Proceedings

of the

North Dakota Academy of Science

Volume I — Grand Forks, North Dakota — 1948

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NORTH ACADEMY OF SCIENCE

Minutes of the Thirty-Ninth Annual Meeting
University of North Dakota, May 2 and 3, 1947

Friday, May 2, 1947

Assembly was called to order by President A. M. Cooley at 9:30 a. m., in Room 18, Merrifield hall, on the University campus.

After brief words of welcome to visiting members and guests, he introduced the program of papers. All papers scheduled for the morning session were presented and briefly discussed. Attendance at this session was about fifty.

Because of heavy student enrollment, and the meetings of other organizations on the campus, the Academy luncheon was held at 1 p. m. at the University Commons, with visiting members as guests of the University, and local members lunching with their guests.

The Academy reconvened at 2:00 p. m., in Room 18, Merrifield hall. After brief announcements and committee appointments, and the introduction of the distinguished dinner guest speaker, Dr. Herbert Hunter, of Cambridge, England, who attended the session, the program of papers was resumed. All papers scheduled for this session were presented and briefly discussed, except one by D. Q. Posin, who was absent. The Academy adjourned at 4:45 p. m.

At 6:30 p. m., Friday evening, the informal dinner of the Academy was held at the University Commons, sponsored by the local chapter of Sigma Xi.

President A. M. Cooley called upon Dean H. L. Walster, of the Agricultural College to introduce the guest speaker. Dr. Walster responded in a very happy manner, recounting the outstanding accomplishments of Dr. Herbert Hunter in the special field of plant breeding, and especially his improvement of barley culture in Great Britain.

Dr. Hunter received the Doctor of Science degree from the University of Leeds, and the honorary degree of M. A. from the University of Cambridge where he was for a time a member of the faculty. He is a recognized specialist in genetics, and in addition to his many scientific papers, he has published a book on barley, and he is the senior author of the work on "Recent Advances in Agricultural Plant Breeding."

His early researches were conducted at Dublin. Later, for several years he served as Director of the Plant Breeding Institute of the School of Agriculture of the University of Cambridge. During the war he served as Director of the British National Institute of Agricultural Botany.

Dr. Hunter spoke on "Malting Barley in Great Britain." His audience was much impressed with his charming personality, scholarly dignity, genial manner, and his clear, simple diction. He modestly recounted important developments, which his hearers well knew were made possible only by his own personal contributions.

About seventy-five members and guests attended the dinner.

Saturday, May 3, 1947

The Academy reconvened at 9:15 a. m., in Merrifield hall, President Cooley presiding. The remaining papers scheduled were read and discussed. After a five minute recess, the Acadmy reassembled for the business session.

The minutes of the previous Annual Meeting, at the Agricultural College, were read by the Secretary, and approved.

The report of the Treasurer was presented, and accepted on motion of Rae H. Harris, second G. C. Wheeler. The Secretary was instructed to send a telegram of greeting to Dr. W. B. Thomas, a charter member of the Academy who was seriously ill in a hospital at Chicago.

President Cooley announced that for the first time in its history, the Academy would be able to publish its proceedings with funds furnished jointly by the University and the Agricultural College. Upon motion of Rae H. Harris, second, R. E. Dunbar, the Academy voted to accept the offer and proceed to publish its Proceedings. President Cooley appointed a Committee on Publication, consisting of: Wilson M. Laird, chairman; Rae H. Harris, R. E. Dunbar, and G. A. Abbott.

Dr. Rae H. Harris was requested to prepare memorial tribute to the late Dr. C. B. Waldron, a charter member of the Academy, and one of the key men active in its organization. This memorial is as follows:

"March 6, 1947, marked the passing of one of North Dakota's outstanding men. He was Dr. C. B. Waldron, faculty member of the North Dakota Agricultural College since 1890, and civic leader in Fargo for many years, as well as a charter member of the North Dakota Academy of Science. The Academy's first meeting took place in 1908, at Valley City, with Dean M. A. Brannon, H. L. Bolley, Lynn B. McMullen, and C. B. Waldron attending.

"Dr. Claire Bailey Waldron was born in Ravenna, Ohio, on December 6, 1863. He spent his boyhood days on a Michigan farm and attended high school in Ionia, Michigan. On 1887 he received his degree of Bachelor of Science from the Michigan Agricultural College, where he remained as assistant under Dr. W. J. Beal. In 1890 he came to North Dakota to complete a botanical survey of the state and accept a position as the first instructor on the staff of the Agricultural College.

"The campus at North Dakota Agricultural College was landscaped under his guidance; he actually saw this school to which he devoted most of his life, grow from a barren prairie to one of Fargo's scenic spots. Dr. Waldron served 35 years on the Fargo Park Board, and the city's parks and other spots of beauty, as well as those in many other places throughout the state, are an everlasting memorial to him. He laid out the grounds for the Minot State Teachers College, the Institution for the Feeble Minded at Grafton, the School for the Blind at Bathgate, the School for the Deaf at Devils Lake, and the Normal and Industrial School at Ellendale, the State Park at Abercrombie, and many individual city parks.

"In 1904 he was a member of the jury awards committee at the St. Louis World's Fair, and was also chairman of that committee during the Exposition at Portland, Oregon.

"He served as chairman of the State Agricultural Committee of the Tri-State Grain and Stock Growers Association, as president of that group, head of the North Dakota Conservation Committee, and president of the North Dakota Academy of Science.

"The state has suffered a severe loss in the death of C. B. Waldron, who was a fine scholar, and whose life was devoted to the agricultural and cultural welfare of North Dakota."

Signed:

Rae H. Harris

The report of the committee on resolutions, consisting of C. I. Nelson, chairman; E. D. Coon, and H. L. Walster, was received and adopted.

The committee on nominations, consisting of G. C. Wheeler, chairman; J. H. Seymour, and R. E. Dunbar presented the following nominations for officers for the ensuing year. They were unanimously elected.

President—Dr. Rae H. Harris, Cereal Technologist, Agricultural College.

Vice President—Dr. R. B. Witmer, Professor of Physics, University.

Secretary-Treasurer—Dr. G. A. Abbott, Professor of Chemistry, University.

Additional members of the Executive Committee—W. Van Heuvelen, State Public Health Laboratory, Bismarck; H. E. Murphy, Professor of Chemistry, State Teachers College, Dickinson.

The Academy adjourned to hold its next Annual Meeting at the Agricultural College.

A. M. Cooley, President
G. A. Abbott, Secretary-Treasurer

NORTH DAKOTA ACADEMY OF SCIENCE

Roster of Active Members, April, 1947

1. Abbott, G. A. (Chemistry) University, Grand Forks.
2. Addicott, Harold B. (Geography) State Teachers College, Mayville.
3. Aldrich, Vernice (Geography) Grand Forks.
4. Anderson, E. X. (Chemistry) University, Grand Forks.
5. Arnason, A. F. (Forestry) Commissioner, State Board of Higher Education, Bismarck.
6. Beck, Lyle (Dairying) Agricultural College, 1946.
7. Bolley, H. L. (Plant Breeding) Agricultural College. Charter Member.
8. Bolin, D. W. (Nutrition) Agricultural College. 1946.
9. Boudyne, M. R. (Chemistry) Agricultural College. 1946.
10. Bryant, Clarence (Public Service Commission) Bismarck. 1946.
11. Brandeis, Gordon (Agr. Research) Flaat Farms Co., Grand Forks.

12. Brezden, William (Chemistry) State Mill and Elevator, Grand Forks.
13. Brinsmade, J. C. (Exp. Station) Mandan.
14. Burr, Alexander C. (Chemical Engineering) State Research Foundation, Bismarck.
15. Christensen, F. W. (Animal Nutrition) Agricultural College.
16. Cooley, A. M. (Chemical Engineering) University. 1938.
17. Coon, Ernest D. (Chemistry) University.
18. Davis, Joe (Biology) State Wild Life Administration, Bismarck. 1938.
19. Dunbar, Ralph E. (Chemistry) Agricultural College.
20. Dunlap, W. A. (Public Health) Asst. Director State Public Health Labs., Bismarck. 1946.
21. Eveleth, D. F. (Bacteriology) Agricultural College.
22. French, H. E. (Medicine) University.
23. French, Leslie A. (Engineering) State Highway Dept., Bismarck. 1943.
24. Fox, Adrian (Soil Conservation) Park River.
25. Gillette, John M. (Rural Sociology) University.
26. Goldsby, Alice (Biology) Agricultural College. 1946.
27. Grimes, Ruby (Mathematics) Agricultural College. 1946.
28. Gustafson, Ben G. (Chemistry) University.
29. Hagen, Irven (State Seed Dept.) Agricultural College. 1946.
30. Hankenson, Kermit (Mathematics) Agricultural College. 1946.
31. Hanning, Irene (Mathematics) State Research Foundation, Bismarck. 1943.
32. Hardaway, Elliott (Library) Agricultural College. 1946.
33. Harrington, L. C. (Engineering) University.
34. Harris, Rae H. (Cereal Technology) Agricultural College.
35. Hart, A. B. (Chemistry) Jamestown Collgee, Jamestown.
36. Hayman, W. J. (Plant Pathology) Agricultural College. 1946.
37. Helgeson, E. H. (Botany) Agricultural College.
38. Hemphill, Perry V. (Agr. Extension) Agricultural College.
39. Henderson, Donald (Physics) University. 1945.
40. Hill, Glenn A. (Mathematics) Agricultural College. 1946.
41. Hundley, John L. (Physics) University.
42. Hurst, H. J. (Physics) State School of Forestry, Bottineau. 1945.
43. Jensen O. (Dairy Husbandry) Agricultural College.
44. Jesperson, Ethel (Cereal Technology) Agricultural College. 1946.
45. Johanson, J. F. (Social Science) Carrington High School, Carrington.
46. Johnson, Madelyn (Cereal Technology) Agricultural College. 1945.
47. Kelley, Eunice (Nutrition) Agricultural College. 1943.
48. Kirk, H. H. (Biology) Supt. Schools, Fargo. 1938.
49. Kjerstad, C. L. (Psychology) University.
50. Knight, G. N. (Biology) Jamestown College, Jamestown.
51. Koons, Melvin E. (Public Health Lab.) University. 1943.

52. Koth, Arthur W. (Chemical Engineering) University.
53. Laird, Wilson M. (Geology) University. 1941.
54. Larson, Kermit (Chemistry) State Mill and Elevator, Grand Forks. Absent from State. Grad. Student, U. of California) 1943.
55. Lauster, K. C. (State Health Dept.) Bismarck.
56. Longwell, J. H. (Animal Husbandry) President, Agricultural College.
57. Loomis, Fred (Cereal Chemistry) Loomis Laboratories, Grand Forks.
58. Lundy, Dr. John L. (Anesthesiology) Mayo Clinic, Rochester, Minn. 1938.
59. Mason, Sewell (Mathematics) University. 1946.
60. Mattson, Harold (Horticulture) Agricultural College.
61. Miller, Cap E. (Agriculture) Agricultural College.
62. Moberg, Wenzel (Agriculture) Agricultural College. 1943.
63. Moomaw, Leroy (Exp. Station) Dickinson.
64. Moran, Walter H. (Chemistry) University. 1927.
65. Murphy, H. E. (Chemistry) State Teachers College, Dickinson.
66. Oehler, Mrs. Alma (Nutrition) State Mill and Elevator, Grand Forks. 1945.
67. Opton, Edward (Physiology) Agricultural College. 1946.
68. Osgood, H. S. (Chemistry) Agricultural College. 1946.
69. Prommersberg, W. J. (Social Science) Agricultural College. 1938.
70. Peterson, Hjalmer (Chemistry) Agricultural Supply Co., Grand Forks. 1946.
71. Prommersberg, W. J. (Social Science) Carrington High School, Carrington.
72. Redman, Kenneth (Pharmacy) Agricultural College. 1943.
73. Reid, Russell (Natural Science) State Historical Society, Bismarck.
74. Reierson, W. T. (Biology) State Normal and Industrial School, Ellendale.
75. Riley, K. W. (Chemistry) City Chemist, Grand Forks.
76. Robertson, Miss Ina G. (Geography) State Teachers College, Valley City.
77. Rhodes, L. D. (Physical Science) State Teachers College, Valley City.
78. Rognlie, Phillip (Mathematics) University. 1946.
79. Rue, Miss Julia (Geography) State Teachers College, Minot.
80. Saiki, Arthur K. (Pathology) University.
81. Samuelson, Theodore A. (Pharmacy) State Laboratories, Bismarck.
82. Saugstad, Stanley (Entomology) Wild Life Administration, Bismarck.
83. Seymour, J. H. (Biology) State Teachers College, Valley City.
84. Sheppard, Mrs. Adele G. (Chemistry) 1018 Seventh Street North, Fargo.

