July, 1917

Bulletin No. 172

MANAGING A TUBERCULOUS HERD

The quarantine herd in its quarters in fall of 1912

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Animal Husbandry and
Veterinary Sections

Ames, Iowa

MANAGING A TUBERCULOUS HERD

PART I. HISTORY OF THE TUBERCULOUS HERD AT IOWA STATE COLLEGE SINCE 1909

BY W. H. PEW

Valuable breeding animals discovered to be tuberculous need not be sacrificed if they and their calves be handled according to the Bang method, or a modification of that method, of controlling tuberculosis and eradicating it from a herd. Of 23 calves born to the tuberculous cows of a quarantine herd on the Iowa State College farm, in the period from 1907 to 1915, inclusive, 18 passed the tuberculin test and proved to be free from tuberculosis; only 3 reacted to the test; 2 others were twins and were sold as veal at a few months of age. Among the 21 animals to be considered, the loss was 14.3 per cent.

This experiment was undertaken following the discovery of a considerable number of tuberculous animals in the college herd in 1907.* It was decided to keep some of the most valuable breeding animals, maintain them in a quarantine pasture where they would drop their calves and nurse them until weaned, and then test the calves and transfer them to a healthy herd. This method may properly be called the "modified Bang system," for it is based on the findings of Bang and others that the calves born to tuberculous cows are probably free from the disease and, if removed at once to healthy cows, will remain so. It differs from the Bang system in that the calves are permitted to remain with their dams until several months of age, on the supposition that the extra loss thereby incurred will be less than the expense of supplying healthy nurse cows for the calves.**

Immediately after the entire college herd had been tested in 1907, 21 animals in all were transferred to the quarantine pasture. On account of the lack of pasture, however, it was determined to eliminate young heifers and only fair breeders from the quarantine herd and send them to market, subject to inspection. Twelve in all were thus disposed of, leaving nine of the original number. By the end of 1909, the herd had been still further reduced in numbers, five of the original cows remaining with one new one added that year. In the spring of 1915, after the dis-

* The records of the tests of the herd are reported in Iowa Agricultural Experiment Station bulletin 107.

** The methods employed in the study of the tuberculous herd were suggested to Director C. F. Curtiss by Dr. E. C. Schroeder of the Bureau of Animal Industry. This work was under the supervision of W. J. Kennedy until 1912; since that date it has been under the supervision of the authors of the various sections of this bulletin.

posal of some aged cows which had become non-producers, only three head remained, one 3-year-old cow and calf (cow added to herd in 1913) and one 5-year-old cow (added in 1912). In the summer of 1915 two cows were sold for beef, subject to inspection.

CARE OF THE HERD

This tuberculous herd was maintained in a separate pasture at the north side of the college farm. During the pasture months the older cattle were given no extra feed, but were maintained on pasture alone. Water was obtained winter and summer from a creek running thru the pasture. At all times the calves were given the run of a creep in which was placed a feed trough for grain. It was planned to have the cows bred so that the calves would be dropped in the late spring or early summer. Some calves, however, were dropped in the winter. During the winter the cattle were fed roughage for maintenance, either shocked corn fodder, hay, or cane. The only protection afforded was a small shed, open to the south, as shown on the cover page illustration, together with trees in the pasture.

The cows in the tuberculous herd were tested after 1909 at different times. In all cases of retesting, reactions took place.

The healthy college herd, to which some of the offspring of the tuberculous herd were transferred, was tested regularly each

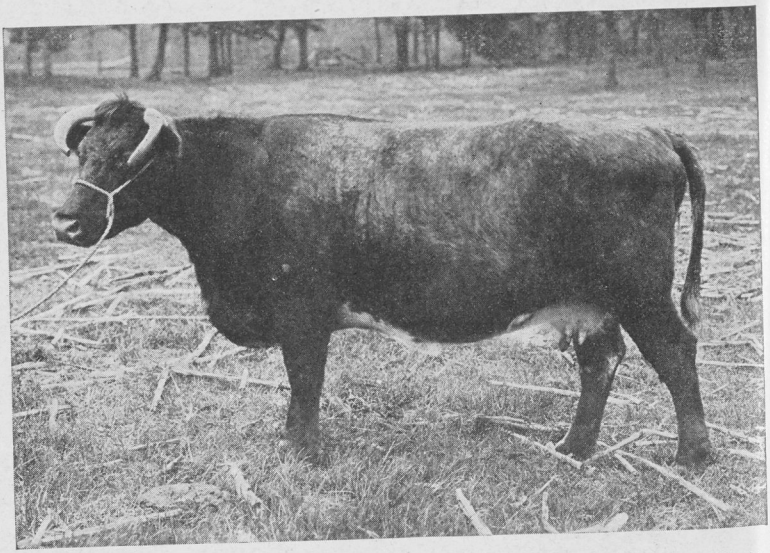

Fig. 1. **Beatrice of Ames.** Aged cow, put in quarantine in 1907. Photograph taken in spring of 1914. Sold in July, 1914, and condemned for generalized tuberculosis and udder infection.

