6-1-1932

Electricity on New England Farms--II, Bulletin, no. 266

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New Hampshire Agricultural Experiment Station

Bulletins 251-271 OK - RBS 4/10/42

#256 - 42d Ann. Rpt. - 1930
#262 - 43d Ann. Rpt. - 1931
#270 - 44th Ann. Rpt. - 1932
} OK - RBS 4/24/42

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Bulletin 266 June, 1932

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

ELECTRICITY ON NEW ENGLAND FARMS—II

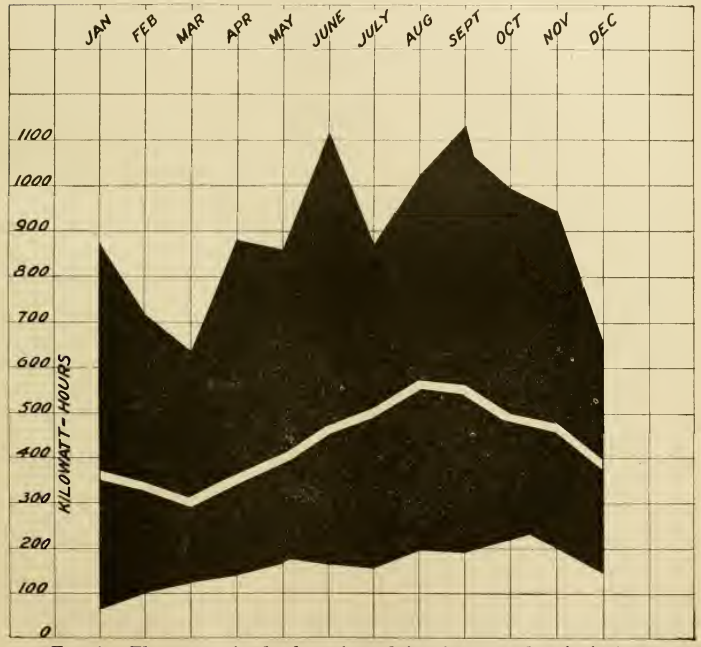

FIG. 1. *The composite load on four dairy farms and a fruit farm for a five year period.* *(See page 50)*

A Report of the New Hampshire Project on the Relation of Electricity to Agriculture for the Years 1925-1930

By W. T. ACKERMAN

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ELECTRICITY ON NEW ENGLAND FARMS—II

By W. T. Ackerman

Under date of March, 1927, a progress report was issued on the results obtained in 1925 and 1926 from seven experimental farms comprising a New England project to test the practicability of using electricity for light, heat and power in farm operations. This report covered but two years of operation, and a continued check of the experimental group was deemed advisable to verify the results of electrical usage over a greater period of time. The present report covers the six year period extending from 1925 to 1930.

The principal questions confronting the first two years' work were "Would electricity be practical power on a farm?", and, "Could economic volume of use be built up sufficiently to support the required investment?" This and previous reports, together with general experience to date, answer the first question in the affirmative. A similar answer to the second question may be discerned in the data presented in the following pages, which show that over a period of time the use of electricity increases, rather than decreases, and that the limitation to further expansion of use is the availability of equipment, especially designed to meet farm requirements and the ability of farms to finance the necessary investment.

Another question supplanting previous ones is, "Will the electric load on the farm fall off with time or due to financial or other reverses?" The past few years have provided excellent conditions for acquiring data on this characteristic, and to make the experimental conditions as impartial as possible these farms have been left to their own devices for the years 1929 and 1930, when contacts were reduced to two or three per year for the collection of records.

The test groups, comprising dairy, fruit, and poultry farms were selected and equipped with appliances metered in such a way that detailed records could be secured each month for each piece of equipment. In some cases comparative tests with other forms of power were made. Sixty major and 40 minor pieces of equipment were in use on the farms, covering 36 or more distinct operations and involving 50 or more different makes.

Note: This is a progress report of the New Hampshire experiment on rural electrification for the New England territory carried on by the University of New Hampshire Experiment Station in co-operation with the National and New England Committees on the Relation of Electricity to Agriculture for the six year period ending December 31, 1930. Reports, covering some groups of appliances and their operating characteristics in greater detail, are available; and others are planned.

Appreciation is here expressed to the manufacturers of equipment, co-operating farmers, agricultural organizations, electrical interests and others who have generously given of their support, financial and otherwise, to make this work possible. Co-operating farmers are: D. T. Atwood, Franklin; R. T. Gould, Contoocook; J. R. Graham, Boscawen; R. E. Holmes, Stratham; S. D. Sterling, Dover; N. F. Stearns, West Lebanon; and G. E. Townsend, Salem.

The farms comprising the experimental group were selected with considerable care with particular emphasis on the number of operations that could be experimented with and the intention of the farmer to exert himself in furnishing accurate and full information. These farms cannot be classed as average farms of New England. They are considerably above the average in productiveness, man-power and industry. For reasons that need not be enlarged upon here, it was necessary to select such a type to provide opportunities for testing out a greater variety of operations. On the other hand, none is in the nature of a "gentleman's estate" or endowed with an undue amount of capital or wealth. They are typical of the substantial and successful farm, operated with modern, well balanced methods.

FARM NO. 1 (RETAIL DAIRY)

Among the group of four dairy farms on which experimental equipment was installed in 1925-1926, none presented a greater number of possibilities than Farm No. 1. Its tillable area is much greater than any of the other seven, it is stocked with a large herd of cattle and carried on a well diversified program in which the home growing of feeds, other than grain, is a feature. In addition, cash crops, such as potatoes, are produced in liberal amount, and, since 1927, poultry raising has been added as an important side line.

Description. Five-man farm. Family of four adults. Ten room brick house. Large dairy barn with silos attached, large implement shed, other out-buildings. 225 acres of river bottom land, level and free of stone. 50 head of cattle, 25 milked, 2 horses, 1 tractor, 2 delivery trucks, pleasure car, modern machinery. Farm wholesales 320 quarts of milk and cream a day. Two transformers of 10 K. V. A. capacity used in parallel to balance load.

Equipment—Household: House lights; Flat Iron; Percolator; Curling Iron; Washing machine; Vacuum Cleaner; Household Refrigerator; Kitchen Range; Sewing Machine Motor; Radio.

Farmstead: Barn and Poultry Lights; Milking Machine; Cream Separator, motor equipment; 7½ h. p. Portable Utility Motor; Water Pump, Owner's House; Water Pump, Tenant House; Hay Hoist; Concrete Mixer; Dairy Cooling Room; Stock Clippers; Farm Shop.

The general proportions of the business put this farm and Farm No. 7 in the group of large, progressive and unusually active farms—a position held by relatively few in New England but found at well spread intervals over this section. The remaining five farms are in the average-sized group but operated under better than average methods.

The total equipment on this place was large, both as regards quantity and investment. In the list of equipment given, those articles that were discarded, little used, or of purely an experimental nature are not included. (A fireless cooker, water heater, shop motor and flood light were tried but not continued in service.)

The load was about equally balanced between the house and farm as far as number of appliances is concerned,—50% in each case, but some of those in the house were of small value, and 64% of the total investment was in the farm work group—the largest percentage on any of the seven farms.

With the farm equipment predominating to this extent, particularly the refrigeration of milk, it is not surprising (See Figure 2) that the

load curves show the peak in midsummer which has proven to be an agricultural characteristic particularly where any amount is applied on farm work proper, and which reflects the more strenuous activities of late spring, summer and early fall.