85. Sheppard, Wyman (Horticulture) East Grand Forks, Minn. 1943.
86. Sinner, Eugene M. (Pharmacy) State Laboratories, Bismarck.
87. Skewes, George (Physical Science) State Teachers College, Mayville.
88. Smith, Glenn (Exp. Station) Agricultural College.
89. Staley, R. C. (Mathematics) University. 1946.
90. Sibbitt, L. D. (Cereal Technology). 1946.
91. Sands, Frederick H. (Chemistry) Agricultural College. 1946.
92. Stevens, O. A. (Botany) Agricultural College.
93. Stoa, Theodore (Agronomy) Agricultural College.
94. Street, Thomas M. (Biology) State School of Forestry, Bottineau.
95. Stewart, Donald L. (Chemistry) American Beet Sugar Co., East Grand Forks, Minn.
96. Sudro, W. F. (Pharmacy) Agricultural College.
97. Svore, Jerome (Sanitary Engineering) State Health Department, Bismarck.
98. Taintor, E. J. (Agriculture) Taintor Seed House, Grand Forks.
99. Telford, C. W. (Psychology) University.
100. Thomas, William B. (Chemistry) Jamestown College, Jamestown.
101. Thompson, Matilda (Mathematics) Agricultural College.
102. Van Heuvelen, W. (Chemistry) State Health Laboratory, Bismarck. 1945.
103. Voedisch, Fred W. (Geology) Grand Forks.
104. Waldron, Louis R. (Agronomy) Agricultural College.
105. Walster, H. L. (Agronomy) Director Exp. Station, Agricultural College.
106. Wardner, Arthur K. (Agr. Chemistry) Flaat Farms Co., Grand Forks. 1938.
107. Whedon, Arthur D. (Zoology) Agricultural College.
108. Wheeler, George C. (Zoology) University.
109. Wiidikas,William (Agronomy) Agricultural College.
110. Winstead, Miss Hulda (Physical Science) State Teachers College, Minot.
111. Witmer, Bonner (Physics) University.
112. Zarling, Miss Lillian (Mathematics) State School of Forestry, Bottineau.
113. Schmidt, Carl (Social Science) Agricultural College.

New Members elected at the Thirty-Ninth Annual Meeting

Banasik, Orville (Cereal Chemistry), Agricultural College.
Bavone, A. L. (Sanitary Engineering), Minot.
Chetrick, M. H. (Chemical Engineering), University.
Clagett, C. O. (Agr. Chemistry), Agricultural College.
Espe, Dwight (Dairy Husbandry), Agricultural College.
Evensen, Harlow (Physics), State School of Forestry, Bottineau.
Fordice, Ira (Chemistry) University.

Freier, Herbert E. (Chemistry) University.
Grossman, Irving (Geology) University.
Hoyman, W. B., Agricultural College.
Johnsgard, Gordon (Soils) Agricultural College.
Kruschwitz, Earl H. (Physics) State Teachers College, Valley City.
Larson, Edith (Biology) University.
Lejuene, A. J. (Agronomy) Agricultural College.
Leraas, Marvin A. (Biology) State Teachers College, Valley City.
McMillan, William (Chemistry) State Research Foundation (working at University).
McKean, William (Animal Biology) Agricultural College.
Miller, C. E. (Pharmacy) Agricultural College.
Nystuen, Peder (Agriculture) Agricultural College
Ovrebo, G. O. (Physics) State Teachers College, Valley City.
Schultz, Frederick (Physics) University.
Steinmeier, L. D. (Chemistry) State School of Forestry, Bottineau.
Treumann, William B. (Chemistry) Agricultural College.
Varland, Robert (Chemistry) University.
Volkerding, Clifford (Soils) Agricultural College.
Wanner, Donald F. (Agr. Economics) Farm Security Administration, Jamestown.
Weeks, Oliver (Bacteriology) Agricultural College.
Winchester, Burl (Animal Husbandry) Agricultural College.
Witz, R. L. (Agr. Engineering) Agricultural College.

THE WATER ANALYSIS PROGRAM OF THE NORTH DAKOTA STATE HEALTH DEPARTMENT LABORATORY

W. Van Heuvelen

The chemical laboratory in the North Dakota State Health Department was reopened in June, 1946. In setting up the work of the laboratory, a program for water analysis was developed with the objective of making the most use of the data obtained.

First, we began to collect data on the supply of water being analyzed. We insist that an information sheet be filled in completely and sent into the laboratory with the sample before the analysis is made. The upper half of the information sheet requests data as to the exact location, type of supply, capacity, and the water-bearing strata. The information obtained is filed with the analysis in the sanitary engineering division in the State Health Department and in time will provide our department, or anyone who wishes such data, a better picture of North Dakota ground water supplies.

The lower half of the information sheet calls for data as to the nature of the water and the reason for the analysis. This is used as a time saving device by pointing to the constituents in the water that will need special attention. Also from the answers to these questions and the analysis, data will be obtained on the concentration where various ions become objectionable. Our data is limited due to the fact that we have been collecting information for ten months on samples of which less than five per cent have some objectionable ion present. The tentative results to date point to the following values:

Alkalinity of 800 ppm or over gives water a flat taste.

Sulfate of 800 ppm with high calcium and magnesium shows laxative effects.

Sulfate of 1000 ppm shows laxative effects regardless of cation present.

Chlorides of over 250 ppm give water a salty taste.

Sulfates of over 2000 ppm give water a salty taste.

Copper of 3 ppm or over give water a bitter taste.

In interpreting the results of the analyses as the second part of our program, some method was needed to express the results so that the layman and one not familiar with the terms part per million could derive some value from the report. The widely accepted Treasury Standards cannot be applied successfully to the highly mineralized North Dakota water. We find that the average sulfate, chloride, and total solids content of 509 North Dakota water supplies published in Bulletin No. 11 by the North Dakota Geological Survey with G. A. Abbott and F. W. Voedisch as authors all exceed the limits set by the Treasury Standards. If the Treasury Standards were used as a basis for interpreting results of analyses and grading waters, most North Dakota well water would be classified as chemically unfit for human use, which is obviously not the case.

To establish a grading system the analyses of 68 municipal wells from every part of the state were taken and the values for each constituent were arranged in their increasing order. From the distribution each set of values was divided into six areas. The area above and below the numerical average was labeled as average. Those values below average were divided into three groups: satisfactory, fairly low, and low, according to the distribution. The area above average was divided into two divisions labeled high and very high. The lower limit of the very high classification was set at a point where it appeared that water containing this amount of the named component would be unsatisfactory for domestic use. The scale gives us a yardstick for interpreting our analysis.

For the grading of irrigation waters the standards are taken from circular No. 707, United States Department of Agriculture, published in 1944. The water is graded on total salt content and the per cent of sodium ion in terms of the total cation concentration.

Standards for irrigation waters from Circular No. 707

		Total salt content	Sodium
Class 1	Excellent to good	700 ppm.	60%
Class 2	Good to injurious	700-2000 ppm.	60-75%
Class 3	Injurious to unsatisfactory	2000 ppm. and over	75%

The third portion of our program, that of developing and adopting shorter methods of analysis is still in the formative stage. We hope to have at a future date some information to present along this line. The procedures used by our laboratory are taken from "Standard Methods for the Examination of Water and Sewage." We are using colorimetric methods where feasible to speed up our work.

REGIONALISM: A NAME OR MEASUREABLE REALITY?

J. M. Gillette

This discussion treats these statements in their order.

1. Prediction is taken as the criterion of scientific objectivity, the social sciences being deficient here, because of their dependence on only the probability resident in averages and trends.

2. Regionalism is a highly contingent concept, exact prediction from environmental cultural behaviour factors being impossible.

3. Geo-cultural regionalism would hold that the collective behaviour of a region is the result of the natural fiats of physical environment. Our interest centers on it.

4. Social evolution discounts the scientific truth of regionalism because culture so increasingly intervenes between man and nature that the direct force of fiats of nature decrease with cultural development and stand in inverse ratio to it.

5. Culture tends to be self-determining in higher culture levels because of a body of tastes, attitudes, conventionalities, institutions which may disregard fiats of nature.

6. Regionalism has been largely territorial allusion and subjective illusion, because it cannot read from natural fiats through to cultural results in any accurate cause and effect way.

7. Crop response is a fit testing ground for regionalism because crop-response belts are often coextensive with region and because the nexus between nature antecedents and supposed cultural results stand as a simplex. Tests have been made in three crop-response belts: Cotton, corn, and wheat.

8. The nexus between nature and crop-response behaviour is obfuscated or clouded by at least three factors. (1) The complex nature of crop and crop response due to a mingling of nature and culture, since crops and crop-response are man-made things. (2) The uncertainty of degree of dominancy of a dominant crop in crop-response belt. (3) The vagueness of crop-belt intensity and boundary due to overlapping of crops and shading of one into the other.

9. The predictive weight of natural fiats such as precipitation and temperature in crop-response belts was tested by means of number index and correlation regarding such crop-response results as yield, proportionate acreage, and proportionate crop income, as well as regarding such cultural factors as size of family, educational index, per cent of urbanism, per capita income and so on. No certain and accurate forecasting was possible in any case.

10. The northern section of the Great Plains, appearing to be "a natural," regionally, has been intensively studied for symptoms of ability to predict both natural and cultural phenomena, with only significant negative results. Over twenty factors condition state wheat income, many of the physical environment ones being indeterminable, and the cultural ones ranging from state to national and international. No one can determine what next year's wheat crop or income is to be.

11. Location within the continent is a factor, at first seemingly a fiat of nature, and then dissolving into largely a cultural affair. The future economic status of North Dakota can be more nearly guessed from this than from natural resources in themselves.

12. The judgement of certain prominent regionalists that the economic lag of a southern region is due to super-regional freight rate manipulations is scarcely consistent with their regionalism conclusions elsewhere and overlooks the man-made fiats of bi-racialism.

13. Common sense and logic point irrefutably to super-regional influences of nation and world to explain much of collective behaviour which may wear the marks of regionalism.

There is no pronounced regionalism apparent in the distribution of death rate for either general death rate in the United States or for specific mean death rate for greatest man killers such as heart, cancer, tuberculosis, etc. Simple correlation relative to the general rate is not significant. That for three year men for heart and cancer are rendered

insignificant when partial correlation is applied. Those two and others are shown to be more urban than nature fiat matters. Tuberculosis is regional to a large extent, with emphasis on the southern belt. Spot maps show contradictions which destroy significance of natural fiats. Similar climatic states yield divergent rates, while states with widely different climates show similar rates. Compare Maine and New Mexico for mean general rate or Montana and Mississippi, or Mississippi with Florida and Minnesota with Maine. Relative tuberculosis, states with divergent climates like Montana and Oklahoma show similar rates, while states having similar temperatures such as New Mexico and Georgia exhibit divergent rates. Urbanization, migration, age distribution and the like obfuscate fiats of nature.

A REPORT ON INFLUENZA VACCINATION AT THE UNIVERSITY OF NORTH DAKOTA

By John F. Vaughan, M. D.

In the past few years, influenza virus vaccine has been gathering more popularity and widespread usage as a prophylactic measure in the prevention of influenza, more commonly know as "the flu."

HISTORY

Before taking up the subject of this paper, I would like to give a short history of the important events that led to the acceptance of influenza virus vaccine as a valuable addition to preventative medicine.

There are two commonly recognized types of influenza virus: they are type A which was discovered in 1933 and type B which was first described in 1940. These two types characteristically exert their pathogenic effect on the epithelium of the respiratory tract after which the symptons of influenza appear in short order.

In 1936 the first attempt at influenza vaccination was made. The investigators[1] gave intramuscular injections of human and swine influenza virus to the inmates of an Eastern mental hospital and then compared the number of upper respiratory infections that developed with that of a control group of non-vaccinated inmates. They found a decreased incidence of infection in the vaccinated group.

Other investigators[2] demonstrated that the results were just as satisfactory when formalin attenuated virus are used in the vaccine.

Until 1940 only virus type A had been used, but with the discovery of type B, it, too, was added to the vaccine thus making a more effective preparation.

The big step in bringing the vaccine to the public's attention was made during the widespread influenza epidemic of November and December of 1943 and the first few months of 1944, when a military commission[3] investigated the influence of the vaccine on the incidence of clinical influenza in a series of A. S. T. P. units. The results of this investigation proved so favorable that the armed forces immediately

[1] Chenoweth, Waltz, Stokes and Gladen. Amer. Jour. Dis. Child., 52:757-758, 1936.
[2] Taylor and Dreguss. Amer. Jour. Hygiene, 31:31-35, 1940.
[3] Eaton et al. J. A. M. A., 124:982, 1944.

began using the vaccine for mass immunization. This was in turn followed by the adoption of the new agent for use in civilian life, especially by large industries which are almost annually hit hard by an influenza epidemic.

As the fine results continued to be reported, the use and popularity of influenza virus vaccine soon became nationwide, and so, last fall the vaccine was made available at the University dispensary for the first time.

PURPOSE OF PAPER

Earlier this spring, when the campus was swept by an outbreak of influenza which for a time threatened to close the school, I was asked to assist in the dispensary. After things had quieted down somewhat, I began thinking of a plan whereby these almost yearly epidemics might be avoided. In going through the dispensary records it was found that only 150 students, teachers and employees had taken advantage of the fifty cent influenza "shot." It was clear to me that if the morbidity of influenza was to be reduced in the years to come, more persons would have to be vaccinated. To achieve this end I decided to make a survey to demonstrate just how effective influenza virus vaccine was on this campus with the hope that by so-doing we could get a better turn-out when the vaccinations are offered next year.

