regions of the United States. This should be conducted for a number of years, long enough to be able through the accumulated data to eliminate the accidental and temporary conditions controlling crop yields and determine the effect of the soil factor. This work should be begun now. It is not necessary to undertake to cover all the country at once, but studies can be begun in a small way and expanded as methods are worked out and soil-survey work is extended.

One phase of this work concerns the relation of soil types to the development and the spread of plant diseases.

During the past field season a limited amount of cooperative work with the division of plant pathology of Texas was undertaken for the purpose of studying the relationship of soil types to the root rot of cotton. As a result of this preliminary survey it seems certain that a very definite relation exists between certain soil types and the development and spread of this disease in Texas, and it is hoped that a continuation of this line of soil study will be of material aid in indicating the soils in which the disease will develop, as well as the characteristics of types and the particular field conditions which favor the spread of the organism responsible for this disease.

TABLE 1.—Individual areas surveyed and mapped during the fiscal year ended June 30, 1928

State	Area	Area surveyed		State	Area	Area surveyed	
		Square miles	Acres			Square miles	Acres
Ala.....	Mobile County.....	212	135,680	Nebr....	Clay County.....	579	370,560
	Perry County <sup>1</sup> .....	56	35,840		Hamilton County.....	538	344,320
Ariz.....	Gila Bend area.....	193	123,520		Pierce County.....	232	148,480
	Paradise Verde area.....	165	105,600		Saline County.....	462	295,680
Calif....	Clear Lake area.....	389	248,960		Thayer County.....	578	369,920
	Paso Robles area.....	1,001	640,640		York County.....	575	368,000
Colo....	Fort Collins area.....	384	245,760	N. Mex..	Deming area.....	219	140,160
Ga.....	Cook County.....	241	154,240	N. Y....	Nassau and Suffolk Counties <sup>1</sup> .....	359	229,760
	Elbert County <sup>1</sup> .....	191	122,240	N. C....	Craven County.....	259	165,760
	McIntosh County.....	171	109,440		Davie County.....	258	165,120
	Worth County <sup>1</sup> .....	269	172,160		Gates County.....	70	44,800
Idaho...	Jerome area.....	213	136,320		Martin County <sup>1</sup> .....	152	97,280
Ind....	Dubois County <sup>1</sup> .....	199	127,360		Person County.....	99	63,360
	Miami County <sup>1</sup> .....	142	90,880		Watauga County.....	196	125,440
Iowa....	Butler County.....	134	85,760	Ohio....	Belmont County <sup>1</sup> .....	224	143,360
	Crawford County.....	715	457,600		Butler County <sup>1</sup> .....	285	182,400
	Pocahontas County.....	482	308,480		Licking County.....	45	28,800
	Sac County.....	291	186,240		Ottawa County.....	226	144,640
	Union County.....	427	273,280		Putnam County <sup>1</sup> .....	64	40,960
Kans....	Crawford County.....	114	72,960	Oreg....	Columbia County.....	199	127,360
	Johnson County.....	266	170,240		Marion County <sup>1</sup> .....	588	376,320
	Wilson County <sup>1</sup> .....	189	120,960	Pa.....	Tioga County.....	182	116,480
La.....	Beauregard Parish <sup>1</sup> .....	533	341,120	S. C....	Williamsburg County <sup>1</sup> .....	595	380,800
Md.....	Anne Arundel County.....	51	32,640	Tex....	Frio County.....	314	200,960
	Calvert County.....	94	60,160		Midland County <sup>1</sup> .....	260	166,400
	Cecil County.....	377	241,280		Polk County.....	194	124,160
Mass....	Hampshire and Hampden Counties <sup>1</sup> .....	321	205,440		Potter County.....	120	76,800
Mich....	Alger County.....	113	72,320		Van Zandt County <sup>1</sup> .....	434	277,760
	Branch County <sup>1</sup> .....	260	166,400	Va.....	Orange County <sup>1</sup> .....	302	193,280
	Crawford County.....	575	368,000	W. Va..	Hardy County.....	60	38,400
	Jackson County.....	707	452,480		Hampshire County <sup>1</sup> .....	257	164,480
	Kalkaska County <sup>1</sup> .....	390	249,600		Bayfield County.....	280	179,200
	Mecosta County <sup>1</sup> .....	315	201,600	Wis....	Trempealeau County <sup>1</sup> .....	320	204,800
	St. Clair County.....	245	156,800		Vernon County.....	232	148,480
Minn....	Hennepin County.....	136	87,040		Winnebago County <sup>1</sup> .....	365	233,600
	Mille Laes County <sup>1</sup> .....	227	145,280	Wyo....	Basin area <sup>1</sup> .....	359	229,760
Miss....	Hancock County.....	113	72,320		Total.....	21,838	13,976,320
Mont....	Milk River Valley area.....	456	291,840				