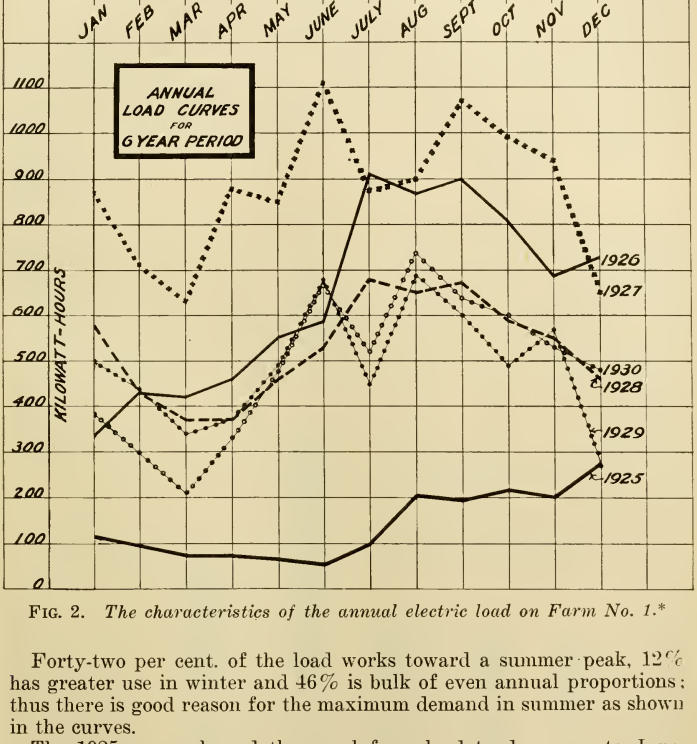

FIG. 2. *The characteristics of the annual electric load on Farm No. 1.**

Forty-two per cent. of the load works toward a summer peak, 12% has greater use in winter and 46% is bulk of even annual proportions; thus there is good reason for the maximum demand in summer as shown in the curves.

The 1925 curve showed the usual farm load tendency up to June, prior to rural electrification activities. The installation of equipment at this time broke into the completion of this curve, on the old basis, for

* There is a slight decline in total current used in the last two years, due to the fact that the owner and wife left the farm on a vacation (the first since the farm was purchased) from November to April, 1929-30, during which time no current was consumed in the household. During this period farm activities were maintained as usual by the hired help. This fact points to the total of 1928 as being more nearly the true load for 1929-30, assuming the household in customary use.

the rest of the year, but a basin contour would probably have formed since this is normal to farms using small quantities of current.

In 1926 a considerable amount of equipment was in use, raising the maximum consumption from 200 to 900 kw.-hrs. per month. During the summer of 1927 was the period of greatest experimental activity, and 1,100 kw-hrs. was registered in June.

Table No. 1.

Farm No. 1.—*Kilowatt hours and current costs—five-year electrification period.*

Month	Kilowatt hours used.						
	Pre-electrification Period 1925	1926	1927	1928	1929	1930	Monthly Average
January	116	334	870	580	500	384	533.6
February	94	430	710	430	440	300	462
March	75	420	630	370	340	210	394
April	72	460	880	370	370	330	482
May	67	550	850	460	490	480	566
June	56	590	1,110	530	680	670	716
July	99	910	880	680	450	520	688
August	203	870	900	650	690	740	770
September	195	900	1,070	670	600	640	776
October	217	810	990	590	490	600	696
November	201	690	940	550	570	530	656
December	277	730	650	460	270	480	518
Yearly total	1,672	7,694	10,480	6,340	5,890	5,884	7,257.6
Ave. per month	139.3	641.1	874	528	490.8	490.3	
Daily ave.	4.57	21.07	28.7	17.3	16.1	16.1	
Ave. rate per kw.-hr.	.0792	.0455	.0438	.0458	.046	.04	
	Current costs.						
January	$11.80	$16.88	$38.32	$26.48	$22.88	$15.04	$21.90
February	9.16	20.72	32.48	20.44	20.24	14.64	19.61
March	8.20	20.32	28.48	18.08	16.24	11.04	17.06
April	7.69	21.92	38.48	18.08	17.44	15.84	19.91
May	6.78	25.52	37.28	21.28	22.24	21.84	22.49
June	6.31	27.12	47.68	24.08	29.84	29.44	27.41
July	8.68	39.92	38.48	30.08	20.64	19.12	26.15
August	13.64	38.32	39.28	28.88	30.24	25.72	29.35
September	13.07	39.52	46.08	30.38	26.64	22.72	29.74
October	15.17	35.92	42.88	26.48	22.24	21.52	27.37
November	14.56	31.12	40.88	24.88	25.44	19.42	26.05
December	17.41	32.72	29.28	21.28	14.44	17.92	22.18
Yearly total	132.47	350.00	459.60	290.46	268.52	234.26	189.22
Ave. per month	11.03	29.16	38.30	24.20	22.38	19.52	
Daily ave.	.36	.958	1.26	.796	.736	.641	

During 1928-29-30 the load subsided to proportions showing more normal use. The curves for these three years follow each other quite

closely, showing the establishment of routine use of the equipment retained after the experimental period and indicating how a steady and methodical plan is carried on from year to year.

Particular attention is called to the curves and kw.-hr. readings from June, 1926, to November, 1927, during which period an electric hot-water heater was operated under very adverse conditions. The current consumed each month by this heater was abnormal, but when these amounts are deducted from the farm total kw.-hrs., the curves for these two years have the same characteristics and contour as for the last three years, although they register a higher average volume. This experience substantiates observation made in the field that the water heating problem presents difficulties which require unusual care in installation. Similar difficulties were encountered on Farm No. 6 and will be discussed in the following pages.

Bulk Load.

From the standpoint of bulk load, Figure 3 shows that the 1,672 kw.-hrs. used in 1925 was increased 360% in 1926 and 520% in 1927. That a considerable portion of this was due to experimental activities needs no explanation. The important and lasting results, however, appear in Table 1, and the columns in Figure 2 for 1928-29-30. During this period the farm settled down to a natural and normal routine which developed an annual total consumption of around 6,000 kw.-hrs.

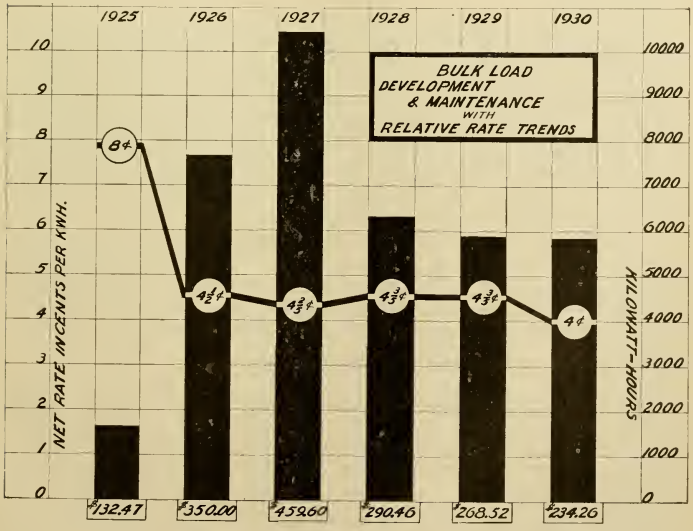

FIG. 3. *The development of volume and the trend of rates on Farm No. 1.*

While this reaction is expected from the experimental group, due to the concentrated installation of equipment and other operations in a relatively short period of time, much of which was accepted on the recommendation of the project engineer, the value of new equipment will be measured by the average farm customer from available data *before* he purchases. Thus, if reports of such a nature or points of information are lacking, his interest in investing will be correspondingly retarded, making the building of load on rural lines slow in the initial stages. That the rate of increase of load on rural lines bears a distinct relation to the preparations made to adequately serve this class of business by the power company, agricultural institutions and other organizations has been observed in the varying conditions existing in the different New England States.

