

Historical Document
Kansas Agricultural Experiment Station

EIGHTEENTH ANNUAL REPORT

OF THE

EXPERIMENT STATION.

OF THE

**Kansas State Agricultural College,
MANHATTAN.**

FOR THE FISCAL YEAR 1904-'05,

WITH AN

Index to Bulletins 124 to 129.

STATE PRINTING OFFICE,
TOPEKA, 1906.
1145



KANSAS STATE AGRICULTURAL COLLEGE.

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- Hon. GEO. P. GRIFFITH (1909),
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- Pres. E. R. NICHOLS (*ex-officio*), Secretary,
Manhattan, Riley county.

Miss LORENA E. CLEMONS, Assistant Secretary,
Manhattan, Riley County.

STATION STAFF.

COUNCIL.

- | | |
|---|--|
| E. R. NICHOLS, A. M.,
Chairman <i>ex officio</i> . | A. M. TEN EYCK, B. AGR., |
| J. T. WILLARD, M. S.
Chemist and Director. | OSCAR ERF, B. S.,
Dairy Husbandman. |
| E. A. POPENOE, A. M.,
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Veterinarian. |
| H. F. ROBERTS, M. S.,
Botanist. | |
| ALBERT DICKENS, M. S.,
Horticulturist. | LORENA E. CLEMONS, B.S.,
Secretary. |

ASSISTANTS.

- | | |
|--------------------------|------------------------------|
| V. M. SHOESMITH, B. S. | Assistant Agriculturist. |
| G. A. DEAN, B. S. | Assistant Entomologist. |
| C. L. BARNES, D. V. M. | Assistant Veterinarian. |
| ROSCOE H. SHAW, B. S. | Assistant Chemist. |
| R. J. KINZER, B. S. AGR. | Assistant Animal Husbandman. |
| R. E. EASTMAN, M. S. | Assistant Horticulturist. |
| G. F. FREEMAN, B. S. | Assistant Botanist. |
| ALICE M. MELTON, B. S. | Clerk in Director's office. |

FORT HAYS BRANCH STATION.

- | | |
|------------------------------|---|
| Superintendent. | A. D. COLLIVER, B. S.,
Assistant in Agriculture. |
| O. H. ELLING, B. S., Foreman | J. L. PELHAM,
Assistant in Horticulture. |
| | GEO. K. HELDER, Bookkeeper. |

*Term expires.

KANSAS STATE AGRICULTURAL COLLEGE,
MANHATTAN, KAN., January 27, 1906.

To his Excellency E. W. Hoch, Governor of Kansas:

DEAR SIR—I herewith transmit, as required by act of Congress approved March 2, 1887, the Eighteenth Annual Report of the Experiment Station of the Kansas State Agricultural College, for the year ending June 30, 1905, including financial statements for that period. It does not contain much of the results of experimentation in the different departments and at the Fort Hays Branch. These are printed in bulletins, paged consecutively throughout the year, and an index to those issued within the year is included with this report. The cooperative work with the United States Department of Agriculture is presented at some length, in so far as it has not been published already.

Respectfully,
E. R. NICHOLS,
Secretary Board of Regents.



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EXPERIMENT STATION
 OF THE
KANSAS STATE AGRICULTURAL COLLEGE
 MANHATTAN.

EIGHTEENTH ANNUAL REPORT—FISCAL YEAR 1904-'05

FINANCIAL STATEMENTS.

Report of the Custodian.

To the Board of Regents of the Kansas State Agricultural College:

GENTLEMAN—Herewith is submitted my report of receipts and expenditures on account of the Experiment Station for the period between July 1, 1904, and June 30, 1905:

Balance on hand July 1, 1904.....	\$847 30
Received from the treasurer of the United States	15,000 00
Received from cash sales of products.....	<u>3,418 75</u>
Total.....	\$19,266 05
Approved vouchers Nos. 1 to 437, including credits.....	<u>18,586 86</u>
Balance on hand June 30, 1905.....	\$679 19

Expenditures by departments are exhibited on the following page.

Expenditures by Departments, 1904-'05.

Items.	General.	Farm.	Botanical.	Chemical.	Dairy and animal husbandry.	Entomological.	Horticultural.	Veterinary.	Total.
By salaries.....	\$1,180 00	\$1,100 00	\$1,066 67	\$1,400 00	\$1,330 00	\$1,100 00	\$1,100 00	\$250 00	\$8,626 67
Labor.....	25 30	1,328 42	328 21	183 96	777 66	.....	1,669 24	141 66	4,952 54
Publications.....	38 85	107 40	21 10	.....	203 25	6 12	20 17	-28 88	425 27
Postage and stationery.....	19 69	2 85	10 73	10 96	21	2 90	6 77	16 61	70 15
Freight and express.....	92 83	80 41	28 80	38 63	24	82	67 79	35 19	344 61
Heat, light, water, and power.....	.....	52 63	.....	.....	.....	1 80	.....	6 55	60 98
Chemical supplies.....	.....	.....	22 95	58 61	9 58	.....	68 75	35 70	185 49
Seeds, plants, and sundry supplies.....	.....	105 64	55 51	16 55	.....	.....	175 71	23 62	440 03
Feeding-stuffs.....	.....	253 62	5 16	.....	507 67	.....	.....	113 78	885 23
Library.....	2 10	.....	85 56	.....	.....	.....	.....	2 24	89 90
Tools, implements, and machinery.....	42 50	40 25	36 00	367 40	133 83	262 50	20 00	15 25	907 73
Furniture and fixtures.....	1 98	.....	.....	16 60	.....	.....	.....	58 95	76 93
Scientific apparatus.....	.....	120 70	60 68	171 86	.....	.....	.....	164 07	517 31
Live stock.....	.....	.....	.....	.....	270 25	.....	.....	.....	270 25
Traveling expenses.....	.....	.....	.....	.....	23 75	89 05	34 57	2 00	149 37
Contingent expenses.....	183 85	.....	21 60	18 42	.....	.....	167 94	3 40	395 21
Building and repairs.....	.....	23 80	16 30	170 66	8 78	26 00	1 17	32 48	279 19
Totals.....	1,687 10	3,880 72	1,767 27	2,453 45	3,265 22	1,479 19	3,235 11	9,38 71	18,586 86



The following statements of the financial affairs of the Experiment Station are as reported to the United States Department of Agriculture; the several items of this account are covered by vouchers approved by the disbursing officer, certified by the secretary, and allowed by the president of the Board of Regents:

Experiment Station, Kansas State Agricultural College, in account with the United States appropriation, 1904-'05.

	Dr.	
To receipts from the treasurer of the United States, appropriation for fiscal year ending June 30, 1905, as per act of Congress approved March 2, 1887.....		\$15,000 00
	Cr.	
By salaries.....		\$7,828 33
Labor		4,038 30
Publications		329 55
Postage and stationery.....		37 97
Freight and express.....		331 18
Heat, light, water, and power.....		32 80
Chemical supplies.....		136 36
Seeds, plants, and sundry supplies.....		355 89
Feeding-stuffs		553 15
Library.....		20 06
Tools, implements, and machinery.....		212 95
Furniture and fixtures.....		73 88
Scientific apparatus.....		485 74
Live stock.....		270 25
Traveling expenses.....		80 87
Contingent expenses.....		35 00
Building and repairs.....		177 72
Total.....		<u>\$15,000 00</u>

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Experiment Station, Kansas State Agricultural College, for the fiscal year ending June 30, 1905; that we have found the same well kept, and classified as above; and that the receipts for the year from the treasurer of the United States are shown to have been \$15,000, and the corresponding disbursements \$15,000; for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving no balance.

And we further certify, that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

(Signed)	J. S. McDOWELL,
[SEAL.]	A. M. STORY,
	GEO. P. GRIFFITH.
	<i>Auditors.</i>

ATTEST: LORENA E. CLEMONS, *Custodian.*



Supplementary Statement.

Dr.

To receipts from other sources than the United States for the year ending June 30, 1905:

Balance on hand July 1, 1904.....	\$847 30
Farm and garden products.....	<u>3,413 75</u>
Total.....	<u>\$4,266 05</u>

Cr.

By salaries.....	\$698 34
Labor.....	914 24
Publications.....	95 72
Postage and stationery.....	32 18
Freight and express.....	13 43
Heat, light, water, and power.....	28 18
Chemical supplies.....	59 13
Seeds, plants, and sundry supplies.....	84 14
Feeding-stuffs.....	332 08
Library.....	69 84
Tools, implements, and machinery.....	694 78
Furniture and fixtures.....	3 05
Scientific apparatus.....	31 57
Traveling expenses.....	68 50
Contingent expenses.....	360 21
Building and repairs.....	<u>101 47</u>
Total.....	<u>\$3,586 86</u>
Balance.....	<u>679 19</u>
Grand total.....	<u><u>\$4,266 05</u></u>

Respectfully submitted.

LORENA E. CLEMONS,
Custodian.

REPORT OF THE COUNCIL.

The Staff.

The changes in the staff have been fewer than for many years. Dr. N. S. Mayo, veterinarian, resigned September 1 to take the position of chief of the bureau of animal industry in the republic of Cuba. His successor, Dr. F. S. Schoenleber, began service April 1, 1905. The vacancy in the assistantship in botany was filled by the election of Mr. Geo. F. Freeman, whose term of service began September 1, 1904. At the Branch Station, Mr. J. G. Haney closed his connection December 31, 1904, since which time Foreman O. H. Elling has been in charge. Mr. A. D. Colliver has been assistant in agriculture since March 29, 1905, and Mr. J. L. Pelham began work as assistant in horticulture March 27, 1905. Geo. K. Helder began service as bookkeeper April 19, 1904, and still fills that position.

Publications.

The publications for the year include the Seventeenth Annual Report, Bulletins Nos. 124 to 129, and Press Bulletins Nos. 132 to 142. Though the bulletins are few in number, they are of larger size than heretofore, the total number of pages being 404. This is more than in any preceding year. A brief summary of the publications follows:

ANNUAL REPORT.

SEVENTEENTH ANNUAL REPORT, 1903-'04, November, 1904. 3000 copies. This contains the financial statements of the custodian and secretary, the report of the Council, and a list of the publications to date. The report of the Council includes brief statements concerning the work of the departments and of that of the Fort Hays Branch Station, the work at McPherson in cooperation with the United States Department of Agriculture, and of the progress in destruction of gophers and other noxious mammals. A presentation of the need of more money for experimental work was also made.

BULLETINS.

