

C = R = E = A Bulletin

E. A. WHITE, Editor

FRANK D. PAINE, Assistant Editor

Published by Committee on the Relation of Electricity to Agriculture

1116 GARLAND BUILDING

-:-

CHICAGO, ILLINOIS

Volume II

May 12, 1926

Number 6

A Report on the Present Status
OF
RURAL ELECTRIFICATION IN VIRGINIA
BY
**THE VIRGINIA COMMITTEE ON THE RELATION OF
ELECTRICITY TO AGRICULTURE**



Section of experimental line near Richmond.

Prepared from a Study by Field Investigations and Questionnaires

BY

J. A. WALLER, Jr., Project Leader

Under the Direction of

CHAS. E. SEITZ, Head Department of Agricultural Engineering, Virginia Polytechnic Institute

Personnel
OF
The Virginia State Committee
ON
The Relation of Electricity to Agriculture

- Chas. E. Seitz, Head Department of Agricultural Engineers, Virginia Polytechnic Institute, Blacksburg, Virginia, Chairman.
- Wm. C. Bell, Chief Engineer Virginia Electric & Power Company, Richmond, Virginia.
- E. A. Feldtkeller, Gen. Mgr. Virginia Public Service Company, Alexandria, Virginia.
- A. H. Grimsley, Pres. & Gen. Mgr. Virginia-Western Power Company, Clifton Forge, Virginia.
- J. R. Horsley, Farmer, Director Virginia Water Power and Development Commission, Stapleton, Virginia.
- W. L. Kirby, Agricultural Agent, Richmond Chamber of Commerce, Richmond, Virginia.
- G. A. Lamberth, President Virginia Farmers Union, Rural Retreat, Virginia.
- J. H. Meek, Director Bureau of Markets, Department of Agriculture, Richmond, Virginia.
- N. L. Drexler, Mgr. Newport News & Hampton Ry., Gas & Electric Co., Newport News, Virginia.
- James A. Waller, Jr., Assistant Professor Agricultural Engineering, Virginia Polytechnic Institute, Project Leader, Blacksburg, Virginia.

Acknowledgments

We are grateful for the co-operation received from the United States Department of Agriculture, the Virginia Department of Agriculture, the State Corporation Commission, and the various power companies operating in the state; to Mr. D. C. Heitshu and Mr. F. M. Sommerville, of the Department of Agricultural Engineering, Virginia Polytechnic Institute, for their work on individual electric lighting systems, and to Mr. W. G. Nunn, of the Department of Agricultural Engineering, V. P. I., for generous help in compiling the data.

Rural Electrification in Virginia

In the project statement, drawn up by the Virginia Committee on the Relation of Electricity to Agriculture, at its first meeting, it was decided to work along three lines hereafter known as Sub-Projects.

Sub-Project—I: A field study to determine the optimum economic uses of electricity in agriculture.

Sub-Project—II: A general survey of the present available sources of electric power, covering its application to agriculture, its geographical distribution, etc.

Sub-Project—III: A farm power survey for the purpose of finding out the power requirements for each distinct type of agriculture in the state.

To fulfill the requirements of Sub-Project I, a community having as many different types of farming as possible was selected. With this in mind a rural electric line was built thru five miles of Fairfield District in Henrico County. Thirty farmers along this line contributed toward the construction of the line and five of this number were selected as desirable places on which to conduct intensive studies on the relation of electricity to such types of agriculture as dairy, truck, poultry, and general.

Considerable difficulty was experienced in finding a community having several types of farming in a reasonable distance and within reach of a power line. The Fairfield line offers an opportunity to secure data which will be representative of other farms in the state of the same type.

The line was finished in May, 1925. All farms and farmsteads have been surveyed and drawn to scale. Considerable electrical equipment has been installed, each motor having a separate meter and each water system having a separate water meter. All necessary records are being kept. Equipment is still being installed and it will be some time before conclusive data will be available.

In answer to Sub-Project II, the survey covered in this report was made. It was made to learn the present status of rural electrification in Virginia. We wanted the information as a fundamental basis for future development, and to place ourselves in a position to be of the most service to both the farmers and the power companies.

The survey covering Sub-Project II was made having in mind Sub-Project III. Much data applying to the former has a definite bearing on the latter. Therefore, the projects will not be wholly separated. Information gathered while on this survey, recent U. S. D. A. bulletins, and figures available at the State Department of Agriculture were used to satisfy Sub-Project III.

The available sources of electric energy are from generators driven by water wheels or small turbines on small streams, individual plants (gas engine driven generators), and from power companies known as central stations.

There are some very interesting small water-driven plants, with and without batteries, in the state. However, they are comparatively few in number and are found in the southwestern, western, and valley sections. When the conditions are right and the plant correctly installed it will supply good service. Some of these power plants operate continuously and use a control device to regulate the voltage. Others operate intermittently to charge a battery set. The battery is often the most expensive item and with good care will give satisfactory service for only about five years.

Individual gas engine driven electric plants are found in rather large numbers. There are approximately 10,000 in the state and are found in every section, though they are, in most cases, on places more or less removed from the central station lines. Due to ever increasing eagerness farmers are showing for electric service, and to the inability of the power companies to supply a great many of them living in the outlying country, there will continue to be a good demand for isolated plants. Some figures obtained in the laboratory of the Department of Agricultural Engineering, Virginia Polytechnic Institute, may be of interest and will be given later in this report.

Central station service was the special study on this survey. We wanted to know just how this type of service had developed in the state.

Two sets of questions were decided upon,—one to cover the power lines and the other to cover the farms on the power lines. The former was designed to learn the type and cost of the construction of each rural extension, kind of service rendered, rates, etc. The latter was designed to get the amount of this service the different farms consumed, the number and kind of appliances, motors, etc. used, the farmer's attitude toward this service, peak loads, the relation of one type of agriculture to another with respect to the amount of current used, etc. This survey was made by personal investigation.

Before any travelling was done, the co-operation of the State Corporation Commission was enlisted and we were given the names and addresses of the various power companies selling electric energy in the state. Then each company was asked to advise us relative to the number of rural extensions, their lengths, and the number of "dirt" farmers they served. With this information, the itinerary could be arranged so that little unnecessary travelling was

done. Later, they were asked to assist in answering the questions in the first set. Practically every extension reported on was visited.

To a considerable extent then, the completeness of this report depended on the co-operation, or the

lack of co-operation, given by the power companies. It is estimated that the extensions visited represent 90 per cent of those in the state and that the farms visited represent 85 per cent of all those in the state on central station lines.

State Wide Survey of Electric Lines from Which Farms Are Served

There is some difference of opinion as to the definition of a farmer. In this survey it was taken to mean a person living on at least ten acres of land and obtaining the major portion of his income therefrom.

All kinds of places were visited in order to get the most information on the largest possible number of applications of electricity. Adjacent to all large towns there are a good many "rural connections" with business in town and simply having their homes in the country. Also, in several sections of the state there are retired city men who now make a hobby of farming. As stated, these were visited but since they are not representative of practical agriculture in Virginia, they are not included in this report.

The survey included 414 visits to typical farms located on 86 different extensions in 37 different counties. These extensions cover a mileage of 313 miles and of the lines reported on, 33.5 per cent are owned and maintained by the consumers. No community power plants were found to be operated by farmers.

Below are some interesting data picked from the survey:

- 62.5% of extensions were financed by consumers.
- 21.5% of extensions were financed by power companies.
- 14.3% of extensions were financed by both.
- 1.8% of extensions gave service for right-of-way.
- Average cost of one mile by districts:

Single Phase

District No. 2.....	\$ 986.96
District No. 4.....	755.98
District No. 5.....	614.34

District No. 7.....	791.67
Average for state.....	\$ 787.24

Three Phase

District No. 2.....	\$1,625.00
District No. 4.....	1,174.93
District No. 5.....	920.00
District No. 6.....	1,177.70
District No. 7.....	400.00
District No. 8.....	1,210.53
Average for state.....	\$1,084.69

- 92.5% of poles are chestnut.
- 4.5% of poles are cedar.
- 3.0% of poles are cypress.
- 87.0% of extensions are 2300 volts.
- 10.0% of extensions are 6600 volts.
- 3.0% of extensions are 3330 volts.
- 64.0% of extensions are single phase.
- 36.0% of extensions are three phase.

50.0% of the lines classed as strictly rural by the power companies were considered profitable by them.

11.38 cents per kw.-hr. was found to be the average initial lighting rate for the state.

7.95 cents per kw.-hr. was found to be the average initial power rate for the state.

\$1.36 per month is the average minimum rate on lights.

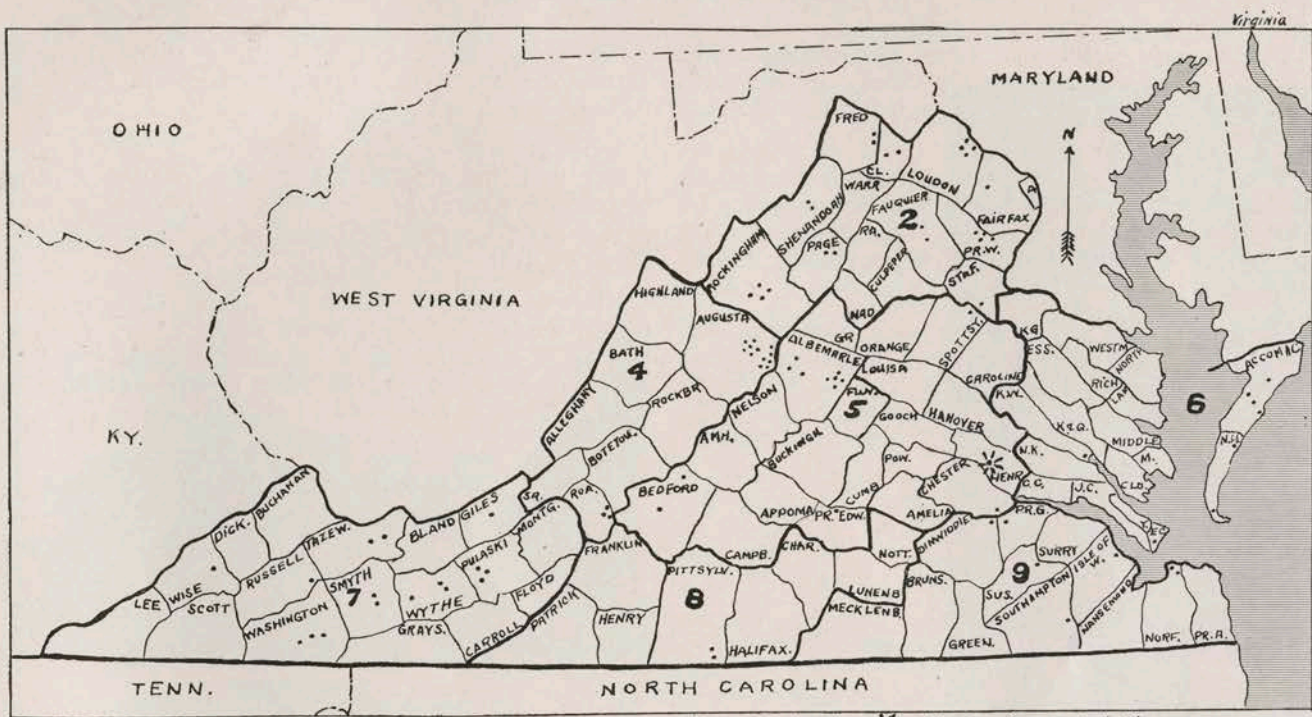
\$1.43 per h.p. per month is the average minimum rate on power.

825 farms on the lines surveyed—2.63 per mile.

611 farms served by same lines—2.00 per mile.

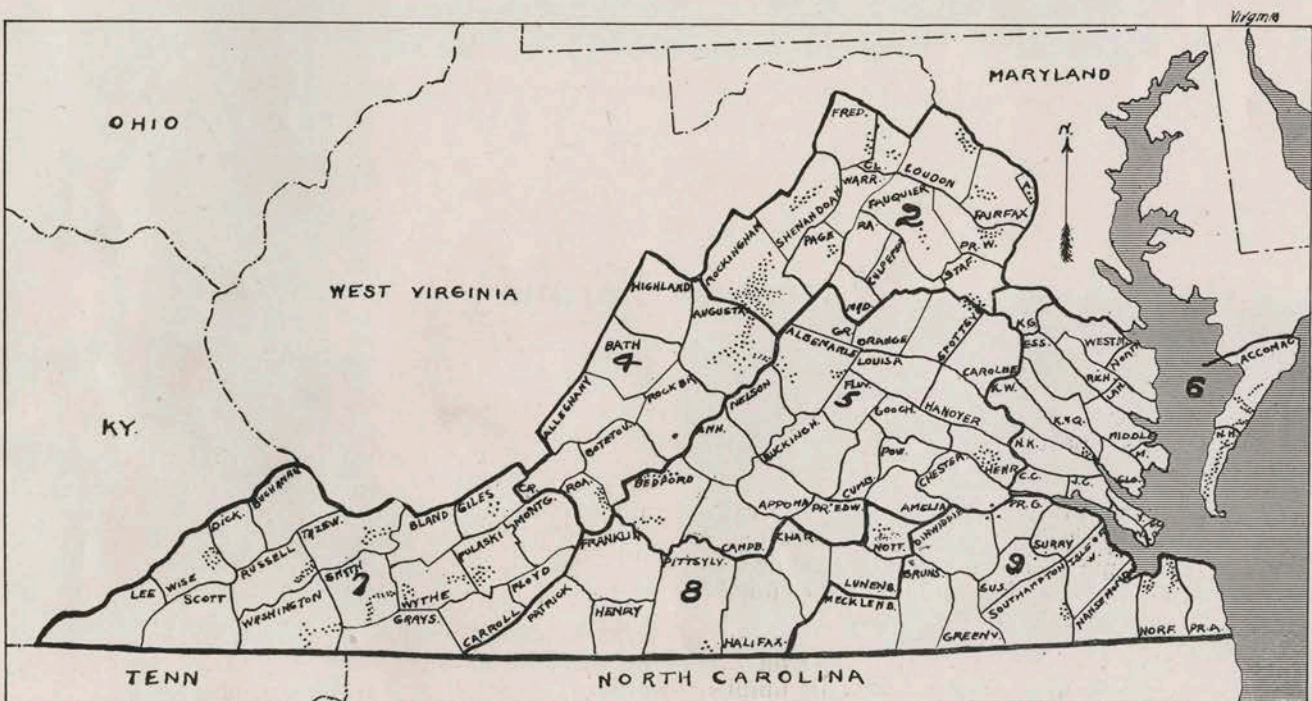
Power companies serve 74% of farms on their rural lines.

Distribution of extensions from which farms are served. One dot represents one extension.



* Experimental line.

Distribution of farms being served by central stations. One dot is one farm.



General Farming

This type of farming is found to some extent in each of the districts, though chiefly in numbers two, four, and seven. 133 of such farms were surveyed.