Quantity use of electric current is usually accompanied by a lower cost per unit. The results of moderate and liberal use on the net rate paid for electricity are shown in Figure 3. In 1925 the total consumption of 1,672 kw.-hrs. involved an 8c unit charge. While this is a far better total than the average New England farm at present, it represents but moderate use when the potential load on this farm is considered. Without change in rate in 1926, an increase to 7,694 kw.-hrs. reduced the unit charge to 4½c. While a decrease in the scheduled rates of the company was made in 1927, the "sliding scale" or "blocks" did not extend far enough to yield a significant or proportionate saving over the preceding year in the total consumption of 10,480 kw.-hrs.

The "blocks" or "steps" in this case were such that while the average farm might be affected, a heavy user such as this farm failed to respond, showing that an urban rate is inadequate, at least in one respect, for use in rural territories. That the "scale" was not sufficiently responsive is seen again in the 1928 total, which drops to 6,340 without causing the expected upturn in the rate; for while a slight reduction in the scheduled rates was made it was not sufficient to offset the drop in consumption and hold the net rate at 4 3-5c as shown. A further slight rate reduction in 1929 about matched the decline to the 5,890 kw.-hr. mark and, therefore, maintained the same net rate.

In 1930 a distinct decrease in rates was made, and at the same time another "block" added to the sliding scale. This change in scheduled rate was the only one of five made in the 6-year period which produced tangible results to the customer—the decline from 8c to 4½c in 1925-26 being entirely an effect of small and large volume of use.

Resistance to Adversities Demonstrated.

On all the experimental farms little or no effect of the financial depression, which became more acute toward the close of the 6-year period, can be traced. There is no doubt that such conditions seriously affect farms, but it is of more than ordinary interest that the use of current is not deflected in a noticeable degree. If such is the case for farms in general, the rural load would appear to have more than ordinary substantial qualities.

Moreover, this particular farm was visited by two unusual and costly rampages of nature. In August, 1926, a small tornado demolished a large storage building on the place, felled large trees across roads, and generally paralyzed power, communication and travel lines in the vicinity for close to 48 hours. The repairs on the farm amounted to about $1,000. Yet, a slight depression in the August peak of the 1926 load curve (Fig. 2) is the only visible evidence of the effect on the electric current consumption.

Likewise in November, 1927, this farm, which lies on the banks of the Merrimack River, was isolated for hours and badly torn up by the flood which caused such wide-spread damage in New England that year. Cellars storing a large crop of potatoes were flooded, equipment was damaged by immersion and rust, deep channels made about the drives and buildings, silos were nearly undermined, small buildings were moved and the land generally covered with debris. The damage required at least another $1,000 to repair. The only indication of this serious upset in the electric consumption, is in the November and December sections of the 1927 curve, but since the load falls off normally at this time any reaction from the calamity is difficult to find.

Not only do these experiences indicate a solid character of load, but they point to a use of current for work operations that are little affected by even extreme conditions.

Equipment Difficulties.

Some difficulty was experienced with a leaky valve in the house refrigerator which was corrected.

Tests of silo filling with a 7½ h. p. motor failed for lack of an ensilage cutter designed for motor use.

The original hay hoist was unsatisfactory but was replaced with another which is in continual use.

The water heater installation was incorrect, and unsatisfactory results were obtained.

Additional Uses Developed.

In 1927 a start was made in a side line of poultry with a flock of 500 chicks. This has been developed until in 1930, 2,500 laying hens were carried and 10,000 baby chicks and broilers handled.

This additional enterprise required the construction of a two-story brooder house and the use of several other small out-buildings. $200 was invested in wiring to operate about 30 additional lights, three of which burn all night in the range yards as theft protection.

Adequate shop equipment has developed slowly and now consists of a table saw and tool grinder.

Stock clippers have been found of decided advantage in producing clean milk by keeping the cows' flanks and udders closely cropped, thereby reducing the dirt which usually accumulates in longer hair.

FARM NO. 2 (RETAIL DAIRY)

Farm No. 2 was a pioneer in developing ways of doing farm work electrically. Many of the applications and hook-ups were worked out by the owner before the days of rural electrification with the result that the working units were not always efficiently balanced. For example, a five horse power motor was originally used to run the milking machine. With the introduction of milker vacuum pumps operating successfully on ½ to 1½ h. p., the outfit was discarded and the new equipment installed in its place. Many of the first attempts were made with material readily available at a fair price, and a "cut and try" method of hooking up different combinations was followed until a fairly successful result was obtained.

Description. Three to four-man farm. Family of three adults. Nine room house. Large dairy barn with silo attached; two garages and implement shed. 75 acres of which 30 acres are tillable. 36 head of milking cattle, 2 tractors, 1 delivery truck, pleasure car, modern machinery. Farm located on state road. Retails 250 to 300 quarts of milk and cream daily in city one mile distant. House and barns wired 10 years under cooperative arrangement between farmers and service company, one transformer of 3 K. V. A. capacity.

Equipment. Light Circuit: House lights, 25 outlets, average 40 watt lamps; Barn lights, 22 outlets, average 40 watt lamps; Flat Iron; Washing machine; Bottle brush; Shop equipment; Vacuum cleaner; Milking machine, 1½ h. p.; Battery charger; Radio.

Power Circuit Equipment: House refrigerator; Dairy cold storage; Milk cooling pump.

The fact that this farm shows little or no tendency to increase the annual current consumption from year to year (in fact the 1928 column shows an inclination to curtail) is due primarily to unusually high rates resulting from a small customer-owned distribution company which serves this territory. High monthly bills and comparisons with surrounding communities' rates constantly emphasize to this farm owner the fact that he is paying more for the service rendered than others. This has resulted in a curtailing of work done by electricity and an observance of strict economy in equipment so operated. Changes in motor power, hook-ups, etc., are made at once on this farm as soon as it becomes evident that the same amount of work will be done with more efficiency and less current; and these account in part for the decline in quantity of current used. It is worthy of note, however, that unusually sharp scrutiny of the cost of operating equipment on this farm was primarily induced by the high rate. The same rate condition made the use of any major heating equipment in the house prohibitive.

The critical observation above mentioned serves to bring out a quality which is characteristic of most alert farm operators. Stated briefly it is, "Electricity must do real work," as compared to some uses in urban residences, where the principal element is not always the actual work performed but the convenience derived. Convenience is greatly appreciated by the farmer and more especially by the farmer's wife, but continued observation of many farm owners indicates that for farming operations, "satisfactory work" comes first and "conveni-

ence'' second. As one cooperator remarked, ''We are used to being inconvenienced.''