METHOD OF STUDY

In order to obtain the information that was necessary for this survey, a list of the names of those persons who had been vaccinated was made. To this list was added an equal number of names of persons who had not received the vaccine. The roster of names was then placed on bulletin boards around the campus with the request that the persons whose names were on the list report to the University dispensary. Of the 147 who reported, 74 had been vaccinated and 73 had not. Each student was questioned as to whether or not he had been sick with the flu since the first of the year, and if so, what symptons he had had, etc. From the information gained during the interview, it was decided whether the person had really come down with influenza. Since the cardinal symptons of influenza are fever, general malaise and muscle or joint aching, only those students who had at least the first two symptons were considered positive, or, in other words, to have had the flu.

RESULTS

The findings of this survey were as follows:

Of the 74 persons who had received the vaccine, only 12 gave a positive clinical history of having had influenza—an incidence of 16%. It should be noted here that several of the positives did not come down with the flu until a period of between 3 and 4 months had elapsed since their vaccination; and although the exact duration of immunity is not known, it is generally accepted that the optimal period of efficiency for this vaccine is three months.[4]

In the control group of 73 students and faculty members, 25

[4] Salk et al. Amer. Jour. Hygiene, 42:307, 1945.

gave a positive history for an incidence of 34% or a little over twice that of the protected group.

TABLE I

Control group of non-vaccinated persons who developed influenza

Patient	Fever	General Malaise	Muscle & Joint Complaints	Digestive Upset	Duration of illness in days
1. K. A.	x	x	x	x	9
2. M. A.	x	x			4
3. J. B.	x	x	x		2
4. F. B.	x	x	x		3
5. T. D.	x	x	x	x	3
6. R. E.	x	x	x	x	3
7. S. F.	x	x	x		1
8. J. F.	x	x		x	10
9. W. F.	x	x			3
10. S. F.	x	x			5
11. P. G.	x	x	x		2
12. L. G.	x	x	x		2
13. J. H.	x	x	x		3
14. C. L.	x	x	x		5
15. J. Mc.	x	x			4
16. L. N.	x	x	x		3
17. K. O.	x	x	x	x	2
18. E. P.	x	x	x	x	3
19. M. R.	x	x	x		3
20. F. S.	x	x		x	4
21. W. S.	x	x	x		2
22. A. O.	x	x		x	3
23. R. K.	x	x	x		7
24. E. G.	x	x	x	x	6
25. M. T.	x	x	x		5

TABLE II

Test group of vaccinated persons who developed influenza

Patient	Date of Vaccination	Date of Illness	Malaise & Fever	Muscle or Joint Complaints	Digest Upset	Dur. of Illness in Days
1. J. C.	12/13 - 46	3/26 - 47	x	x	x	4
2. G. D.	12/14 - 46	3/26 - 47	x		x	4
3. D. G.	2/13 - 47	4/ 2 - 47	x		x	2
4. G. H.	1/ 9 - 47	3/27 - 47	x			5
5. R. H.			x			1
6. E. L.	1/17 - 47	4/ 3 - 47	x		x	5
7. M. M.	12/14 - 46	3/21 - 47	x	x		5
8. G. M.	12/16 - 46	3/27 - 47	x	x		3
9. M. N.	1/ 8 - 47	3/31 - 47	x	x		6
10. G. T.	12/13 - 46		x			7
11. S. T.	12/13 - 46	4/ 4 - 47	x	x		7
12. W. G.	1/ 8 - 47	3/19 - 47	x	x	x	3

As can be seen by refering to tables 1. and 2., there was no appreciable difference in the severity or duration of illness in the two groups, although the control group did exhibit a higher percentage of muscle and joint discomfort. The average duration of the infection was four days.

CONCLUSIONS

From the results of this survey, it can be readily seen that influenza virus vaccine is a prophylactic agent worthy of more widespread acceptance. While it does not give 100% protection, it will give a high enough percentage of immunity to be of great value in lowering the number of working days lost and in preventing yearly epidemics.

In my opinion, a very effective vaccination program would be one calling for an injection in October followed by another in January. In this way a high degree of protection would be maintained throughout the influenza season.

I earnestly hope that some such program will be adopted on this campus for the coming year. I am sure the results will prove most gratifying.

FOOD HABITS OF 204 NORTH DAKOTA RED FOXES

William T. McKean

A discussion is given as a progress report on a study of food items found in the digestive tracts to two hundred and four North Dakota red foxes. The purposes of the study are two: first, to observe the nature and extent of predation on both game species and farm animals; and second, to secure more detailed information on fox food habits in order to better manage this fur resource. The method of study was by laboratory analysis of stomach and colonic content and conisted in the identification of the various food items, separation of them and volumetric measurement of each one. Results were expressed as percentages.

Data involved two separate years—1941 and 1946 and three seasons. There were thirty-six fall (1946) stomachs, one hundred and forty-six winter (1941), and twenty-two spring (1946) stomachs.

In all periods, rabbits and rodents were of greatest importance among all food classes taken. They occupied no less than 49 percent (spring) of the diet in any one period and occurred as abundantly as 67 percent (winter). Rabbits were twice as easy to catch in 1941 as in 1946.

At ieast eighteen different kinds of foods have been identified in the foxes, including: rabbits, mice, squirrels; sheep, hogs, foxes; pheasants, prairie chickens, ducks, partridge; poultry; non-game birds; corn, barley, wheat and weeds. Vegetable material present ran very high in the fall of 1946 (15%) but it is probable that much of this was taken incidental to foraging for other things. Most of the cereals however, were believed to have been taken as food.

Carrion of many kinds was an important item and suggested the utility of the fox as a scavenger. It occurred volumetrically as 24%,

16%, and 12% in the fall, winter and spring periods respectively. Predaton on game birds is heaviest during the spring nesting season and when deep snows make rodents hard to obtain.

The information reported upon lacked full seasonal representation and adequate numbers but seems to be following very closely the results obtained in similar studies in many other states.

STANDARIZATION OF COMPOSITION AND QUALITY OF NORTH DAKOTA BUTTER

C. Jensen and L. D. Beck, Department of Dairy Husbandry North Dakota Agricultural Experiment Station

Introduction

Development of the butter industry in North Dakota is of importance in stabilizing agriculture. The cow converts home grown feeds into highly concentrated and valuable food products, thus materially reducing the transportation costs in shipping the products to the markets. By virtue of the cows ability to convert feeds, she also contributes more than other livestock in maintaining soil fertility. During drouth periods and time of low feed prices the cow is called into action in order to increase the market value of home grown feeds.

With increased demand for fluid milk and cream by the urban centers there is a continual shift of producing areas. Fluid milk and cream are highly perishable and since they are consumed mostly in fluid form they command higher prices than cream intended for butter-making. Hence, the butter producing territories must give way to the ever expanding demands for sweet, fluid milk and cream. This type of expansion was very much in evidence during the war years, when government price relationships tended to emphasize milk and de-emphasize butter production. The result was that leading butter producing states like Minnesota and Wisconsin shifted largely to milk production. Thus, the butter producing area was forced to move westward. The time is now at hand when the butter industry is migrating on to the great plains states from Mississippi valley. Therefore, it is anticipated that North Dakota will play an increasingly active role in butter production in the future.

Progressive development of the butter industry in North Dakota is predicated upon the ability to obtain economical production of good quality milk and cream, as well as efficient plant processing and marketing. In order to attain these objectives, standards need be enacted and technological control of the product affected through the facilities of a laboratory. Such clinical diagnosis is especially valuable to the small creameries which are not equipped with adequate laboratory facilities nor personnel to do their own testing. It is also of value to larger plants which have laboratory service available in their organizations, as it affords an additional check on the plant laboratory.

In view of the need of this type of laboratory service to the North Dakota creameries a project entitled "Standardization of Composition

and Quality of North Dakota Creamery Butter" was initiated. The project has now been in operation two years. Sponsorship is shared jointly by the North Dakota Research Foundation, North Dakota Agricultural Experiment Station, North Dakota Agricultural Extension Service and the participating creameries.

Methods

A five pound butter sample obtained from a regular churning is submitted once monthly to the Dairy Department Experiment Station laboratory at North Dakota Agricultural College. The butter is analyzed according to standard methods of analysis as follows: composition, (percentages of fat, water, salt and curd), pH of butter serum (aqueous phase of butter), mold and yeast count per gram, mold mycelia count, and a quantitative and qualitative test for sediment. It is also scored organoleptically and visually for flavor, body and color, as well as for keeping quality, as determined by change in score after one months storage at about 45° Fahrenheit. Recently, bimonthly examination for coli-form, lipolytic and proteolytic bacteria have been included in the analysis, to serve as additional checks on sanitation with respect to plant processing.

On the completion of one month's analysis a combined laboratory report is prepared and sent out to the creameries. Each creamery is identified by an identification number known only to the plant operator and the laboratory personnel. A combined report of this type gives the creamery operator an opportunity to see how his results compare with others on the list without knowing the identity of the plant with which the comparison is made.

Personal visitation of the participating plants is made annually by someone of the experiment station personnel connected with the project and the extension dairyman. The laboratory records pertaining to the plant are then discussed with the operator and helpful suggestions are made with respect to solving the plant problems revealed by the reports.

Results

This paper is a progress report comparing the analytical results of the first with the second year, as presented in Table I. The table is subdivided alphabetically into sections A, B, C, D, E, F, and G.

Section A gives a comparison of the fat tests of butter samples submitted during the first, with those analyzed during the second year. The samples were grouped according to the range of fat tests. The recommended fat test for butter lies within the range of 80.3 to 80.5. When the fat test is below the recommended minimum there is a danger of it being below the legal standard of 80 per cent. When the test is above 80.5 it indicates inefficient operation, since it results in financial loss to the creamery.

Results from section A show no appreciable changes in the percentages of butter samples at the different fat levels. A higher percentage of butter samples were within the recommended fat range during the first year than during the second year. In both years only

about one-fourth of the samples were within the recommended range with respect to fat content. During the second year a smaller percentage of the butter samples were below and a larger percentage above the recommended levels than during the first yar.

Section B gives a comparison of the hydrogen ion concentration of the butter sera (aqueous phase) of samples analyzed during the first year with those submitted for analyses during the second year. The recommended pH range of butter serum ranges from 6.6 to 7.2. Storage defects develop more rapidly in butter with lower or higher pH values.

Results show that a lower percentage of the second year's samples were within the recommended pH range. During the second year fewer samples were at low pH level while more were at a high pH level than in the first year's samples.

Yeast and mold count in butter is regarded as a sanitary index of processing. Adequate pasteurization results in destruction of yeasts and molds in cream. Therefore, excessive counts of these microorganisms in butter would be due to contamination subsequent to pasteurization. According to the standard set up, yeast and mold counts in butter ranging from 1 to 20 per gram is considered good; 21 to 50 fair; 51 to 100 poor and plus 100 very poor.

The data shows definite improvement in yeast and mold counts during the first two years. An appreciable higher percentage of the samples were within the 1 to 20 group in the second than in the first year. Also, there was a definite decrease in the number of samples with counts greater than 100 per gram in corresponding periods.

Mold mycelia count is a record of the dead mold filaments in butter, carried over from the cream. Hence, it reflects the mold content of the cream from which the butter was made. Mold mycelia are counted by a modification of the Howard Cell technique for determination of mold in tomato catsup. The counts are given as the percent of positive field of the fields counted. The maximum mold mycelia permitted according to the standards set up by this project are 20 positive fields. Counts ranging from 0 to 5 per cent positive field are considered very good; from 6 to 10 percent, good; 11 to 20 percent fair and plus 20 percent poor. Federal Food and Drug permits up to 60 percent positive fields.

Data shows considerable improvement in the mold mycelia count of the butter during the second as compared with the first year. It is of interest to note that 80.5 percent of the samples analyzed in 1946-47 contained from 0 to 10 molds per gram, as compared with corresponding values of 66 percent in the 1945-46 period.