BULLETIN No. 124.—EXPERIMENTS IN FEEDING STEERS AND IN BREEDING AND FEEDING PIGS. (*Pages 1-58.*) March, 1904. Animal Husbandry Department. 25,000 copies.

This large bulletin, illustrated by fifty-two cuts, describes experiments in

feeding ensilage, alfalfa hay, corn and Kafir-corn to steers of different ages. Observations and experiments with pigs are on a number of points, among them: Gains of shoats on alfalfa or rape pastures, as compared with dry feeding; feeding alfalfa hay to shoats; comparative test of pure-bred and cross-bred pigs; arrangements for dipping hogs; farrowing houses for sows, and slaughter tests.

BULLETIN NO. 125.—EXPERIMENTS WITH DAIRY COWS. (*Pages 59-162.*) May, 1904. Animal Husbandry Department. 25,000 copies.

This bulletin brings up to date the experiments of the department. Many were begun or conducted several years previously. Investigations as to what the average Kansas cow is doing, dairying with common cows, dairying with grade cows, and dairying with pure-breds, with much collateral work, are described. Studies of feeding dairy cows, as to grain, roughage and pasture are included. The subject of milk testing and causes of variation in the test received much attention. The bulletin contains thirty-nine cuts.

BULLETIN NO. 126.—EXPERIMENTS WITH HAND-FED CALVES. (*Pages 163-198.*) May, 1904. Animal Husbandry Department. 25,000 copies.

The importance of successful rearing of calves by hand is recognized, and the results of many lines of experimentation described, such as feeding milk and skim-milk, feeding whey, feeding hay tea, feeding grain, feeding roughage, water and salt, calf ties, scours, dehorning calves, and weight of skim-milk calves. There are fourteen illustrations.

BULLETIN NO. 127.—THE ROOTS OF PLANTS. (*Pages 199-252.*) June, 1904. Farm Department. 25,000 copies.

Illustrations and descriptions are given of the root systems of corn, Kafir-corn, sorghum, wheat, oats, barley, flax, orchard-grass, *Bromus inermis*, Big bluestem grass, buffalo-grass, Kentucky blue-grass, clover, alfalfa, soy beans, cowpeas, potatoes, sugar beets, and certain trees. Some results of soil-moisture studies are included.

BULLETIN NO. 128.—EXPERIMENTS 1902-'04. (*Pages 253-330.*) December, 1904. Fort Hays Branch Station, 25,000 copies ordered.

This, the first bulletin issued by the branch, begins with a history of the origin of the Station, and includes a somewhat detailed statement of the work of the first three years. The following are among the most important topics: Beginning of work, improvements, prairie-dogs, alfalfa, barley, macaroni wheat, winter wheat, corn, grasses, irrigation work, horticulture, and forestry. Fourteen plates show scenes at the Station.

BULLETIN NO. 129.—KANSAS MAMMALS IN THEIR RELATION TO AGRICULTURE. (*Pages 331-404.*) December, 1904. General Department. 25,000 copies.

This bulletin was prepared in accordance with an act of the legislature

authorizing the regents of the College to employ a suitable person to make a study of the food habits of the mammals and birds of the state and to make reports thereon. It includes a complete systematic list of the mammals that have been found in the state in recent times, but the bulk of the bulletin is made up of consideration of their economic relation to agriculture, and of methods of repressing injurious ones.

PRESS BULLETINS.

No. 132.—THE COMMON GARDEN MOLE. July 19, 1904. General Department. 4500 copies.

No. 133.—GRASSHOPPER POISONS. August 16, 1904. Entomological Department. 2700 copies.

No. 134.—BABY BEEF. August 23, 1904. Fort Hays Branch. 2700 copies.

No. 135.—RINGBONE AND SPAVIN. February 21, 1905. Veterinary Department. 4000 copies.

No. 136.—CONTAGIOUS ABORTION IN CATTLE. March 7, 1905. Veterinary Department. 5000 copies.

No. 137.—SOME TROUBLES OF SWINE. March 21, 1905. Veterinary Department. 4000 copies.

No. 138.—TESTING SEED-CORN FOR VITALITY. March 28, 1905. Farm Department. 3000 copies.

No. 139.—GARGET. April 11, 1905. Veterinary Department. 6000 copies.

No. 140.—KANSAS EXPERIMENT STATION EGG-LAYING CONTEST. May 16, 1905. Dairy and Animal Husbandry Department. 4000 copies.

No. 141.—SWINE-FEEDING TEST WITH SORGHUM-SEED MEAL, KAFIR-CORN MEAL, SOY-BEAN MEAL, AND CORN-MEAL. May 23, 1905. Dairy and Animal Husbandry Department. 3000 copies.

No. 142.—SUMMER PRUNING. June 27, 1905. Horticultural Department. 3200 copies

Work of the Departments.

In the following paragraphs brief summaries are presented of work in progress, and of other duties of the departments concerning which bulletins are not issued. The chief accomplishments of most of the departments are published in bulletins.

AGRICULTURAL DEPARTMENT. The department is increasing the work in seed selection and propagation. Several hundred bushels of choice seed-grain and seed-corn were sold and distributed

among the farmers of the state last winter and spring. Cooperative experiments in the growing of crops have been begun with several farmers and certain county poor-farms in different parts of the state. Large numbers of variety tests are being made of wheat, rye, barley, oats, emmer, einkorn, flax, buckwheat, millet, soy beans, cowpeas, sorghum, Kafir-corn, mangles, grasses, etc. Twenty different plans of crop rotation have been started, one-fourth-acre plats being used. Many experiments and observations on soil moisture have been made in connection with experiments with seed crops and catch crops; cultivation experiments with corn; methods of preparing the seed-bed for corn; experiments in rotation of crops, and experiments to determine the amount of water required by different crops.

The department is breeding seven different varieties of corn by the selection of individual ears and planting the seed of each ear in a single row. With small grains, a selection has been made from the best heads of desirable plants for the purpose of securing a pure strain of the best-producing varieties. Efforts are being made to develop hardy winter varieties of durum wheat, emmer, oats, and barley. Some work is being done in breeding alfalfa and grasses, with the purpose of developing pure types as well as improving them. Several species of wild grasses are under cultivation. Experiments in date of planting are being conducted with wheat, oats, barley, soy beans, cowpeas, corn, Kafir-corn, and sorghum. Experiments with sod crops are in progress. Nitro-culture preparations are being tested on the seed of alfalfa, Red clover, Crimson clover, cowpeas, and soy beans. Experiments with corn include study of the preparation of the seed-bed and deep and shallow cultivation. Observations on soil temperature were commenced last spring, and the effect of different conditions of cultivation of the soil and of different crops on the temperature is being studied. The root development of certain crops is still under observation.

BOTANICAL DEPARTMENT. The experiments reported in previous years in the breeding of soy beans, corn and the small gains have been continued. Breeding and improvement of soy beans has reached a definite conclusion. A race of plants found to retain its seeds and pods for an unusual length of time—a desirable feature in the soy bean as a grain crop—has been isolated and definitely established, the past season's work being the last that will be necessary in the way of selected breeding. During the present season the object will be to increase the yield for general planting. Ex-

periments in corn breeding, for increased protein content, have been continued as usual, although the number of varieties experimented with has been reduced. The considerable number of corn hybrids made during the previous year have been close-fertilized, and the seed has been planted again during the present season. The object is twofold: First, to ascertain more facts regarding the behavior of corn hybrids, and especially the extent to which hybridization of corn can be relied upon as a means of originating new varieties with fixed characters in certain important particulars; and second, to determine the effect of continued close pollination, extending over a considerable period of years, in the case of plants that normally cross-pollinate, for the most part. In wheat, a considerable number of new hybrids were originated during the past season, and as of particular moment may be mentioned certain hybrids effected between spelt and wheat and between emmer and wheat, the object of hybridization in this case being the origination of hardier races of bread wheat for the plains region farther west. Problems involved in acclimatization are receiving serious attention, and cooperative experiments in the acclimatization of corn have been arranged for and entered upon this year with the experiment stations of North and South Dakota, Nebraska, and Texas.

Investigations in plant diseases have occupied considerable time during the past winter and spring, resulting in the discovery of the nature and character of an important disease affecting the Austrian pine. The plum-tree canker, a local disease of cultivated peppers and a greenhouse malady of cultivated violets have also been under investigation, with results partially completed. Investigation of adulterations, substitutions and impurities in commercial seed, particularly of forage crops, such as alfalfa, *Bromus inermis*, English blue-grass, etc., has been undertaken on an extensive scale. Material and data at hand are being embodied in a bulletin to this end. A small increase has been made in the departmental library, so far as literature regarding plant-breeding and plant diseases is concerned. In respect to equipment, the changes from last year have been minor.

CHEMICAL DEPARTMENT. The work of the year included the completion of the chemical examination of lime-sulphur cattle dips begun the previous year. The products obtained by different formulas were analyzed, with a view of discovering the best and most economical. The changes that take place on exposing a dip to air were investigated. Methods of analysis were devised in this connection. The results are nearly ready for publication in a bul-

letin. Numerous determinations of the nitrogen in corn were made in connection with the efforts of the Botanical and Farm Departments to establish new varieties of high quality and to improve existing varieties. There is now in progress an investigation concerning the physical characteristics and chemical composition of the eggs produced by four pure breeds of fowls. This involves examination of all the eggs produced by six hens of each of the breeds Plymouth Rock, American Red, White Wyandotte and Leghorn during a period of six weeks. This work is in connection with the egg-laying test conducted by the Dairy and Animal Husbandry Department. Much time has been required by miscellaneous analyses for other departments of the Station and by analyses for the public. Testing concentrated feeds on sale in the state has been frequently called for in this connection. Analyses of commercial fertilizers were made at the request of Sec. F. D. Coburn. These were samples furnished in accordance with the present state law. For most of the outside work charges were made designed to cover the cost. The need of effective laws concerning the sale of concentrated feeding-stuffs and fertilizers becomes more manifest constantly. In preparation for future study of the milling and baking qualities of flour produced from the numerous varieties of wheat now under culture by the Station and its branches, an experimental reduction mill was purchased just at the close of the year.