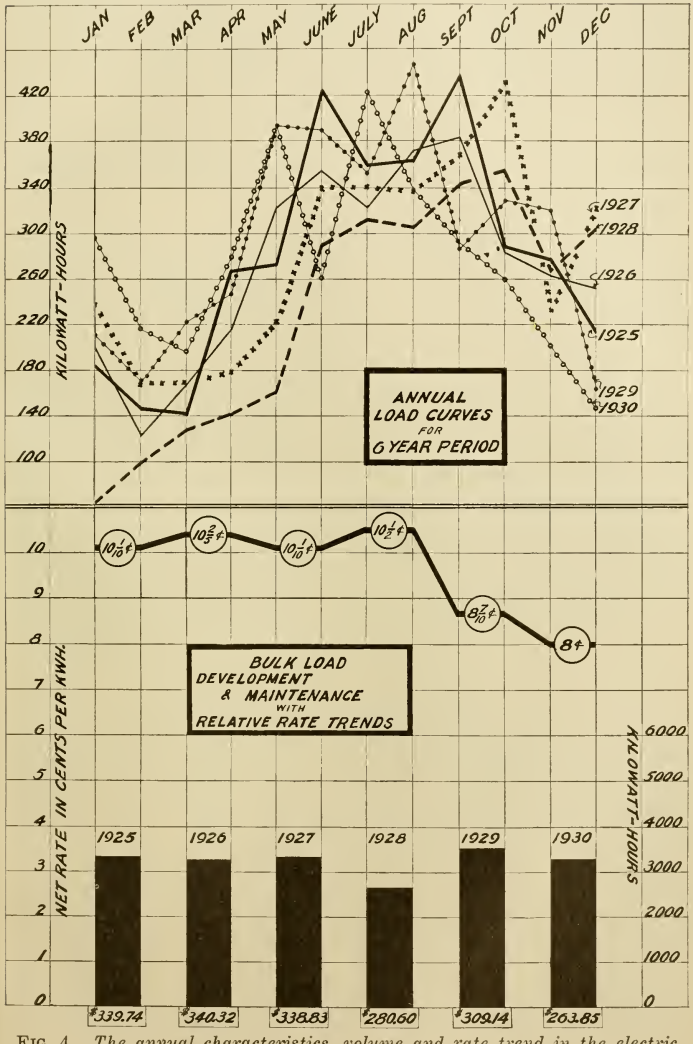

FIG. 4. *The annual characteristics, volume and rate trend in the electric load on Farm No. 2.*

In contrast to Farm No. 3, where the load curves fail to show a concentration in the summer months due to a predominance of household equipment and lack of refrigeration, it will be observed that the curves for Farm No. 2, where the load is largely developed from farm operations, including refrigeration, show the summer peak which is desirable to the average central station (see Fig. 4).

While the concentration from year to year varies between the months of May and October, the load has maintained its characteristics steadily and uniformly for 6 years. In this case the load is regularly inclined to come to two peaks, one in June and another in September with a drop between, which reflects the let-up in farm work between the spring planting and fall harvest.

Seasonal weather conditions influence this variation in peaks in the load curve for any particular year. Nearly 60% of the applications on this farm are of a farmstead nature—the heaviest proportionate loading in farm work of any of the seven. Yet while the bulk of the operations were on the farm, the cost of such equipment was not as high as for the house; 43% of the applications were of a household nature and consumed 51% of the total equipment cost.

One of the fundamental operations on a farm, pumping water, does not appear on the above list of applications, since the buildings are within reach of the city water system. This situation reduces the bulk load considerably as compared to the usual farm location; but since this would be a uniform load throughout the year, it does not affect the contour of the curves.

The load distribution (refer to Table 8) shows that 52% of the total consumption comes from equipment which spreads it evenly throughout the year; 41% from equipment which utilizes a great amount of current in the summer and but little in the winter; and only 7% from equipment which has a high winter demand. The load curves, shown in Figure 4, have both substantial gross quantity throughout the year with the added feature of the maximum demand coming in the midsummer season.

The importance of refrigeration in developing this quality in the farm load is very evident; two-fifths of the current consumed was required by the house and dairy refrigeration equipment, the larger part of which was confined between the months of May and October. (No single application which the project has as yet worked with can equal refrigeration in its ability to produce a peak in midsummer, and it may well be called the back-bone of the rural load.)

The fact that this farm was fully equipped at the start gives six years of load curves instead of five as in most of the other cases.

No change in rate schedule occurred until 1928, when the high point of 10½ cents net caused a considerable drop in volume. The following year this schedule was abandoned for a lower one, and the year's bulk rose to the highest point in the six years. In 1930 another decrease in rate was made, but the farm was not greatly influenced and remained at its normal gross load—about equal to that of the first three years. The rapid slide of milk prices in the latter part of this year necessitated the curtailing of any non-essential operations.

Farm Not Yet Under Full Load.

While this farm used an average of 3,220 kw.-hrs. per year or about 270 kw.-hrs. per month (see Table 2), it has not in any sense reached its capacity as yet. Late in 1930 a complete pasteurizing plant was installed which will increase the bulk load materially for 1931.

TABLE No. 2.

FARM No. 2.—*Kilowatt hours and current costs—five-year electrification period.*

Month	Kilowatt hours used.						
	Pre-electrification Period 1925	1926	1927	1928	1929	1930	Monthly Average
January	183	198	236	64	210	297	201
February	145	121	166	99	169	216	154.2
March	141	166	168	129	221	196	176
April	265	216	178	141	245	278	211.6
May	272	322	222	162	394	394	298.8
June	423	354	340	289	390	261	326.8
July	358	322	340	312	354	422	350
August	363	372	337	306	447	338	360
September	437	384	369	343	287	292	335
October	286	283	432	356	329	260	332
November	276	262	232	267	320	203	256.8
December	213	252	322	206	164	148	218.4
Yearly total	3,362	3,252	3,342	2,674	3,530	3,305	3,220.6
Ave. per month	280.1	271	278.5	228.8	294	275.4	
Daily ave.	9.21	8.91	9.16	7.33	9.7	9.0	
Ave. rate per kw.-hr.	.101	.104	.101	.105	.087	.08	
	Current costs.						
January	$23.79	$25.44	$25.38	$7.98	$18.81	$22.73	$20.69
February	18.31	15.49	19.36	12.49	13.00	17.18	15.97
March	16.17	21.28	19.50	15.56	17.33	16.70	17.76
April	27.73	24.54	20.58	16.74	22.59	23.44	22.60
May	25.94	32.74	24.30	18.96	33.05	33.14	28.02
June	38.55	32.28	32.89	29.91	33.05	26.39	32.18
July	31.54	29.56	32.87	30.84	32.87		31.54
August	32.07	34.80	32.62	30.37	38.08	$124.27	33.59
September	40.97	37.38	35.05	33.08	28.12		34.92
October	28.84	26.89	39.60	34.02	27.74		31.42
November	28.68	28.30	25.06	27.56	26.64		27.25
December	27.15	31.62	31.62	23.09	17.86		26.27
Yearly total	339.74	340.32	338.83	280.60	309.14	263.85	312.08
Ave. per month	27.85	28.37	28.20	23.40	25.76	21.99	
Daily ave.	.930	.932	.0928	.077	.846	.723	

The availability of lower rates* now opens the possibilities of additional uses in the household, among which are the electric or combination range, water heating, ironer and numerous small heating and motor appliances.

In the farm operations there are also many possibilities, among which are equipment for sterilizing the dairy utensils, bottles, etc., pasteurization by electricity instead of coal—generated steam, hay hoisting, wood cutting and silage filling with a heavy-duty portable motor, feed mixing, spraying equipment for painting, barn ventilation, disinfecting and white washing of buildings and stables.