year after the quarantine herd was established. Since 1912 the breeding herd of cattle, as well as the steer herd kept at the college barn, has been tested annually with the result that no reactions have taken place. In January, 1917, a test was made on breeding cows, steers, bulls, and calves over six months of age without a reaction. The herd of beef cattle on the college farm is now considered a tuberculosis-free herd.

The illustrations in this bulletin show the conditions of representative animals at different times of the year. The herd picture shown in the cover illustration was taken in the fall before the calves were weaned.

REPORT ON TUBERCULOUS COWS AND THEIR CALVES

BEATRICE OF AMES

Shorthorn cow—roan.
Calved, Oct. 12, 1901.
Reacted, 1907. Put in quarantine, 1907.
Dropped calves as follows:
March 6, 1908—Bull calf (later steered). Nursed dam for one year. Tested and put with herd and fattened for market. Passed inspection.
Nov. 27, 1909—Bull calf (steered). Nursed dam for one year. Tested and put with herd and fattened for market. Passed inspection.
Sept. 12, 1911—Heifer calf. Nursed dam for one year. Tested, returned to herd for one year—reacted spring 1913. Non-breeder, sold for beef, summer 1914. Passed inspection.
Sept. 25, 1912—Bull calf. Nursed dam for one year. Tested and retested. Passed. Sold for breeder.
Sold summer 1914 subject to inspection of college veterinarians. Condemned.

NONPAREIL LASSIE

Shorthorn cow—roan.
Calved, March 22, 1895.
Reacted, 1907. Put in quarantine, 1907.
Dropped calves as follows:
Feb. 4, 1908—Bull calf. Nursed dam for one year. Tested and taken to herd. Died March 19, 1909, pleurisy.
Nov. 14, 1909—Bull calf. Nursed dam for one year. Tested and retested. Sold for breeder.
Aug. 14, 1911—Bull calf and heifer calf. Nursed dam for one year. Both tested and retested. Passed. Bull sold for breeder. Heifer shipped for beef. Non-breeder. Passed inspection.
Sold Nov. 5, 1913—passed.

SOPHRONISBA

Hereford cow.
Calved, Aug. 28, 1898.
Reacted, 1907. Put in quarantine, fall, 1907.
Dropped calves as follows:
Jan. 5, 1908—Heifer calf. Nursed cow 10 months. Tested, passed and taken to herd.
Sold for beef, fall, 1908.

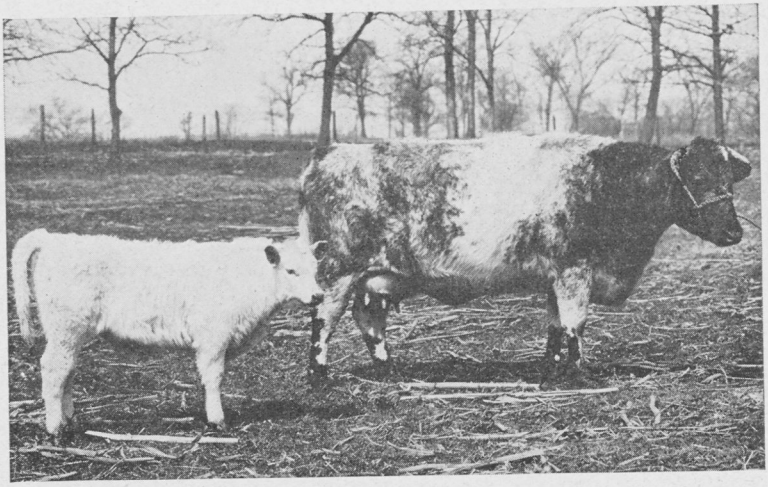

Fig. 2. **Nonpareil Maid and Calf.** Put in quarantine as yearling in 1907. Photograph taken in fall of 1914. Cow kept until July, 1915, then sold and condemned at slaughter. Calf tested at weaning and reacted; sold for beef and passed inspection.