<sup>1</sup> These figures do not include portions of these areas surveyed in preceding years.



TABLE 2.—Areas surveyed and mapped in the several States during the fiscal year ended June 30, 1928, and the areas previously reported

## DETAILED

State or Territory	Work during 1928	Work previously reported	Total		State or Territory	Work during 1928	Work previously reported	Total	
			Square miles	Acres				Square miles	Acres
Ala.....	268	51,743	52,011	33,287,040	N. H.....		1,411	1,411	903,400
Ariz.....	358	2,433	2,791	1,786,240	N. J.....		9,895	9,895	6,332,800
Ark.....		15,547	15,547	9,950,080	N. Mex.....	219	596	815	521,600
Calif.....	1,390	27,940	29,330	18,771,200	N. Y.....	359	25,712	26,071	16,685,440
Colo.....	334	3,520	3,904	2,498,560	N. C.....	1,034	39,898	40,932	26,196,480
Conn.....		1,704	1,704	1,090,560	N. Dak.....		16,878	16,878	10,801,920
Del.....		2,276	2,276	1,456,640	Ohio.....	844	14,300	15,144	9,692,160
Fla.....		15,160	15,160	9,702,400	Okla.....		6,540	6,540	4,185,600
Ga.....	872	32,443	33,315	21,321,600	Oreg.....	787	13,151	13,938	8,920,320
Idaho.....	213	10,106	10,319	6,604,160	Pa.....	182	16,721	16,903	10,817,920
Ill.....		6,770	6,770	4,332,800	P. R.....		330	330	211,200
Ind.....	341	16,507	16,848	10,782,720	R. I.....		1,085	1,085	694,400
Iowa.....	2,049	40,307	42,356	27,107,840	S. C.....	595	23,394	23,989	15,352,960
Kans.....	569	11,507	12,076	7,728,640	S. Dak.....		8,286	8,286	5,303,040
Ky.....		5,020	5,020	3,212,800	Tenn.....		11,198	11,198	7,166,720
La.....	533	16,236	16,769	10,732,160	Tex.....	1,322	48,736	50,058	32,037,120
Me.....		2,197	2,197	1,406,080	Utah.....		2,419	2,419	1,548,160
Md.....	522	11,704	12,226	7,824,640	Vt.....		1,175	1,175	752,000
Mass.....	321	7,283	7,604	4,866,560	Va.....	302	9,770	10,072	6,446,080
Mich.....	2,605	19,953	22,558	14,437,120	Wash.....		10,752	10,752	6,881,280
Minn.....	363	8,600	8,963	5,736,320	W. Va.....	317	20,213	20,530	13,139,200
Miss.....	113	29,026	29,139	18,648,960	Wis.....	1,197	23,825	25,022	16,014,080
Mo.....		37,177	37,177	23,793,280	Wyo.....	359	1,597	1,956	1,251,840
Mont.....	456	882	1,338	856,320					
Nebr.....	2,964	47,294	50,258	32,165,120	Total.....	21,838	731,869	753,707	482,372,480
Nev.....		652	652	417,280					