Butter quality is ascertained by determination of the flavor and odor. Body, texture, salt and color are also to be considered. The butter was scored when fresh and again, after a storage period of one

TABLE I. COMPARISON OF BUTTER ANALYZED DURING FIRST YEAR WITH SAMPLES TESTED DURING SECOND YEAR

A. Fat tests of Butter.

Year	Total No. Samples	Percentage of butter samples of different fat test values: < 80.0	80-80.25	80.26-80.55	80.56-81.0	> 81.0
1945-46	370	10.4	16.2	27.1	25.5	20.8
1946-47	395	8.1	16.5	24.1	28.7	22.6

B. Hydrogen Ion Concentration of Butter Serum

Year	Percentage of butter samples at different pH levels: < 6.6	6.6-7.2	> 7.2
1945-46	23.6	65.1	11.2
1946-47	19.2	60.0	20.8

C. Yeast and Mold Counts of Butter

Year	Percentage of butter samples with different yeast and mold counts per gram: 1 - 20	21 - 50	51 - 100	> 100
1945-46	35.8	17.9	12.0	31.3
1946-47	50.0	17.0	11.0	23.0

D. Mold Mycelia Counts, Per Cent Positive Fields

Year	Percentage of butter samples with different mold mycelia counts: 0 - 5	6 - 10	11 - 20	> 20
1945-46	44.2	21.8	21.8	12.8
1946-47	60.0	20.5	15.0	4.5

E. Quality Scores of Fresh Butter

Year	Percentage of samples at different score levels: 88 - 89	90 - 91	92 - 93
1945-46	19.2	75.3	5.5
1946-47	18.9	75.4	5.7

F. Quality Scores of Stored Butter; One Month at 45° F.

Year	Percentage of samples at different score levels: 88 - 89	90 - 91	92 - 93
1945-46	36.2	59.4	4.4
1946-47	28.0	70.0	2.0

G. Keeping Quality of Butter One Month at 40-45° F. Indicated by Decline or Increase in Flavor Score

Year	Total No. Samples	Range of change in scores: +2	+1	0	−1	−2	−3
1945-46	369	1.3	8.9	49.6	35.2	4.3	0.8
1946-47	367	0.7	12.8	53.7	27.0	5.5	0.3

NOTE: Arrow pointing left (<) means less than; pointing right (>) greater than.

month by at least three competent butter judges. The majority scores were in most instances regarded as official. According to standard practice of scoring butter, the scores are given numerical ratings based on a score of 100, a possible 100 points for a perfect score. Butter scoring 93 or higher is regarded as a fine product, it cannot possess objectionable flavors or odors. Butter with a score of 92 may have a slight trace of aged fat or be slightly coarse in flavor. Butter scoring from 91 to 90 is characterized by old cream flavors and various other defects, however, these defects must not be pronnounced. The quality of such butter could for the most part be classified as being of fair quality. When butter scores 89-88 it possesses flavor defects in pronounced form. Typical criticisms are staleness, oxidized, tallowy, rancid, fishy, pronounced utensil and others. Comparison of the scores of the fresh butter samples scored during 1946-47 period are compared with those of the previous year.

According to the data showing the percentage of samples at different score levels, it is evident that there was no change in the quality of the butter submitted during the two year period.

Comparison of the scores of the butter submitted for scoring during 1946-47 were made with samples scored during the 1945-46 period. Results are presented in Section F.

Data from section F indicates some improvement in the keeping quality of butter made during the second period (1946-1947) as compared with the first (1945-1946), as demonstrated by 70 percent of the samples showing no change in score during the latter period, in comparison with 59.4 percent of the samples during the first period.

Section G gives results comparing quality of the butter samples submitted during each of the two year periods, on the basis of the points decline or increase in score of the samples.

Data from Section G agrees essentially with that presented in Section F in demonstrating somewhat better keeping quality of the butter made during the second year as compared with those scored in the first year.

In conclusion, it is apparent that some improvement has been made in the efforts to standardize the composition and quality of North Dakota butter. It is also apparent that the laboratory service needs to be followed and supported by considerable educational effort among the North Dakota creamery operators in order to bring about needed standardization.

Not evident from the data presented here, are numerous potential research problems which have been revealed by the routine analytical work in connection with the project. Therein, perhaps lies one of the important values of the standardization project.

LISTERELLOSIS, A DISEASE OF MAN AND ANIMALS

D. F. Eveleth and Alice I. Goldsby

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The organism which is known as Listerella monocytogenes was first described by Murray, Webb, and Swan[5] at Cambridge, England. The second report on this organism was by Pirie[6] from South Africa in 1927. Since that time the organism and the disease have been described in nearly all countries in the world. The species affected have included most of the rodents, chickens, hogs, sheep, goats, cattle, and man. Horses, cats, and dogs have also been experimentally infected.

Listerellosis in North Dakota has as far as we know been confined to sheep flocks. There is a report of an outbreak prior to 1943 in the north west part of North Dakota. It was clinically diagnosed in several flocks of sheep in 1943 and 1944. In 1945 the organism was isolated and identified[7] in sheep from Fargo, North Dakota.

Listerella infections may manifest themselves either as a septicemia or as a meningitis. The common name "circling disease" was chosen because of the frequency with which infected sheep travelled in a circle.

Our interest in this disease has been of a twofold nature. In the first place the incidence of listerellosis is apparently increasing and constitutes an economic loss to the farmers and ranchers and secondly, the fact that listerellosis is also a disease of man, makes it a disease of significance from a public health standpoint.

During the past four years outbreaks of listerellosis have been encountered in the following areas: Hawley, Ada, McIntosh, and Osakis, Minnesota, and Fargo, Buffalo, and Wheatland, North Dakota. One case was submitted in 1944, another in 1945, two cases in 1946 while in the first six months of 1947 six cases were submitted.

The epidemiology of this disease is very interesting. During 1943, 1944, and 1945 cases of listerellosis occured in the sheep flock belonging to the college. There were two apparent recoveries in about sixteen cases. Both of these cases were treated with large and repeated doses of neoprotosil. One case, a lamb was left with a permanent torticollis. No cases were encountered in 1946 or so far in 1947.

In one case the introduction of sheep from a Listerella infected flock to an apparently normal flock has been followed by clinical cases of listerellosis in the previously infected flock.

The sporadic nature of the disease as well as its manifestations either as a meningitis or as an abortion producing disease further increases the difficulties in studying its epidemiology.

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[5] Murray, E. G. C., Webb, R. A., and Swann, M. B. R. 1926. A Disease of Rabbits characterized by a Large Mononuclear Leucocytosis, Caused by a Hitherto Undescribed Bacillus Bacterium Monocytogenes (n. sp.), Jour. Path. and Bact. 29:407-439.

[6] Pirie, J. H. H. 1927, A New Disease of Veld Rodents. "Tiger River Disease." Publ. So. African Inst. Med. Res. 3:163-86.

[7] The authors are indebted to Dr. L. R. Vawter, Reno, Nevada, for identification of the organism.

Treatment and prophylactic vaccination against listerella infections have been disappointing: The sulfonamids have in some cases been of apparent benefit when admisitered at the first sign of symptoms. However, in most cases of field outbreaks, animals showing symptoms have died. We have one exception in which case the ewe showing symptoms of listerellosis was given a purgative dose of epsom salts and eventually recovered. This ewe also exhibited a mild type of torticollis after other clinical symptons had disappeared.

In one outbreak where the morbidity and mortality was about six sheep per day, six sheep were selected and an intra-cerebal injection of penicillin was tried on one sheep, three were given penicillin subcutaneously and two were not treated. Two of those given penicillin subcutaneously recovered.[8]

These data would suggest that penicillin be tried in further investigation on listerellosis.

The danger of listerellosis spreading from sheep to man appears to be most likely in those cases where abortion occurs. The organisms have been isolated from the stomachs of feti, from the amniotic and alloutoic fluids and from the cotyledons. It would appear that the aborted fetus with its membranes would be a logical means of disseminating the listerella organisms. The attendant could easily become infected through the handling of aborted feti.

Summary

Listerellosis in sheep in North Dakota may manifest itself as either a meningitis or by abortions.

The epidemiology is not known.

Preliminary trials indicate that penicillin may be of value in curing cases presenting the early symptons of listerellosis.

Listerella produced abortions may be a factor in disseminating the disease.

IONIZATION BY RADAR WAVES IN AIR

Dr. D. Q. Posin

Studies were made during the war and for six months thereafter on the ionization produced in air by microwaves of 1 to 10 cms. in length. It was found that the intensity of ionization and ultimate sparking were functions of a number of parameters, among them the gap width between "anode" and "cathode," the duration of the microwave pulse running through the waveguide, the frequency at which successive pulses of microwaves followed upon each other, and several other parameters.

An attempt was made to formulate a theory of sparking at the radar frequencies.

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[8] The authors are indebted to Dr. Jo Browne for treating the sheep with penicillin.

SOME ASPECTS OF THE PROBLEM OF CEREAL STARCH SWELLING POWER

Orville Banasik and R. H. Harris

A brief summary of investigations on starch swelling power carried out at the North Dakota Agricultural Experiment Station is followed by a description of an inquiry conducted by the authors into the effect of various electrolytes.

The work falls naturally into two parts; the effect of starch preparation on swelling power, and the effect of electrolytes in the starch cooking solution. Some improvements were also made in the cooking apparatus previously employed.

Variations in the chemical treatment during preparation of the starch had a very marked influence on swelling, NaOH was particularly effective. Chlorine was another very active agent, corresponding to commercial use of this reagent in starch modification.

Electrolytes in the cooking solution had important effects on swelling in some instances. H and OH ions were probably more active than salt ions. The valency of the cation apparently affected swelling but more work is required on this point.

USE OF THE AIR JET METHOD FOR DETERMINING HULL PROPERTIES IN NORTH DAKOTA BARLEY

R. H. Harris and G. M. Scott

An air jet method is described for determining the proportion of the hull component of the barley kernel. The method consists in causing the kernels to strike violently against a wire cage lining a metal container. An air jet operating under a line pressure of 17½ lbs. per sq. in. is the activating force. Two samples can be hulled simultaneously.

An experiment was set up in which five barley varieties each grown at six North Dakota stations were subjected to dehulling treatment for 5, 10, 15 and 20 minute periods. The data were analyzed statistically.

Very significant differences were found between the varieties in respect to hull percentage. Growth location also had an important effect. Length of dehulling treatment naturally had a very marked influence on amount of hull removed. Little relationship was noted between variety and rate of hull removal.

Correlation coefficients between the percentage of hull removed by various tratment periods were too low to permit prediction of hull removal by other treatments from information secured from one treatment.

THE DETERMINATION OF PHOSPHORUS IN PLANT MATERIAL

D. W. Bolin

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Phosphorus and protein are two of the most variable constituents in forages. This variation may be due to several factors, such as; lack of available phosphorus in the soil, loss of leaves, leaching during curing in the field, and harvesting forages when too mature. The phosphorus and protein content of a forage serves as a good index to its nutritive value. The Kjeldahl method for the determination of proteins is relatively rapid in comparison to the methods used for the determinations of phosphorus.

A rapid quantitative method for the determination of phosphorus is desirable. One of the time consuming procedures in the analyses of forages for phosphorus is the destruction of the organic matter. This is usually done by ashing in the presence of magnesium nitrate. Perchloric acid either alone or in combination of other acids has been used for the oxidation of organic matter[9] [10]. Bolin and Stamberg[11] have shown that the addition of molybdenum to a mixture of perchloric and sulfuric acids markedly increased the rate of oxidation.

The uses of ammonium vanadate and ammonium molybdate for the determination of phosphorus colorimetrically has been reported in the footnotes 12, 13. The color developed by this method is more stable in comparison to other well known colorimetric methods for phosphorus.

A rapid quantitative method for the determination of phosphorus in forages using perchloric and sulfuric acid in the presence of sodium molybdate for digestion of the organic matter and the use of ammonium molybdate and ammonium vanadate for the development of the color is described.

Procedure

Preparation of Reagents:

Digestion Mixture: Dissolve 10 grams of sodium molybdate in 150 ml. of water. Add slowly 150 ml. of concentrated sulfuric acid. Cool, add 200 ml. of perchloric acid (70-72%).

Ammonium Molybdate Solution: 5 percent. Dissolve 50 grams $(NH_4)_7MO_7O_{24}$ $4H_2O$ in warm water. (50°C) Dilute to one liter.

Standard Phosphorus Solution: Dissolve 4.39 grams KH_2PO_4 in exactly one liter of water containing 10 ml. of 10 N H_2SO_4. This solution contains 1 mg. of phosphorus per ml. Dilute this solution to 0.1 mg. per ml. Standard solutions containing .05 - 1.4 mg. per 110 ml. are satisfactory for determination of the standard curve for the Evelyn Photoelectric Colorimeter using a 440 millimicron filter.

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[9] Gerritz, H. W., Ind. Eng. Chem., Anal. Ed., 7, 116 (1935).
[10] Giesiking, J. E., Snider, H. J., and Getz, C. A., Ibid., 7, 185 (1935).
[11] Bolin, D. W., and Stamberg, O. A., Ind. Eng. Chem. Anal. Ed. 16, 345 (1944).
[12] Koenig, R. A., and Johnson, C. R., Ibid., 14,155 (1942).
[13] Misson, G., Chem.-Ztg., 32, 633 (1908).
[14] Sherman, M. S., Ind. Eng. Chem., Anal. Ed., 14, 182 (1942).

Analytical Method:

Transfer not more than 500 mg. sample to a Kjeldahl flask which has been previously graduated to 110 ml. and add 5 ml. of the digestion mixture and a few glass beads to prevent bumping. Heat flask over a micro burner. Oxidation will begin in one or two minutes. Allow the sample to digest, then twirl the flask to get the undigested samples on the side of the flask in contact with the hot acid. Turn off burner and add 2 ml. of perchloric acid in such a manner that the remaining undigested residue is washed down in the flask. Digest for three to four minutes. Allow the flask to cool for approximately 5 minutes and add approximately 50 ml. of water. Add 10 ml. of the vanadate solution, and 20 ml. of the 5 percent ammonium molybdate. Shake. Dilute to volume with distilled water. Mix well, and allow the solution to stand until silca has settled. Pour off gently the yellow solution from the Kjeldahl flask in a colorimetric tube and read using 440 millimicron filter.