NONPAREIL MAID

Shorthorn cow—roan.
Calved, March 28, 1906.
Reacted, 1907. Put in quarantine, 1907.
Slaughtered, July, 1915. Condemned.
Dropped calves as follows:

Nov. 2, 1909—Heifer calf—Nonpareil Lucy. Nursed dam for one year. Tested and taken to herd. Has been in herd six years. Passed test each year. Regular breeder.

Sept. 5, 1911—Bull calf (steered). Nursed dam for one year. Tested, taken to herd and exhibited at International, 1913. Passed inspection.

Jan. 18, 1913—Bull calf (steered). Nursed dam until Dec., 1913. Tested and reacted. Sold for beef subject to inspection. Passed inspection.

WINNIE OF MEADOW BROOK

Aberdeen Angus cow.
Calved, January 17, 1904.
Reacted, 1909. Put in quarantine, 1909.
Died, Aug. 5, 1913, of tuberculosis.
Dropped calves as follows:

Aug. 10, 1911—Bull calf (later steered). Nursed dam for ten months and sold to butcher subject to inspection. Passed and free from tuberculosis.

June 23, 1913. Heifer calf, Winnie's Last. Nursed cow until cow died, Aug. 5, 1913. Put on nurse cow that was free from tuberculosis. Calf tested in March, 1914. Reacted. Slaughtered, July, 1915. Condemned.

SCOTLAND'S MAY

Shorthorn cow—roan.
Calved, March 14, 1903.
Reacted, 1907. Put in quarantine, 1907.
Dropped calves as follows:
Oct. 6, 1908—Twins, bull and heifer. Sold to butcher for veal.
Jan. 12, 1910—Heifer calf, College May. Nursed dam for one year. Tested and taken to herd. Has been in herd six years. Passed test each year. Regular breeder.
Shipped to Agar Packing Company, Des Moines, Dec. 13, 1910. Passed.

BEATRICE FAREWELL 4th

Shorthorn cow—roan.
Calved, May 18, 1899.
Reacted, 1907. Put in quarantine, summer, 1907.
Dropped calves as follows:
June, 1908—Heifer calf. Nursed cow 6 months. Tested and reacted.
Cow and calf shipped to market, December 23, 1908. Both animals passed inspection.

EUDALIA

Aberdeen Angus cow.
Calved, Jan. 20, 1899.
Reacted, 1907. Put in quarantine, fall, 1907.
Dropped calves as follows:
Nov. 5, 1907—Heifer calf. Nursed cow 10 months. Tested, passed and taken to herd. Sold for beef, Nov. 5, 1913. Passed inspection.
Died of tuberculosis, spring, 1909.

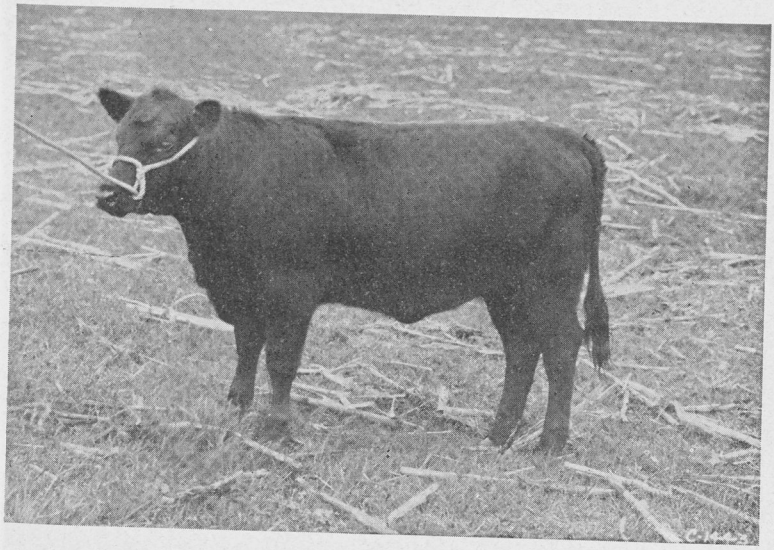

Fig. 3. **Winnie's Last.** Heifer one-year-old, calved June 23, 1913; daughter of Winnie of Meadow Brook. Photograph taken in spring of 1915; sold in July and condemned at slaughter.