## RECONNAISSANCE

Alaska.....		31,915	31,915	20,425,600	Ohio.....		41,420	41,420	26,508,800
Ark.-Mo.....		53,000	53,000	37,120,000	Pa.....		41,405	41,405	26,499,200
Calif.....		32,135	32,135	20,566,400	S. Dak.....		41,400	41,400	26,496,000
Kans.....		39,960	39,960	25,574,400	Tex.....	16,920	135,935	152,855	97,827,200
Mich.....		1,322	1,322	846,080	Wash.....		16,540	16,540	10,585,600
Minn.....		1,923	1,923	1,230,720	Wis.....		14,425	14,425	9,232,000
Mont.....	665	31,254	31,919	20,428,160					
Nebr.....		53,064	53,064	33,960,960	Total.....	17,585	579,938	597,523	382,414,720
N. Dak.....		39,240	39,240	25,113,600					

## SOIL-FERTILITY INVESTIGATIONS

Using the soil survey as the basis, the division of soil fertility is engaged in determining the fertilizer requirements of the different soils and the application of these results to different crops and cropping systems. In addition to the work in the ordinary commercial fertilizers and mixtures, new carriers of plant-food materials from various sources are tested, both in the field and in the laboratory.

During the past year there have been placed upon the market from abroad a great number of new materials about which there is insufficient information concerning their effect upon crop plants under North American conditions. The fertilizer industry, State experimental stations, farmers' organizations, and farmers themselves are pressing for authentic

information, which can be secured only by means of well-controlled experimental work conducted under local field conditions. It is essential that the different fertilizer materials be studied not only from the viewpoint of increased yields but also as to their effect upon keeping qualities, color of fruit, and other characteristics.

## SOIL-CHEMISTRY INVESTIGATIONS

Under the agricultural appropriations act the chemical laboratory is charged with the duty of making investigations of the soil with reference to their chemical composition and mineral content, and of studying the chemical properties of soils in their relation to soil formation, texture, and productivity. In addition to the large number of routine analyses made in connection with the samples collected by



the soil survey, this laboratory is devoting considerable time to a study of the exceedingly fine particles, known collectively as soil colloids. Studies dealing with this colloidal material have shown that laboratory examinations of soils can be used for predicting how they will behave under given cropping systems and in certain engineering projects, such as road building.

The results of the large number of examinations that have been made for individual farmers and for other branches of the Government service have been used in the prosecution of land frauds, in detecting localities where concrete tile would disintegrate, in determining the causes of crop failures, and in judging the adaptability of soils to certain crops and their probable response to cultural treatments.

It is quite important that both these lines of work should be enlarged if the soil divisions of the bureau are to function most efficiently. More samples should be analyzed for soil-survey work than is possible with existing facilities, and the work on other projects could be considerably advanced if it were possible to carry on more chemical work. Also, there should be a substantial increase in the investigations of soil chemistry. Studies of the fundamental nature of soil constituents and soil processes are needed, and improved methods of soil examination must be devised if practical problems, such as soil erosion, are to be solved. The recent studies of the colloidal soil material demonstrate this. This bureau is the only governmental agency directly concerned with such investigations, and other Federal and State institutions naturally look to the bureau for the latest information.

#### SOIL-PHYSICS INVESTIGATIONS

Closely correlated with the chemical work, the soil-physics laboratory conducts investigations of the important physical properties of the soil, such as moisture relations, aeration, heat absorption, texture, and the physical effects of different amounts and proportions of colloidal material. Knowledge gained in this work of the physical properties of soils and the methods for their measurements is essential to their classification and agricultural utilization and is useful for such purposes as the construction of roads, dams, levees, and general engineering projects.

During the present fiscal year mechanical analyses have been made for the Bureaus of Public Roads, Plant Industry, and Entomology, and the Forest Service, as well as for experiment stations, universities, engineers, and agronomists. Experimental work on new methods has also been in progress, and determinations have been made of moisture equivalent, wilting coefficient, soluble salts, volume weight, and Atterberg plasticity constants. Studies are being made of soils having varying susceptibilities to erosion, in an effort to determine what relationships exist between erosivity and other physical properties of soils. Through cooperation of the Navy Department and the Fixed Nitrogen Laboratory of this bureau, a Wood & Loomis supersonic oscillator is being installed at the American University laboratory. This apparatus will be used by the divisions of fertilizer investigations, soil chemistry, and soil physics. Studies will be made on the effect of high-frequency, high-intensity sound waves on the dispersity of soil material. It is anticipated that this will be used to isolate soil colloids for further chemical and physical investigations. There is urgent need for an increased amount of research work in this laboratory. Soil physics is now the weakest link in the chain of soil research not only in the Department of Agriculture but in the State experiment stations as well.