A reference solution for setting the galvanometer at 100 is made by addition of all reagents used and diluting to volume with distilled water.

A standard reference curve is made from the standard phosphorus solutions and plotting the readings of the galvanometer versus the concentrations on semi-logarithmic paper.

Several hundred forage samples have been analyzed for phosphorus by this method. This method has given comparable results with other methods of phosphorus analyses. One of the objections offered to the use of perchloric acid digestion is the danger of explosions. No explosions have resulted from the large number of digestions. With a sample of 500 mg. or less the reaction proceeds smoothly and a set of six samples can be digested in less than 15 minutes.

For best results, the micro burners should be regulated to give the desired amount of heat. It has been found that the holes in the asbestos board, that comes with these micro burners when purchased, are not large enough to get the desired amount of heat for a 100 ml. Kjeldahl. These holes are made larger so that the samples will begin to digst in 1 or 2 minutes. When the last 2 ml. of perchloric acid are added, care should be taken not to digest the samples too long and boil off the perchloric acid in order to have the proper acidity for the development of the color. Too small amount of acid present will result in the development of color from the ammonium molybdate per se present.

Summary

A rapid quantitative method for the determination of phosphorus in plant material has been described.

INHERITANCE OF RUST-RESISTANCE IN FLAX[15]

H. H. Flor

Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering Research Administration, United States Department of Agriculture.

In 1942 rust reduced the yield of flaxseed in North Dakota by 2,000,000 bushels. Due largely to the use of rust-resistant varieties, losses from rust in 1946 were negligible. Basic research on flax diseases made possible this rapid shift from rust-susceptible to rust-resistant varieties.

More than 300 varieties of flax of diverse types were obtained from various flax producing regions of the world either by plant explorers of the United States Department of Agriculture or from flax investigators abroad, and their rust-reactions determined to available races of rust. These tests showed that rust-resistance in flax is conditioned by numerous factors. At least 25 distinct rust-conditioning factors have been identified. Any one of 15 of these factors satisfactorily conditions resistance to all races of flax rust known to occur in the flaxseed producing region of Minnesota, North Dakota and South Dakota. Consequently, there is an abundance of parental material having satisfactory rust-resistance. The greatest danger to our rust-resistant varieties lies in the possible introduction into this region of races having the pathogenic capacities of those occurring in South America, to which all of our flax varieties are highly susceptible. Furthermore, we have races attacking the Bombay factor, the only factor known that resists the South American races. If the South American races become established they would probably hybridize with our domestic races and from these hybrids would evolve a strain of rust capable of attacking all known flax varieties.

FREQUENCY OF HIGH AND LOW YIELDS OF WHEAT AND SOME STUDIES ON THE CORRELATIONS BETWEEN MAY AND JUNE RAINFALL AND WHEAT YIELDS IN NORTH DAKOTA COUNTIES

by H. L. Walster and Peder A. Nystuen

The relation of seasonal precipitation to the yield of wheat in each of the 53 North Dakota counties was examined by Rex E. Willard and O. M. Fuller in 1927 (See North Dakota Agricultural Experiment Station Bulletin 212, July, 1927.). They calculated the correlation coefficients between May plus June rainfall and the annual wheat yields in the respective counties for the 16 year period 1911 to 1926 inclusive. The present authors having available more data have made similar calculations for the 35 year period 1911 to 1945 inclusive.

In general there now appears to be no significant correlation between May and June rainfall in any Red River county except

[15] Cooperative investigations of the Division of Cereal Crops and Diseases and the North Dakota Agricultural Experiment Station.

Richland, and in Nelson, Steele, Barnes, Ransom and Sargent, which are a group of counties adjoining the Red River Valley counties. Similar lack of significance appears for Towner, Foster, and McIntosh. Significant relationships between May plus June rainfall appear for 12 counties including Bottineau, Rolette, Cavalier, Benson, Sheridan, Griggs, Stutsman, Logan, LaMoure, Dickey, Richland and Golden Valley counties. All of the counties west of the 100th meridian show highly significant positive correlations except Bottineau, Sheridan and Golden Valley which lie in the merely "significant group."

The general grouping of the counties of the state made by Willard and Fuller is confirmed by these longer time studies.

Frequency of High and Low Yields of Wheat in North Dakota Counties 1911 to 1945 inclusive

A study of the frequency of yields of 15 bushels per acre or more in the 35 year period awards the high frequency banner to Trail County with 17 years; it is followed closely by Pembina with 15 years; Walsh with 13 years; Cavalier, Grand Forks, Ramsey, Cass, each with 12 years; Divide, Renville, Ward, Williams, Dunn and McKenzie, each with 11 years; Burke, Bottineau, Nelson, Mercer, Oliver, Wells, Steele and Stark, each with 10 years; Benson, Rolette, McLean, Barnes and Morton, each with 9 years; Mountrail, Towner, Eddy, Griggs, Billings, Golden Valley, Hettinger, Ransom and Richland, each with 8 years; McHenry, Pierce, Foster, Sheridan, Adams and Slope, each with 7 years; Stutsman, Bowman, Grant and Sargent, each with 6 years; Burleigh Emmons, Dickey and LaMoure, each with 5 years; Sioux and Logan with only 4 years each; and Kidder and McIntosh with only 3 years each. In most of the counties the high yields of the fabulous 1940's account for nearly half of the 15 bushel crops.

A COLORIMETRIC METHOD FOR THE DETERMINATION OF BLOOD SERUM PROTEINS

Lucille Book and Donald W. Bolin

(Published with the approval of the Director of the North Dakota Agricultural Experiment Station.)

It has been shown in literature that human blood serum protein values vary with such factors as low protein diets, poor quality proteins, tissue injury and other abnormalities. Literature reports that relatively little or no work has been done to determine what factors affect the serum proteins of farm animals. In view of the above statement and that a large number of samples were being collected from cattle and sheep for other studies, Drs. D. F. Eveleth and F. M. Bolin of the Veterinary Department suggested that these studies be extended to include the blood serum proteins. One of the first prerequisites for this extended study was to find a method for determination of these serum proteins, that was rapid and accurate. The Kjeldahl method is too time consuming and costly for analyzing a large number of samples of blood proteins for a preliminary survey.

Several colorimetric methods have been published[16], Kingsley[17] developed a colorimetric method using the principle of the biuret reaction. Some of the objectionable features to this method are the instability of the developed color, and the use of concentrated sodium hydroxide to keep the copper in solution.

A simplified method has been developed in this laboratory and these objectionable features of the Kingsley method eliminated. The color developed by this new method remained stable for several days. This method has been used for the determination of several hundred blood serum proteins and the results obtained have been found to be in a good agreement with the Kjeldahl method.

Procedure

Preparation of Reagents: Urea solution: Dissolve 30 grams of urea in 100 ml. of distilled water.

Copper solution: Dissolve 5 grams of potassium iodide and 45 grams of sodium potassium tartrate in 400 ml. of 0.2 N sodium hydroxide solution. Add 15 grams of crystalline copper sulfate to this solution and stir until the copper sulfate is dissolved. Dilute to 1 liter and then add 1 liter of 2 N sodium hydroxide making a total volume of 2 liters.

Analytical: Transfer 0.1 ml. of plasma or serum to a photoelectric colorimetric tube. Then add 1 ml. of urea solution, 3.9 ml. of distilled water, and 5 ml. of copper solution and shake. Allow to stand for 30 minutes or longer.

For the reference tube replace the serum with the same amount of water, and add all other reagents in exactly the same manner.

Place reference tube in the photoelectric colorimter and set galvonometer at the reading of 50. Replace the reference tube with the tube containing the serum and record the galvonometer reading.

Calibration of the Photoelectric Colorimeter

The total protein of the serum was determined by the Kjeldahl method. This serum of known protein content was diluted with the urea solution to give the solutions ranging from 0.1 to 1.0 percent of protein. One ml. of these solutions with different percentages of protein were used for the calibration of the constant K for the photoelectric colorimeter.

$$K_1 = \frac{L}{C} = 5.85$$

C is the percent protein in solution and L is the log value of twice the galvonometer readings taken from the log tables supplied with the Evelyn Photoelectric colorimeter. Values of K were found to be constant for the amounts of protein present ranging from 0.1 to 1.0 percent.

$$\text{Percent Protein} = L \times K_2 \text{ where } K_2 = \frac{1}{K_1}$$

The value for K2 for the Evelyn instrument was found to be 17.1.

[16] Peters, J. P., and Van Slyke, D. D., Quantitative Clinical Chemistry Vol. II Methods, pp. 684, Baltimore: Williams and Wilkins Co., 1932.
[17] Kingsley, G. R., J. Biol. Chem. 131: 197-200 (1939).

Results

COMPARATIVE PROTEIN VALUES OF VARIOUS BLOOD SERUM DETERMINED BY THE KJELDAHL AND BY THE COLORIMETRIC METHODS

Animal	Sample No.	Kjeldahl %	Colorimetric %	Difference
Sheep	233	7.68	7.28	-.40
	234	7.50	7.18	-.32
	235	8.70	8.58	-.12
	236	7.16	7.08	-.08
	238	7.91	7.59	-.32
	239	7.22	6.80	-.42
	240	8.24	8.02	-.22
	241	7.82	7.80	-.02
	242	7.78	7.59	-.19
	243	8.24	8.02	-.22
	245	7.64	7.49	-.15
	246	7.54	7.18	-.36
	247	8.75	8.58	-.17
Calf	292	5.56	5.22	-.34
	289	7.08	6.80	-.28
	290	7.32	7.18	-.14
Pig	300	6.20	5.76	-.44
Turkey	301	4.44	4.58	+.14
Chicken	302	6.30	6.28	-.02
Duck	303	5.79	5.61	+.18

Discussion

In Table I results are presented for a comparison between the Kjeldahl method and the colorimetric method. The results are in good agreement since the Kjeldahl method determines th non-protein nitrogen as well as the protein. These differences between the two methods may be due to the difference of non-protein nitrogen in the serum.

This method was also used to determine the albumin and the globulin proteins. The albumins were separated by the buffered methyl alcohol method as described by Pillemer and Hutchinson[18]. The percentage of albumin was determined colorometrically and the percentage of globulin was calculated by the difference between the total protein and albumins.

Summary

A simplified rapid and accurate colorimetric method for the determination of blood serum proteins has been presented.

[18] Pillemer and Hutchinson, Jour. Biol. Chem. 158: 299-301 (1945).

STUDY OF BOTULINUM TOXIN

Casper I. Nelson

Cl. botulinum as a cause of food poisoning in North Dakota has appeared at infrequent intervals but with outstanding results whenever it did so appear. Within our own memory there have been three major outbreaks involving a score of deaths. In all cases the outbreaks have resulted from the use of home canned vegetable matter of very low acid content, prepared and processed by methods which did not sterilize. Identification of the organism concerned has depended upon the ability of the organism to produce toxin which when injected into laboratory animals gave certain symptomatic effects. In all cases the evidence has pointed to the certain possibility that the causal organisms originated in the soil of gardens or fields which produced the vegetables. It would seem reasonable, therefore, to assume that the soils of the state are fairly well impregnated with Cl. botulinum spores and quite constantly. If such is the case the question becomes this,—knowing how generally inadequate the methods of food preservation in the kitchens of North Dakotan's homes are, and knowing very well that these methods do not eliminate the resistant spores of C. botulinum from the non-acid vegetable matter being canned, why don't we have a greater incidence of botulinum poisoning? With this in mind an attempt was made to search the soils of the state for C. botulinum. In 1922 Meyer and Dubovsky,[19] in a general study of the distribution of Cl. botulinum in the 1538 specimens of soils, vegetables, fruit, manure and sewage from every state except Virginia, reported type A present in some soil samples from Fargo and in seven specimens of vegetables and feed materials from the same area. Our own efforts in studying some 20 soils distributed over the state have failed to produce one identifiable culture of Cl. botulinum. Undoubtedly if we had continued the search we would have found the organism in some soil samples and perhaps several times.

Cl. botulinum is an anaerobe. It grows in organic matter under conditions which exclude oxygen. All of the soils which we studied contained many anaerobes, some of these could not be differentiated from Cl. botulinum by morphological or cultural characteristics. Yet none of the organisms isolated produced a toxin which would cause the death of laboratory animals in the manner of Cl. botulinum. The fact is that specific toxin production seems to be the general criterion for identification of Cl. botulinum, and if no such toxin is found the findings are negative.

It is very well known that Cl. botulinum toxin is fragile. Heating to 80 degrees C for 10 minutes is sufficient to make it non-toxic. On standing and aging it loses toxicity. In the presence of alkali it loses toxicity. During the last 2 or 3 years, Dr. Lamanna and co-workers, at an eastern government laboratory, have announced a method for the preparation of crystalline toxin with a toxicity of approximately

[19] Meyer, K. F. and Dubovsky, B. J., Jour. Inf. Dis.: 31, (1922) 559-594.