MISS CHLOE

Hereford cow.
Calved, March 20, 1905.
Reacted, 1907. Put in quarantine, fall, 1907.
Dropped calves as follows:
May 19, 1908—Heifer calf. Nursed dam 8 months, tested, passed and taken to the herd. Sold for beef, March, 1910. Passed inspection.
Sept. 3, 1910—Cross-bred heifer calf. Spayed. Nursed dam 4 months, taken to herd and tested at 8 months of age. Passed. Fed and exhibited at International in 1911 and 1912. Sold for beef at International, 1912. Passed inspection.
Sold for beef, December, 1910. Passed inspection.

RUTH RUSTIC

Shorthorn cow—white.
Calved, Oct. 28, 1911.
Reacted, March, 1913. Put in quarantine, 1913.
Dropped calves as follows:
February 12, 1914—Heifer calf. Nursed cow 11 months. Tested and taken to herd. Retested and sold for breeder.
Sold for beef, fall 1915. Passed inspection.

EMMA

Shorthorn cow—red.
Calved, March 12, 1910.
Reacted, December, 1912. Put in quarantine, 1912.
Dropped calves as follows:
August 10, 1912—Bull calf. Nursed dam for one year. Tested and retested. Passed. Sold for breeder.
Sold for beef, summer 1915. Passed inspection.

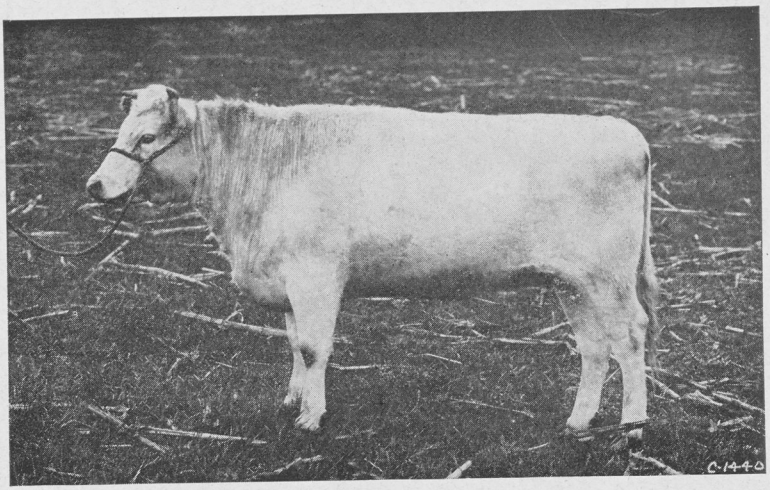

Fig. 4. **Ruth Rustic.** Yearling heifer, put in quarantine in 1913. Photograph taken in spring of 1913. Produced calf next spring and nursed calf until fall. Cow sold in fall of 1915 and passed inspection. Calf also passed test.

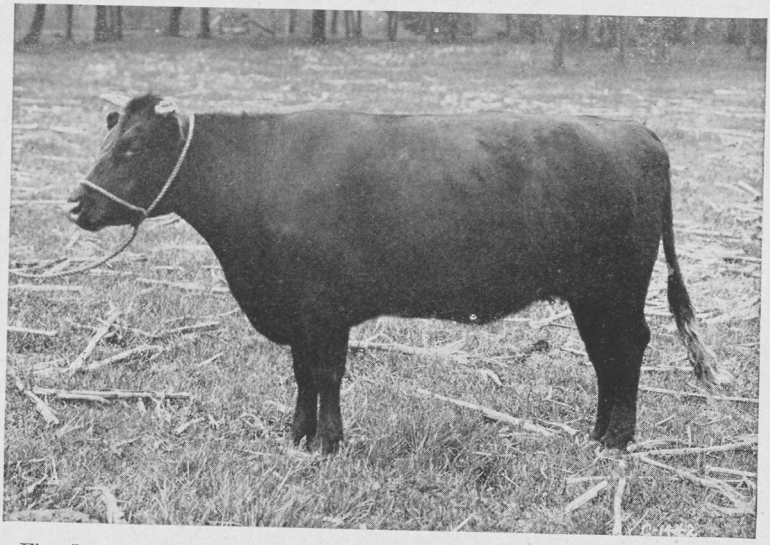

Fig. 5. **Emma.** Two-year-old heifer, put in quaratine 1912. Photograph taken in spring of 1913; produced calf in summer of 1912 which was kept for a year and sold as breeder after passing inspection. Cow sold and passed inspection.