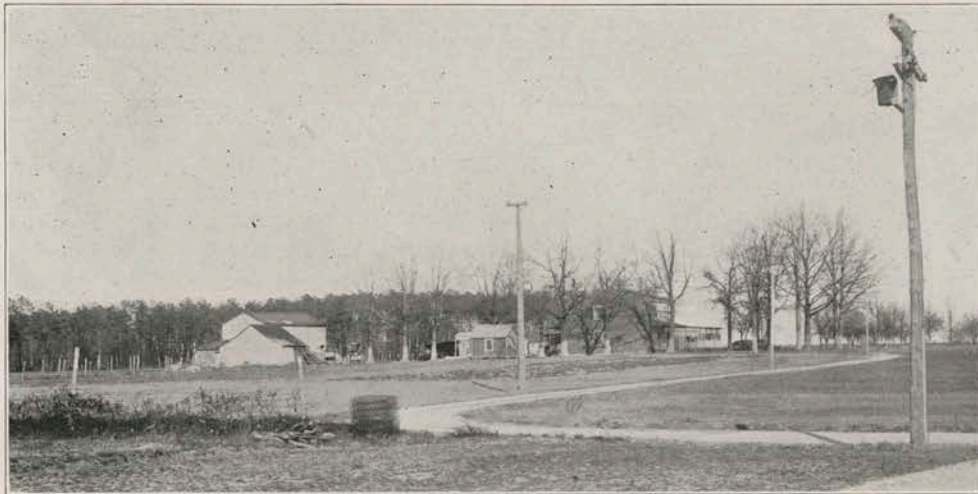
The amount of current used is fairly constant for the different months. There are no peak loads. This is as would be expected, since there are no specialties—all the different types being represented.

On the average farm coming under this type was found about three horses, two cows, twelve fruit trees, a home garden, and 100 chickens. The principal crops are corn, wheat, and hay. The Vir-

ginia Department of Agriculture gives 194,000 farms of four acres or more for the state for 1925, 92% of which raised corn.

General farming ranks second among the types of farms in point of electrical energy used and fifth per average farm in six types. It is closely estimated that there are 150 general farms in Virginia using central station service.

Electric water systems are used generally. A refrigerating machine is found occasionally. Lights are most often the main reason for obtaining the service, though a considerable number of household appliances are found in all districts.



Portion of experimental line showing farm line connected to main line.

Livestock Farming

The livestock farms are found in districts number two, three and seven. Forty-one farms of this type were visited—65% of this number being in the southwestern part of the state or in district number seven.

The current consumption for this type is rather uniform except during several months in late summer. At this time it is usually hot and dry and more current is required for pumping water for livestock.

Farms falling in this classification had on them hogs, sheep, beef cattle, horses, etc., in numbers

greater than were included in General Farming. Raising and selling livestock was their main business.

Livestock farming ranks fourth in this survey in the consumption of electricity, and second in amount used per farm of all types. It is conservative to state that there are not over 50 farms of this type in the state being served by central stations.

Some of the electrically driven equipment found on these farms includes feed grinders, feed mixers, pumps, sausage grinders and clippers.

Dairy Farming

Dairy farms are fairly well distributed over the state. Though, because of the nature of the business they are found near the larger centers of population.

This survey showed that those using electricity from central stations are located in districts number two, four, five, seven and nine. District number six has a great many dairy farms, but it has no rural lines. Of the 105 farms of this class visited, 57 of them are in district number two, having Washing-



Modern dairy.

ton as a market. The others are centered around the cities of Richmond, Norfolk, Roanoke, Staunton, Petersburg, and Charlottesville. There are no strictly rural lines out of Lynchburg.

In selecting this class it was decided to call a farm a dairy farm if there were as many as ten dairy cows.

This type uses electricity rather uniformly. Summer and winter are the peak seasons. In the summer more current is needed for pumping and in winter more lights are used in the cow barn due to the short days. The milk cooling load and the milking machine load are about the same all the year. It ranks first among types and first in amount used per farm of all types.

Besides the application of electricity to this type of farming just mentioned, there are bottle washers, refrigerating systems, separators, churns, etc.



A modern farm "bell."

About 125 would cover all dairy farms in Virginia using central station service. The Virginia Department of Agriculture states that there are 5,000 commercial dairymen in the state.

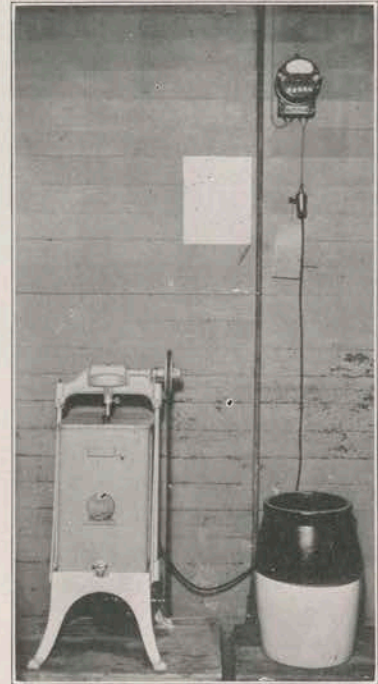
On the experimental line near Richmond, the cost of pumping 1,000 gallons of water is around \$0.16, with a rate of \$0.10 per K. W. H.

Truck Farming

Districts number six, seven and nine include the majority of the truck farms having service from central stations. This survey covers 83 truck farms, 51 of which are located in district number six. Practically all of the truck farms in district number six having electric service lie in Accomac and Northampton counties. Quite a few are around Rural Retreat, and one very large trucker operates near Danville.

Here we find a very decided peak in the distribution of current over the different months. All through the summer the load is high—July, August and September being the highest months. This is due to the fact that more water is pumped for irrigation purposes at that time. Considerable current is used for cold storage plants, and in one case considerable current is used for trapping such moths as the tomato worm moth.

The truck farms using the greatest amount of current are located around Norfolk and Danville.



Electric churn. A time saver.



Electric lights replacing lanterns

They use motors of from five to twenty horsepower each for pumping.

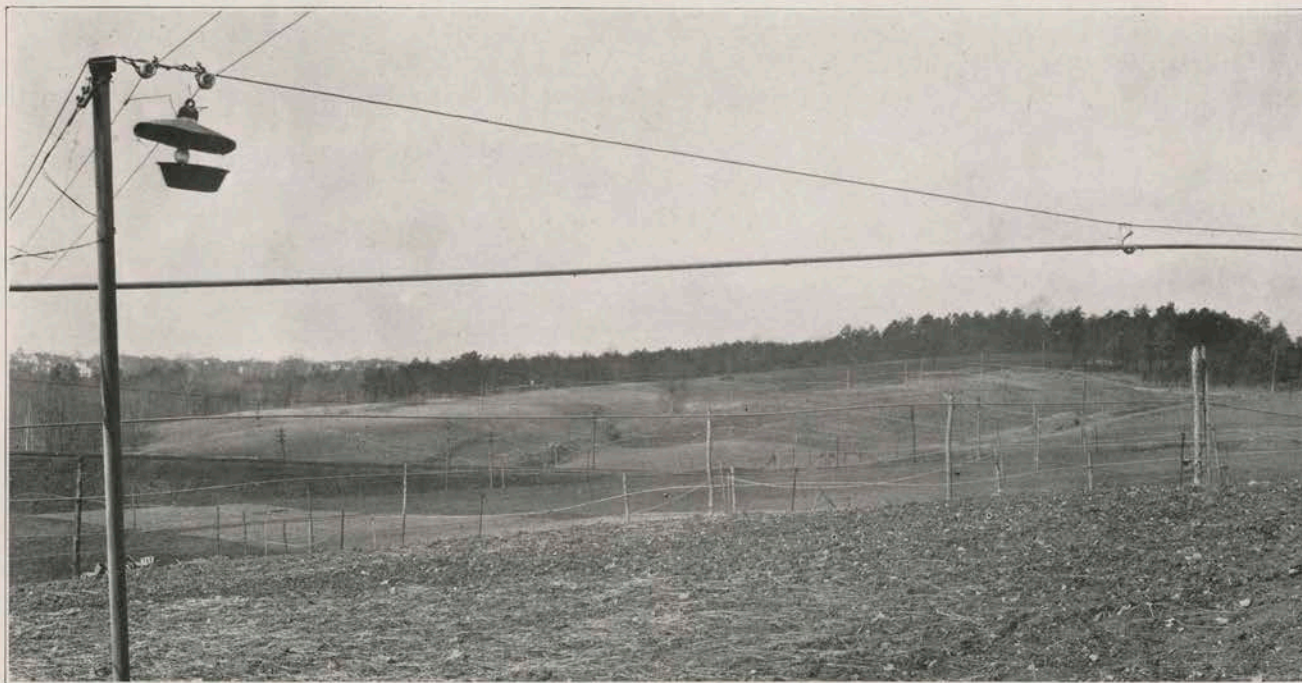
Truck farming ranks third among the different types in current consumption, and third in amount used per farm, including all types. A great deal of water is required for irrigating and washing. Besides these uses, there are tying machines, graders, sizers, etc. The Virginia Department of Agriculture states that there are 20,000 commercial truckers (1920). There are less than 100 truck farms in the state using current from central stations.

A Highly Developed Truck Farm

An example of how this type of agriculture can be developed is near Danville, and the farm is owned by L. W. Purdum & Sons. This farm of 32 acres is irrigated by means of overhead pipes—a 20 h. p. motor pumping water from a creek. This same field is wired for electric lights. The purpose of the lights is not to facilitate night work, but to trap tomato worm moths. The traps are placed three to an acre and about ten feet from the ground. A re-

flector is used over the light to prevent rain and irrigation water from diluting the kerosene which is in a three-quart pan suspended by means of four wires from the reflector, and about six inches under the light. It was noticed that whenever a moth flies against a light, it drops, and in this instance is caught in the kerosene. The owner stated that before the installation of these lights, he lost approximately half of his tomato crop. The wiring job cost \$900.00, and the first year after the lights were used, Mr. Purdum stated that he lost only half as many tomatoes as he lost the year before and at the present time is losing very few. The lights are turned on at the proper times during the summer and at the expense of \$5.25 per night. The owner states that he can attribute a profit of from \$2,000.00 to \$4,000.00 a year to this investment of \$900.00. Intensive studies of this project will be made this summer to determine what other destructive moths can be trapped.

On this farm there is a 15 h. p. motor driving a compressor in the cold storage plant.



Truck Farm of L. W. Purdum & Sons, Danville, Virginia, Showing Overhead Irrigation System for 32 Acres. Also Shows Wiring Layout for Trapping Tomato Worm Moths.

Poultry Farming

If a farm had as many as 200 chickens and they constituted the main source of the farmer's living, it was classed as a poultry farm. District number two is in the main district using electricity in connection with poultry. Of the 38 farms visited, 28 are located in this district and mostly in Rockingham County.

The use of current on poultry farms is fairly well distributed. It shows a little high in summer which is probably due to more water being used at that time. It is expected that before many years the reverse will be true. At a number of different places, experiments have been conducted to show that by giving the hens a longer day by means of electric lights, they will much more than pay the cost of the service in number of eggs laid. Work along this line is now being done by the Virginia Committee on the Relation of Electricity to Agriculture, and shows considerable promise.

Among the applications to this type of farm are lights, incubators, brooders, egg testers, feed grinders, shell grinders, etc.

This type stands fifth in standpoint of current consumption, and sixth in current used per type of farm.

Poultry House Lighting

Work of this nature is being done at the farm of Mr. R. L. Putze, on the experimental line near Richmond. Ten days previous to February 1st, a tar paper partition was built across the center of the poultry house and the flock of 390 hens equally divided into two pens. Laying record cards were placed in each pen and during these ten days it was found that the pen now lighted laid an average of 6.4 eggs a day more than the pen now unlighted. This figure was deducted in figuring the net profit. One pen was lighted with 40 watt Mazda lamps under 14 inch reflectors and placed ten feet apart, 6 feet from the floor. Lights were turned on at five o'clock, A. M. by means of an alarm clock operating a knife switch, February 1st and the project continued until April 1st. The hens were working from 12 to 13 hours a day.

DAILY EGG RECORD OF FLOCK OF 390 WHITE LEGHORN HENS OWNED BY ROBT. L. PUTZE, ON EXPERIMENTAL LINE, NEAR RICHMOND, VIRGINIA.

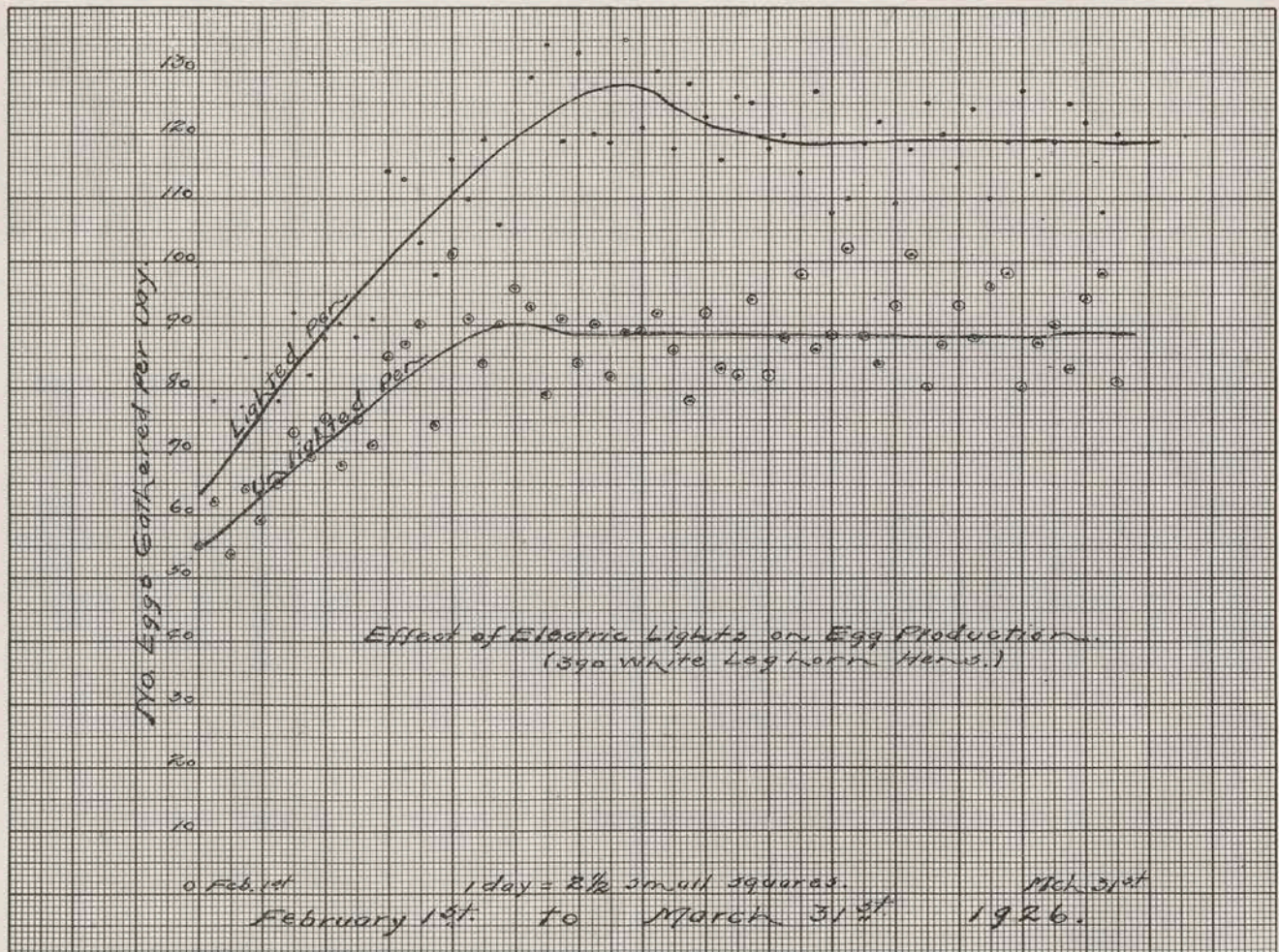
	NO LIGHTS			LIGHTS		
	Jan.	Feb.	March	Jan.	Feb.	March
1		55	89	1	63	121
2		62	92	2	78	130
3		54	86	3	59	118
4		64	78	4	85	128
5		59	92	5	69	123
6		65	83	6	78	116
7		73	82	7	92	126
8		69	94	8	82	125
9		75	82	9	88	118
10		68	88	10	90	120
11		75	98	11	88	114
12		71	86	12	91	127
13		85	88	13	114	108
14		87	102	14	113	110
15		90	88	15	103	119
16		74	84	16	98	122
17		101	93	17	116	109
18		91	101	18	110	118
19		84	80	19	119	125
20		90	87	20	106	120
21		96	93	21	97	115
22	60	93	88	22	65	124
23	66	79	96	23	69	110
24	58	91	98	24	61	119
25	61	84	80	25	64	127
26	58	90	87	26	63	114
27	54	82	90	27	58	119
28	66	89	83	28	69	125
29	56		94	29	74	122
30	50		97	30	65	108
31	65		81	31	70	120
Totals	594	2196	2760	658	2828	3700