#### SOIL MICROBIOLOGY

The division of microbiology is devoted to a study of the soil population, which includes such microscopic forms as bacteria and the larger organisms, such as fungi and molds. In addition to these fundamental studies the laboratory distributes legume bacteria cultures, for experimental and demonstration purposes, through the Extension Service and in cooperation with the State experiment stations. During the past year about 25,000 cultures were sent out at the request of Congressmen, county agents, farmers, and investigators located in all parts of the United States. In the emergency situation created by the recent overflowing of lands in the lower Mississippi Valley this laboratory is assisting in the re-establishment of the legume crops by supplying the proper bacteria to the county agents in the flooded areas. In addition to this distribution service, an annual inspection of the several brands of commercial bacterial cultures sold in the United States is made,



in order to protect the farmer and others against unscrupulous dealers and manufacturers.

Since the inclusion of this work in the Bureau of Chemistry and Soils there have been tested, or are in the process of being tested, 31 brands of commercial inoculating materials and 15 types of material from agricultural institutions. Legume bacteria culture tests are usually made in duplicate on five strains of each brand of cultures, including, as a rule, nodule bacteria from alfalfa, red clover, cowpeas, soy beans, and vetch, and legumes related to these from a nodule-producing standpoint. On the average, about eight units are obtained in each official sample. Each unit is homogenized, diluted, and plated to determine the numbers of legume nodule bacteria present and the extent of contamination, if any. Part of the material from each unit is used in treating seed to determine whether the organisms contained in it are efficient from a nodule-producing standpoint. This requires that sterilized seed, and sterilized media in bottles be prepared, inoculated, placed in the greenhouse, and after about two months' growth be examined for the production of nodules. Some field work is done in connection with the testing of certain strains of legume bacteria cultures.

The information obtained from these tests is given to authorized persons in agricultural institutions when requested and is given to the public in the form of an annually revised sheet showing a list of sources from which inoculating material may be obtained.

In the case of biological fertilizers which include sulphur, peat, and other inoculated preparations which appear on and disappear from the market from time to time, claims are usually made on the basis of the organisms they are purported to contain, and special tests are used to determine the efficiency of the organisms in comparison with those in fairly fertile soil. It is significant that in all these tests made on various products of this type the organisms of fertile soil have proved superior to those in cultures. When conditions warrant, information obtained in these tests is made available in periodicals or to county agents in the regions in which the material is being sold.

A study is being made of the relationship of carbohydrate to nodule formation and nitrogen fixation by legumes. This study has for its aim the determination of the operation of at least one of the fundamental factors

concerned in the important economic process of nitrogen fixation by legumes. It has been found already that by limiting the light or the leaf surface, nodule formation can be modified.

#### MUCK AND PEAT INVESTIGATIONS

Peat-land and muck-land investigations were inaugurated in the Bureau of Plant Industry in 1915 with a preliminary survey of some of the fundamental differences between peat and muck. With the advancement of our knowledge of the botanical composition of plant remains and of the stratigraphic features of peat areas, it has been possible to adopt more refined methods of study and classification of this important agricultural resource. Since the transfer of this work to the Bureau of Chemistry and Soils, steps have been taken to enlist the cooperation of the States in the working out of a comprehensive national plan for peat-land utilization.

The work now in progress includes the mapping of local and regional areas of peat; studies of the character of the surface vegetation; profile soundings to determine the nature of the vegetation of former periods that has contributed to the present formation; laboratory studies of botanical, chemical, and physical characteristics of samples from typical areas in different geographic regions; and finally the establishment of cooperation with the States with a view to coordinating the work of inquiry and research on a broad national basis.

#### SOIL EROSION

Continued observations and additional information collected during the past year serve to confirm our previous convictions that both hillside and sheet erosion are a serious menace and among the most active factors in the deterioration of farm lands.