Of the 23 caves dropped in quarantine 18 were non-reactors; 21 calves were kept to an age for testing. Three reacted to the tuberculin test.

The summary would, then, properly be 21 calves tested at weaning time; 18 passed the test proving to be free from tuberculosis; and 3 reacted to the test.

SUMMARY OF RECORD OF CALVES

Name of cow	No. of calves dropped in quarantine	No. calves not reacting	No. calves reacting
Beatrice of Ames	4	4*	0
Nonpareil Lassie	4	4	0
Nonpareil Maid	3	2	1
Scotland's May	3**	1	0
Winnie of Meadow Brook	2	1	1
Ruth Rustic	1	1	0
Emma	1	1	0
Beatrice Farewell 4th	1	0	1
Miss Chloe	2	2	0
Eudalia	1	1	0
Sophronisba	1	1	0
	23	18	3

* One heifer from Beatrice of Ames passed test, was taken to herd and reacted after being in the herd one year.

** Two of these calves were twins ands were sold for veal at a few weeks of age.

The results of this "modified Bang system" would tend to show that it is not necessary to discard reacting animals and that calves can be kept with the cows in open conditions with a fair degree of safety from spread of the disease. True there was some loss. It is a question which would have been the better policy, taking the cows from the calves immediately after birth and going to the expense of nurse cows, thereby reducing the loss by tuberculosis to the minimum, or permitting the calves to nurse their dams until weaning time and taking the chance of greater loss. The loss from reacting calves in this case was 3 out of 21 or nearly 14.3%.

In this case it woud seem that the cheaper method was the system which was followed. In the case of cows known to be producers of high priced calves, it would be more economical to provide nurse cows and not run the chance of the calves becoming infected from the dam.

PART II. PLANS FOR THE CONTROL AND ERADICATION OF TUBERCULOSIS

BY C. H. STANGE

BANG METHOD

One of the earliest methods suggested for the control and eradication of tuberculosis in cattle was the "Bang method," formulated and put into operation by Professor Bang of Denmark. This method consists of removing from the herd those animals showing clinical symptoms of tuberculosis, isolating the other infected animals, as based on the tuberculin test, and raising the calves on milk that is free from tubercle bacilli.

Under this plan it is necessary to make a careful clinical examination of all animals in the herd in order to remove those with physical symptoms. After the remainder have been tested two herds are established, one healthy and one infected, with separate pasture, stables, and attendants for each. The calves from the reacting cows are removed from the dams at the end of 24 hours, or after the colostrum has been secured from the dams' udders. The calves are afterward fed on milk from healthy cows, or the pasteurized milk from the reacting cows. The calves are subjected to the tuberculin test as soon as possible (in about six months) and the non-reactors (about 98 to 99%) are placed with the healthy cows, or preferably in a separate herd of healthy young stock.

This method reduced the percentage of reactors in Denmark from 40 per cent in 1893 to 8.5 per cent in 1908. On account of the difficulties surrounding the maintenance of separate herds,

the "Bang method" is not entirely practical under Iowa conditions.

MODIFICATIONS OF BANG'S METHOD

To meet different conditions, the Bang method has been modified by other experimenters. The best known of these modifications is probably that of Ujhelyi of Hungary who permits the calves of reactors to nurse healthy cows or, if necessary, allows them to nurse their dams, and tests them at weaning time and places the non-reactors in the healthy herd. Otherwise Bang's method is followed. In eight districts in Hungary the reactors were reduced from 59 per cent in 1898 to 3 per cent in 1904.

OSTERTAG'S METHOD

Ostertag does not apply the tuberculin test to the herd and therefore does not divide the herd into two groups, one reactors and another healthy, but emphasizes the removal of animals with open lesions (spreaders) and raising of calves on pasteurized milk or that from healthy cows. The calves are tested as under Ujhelyi's plan. The cows are carefully examined twice each year and a bacteriological examination is made of the milk and other secretions. This plan is being more generally adopted in Prussia each year and is leading to a gradual decrease in the prevalence of the disease but its eradication by this method is questioned.