DAIRY AND ANIMAL HUSBANDRY DEPARTMENT. This department has had numerous experiments under way. Among the feeding experiments was one with fattening cattle, the object being to compare a balanced ration of alfalfa and concentrates with one of a variety of forage and concentrates. The results were favorable to the alfalfa. Another experiment compared the value of rations with large and small percentages of concentrates for dairy cows. An experiment was conducted to compare steers with open heifers for feeding; this was tried with yearlings and duplicated with calves, and the steers gave the best returns. Experiments in feeding swine had for their object a determination of the relative feeding value of tankage, sorghum seed, soy beans, Kafir-corn, shorts, and corn. An experiment was conducted in the production of mutton. One hundred head of sheep were fed—fifty Mexicans and fifty Montanas. Each class was divided into four lots, which were fed different rations, the object being to determine the profitability of each class of sheep and of the rations fed, respectively. In connection with an organization of poultry-raisers an experiment was begun November 1, 1904, with seven of the leading breeds of

fowls, namely: Single-comb White Leghorns, Rose-comb White Leghorns, Plymouth Rocks, Buff Wyandottes, White Wyandottes, American Reds, and Brahmas. The test will cover a year's time, and will include a detailed record of the egg production of each hen and an account of the feed cost of each lot, six hens of each breed being used. An effort is being made to breed cattle that will be immune from blackleg, using calves that have been found to be so. Experiments in the dairy have been made to test the results from different methods of cleansing utensils, in which the bad effects of careless cleansing were strongly brought out; conditions causing a variation in the percentage of fat delivered from various cream separators were studied; some experiments were made touching the influence, on milk production, of manipulation of the udder of the cow by hand or by mechanical means, or stimulation by electricity. A number of other minor experiments were also conducted in the creamery.

ENTOMOLOGICAL DEPARTMENT. Since the withdrawal of state appropriation for the continuance of the work of extermination of the prairie-dog and pocket-gopher, and the resignation of the former field agent in charge, the preparation and distribution of prairie-dog and gopher poison has been made a part of the work of this department. In connection therewith there has been pursued a study of the habits and distribution of small mammals of economic interest, notably the pouched rats, the wood-rats, and the field-mice. In conjunction with the Horticultural Department, with a view to solving the problem of efficient and reasonably cheap application of orchard sprays on a large scale, there was undertaken a comparative test of several widely advertised makes of power sprayers, typical of the most practical methods of power application for this purpose. The collection and study of the scale-insects begun several years since has been prosecuted with advantage. The remaining time at the disposal of the force has been used in the continuance of the accumulation of data looking toward a general treatment of injurious insects of the garden and orchard.

GENERAL DEPARTMENT. The executive work of the Station has been much as in previous years, and calls for little special comment. The prompt and careful attention to some 6000 letters and postal cards received; the constant care of the mailing-list, now including 21,450 addresses; business in connection with the Station at Mc- M
Pherson conducted in cooperation with the United States Department of Agriculture oversight of the printing and binding of

Station publications, and many other items of a general character, have been part of the work of the director's office. The president has certified to all vouchers and the secretary has kept the accounts as heretofore. The mailing of publications has been supervised by Superintendent Rickman, which is an assurance that it was well done. The mailing sheets are furnished him by the director. These are galley proofs from linotype lists kept for us in Topeka. This method of handling the mailing is very convenient and the cheapest yet devised, and has been retained in spite of earnest solicitations to change on the part of interested representatives of other modern systems of mailing. Current requests for publications are attended to by the director's clerk.

HORTICULTURAL DEPARTMENT. A considerable part of the work of the department has been a continuation of experiments inaugurated in former years and noted in previous reports. Orchard treatment for various tree fruits is being continued; tests of varieties are being extended and numbers of new ones added; the study of pollination of apples is being continued. With grapes, tests of spraying materials, effectiveness, and cost, and keeping qualities in cold storage are being investigated. Of the wild fruits under cultivation, a number of plums and persimmons have come into bearing and the fruit has been carefully described. Tests of the propagation of both are being continued. In the forest plantation recent plantings have been thinned, reproduction from coppice growth and general observations and measurements have been continued. Tests of vegetables for commercial purposes, especially varieties for shipping and canning, are being continued. In the nursery work, the matter of stock selection for the various fruits and the treatment of stock and soil for the prevention of crown gall is still under observation. The matter of protection of potatoes from scab and blight is still under observation.

The work undertaken within the year consists of: Investigations as to the cost and efficiency of power spray pumps operated by the following sources of power: Gasoline, compressed carbonic acid gas, compressed air, pump driven by geared truck wheel, compressed-air pump operated by hand, and common hand force-pump. Fertilizer test for strawberries and other fruits. Summer pruning of unfruitful apple trees compared with pruning done in the dormant season. A test of intensive culture applied to a small garden, noting the expense of growing, the possibility of succession of crops, and the value of the products. Propagation of coniferous

trees from native seed has given very encouraging results, especially with the Red cedar, *Juniperus virginiana*, and the Bull pine, *Pinus ponderosa*.

The work at the Fort Hays Branch Station has embraced tests of dry culture, mulching and irrigation of vegetables and small fruits, and a test of varieties under such treatment. Considerable plantings of Russian mulberry, *Morus alba*, Osage orange, *Toxylon pomiferum*, catalpa, *Catalpa speciosa*, honey-locust, *Gleditschia triacanthos*, cottonwood, *Populus deltoides*, and various willows have been made. Acorns and walnuts planted in November, 1904, in locations where the trees are wanted permanently, have made very good growth. The Red cedar has up to date been inferior in rate of growth and apparent hardiness. The Scotch pine has made a very fine showing. Orchard-trees have made good growths, and grape-vines are succeeding very well.

VETERINARY DEPARTMENT. — The loco experiments are still in progress. The efficiency of some of the most common coal-tar products used in the preparation of dips for cattle and hogs and the relative antiseptic and germicidal values are being determined. The preparation of blackleg vaccine has passed the experimental stage, and its efficiency is now firmly established.

Fort Hays Branch Station.

The Fort Hays Branch Experiment Station of the Kansas State Agricultural College receives its maintenance from appropriations by the state legislature, supplemented by such revenue as is derived from the sale of surplus grain, seed, live stock, and other produce, the proceeds from which are reappropriated for support of the Station.

The legislative appropriations available for the fiscal year ending June 30, 1905, together with the purposes for which such funds were expended, follows herewith:

CURRENT EXPENSES.....	\$5,200	Officers salaries labor merchandise, supplies, sundry repairs, and expense.
CATTLE SHEDS AND YARDS, ..	750	New stock sheds. enclosures and feed-lot equipment.
FENCING.....	700	Pastures and fields enclosed as funds permitted.
IMPLEMENTS	1,000	New working equipment.

The supplemental income, known as fees and accounts, derived

from sales of Station products, is set forth in the following statement for the fiscal year 1904-'05:

Balance July 1, 1904.....	\$1,185	51
Cattle sold.....	3,305	75
Grain.....	2,297	85
Seed.....	675	70
Feed.....	38	15
Potatoes.....	255	58
Miscellaneous.....	49	75
Paid out toward general expenses of Station main- tenance.....	\$4,867	45
Balance on hand June 30, 1905.....	<u>2,940</u>	<u>84</u>
Totals	\$7,808	29 \$7,808 29

The harvesting of the crop of 1904 showed good results, though the yields were rather low, owing to the dry weather during the winter and early spring, and excessive rains during May and June, causing much injury to small grain by rust. The spring crops suffered most injury; oats, barley, emmer and spring wheat all made low yields.

The area devoted to winter wheat was 275 acres. This acreage includes thirty-one one-acre plats, rotation experiment, treatment of land for wheat, preparation of seed-bed tests, cultivation wheat plats, and 176 varieties on one-hundredth-acre plats.

The test of varieties of small grain was unfavorable. Winter wheat yielded but one-half as much as in 1903, but the best yielding varieties were the same both years, the Kharkov being the highest. Spring small grains were practically a failure, with the exception of oats; and of these, the Kherson gave the best yield and the Texas Red the next.

All forage crops made good yields. Alfalfa made three good crops, though *Bromus inermis* and other grasses have not made as favorable a showing as was hoped. Corn produced a good yield. The irrigation work was made more extensive and good results were obtained. However, it appears that our method of pumping water is rather expensive for irrigating common crops. Potatoes and vegetables, and perhaps alfalfa, give profitable returns for irrigation. Nearly all the experiments were successfully carried out, and the results published in Bulletin No. 128, which also gives results of the previous year, and contains 65 pages of printed matter and 14 illustrations.

A great deal of the field-work of 1904 is being repeated in 1905, though more extensively. A new series of experiments with flax

is now in progress, to test date and thickness of seeding and the effect on the land.

New varieties of corn were received from North Dakota, Colorado, and Manhattan, and tests to determine best methods of planting and preparation of seed-bed are being tried. More alfalfa is being seeded, and Sand lucerne is also on trial.

By selection, the winter wheat varieties have been increased to 380. As many as five distinct types were selected from a single hybrid, the purpose being to originate more hardy varieties that will produce better yields. All together, some 800 varieties of winter wheat, oats, barley, durum wheat, flax, soy beans and sorghum are on trial. Most of these are being tried on one-hundredth-acre plats, though including plats to test the rate and time of seeding, four ten-acre plats, three eight-acre plats, four five-acre plats, 120 one-acre plats and twenty ten-acre plats are being seeded. The land in cultivation comprises about 800 acres, with sixty acres in alfalfa and *Bromus inermis*.

Considerable work in horticulture and experimental vegetable gardening is being done. A variety orchard of 300 trees, consisting of apple, plum, and peach, set out in 1903, gives promise of a good orchard and the forest-trees are doing nicely. About six acres of acorns and walnuts were planted, and 8000 forest-trees, such as hackberry, catalpa, locust, elm, Russian mulberry, cottonwood, and maple, were set out this year. Experiments with nearly 100 varieties of vegetables, and tests to determine best methods of growing, are in progress.

The provision of the congressional bill which required that a public park be established was fulfilled by setting apart about forty-three acres of land along Big creek, where the timber has been spared. The Station set out some 2500 trees, graded the drives, and installed gates and fences.

In the latter part of April a feeding experiment with eight lots of two-year-old steers was concluded. Each bunch was fed a different ration, the object being to test Western-grown feeds for beef production. It demonstrated the importance of the balanced ration as a guide to all practical feeders. It showed alfalfa hay far superior to either Kafir-corn hay or sorghum in beef production, and that one pound of ground Kafir-corn is about equal to one pound of corn-and-cob meal.

The Station herd was divided into two classes, grade Shorthorn and grade Hereford. For the former a pure-bred Shorthorn bull was secured, and for the latter a pure-bred Hereford. The culls

were thrown out, the purpose being to grade up these two herds by the use of pure-bred bulls.

A few of each of the following breeds of hogs have been purchased : Poland-China, Duroc-Jersey, and Berkshire.