1 to 32 billion times normal as measured in 20 gm. mice. Unfortunately we have discovered that any standardization of this toxin in terms of minimum mouse doses has to be repeated practically as often as we wished to use it experimentally. Over a period of a few months our high potency toxin dropped in toxicity from 1 billion M.M.D. to 400,000,000, to 300,000,000, to 1,200,000, to 500,000, and finally to 300,000 M. M. D. Undoubtedly there are reasons for this instability which are controllable thru the conditions of solution, temperature, and exposure to oxygen. Its greatest stability is in acid solution at pH 4.2 to 4.3. Solution of toxin in a full stoppered bottle seems to be more stable than in one containing air. Last May at the S.A.B. meeting in Detroit, Dr. Lamanna described botulinum toxin as a huge molecule with molecular weight between 900,000 and 1,300,000. It is composed of some 14 amino acids, 10 of them essential to animal nutrition.*

*Amino acids present in purified Cl. botulinum toxin.

Aspartic acid	+	Glutamic acid	14.9%
Valine	4.0%	Leucine	8.7%
Serine	3.0%	Isoleucine	11.0%
Threonine	7.3%	Cystine	0.48%
Arginine	3.2%	Methionine	0.83%
Lysine	7.9%	Phenylalanine	1.08%
Histidine	1.0%	Tyrosine	9.5%

One of these is histamine present in approximately 1% amounts. Dr. Lamanna describes this huge molecule as a complete protein. Considering its size there need be little wonder at the fragility of this toxin. It has been reported[20] that the toxin elaborated from Cl. botulinum is not destroyed by either peptic or tryptic digestion and is of the nature of a true secretion.

For our purposes we have been using a culture isolated years ago by Dr. Ivan C. Hall of Denver, which is considered a standard strain for toxin production. With it we have usually had little trouble in preparing a potent toxin. However, during the past year, in spite of adhering as strictly as possible to our usually successful procedures, our culture has suddenly lost its capacity to produce toxin abundantly. This has been the experience of many other workers using the same or other strains of Cl. botulinum. It indicates the tempermentalness of the organism in its production of toxin,—it indicates our unfamiliarity with the total of the facts involved in such toxin production.

If an organism is so subject to variation in its ability to produce a characteristic secretion that there are times when it is atoxic the same thing may prevail under natural surroundings. A number of suggestions have been made, backed more or less by experimental proof, to explain such variability, as for example, the antagonistic influence of other anaerboic bacteria, variation in pH, or other variations in environment. It is possible that herein lies an explanation for the

[20] The Relationship Between Intracellular Globulin and the Toxin of Cl. Botulinum. C. I. Nelson, Jr. Inf. Dis., 41, 1927, 9-12.

fact that the soil taken from the very garden in Grafton which in 1931 produced an organism responsible for the death of 13 people, did not yield us a single culture that would produce toxin of this nature. Why should such a discrepancy occur unless there is a variability in the toxin production due to such ecological factors suggested. The foregoing situation is such that a study of the behavior of botulinum toxin on the animal body suggests itself as a means of learning something about the biochemistry of the organism in its production of this secretion. The toxin is generally described as having a paralytic effect on the peripheral motor nerve endings, resembling the drug, curare, in that respect.

It is particularly effective against the nerves concerned in respiration, swallowing, and vision. In view of the hypothesis of the role acetylcholine plays in the propulsion of the nerve impulses, we had postulated in our laboratory that botulinum toxin must somehow interfere with this mechanism. We considered it might do this by (1) destroying the acetylcholine at the nerve, (2) or by destroying the special cholinesterase at the synapse. Considerable time was devoted to this phase of investigation with only negative results, so far. Along with other investigators it appears to us that a very complicated situation exists in the neural paralysis produced by the toxin. In some respects a significant parallelism exists between the behavior of botulinum toxin and that of the cholinesterases, the specific group of enzymes which limit the physiological activity of acetylcholine in nerve function.

This parallelism has served as a means of approach to a concept of the toxin behavior. Choline compounds are quaternary ammonium compounds. Acetyl choline chloride which is recognized in nerve function is such a compound, and it is hydrolyzed by cholinesterase in situ. Bodansky[21] summarized the results of various workers who have investigated cholinesterase inhibitors. Among these compounds are physostygomine, morphine, codeine, caffeine, and other narcotics, and complex dye compounds. It was shown that the degree of inhibition by these compounds varies with respect to chemical structures (side chains), pH, and the enzyme source. These facts suggest a similar line of procedure in toxin investigation. Can it be that the toxin plays an enzymic role such as is played by cholinesterase?

Dr. C. E. Miller has been cooperating with us in this investigation. He has prepared compounds more or less of the quaternary ammonium type to be used as in vivo inhibitors of botulinum toxin. Such inhibitors might throw light on a subject as yet very dark. It might also have its practical applications.

[21] Annals of the New York Academy of Sciences, Vol. XLVII, Art. 4. The Physico-Chemical Mechanism of Nerve Activity, New York, Dec. 15, 1946, p. 521-547.

CHEMICAL INHIBITION OF BOTULINUM TOXIN

C. E. Miller[22] *and C. I. Nelson*[23]

It has been reported that anaesthetization of an animal[24] at the time of injection of lethal botulinum toxin has the result of delaying the effect of the toxin until after the disappearance of the anaesthetic from the tissues. It has also been suggested[25] that the injection of alcohol simultaneously with botulinum toxin inhibits the action of the latter. Investigation of inhibition of botulinum toxin effect on the animal by organic compounds may lead not only to profitable knowledge in direct treatment of such intoxication but should also give information on the chemical nature of the toxin and the biomechanics of its effect.

Almost the only proof of the identity of Cl. botulinum lies in its ability to produce an identifiable soluble toxin. The conditions under which the production of the toxin is constant are not yet known, nor is the mechanism by which the neurological blocking is effected. One may assume that such an effect represents interruption or disarrangement of chemical structures involved in nerve impulse propulsion. If so, the use of compounds of a type identical to or similar to the nerve impulse compounds interfered with would seem like an interesting and a promising line of investigation. The general plan used and reported upon herein consisted of injection of minimum lethal doses of botulinum toxin followed after a suitable lapse of time by injection of the trial compounds. Any deviation in the effect of the toxin resulting either in delay of death or change in behavior of the test animal then may be investigated or verified.

The chief significant compound which is associated with nerve impulse propagation is acetylcholine, a quaternary ammonium type of compound. Therefore, its use in these tests was indicated. A number of other compounds tried as inhibitors of toxic effect were also quaternary ammonium halides, (tetra-n-propyl ammonium iodide; tetra-butyl ammonium iodide; tetra-methyl ammonium bromide; trimethyl-phenyl ammonium iodide, trimethyl acetylhydrazide ammonium chloride; and 2-hydroxy methyl-2-propyl ammonium chloride) or compounds of similar structure.

Botulinum toxin of a high degree of purity was diluted in McIlvain's buffer diluent at pH 4.3 so as to afford the minimum lethal mouse dose in convenient volume for injection. Minimum mouse doses (M.M.D.) of the toxin were injected intraperitoneally in one side of young adult mice of approximately 20 gms. weight and after the lapse of about 15 minutes, maximum tolerated doses of the compounds tested were injected intraperitoneally in the opposie side. Due to the extreme lability of botulinum toxin it was necessary to redetermine its M. M. D. for each series of compounds tested. The order of toxicity of

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[22] Professor of Pharmaceutical Chemistry, N. D. A. C., Fargo, N. Dak.
[23] Professor of Bacteriology, N. D. A. C., Fargo, N. Dak.
[24] Bronfenbrenner, J. J., & Weiss, H. Journ. Expt. Med. 39: 517-532, 1924.
[25] Allen, R. W. & Eclund, A. W., Journ. A. M. A. 557-559, 1932.

the toxin was usually between 67 million and 100 million M. M. D.'s per gm. Death by toxin was characteristically respiratory and occurred within 36 to 48 hours. Such moribund animals are quite inactive, do not eat, and ruffle their fur.

Most of the compounds used in the experiments were exceedingly neurotoxic. Even with non-lethal doses the animals were very tense and excitable. In some cases no practicable tolerated doses were found and such compounds were eliminated from further trial. Among the compounds thus eliminated were the six quaternary ammonium halides listed above, as well as the sulfur compounds thiophene and acetyl-thiophene.

Compound No. 5[26] in the series used, ammonium 2-nitrobutane-1-sulfonate, was also a very neurotoxic water soluble compound. A series of mouse injections indicated its maximum tolerance of slightly over 33.88 mgms.

Compound No. 7, is chemically related to compound No. 5. It is 2-hydroxy methyl-2-butyl ammonium chloride. Its toxic dose is approximately 51.12 mgms. for a 20 gm. mouse. When used in the same manner as No. 5, a striking resemblance in effect was observed. Both compounds had the effect of inhibiting the lethal action of botulinum toxin as described herein. Death was delayed in so far as tested, for periods varying from 3 days to more than 2 weeks.

Compound No. 8, is also chemically related to compound No. 5, but with one less carbon atom. It is designated 2-hydroxymethyl-2-propyl ammonium chloride. This compound is not inhibitive of the toxin.

Acetyl-choline bromide was not tolerated in amounts above 3.67 mgms. per 20 gm. mouse injected peritoneally after a sublethal threshold dose of botulinum toxin, 3.67 mgms. of acetyl-choline bromide killed a 20 gram mouse within 48 hours. It had no inhibitive effect on the toxin.

TABLE I

Mouse	Botulinum Toxin	Comp. No. 5	Results
1	1 cc. Lethal Dose		died in 17 hours
2	.5 cc. L. D.		died in 17 hours (a)
3	.1 cc. L. D.—M.M.D. (Minimum Mouse Dose)		died in 17 hours
4		0.0784 gms.	died in 5 minutes
5		0.0392 gms.	died in 24 hours
6		0.00784 gms.	alive after several days (b)
7	1 cc. L. D.	0.0392 gms.	died in ½ hour
8	.5 cc. L. D.	0.0392 gms.	died in ½ hour (d) no inhibition of toxin
9	.1 cc. L. D. or 1 M.M.D.	0.0392 gms.	died in ½ hour
10	1 cc. L. D.	0.00784 gms.	alive after 72 hours
11	.5 cc. L. D.	0.00784 gms.	alive after 72 hours (e)
12	.1 cc. L. D. or 1 M.M.D.	0.00784 gms.	inhibition of toxin alive after 72 hours

[26] Supplied by the Visking Corporation, Chicago, Illinois.

TABLE II

Mouse	Botulinum Toxin	Comp. No. 5	Comp. No. 7	Comp. No. 8	Results
1	1 cc. Lethal Dose				died within 20 hours
2	.5 cc. L. D. (or M.M.D.)				moribund in 20 hours, dead in 45 hours
3		.03385 gms (b)			atoxic dose
4		.0225 gms (b)			atoxic dose
5			.03135 gms (c)		atoxic dose
6			.02237 gms (c)		atoxic dose
7				.0311 gms (c)	atoxic dose
8				.03898 gms (c)	atoxic dose
9	1 cc. Lethal Dose	.03385 gms (f)			dead in 48 hours
10	1 cc. L. D.	.0225 gms (e)			alive after 2 weeks
11	1 cc. L. D.		.03135 gms (f)		dead in 48 hours
12	1 cc. L. D.		.02237 gms (e)		alive after 2 weeks
13	1 cc. L. D.			.0311 gm (f)	dead in 48 hours
14	1 cc. L. D.			.03898 gm (e)	dead in 36 hours

Discussion of Tables

a. While 1 cc. and .5 cc. amounts of toxin were lethal in 17 hours, .1 cc. was the minimum mouse dose.

b. The tolerable dosage of compound No. 5 lies between .03385 gms. and .0784 gms.

c. The tolerable dosage of compounds No. 7 and No. 8 is approximately the same.

d. Toxic doses of compound No. 5 **add** their toxicity to that of the toxin in lethal doses as indicated by the shortened death period.

e. Subtoxic doses of compounds No. 5 and No. 7 are generally inhibitive to the lethal effect of botulinum toxin, but not when the doseage approaches the threshold of toxicity as at (f),—

f. In that case the effects of the two toxic substances are additive.

Summary

Data from this preliminary report seem to show that quaternary ammonium compounds and acetyl-choline bromide have no inhibitory action upon the lethal effect of limited doses of pure botulinum toxin injected into white mice.

Two compounds of similar chemical structure are reported as possessing inhibitive effect against the lethal action of M.M.D. injections of botulinum toxin. The toxicity of these compounds at the lowest lethal concentration for 20 gm. mice seems to be additive to the toxicity of botulinum toxin, but at the slightly lower concentration which is tolerated the compounds seem to be inhibitive to the toxin effect.

The chemistry of these several compounds will be reported elsewhere.