The insidious processes of soil erosion have not been confined to the boundaries of the older Eastern States but have extended over the rolling parts of the fertile prairie States. Probably not less than 10,000,000 acres of land formerly cultivated has had its productive capacity permanently impaired by rainwash. Much of this land could have been saved by timely terracing and judicious cropping.

The bureau recognizes the immediate need for fundamental data relating to the factors concerned in soil erosion and is taking steps to collect information upon which to make recommendations looking to an effec-



tive control of this menace. An evaluation of all soil surveys is being made in order to gain a better conception of the distribution and the extent of all the more vulnerable soil types and to secure an inventory of the areas that are better suited to forestry or grazing than to the production of farm crops. In this work the cooperation of the States is being sought, with a view to establishing local experimental fields upon which to study the relative erosivity of different soil types, the effectiveness of different methods of terracing, and the extent to which cropping systems may be employed to minimize the destructive effects of rainwash.

In this connection studies are being made of a number of samples of easily eroded soils to determine what physical difference, if any, exists between these soils which readily erode and those which do not easily wash or gully. It is hoped that the results of these tests will furnish important information to the agricultural engineer in his attempts to plan erosion controls suited to particular fields, slopes, and localities.

### FERTILIZER AND FIXED NITROGEN INVESTIGATIONS

F. G. COTRELL, *Chief*

The growing appreciation of the essential nature of fertilizers in agriculture, as agents for conserving soil fertility and increasing farm profits by effecting the reduction of acreage cultivated and the increase of yields per acre and per man power, demands an increasing fund of fundamental data with which to proceed to the enlargement of domestic supplies of fertilizer ingredients and the termination of dependence on foreign sources. This enlargement of domestic supplies of fertilizers can be accomplished through the more efficient utilization of domestic raw materials, the development of new compounds, and the transformation of old compounds into more useful forms, all with improved technology and economy. The impending transition of the fertilizer industry to a chemical basis, as illustrated by domestic and particularly foreign changes, implies an obligation that modern chemical science be placed at the service of the industry to anticipate demands for fundamental technical data on a wide range of pertinent subjects.

### AMMONIA SYNTHESIS

Since the fixation of atmospheric nitrogen by the chemical combination of nitrogen and hydrogen under high pressures and in contact with catalytic agents remains the keynote in modern fertilizer developments, that field of research has been continued and somewhat broadened. During the year progress has been made in ammonia synthesis through a study of the mechanism of catalysis, to which have been applied chemical, physical, and mathematical methods. The molecular arrangement of catalyst surfaces, as revealed by X-ray methods, and their electrical properties have sufficient bearing on the chemical reactions induced by catalytic agents to warrant more intensive research with these methods. Catalysts of greatly increased efficiency in the production of hydrogen from water gas and steam have been developed and their commercial value indicated. The purification of hydrogen from carbon monoxide by catalytic oxidation has been compared with purification by established methods. The behavior of iron catalysts in ammonia synthesis has been further studied under varying conditions, as determined by the temperature, pressure, composition, and impurities of the gas mixtures employed. Special attention has been given to the mechanism of the action of two types of iron catalysts for ammonia synthesis, of cobalt catalysts for the production of hydrogen from water gas, of copper-oxide and manganese-dioxide mixtures for the separation of carbon monoxide from hydrogen by selective oxidation, of cobalt or nickel catalysts in the production of hydrogen from methane and steam, and of catalyst poisons in ammonia synthesis at high pressures. The characteristics of the nitrogen atom, as revealed by nitrogen linkage in azo and diazo compounds and by band or molecular spectra, are being studied.

### NITROGEN FIXATION BY ORGANISMS

To gain additional information on the nitrogen fixation processes taking place in nature through the instrumentality of organisms, studies have been continued with symbiotic and non-symbiotic nitrogen-fixing bacteria. Since it has now been shown that *Bacillus radicicola* apparently has little or no power to fix nitrogen in the absence of the host and further that the juices extracted from the host



plant are highly stimulating to the growth of these bacteria, research is being conducted to determine the nature of this stimulant and its function in symbiosis and nitrogen fixation. An effort is being made to determine whether ammonia is the first product of nitrogen fixation by the nonsymbiotic organisms and to determine the function of enzymes in that synthesis.