The appropriation provided for only a few improvements. Four sheds have been built in the feed-lots, making twelve in all. Nearly two and one-half miles of hog- and cattle-yard fence of woven wire have been built, and a very substantial corral joined to the horse barn. A new bullock scale with pen was installed at the feed-yards, to avoid driving the fattening cattle for weighing.

In the way of implements, a Hapgood-Hancock ten-disk plow, a Dain side-delivery rake, a Champion mower, a Plano self-binder, a New Deere hay-loader, a Lightning hay-press, a walking-plow, two farm wagons, a heavy, three-seated spring wagon and sundry small tools were purchased.

***Cooperative Experiments with the United States
Department of Agriculture.***

Cooperative experiments with the Department of Agriculture have been continued in investigation of cereals at the Station at McPherson and at the Fort Hays Branch Station. These are in connection with the Bureau of Plant Industry. In addition, investigations in irrigation have been carried on in cooperation with the Office of Experiment Stations.

CEREAL INVESTIGATIONS.

The cereal investigations have for their object the testing of newly introduced varieties and of hybrids and selections made by the Station or the department. The department furnishes seed, and, last year, \$200 toward expenses at Hays, and the same for expenses at McPherson. The Station furnishes the man in charge at Hays, and all permanent equipment, fencing, land, etc., at both places. The results obtained at these two points, in connection with those at Manhattan, furnish excellent data for forming conclusions concerning the adaptability of grains in the state.

Many of the results obtained at the Fort Hays Branch Station have been published in Bulletin No. 128. The following summary is furnished by Mr. Elling:

"The variety tests of small grain in cooperation with the Bureau of Plant Industry of the United States Department of Agriculture were a continuation of the work begun in 1903. No cross-pollination was done, as the number of varieties and hybrids on trial required considerable time and

attention. The end sought in the trial of varieties is to originate by careful selection more hardy, better-yielding sorts that will prove to be more profitable in this western section. On account of the rather dry spring and heavy June rains, which gave ideal conditions for rust, the yields of all small grains were low. Winter wheat averaged less than ten bushels per acre, and durum wheat, barley, oats and emmer all gave light crops. In 1904, 24 one-acre plats, 95 one-hundredth-acre plats, and 60 small plats, less than one-hundredth acre, of winter wheat, and 25 one-acre plats and 50 hundredth-acre plats of spring grain, were harvested. The yields were secured on all plats containing one-hundredth acre or more, and show a great variation per acre. However, in the field-tests the Kharkov, Imported Turkey and Weissenberg proved promising. By selection, the winter wheat varieties have been increased to 380; as many as five distinct types were selected from a single hybrid, the purpose being to originate hardy varieties that will produce better yields. Twenty-six one-acre plats, 7 one-fifth-acre plats, 4 one-tenth-acre plats, 123 one-hundredth-acre plats and 220 smaller plats were planted. Some 22 varieties of durum wheat and 26 varieties of oats were received from the department, making a total of 46 durum wheats, 56 oats, 34 barleys, seeded the spring of 1905. Six of the durum wheats, 6 of the oats and 16 of the barleys were seeded on acre plats, while the remainder, with the exception of 13 one-tenth-acre plats, were seeded on small plats in the variety garden."

The detailed observations on these cooperative plantings are reported to the Department of Agriculture and filed for reference. They cover eight large pages of tabulation.

The cereal investigations now conducted at McPherson are in continuation of those begun on the College farm by Mr. Carleton, cerealist of the department, and later transferred to Halstead, where they were carried on until the fall of 1903, when they were transferred to McPherson. Thirty acres are now leased there, and a seed-house and a shed for implements and small lots of unthrashed grain have been erected by the Station, or contracts let for them.

Last fall the assistant in charge was Mr. L. A. Fitz, while the spring work and harvest have been attended to by Mr. H. F. Blanchard. The following statement of yields is extracted from Mr. Fitz's report for the year ending December 31, 1904:

WHEAT (winter).

C. I. No.	Name.	Yield.	C. I. No.	Name.	Yield.
	Currell.....	25.11 bu.	1559.....	Crimean.....	26.53 bu.
1436.....	Crimean.....	23.50 "	1560.....	Banat.....	20.17 "
1437.....	Crimean.....	23.66 "	1561.....	Theiss.....	24.00 "
1438.....	Ghirka Winter.....	27.04 "	1562.....	Bacska.....	22.23 "
1439.....	Ulta.....	25.42 "	1563.....	Weissenberg.....	26.63 "
1442.....	Kharkov.....	29.50 "	1564.....	Pesterboden.....	18.75 "
1558.....	Turkey.....	35.33 "	1583.....	Kharkov.....	26.54 "

DURUM OR MACARONI VARIETIES (spring).

C. I. No.	Name.	Yield.
2086.....	Pelissier.....	11.00 bu.
2094.....	Kubanka.....	12.67 "
2100.....	Black Don.....	11.67 "
2228.....	Saragolla.....	10.33 "
2246.....	Kubanka.....	16.25 "

BARLEY (winter).

C. I. No.	Name.	Yield.
257.....	Tennessee Winter...	62.50 bu.

BARLEY (spring).

C. I. No.	Name.	Yield.	C. I. No.	Name.	Yield.
190.....	Beldi.....	27.50 bu.	264.....	From Garton Bros..	22.35 bu.
194.....	Telli.....	24.15 "	265.....	" " "	20.22 "
195—S. P. I....	7969.....	22.78 "	266.....	" " "	25.90 "
			267.....	" " "	10.14 "

OATS.

C. I. No.	Name.	Yield.
135.....	Tobolsk.....	8.75 bu.
165.....	Sixty Day.....	44.80 "
293.....	Burt.....	40.71 "
337.....	(From Algeria).....	29.36 "

The following, furnished by Mr. Blanchard, shows the extent of the plantings this year and includes a number of general statements of interest:

"The object of the experiments at the McPherson Station has been to determine upon good varieties of grain especially adapted to central and western Kansas with regard to yield, rust resistance, drought resistance, earliness, and a high nitrogen content. In carrying on these investigations a large number of department and Kansas hybrids, which are showing themselves as especially adapted to our conditions, have been grown; also many of the standard varieties, including wheat, oats, barley, emmer, einkorn, rye, etc., for the purpose of determining upon their adaptability to different sections of the state.

"Owing to the fact that the location of the Station for the year 1903-'04 was not an altogether favorable one, due to an unevenness of the land and also to its foulness, it was considered advisable to change the location to a point one-half mile due north. The present Station comprises thirty acres of land one-half mile north and one mile west of the post-office, the section lines running on the south and west boundaries. This is as favorable a piece of land as could be obtained in the vicinity of McPherson and is fairly representative of the central section of the state.

"The soil of the Station and about McPherson is of a clayey nature, the

particles being comparatively small. There is very little sand mixed with it. Owing to a very great amount of rainfall during the harvest season of 1904, much of the wheat that was grown that year was left on the ground; this germinated rather late in the fall and came up with our earliest fall seeding, causing much extra work throughout the year in our attempts to eliminate the volunteer grain from that which we had seeded. This volunteer wheat and rye provided a good place for the start of the fall brood of the Hessian fly.

"The fall brood of the Hessian fly accomplished considerable damage in many of the plats of our earliest fall seeding, cutting down the yield of these plats about half. This fly did not seem to survive the winter, and the plats were not again attacked by them during the spring, as is often the case. The chinch-bugs put in an appearance late in the spring, but not soon enough to do any particular damage. We did not notice them at all until we began cutting our latest spring seeding of barley and oats. The harvest bugs interfered with our work to some extent by cutting the strings on the tags, so that in a few instances we lost track of numbers altogether; these were not only a nuisance in the field, but also got into the bundles after they had been stored in the thrashing shed. For a while it looked as though the wild buckwheat would choke out some of the later plats of spring barley. However, the dry weather of the latter part of May and the first of June, along with a hot wind that occurred at that time, gave this weed such a setback that the barleys had a much better chance to make the necessary amount of growth, although this dry weather damaged many of the spring barleys.

"Crab-grass, sunflowers and cockle-burs are other bad weeds. There is in the soil much of this seed that does not germinate in the fall until after the seeding. Good cultivation and rotation of crops may in time exterminate any of these weeds. The wild buckwheat does not appear except in the spring seeding; the winter character of the fall grain keeps it back in the early spring. Although there was a great deal of rust during the season of 1904, its non-appearance in the plats was quite noticeable this season. The orange leaf-rust was noted in many of the plats that were seeded in the fall, but there was not enough in any case to make any difference in the yield or quality of the grain. The black stem-rust did not make an appearance except in some of the very latest cuttings, and in these instances barely enough to be noticeable. Smut appeared a little later in the Tennessee Winter barley and Sixty Day oats; other varieties were free from it.

"From the results of the year we would say: Plow as soon as possible after harvest; keep well harrowed, in order to conserve moisture for fall seeding and kill out weeds and volunteer grain. As the present location of the Station was not decided upon until rather late, it was along in August before twenty acres of the Station were plowed, while the remaining ten acres were plowed as late as December. The difference in growth and yield has shown itself very distinctly in each case on this early and late plowing, everything being in favor of the early fall plowing. The effect of the amount of cultivation after plowing was also very noticeable, being much in favor of that which has been given the most thorough cultivation. The preparation of the soil for seeding has consisted of plowing about five inches deep,

and following this with the disk and leveling harrow. The finer the surface the better, but in drilling in the seed the drill rows should be at right angles with the prevailing winds.

"During this season the time of seeding in the fall has influenced the vigor and growth of plants very materially. Grain seeded as late as the middle of October has shown up much better throughout the entire season than that sown from the 15th to the 20th of September. The exact reason for this is not perfectly clear. After the early seeding had made considerable growth there were a few weeks of dry weather, affording little moisture for the large, vigorous plants; at the same time the Hessian fly attacked these plants quite severely, causing many of the leaves to lose their green appearance and die down to the crown of the plant. The severe cold of winter came on with these plants in an unhealthy condition, and as a result when spring opened these plants were not in the healthy, vigorous conditions conducive to proper growth and yield. At time of ripening these plats were characterized by small, short heads and low yields. The late seeding gave better results in vigor, growth, and yield. During the dry weather of the fall the plants were small, and did not require a great deal of moisture; they were not attacked by the Hessian fly, and in nearly all cases came through the winter with a good, vigorous appearance, although quite small. In this later seeding the soil received more cultivation in our efforts to get rid of the volunteer wheat and rye. Most of the seeding was delayed with the farmers on account of the very late harvest, and the average yield is about eighteen bushels per acre.