No difficulties or troubles with equipment of sufficient importance to impress the owner have occurred during the 6 year period. Line troubles and current interruptions from storms were the major difficulties.

FARM NO. 3 (WHOLESALE DAIRY)

Description. Three-man farm. Family of three adults, two children. Fourteen room house. Large dairy barn with silo, horse barn, garage and shop, medium-sized ice house, granary, implement shed, and medium-sized hay barn. Hill farm of 330 acres, of which 75 are tillable. 47 head of cattle, 27 milked, 3 horses, one tractor, one delivery truck, pleasure car, modern machinery. Farm delivers an average milking in morning and night of 225 to 250 quarts of milk and cream per day to retailers in town three miles distant. House and buildings wired in 1903 from nearby line without construction cost. Transformers used—light and heat circuit 7.5 K. V. A., power circuit 2.5 K. V. A.

Equipment. Light Circuit Equipment: House lights, 55 outlets, average 40 watt lamps; Barn lights, 20 outlets, average 40 watt lamps; House water pump; Vacuum cleaner; Curling iron; Radiant heater; Radio.

Heat Circuit Equipment: Combination wood-electric range; Dishwasher; Clothes washer; Hot water heater; Waffle iron; Toaster; Percolator; Flat iron; Ironer.

Power Circuit Equipment: 2 h. p. motor, operating the milking machine, cream separator and milk cooling pump; Centrifugal water pump for milk cooling.

A study of the load curves, Figure 5, for the six years on this farm make it appear at first glance to be something of an enigma. They lack the characteristic peak in midsummer which predominates in the other cases. In fact, except for the 1930 curve, there is a distinct tendency toward a slump in the load at midseason.

It will be recalled that this farm, when taken for one of the experimental group in 1925, was already well equipped for that period, and further development did not appear feasible at the time to the owner. The development had also been made entirely by the owner and his wife without outside guidance. Of nine major operations being conducted electrically seven are in the household. In number of appliances and in the proportionate cost, 83% and 87% respectively were for the home. Only 16.7% by number, or 12.5% by proportionate cost, were represented in the farm operations. This farm had the greatest per cent. of equipment in the household of any of the seven. With this predomi-

*This company was sold to a large system in 1931 and is now served under very much more equitable rates.

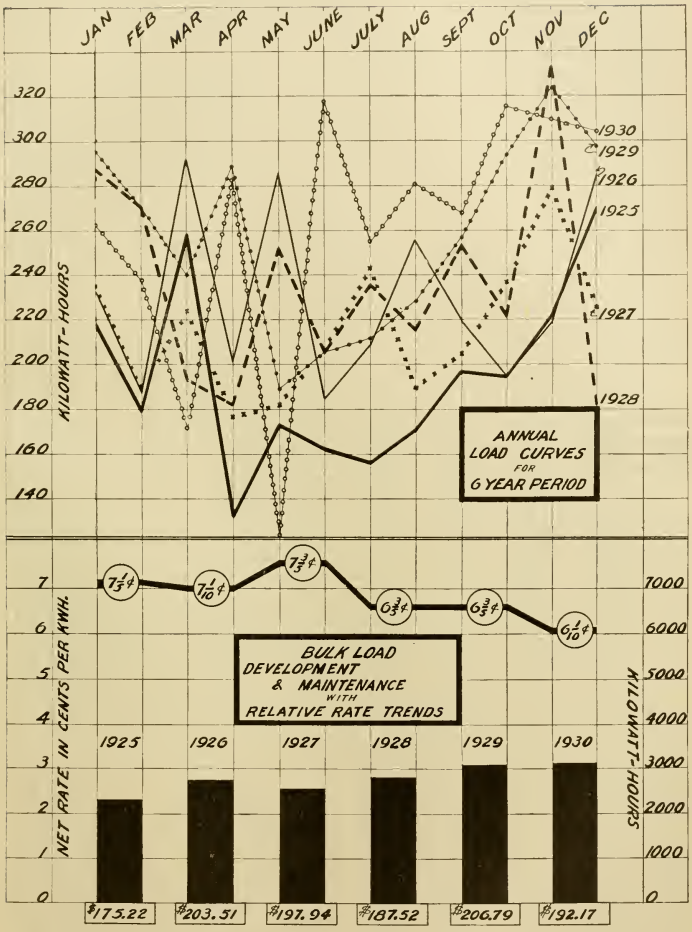

FIG. 5. *The annual characteristics, volume and rate trend in the electric load on Farm No. 3.*

nance of home equipment it would be natural to expect the quality of the curve to reflect the use in any home, whether city or farm, and it is this characteristic use of appliances in this home, together with the absence of refrigeration, which is the principal cause of the failure to develop a peak load in midsummer.

This suggests that while the building of the load in the farm home may develop the total gross load, it may not develop a quality of load which blends with urban and commercial load curves of the central station to give a greater evenness of current production throughout the year, thereby losing one of the possible qualities of rural electrification. If duplicated on other farms, the net benefit to the electrical industry would be an increase of total current generated with qualities similar to the present city load. No evening effect on the total generation curve would result; in fact the usual late fall, winter and early spring peaks of the plant production curve would be increased and the midsummer depression more accentuated.

The curves bear a considerable degree of resemblance with each other in general characteristics and indicate a standard and stabilized routine which is the usual quality to be expected of farms in general. The tendency with this character of load is to run into peaks in March, April or May and in the late fall, with a depression between.

Twenty-four per cent. of the load has maximum use in cold weather while only 13.5% tends toward a summer peak, so that considerable reason for the midsummer slump is evident (refer to Table 8).

While this is a wholesale dairy farm, no electrical refrigeration was used for cooling or storing the milk during this period. Neither was electric refrigeration used in the house. The absence of this application will be immediately observed by comparing the curves with those of the three other dairy farms, Nos. 1, 2, and 4, where it was in use.

It is also of interest to observe that while only 12.5% of the equipment investment was for farm operations proper, this small per cent. consumed 66% or $\frac{2}{3}$ of the electricity per year and included only the barn lights and milking machine. The latter contributed the bulk of this, or 59%, but since this machine is used daily to the same extent, it produces no effect on the contour of the curve. Its principal value is in developing a large quantity use. This serves to indicate that one good farmstead application, properly applied, may easily surpass the entire household load and that continued emphasis should be placed on the development of applications in the farm work group.

The failure of this farm to develop the expected annual curve contour lies in the negative qualities of the large amount of household equipment plus the same quality in the milking machine, and, lastly, the absence of household and dairy refrigeration. In other words, the equipment employed and methods of use produce negative or erratic qualities, and there is little that reflects the busy summer season.

Whereas most combination ranges are expected to have the electrical section in greater use in the warm weather, such did not prove to be the case in this instance, due to the particular design of this range, which was provided with an oven heated from the firebox with an additional electric oven as well. (The average combination, such as the type

on Farm No. 4, has but one oven electrically heated, requiring all baking the year round to be done with current.) On early mornings on this and many farms the air is chill and a fire is lighted to start the day. Breakfast is prepared by wood or coal, the water tank is heated and the chill taken from the room at the same time. Baking may also be started, since the oven is well heated and ready to use. One operation thus begets another, and the wood section and oven may run throughout the day. Only on days when the weather is exceedingly hot is the housewife's attention forced to the electric oven. In this more or less natural way the use of the electric oven is much reduced.

TABLE No. 3.