#### HIGH-PRESSURE STUDIES

Ammonia synthesis, as applied industrially, involves gas pressure so high as to exceed the range over which known data apply. To know the behavior of single and mixed gases at high pressure is essential to correct engineering practice. The determination of the physical constants of gases at high pressures has been continued with a study of the compressibility of hydrogen, nitrogen, and a 3:1 hydrogen-nitrogen mixture at pressures to 1,000 atmospheres and temperatures from 0° to 400° C., and of a 3:1 hydrogen-nitrogen mixture containing ammonia, and of pure carbon monoxide. The solubility in water of a 3:1 hydrogen-nitrogen mixture at 25° C. and at pressures to 1,000 atmospheres has been determined, also the viscosity of compressed gases. The physical properties of compressed nitrogen have been calculated from compressibility data. The engineering involved has included the design, construction, and installation of three compression systems, for the development of gas pressure to 1,500 atmospheres, and auxiliary apparatus and equipment for the study of gases at these pressures and at temperatures to 400° C., including dead-weight and floating piston dial gauges, relief valves, a high-pressure booster compressor, and a carbon-monoxide generating and compressing system.

The deteriorating effect of gases at such pressures on materials of construction is of such fundamental engineering importance that research has been continued to determine the metals and alloys most resistant at a prolonged pressure of 9,000 pounds and a temperature of 300° C.

#### NITROGENOUS FERTILIZER MATERIALS

The transformation of synthetic ammonia into nitrogen compounds of chemical and physical properties best adapted to fertilizer use is a research of fundamental importance which has been continued, special emphasis being placed on urea synthesis, the oxidation of ammonia to nitric acid, and the

absorption of ammonia to form the more desirable salts.

#### UREA

Among the nitrogenous fertilizer compounds none is more highly concentrated than urea, which contains 46 per cent nitrogen. Its synthesis from ammonia and carbon dioxide has potentially great industrial importance. To reduce its manufacturing cost through improving the yield obtainable, the mechanism of the reaction involved has been further studied. A method has been devised for determining the state of combination of water in the converted charge, and the liquid areas have been charted on the triangular diagram by means of melting-point determinations in the three-component system—ammonia, carbon dioxide, and urea. Equilibria which have been determined in the carbamate-ammonia system show that at 150° C. and in the presence of an ammonia excess of 100 per cent, the efficiency of the carbamate-dehydration reaction is increased to 70 per cent as compared with 40 per cent, the maximum formerly obtainable. Definite progress has been made in the further development of a pilot plant for the experimental and demonstrational manufacture of urea. Preliminary operations involving the pumping and measurement of liquid ammonia and liquid carbon dioxide, their introduction into a high-pressure autoclave, and the discharge of the reaction products, have been successfully carried out. A new method has been devised for reducing the hygroscopicity of urea, the present greatest deterrent to its use.

#### NITRATES

The oxidation of ammonia as a source of nitrates has been studied further by comparing the platinum catalyst with cobalt and bismuth, which demonstrated the superiority of platinum on the basis of both efficiency and cost. Apparatus for controlling the explosive oxidation of ammonia with pure oxygen has been successfully developed, providing for the efficient production of liquid nitrogen peroxide, a source of concentrated nitric acid, and nitrogen trioxide, a source of nitrous acid, products of great importance in industrial chemistry, national defense, and agriculture. Equilibria involved in the reaction whereby nitric oxide is absorbed in potassium-chloride solution to form potassium nitrate and hydro-



chloric acid have been studied in both gaseous and liquid systems, from the viewpoint of a continuous process. Further work has been accomplished in improving the methods of preparation of the ammonium phosphates. The chemical and physical properties of these important new fertilizer compounds have been studied.