"We used the standard tenth-acre plat as a unit—a plat two chains long and one-half chain wide; the alley between plats five links wide, which is hardly wide enough to admit the bull-wheel of the binder in harvest. The hand plats consisted of rows run the narrow way of the tenth-acre plats; all of these rows as well as the drill rows running east and west, on account of the prevailing wind. Our method of seeding hand plats has been, first, to make a furrow about three inches deep, and then run along in the bottom of this furrow with the hand seed-drill; this method works exceedingly well at this Station. In planting the department hybrids we made one row thick and one row thin; this worked to advantage when we made selection of plants. The row of thick-seeded offset any advantage that the row of thin-seeded had over the soil. In harvesting the hand plats we cut just as soon as the first best heads were ready, in this way selecting for earliness, as the late-ripening heads were still green, and the grain from them would shrivel and could be easily eliminated. Our object has been, in harvesting grain, to cut at once when the grain was ready and not wait until dead ripe.

"As this has been an exceptionally good year for the grain producers in this section, it has been a poor year to get results in our experimental work, as there was comparatively little of rust and smut to contend with. The atmospheric conditions were such that we could make only fair determinations on tenacity and strength of straw. As the Hessian fly attacked the early seeding in autumn of plats that we had planted especially for yield tests, our results along this line are not what they might have been.

Rainfall during the season of 1904 and 1905.

McPherson, Kan., July 1, 1904, to July 1, 1905.

July.....	10.86 inches	January.....	1.5
August.....	2.81 "	February.....	1.5
September.....	5.14 "	March.....	2.5
October.....	1.53 "	April.....	2.5
November.....	.24 "	May.....	5.5
December.....	.33 "	June.....	5.0
Total, 39.45 inches.			

LIST OF PLATS OF AUTUMN AND SPRING SEEDING.

Autumn, 1904.

- 4 acre plats of common bread wheats.
- 2 acre plats of Tennessee Winter barley.
- 16 tenth acres of common bread wheats.
- 2 tenth acres of Currell wheat.
- 1 tenth acre of Zimmerman wheat.
- 7 tenth acres of einkorn.
- 2 tenth acres of Tennessee Winter barley.
- 2 tenth acres of Ivanov rye.
- 33 increase plats of common bread and soft wheats.
- 2 increase plats of rye.
- 1 increase plat of spelt.
- 3 increase plats of winter oats.

These increase plats varied in size, the largest being not more than one-half acre. In each case we planted all of the seed that we had on hand, as they were grains that had made an especially good showing the previous seasons.

Row Planting.

- 265 types of department hybrids.
- 144 types of Kansas hybrids.
- 121 standards of bread and soft wheats.
- 26 standards of rye.
- 2 durum wheats.
- 6 barleys.
- 2 oats.
- 25 Farrer's hybrids (none survived winter).
- 125 Halstead hybrids.

Spring, 1905.

- 5 acre plats of oats.
- 13 tenth acres of oats.
- 15 increase plats of oats.
- 74 row plantings of oats..
- 1 third acre of barley.
- 2 sixth acres of barley.
- 4 tenth acres of barley.
- 18 increase plats of barley.
- 148 rows of barley.
- 1 row planting of spring rye.
- 2 increase plats of emmer.
- 1 increase plat of engrain double.

- 5 tenth acres of durums.
- 31 row plantings of durums.
- 4 row plantings of Minnesota wheat.
- 5 tenth acres of common white corn.
- 19 varieties of department corn.
- 2½ acres of department corn from Mr. Hartley.
- 1 tenth acre of alfalfa.
- 5 varieties of buckwheat.

With the larger acreage now at command, we hope soon to have considerable quantities of the better sorts of grain which can be sold to farmers of the state; in fact, this has already been done to a certain extent. The hybrids originated by the Department of Agriculture and by this Station are also increasing in quantity, so that their qualities are becoming apparent. Chemical and milling tests will be made later.

IRRIGATION INVESTIGATIONS.

The cooperative investigations in irrigation undertaken in connection with the Office of Experiment Stations, Washington, D. C., were made at the Fort Hays Branch Station and near Garden City, Kan. The object and plan of the work is set forth in the following: *Agreement between the Office of Experiment Stations of the United States Department of Agriculture and the Kansas State Agricultural College Experiment Station.*

THIS AGREEMENT, Made this 22d day of February, 1904, between the Office of Experiment Stations of the United States Department of Agriculture and the Kansas State Agricultural College Experiment Station, witnesseth:

1. That the parties to this agreement are to carry on a cooperative investigation at the Fort Hays Branch Station of the Kansas State Agricultural College Experiment Station to determine:

(a) The cost of pumping water from the well at the Fort Hays Branch Station and of its application to land.

(b) The lowering of the level of the water in the well by pumping at different rates and the maximum quantity of water that the well will furnish.

(c) The amount of water applied and the yield of crops on land irrigated and the yield on adjacent unirrigated land.

(d) The effect of irrigating in winter only.

(e) The amount of rainfall and evaporation.

The crops under experiment are to be garden vegetables, potatoes, sugar beets, alfalfa, and, if there is sufficient water available, Kafir-corn, sorghum, and corn.

The Kansas State Agricultural College Experiment Station shall be held responsible for the proper carrying out of these investigations and for the preservation of the original records.

These records shall be open to the inspection of the agents of the Office of Experiment Stations at any time, and the Kansas State Agricultural Col-

lege Experiment Station shall furnish to the Office of Experiment Stations, on or before January 15, 1905, a complete report of these investigations.

2. The collection of information regarding the cost of pumping water from wells in southwestern Kansas and the relative efficiency of different forms of pumps and of different kinds of motive power; the gathering of information regarding the methods of applying water to land in irrigation and the introduction of better methods than those in common use, and the determination of the duty of water in this portion of Kansas.

The irrigation investigations of the Office of Experiment Stations, United States Department of Agriculture, shall be held responsible for the proper execution of these investigations and for the preservation of the original records.

A report of these investigations will be furnished by the Office of Experiment Stations to the Kansas State Agricultural College Experiment Station on or before January 15, 1905.

The results of these investigations may be published by either party, but such publication must include a statement that they were obtained in cooperative investigation and give proper credit to both parties thereto.

The expense of the investigation at Hays, Kan., shall be borne by the Kansas State Agricultural College Experiment Station, but the Office of Experiment Stations shall furnish the instruments for measuring the water applied, the rainfall, and the evaporation. The expenses of gathering of facts regarding pumping water in southwestern Kansas and the application of water to crops in this region shall be borne by the Office of Experiment Stations.

OFFICE OF EXPERIMENT STATIONS.

By A. C. TRUE, *Director*.

KANSAS STATE AGRICULTURAL COLLEGE EXPERIMENT STATION.

By J. I. WILLARD, *Director*.

Approved: JAMES WILSON, Secretary of Agriculture.

The results obtained at Hays were printed in Bulletin No. 128, pages 307-315, and showed good results from irrigation, but at too high a cost. The traction-engine used in pumping was not economical for the purpose. The work in southwestern Kansas was reported by the Office of Experiment Stations as follows:

INTRODUCTORY.

The valley of the Arkansas river at Garden City, Kan., is divided into two distinct flats or levels, each with a natural slope of about seven feet per mile in an easterly direction, or in the same general direction and with the same average slope as the river-bed. The lowland, or first bottom, as it is termed, extends from one-fourth to one-half mile on either side of the river, and is devoted wholly to the raising of hay, as during periods of exceptionally high water it is completely flooded. The higher flat, or second bottom, on the north side of the river, owing to its uniform slope and the general character of the soil, is particularly adaptable to irrigation. From a point about three miles west of Garden City

to a point about five miles east, where the sand-hills on the south and the bluffs on the north suddenly close to within a half-mile, this bottom is entirely covered by the Garden City ditch and its laterals, which are owned and controlled by citizens of Garden City. The ditch was originally planned to irrigate 6000 acres, but owing to an injudicious use of water in irrigation, seepage, and evaporation, and to losses due to poor construction and equally poor maintenance, the maximum irrigating capacity of the system has been only about 3000 acres, and even this was possible only during periods of exceptionally high water in the Arkansas river. As the supply of water from the river is not to be depended upon, a large number of windmills are used to raise water for irrigation, and in several instances small centrifugal pumps and gasoline-engines have been installed for this purpose. The areas irrigated in this manner are not large, yet, in view of the uncertainty of water-supply from other sources, to irrigate the smaller areas by individual pumping plants and to specialize crops are economic lines along which most successful results can be obtained. Opposed to this, the citizens of Garden City advocate the combination of the water brought to the surface by pumps or by gravity, and its discharge into and distribution through the ditches already established. Of the two methods of obtaining water a gravity system is perhaps the more strongly advocated. Numerous engineers have been consulted regarding the feasibility and probable cost of such development, and the opinions advanced have been as varied as the methods proposed for bringing the water to the surface.

THE APPARENT SUPPLY OF UNDERGROUND WATER.

That the so-called "underflow" is enormous in this district is unquestionable, but to what extent it can be drawn on without having to wait for a replenishing of the affected area is a question that can be decided only by a practical test. In such plants as are in operation it is impossible to affect materially the supply, and continuous pumping adds to rather than detracts from the efficiency of the wells.

The surface of the ground-waters in this region is a plane with a slope to the east of seven feet to the mile. The river-bed has the same general direction and slope, but the underground waters do not seem to depend at all on the water conditions of the river, except that continued high water produces a slight rise in the ground level. Following the receding of the river the surface of the ground-water gradually assumes its normal level, and continued stages of low water, or times when the river is dry, do not affect it.

The yearly contribution to the supply by precipitation alone must necessarily be great. The catchment area is large, and with a rainfall of about twenty inches per year draining into this water-bearing stratum, the supply would appear to be inexhaustible. Observations made of the water-supply in established pumping stations sustain this assumption.

The largest plant in this vicinity is the one from which the city is supplied with water. Here a 20-foot circular well was dug, and curbed with brick and cement work, and from the bottom of this a 12-inch perforated-iron feeder was sunk to the depth of 20 feet. This single feeder furnishes 500,000 gallons of water per pumping day of sixteen hours. During this pumping the water in the main well is lowered about 15 feet, but at this point the water supplied by the feeder becomes equal to the demand, and a further lowering at this rate of pumping is impossible. Several times, however, through forced pumping, the water has been pumped beyond the capacity of the feeder, and the consequent lowering of water has exposed the action of the feeder, which, with all pressure removed from above, becomes practically an artesian well. Measurements by Mr. Willard Johnson during one of these periods gives the discharge of the feeder at 900 gallons per minute.