FARM No. 3—*Kilowatt hours and current costs—five-year electrification period.*

Month	Kilowatt hours used.						
	Pre-electrification Period 1925	1926	1927	1928	1929	1930	Monthly Average
January	218	233	235	288	296	263	263
February	179	189	190	270	270	238	231.4
March	259	292	224	193	240	172	224.2
April	132	201	177	182	289	283	226.4
May	173	286	182	252	189	134	208.6
June	162	185	207	206	206	318	224.4
July	156	209	243	236	212	255	231
August	171	256	190	216	229	281	234.4
September	197	220	215	253	257	268	242.6
October	195	195	237	222	294	316	252.8
November	222	219	279	333	324	310	293
December	269	285	226	182	298	304	259
Yearly total	2,332	2,770	2,605	2,833	3,104	3,142	2,890.8
Ave. per month	194.3	230.8	217.0	236	259	262	
Daily ave.	6.38	7.58	7.14	7.76	8.5	8.61	
Ave. rate per kw.-hr.	.0715	.0707	.076	.066	.066	.061	
	Current costs.						
January	$17.14	$18.26	$18.80	$21.40	$19.97	$18.18	$18.96
February	14.76	15.52	15.97	19.47	17.89	16.36	16.66
March	16.22	21.41	17.04	14.90	3.00	11.84	14.07
April	10.96	15.40	13.79	12.16	29.64	16.73	16.45
May	13.50	20.28	14.04	16.36	12.42	9.78	14.40
June	11.60	13.78	14.80	13.16	18.64	19.45	15.24
July	11.59	13.84	15.78	13.56	13.30	15.74	13.97
August	12.38	15.96	13.58	13.01	14.33	16.56	14.30
September	14.47	15.93	17.96	14.95	16.28	15.96	15.92
October	14.80	14.45	17.59	14.41	19.22	17.61	16.35
November	17.08	17.28	20.83	20.92	21.93	17.52	19.26
December	20.72	21.40	17.76	13.22	20.17	16.44	18.28
Yearly total	175.22	203.51	197.94	187.52	206.79	192.17	193.86
Ave. per month	14.60	16.96	16.50	15.63	17.23	16.01	
Daily ave.	.48	.556	.542	.514	.567	.526	

The absence of refrigeration on this farm up to 1930 (equipment for both house and dairy were installed in 1931) was due to the location of an ice pond within a few hundred feet of the barns and house. The local conditions were such that the cost of obtaining ice on this farm was considerably under that of the average. The gradual depreciation of both ice house and pond dam, together with increasing stringency of milk handling regulations, eventually proved the older method inadequate however, and electrical equipment has since taken its place

The bulk load graphs in Figure 5, and kw.-hr. readings in Table 3 show that, while this farm reacted to the stimulus of the activities in load building in 1926, the consumption has not only been maintained but has gradually grown, year by year, from the original start in 1925 of 2,232 kw.-hrs. until in 1930 it was well over the 3,000 kw.-hrs. per year mark. This took place with the addition of only two major appliances, the ironer and hot water heater, (side-arm type, used as a booster on the range boiler) during the six year period. The increase raised the monthly average from 192 kw.-hrs. to 262 kw.-hrs.

The stimulus developed in 1926 was somewhat set back in 1927 when a new rate schedule, developed by the company, reacted to the disadvantage of the rural user, but recovered in 1928 when the rate was again changed and became more favorable. With the exception of 1927, rates in general have declined and consumption has increased. Since the next rate in effect is not particularly conducive to a freer use of current, the bulk load increase is not striking.

FARM NO. 4 (RETAIL DAIRY)

One of the most evident qualities of Farm No. 4 is the regular and constant volume of electrical usage it has maintained throughout the six year period. The method practiced by the owner has been to keep the farm at a point of production which balances with an economical use of man power and equipment. This point is where the curve of volume of business crosses that of the lowest possible man power and, theoretically, is the point of highest efficiency and net return. For this reason the farm has neither increased nor decreased in size or amount of business. This quality is reflected directly in the current consumed each year, as will be seen in Table 4 and Figure 6.

The original size and character of business in 1925 was as follows:

Description. Three to four-man farm. Family of six adults. Twelve room house. Large dairy barn with silo, bottling room, dairy wash room, refrigerator room, carriage house, and horse stable. 190 acres, of which 65 acres are tillable. 27 head of cattle, 19 milked, 2 horses, 1 delivery truck, 1 pleasure car, modern machinery. Farm purchases some milk from nearby farm and retails 300 quarts daily in city two miles distant. Buildings wired in 1919 from nearby line without construction costs. Transformer of 10 K. V. A. capacity.

The only change which has occurred in the 6 year period ending December 30, 1930, is the reduction in number of adults at home from 6 to 4, and a closer adherence to a three-man operating basis.

Equipment. Light Circuit Equipment: Wiring house and barns; House lights, 55 outlets, average 40 watt lamps; Barn lights, 15 outlets, average 40

watt lamps; Washing machine; Sewing machine motor-drive; Curling iron; Toaster; Percolator; two Radiant heaters; Battery charger; Oscillating fan; Vacuum cleaner; Separator motor equipment.

Heat Circuit Equipment: Combination coal-electric range; Ironer; Flat iron; Combination dairy cooling room and household refrigerator.

Power Circuit. (Special circuit wiring): Milking machine; Deep well pump.

The changes since 1926 consist of an increase in the total number of lights from 51 to 70; the elimination of the hot water heater as not essential, in view of the operation of the coal section of the combination range, which

TABLE No. 4.

FARM No. 4.—*Kilowatt hours and current costs—five-year electrification period.*

Month	Kilowatt hours used.						
	Pre-electrification Period 1925	1926	1927	1928	1929	1930	Monthly Average
January	195	263	510	505	516	444	447.6
February	227	531	474	491	474	490	492
March	121	345	468	422	435	414	416.8
April	219	397	539	449	488	560	486.6
May	183	463	511	486	544	578	516.4
June	120	476	534	572	679	673	586.8
July	99	864	632	792	719	694	740.2
August	100	1,025	975	800	863	752	883
September	119	1,137	658	714	819	914	848.4
October	156	716	605	676	632	768	679.4
November	257	721	593	692	666	698	674
December	230	544	555	492	630	457	535.6
Yearly total	2,036	7,482	7,054	7,091	7,465	7,442	7,306.8
Ave. per month	169.6	623.5	587.8	590.9	622.1	620.2	
Daily ave.	5.57	20.5	19.3	19.4	20.4	20.4	
Ave. rate per kw.-hr.	.0855	.0494	.049	.042	.036	.036	
	Current costs.						
January	$16.60	$24.35	$27.71	$29.96	$20.27	$19.03	$22.99
February	19.16	33.63	25.78	28.06	19.42	19.78	24.30
March	10.68	23.04	24.46	23.75	18.54	18.08	39.52
April	18.52	23.24	27.25	23.12	19.56	21.12	22.14
May	15.64	24.30	25.08	24.37	20.83	21.80	22.00
June	10.60	22.90	25.64	26.06	23.38	23.30	21.98
July	8.92	35.00	28.12	25.63	24.30	23.72	24.28
August	9.00	40.42	40.72	25.29	27.63	25.14	28.03
September	10.52	46.20	29.71	23.87	26.86	28.57	27.62
October	13.48	33.00	29.08	23.23	23.00	25.79	24.60
November	21.56	36.02	32.57	23.75	23.75	24.18	26.97
December	19.40	27.62	30.98	19.67	23.18	19.13	23.33
Yearly total	174.08	369.72	347.10	296.76	270.72	269.64	288.00
Ave. per month	14.50	30.81	28.92	24.73	22.56	22.47	
Daily ave.	.47	1.01	.951	.813	.742	.739	

has a water-front, in the early morning of each day, and the addition of the following articles: Heating pad; Egg beater; Corn popper; Oscillating fan; Electric clock, and Motor driven grindstone. All these new appliances are operated from the light circuit. With the exception of the grindstone and 6 lights in the barn, all additions have been for the home and none are heavy current consumers.