#### PHOSPHATES

The production of fluorides as a by-product of the phosphate industry has gained importance through the increased use of these compounds as insecticides. A survey has been made of the fluorine content of phosphate rocks to determine the potentialities in this direction. Liquid phosphoric acid remains the most promising of fixing agents for ammonia, as such being in a sense the basis of the concentrated-fertilizer program. Accordingly researches looking to its cheap production have been continued to determine the mechanism of the reactions underlying the reduction of phosphates by carbon, on the one hand, and on the other blast-furnace principles have been applied to determine the effect of such variables as furnace diameter and height, blast temperature, oxygen content of blast, rate of blowing, time, and temperature. Thermal efficiencies and slag characteristics have been measured. Two experimental blast furnaces have been operated, and a third, embodying the developments indicated by the results of the first two, is now under construction. Substantial progress, it is felt, is being made toward the solution of the problem of the cheap production of liquid phosphoric acid.

Further progress has been made in the decomposition of phosphate rock by nitric oxide, which shows that a satisfactory absorption of the oxides and decomposition of the rock can be accomplished in one operation with the formation of a product containing both available phosphoric acid and calcium nitrate. The economies thus effected over methods employed in the past lend potential importance to this process and product.

#### POTASH

While the potash imported from Europe shows a decline in tonnage, due to increasing prices it still represents an annual expenditure of \$18,000,000. Rapid progress is being made in the development of the American industry, an increased production of 85 per cent having been registered during the

year. New potash raw materials have been placed under exploitation. Progress has been such as to warrant confidence that present developments will be continued to a point where national independence with respect to this fertilizer essential will be achieved. Present researches are conducted with a view to the concurrent production of side products to cover the costs of the potash extraction, for the prime essential is that potash be cheap. The greensand deposits of New Jersey and Texas continue to be the largest potential sources so far discovered. The by-products afforded in extraction methods so far developed, both from this and other raw materials under study, would tend to make potash recovery an integral part of other industry. Effort accordingly is being made to effect a tie-in with the major industries with a view to greater production. From this viewpoint the experimental blast furnace has been adopted as a means of liberating potash from its ores as an operation incidental to the manufacture of phosphoric acid and other fertilizer products. While the main objective has been agricultural potash in high concentration to reduce transportation costs, the possibility of developing cheap processes for producing other and relatively low-grade products has not been overlooked.

#### CONCENTRATED FERTILIZERS

The present trend in fertilizer manufacture is toward the more concentrated mixtures which make possible substantial reductions in transportation, sacking, and handling costs. These fertilizers, in turn, call for more concentrated ingredients, fertilizer salts in which nitrogen, phosphoric acid, and potash are combined with the minimum of nonfertilizing elements. An essential of mixed fertilizers being their free-flowing and noncaking properties, studies are made of the chemical and physical properties of the new salts, their interaction when mixed, and their behavior in storage and in the fertilizer drill. Granulation and other methods have been devised for improving their drillability and for reducing their hygroscopicity. Studies have been made of commercial drills to determine their adaptability to the accurate distribution of fertilizers demanded by the new, highly concentrated materials. A simplified system for computing fertilizer mixtures from concentrated materials has been completed.



## ANALYTICAL CHEMISTRY

Contributions of general interest have been made in analytical chemistry as applied to the volumetric and gravimetric analysis of phosphates. A new method has been developed for the determination of fluorine in phosphate rock. Service has been rendered the public in the analysis of fertilizer raw materials. Of especial value has been the service rendered by the analytical laboratories to the research units in providing analytical data concerning intermediate and final products.

## ENGINEERING

Essential contributions to the work of the unit have been made through the design, construction, and installation of glass, electrical, and mechanical equipment, some of it of extreme delicacy and intricacy and covering a wide range of applications, from high-pressure compressors on the one extreme to instruments of precision on the other.

## INFORMATION SERVICE

Services have been rendered to outside interests through correspondence and conference on a wide range of pertinent subjects, thus placing the results of research at the service of the public. Information has been supplied to Congress on the Muscle Shoals problem and to other governmental agencies as demands have arisen. Collaborations have been established with other units in this and other departments with a view to the acceleration of the public work.

**PUBLICATIONS OF THE BUREAU OF CHEMISTRY AND SOILS ISSUED DURING THE YEAR JULY 1, 1927, TO JUNE 30, 1928**

## TECHNICAL BULLETINS

No. 1. Tests of Methods for the Commercial Standardization of Raisins.