At the Richter well, 1.5 miles west of Garden City, a 12-foot circular sheet-iron casing was sunk to a depth of 16 feet, and from the bottom of this four perforated feeders, three 6 inch and one 12 inch, were sunk to a depth of 14 feet. Measurements of the water-level were taken during a pumping test of an hour and forty-five minutes on September 3, 1904. At ten o'clock A. M. the water-level was 9.2 feet below the top of the casing. This level is counted the normal. The measurements are as follows:

Changes in the water-level of the Richter well during pumping.

TIME.	Depth.	TIME.	Depth.	TIME.	Depth.	TIME.	Depth.
	<i>Feet.</i>		<i>Feet.</i>		<i>Feet.</i>		<i>Feet.</i>
10:00 A. M.	9.2	10:07 A. M.	13.2	10:14 A. M.	14.2	10:25 A. M.	14.4
10:01 "	10.0	10:08 "	13.5	10:15 "	14.3	10:30 "	14.4
10:02 "	10.9	10:09 "	13.7	10:16 "	14.4	10:45 "	14.4
10:03 "	11.7	10:10 "	13.8	10:17 "	14.4	11:00 "	14.4
10:04 "	12.4	10:11 "	13.9	10:18 "	14.4	11:15 "	14.4
10:05 "	12.8	10:12 "	14.0	10:19 "	14.4	11:30 "	14.4
10:06 "	13.0	10:13 "	14.1	10:20 "	14.4	11:45 "	14.4

This well is equipped with ten-horse-power gasoline-engine and a pitless pump of 800 gallons capacity per minute. Owing to general disorder of the engine and to the rotting away of the wooden casing surrounding the pump, the efficiency of the plant

was low, only 405 gallons per minute being pumped during this test. Reliable authority states that after an eight-hour test of this well, during which time 800 gallons per minute was pumped, 16.6 feet below the surface was the greatest depth to which the water was lowered.

In the tests of the Richter well uniformity of the results obtained is due to the continued pumping. This well is one of the oldest in the valley, and from long and continued use the water, its head varying with the amount of water pumped, has, in following the lines of least resistance, opened up new channels that have in time been drained of the finer material, and the velocity of the flow has greatly increased. A comparison of the test of the Richter well and the following tests taken at King Brothers' well, eight miles north-west of Garden City, August 30, 1904, shows a decided difference in the velocities with which the water enters the wells.

The following notes were taken at the first pumping of the King Brothers' well:

A 4-inch centrifugal pump was set at the water-level, 40 feet below the surface of the ground. The arrangement of idlers and the shaft bearing would not allow continuous pumping without too great a heating of the parts, and the measurements are not, therefore, so satisfactory as it is probable later ones will be. The measurements following were taken in two wells—the main well, which was 91 feet deep, and from which the water was pumped, and the test well, 87 feet deep, and placed 25 feet south. A distance from the surface of 42.2 feet was taken as the normal level. The first test began at 11:05 A. M.

Changes in the water-level in the King Brothers' well during the first pumping test.

TIME.	Depth in main well.	Depth in test well.	TIME.	Depth in main well.	Depth in test well.
	<i>Feet.</i>	<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
11:05 A. M.	42.2	42.2	11:12 A. M.	60.0	45.0
11:06 "	49.2	42.2	11:13 "	59.0	45.0
11:07 "	53.7	43.1	11:14 "	46.6	44.6
11:08 "	59.6	43.5	11:18 "	45.6	44.4
11:09 "	59.8	44.8	11:20 "	43.8	44.0
11:10 "	60.0	44.9	11:25 "	43.0	44.0
11:11 "	60.0	44.9			

* Pumping ceased.

The second test began at 2:15 P. M. The water in the well had not at this time reached its previous height, and the water-level was forty-three feet below the surface. The following table shows the results of pumping:

Changes in the water-level in King Brothers' well during second, pumping test.

TIME.	Depth in main well.	Depth in test well.	TIME.	Depth in main well.	Depth in test well.
	<i>Feet.</i>	<i>Feet.</i>		<i>Feet.</i>	<i>Feet.</i>
2:15 P. M	43.0	43.0	2:27 P. M	58.8	43.9
2:16 "	52.5	43.0	2:28 "	59.9	43.9
2:17 "	55.0	43.4	2:29 "	60.0	43.9
2:18 "	57.2	43.7	2:30 "	60.0	43.9
2:19 "	58.5	43.9	2:31 "	60.0	43.9
2:20 "	59.0	43.9	2:32 "	60.0	43.9
2:21 "	58.8	43.9	2:33 "	60.0	43.9
2:22 "	58.8	43.9	2:34 "	59.7	43.9
2:23 "	58.8	43.9	2:35 "	59.7	43.9
2:24 "	58.8	43.9	2:36 "	59.7	43.9
2:25 "	58.8	43.9	2:37 "	59.7	43.9
2:26 "	58.8	43.9			

During this pumping an even discharge of 175 gallons per minute was attained, except when the water, under increased head, brought into the feeder a quantity of fine sand. There was sufficient pressure to raise this to the suction-pipe, and the discharge of the pump when throwing a large percentage of sand was materially diminished. At three different times during this pumping this condition was noticeable, but with continued pumping it became less pronounced, and in time this finer material will be drawn off within the circle of influence developed by the well to such an extent that the water will flow into the well with a greater velocity, and will be entirely free from the finer sand. In other words, the efficiency of these feeders sunk to within a foot or eighteen inches of the impermeable bed of silt that underlies the valley increases rather than diminishes with use. This bed of river silt being uneven, in a great number of cases the feeders in the plants in operation have not reached its depth. It has been found that the supply of water in feeders that do not reach this depth is much less than in those that do, and that the increase in water-supply with increased depth of feeders is far greater proportionately than the increase in depth.

WINDMILL IRRIGATION NEAR GARDEN CITY, KAN.

Thirty-one windmill plants were visited, and measurements taken of the size of mills, reservoirs, land irrigated, and water supplied. As it is not possible to determine the duty of a mill directly from an observation of the amount pumped without in some way measuring the velocity of the wind, the method of getting at the duty of a mill and the duty of an acre-foot of water was to question the irrigator as to the time required to fill the reservoir in a good wind, the average number of times per week through the season that the reser-

voir is filled, and the number of reservoirs of water usually applied to any specified piece of land. There are several serious elements of error in this sort of data. The time for one filling was in most cases given in days or half-days. The depths drawn off from the reservoirs was in nearly every case reported greater than the total vertical distance between the bottom of the outlet and the top of the bank. Notwithstanding these sources of error, it is believed that the data as collected show approximately, enough for practical use by those contemplating windmill irrigation, what one can reasonably expect to do with a mill of a given size with a moderate lift. The data on the duty of water are believed to give a reliable average for single irrigations. The number of applications varies greatly with the season.

Nearly all of the pumps used are of the design known as the Stone pump, made in Garden City. This is a piston pump, made in large sizes, from 6 to 12 inches in diameter, and is used with a stroke of 6 to 12 inches. It is customary to use a pump the size of which is two less than the diameter of the windmill in feet; that is, a 6-inch pump is used with an 8-foot mill, etc. In most cases the stroke of the mill is adjusted to 10 or 12 inches. As it is not possible to make a study of the efficiency of these pumps without disconnecting them from the mills, in this report only the diameter of the mill is considered, disregarding the leakage and efficiency of the various pumps.

In giving the duty of windmills of various sizes, the number of acre-feet per day pumped by each-mill in a "good wind" is given, but the number of acre-feet in a season (twenty weeks), which is estimated from statements made by irrigators as to the average amount pumped, is not based on continuous operation at that rate, but takes into account the time during which the wind blows. In many cases mills of two sizes were used to pump water into a single reservoir. In such cases the amount pumped by each mill is assumed to be in proportion to the surface exposed by each wheel to the wind. The data regarding the thirty-one windmills observed are condensed in the following tables:

Average duty of windmills.

MILLS.	Lift.	Amount pumped per day.	Amount pumped in season (20 weeks).	Area irrigated.
	<i>Feet.</i>	<i>Acre-feet.</i>	<i>Acre-feet.</i>	<i>Acres.</i>
Six 8-foot mills.....	13	0.03	3.4	2.1
Eleven 10-foot mills.....	14	.17	7.0	4.1
Thirteen 12-foot mills.....	14	.27	11.7	5.7
One 25-foot mill.....	12	1.20	54.0	8.0

It is evident that the surface exposed by a windmill to the wind varies as the square of the diameter, and it is reasonable to expect that the amount of work done will vary in the same ratio. The above table shows, however, that there is a very marked increase in the amount of work done by the larger mills. For instance, an 8-foot mill raises 3.4 acre-feet in a season, so that one would expect to find that a 12-foot mill would raise $9/4$ times 3.4, or 7.6 acre-feet, but as a matter of fact the twelve-foot mills averaged 11.7.

The area irrigated by a single mill does not seem to bear any definite ratio to the amount pumped in a season. This is due to the fact that many of the plants covering small areas are shut down a good part of the season, which is not taken account of in the estimates of the amount pumped in a season.

It is probable that all the mills falling below the averages given above do so because of leakage or lack of care, or poor exposure to the wind. The following table is made by throwing out all mills which fall below the average, and is probably a better measure of the duty of mills than the table given above:

Duty of mills pumping more than the average.

MILLS.	Lift.	Amount pumped per day.	Amount pumped in season (20 weeks).
	<i>Feet.</i>	<i>Acre-feet.</i>	<i>Acre-feet.</i>
Three 8-foot mills.....	13	0.09	4.0
Four 10-foot mills.....	14	.26	11.5
Eight 12-foot mills.....	14	.34	14.4

In order to determine the number of acres which can be irrigated by an average windmill plant, it is necessary to first ascertain the duty of water. This was found to vary greatly in different cases. The depth applied at a single irrigation on fruit-trees averaged 0.24 foot; on beets, 0.54 foot; on sweet potatoes, 0.32 foot, and on garden vegetables, 0.6 foot. The last figure, however, contains two estimates, one of 1 foot and one of $2\frac{1}{2}$ feet, for single irrigations. If these are disregarded, the depth applied to garden vegetables averages 0.12 foot. The average single irrigation on all crops is 0.37 foot depth. The number of irrigations is variously reported as from 2 to 7. It is not possible, however, to estimate closely from such data what the duty of water would be in a dry year, as the rainfall in 1904 was quite sufficient for some crops (such as alfalfa), and nearly sufficient for all. It is probable that a depth of $1\frac{1}{2}$ feet would be sufficient in any except extremely dry years. Using this as a basis, it is fair to say that an 8-foot mill should ir-

rigate 6 acres, a 10-foot mill nearly 8 acres, and a 12-foot mill nearly 10 acres, the season being considered as 20 weeks. The heaviest winds during the irrigating season are in May and June. During July and August many plants do very little work for days at a time; so that the number of acres which can be irrigated, if dependent on the duty of a mill during July and August, may be somewhat less. The actual number of acres irrigated is far smaller than the above estimates, being 2.1 for an 8-foot mill, 4.1 for a 10-foot mill, and 5.7 for a 12-foot mill.