INTERNATIONAL COMMISSION'S RECOMMENDATIONS

The International Commission on the Control of Bovine Tuberculosis, provided for by the American Veterinary Medical Association, after a careful consideration of the several questions concerning tuberculosis, recommended as follows on eradication:

THE COMMISSION'S RECOMMENDATIONS ON ERADICATION—A COMPOSITE OF THE METHODS OF BANG AND OTHERS

The Commission recommends the following plan of procedure:

It is recognized that in several points there are opportunities, in order to meet individual needs, to change or modify the directions herein given. It is understood, however, that whenever such modifications are made they should conform in the greatest detail to the principles laid down in the report of this Commission. The plan has for its purpose the conservation of the herd whenever that is possible.

The control of bovine tuberculosis involves a definite procedure under two distinct and different conditions, namely: (1) where a herd of cattle is free from tuberculosis and it is to be kept so, and (2) where one or more animals in the herd are infected and the purpose is to eradicate the disease and establish a sound herd.

PROCEDURE UNDER CONDITION ONE

The prevention of tubercular infection in cattle, free from tuberculosis, consists simply in keeping tuberculous cattle or other animals away from the sound ones; in keeping tuberculous animals out of pastures, sheds or stables where sound ones may be kept. Healthy cattle should not be ex-

posed to possible infection at public sales or exhibitions. Raw milk or milk by-products from tuberculous cows should not be fed to calves, pigs, or other animals. Cars that have not been thoroly disinfected should not be used for the transportation of sound cattle. Cattle that are purchased to go into sound herds should be bought from healthy or sound herds only.

PROCEDURE UNDER CONDITION TWO

The eradication of tuberculosis from infected herds requires for conservation of the herd different procedures according to the extent of the infection. For a guide to the control of the disease, tuberculous herds may be divided into three groups, namely:

1. Where fifty per cent or more of the animals are infected.
2. Where a small percentage (15% or less) of the animals are infected.
3. Where a larger number (15% to 50%) of the animals are diseased.

In eliminating tuberculosis from infected herds the following procedure is recommended:

GROUP 1

Herds where a tuberculin test shows fifty per cent or more of the animals to be infected should be treated as entirely tuberculous. The procedure here is as follows:

1. Eliminate by slaughter all animals giving evidence of the disease on physical examination.
2. Build up an entirely new herd from the offspring. The calves should be separated from their dams immediately after birth and raised on pasteurized milk or on that of healthy nurse cows. This new herd must be kept separate from any reacting animals.
3. The young animals should be tested with tuberculin at about six months old, and when reactors are found at the first or any subsequent test—the others should be tested not more than six months later. When there are no more reactors at the six months' test annual tests should thereafter be made. All reacting animals should at once be separated from the new herd and the stables which they have occupied thoroughly disinfected.
4. When the newly developed sound herd has become of sufficient size the tuberculous herd can be eliminated by slaughter under inspection for beef.

GROUP 2

1. The reacting animals should be separated from the non-reacting ones and kept constantly apart from them at pasture, in yard and in stable.

(a) Pasture. The reactors should be kept in a separate pasture. This pasture should be some distance from the other or so fenced that it will be impossible for the infected and non-infected animals to get their heads together.

(b) Water. When possible to provide otherwise reacting cattle should not be watered at running streams which afterwards flow directly through fields occupied by sound cattle. The water from drinking trough used by infected animals should not be allowed to flow into stables, fields, or yards occupied by sound animals.

(c) Stable. Reacting cattle should be kept in barns or stable entirely separate from the ones occupied by the sound animals.

2. Calves of the reacting cows should be removed from their dams immediately after birth. Milk fed these calves must be from healthy cows, otherwise it must be properly pasteurized. These calves should not come in contact in any way with the reacting animals.

3. The non-reacting animals should be tested with tuberculin in six months, and when reactors are found at the first six months, or any subsequent test, the others should be retested not more than six months later. When there are no more reactors at the six months' test, annual tests should

thereafter be made. All reacting animals should at once be separated from the new herd and the stables which they have occupied thoroughly disinfected.

The milk of the reacting animals may be pasteurized and used.

5. Any reacting animal which develops clinical symptoms of tuberculosis should be promptly slaughtered.

6. An animal that has once reacted to tuberculin should under no circumstances be placed in the sound herd.

7. As soon as the sound herd has become well established, infected animals should be slaughtered, under proper inspection.

GROUP 3

Herds that come within this group should be dealt with either as in Group 2, where the herd is separated, or as in Group 1, where all of the animals are considered as suspicious and an entirely new herd developed from the offspring.