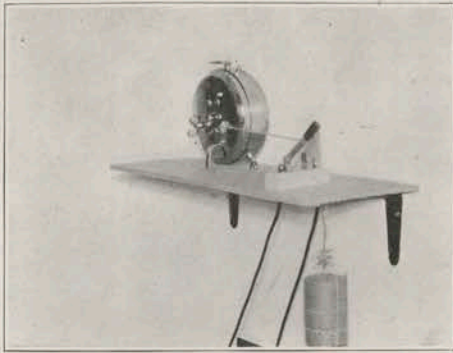
Results by Ten Day Periods

NO LIGHTS			LIGHTS		
	No. Eggs	Average Per Day		No. Eggs	Average Per Day
10 days before test	594	59.4	10 days before test	658	65.8
(1) 10 days in February	644	64.4	(1) 10 days in February	784	78.4
(2) 10 days in February	848	84.8	(2) 10 days in February	1,058	105.8
(3) 10 days in February	885	88.5	(3) 10 days in February	1,237	123.7
(1) 10 days in March	869	86.9	(1) 10 days in March	1,215	121.5
(2) 10 days in March	904	90.4	(2) 10 days in March	1,170	117.0
(3) 10 days in March (9 days)	806	89.6	(3) 10 days in March (9 days)	1,064	118.2
Total for February, 2,196; March, 2,760.			Total for February, 2,828; March 3,700.		
Average per day for February, 78.4; March, 89.0.			Average per day for February, 101.0; March, 119.4.		
Total for February and March, 4,956.			Total for February and March, 6,528.		
Average per day for February and March, 84.0.			Average per day for February and March, 110.5.		

The lighted side had advantage of 6.4 eggs per day.
 The lighted side had advantage of 377.6 eggs for 59 days.
 Increase due to lights, 1,194.4 eggs, or 99.5 dozen.
 The average price was \$.40 per dozen.
 Income of lighted hens over unlighted hens....\$39.80
 Consumption of electricity..... .96
 Net profit\$38.84

NOTE: This work will be continued next October.





"Call boy" for laying hens.



Up at 430 A. M.

Fruit Farming

Of the 14 fruit farms visited, 13 of them were in district number two. The Virginia Department of Agriculture gives 3,200 commercial fruit growers for the state, and there are less than 25 of them receiving electric service from central stations. The fruit section is confined to districts number two, four, and five.

The consumption of electricity is fairly well spread over the year. It runs somewhat higher during the fall and winter months, probably caused by apple grading and dormant spraying. From the standpoint of current consumption, this type of farming is the least important at present, but stands fourth in average amount used per farm in all types.

The cost of supplying these farms is usually high, as they are large and not close together. However,

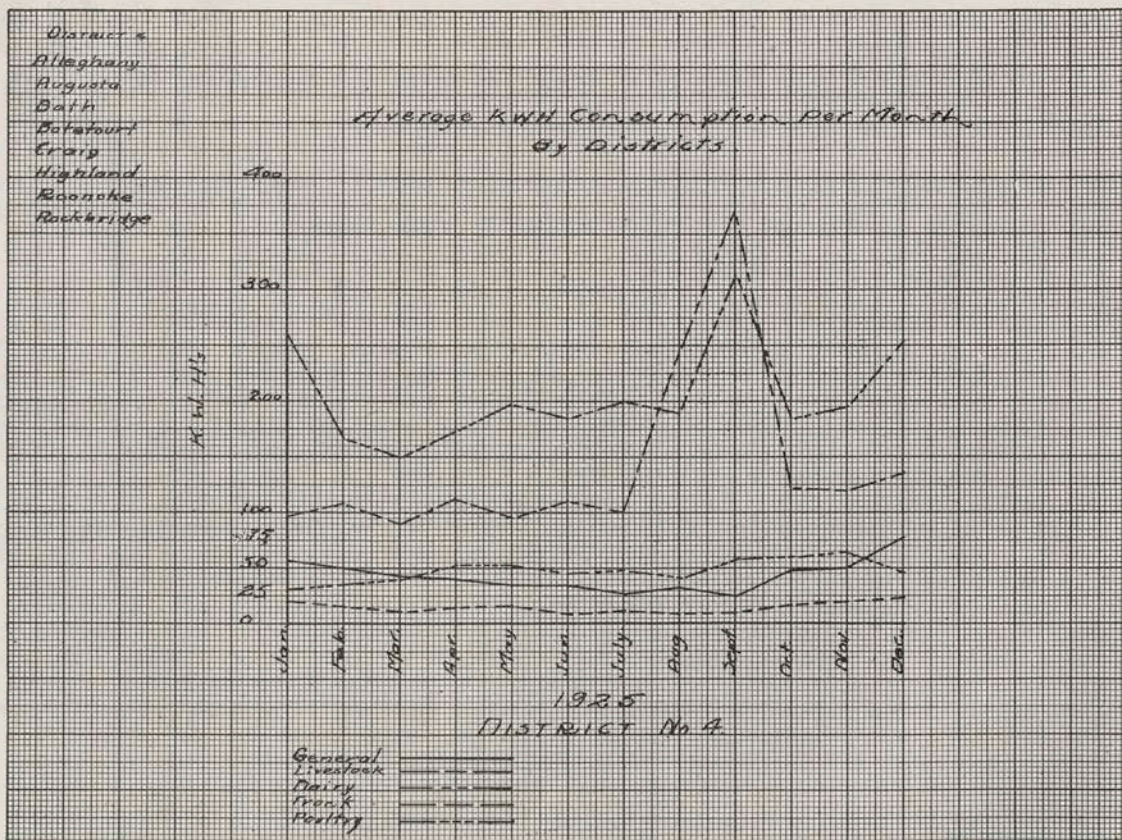
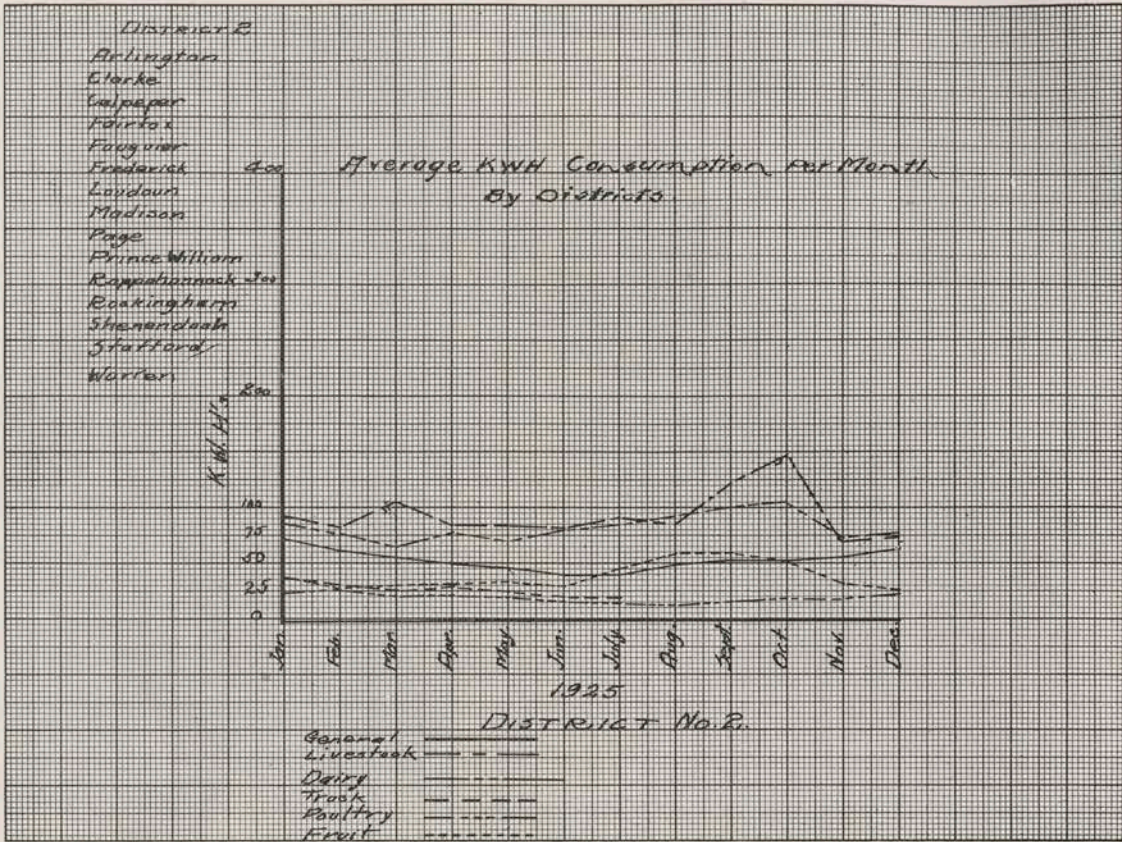
considerable use can be made of the current,—spraying thru a central system, pumping water for spraying, and grading.

AVERAGE KWH CONSUMPTION PER FARM PER MONTH BY DISTRICTS DISTRICT NO. 2

Types of Farms	No. Farms Visited	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
General	74	72.5	61.9	55.4	51.6	48.5	39.9	41.4	48.3	51.5	51.9	54.0	64.2
Livestock	8	91.3	82.7	106.0	86.7	84.0	83.4	93.0	36.1	120.7	145.3	71.4	74.3
Dairy	57	85.3	77.2	66.8	78.0	69.2	81.7	86.1	92.7	101.8	105.9	73.2	75.7
Truck	1	36.0	31.0	26.0	29.0	26.0	21.0	20.0					
Poultry	28	24.9	28.3	23.1	22.9	20.3	18.1	17.8	13.8	16.4	19.4	19.4	22.9
Fruit	13	36.7	29.0	29.0	30.1	32.2	31.5	46.4	58.0	59.0	51.8	34.1	25.1

DISTRICT NO. 4

Types of Farms	No. Farms Visited	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
General	13	56.5	49.0	43.0	41.0	34.5	36.5	26.3	32.6	25.0	48.8	50.4	72.5
Livestock	3	96.3	108.3	89.0	113.3	97.3	110.3	102.0	244.6	369.0	122.6	121.0	136.0
Dairy	14	260.2	167.9	150.4	172.0	196.8	184.8	200.1	190.4	312.0	182.1	192.0	253.1
Truck	1	20.0	15.0	11.0	13.0	16.0	8.0	12.0	9.0	10.0	16.0	15.0	22.0
Poultry	2	31.5	36.0	38.5	51.5	51.5	45.0	47.0	42.0	57.0	61.0	64.5	47.0
Fruit	0	0	0	0	0	0	0	0	0	0	0	0	0



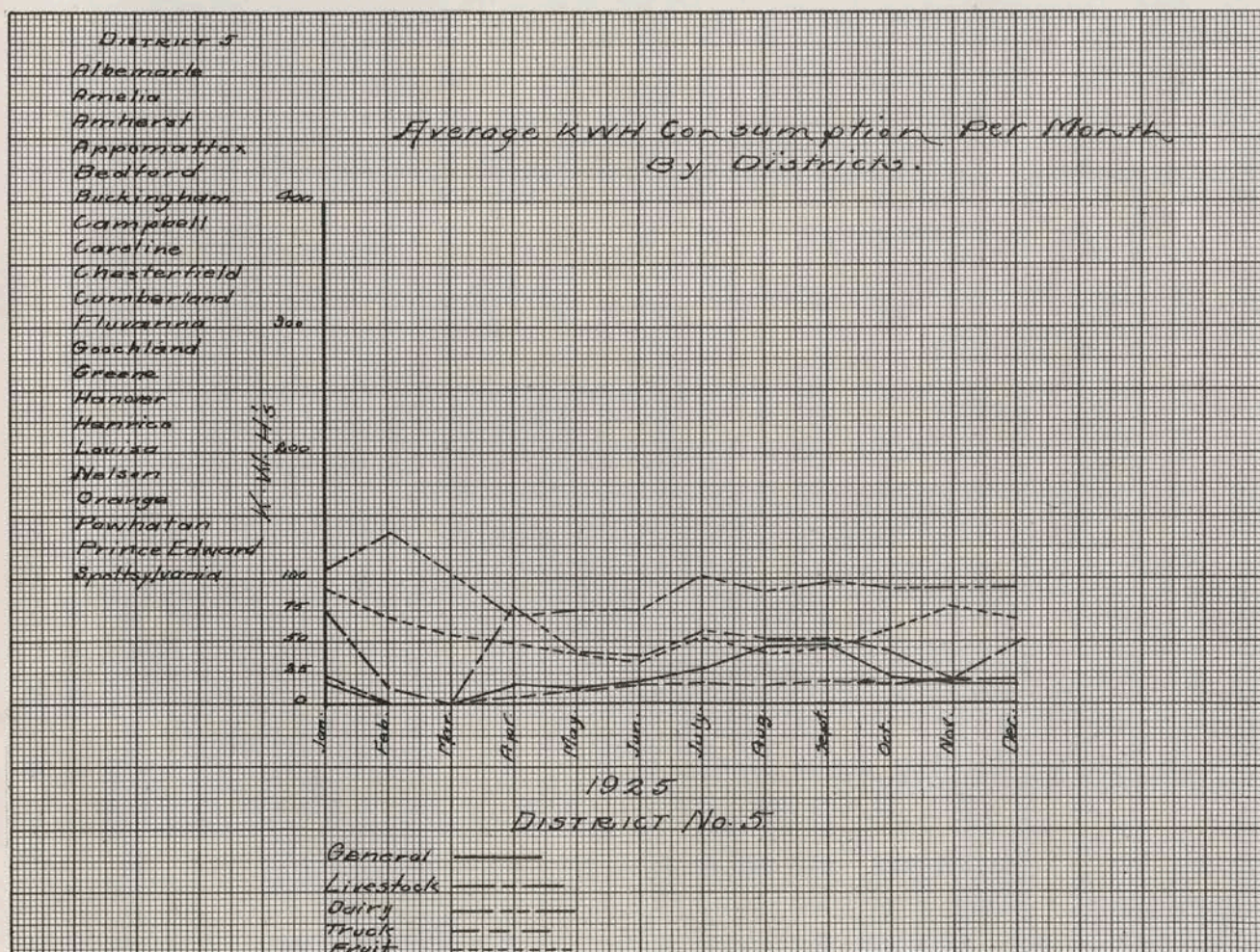
AVERAGE KWH CONSUMPTION PER FARM PER MONTH BY DISTRICTS