COST OF WINDMILL PLANTS.

The first cost of putting land under water by a windmill plant is much less to-day than it has been heretofore, on account of the strong competition between various manufacturers and the lower cost of transportation. For this reason the cost of plants, as reported by the owners, is much greater than the present cost would be in many cases.

The cost of a number of plants observed was:

12 foot.....	\$150
10 foot	120
8 foot.....	90

The above estimates do not include the cost of reservoirs. The average cost of a large number was given as about \$60, which includes in most cases the cost of lining the banks with sod, or puddling the sides and bottom by driving cattle around the reservoir. In many reservoirs the leakage is so great that the efficiency of the plant is seriously reduced. A loss of two to six inches per day is not uncommon. Proper construction, and, if necessary, the use of clay as a puddle, should reduce the leakage to not more than say one inch per day, which is more than the loss from many plants.

The cost per acre irrigated ranges from about \$20 to \$75 or \$80. Such high cost is found in plants irrigating much less than their capacity. For instance, a two-mill plant, costing \$280, is used on four acres of sweet potatoes, while it should water at least ten acres.

Windmill plants near Garden City, Kan.

The following data regarding other windmills near Garden City were collected by Mr. Collins:

No.	OWNER.	Size of mill.	Size of pump.	Depth to water.	Depth in water.	Total.	Tank or reservoir.	Irrigating head.	Area irrigated.	Year erected.	Cost per acre.
		<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Acres.</i>	<i>Year.</i>	<i>Year.</i>
1	Robert Johnson.....	8	6	11	26	37	30 by 30.....	2.5	2	1900	\$2 50
2	Sam. Austin.....	10	8	13	23	36	50 by 50.....	2.5	3	{1901	2 00
		10	8	13	23	36				{1894	2 00
3	Frank Penington.....	8	4	13	23	36	50-barrel tank			1902	2 00
		12	10	11	22	33				70 by 80.....	3
4	J. I. Pierce.....	8	6	9	20	29	50 by 50.....	3	2.50	1892	2 00
5	Ed. Pyle.....	12	8	10.5	22	32.5	40 by 70.....	3	1	1900	3 00
6	Shep. Norris.....	8	6	12	20	32	40 by 70.....	3.5	1	1896	1 50
7	B. F. Stocks.....	10	8	10	21	31	60 by 65.....	3.5	4	1892	2 00
8	O. V. Fulsom.....	12	10	10	32	42	120 by 70.....	2	2.50	1896	3 50
9	J. C. Kitchen.....	10	8	13	22	35	75 by 85.....	3	5	{1902	6 00
		12	8	13	22	35				{1894	
10	N. F. Weeks.....	8	6	11	19	30	50 by 20.....	1.8	1.50	1899	.....
11	Ed. Pyle.....	8	6	10	11	21	50 by 50.....	1.8	1.50	1896	2 00
12	R. L. McConahay.....	8	4	11	19	30	40 by 40.....	1.4	.50	1900	1 75
13	Ed. Pyle.....	8	6	10	12	22	15 by 35.....	2	1	1902	1 00
14	R. L. Hoslet.....	8	4	11	13	29	20 by 30.....	2.5	.50	.....	.....
15	J. Bondurant.....	10	6	10	21	31	50 by 20.....	2	.50	1900	2 50
16	W. E. George.....	8	6	10	20	30	50-barrel tank	.....	.50	1900	2 00
17	W. J. Green.....	6	6	10	20	30	30 by 30.....	3	.75	1900	1 50
18	G. W. Worden.....	6	5	11	20	31	20 by 35.....	3	2.50	.....	.....
19	G. D. Lathrop.....	10	4	11	14	25	20 by 15.....	1.8	1.25	1903	.....
20	N. C. Jones.....	10	5	.....	.....	.....	20 by 20.....	1.6	.....	.....	.....
21	H. S. Bosworth.....	10	1.5	.....	.....	130	.....	.....	.....	.....	.....
22	G. A. Ferguson.....	6	4	10	25	35	12 by 20.....	2.5	1	1903	.....
23	R. P. Hoover.....	8	6	9	20	29	30 by 30.....	2.5	.75	1902	1 75
24	W. R. Hopkins.....	10	6	4	17	21	35 by 35.....	3	2	1901	6 00
25	W. O. Carter.....	8	6	10	20	30	30 by 50.....	3	1.75	1900	1 25
26	P. M. Bowser.....	6	4	10	16	26	20 by 20.....	2.5	.50	1899	1 50
27	.....	8	4	8.5	.....	.....	18 by 18.....	1.8	1.50	.....	.....
28	W. A. Pierce.....	10	4	8.5	20	28.5	20 by 20.....	1.7	1.50	.....	4 00
29	Frank McCune.....	8	6	8.5	18	26.5	30 by 25.....	2	1	.....	.....
30	W. E. Truell.....	8	6	8.5	.....	.....	.....	.....	.....	.....	.....
31	W. J. Covert.....	8	4	8.5	11	19.5	12 by 16.....	2	.75	1901	2 00
32	Will. Holmes.....	10	6	7.5	18	25.5	12 by 18.....	1.8	1.50	1903	75
33	John Cooper.....	6	6	8	9	17	50 by 50.....	2	5	1899	4 00
34	Mrs. Edwards.....	10	6	8	10	18	.....	.....	.50	1900	3 00
35	Mrs. Baird.....	10	6	8.5	18	26.5	20 by 20.....	1.5	1	1900	4 00
36	Jay Brown.....	8	6	8	16	24	45 by 40.....	2	1.25	1902	1 50

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Report of the Council.

Windmill plants near Garden City, Kan. — Concluded.

No....	OWNER.	Size of mill.	Size of pump.	Depth to water.	Depth in water.	Total.	Tank or reservoir.	Irrigating head.	Area irrigated.	Year erected.	Cost per acre.
		<i>Fect.</i>	<i>Inches.</i>	<i>Fect.</i>	<i>Fect.</i>	<i>Fect.</i>	<i>Fect.</i>	<i>Fect.</i>	<i>Acres.</i>		<i>Year.</i>
37	O. W. Finch.....	8	4	8.5	15	23.5	35 by 50	3	2.25		
33	Zeph. Roberts.....	8	3	8	20	28	Tank.....		.50		
39	N. Johnson.....	8	4	9.5	20	29.5	20 by 12	1.8	.50	1903	
40	Dan. Kelcher.....	10	6	9			Tank.....				
41	Mrs. Calahan.....	8	6	9.5	28	37.5	50 by 50	3	2	1900	\$1 50
42	Court-house.....	10	4	11			Tank.....	1	.75		
43	W. R. Peterson.....	8	6	10	22	32	30 by 30	2.5	.50	1902	1 50
44	L. V. Smith.....	8	4	8.5					.50		
45	L. V. Smith.....	10	5	8.5			30 by 20	1.8	.50		
46	W. W. Perin.....	8	3	8.8					.50		
47	Will. Rowlon.....	8	4	8.5					.25		
48	W. M. Robinson.....	8	4	8.5	20	28.5			.25		
49	J. Worthing.....	6	3	10	15	25	6 by 8	5	1	1901	2 25
50	J. Zimmerman.....	8	6	13	24	37	45 by 50	3.1	.75	1900	1 50
51	S. P. Boyer.....	8	4	11	23	34	40 by 10	1.8	.50		
52	Geo. Inge.....	8	4	12.5	20	32.5	Tank.....		.50		
53	Fred. Pyle.....	{ 8	4	11	18	29	Tank.....			1900	4 00
		{ 10	8	11	18	29	50 by 50	2.5	4	1894	3 25
54	G. D. Gould.....	8	6	10	20	30	40 by 30	2.4	1.75	1900	2 25
55	A. E. Hearst.....	10	4	12	13	25	Tank.....		.25	1902	2 00
56	W. D. Evans.....	8	4	10	18	28	Tank.....		.25	1901	1 25
57	G. S. Boyd.....	8	4	10	25	35	15 by 15	3	.50	1895	2 00
58	J. Gorloch.....	8	6	10	18	28	35 by 35	3	1.25	1903	
59	G. S. Boyd.....	{ 12	8	10	20	30	100 by 100	2	7	1901	{ 2 00
		{ 12	8	10	20	30					{ 1 75
60	M. Griggs.....	10	10	10.5	18	28.5	50 by 160	2	6		
61	G. Miles.....	{ 12	8	9	23	37	Tank.....			1895	
		{ 8	6	9	23	37	20 by 20	1.5	2	1895	3 00
62	Doctor Love.....	8	4	8.5	23	30.5	Tank.....			1901	
63	B. Simmonds.....	8	4	11	14	25	80 by 20	2.4	.75	1890	1 00
64	E. W. Hamilton.....	10	4	11	20	31	40 by 40			1903	
65	C. L. Groff.....	10	8	11	22	33	50 by 50	2.4	3	1903	
66	W. B. Nolen.....	12	10	9.2	20.8	30	30 by 80	1.5	5		
67	J. S. Covert.....	{ 8	6	11	25	36	30 by 50	3	2	1901	
		{ 8	6	10	12	22				1898	
68	John Baker.....	{ 8	6	10	12	22	50 by 50	2.8	6	1898	
		{ 8	6	10	12	22					

VALUE OF CROPS IRRIGATED.

ALFALFA. The popular impression that alfalfa yields from 5 to 8 tons per acre is entirely erroneous, for the usual tonnage does not run above 4 tons. Three tons is a fair average. The hay brings from \$4 to \$6, making a return of \$10 to \$24 per acre. Deducting \$1.50 per ton for labor, the net return from 1 acre is \$7.50 to \$18.