The distribution of equipment (refer to Table 8) shows that 81% of the number of appliances were used in the home and 19% on the farm. The cost of equipment was about equally divided between the two.

Figure 6 shows the fixed scale of operations in both the load curves and bulk-use columns. Except for variations which are readily traceable to seasonal conditions and the like, the load curves have the same general contour year after year. The midsummer peak in this case is practically ideal, being condensed between June and October. Refrigeration and the greater use of the electric section of the combination range are largely responsible for this.

During the winter, consumption runs between 400 and 600 kw.-hrs. per month. During the summer months it runs from 800 to nearly 1,000 kw.-hrs. per month. The utility of electricity on the farm when given proper attention is evident by a comparison of the five upper curves with the lower curve, which represents normal use before this field was developed.

In bulk load this farm is a model of steadiness. During the last five-year period the average total annual consumption has been 7,306 kw.-hrs., from which it has varied less than 3% per year. In 1927 and 1928 there was a decrease of some 400 kw.-hrs. when some trial equipment was removed. Left to its own devices during 1929 and 1930, the load was built up close to the high point of 1926. It will be observed that there is no evidence of any tendency to reduce the use of current after the conclusion of the load-building activities which were completed by the close of 1926.

Aside from the reduction from 8½c to 5⅓c per kw.-hr. in 1926, which was solely the result of increased volume of use, the rate reductions following this have been made by the utility and indicate the general downward trend in cost of current which has occurred in a large part of the New England territory during this period.

The combination range not only satisfies the requirements of heating the farm kitchen, but is responsible for more than two-thirds of the summer load.

Observation of this and other cases leads to the conclusion that this type of combination range, as contrasted to that on Farm No. 3, should always be considered first for farm use, after which the standard type may be resorted to for kitchens already heated or for other reasons. In this way both the utility and the farmer are satisfactorily taken care of.

The current consumed by this particular range is probably somewhat high, however. The range is equipped with a two-cover wood section and four surface plates and only an electric oven. Under these conditions all oven baking is done electrically. There is no automatic temperature control on the oven, and the housewife feels confident that the manual control is not only wasteful of current, but is much

less efficient and exact in any baking operation. Time controls are not considered valuable in this case.

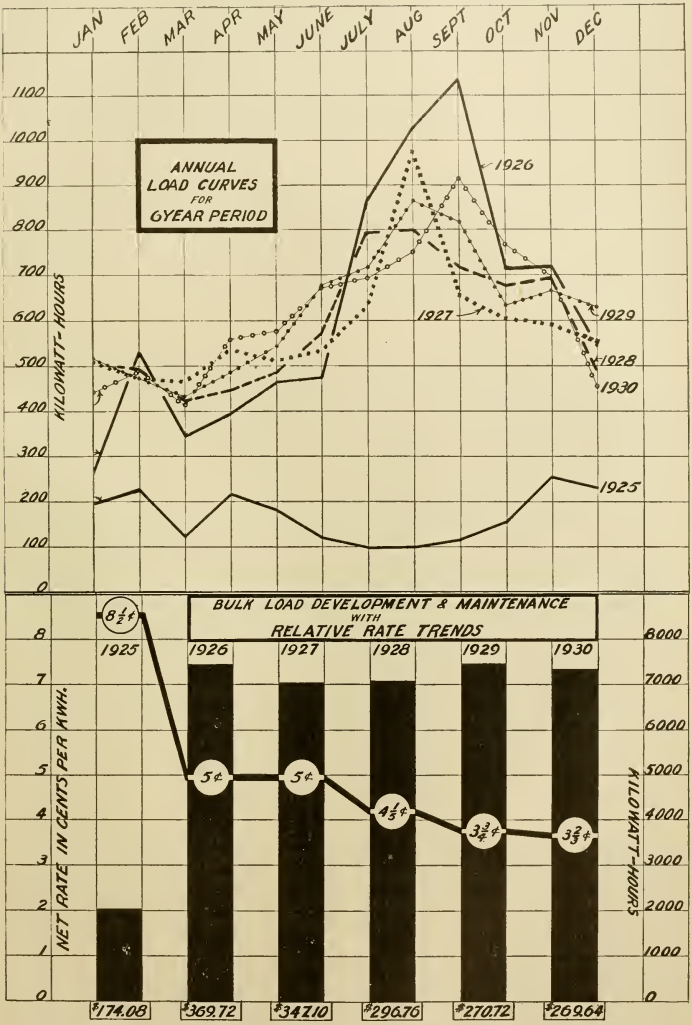

FIG. 6. *The annual characteristics, volume and rate trend in the electric load on Farm No. 4.*

Of all the equipment on the farm, the electric section of this particular range has given the only trouble worthy of mention. Its selection in 1925 was made with knowledge of its somewhat inferior construction, but because of the limited number of combination models within the farm price range at that time, little alternative existed. The oven units in particular, have been a great source of trouble and expense and have had to be renewed on an average of twice a year. They are of light construction with small terminal posts and connecting blocks. The solid-surface plates all developed cracks within four years, but have not as yet failed.

In spite of the expense and annoyance with this particular range, the housewife remains firm in her conviction that the combination type is correct, and that the advantages of electric cookery outweigh her difficulties. The cost of maintaining such equipment, however, is excessive, and points to the fact that the work demanded of equipment on the farm does not permit the use of inferior appliances.

Possible Future Load.

The possibility of expanding the number of operations on this farm are reasonable but not great under the present system of management. Short term operations, such as silage cutting, are hired out to nearby farmers who have the equipment, on the basis that the cost in overhead and extras would exceed the material advantages of owning equipment for this type of work.

In the dairy room a wood-fired steam boiler furnishes hot water for washing bottles and utensils and steam for sterilizing. Considerable labor could be saved by heating the water electrically and using an electric sterilizing cabinet instead. This would add considerably to the bulk load and will eventually be done.

Plans have been made for increasing the size of herd in considerable amount, which would increase the current consumption of the present equipment without increasing the investment. This, however, will not occur until business conditions improve.

As the farm stands today it represents an ideal electric load—reasonable bulk in winter, spring and fall, and an excellent peak outline from June to October. For this reason the equipment and make-up of the connected load are worthy of particular attention.

FARM NO. 5 (FRUIT)

While fruit farms in general appear now to offer fewer opportunities for the use of electricity in the farm operations, due to the outlying and widespread area which the producing trees cover and the necessity of much mobile equipment, Farm No. 5 has, as predicted in the original report of 1927, forged steadily ahead in the development of a substantial load.

Because this farm is the only one in the group that started the experiment without electricity on the place (a line extension first reached the farm in August, 1925), it shows something of the steps of the new rural consumer in his initiation to high line service.

Description. Two-man farm. Family of two adults. Fourteen-room house, with apartment for hired man and family. Medium-sized stock barn, two buildings for handling and storing crop, garage, implement shed, ice house. 50 acres of tillage, hilly, with over 2,000 apple trees. Produced 1,600 barrels in 1924. Ten head of grazing young stock, small flock of sheep, 2 horses, delivery car, pleasure car, modern machinery. Farm located one mile from state road, two miles out from village. Buildings wired in July, 1925. Transformer of 10 K. V. A.