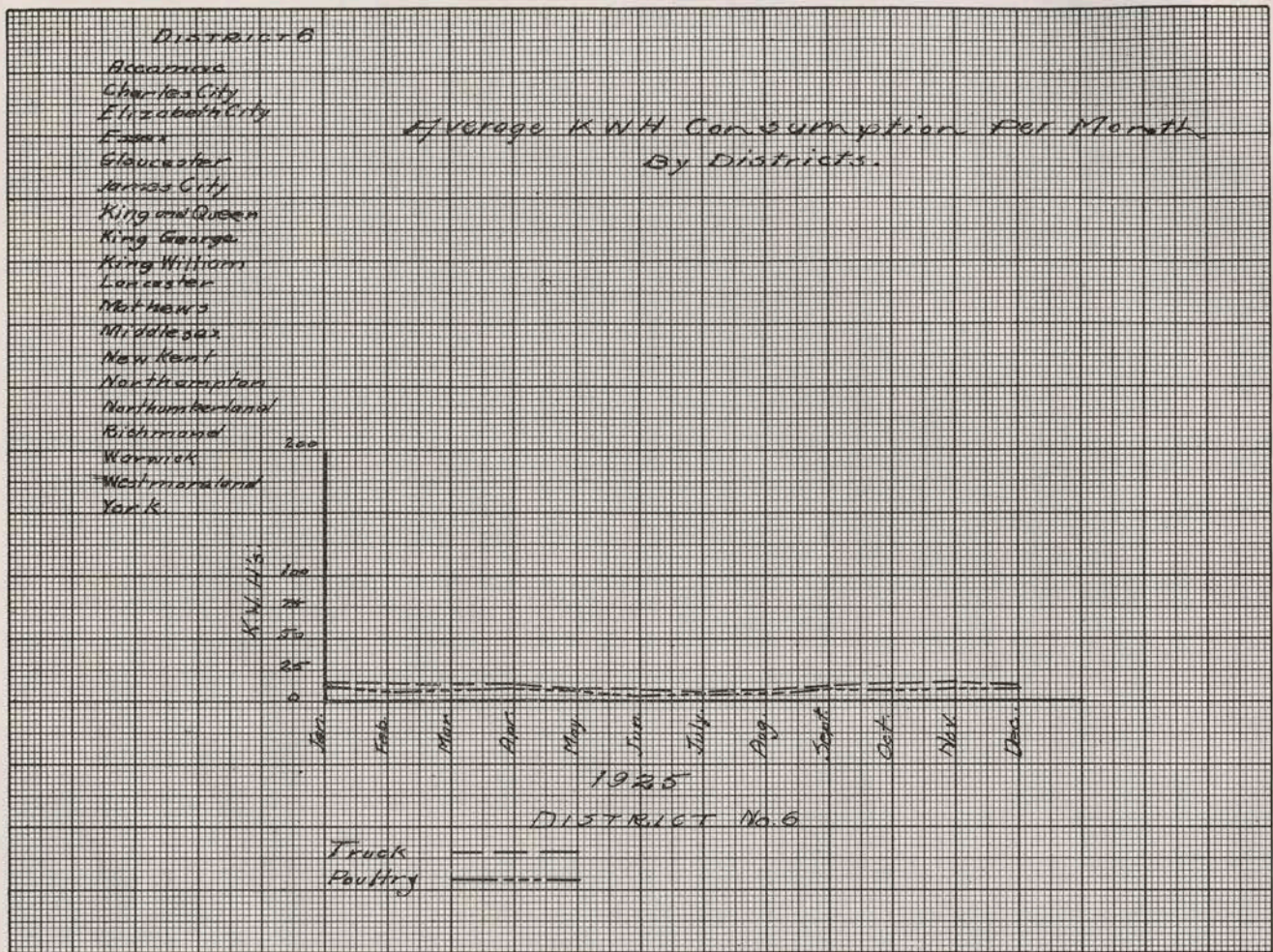
DISTRICT NO. 5

Types of Farms	No. Farms Visited	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
General	3	18.3	0	0	16.0	13.0	18.3	27.6	45.3	47.0	23.3	16.6	16.0
Livestock	1	75.0	14.0	0	78.0	41.0	37.0	57.0	54.0	52.0	44.0	18.0	47.0
Dairy	9	106.6	135.8	106.0	70.6	75.7	76.9	103.7	90.1	97.0	92.0	94.8	92.9
Truck	3	21.6	0	0	6.0	13.0	17.7	18.0	15.7	18.0	17.7	20.0	19.0
Poultry	0	0	0	0	0	0	0	0	0	0	0	0	0
Fruit	1	89.0	71.0	55.0	48.0	40.0	34.0	54.0	42.0	45.0	60.0	78.0	69.0

DISTRICT NO. 6

Types of Farms	No. Farms Visited	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
General	0	0	0	0	0	0	0	0	0	0	0	0	0
Livestock	0	0	0	0	0	0	0	0	0	0	0	0	0
Dairy	0	0	0	0	0	0	0	0	0	0	0	0	0
Truck	51	16.2	14.5	13.1	12.3	9.9	10.2	8.8	12.4	12.2	13.5	15.4	14.8
Poultry	5	12.7	9.0	8.5	10.2	10.6	5.6	7.6	7.4	10.0	9.3	10.6	10.3
Fruit	0	0	0	0	0	0	0	0	0	0	0	0	0



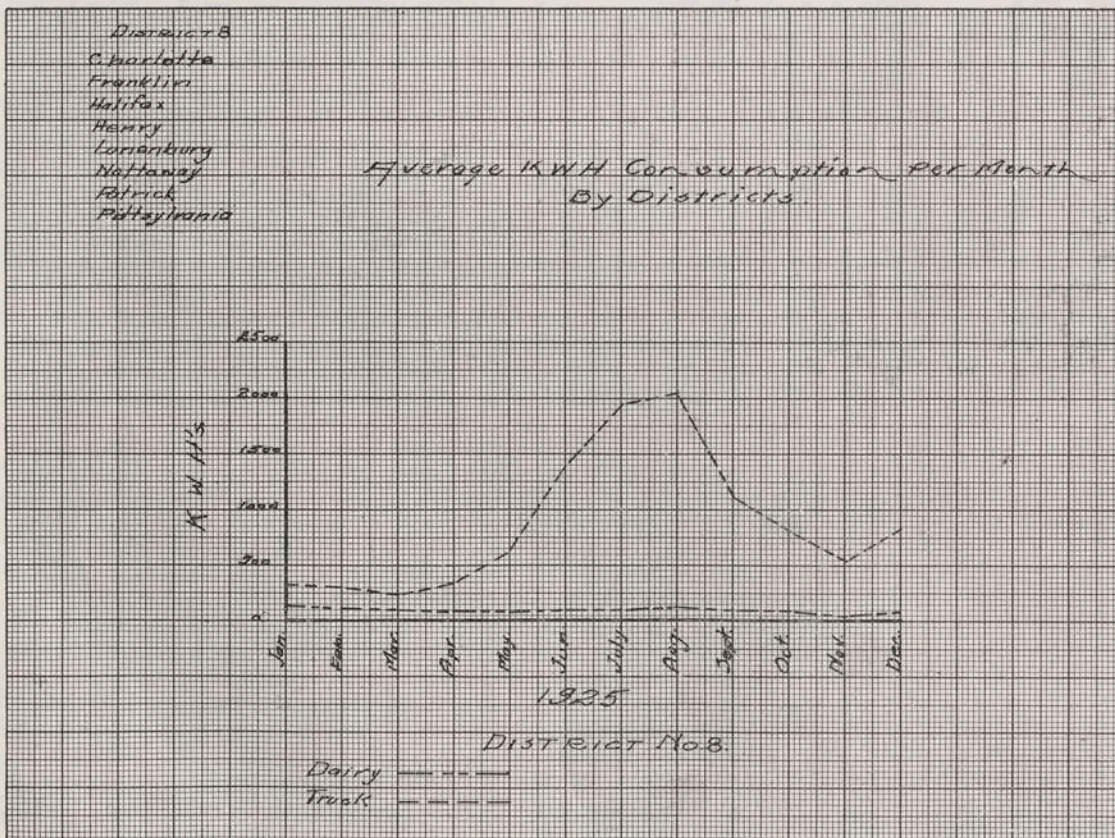
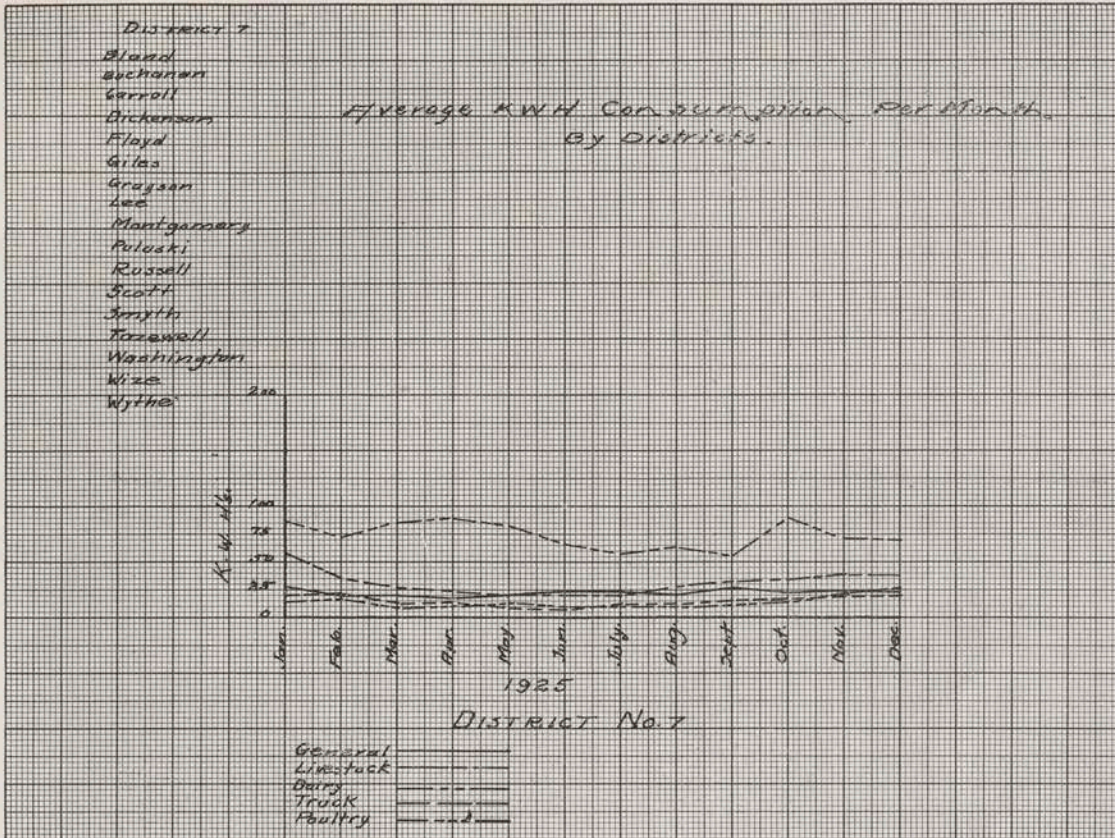


AVERAGE KWH CONSUMPTION PER FARM PER MONTH BY DISTRICTS
DISTRICT NO 7

Types of Farms	No. Farms Visited	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
General	39	26.1	20.5	20.0	17.4	18.9	22.4	23.7	21.8	25.4	22.8	23.8	22.8
Livestock	27	58.8	35.0	27.0	24.5	19.3	20.2	21.3	25.6	30.2	33.8	38.4	39.8
Dairy	15	86.2	71.7	86.8	89.4	82.6	66.7	58.2	68.2	52.0	88.5	71.8	70.7
Truck	9	20.6	21.8	13.7	13.7	9.0	8.3	12.4	12.4	14.1	16.6	19.6	20.1
Poultry	1	14.0	19.0	9.0	10.0	12.0	10.0	10.0	11.0	13.0	16.0	20.0	24.0
Fruit	0	0	0	0	0	0	0	0	0	0	0	0	0

DISTRICT NO 8

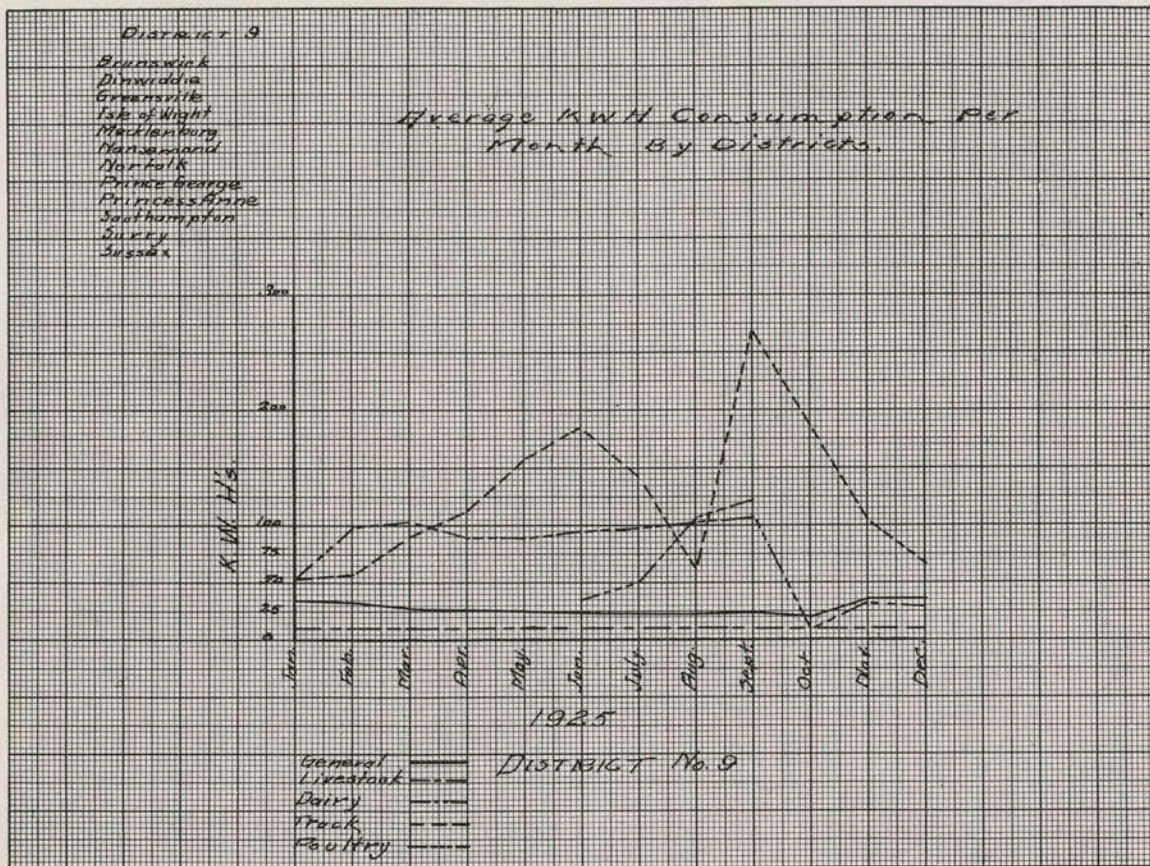
Types of Farms	No. Farms Visited	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
General	0	0	0	0	0	0	0	0	0	0	0	0	0
Livestock	0	0	0	0	0	0	0	0	0	0	0	0	0
Dairy	2	117.5	108.5	95.0	81.5	84.5	101.5	96.5	104.0	96.5	94.5	48.0	78.0
Truck	2	309.5	276.0	230.0	341.5	641.5	1380.0	1933.5	2048.0	1119.5	823.5	545.0	826.0
Poultry	0	0	0	0	0	0	0	0	0	0	0	0	0
Fruit	0	0	0	0	0	0	0	0	0	0	0	0	0