BEETS. Sugar beets yield on the average, in the Arkansas valley, about 13 tons to the acre. The average tonnage on fields well cared for is much higher, running up to 18 and even 25 tons. The beets raised under windmills are all well tended, and bring \$6 per ton to the grower (\$1 bounty from the state of Kansas), or from \$90 to \$120 per acre. Deducting \$35 per acre for all labor, a profit of \$55 to \$85 is left, cost of hauling not being considered.

FRUIT. Apples, plums and cherries do well in the vicinity of Garden City, while peaches, apricots and pears are less in favor, although some very fine peaches were seen in 1904, and several young orchards have been recently put in. Cherries are a sure crop, and in 1904 yielded as high as 200 bushels to the acre, \$2 to \$3 per bushel.

SWEET POTATOES. Sweet potatoes do exceptionally well around Garden City, the average yield being reported at 100 to 300 bushels per acre. The price varies from \$1.50 per bushel early in the season to as low as 50 cents later in the season. The average is given as \$1. The cost of the plants and the labor of setting them out is \$20 to \$30, making the net return from one acre about \$150 to \$200. One 4-acre piece in sweet potatoes was seen that was being worked on shares, the owner to furnish the land, water, seed, and half the cost of planting, and to receive half the crop and half of any surplus plants started in the hotbed. His investment was as follows:

Land at \$60 per acre.....	\$240
Plant for irrigation.....	282
Seed.....	28
Half planting.....	21
Total.....	\$571

Returns from one crop were: Half of 50,000 plants, at \$2 per 1000, \$50; half of 800 bushels of potatoes, at 75 cents per bushel, \$300; total, \$350.

ONIONS. The yield per acre of onions was given as from 500 to 1000 bushels, which sell at 2 to 3 cents per pound, returning the generous sum of \$500 to \$1500 per acre. The cost of seeding and thinning is \$15 per acre. Others give the return as from \$300 to \$500 per acre.

BERRIES. A patch of raspberries measuring one-fourth acre yielded \$78, or at the rate of \$312 per acre.

CABBAGE. The value of an acre of cabbage is given as \$200.

OTHER GARDEN CROPS. The return from mixed garden crops is variously estimated at from \$200 to \$500 per acre. A measured one-third acre in asparagus, onions and rhubarb produced in one season \$190, or at the rate of \$570 per acre.

The value of various crops raised by windmill irrigation near Garden City may be summarized as follows:

Value of crops per acre.		
Alfalfa.....	from	\$12 to \$20
Alfalfa seed.....	17	50
Sugar beets.....	90	120
Sweet potatoes.....	100	300
Onions.....	300	500
Cabbage.....	150	250
Garden crops generally,	200	500

EUREKA CANAL ABOVE INGALLS, KAN., 1904.

Some ten or twelve years ago an attempt was made to get a permanent supply of water for a large ditch from the "underflow" a mile above Ingalls, the idea being to dig or dredge out a large sump, and to pump therefrom into the canal with low-lift pumps. The failure of this enterprise on account of financial difficulties has given the underflow a black eye, since it is popularly supposed that this ditch was intended to be a gravity canal. Such is not the case and this is written to answer the objections raised to gravity works on account of this failure.

On August 5 the long-abandoned head-works of the Eureka canal were visited. A trench 50 feet wide and perhaps 2000 feet long still remains, the upper half being filled in with sand a foot above low-water level in the river, and the lower end containing from one to two feet of water. The remnant of a bulkhead remains at the lower end, which allows the passage of a tiny stream (0.5 cubic foot per second) of water, which runs down a mile or two and is used on alfalfa. The trench parallels the river, being about 100 to 200 feet from it.

The original depth of the trench is said to have been from 6 to 14 feet, the lower end being deep enough for diving for several years. The canal and head-works are said to have cost \$1,000,000, the ditch being now held by English capitalists. It runs down the river beyond Dodge, being 30 to 40 miles long. It was evidently built to sell, for to carry pumped water so far is folly.

SMALL PUMPING PLANTS.

Plant of GOODNER BROTHERS, Rocky Ford, Colo.

Engine: 3 horse-power Fairbanks-Morse; 360 revolutions per minute.
Pump: 6-inch Goodner, a chain and float type, with a bored 6-inch cylinder 40 inches long, the floats being fitted with expanding cast-iron rings spaced 36 inches apart on the chain.
Discharge: 0.92 cubic foot per second computed from speed of pump, or 0.96 cubic foot per second measured with current meter.
Lift: 13 feet.
Fuel used: 1 gallon of gasoline in 3 hours 5 minutes.
Useful work: 1.36 horse-power.
Gasoline horse-power: 3.25 (1 gal. equals 10 h.-p. hours).
Efficiency: 42 per cent.
Acre-feet per gallon of gasoline: 0.23.
Cost per acre-foot: \$0.87 (gasoline at 20 cts. per gal.).
Cost per acre-foot for each foot lift: \$0.067.

This pump would give much better efficiency if run slower. In the case observed the floats had a velocity of 5 feet per second, and in entering the water carried down considerable air, and caused an impact which must have absorbed a good deal of power. It should be made of larger bore for this capacity. The pull on the chain required to just start the pump with a 10-foot lift was 32 pounds in excess of the weight of the water column, which indicates an efficiency of 79.5 per cent. when run very slow, no account being taken of leakage, which was too small to be detected. Measured with spring balance.

Plant near bridge north of Lamar, Colo.

Engine : 4 horse-power Stover.
P u m p No. 5 Fountain, a centrifugal pump made in Denver.
Discharge : 0.95 cubic foot per second by current meter.
Lift : 10 feet.
Fuel used: 1 gallon of gasoline in 2 hours 30 minutes.
Useful work: 1.08 horse-power.
Gasoline horse-power: 4.
Efficiency: 27 per cent.
Acre-feet per gallon of gasoline: 0.196.
Cost per acre-foot: \$0.98.
Cost per acre-foot for each foot lift: \$0.098.
Cost of plant: Engine, \$250 ; pump, \$100.

This plant irrigates about 20 acres in cantaloups, fruit, and garden. Three to five acres are watered in 10 hours, which indicates the application of from 0.16 to 0.26 foot in depth at each irrigation. About 1.8 feet in depth is applied in a season, which costs \$35 for 20 acres, or about \$1.80 per acre. The owner sold his water-right in a ditch because of difficulty in getting water when he wanted it. This was apparently due to very poor construction of a dike leading the water to this lowland lying near the river. He is confident that it costs him less to pump than to use ditch water.

Plant of D. H. LOGAN, near Garden City, Kan.

Engine: 6 horse-power Fairbanks-Morse; 330 revolutions per minute.
Pump : No. 3, made by Morris Machine Works, Baldwinsville, N. Y.
Discharge: Measured by the United States Reclamation Service, over weir, 0.61 cubic foot per second.
Lift: 21 feet.
Fuel used: 1 gallon of gasoline in 1 hour 26 minutes.
Useful work: 1.46 horse-power.
Gasoline horse-power: 7.
Efficiency: 21 per cent.
Acre-feet per gallon of gasoline: 0.072.
Cost per acre-foot: \$2.78.
Cost per acre-foot for each foot of lift: \$0.134.
Cost of entire plant, by contract: \$500.

The water pumped by this plant by one gallon of gasoline was applied to 0.16 acre of beets, making a theoretical depth of 0.45 foot. But by seepage in 200 feet of lateral, 30 per cent. of the water was lost, making the depth applied only 0.3 foot. This loss of water pumped for 8 acres, assuming that 2 feet in depth is required in a season, amounts to about 8 acre-feet in a season, or \$22, which would pay for the cost of 110 feet of small flume each year, or would pay 10 per cent. on the cost of 1100 feet of fluming (lumber at \$27.50). This plant is used to supplement a windmill supply, and the expense of operation varies greatly in different seasons. The amount of fuel used in 1902 and 1903 cost \$90 a year, which indicates the raising of about 32 acre-feet a year. This water was used on 16 acres.

HOLCOMB'S PUMPING PLANT.

A plant is under construction at Sherlock, Kan., with a capacity of 6000 gallons per minute (13.5 cubic feet per second) to irrigate a ranch of 1000 acres. It is intended to increase the area irrigated to 2000 acres or more. The well consists in a large sump about 15 feet below the water-line. A trench extends for 200 feet toward the river, being run out from the bottom of the well on a light grade. The well and trench are lined with sheet-piling. In the well are to be sunk several 16-inch galvanized-iron casings or feeders, and others are to be placed at intervals in the trench. The discharge of one feeder when the water was lowered about 15 feet was 500 or 600 gallons per minute. It is hoped that this discharge can be increased by the use of sand pumps. On July 23, 5 cubic feet per second were being pumped from the well, half of this amount running in from the trench and the rest coming into the main well through the bottom or through two feeders.

A 14-inch Byron Jackson centrifugal pump is to be used, the power being generated by a 60-horse-power Corliss engine, capable of being adjusted from 50 to 90 horse-power. The plant is guar-

anted by the construction company to raise 6000 gallons per minute for twenty-four hours, with a lift of 25 feet, with 2 tons of coal. This represents a guaranteed efficiency of about 64 per cent.

Such a plant will raise 26 acre-feet per day, which should irrigate about 80 acres once. Assuming a duty of 2 feet in depth for 1000 acres, the plant will need to be run for 76 days in a season. The cost of raising water per acre-foot is, approximately, 38 cents for fuel (coal \$5 per ton) and about 23 cents for the services of an engineer—making a total cost of 61 cents.

The method of digging the trench through wet gravel is as follows: All the material above the water-line is first removed by teams and scrapers. A frame sixteen feet long and five feet wide is then laid in the bottom of the excavation as a guide for sheet-piling, which is driven down as far as possible on the two sides. The gravel is then removed by shovelers and the sheet-piling again driven down. It is necessary, of course, to keep the water pumped out while working. A second frame like the first is placed four or five feet above it, connected with suitable uprights, and, as fast as the sheet-piling is driven down and the material removed, the entire frame is rammed down in the same manner. In the well observed, the first sheet-piling was of one-inch material, and was intended to be temporary. The lower crib was of two-inch material, and is to be floored over, so as to form an underground gallery when completed. A manhole is to be left over each galvanized-iron feeder.

Concluding Statement.

The Council regards the work of the past year as at least equal to that of preceding years in amount accomplished, and believes that it will compare favorably with that of any other station with no greater available resources. Attention is again respectfully called to the need of more funds properly to perform experiments that conditions demand, as set forth in detail last year. The need of a larger force in order to extend farmers institute work, or even to do that now asked, is imperative. With the present force, institute work makes too great a demand upon the time of Station workers for the best good of experimentation.

Respectfully submitted.

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