No. 20. A study of Phylloxera Investigations in California as Related to Types of Soils.

No. 64. Bacteriology and Chemistry of Oysters with Special Reference to Regulatory Control of Production, Handling, and Shipment.

No. 74. The Value of Inert Gas as a Preventive of Dust Explosions in Grinding Equipment.

No. —. The Deterioration of Structural Steels in the Synthesis of Ammonia.

<sup>1</sup> Bureau of Standards Technical Paper, No. 361, of which J. G. Thompson and J. S. Vanick, of the Bureau of Chemistry and Soils, were coauthors with W. W. de Sveshnikoff of the Bureau of Standards.

## DEPARTMENT BULLETINS

No. 1373. Dust Control in Grain Elevators (a revision).

## DEPARTMENT CIRCULARS

No. 7. An Apparatus for the Rapid Vaporization of Carbon Bisulphide.

No. 33. Soil Erosion a National Menace.

No. 35. The Commercial Production of Sauerkraut.

No. 419. Grouping of Soils on the Basis of Mechanical Analysis.

No. 423. The Use of the Electrolytic Bridge for Determining Soluble Salts.

## JOURNAL OF AGRICULTURAL RESEARCH ARTICLES

Variation of the Colloidal Material in Typical Areas of the Leonardtown Silt Loam.

An Observed Case of Spontaneous Combustion in Farm Products.

Effect of Hydrogen-Ion Concentration on the Absorption of Phosphorus and Potassium by Wheat Seedlings.

## SOIL SURVEYS

Burt County, Nebr.

Douglas County, S. Dak.

Genesee County, N. Y.

Grant County, S. Dak.

Worcester County, Mass.

Gilroy Area, Calif.

Polk County, Oreg.

Monroe County, Ind.

Hollister Area, Calif.

Appanoose County, Iowa.

Clermont County, Ohio.

Perry County, Miss.

Green Lake County, Wis.

Fulton County, Ohio.

Yadkin County, N. C.

Plymouth County, Iowa.

Lawrence County, Ind.

## FARMERS' BULLETIN

No. 921. Liming of Soils (a revision).

## YEARBOOK ARTICLES

Soil Bacteria of Two Main Groups Fix Air Nitrogen.

Potash Industry is Progressing Despite Foreign Competition.

Fertilizer's Utility Much Affected by its Mechanical Condition.

Phosphoric Acid of Higher Concentration got by New Methods.

Nitrogen from the Air Fixed as Plant Food Mainly by Bacteria.

Sugar-Cane Cream a New Product of Commercial Value.

Soil Erosion Takes \$200,000,000 Yearly from United States Farmers.

Citrus By-product Plants Cut Waste and Sustain Prices.

Footwear Made Water Repellent by Various Modes of Treatment.

Soils as Well as Plants React to Fertilizers Used.

Beets Given Phosphate Make Larger Yields and Have More Sugar.

Tung-Oil Tree Does Best in Southeast Coastal Regions.

Oysters Are High in Food Value; Vitamin Content Exceptional.

Peanuts a Valuable Food for Man and Feed for Livestock.

Fruit Flavors Due Principally to Free and Volatile Acids.

Soil Moisture is an Important Factor in the Tillage of Land.

Lignin Experiments Show Some Uses for Many Farm By-products.

Fire Loss on Farms, \$150,000,000 Property and 3,500 Lives a Year.



Turpentine Distilling by New Steam Still has Many Advantages.

Chemists in Front Ranks in Warfare on Harmful Insects.

Manganese, Needed by Plants, is Deficient in Some Soil Types.

Chemists Explore Ways to Utilize By-products Now Called Farm Wastes.

Soil Acidity Helps some Plants; Others Require Alkalinity.

Wheat Protein is Increased by Using Nitrate at Heading.

Chemist's Field in Agriculture almost limitless in Scope.

#### MISCELLANEOUS

Review of United States Patents Relating to Pest Control, from April, 1927, to April, 1928, inclusive.

One hundred and sixty-five articles in trade and scientific journals.