AVERAGE KWH CONSUMPTION PER FARM PER MONTH BY DISTRICTS

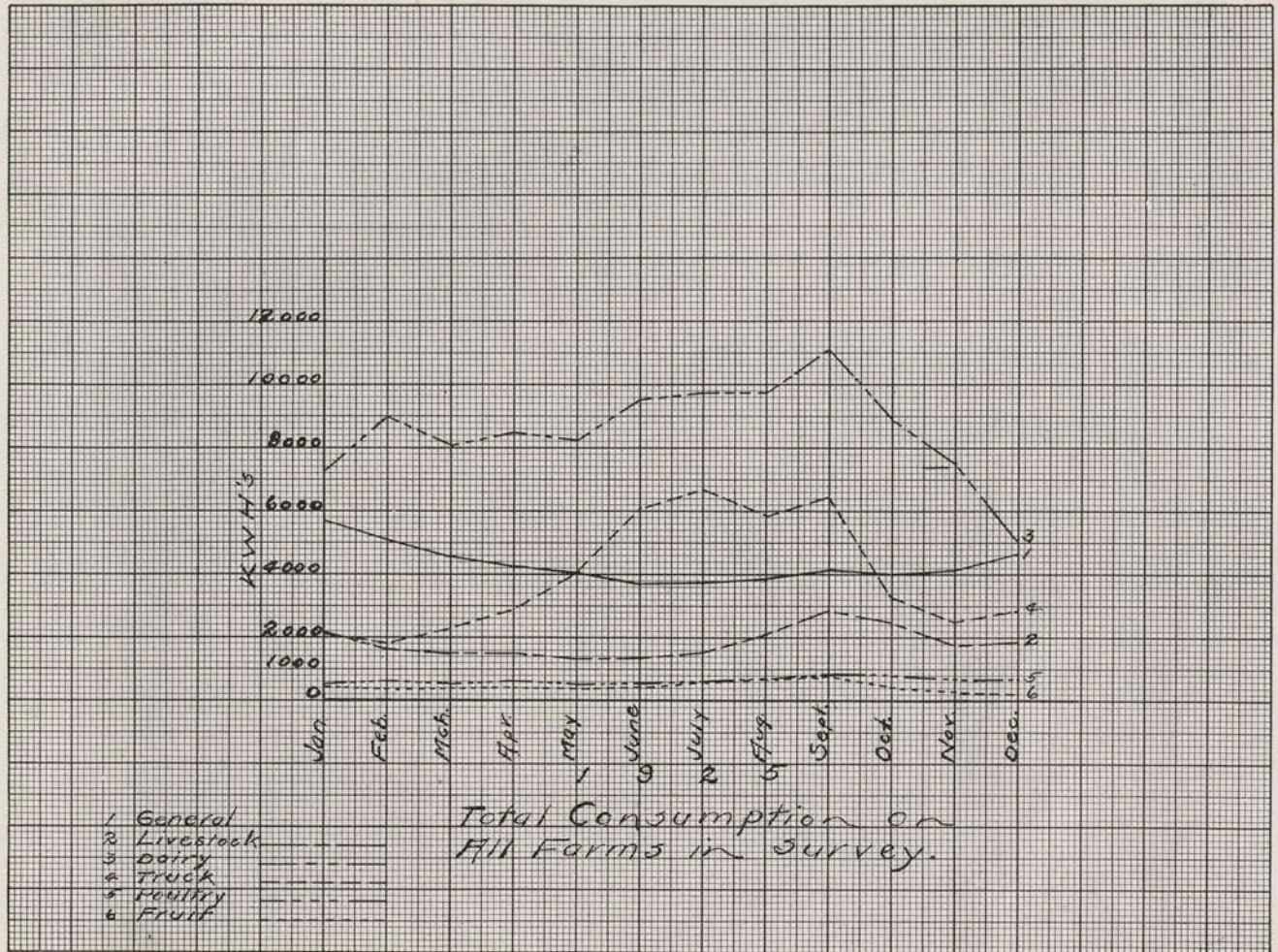
DISTRICT NO 9

Types of Farms	No. Farms Visited	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
General	4	36.3	34.3	26.0	25.2	23.5	22.7	22.7	22.2	23.2	21.5	35.3	35.3
Livestock	2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Dairy	8	53.4	96.0	102.1	89.0	90.0	96.6	98.0	102.5	108.7	12.0	32.7	28.0
Truck	16	51.7	55.5	88.0	112.6	158.9	184.4	142.6	63.3	270.0	187.2	104.7	66.8
Poultry	2	0	0	0	0	0	36.0	52.5	104.5	123.5	0	0	0
Fruit	0	0	0	0	0	0	0	0	0	0	0	0	0



TOTAL KWH CONSUMPTION BY MONTHS ON ALL FARMS IN SURVEY

Type of Farm	JAN.	FEB.	MAR.	APR.	1 MAY	9 JUNE	2 JULY	5 AUG.	SEPT.	OCT.	NOV.	DEC.
General	5681	5047	4571	4274	4033	3727	3637	3882	4100	4061	4066	4699
Livestock	2189	1627	1559	1525	1337	1389	1536	2127	2891	2431	1769	1898
Dairy	7241	8987	8105	8438	8274	9540	9784	9701	11155	8962	7429	5052
Truck	2121	1852	2343	2933	4008	6021	6783	5849	6463	3340	2570	2901
Poultry	576	666	559	612	575	562	621	660	831	793	648	698
Fruit	530	390	402	410	427	413	611	739	812	475	283	220
Totals....	18338	18569	17539	18192	18654	21652	22992	22958	26252	20062	16765	15468

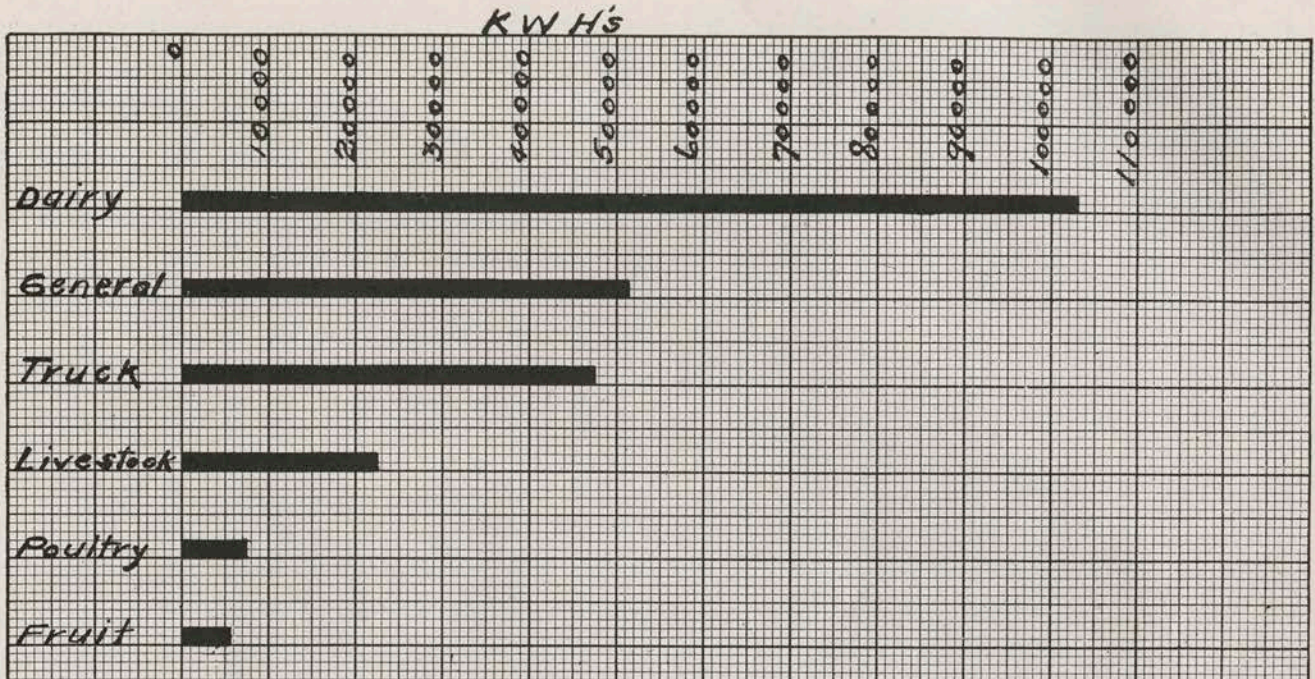


TOTAL KWH CONSUMPTION FOR ALL DISTRICTS FOR YEAR

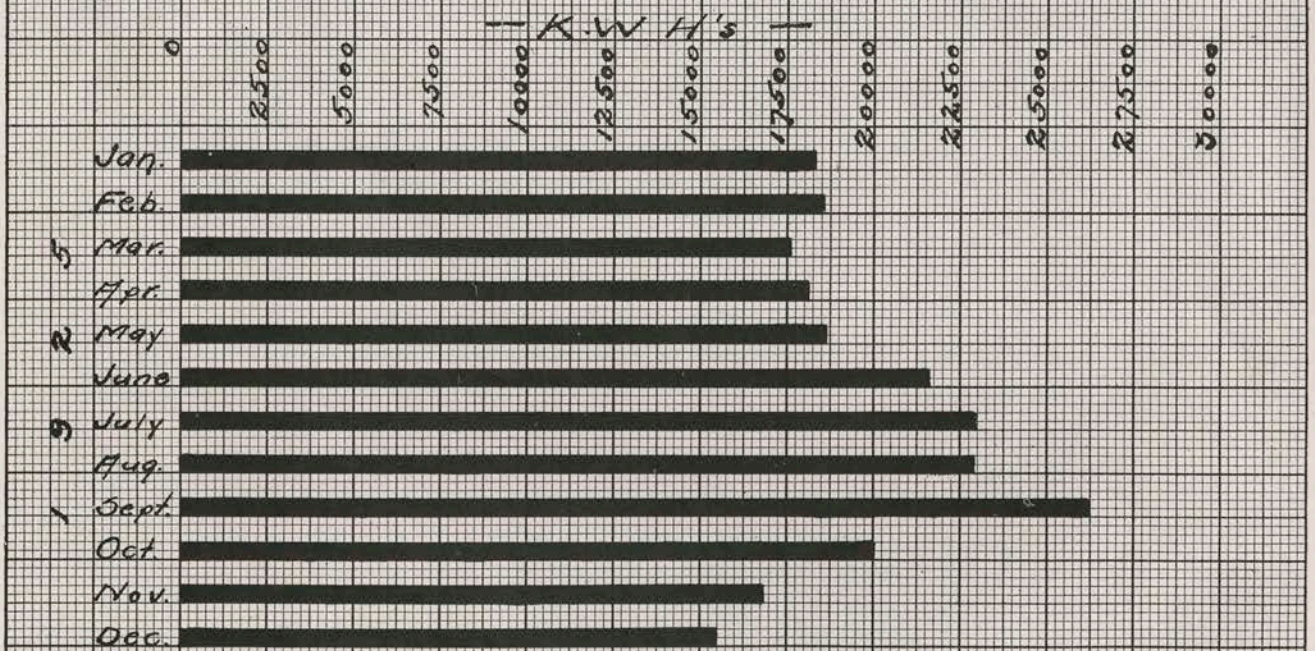
Type of Farm	No. Farms Visited	District No. 2	District No. 4	District No. 5	District No. 6	District No. 7	District No. 8	District No. 9
General	133	35,585	6,053	696		8,271		1,173
Livestock	41	8,374	5,130	517		8,157		120
Dairy	105	45,731	27,368	9,313		11,102	2,212	6,942
Truck	83	189	170	603	6,836	1,543	20,948	16,895
Poultry	38	5,246	1,315		439	168		633
Fruit	14	5,027		685				
Totals	414	100,152	40,036	11,814	7,275	29,241	23,160	25,763.....Grand Total, 237,441

Total KWH Consumption on General Farm For Year.....	51,778	Ave. per farm389.3
Total KWH Consumption on Livestock Farm for Year.....	22,298	Ave. per farm543.9
Total KWH Consumption on Dairy Farm for Year.....	102,668	Ave. per farm977.8
Total KWH Consumption on Truck Farm for Year.....	47,184	Ave. per farm532.3
Total KWH Consumption on Poultry Farm for Year.....	7,801	Ave. per farm205.3
Total KWH Consumption on Fruit Farm for Year.....	5,712	Ave. per farm408.0
Total	237,441		

Average KWH Consumption on the 414 Farms Surveyed, per year573.5
 Average KWH Consumption on the 414 Farms Surveyed, per month 47.8



Total Consumption by Types.