EFFECTS OF MOISTURE ON PLASTIC MOLDINGS

Donald Eells, R. E. Dunbar, S. K. Moxness and Jerome Formo

In previous studies of condensations and polymerizations, very little mention has been made of water entering into the reactions between phenol and formaldehyde in any way other than as a by-product. Water, however, was present in most of the condensations in the initial stage due to the use of a water solution of formaldehyde.

Moxness and Formo[27] have previously made quite detailed studies of the effects of moisture on the final phenolic plastic product when the moisture was introduced into the molding powder (preform) during the preheating process. They found that the plastic molded part was lower in extractable material using acetone as a solvent, than parts molded by the use of other preheating processes and that the parts were approximately equal in every other respect except electrical characteristics. Parts transfer molded by the moisture preheat method cured in a shorter time, were more easily released from the mold and did not stain the mold as easily as when dry powder was used.

A continuation of these studies wherein the preheat time and steam pressure, as it affects the moisture content of the preforms, has been completed.

All experimental work was conducted on Bakelite 3200 molding powder which had been preformed to the shape of discs with a diameter of 1½ in., thickness of approximately one inch, and with a mass of 24.5 gms. The moisture content of the preforms was determined before any experimental work was attempted. The preforms were preheated in a small oven heated by infra-red bulbs, one at either end. Into this oven a jet of live steam was released through an orifice of 1/16 inch diameter. The steam pressure was varied and measured as line pressure with a gage located in the line a short distance from the orifice. It was found through experimental molding that the minimum and

[27] S. K. Moxness and Jerome Formo, Preheating Plastics with Live Steam, Modern Plastics, 24, 141 (February, 1947).

maximum preheat times necessary to insure proper transfer were as follows: for 20 lb. steam pressure 6 min. minimum and 8 min. maximum; for 15 lb. steam pressure 7 min. minimum and 9 min. maximum; for 10 lb. steam pressure, 7 min. minimum and 9 min. maximum; for 5 lb. steam pressure, 7 min. minimum and 10 min. maximum. It was also discovered that the total moisture absorbed by the preforms varied with the preheat time, steam pressure and density of the preform.

The preforms, thus treated at variable temperatures, times, and steam pressures as previously described were now introduced into a commercial transfer molding press, wherein four test pieces were produced consisting of a tensile bar, flexural bar and two discs for use in the subsequent physical and chemical tests. The cure time of the four test bars and discs were varied from 3 to 5 minutes in order to determine the influence of this factor.

The test bars and discs, produced under such variable conditions of preheat time, temperature, steam pressure, and cure time were now subjected to the folowing approved plastic tests[28]:

> Flexural strength, Compression strength, Impact strength, Tensile strength, Dielectric strength, Dimentional stability, Water absorption, Accelerated weathering, and Acetone extraction.

The general results and trends were evaluated by comparing and contrasting the several physical and chemical constants against the total moisture content of the preforms at the time they entered the press. Obviously it would be a physical impossibility to accurately determine the total moisture content of each perform before it was introduced into the molding press, for by so doing the preform would automatically become useless for subsequent molding operations. Therefore, it was deemed necessary to carefully determine the total moistur content of representative preforms when treated under all of the variable conditions employed in the preheating process. It was then subsequently assumed that other like preforms would absorb an equal amount of moisture when given identical treatment, and such moisture values have been used in all interpretations.

From the accumulated data it is evident that as the moisture content of the preform is increased, the flexual strength and tensile strength of the final castings are materially increased, while the compression strength, dielectric strength, and amount of acetone extractable material are somewhat decreased. The impact strength, dimensional stability, water absorption, and accelerated weathering tests did not display any significant or consistent variation with changing moisture content of the preforms.

Our experience and the results obtained seem to justify the following conclusions:

[28] A. S. T. M. Committee D-20, 'A. S. T. M. Standards on Plastics' American Society for Testing Materials, Philadelphia 2, Pa. (May, 1945).

1. The transfer and cure time for Bakelite 3200 when steam-preheated is greatly reduced as compared to previous dry preheat treatment.

2. One-minute cure time, with adequate steam preheat treatment will produce objects approximately as good as those produced by much longer cure time.

3. The steam preheat treatment of preforms makes possible much shorter cycles for the molding operations.

4. In general, the evidence presented indicates that this is a method of preheating which, in spite of its simplicity and low cost, is an eminently suitable means of cutting molding costs without impairing the quality of the finished product appreciably.

SOME NEW ANALOGS OF D. D. T.

A. O. Geiszler and R. E. Dunbar

The symbol D. D. T. is a contraction for dichloro-diphenyl-trichloroethane, but in current use refers specifically to 1,1,1-trichloro-2,-2-bis(p-chloro phenyl) ethane. This compound was first prepared by Zeidler[29] in 1874. Its real insecticidal properties were never appreciated until 1939 when it was effectively used against potato beetles in Switzerland. Its subsequent use in the United States readily established its potency against numerous other insects. Its extensive use by the armed forces during World War II is well known. Likewise an appreciation of its great insecticidal properties, has led to almost countless synthetic studies for its preparation and many other related compounds. A casual inspection of recent chemical literature reveals no less than 82 such analogs. The general method for the preparation of these compounds has been to condense chloral hydrate, bromal or butyl chloral with halogenated and otherwise substituted aromatic nuclei in the presence of fuming sulfuric acid. In several instances a subsequent treatment with alcoholic potassium hydroxide removed hydrohalic acid. The resulting molecules were then directly halogenated or oxidized to new, different and related structures. By these technics no less than six new analogs have been synthesized, apparently for the first time, and are here reported.

1,1,1-Trichloro-2,2,bis (p-iodo phenyl) ethane was prepared by condencing 1 mole of chloral hydrate with 2.5 moles of iodobenzene in the presence of 15% fuming sulfuric acid, and external cooling. The reaction mixture was poured into cracked ice, and recrystallized from butyl acetate and ethanol in turn. The melting point was 179.5-180.0 degrees C. (Corrected). Theoretical silver halide for $C_{14}H_9Cl_3I_2$; 1.674 g./g. compound; found, 1.676 g./g. compound.

1,1,1-tribromo-2,2-bis (2-chloro-5-bromo phenyl) ethane was similarly produced by heating at 85-90 degrees a 1 to 2.0 mole ratio of bromal, instead of chloral hydrate, with p-chloro bromo benzene. When recrystallized from 50% ethanol and 50% trichloro ethylene,

[29] Zeidler, Ber., 7, 1180 (1874).

and then absolute ethanol, the product melted at 163.0-163.7 degrees C. (Corrected). Here there is some question regarding the actual point and position of condensation. Theorteical silver halide for $C_{14}H_7Cl_2Br_5$; 1.898 g./g. compound; found, 1.895 g./g. compound.

1,1,1-tribromo-2,2-bis (2,5-dibromo phenyl) ethane resulted from a similar 1 to 2.0 mole ratio of bromal and p-dibromobenzene heated at 70 to 80 degrees C. for four hours. The theoretical bromine content of $C_{14}H_7Br_7$ is 76.15%, found 76.67%. The melting point of the recrystallized product was 179.8-180.6 degrees.

1,1-dichloro-2,2-bis (p-iodo phenyl) ethylene was prepared from the related saturated 1,1,1-trichloro-2,2-bis (p-iodo phenyl) ethane by refluxing with alcoholic potassium hydroxide and recrystallization from ethanol. The melting point was 146.4-147.0 degrees C. (Corrected). This compound was oxidized by chromium trioxide in acetic acid to p-p diiode benzophenone (M.P. 235-236 degrees C) as further proof of its structure.[30]

1,1,1-trichloro-2,2-bis (3-nitro-4-iodo phenyl) ehtane was formed by the nitration of 1,1,1-trichloro-2,2-bis (p-iodo phenyl) ethane using glacial acetic acid and fuming nitric acid which forms the mononitrated ring. The melting point was 173.7-174.3 degrees C. (Corrected). Theoretical nitrogen for $C_{11}H_7Cl_3I_2N_2O_4$, 4.46%; found 4.52%.

1,1,1,2-tetrachloro-2,2-bis (p-bromo phenyl) ethane was obtained by chlorinating 1,1,1-trichloro-2,2-bis (p-bromo phenyl) ethane in a soultion of carbon tetrachloride while the reaction mixture was strongly illuminated. After recrystallizing from absolute ethanol the product melted at 95-96 degrees C. Theoretical silver halide for $C_{14}H_8Cl_4Br_2$; 1.98 g./g. compound, found, 2.016 g./g. compound.

These six new D. D. T. analogs along with numerous others, previously reported and again prepared, presents an interesting and related synthetic series that illustrates many common methods of preparation and related properties. It is likewise possible or even probable that some of them may display peculiar and specific insecticidal properties. Additional studies will be conducted to determine their halogen content and definite structures, where yet in doubt, besides insecticidal values.

POPULATIONS OF HETEROTROPHIC BACTERIA IN TWO SEDIMENT LAYERS OF WESTERN LAKE ERIE

Owen B. Weeks

Attempts to define productivity of fresh water environments usually center about studies of the groups of primary producer-organisms such as phytoplankton. The amount of this basic crop is directly dependent upon the physical, chemical, and biological cycles of the environment. The heterotrophic bacteria are among the biological factors associated with the organic matter cycle. The data reported in this paper were

[30] Montague, Ber., 51, 1486 (1918).

obtained as one part of the biological research program being conducted by the Ohio State University, Franz Theodore Stone Laboratory, on Western Lake Erie.

Studies of the aerobic and anaerobic heterotrophic bacteria of western Lake Erie were confined largely to quantitative determination of these populations in sediment material. All of the sediments were collected near South Bass Island from one area known as Station I. Samples were obtained with a corer or by means of a small Peterson dredge.

The sediments of Station I are described, in this study, by mechanical analyses, pH, and organic matter determinations. Mechanical analyses[31] showed the upper 2 cm of sediment to contain 39.1 per cent sand, 2.0-0.5 mm in size; 27.8 per cent silt, 0.05-0.002 mm in size; and 37.9 per cent clay, less than 0.002 mm in size. Determinations of hydrogen-ion activity, using a Beckman glass electrode, revealed a relatively constant value of pH 7.4, with individual measurements varying from pH 7.2-7.6. A total of 43 samples of the upper 2 cm of sediment were analyzed for organic matter content using a chromic acid oxidation technique[32], and an average value of 2.3 per cent organic matter was obtained.

Core samplings were started in November, 1941, and continued at approximately monthly intervals until April, 1943. On each date 10 cores were removed from Station I and taken to the laboratory for analysis. The upper 2 cm of each of the 10 cores were sliced off and aliquots taken for bacterial enumeration and moisture determinations.

Beginning in July, 1942, and continuing through April, 1943, surface scrapings from each of 3 to 5 Peterson dredge samples were also secured for study.

The aerobic bacteria counted were those which grew on plates prepared with the sodium caseinate agar described by Henrici and McCoy[33]. The anaerobic colonies counted were those which developed in agar plugs of the same medium when it was contained ni flat-walled agar slant tubes and overlayed with a 1: 1 mixture of paraffin and vaseline. Five replicates of the appropriate dilutions were prepared from each core or dredge sample for both the plates and the tubes. The plates and the tubes were incubated for a three week period at 23 degrees C, since prolonged incubation was necessary for the counts to reach constancy. Experiments have shown[34] that the number of colonies of aerobic bacteria on the sodium caseinate medium increased as much as 32 per cent between the 8th and the 14th day of incubation, and 39 per cent between the 14th and 20th day of incubation. In addition to total aerobic and anaerobic colony counts, a count of the actinomycete-like colonies and of the chromogenic bacterial colonies was

[31] Bouyoucos, G. J., Directions for making mechanical analyses of soils by the hydrometer method. Soil Sci. 42: 225-229. 1936.
[32] Waksman, S. A., On the distribution of organic matter in the sea bottom and the chemical nature and origin of marine humus. Soil Sci. 36:125-147. 1933.
[33] Henrici, A. T. and E. McCoy. The distribution of heterotrophic bacteria in the bottom deposits of some lakes. Trans. Wisc. Acad. Sci. 31: 313-361. 1938.

undertaken. All of the counts given below are expressed as numbers per gram of oven dry sediment. Since the bacterial counts for each date were derived from all of the replicates of the 10 cores or 3-5 dredge samples, it is apparent that each count is a mean obtained from between 30 and 50 plates and 15 to 25 tubes.

The number of aerobic bacteria in the upper 2 cm of the cores varied from approximately 2,600,000 to 7,700,000 during the 18 months of this investigation. The average count for the entire period was 4,300,000. The numbers of anaerobic bacteria were more constant, ranging from 180,000 to 311,000 during this same period. Actinomycete-like colonies accounted for approximately 11 per cent of the total aerobic bacterial population, while chromogenic colonies accounted for nearly 21 per cent of the aerobic bacterial flora.

The total numbers of aerobic bacteria in the mobile layer were without exception higher than the numbers in the core sections. During the period studied the total aerobic bacterial population of this layer was nearly 3 times that found for the core samples. The counts varied from 6,800,000 to 18,300,000. The percentage of actinomycetes was nearly the same as in the core sections, being approximately 12 per cent, while the percentage of chromogenic bacterial colonies was slightly higher, 24 per cent compared with 21 per cent. However, the numbers of anaerobic bacteria found in the mobile layer were significantly lower, with an average figure of 180,000 compared with an average of 225,000 for the core sections.