GENERAL PRECAUTIONS

In all cases animals that show clinical evidence of the disease should be promptly eliminated. They should be destroyed if the disease is evidently far advanced; if not, they may be slaughtered for food under proper inspection.

All milk from tuberculous cows that is used for food purposes should be thoroly pasteurized. This means that it must be heated sufficiently to kill or to render harmless any tubercle bacilli that may be present in it. For this, it is necessary to heat the milk for twenty minutes at 149 degrees F. or for five minutes at 176 degrees F. It is important that pails or other utensils used in carrying the unpasteurized milk should not be used, unless previously sterilized, for storing the milk after it is pasteurized.

When diseased animals are found, the stables from which they are taken should be thoroughly cleansed and disinfected. To accomplish this, all litter should be removed; floors, walls, and ceilings carefully swept and the floors, together with mangers and gutters, thoroly scrubbed with soap and water. Thoro cleaning before the application of the disinfectant cannot be too strongly emphasized. After cleansing, the disinfectant should be applied. A five per cent (5%) solution of carbolic acid, a 1-1000 solution of corrosive sublimate, or a four per cent (4%) solution of sulphuric acid may be used.

When the stable can be tightly closed, formaldehyde gas properly used is reliable and satisfactory.

If tuberculous cattle have been kept in a small yard the litter should be removed, the surface plowed, and the fencing and other fixtures thoroly cleansed and disinfected.

MEMBERS OF THE COMMISSION

Dr. J. G. Rutherford, Ottawa, Canada, Chairman.
Dr. M. H. Reynolds, St. Paul, Minn., Secretary.
Senator W. C. Edwards, Ottawa, Can.
Mr. J. J. Ferguson, Chicago, Ill.
Mr. J. W. Flavelle, Toronto, Can.
Hon. W. D. Hoard, Ft. Atkinson, Wis.
Dr. C. A. Hodgetts, Toronto, Can.
Dr. J. N. Hurty, Indianapolis, Ind.
Dr. J. R. Mohler, Washington, D. C.
Dr. V. A. Moore, Ithaca, N. Y.
Dr. M. P. Ravenel, Madison, Wis.
Dr. E. C. Schroeder, Washington, D. C.
Mr. T. W. Tomlinson, Denver, Colo.
Dr. F. Torrance, Winnipeg, Can.

REPORT OF DR. RUTHERFORD

Dr. J. G. Rutherford, at that time Veterinary Director General of Canada, started some experiments in 1905, the objects being:

1. To ascertain the effects of the open air treatment on the diseased cattle themselves.
2. To ascertain to what extent healthy cattle kept in contact with diseased cattle under open air conditions were subject to infection.
3. To ascertain what percentage of healthy calves it is possible to rear without any precautions from diseased cows kept under open air conditions.

The experiment was continued for three years and his conclusions were as follows:

"The evidence, on the whole, leads to the conclusion that open air treatment is not likely to exercise any marked curative influence on animals already tuberculous, especially when reinfection is possible through cohabitation with clinical cases.

"In view of all the circumstances, the evidence derived from this experiment, as to the likelihood of animals becoming infected under open air conditions, is of no great value. It is, I think, highly improbable that such a large percentage of healthy calves could have been obtained from a herd of the same kind under ordinary stable conditions."

TESTS

The method that has been used in testing at Iowa State College is the same as was developed several years ago and reported in Bulletin 107. This (thermal) method, while surrounded by more or less inconvenience and difficulty, has not been superseded so far as accuracy is concerned by any other form of test.

The intradermal test, which consists of injections of concentrated tuberculin into (not beneath) the skin and the reaction to which is a characteristic, firm swelling at the seat of injection, is apparently coming into more general use. The just claim made for the latter method is a saving in time, labor, and material. These are important from the standpoint of both stockman and dairyman.

The ophthalmic or eye test is also receiving some consideration, but has not come into general use. The comparative accuracy of the different methods of testing for tuberculosis will be very difficult to determine on account of individual variations and characteristics of animals tested. Both the thermal and intradermal are sufficiently reliable to enable a competent person to eradicate tuberculosis from a herd.