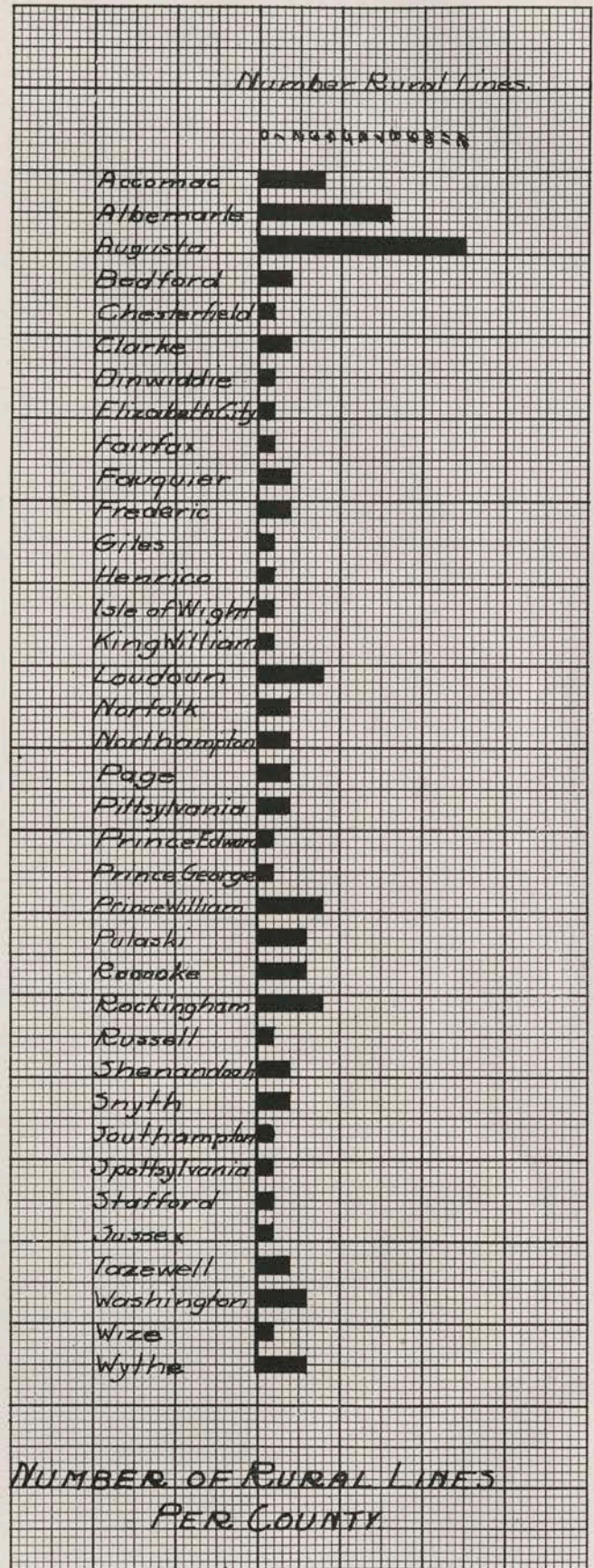


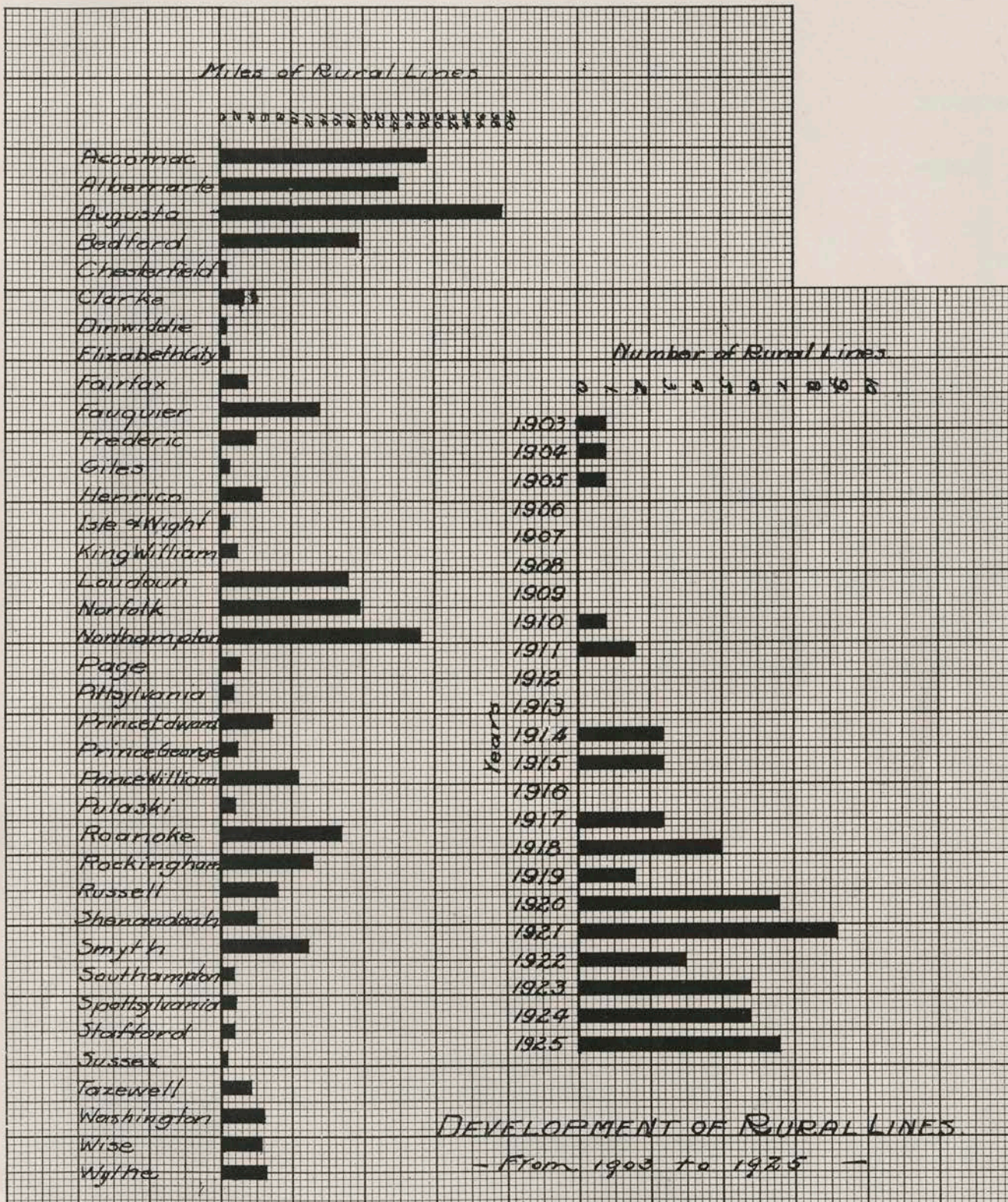
Total Consumption by Months.

TOTAL NUMBER OF VARIOUS APPLIANCES FOR STATE BY DISTRICTS

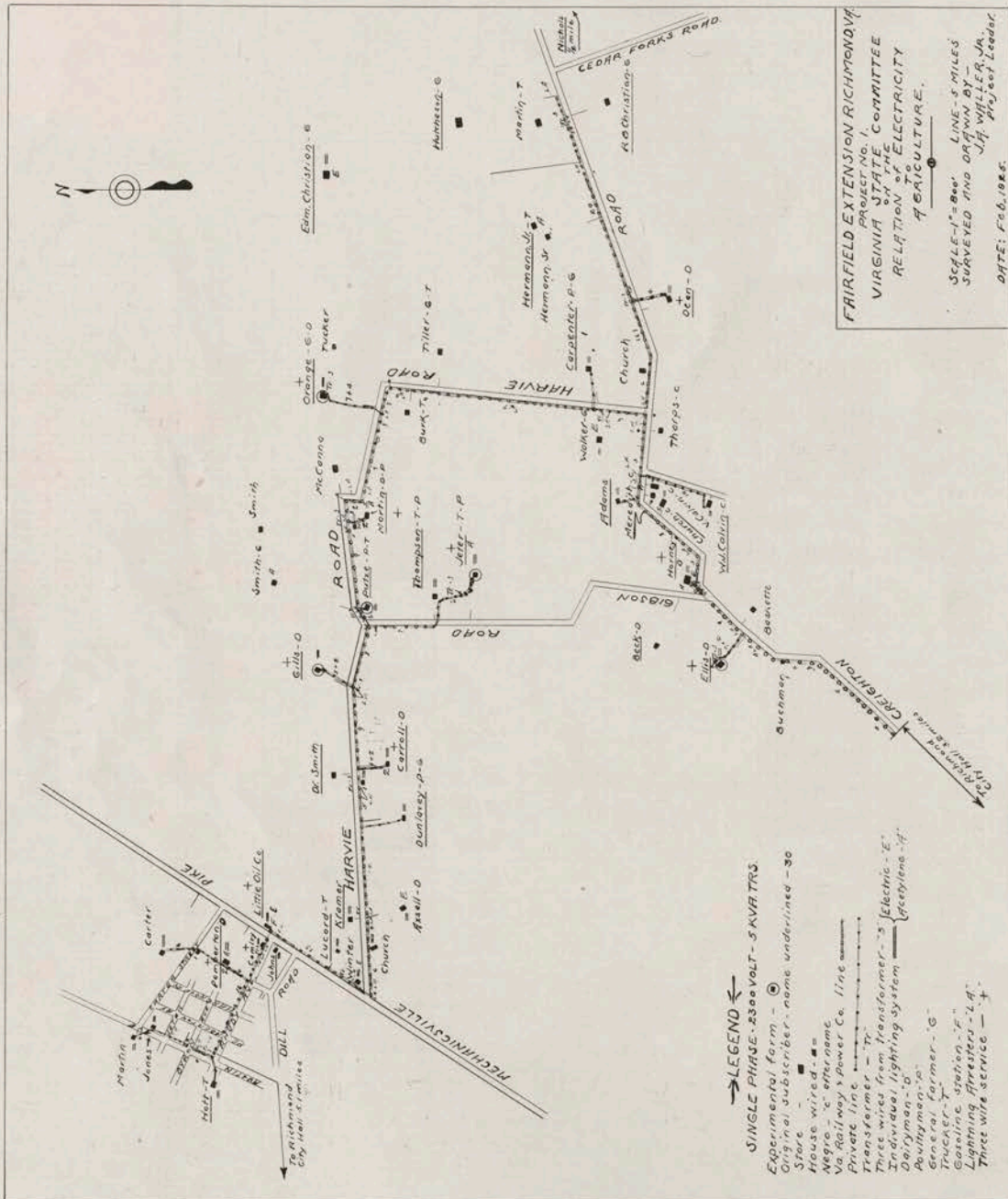
																	District and Type of Farm											
Battery Chargers.....	Bottle Washers.....	Sprayers.....	Brooders.....	Incubators.....	Apple Graders.....	Wood Saws.....	Churns.....	Separators.....	Sewing Machines.....	Waffle Irons.....	Grills.....	Curling Irons.....	Toasters.....	Fans.....	Irons.....	Refrigerators.....	Emerys.....	Heaters.....	Silo Filler.....	Percolators.....	Hot Plate.....	Ranges.....	Vacuum Cleaners.....	Milking Machines.....	Washing Machines.....	Water Systems.....	No. Farms Served.....	
0	0	0	1	1	1	1	1	17	4	5	6	10	19	17	141	9	3	8	1	0	0	4	38	9	44	63	181	District No. 2
0	0	0	0	0	0	0	1	5	1	2	1	1	7	4	54	2	0	2	0	0	0	1	14	0	11	15	74	General
0	0	0	0	0	0	0	0	0	3	3	3	2	1	1	7	1	0	3	0	0	0	0	4	0	0	5	8	Livestock
0	0	0	0	0	0	1	0	4	2	0	2	3	7	9	41	4	3	1	1	0	0	2	11	9	15	34	57	Dairy
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	Truck
0	0	0	1	1	0	0	0	7	1	0	0	1	1	2	27	2	0	0	0	0	0	0	4	0	14	7	28	Poultry
0	0	0	0	0	1	0	0	1	0	0	0	3	3	1	11	0	0	2	0	0	0	1	5	0	4	2	13	Fruit
0	0	0	1	1	0	0	0	4	2	5	2	6	4	3	19	1	0	0	1	0	0	4	11	6	8	16	33	District No. 4
0	0	0	0	0	0	0	0	2	0	1	0	2	1	0	8	1	0	0	0	0	0	0	3	1	2	5	13	General
0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0	0	1	1	0	2	3	3	Livestock
0	0	0	0	0	0	0	0	2	1	4	2	3	3	3	8	0	0	0	1	0	0	3	7	5	4	8	14	Dairy
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	Truck
0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	Poultry
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fruit
1	0	1	0	0	0	0	0	0	2	1	0	3	3	0	14	1	0	2	1	0	0	1	7	4	2	2	17	District No. 5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	1	0	0	0	3	General
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	Livestock
1	0	1	0	0	0	0	0	2	1	0	3	3	0	0	8	0	0	2	1	0	0	1	5	4	2	2	9	Dairy
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	Truck
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Poultry
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	Fruit
1	0	0	0	0	0	0	0	1	7	2	2	6	4	0	38	0	0	4	0	0	1	0	18	0	2	5	56	District No. 6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	General
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Livestock
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Dairy
1	0	0	0	0	0	0	0	1	6	2	2	5	4	0	35	0	0	4	0	0	1	0	14	0	2	2	51	Truck
0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	3	0	0	0	0	0	0	0	4	0	0	3	5	Poultry
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fruit
1	2	0	0	0	1	0	9	6	5	5	5	2	5	10	58	4	2	1	0	6	0	3	18	2	19	17	91	District No. 7
0	0	0	0	0	0	0	2	3	0	0	1	0	0	0	20	0	1	0	0	2	0	1	4	0	4	1	39	General
0	0	0	0	0	0	0	5	0	5	4	3	2	2	7	19	3	1	1	0	2	0	1	12	0	7	5	27	Livestock
1	2	0	0	0	1	0	1	3	0	0	1	0	3	1	11	1	0	0	0	1	0	1	2	2	5	7	15	Dairy
0	0	0	0	0	0	1	0	0	1	0	0	0	0	2	7	0	0	0	0	0	0	0	0	0	3	2	9	Truck
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2	1	Poultry
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fruit
0	0	0	0	0	0	0	1	0	0	0	0	1	0	2	3	1	0	1	0	0	0	0	1	0	3	5	4	District No. 8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	General
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Livestock
0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	2	1	0	0	0	0	0	0	0	0	1	2	2	Dairy
0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	1	0	0	0	0	1	0	2	3	2	Truck
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Poultry
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fruit
1	3	0	0	0	0	0	2	1	1	4	0	2	4	1	21	3	0	0	0	1	1	0	7	1	4	24	32	District No. 9
0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	1	0	0	2	0	0	1	4	General
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3	2	Livestock
1	3	0	0	0	0	0	1	1	1	0	0	1	0	6	6	0	0	0	0	0	0	0	2	1	0	6	8	Dairy
0	0	0	0	0	0	0	0	0	0	2	0	1	1	1	9	1	0	0	0	0	1	0	2	0	3	13	16	Truck
0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	2	2	0	0	0	0	0	0	1	0	1	1	2	Poultry
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fruit

	District									Totals
	No. 2	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9			
No. Farms Served.....	181	33	17	56	91	4	32	414		
Water Systems.....	63	16	2	5	17	5	24	132		
Washing Machines.....	44	8	2	2	19	3	4	82		
Milking Machines.....	9	6	4	0	2	0	1	22		
Vacuum Cleaners.....	38	11	7	18	18	1	7	100		
Ranges.....	4	4	1	0	3	0	0	12		
Hot Plate.....	0	0	0	1	0	0	1	2		
Percolators.....	0	0	0	0	6	0	0	7		
Silo Filler.....	1	1	1	0	0	0	0	3		
Heaters.....	8	0	2	4	1	1	0	16		
Emerys.....	3	0	0	0	2	0	0	5		
Refrigerators.....	9	1	1	0	4	1	3	19		
Irons.....	141	19	14	38	58	3	21	294		
Fans.....	17	3	0	4	10	2	1	37		
Toasters.....	19	4	3	6	5	0	4	41		
Curling Irons.....	10	6	3	2	2	1	2	26		
Grills.....	6	2	0	2	5	0	0	15		
Waffle Irons.....	5	5	1	7	5	0	4	27		
Sewing Machines.....	4	2	2	1	5	0	1	15		
Separators.....	17	4	0	0	6	0	1	28		
Churns.....	1	0	0	0	9	1	2	13		
Wood Saws.....	1	0	0	0	0	0	0	1		
Apple Graders.....	1	0	0	0	1	0	0	2		
Incubators.....	1	1	0	0	0	0	0	2		
Brooders.....	1	1	0	0	0	0	0	2		
Sprayers.....	0	0	1	0	0	0	0	1		
Bottle Washers.....	0	0	0	0	2	0	3	5		
Battery Chargers.....	0	0	1	1	1	0	1	4		





MILES OF RURAL LINES PER COUNTY (100 Counties in state)



FAIRFIELD EXTENSION RICHMOND, VA.
 PROJECT NO. 1.
 VIRGINIA STATE COMMITTEE
 RELATION OF ELECTRICITY
 TO AGRICULTURE.
 SCALE - 1" = 800' LINE - 5 MILES
 SURVEYED AND DRAWN BY -
 J.H. WALLER, JR.,
 PROJECT LEADER.
 DATE: Feb. 1926.

→ LEGEND ←
SINGLE PHASE - 2300 VOLT - 5 KVA TRS
 Experimental form - ○
 Original subscriber, name underlined - 30
 House wiring - ■
 Negro - " after name
 Va. Railway & Power Co. line - ———
 Private line - - - - -
 Transformer - "T"
 Three wires from transformer - "3 Electric - "E"
 Individual lighting system - "Electric - "L"
 Dairyman - "D"
 Aviculturist - "A"
 General Farmer - "G"
 Teacher - "T"
 Lightning protectors - "L.P."
 Three wire service - "3"



Combination telephone and 2300 volt line.



High tension and service line.



2300 volt line.



Private line.

A Study of the Isolated Farm Electric Plant

By D. C. HEITSHU, Assistant Professor Agricultural Engineering

During the past year a study has been made of isolated farm-electric plants as used in Virginia. Paralleling Virginia rural electrification program, this phase of the work is to be given careful attention at the Virginia Polytechnic Institute, and this report is presented as a progress report rather than as the final results of this study.