The total number of aerobes as well as the numbers of actinomycetes and chromogenic bacteria in both of the sediment layers showed fluctuations of an irregular nature during the period studied. The most noticeable increases in both of the sediment layers were apparently related to the deposit, on the sediments of Station I, of allochthonous material brought into the lake by rivers of the drainage basin. Such a relationship became apparent from a consideration of the relation between the bacterial population and the discharge data of Maumee and the Portage rivers as well as the turbidity of the lake water of Station I.[34] In all of the cases but one an increase in numbers of bacteria followed periods of high turbidity of the lake water, especially when this turbidity was due to silt from the drainage basin. Turbidities which were produced through the resuspension of bottom materials during storms did not show a similar relationship. It is suggested that the bacteria were associated with silt material coming from the drainage basin and that the bacteria were carried to the lake bottom during sedimentation of the silt. It is believed, then, that this mechanism played a major part in producing the increases which were observed in the aerobic bacterial population. Data indicate[34] that most of the bacterial forms which were carried to the sediments were not viable one to two months after reaching the sediment. If this

[34] Weeks, Owen B., A survey of the heterotrophic bacterial population in sediments of western Lake Erie. The Ohio State Univ. Abs. Doctoral Diss. 43: 201-308. 1943.

assumption is correct it is apparent that the increases of the bacterial population were not necessarily accompanied by increases of bacterial activity in the sediments.

Comprehensive taxonomic studies were not made of the bacteria found in the sediments, but the following genera were observed to produce colonies with some degree of regularity. These were actinomycetes of the genera **Streptomyces** and **Micromomospora,** the former being more apparent than the latter in the surface material; **Chromobacterium, Bacillus,** and possibly members of the genus **Achromobacter.**

GASTRIC LAVAGE IN THE DIAGNOSIS OF TUBERCULOSIS

Melvin E. Koons

The identification of the causative organism is the test of choice in the diagnosis of any communicable disease. In the case of tuberculosis, the dual sign beyond which nothing is of diagnostic significance is a positive chest plate and the presence of tubercle bacilli in gastric washings or sputum.

Gastric lavage may be carried out in the early cases where there is no sputum, or for purposes of check up on cases which have previously had sputum but are no longer expectorating. In both kinds of cases it is the only fluid in which tubercle bacilli may be found. Unfortunately, since the discovery of the tubercle bacillus, no method for detecting its presence in suspected specimens has yet proven to be infallible. Guinea pig inoculation is generally accepted as the method of choice for the demonstration of tubercle bacilli in gastric washings because microscopic examination yields poor results and cultural methods have been considered somewhat unreliable. The advantage of the cultural method is that it will give positives sooner than animal inoculation. Therefore, it was decided to examine a series of gastric specimens by both the cultural and animal inoculation methods in the Public Health Laboratory. All specimens were collected at the North Dakota State Tuberculosis Sanitorium and the laboratory treated each specimen in the same manner.

Of a total of 418 specimens examined, 159, or 37.7 per cent, gave positives by both methods, 251, or 60.4 per cent, were negative, and 8 specimens, or 1.9 per cent, were unsatisfactory.

A comparison of results shows that only 29 specimens (6.9 per cent) gave positive agreement. 244 specimens, or 58.4 per cent, showed negative agreement. The most significant fact shown, however, was that 111 spcimens, or 26.6 per cent, gave negative cultures and positive pig findings. One specimen gave a positive and the animal died from an intercurrent infection, 8 cultures were negative and the pigs died, in 8 specimens the cultures were contaminated and the pigs negative, and in 10 specimens the cultures were contaminated but the pigs yielded positive findings.

Too definite conclusions must not be drawn from the results of this study. In our hands we can say that the animal method is superior to the cultural method; however, only one type of culture media was used and only one type of specimen examined in this parallel fashion. We can conclude from this series of gastric wash examinations that in the routine procedure as used in the Public Health Laboratory the animal inoculation method is superior to the cultural method in the diagnosis of tuberculosis.

AN EVALUATION OF A TEN YEAR EXPERIMENT IN FARM REAL ESTATE FINANCING

Donald Wanner

Twelve years ago the Congress inaugurated a program of agricultural credit which included a type of real estate loan that might be used as a pattern program to combat the economic ill of tenancy and continued loss of farms because of inadequate capitalization. This was the Bankhead-Jones Act and was administered by the Farm Security Administration, now the Farmers Home Administration.

This act authorized loans at 3%, amortized over forty years, to eligible farm tenants who could not get equivalent credit otherwise, and who were to operate family type farms and carry on a diversified type of ecenomy. Variable payment-building up equities in good years to take care of lean years — loans to include minimum standards of building improvements—purchase price based on appraisal of long time earning capacity — farm not to be larger than the average sized farm in the particular community — the family type farm concept — all these are in the act and a part of the conditions on which loans may be made.

In North Dakota 606 loans have been made for farm purchase of which 123 have been retired in full, and there has been no loss whatever.

The family type farm has a peculiar interest to North Dakotans because of our marked lack of industry other than agriculture. The average farmer in 1946 spent in cash for family living $1073; for farm operating $1957; and for capital goods $1007. From a gross business standpoint it would seem obvious that the greater the number of secure farm families we have in the state, the more total business the state could enjoy.

There have been some results in the matter of other credit agencies trying out some of the new credit conditions — lessened interest rates, longer terms, variable payment, and even the policy of rehabilitating buildings before reselling farms — all a marked improvement over the old single consideration of dollar security. Financially the program has proved profitable to Uncle Sam but the main value is in the social and economic improvement of the families who have been serviced.

A WATER SUPPLY STUDY AT ZEELAND, NORTH DAKOTA

Wilson M. Laird

During July of 1946 a water supply study was conducted in the vicinity of Zeeland, North Dakota, to ascertain if a satisfactory water supply could be secured for the city. After geologically mapping the area, it was found that several possibilities existed and these were checked by test drilling. What appears to be a limited supply was secured from a kame terrace two miles west of town. This material was apparently deposited along an old glacial distributary which was operative during a substage (Tazewell?) of the Wisconsin glacier. The general geology of the area around Zeeland and its relation to water supply is discussed.

NEW COUPLING METHODS IN D-C AMPLIFIERS

By Y. P. Yu

ASBSTRACT

A new pushpull phase inverter circuit and a screen-coupled cathode follower circuit are introduced in this paper. Experimental results show that both the noise level and the percentage of distortion are extremely low in these circuits. Only one power supply of 250 volts is required. Circuit diagrams which are reluctantly omitted because of cost of printing, may be obtained by writing the author.

INTRODUCTION

In industrial electronic control, scientific research, and many other electronic systems, amplifiers with the ability to respond to steady values from the conversion element and to follow slow variations in the process variable are frequently required. The direct-coupled amplifier is the only type of multistage amplifier which satisfies the above requirement and gives the least frequency distortion. The conventional type of amplifier as used in auditorium sound systems, or radio receivers, is generally satisfactory down to only approximately 50 cycles per second. The method of coupling between stages is a difficult problem in the design of d. c. amplifiers with a single power supply because the output of a given stage is usually at a high quiescent d. c. potential above ground. In order to couple this output to the next stage, the high d. c. potential must be cancelled in some manner.

In order to overcome this problem, two new methods are introduced in this paper. One is a pushpull phase inverter arrangement, wherein a large cathode bias may be employed without the usual attendant disadvantages of negative feedback; the other involves coupling the plate of one stage to the screen of a cathode follower stage.

By employing these two methods many improved direct-coupled amplifiers have been successfully built and tested. Results show that a

direct-coupled amplifier operating from a single 250-volt power supply can provide a gain of 60 db for three stages and 80 db for four stages with flat response from zero to 20 kilocycles and almost unmeasurably low circuit noise level.

PHASE INVERTER CIRCUIT

The quiescent d. c. potential at the cathode of a vacuum tube may be raised to a high value by means of a large resistor connected from the cathode to ground. In a phase inverter circuit, two similar triodes are employed as a pushpull arrangement. The grid excitation voltages of both tubes are opposite in phase. Therefore the signal components of plate currents of both tubes, which are also opposite in phase, cancel in the biasing resistor, and there is no loss in amplification even the biasing resistor is very large. Many practical phase inverter circuits with remarkably low noise level are given by the author elsewhere.[35] For high stability, it is desirable to employ a low gain stage for this type of phase inverter circuit unless temperature-compensated resistors are used.

CATHODE-BALANCED STAGE

A double triode with a common cathode, such as 6SC7, is used in a cathode balanced stage, in which one triode serves as amplifier and the other serves to balance out the change in plate current of the amplifier circuit due to the noise generated in the cathode circuit by random change in work function of the cathode surface or due to fluctuations of heater supply voltage. A voltage gain of 30 db can be expected from a 6SC7 in this type of operation.

Experimental data of a d. c. ampilfier which consists of a 6SC7 as cathode-balanced circuit, a 6SN7 as phase inverter, and two 6AE5 as output stages shows: The noise level is down to practically zero with the input terminal shorted. The voltage gain in 70db with a flat frequency response up to 12 kilocycles and less than 1 percent distortion for 5 millivolts sensitivity. Practically constant output has been had for a five-hour run after the initial warmup period. Only one regulated power supply is required.

The advantages of this method of coupling (pushpull phase inverter) are the noise level and the distortion percentage can be reduced to an extremely low value. The operation also can be stabilized to a very high degree if all resistors are temperature compensated and all heater voltages are carefully regulated.

The disadvantage in employing "pushpull phase inverter coupling" is that the plate supply voltage available for the last is low. This defect can be avoided by the screen-coupled cathode follower circuit next to be discussed.

SCREEN-COUPLED CATHODE FOLLOWER CIRCUIT

When the input of a cathode follower circuit is coupled to the screen grid instead of the control grid as in the usual arrangement,

[35] Yu, Y. P., Cathode Follower Coupling in D. C: Amplifiers, Electronics, August 1946.

a circuit is obtained which steps down the quiescent d. c. potential to as low as a few volts at the output terminal of the circuit.

In a screen coupled cathode follower circuit, the input from the plate of the preceding stage feeds directly to the screen of a pentode. The output of the circuit is taken from the cathode-to-ground register, Rk, and directly feeds to the control grid of the next stage. Mathematical analysis for the screen-coupled cathode follower circuit based on its equivalent plate circuit is given by the author elsewhere.* When the screen current of the circuit is very small in comparison with the plate current, the voltage gain equation may be simplified to

$$\text{Voltage gain} = g/(g + 1/Rk)$$

where g is the transconductance of the tube, and Rk is the cathode-to-ground resistance of the circuit. According to this expression, the voltage gain for a screen-coupled cathode follower circuit has its maximum value equal to one when g is very large as compared with 1/Rk. When the plate current and the screen current both are small, Rk can be made large for the purpose of higher stage gain. Because even with a large Rk the cathode-to-ground potential is still not too high to make the coupling into the next stage difficult.

The plate current and the screen current of a tube both can be lowered by increasing the negative fixed bias voltage on the tube. Unfortunately, when the negative bias voltage increases, the screen grid-to-plate transconductance decreases.

The experimental data for a d. c. amplifier which consists of a 6J7 as a screen-coupled cathode follower stage, a 6SJ7 as the first stage shows: The overall voltage gain is 30 db with 0.85 volts peak output. The quiescent d. c. potential at the output terminal of the screen-coupled cathode follower is minus 1.5 volts. This negative 1.5 volts can be utilized as the bias voltage for the succeeding stage; and, therefore, the output terminal can be connected directly to the control grid of the next stage.

Another d. c. amplifier which employs a 6SJ7 as the first stage, a 6J7 as the screen coupled cathode follower stage, and another 6SJ7 as the final stage gives the following results: The total voltage gain is 67 db with 2.5 percent distortion at 15 volts peak output. The frequency response is flat up to 12 kilocycles. When a feedback register is provided from the output of the last stage (the plate of the 6SJ7) to the cathode of the first stage, the frequency response is then raised to 20 kilocycles with a vlotage gain of 60 db; and the distortion is also reduced to less than one percent at 15 volts peak output.

The operation of screen-coupled cathode followers is stable with wide-band frequency because the circuit is highly degenerative. There is no appreciable change in output for a six-hour run after the initial warm-up period.

The value of screen-to-plate transconductance 'g' of a pentode may be obtained by measurement with a simple laboratory setup. In order to avoid excessive amplitude distortion and to avoid high

screen current, the plate potential of a screen-coupled cathode follower circuit usually has to be higher than the peak value of the screen grid potential.

The pushpull arrangement which has been discussed in the early part of this paper may be incorporated with the screen-coupled cathode follower circuit to solve the problem of coupling between stages in a high gain d. c. amplifier using a single common power supply of limited d. c. voltage output. A high gain d. c. amplifier circuit emplowing phase inverter and screen-coupled cathode follower has proved itself to be very satisfactory in operation.