IOWA AGRICULTURAL EXPERIMENT STATION
OFFICERS AND STAFF

State Board of Education

Hon. D. D. Murphy, Elkader
Hon. Paul E. Stillman, Jefferson
Hon. Parker K. Holbrook, Onawa
Hon. Henry M. Eicher, Washington
Hon. E. P. Schoentgen, Council Bluffs
Hon. W. C. Stuckslager, Lisbon
Hon. George T. Baker, Davenport
Hon. Frank F. Jones, Villisca
Hon. Charles R. Brenton, Dallas Center

OFFICERS

Hon. D. D. Murphy, Elkader, President
Hon. W. H. Gemmill, Carroll, Secretary

FINANCE COMMITTEE

Hon. W. R. Boyd, President, Cedar Rapids
Hon. Thos. Lambert, Sabula
Hon. W. H. Gemmill, Carroll

Agricultural Experiment Station Staff

Raymond A. Pearson, M. S. A., LL. D., President
C. F. Curtiss, M. S. A., D. S., Director
W. H. Stevenson, A. B., B. S. A., Vice-Director

AGRICULTURAL ENGINEERING

M. F. P. Costelloe, B. S. in C. E., Acting Chief
A. W. Clyde, B. S., Assistant

AGRONOMY

W. H. Stevenson, A. B., B. S. A., Chief
H. D. Hughes, B. S., M. S. A., Chief in Farm Crops
P. E. Brown, B. S., A. M., Ph. D., Chief in Soil Chemistry and Bacteriology
L. C. Burnett, M. S. A., Chief in Cereal Breeding
John Buchanan, B. S. A., Superintendent of Co-operative Experiments
L. W. Forman, B. S. A., M. S., Chief in Field Experiments
R. S. Potter, A. B., M. S., Ph. D., Assistant Chief in Soil Chemistry
F. S. Wilkins, B. S., Assistant in Farm Crops
R. S. Snyder, B. S., Assistant in Soil Chemistry
F. B. Howe, B. S., Assistant in Soil Survey
H. W. Johnson, B. S., M. S., Assistant in Soils
Knute Espe, B. S., Assistant in Soil Survey
T. H. Benton, M. S., Assistant in Soil Survey

ANIMAL HUSBANDRY

W. H. Pew, B. S. A., Chief
J. M. Evvard, M. S., Assistant Chief in Animal Husbandry and Chief in Swine Production
R. Dunn, B. S., Assistant in Animal Husbandry
Orren Lloyd-Jones, M. S., Ph. D., Assistant in Animal Husbandry
G. M. Turpin, B. S., Chief in Poultry Husbandry
L. S. Gillette, B. S., M. S., Assistant Chief in Dairy Husbandry
A. C. McCandlish, M. S. A., Assistant in Dairy Husbandry
O. C. Ufford, B. S., Assistant in Poultry Husbandry

BACTERIOLOGY

R. E. Buchanan, M. S., Ph. D., Chief; Associate in Dairy and Soil Bacteriology

BOTANY

L. H. Pammel, B. Agr., M. S., Ph. D., Chief
Charlotte M. King, Assistant Chief in Botany
I. E. Melhus, Ph. D., Chief in Plant Pathology

CHEMISTRY

A. W. Dox, B. S. A., A. M., Ph. D., Chief
W. G. Gaessler, B. S., Assistant Chief
A. R. Lamb, B. S., M. S., Assistant
S. B. Kuzirian, A. B., A. M., Ph. D. Assistant
G. P. Plaisance, B. S., M. S., Assistant
G. W. Roark, Jr., B. S., Assistant

DAIRYING

M. Mortensen, B. S. A., Chief
B. W. Hammer, B. S. A., Chief in Dairy Bacteriology
Dairying
D. E. Bailey, B. S., Assistant Chief in

ENTOMOLOGY

H. E. Summers, B. S., Chief (On leave of absence)
R. L. Webster, A. B., Acting Chief

FARM MANAGEMENT

H. B. Munger, B. S., Chief
O. G. Lloyd, B. S., M. S., Assistant Chief

HORTICULTURE AND FORESTRY

S. A. Beach, B. S. A., M. S., Chief
A. T. Erwin, M. S., Chief in Truck Crops
Laurenz Greene, B. S., M. S. A., Chief in Pomology
T. J. Maney, B. S., Assistant Chief in Pomology
G. B. MacDonald, B. S. F., M. F., Chief in Forestry

RURAL SOCIOLOGY

G. H. Von Tungeln, Ph. B., M. A., Chief

VETERINARY MEDICINE

C. H. Stange, D. V. M., Chief

GENERAL OFFICERS

F. W. Beckman, Ph. B., Bulletin Editor
F. E. Colburn, Photographer
C. E. Brashear, B. S. A., Assistant to Director