The objects of this particular study are to determine (1) the current cost for electric light and power secured from this type of plant; (2) the satisfaction these plants are giving in actual service; and (3) the comparative merit of battery and non-battery plants.

To obtain this information, two methods were followed. A survey of plant owners was made by means of questionnaires. Laboratory tests were also run on three plants in the Agricultural Engineering Laboratory at the Virginia Polytechnic Institute. The questionnaire study was carried on by F. M. Sommerville, as his graduate thesis work, while the laboratory tests were run in connection with the work of the senior class in rural sanitary equipment. The test work was found to be accurate and well carried out and the results obtained are a distinct credit to the students who performed the work. Several check tests were later made by the authors and no errors could be found in any of the work.

To obtain the desired information from farmer-owners of isolated plants, questionnaires were sent to about seven hundred farmers. This group included owners of every well known make of plant, and plants that had been in operation from one to fourteen years. About fifty of these questionnaires were sent to owners of non-battery plants. The returns were exceptionally good and, from those returned, one hundred fifty-seven of the battery plants and eighteen of the non-battery plants were tabulated. A few, necessarily, were discarded because of glaring inaccuracies in replies.

A summary of these questionnaires is given in Table I, the answers being divided to cover the battery and non-battery type of plants and thus give a comparison. The first and most striking fact brought out in this survey is the wonderful performance these plants have been giving in actual usage. Any group of machines that has been in use for an average period of 4.6 years and has a record of 93.7 per cent continuous operation speaks well for the engineering backing them. In connection with this record, it is very interesting to note that the troubles experienced were of a minor nature, such as would be expected with any internal combustion engine and electrical apparatus, and that all except battery trouble could be repaired easily by the average user.

The makes, size of plant, and like factors are in general accord with other surveys made in this field. We do not believe, however, that the reports received indicate the true distribution of the various

makes in Virginia. The Delco Light Company was able to furnish us with more names of owners than any other; some of the other large companies could give only a short list. Several of the smaller companies gave a list of all their customers.

The outstanding feature of the comparative summary is the yearly cost of battery and non-battery plants. Before going further with the comparative costs, it is interesting to note that the non-battery, 110-volt plants carry an average load which is greater than the 32 volt battery plants, while the average size is approximately the same.

However, there are several things to say in favor of the battery plant. This group as an average is older and, therefore, less efficient. The engines are worn and the batteries have passed thru a sufficient number of cycles of charge and discharge to have lost some of their vitality. The overhead and depreciation for the battery plants may likewise be slightly in error because of the relative higher purchase price of the older machines.

The starting trouble experienced with the non-battery plant is confined to this type of plant and is a very disagreeable one because there is no current to be had without starting by hand, there being no storage battery to fall back on in case of emergency. This trouble, however, is slight and under good average care should not be experienced.

The answers given in regard to the life of the plant are interesting in that the battery life is longer and the mechanical unit life shorter than that usually agreed upon by engineers. In view of the actual battery replacements reported and the increasing inefficiency, we feel well justified in figuring battery life at five years. Indeed, the chances are that the battery has been favored. The mechanical unit, with good care and proper replacements, will easily have a ten-year life. Taking everything into consideration, it is believed that these figures are true in claiming a slight saving in favor of the non-battery plant.

The latter part of the summary deals with sociological phase of the electric lighting and power plant, and merely goes to prove that the farmer needs and wants electric light and power and is willing to pay for it.

The laboratory tests to determine current costs were run on three plants, namely, Kohler, 1500 watt, Model "D"; Delco, 1250 watt, Model 1278; and Westinghouse, 1500 watt, Type "E," model 60 Goulds battery. The battery plants were given an eight hour charge from a cell voltage of 1.7, followed by a discharge at rated eight-hour rate until the cell voltage returned to 1.7. The charge and discharge determined fuel economy and battery efficiency. Following these tests the battery was again given an eight-hour charge, and the figures used as a check upon the first run. The test to which the non-battery plant was subjected was, of

necessity, different. The plant was tested under varying loads and conditions, as follows: The two-hour minimum load, two-hour one-fourth load, two-hour one-half load; two-hour three-fourths load, and eight-hour rated load, two-hour variable load of 6 minute load periods; two hour start-and-run test at variable load, with 12 minute runs at an interval of 15 minutes; and cranking test.

In view of the very thorough tests run upon the non-battery plant, the test given the battery system would, on first thought, appear inadequate for an accurate comparison. However, because of the many factors entering into battery efficiency, and varied conditions existing in battery plant operation, it is necessary that such a comparison be made. The conditions vary in almost any instance and to secure any reliable data a prolonged study is necessary. It is hoped that the Department of Agricultural Engineering may have these data available within the next year, but in the meantime a very good comparison can be made between the plants tested.

The test methods followed were conventional, no special methods or apparatus being used. The fuel was weighed during the run by mounting a fuel tank upon scales at the normal fuel supply level. The oil and water used was determined by measuring the supply before and after the run. The voltage and amperage readings were taken from a continuous reading voltmeter and ammeter, and checked with a closely calibrated voltammeter. The speeds were obtained by means of Veeder speed counters. The temperatures were taken in accordance with standard test practice, although only water outlet temperature was taken in the Kohler tests. In the battery plant tests, the battery information was secured by the use of voltammeter with cadmium test spikes and standard hydrometer. A lamp bank was used for loading in all tests except as stated in the two tests of non-battery plants.

The gasoline used in these tests weighed 6.25 pounds per gallon and cost 20 cents, while the kerosene weighed 6.56 pounds per gallon and sold at 15 cents. The lubrication oil cost 80 cents per gallon for both grades used. In figuring oil cost, both consumption and replacement costs were included in the total. Oil replacement costs were based upon 600 hours of running for gasoline and 400 hours for kerosene for each crankcase filling.

A summary of all tests for the battery plants and tests Nos. 1 to 5 for the non-battery plant is given

in Table II. The test curves of the Kohler non-battery plant are plotted in Graph I, while Graph II gives the performance curves of the Westinghouse battery plant under test.

These results bring to light nothing unexpected if a careful analysis is made of the characteristics of the four-stroke-cycle, internal combustion engine, the electric generator, and the lead-acid storage battery. The fuel consumption curve and the resulting cost curve of the non-battery plant is as expected, and presents the greatest drawback of this type of plant. It is essential that a sufficient load be applied for economical operation. The problem here is very much the same as that presented in the automobile engine, that is, low efficiency at part throttle, and the same possible solutions present themselves; namely, improving the volumetric efficiency by application of the Dempsey cycle or similar remedy, the development of a reliable, light-weight, high speed Diesel engine. The use of the so-called steam cooling system offers possibilities for this type of plant and is worthy of careful trial.

The battery plants tested are slightly more economical as far as the mechanical-electrical unit goes, running at a higher temperature and burning kerosene successfully. The battery is the weak link in these plants and offers a great field for improvement which, if not forthcoming, undoubtedly means the end of the battery plant in not many years distant. At present, the battery gives cheap current on light loads, but on the heavier demands it becomes more costly and involves the trouble of starting the plant manually to care for the largest loads economically.

The conclusions of this study thus far can be very briefly summarized as follows:

1. The individual farm electric light and power plant is a very satisfactory piece of farm equipment.
2. The cost of current derived from these plants is exceedingly high.
3. The farmer is "sold" on electricity and willing to pay well for its advantages.
4. Over a period of time it would seem that the current cost from the non-battery type of plant is cheaper than from the battery plant.
5. A large field for improvement and development is presented in both types of plant.

Table I

Summary of Questionnaires from 175 Farmers Having Individual Lighting Plants

NATURE OF QUESTIONS	(Answers) BATTERY PLANTS	(Answers) NON-BATTERY PLANTS
Number of plants	157 (100%)	18 (100%)
Name of plants	Delco, 78.9%; Matthews, 8.2%; Fairbanks-Morse, 2.54%; Willys-Knight, 2.54%; Lalley, 2.54%; Western Electric, 1.9%; Westinghouse, 1.27%; Almo, 0.63%; Edison, 0.63%; Phelps, 0.63%.	Kohler, 100%
Size of plant	750 watts 17.8% 850 watts 16.5% 1000 watts 8.2% 1250 watts 14.0% 1500 watts 4.5% 3000 watts 2.5% 6000 watts 0.6% (110 volts) Ratings given in HP 5.1% Did not answer, 29.9%	800 watts, 28% 1500 watts, 72%
Voltage of plant	32 volts, 98.1%; 110 volts, 1.9%	110 volts, 100%
Ampere hour capacity of battery	140 (average) 20.4% wanted larger size	Use only small 24-volt starting battery
Drive—direct connected or belted	Direct, 97.5%; belted, 2.54%	Direct, 100%
Age of plant	Average 4.5 years	Average 1.3 years
Satisfied with plant?	Yes, 95%; No, 5%	Yes, 94.5%; No, 5.5%
Been in continuous operation	Yes, 93.6%; No, 6.4%	Yes, 94.5%; No, 5.5%
Principal troubles	Minor Troubles: Spark plug, exhaust valves, magneto, fuses, meter and auto switch	Starting, 5.5%; none, 94.5%.
Estimated life until repairs must be made of—(average)	(1) Battery Owner's estimate 6.5 years, 20.3% did not answer Dealer's claim 7.1 years, 38.2% did not answer (2) Engine 6.9 years, 46.5% did not answer (3) Generator 7.4 years, 55.4% did not answer Average, 25.1	Good for life of plant
Number of lights used	None, 42.7% Pumps, 28% Irons, 24.8% Washing machines, 11.4% Churns, 8.9% Vacuum cleaners, 8.9% Fans, 7.6% Phonographs, 0.63% Meat grinders, 0.63%	6.6 years, 66.6% did not answer 6.6 years, 66.6% did not answer Average, 22 None, 22.2% Irons, 50% Pumps, 22.2% Washing machines, 16.6% Vacuum cleaners, 16.6% Stove, 11.1% Fans, 11.1% Toasters, 5.5% Percolators, 5.5% Drills, 5.5% Motors, 5.5% Electric cabinets, 5.5%
Cost of present plant installed, including wiring	Average, \$602.46	Average, \$577.22

Table I—Continued

NATURE OF QUESTIONS	(Answers) BATTERY PLANTS	(Answers) NON-BATTERY PLANTS
Annual cost for (average):		
(1) Gasoline	\$39.20—32.4% use gasoline	\$62.33—16.6% did not answer
(2) Kerosene	27.10—62.4% use kerosene; 5% did not answer	
(3) Oil	7.15	7.40—16.6% did not answer
(4) Labor	7.94	5.00—94.5% did not answer
(5) Repairs to battery	3.66—86.6% reported none	None reported
(6) Repairs to engine and generator	1.00—54% reported none	.28—94.5% reported none
Operating expenses—total	\$86.05	\$75.01
Total annual cost	Overhead—Interest on one-half original investment at 6%.....\$18.07	Overhead—Interest on investment (one-half original investment at 6%).....\$17.31
	Depreciation—Battery, \$200.00 at 20% 40.00	Depreciation — Engine and generator, \$427.22 at 10%.. 42.72
	Engine and generator, \$302.46 at 10%..... 30.24	Wiring, \$100.00 at 5%..... 5.00
	Wiring, \$100.00 at 5%..... 5.00	Starting battery, \$50.00 at 20% 10.00
	Operating expenses 86.05	Operating expenses 75.01
	\$179.36	\$150.04
Do without electric lights on basis of what they now cost you?	No, 97.5%; yes, 2.5%	No, 100%
Estimated worth of electric lights	\$472.43 (average); 79.5% did not answer	\$441.30 (average), 83.3% did not answer
Did you have a light plant before	Yes, 15.4%; no, 84.6%	Yes, 33.3%; no, 66.7%
Buy same kind plant again?	Yes, 77.1%; no, 10.8%; undecided, 12.1%	Yes, 88.9%; no, 11½%; one stated Delco
Advantages	Convenience, safety, better lights, use of electrical appliances, help to housewife, cleaner, and time saver	Same as for battery plants
Time saved in doing chores	1.7 hours per day; 29.2% did not answer	1.5 hours per day; 88.9% did not answer
Used less help?	Yes, 21.2%; \$14.06 (average); no, 20.3%; 23.9% did not answer	Yes, 33.3%; \$6.00 (average); 66.7% did not answer
Helpers better satisfied?	Yes, 68.7%; no, 8.2%; 23.1% did not answer	Yes, 44.4%; 55.6% did not answer
Children more interested in home?	Yes, 60.5%; 39.4% had no children or did not answer	61.1%; 38.9% did not answer
Distance from power line	11.5 miles (average); 7.6% did not answer	10.3 miles (average); 5.5% did not answer
Amount willing to invest in rural line	\$463.80 (average); 41.4% did not answer	\$600.00 average; 50% did not answer

Table II

SUMMARY OF KOHLER NON-BATTERY TESTS NOS. 1, 2, 3, 4 and 5

Watt Load	Length of Test Hours	Volts	Amperes	R. P. M.	Fuel Used (Lbs.)	Fuel Per Kilowatt Hour (Lbs.)	Engine Cooling Temp. Degrees F.	Generator Temperature Degrees F.	Room Temperature Degrees F.
73.5	2 hours	122.5	0.6	1084	2.94	19.98	148	73	56
409.27	2 hours	116.6	3.51	1076	3.31	4.05	161	89	64
899.38	2 hours	116.5	7.72	1053	4.25	2.36	164	76	51
1163.48*	2 hours	113.4	10.26	1063	4.75	2.04	174	96	65
1511.43**	8 hours	109.05	13.86	1033	21.69	1.79	179	101	67

*NOTE—Oil and water used measured at end of test No. 4: Oil used, ½ pint; water used, ⅛ pint.

**NOTE—Oil and water used in test No. 5 as follows: Oil used, ⅓ pint; water used, ¼ pint. Some lost through overflow tube of radiator as engine first warmed up.

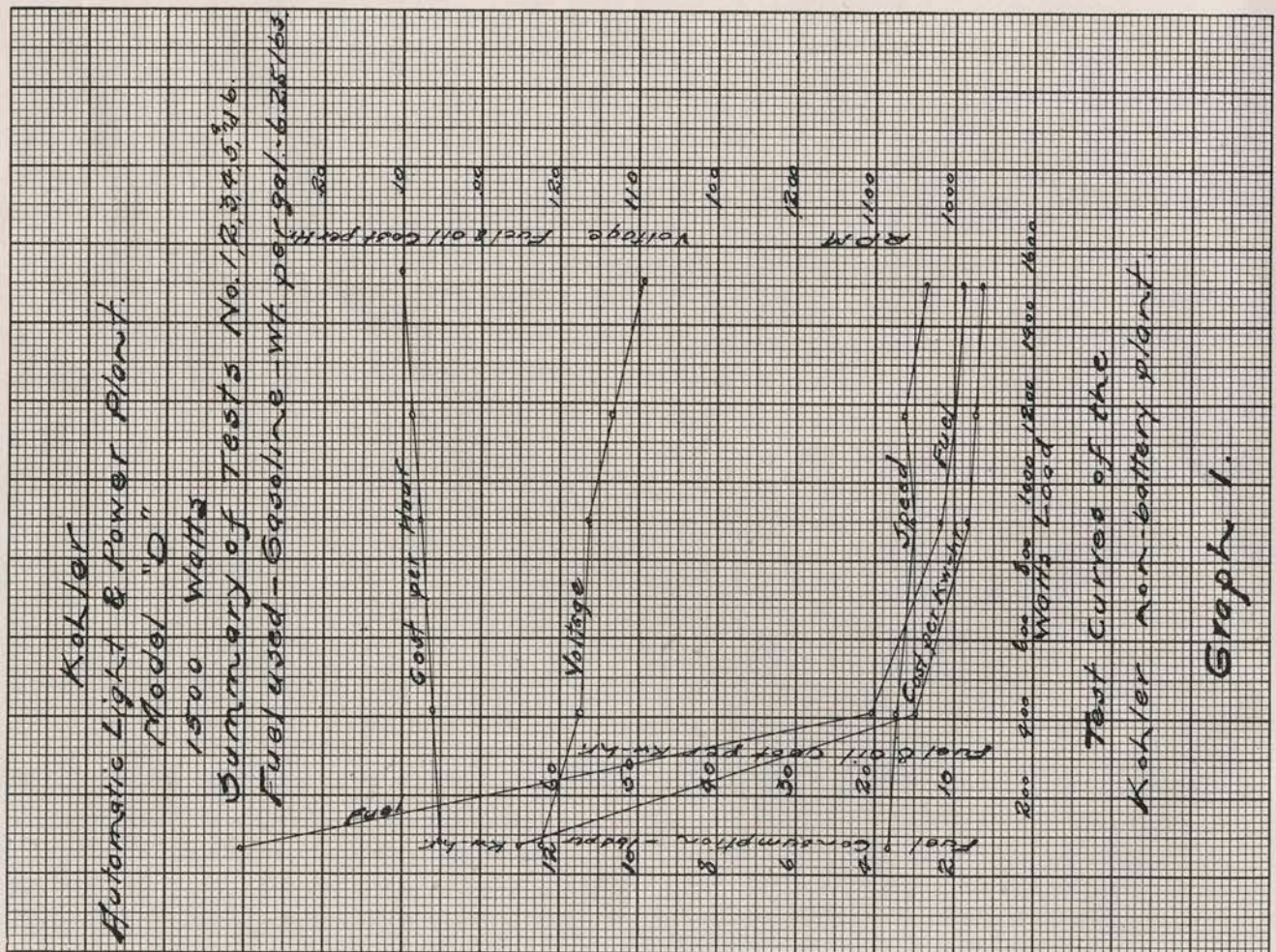
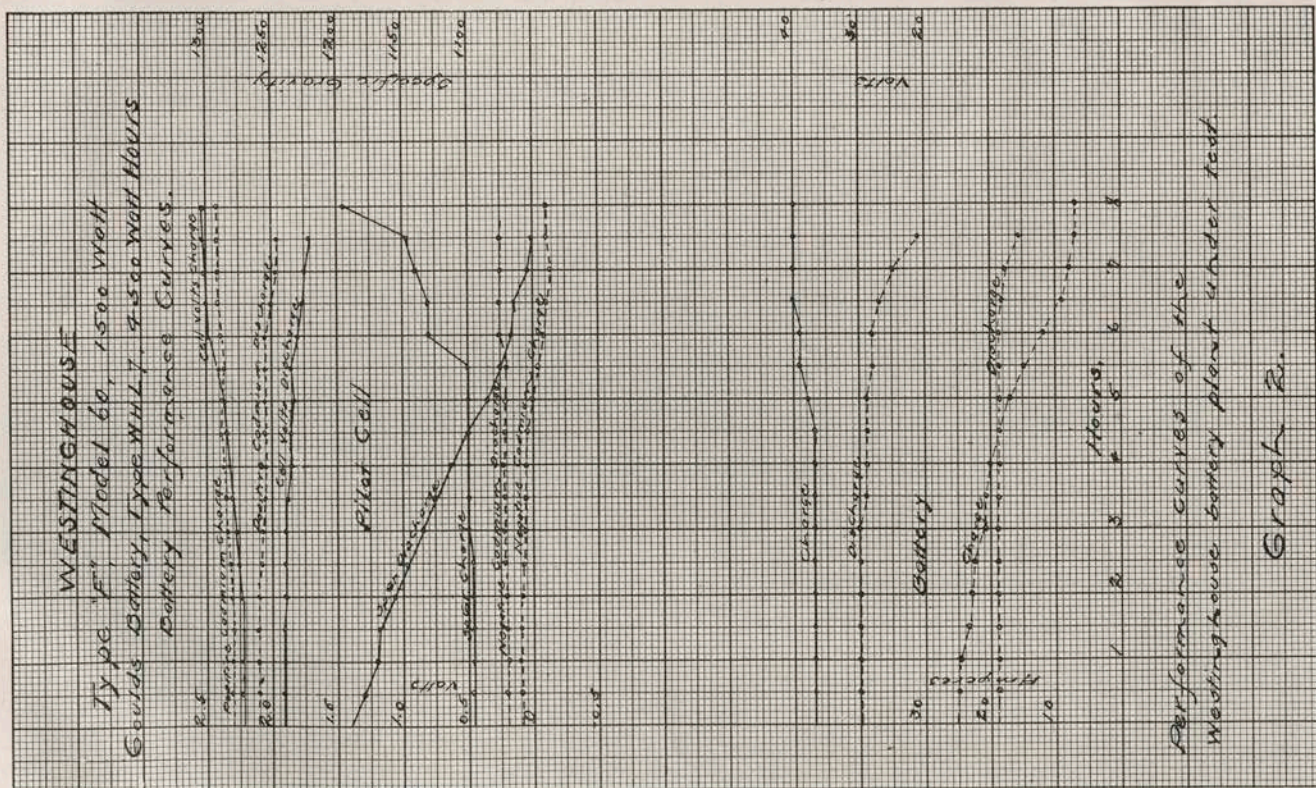


Table III

Summary of Battery Plant Tests

Fuel Used—	(CHARGE)			(DISCHARGE)		
	Kerosene	Gasoline	Kerosene		Gould,	Delco Lgt.
					Type WHL 7	KKXG 13
Speed, r. p. m.	1127	1169	1236	Battery	4500	4800
Amperes	17.73	18.6	17.5	Battery rating, watt hour.....	Very good	Good
Volts	38.15	40.2	39.76	Amperes	18.74	18.35
Watts	676.4	747.72	695.8	Volts	28.56	28.75
Length of test, hours.....	8.0	8.0	8.0	Watts	535.21	527.56
Kilowatt-hour input	5.4112	5.982	5.566	Length of test, hours.....	7.5	8.0
Pounds of fuel consumed....	16.31	20.75	18.75	Battery temperature, deg. F. ..	63.4	62.0
Pounds of fuel per K. W. H....	3.014	3.468	3.369	Room temperature, deg. F. ...	59.0	58.0
Oil used, pints.....	0.5	0.5	0.5	K. W. H. output.....	4.014	4.22
Engine temperature, deg. F. ...	98.3	92.0	129.0	K. W. H. input.....	5.4112	6.982
Battery temperature, deg. F. ...	66.0	59.75	57.0	Efficiency, per cent.....	74.18	70.54
Generator temperature, deg. F.*	77.0	81.5	59.0	Fuel and oil costs per K. W. H.		
Room temperature, deg. F.....	60.5	61.2	53.0	from battery.....	\$0.1092	\$0.1728
Fuel and oil costs per K. W. H.					\$0.1534	
Fuel	\$0.069	\$0.1109	\$0.077			
Oil consumed.....	0.009	0.009	0.009			
Oil replacement.....	0.003	0.002	0.003			
	\$0.081	\$0.1219	\$0.089			

* Construction of the Delco generator prevented getting actual temperature with glass stem thermometer.



KOHLER TEST NO. 6
Variable Load—6 Minute Runs—2 Hours

Time	Room Temp.	GENERATOR			ENGINE			LOAD	REMARKS
		Volts	Amps.	Temp.	R.P.M.	Fuel (Lbs.)	Water Temp.		
9:00	54.0	114	6.75	76	1049	43.56	155	Lights (740 watts)	
9:06	54.5	107	13.5	77	1044	43.31	162	Lights (740 watts) and Delco*	Plant slowed by load;
9:12	54.5	116	8.1	80	1058	43.0	170	Delco	amps 20, volts 50
9:18	55.0	115	11.0	81	1056	42.81	170	Delco and Grinder**	Amps. to 16, volts to 80
9:24	55.0	118	2.1	82	1062	42.56	171	Grinder and 60 watt lamp	
9:30	55.0	117	2.1	82	1087	42.44	166	Lights (180 watts)	
9:36	55.5	116	4.00	82.5	1061	42.25	161	Lights (180 watts) and ¼ h. p. motor	Amps. to 11, volts to 110
9:42	55.5	117	.75	83.0	1074	42.12	161.5	Lights (60 watts)	Volts to 120
9:48	55.5	115	7.75	82.5	1025	41.94	158.0	Lights (60 watts) and Delco	Amps. to 21, volts to 50
9:54	55.5	105	14.0	85	1019	41.69	166.0	Lights (615 watts) Delco and ¼ h. p. m.	Amps. to 16, volts to 100
10:00	56.5	115	6.1	89	1069	41.5	177.0	Lights (615 watts)	Volts to 121
10:06	57.5	114	8.5	88.5	1071	41.25	171.5	Lights (615 watts) and ½ h. p. motor	Amps. to 12, volts to 105
10:12	57.0	116	2.5	89.0	1064	41.0	171.0	Lights (60 watts) and ½ h. p. motor	Volts to 122
10:18	56.5	110	10.0	88.5	1050	40.81	165.0	Lights (60 watts), ¼ h. p. motor and Delco	Amps. to 20.5, volts to 51
10:24	57.5	115	7.5	90.0	1056	40.62	170.5	Lights (60 watts) and Delco	
10:30	57.5	110	10.0	90.0	1046	40.44	172.0	Lights (300 watts) and Delco	
10:36	57.0	108	12.0	91.5	1044	40.25	175.0	Lights (300 watts) and Delco and Grinder	Amps. to 21, volts to 75
10:42	57.5	115	3.5	93.0	1055	40.0	178.0	Lights (300 watts)	Volts to 125
10:48	57.5	116	2.2	92.0	1067	39.81	171.0	Lights (180 watts)	
10:54	57.5	117	1.1	91.5	1072	39.69	164.5	Lights (60 watts)	
11:00	58.5			90.0		39.5	160.5		

NOTE: The volts, amperes and R. P. M. readings were taken at the middle of each run and recorded under the time of the beginning of that particular load run. Water and oil used not measured.

NOTE: Governor handled engine speed with very little variation except upon the addition of the second load. No starting devices used with motors.

* Delco—110 volts, 750 watts, Delco light plant motored with spark plug removed.

** Grinder—½ h. p. high speed motor.

KOHLER TEST NO. 7

Start and Run Test—Variable Load—12 Minute Test Runs with 15 Minute Intervals. Total Running Time 2 Hours.

Run No.	Time	Room Temp.	Time to Start	GENERATOR			ENGINE			LOAD	REMARKS
				Volts	Amps.	T.	R.P.M.	Fuel (Lbs.)	Water Temp.		
1	1:15	61	8 secs.	120	1.5		1062	48.69	164	Lights	Warming up run from 12:40 to 1:00
	1:27	63				80		48.31	162		
2	1:42	62	4 secs.	117	3.75		1052	48.25	154	Lights	Carburetor overflowed during interval following first run
	1:54	62.5				84		47.94	165		
3	2:09	63.5	4 secs.	116	5.5		1049	47.94	161	Lights	
	2:21	64.75				86		47.50	169		
4	2:36	64.5	4 secs.	115	6.75		1033	47.50	164	Lights	
	2:48	64.5				87		47.06	171		
5	3:03	64.5	9 secs.	114	8.0		1037	47.06	164	Lights and ¼ h. p. motor	
	3:15	64.5				88		46.62	174		
6	3:30	64.0	11 secs.	113	9.9		1035	46.62	167	Lights, ¼ h. p. motor, ½ h. p. motor	
	3:42	65.5				92		46.12	178		
7	3:53	65.5	10 secs.	113	9.5		1048	46.12	175	Lights, ¼ and ½ h. p. motors	110 volt relay arced slightly Run started 4 minutes too soon
	4:05	65.0				94		46.69	177		
8	4:20	64.5	5 secs.	110	11.0		1046	45.69	171	Lights, ¼, ½, ½ h. p. motors	Slight arcing at 110 volt relay
	4:32	65.5				94		45.19	178		
9	4:47	64.5	70 secs.	100	15.2		979	45.19	169	Lights, ¼, ½, ½ h. p. motors and Delco	Relay first closed 10 seconds after closing of line switch, then arced for 60 seconds while the engine gained speed. The voltage varied from 30 at beginning to 103 at end of run, while the amperes dropped from 23 to 14.75.
	4:59	65.5				99		44.56	181		
10	5:14	63.5	10 secs.	121	1.5		1079	44.56	170	½ h. p. motor	Readings as relay closed: Volts, 70, amperes 12
	5:26	63.0				94		44.25	163		

NOTE: No starting device used on any motor or load in this test.

*Delco—110 volts, 750 watt. Delco light plant motored with spark plug removed.

Kohler Test No. 8

Cranking Tests—Engine Warm and Cold

ENGINE WARM

Test Made Immediately After Test No. 7

Amperes to break engine.....	38
Amperes to crank engine.....	10
Cranking speed, R. P. M.	326
Cooling water temperature, degrees.....	162
Room temperature, degrees.....	63

ENGINE COLD

Test Made Three Hours, Fifteen Minutes After First Cranking Test

Amperes to break engine.....	50
Amperes to crank engine.....	17
Cranking speed, R. P. M.	222
Cooling water temperature, degrees.....	77
Room temperature, degrees.....	50

CONCLUSIONS

The conclusions of this work can be briefly summarized as follows:

1. A very small per cent of the farms in Virginia have electric service from central plants. Note: There are 194,000 farms of four acres or more, and there are not over 500 farms of 10 acres or more now being served.

2. Northern Virginia (District No. 2) has more farms served from central stations than any other section of the state.

3. No customer on central station lines would be without the service for any reasonable cost.

4. There is a very wide application of electricity to agriculture.

5. Dairying uses more electricity than any other type of farming.

6. The generating stations are fairly well distributed over the state.

7. Farmers are somewhat ignorant concerning why there should be losses in the distribution of electricity.

8. Farmers would like to turn the lines they now own over to the power companies.

9. The farm peak load comes in September, and is due largely to pumping water.

10. The extent to which appliances are used is dependent upon the charge for electric service.

11. Electric irons are the most popular appliance; water systems rank second; vacuum cleaners third; and washing machines fourth.

12. Appliances are much more numerous on farms having central station service than on farms having service from individual plants.

13. The highest rate per kilowatt hour in the state is \$0.20, and is on the eastern shore.

14. No individual electric plants were found on farms located within practical reach of central station lines.

15. Farmers are showing much interest in electricity and are anxious for the service.

16. There is practically no uniformity among the power companies as to rural rates or methods of financing rural lines.

17. Rural electrification will be an important part of the electrical load in future developments.

PLANS FOR THE FUTURE

The organization of the investigational work will be on a somewhat different basis beginning July 1st, 1926. Mr. Waller, Project Leader, now devoting his entire time to the field study, will be placed on the extension staff of the Department of Agriculture Engineering. One of his main extension projects will be rural electrification. Existing rural lines will be selected in different sections of the state or new lines constructed for demonstration projects. An endeavor will be made to completely equip the farms on the rural lines and keep records that will be useful in educating other farmers as to the advantages of electricity on the farm. The isolated electric light plant and the individual small community water power plants will also receive attention. Records will be continued on the experimental lines at Richmond. Purely investigational work will be conducted at the college. A full time man will be placed on the experimental work July 1st, 1926. He will devote his time the first year to investigations in co-operation with the Dairy and Poultry Departments of the college.

It is felt by the committee that the above arrangement will result in a more rapid extension of the use of electricity on the farms of the state, and a consequent higher standard of rural life.