Equipment. Lighting and Power Circuit Equipment: House lights, 52 outlets; Barn lights, 8 outlets; Radio; Waffle Iron; Tablestove; Vacuum cleaner; Sewing machine; Washing machine; Water pump; Auxiliary well pump, 1½ h. p.; Spray tank filling pump, ½ h. p.

Heat Circuit Equipment: Kitchen range; Household refrigerator equipment.

It has been observed that a large proportion of the first rural customers on new line extensions are confronted with a task of considerable proportions to become familiar with this new power. "Our chances, in the past, of ever having electric service," said this farmer, "seemed so remote that we have schooled ourselves to disregard advertising, displays of electrical equipment and educational demonstrations on the basis that the less we knew about them the less we would miss not being able to have them."

Because of the specialized attention given this farm it was possible to accomplish in a matter of weeks what would ordinarily have taken many months, and the installation of equipment was concentrated in a short period. Much of the equipment was accepted more in a spirit of co-operation in the experimental work rather than in confidence that it would work out to their own advantage, notwithstanding the fact that all the applications were selected for their known stability in electrical experience and nothing highly experimental was included.

For example, the electric range was questionable to the housewife, who felt that they would not keep it beyond the experimental period. The shipping crate was carefully stored away in the barn loft. Several washing machines were exchanged and many others considered before the housewife felt well enough informed to make a selection. The same was the case with the flat iron and sewing machine. She had heard much favorable comment in regard to electric refrigerators which had impressed her, and looked forward to one with interest. House lights and the common small appliances were accepted without much question.

To the man of the house, electric power to replace the old windmill for pumping water offered a known improvement.

Uncertainty from lack of acquaintance with the problem was evident in many instances, and it was some time before they had a comprehensive grasp of all the details. Beyond the equipment mentioned it was difficult to do more than interest them with speculation as to possible performance.

The story appears in Table 5 and graphically in Figure 7.

The curve for the six months in 1925 represents the use of lights principally, with a flat iron occasionally. In 1926 a moderate increase occurred, due mostly to refrigeration. The range was installed and ready for use in September, but was utilized only rarely at first. 1927

showed a little more familiarity and freedom of use. By 1928 the range as well as the other equipment was in general use, and the electricity consumed increased to a still greater extent.

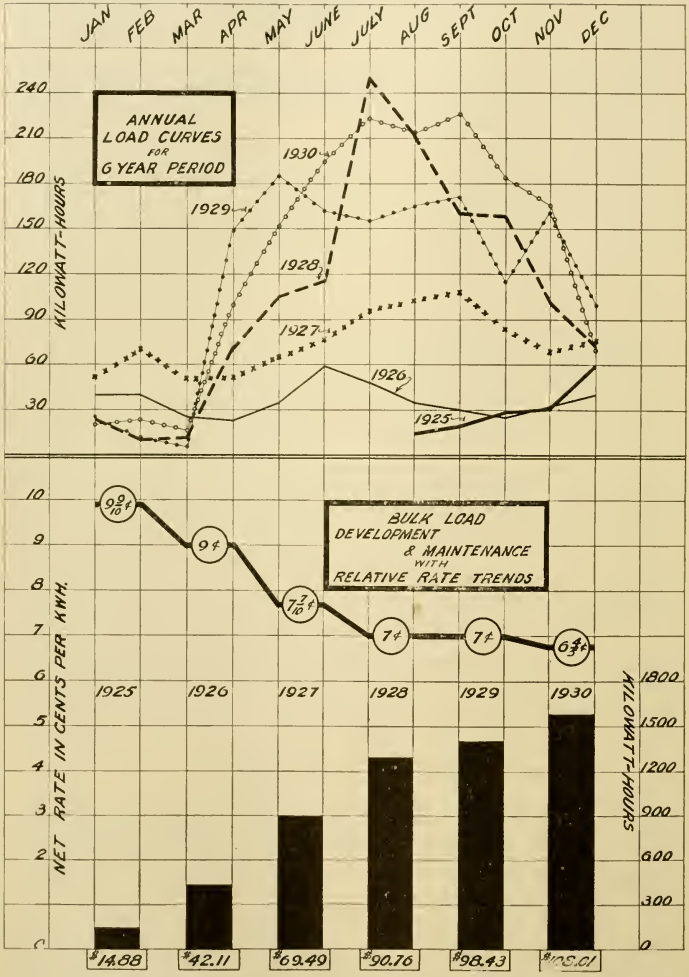

Fig. 7. *The annual characteristics, volume and rate trend in the electric load on Farm No. 5.*

If this case is any index, it would appear that unless special efforts to counteract this slow acceptance and utilization were in effect, the first few years of a line extension would not show outstanding use of current.

Referring to the curves again, it will be seen that the 1928 curve produced the maximum peak of the six years and was more concentrated than any of the others.

In 1929, entirely at the election of the owner, the auxiliary well pump was installed and the pump for filling the spray trucks. This not only

TABLE No. 5.

FARM No. 5.—*Kilowatt hours and current costs—five-year electrification period.*

Month	Kilowatt hours used.						
	Pre-electrification Period 1925	1926	1927	1928	1929	1930	Monthly Average
January		40	52	24	25	21	32.4
February		40	70	10	12	23	31
March		25	50	12	7	17	22.2
April		23	52	70	149	100	78.8
May		35	65	106	185	152	108.6
June		59	77	116	162	195	121.8
July		48	97	251	156	223	155
August	14	35	103	212	166	213	145.8
September	20	30	108	161	172	217	137.6
October	28	25	84	159	116	184	113.6
November	30	32	68	101	161	166	105.6
December	58	40	76	72	100	70	71.6
Yearly total	150	432	902	1,294	1,411	1,581	1,124
Ave. per month	30	36	75.2	108	117	131.7	
Daily ave.	.978	1.18	2.47	3.55	3.86	4.33	
Ave. rate per kw.-hr.	.099	.09	.077	.0701	.0697	.068	
	Current costs.						
January		$3.80	$5.00	$4.40	$3.52	$3.41	$4.03
February		3.80	5.48	3.30	3.04	3.30	3.78
March		2.60	4.60	3.00	3.00	3.00	3.24
April		2.44	4.52	5.00	9.25	7.32	5.71
May		3.40	4.45	6.98	11.25	9.68	7.15
June		5.32	4.80	7.30	9.90	11.59	7.78
July		4.44	6.11	14.05	9.68	13.07	9.47
August	$1.60	3.75	6.74	11.92	10.10	12.85	7.83
September	2.20	3.00	7.08	10.03	10.88	13.37	7.76
October	2.84	2.60	5.91	10.14	8.00	12.16	6.94
November	3.00	3.16	6.28	7.36	11.81	11.70	7.22
December	5.24	3.80	8.52	7.28	8.00	6.56	6.57
Yearly total	14.88	42.11	69.49	90.76	98.43	108.01	7.06
Ave. per month	2.97	3.50	5.79	7.56	8.20	9.00	
Daily ave.	.097	.115	.19	.249	.269	.296	

increased the total load, but increased the use of current in the spring, making the 1929-30 curves spread well over the summer season. The 1930 load in particular represents good volume and an unusually good contour from the central station standpoint.

Since the larger appliances have their major use in summer (see Table 8, page 42), excellent load qualities are developed despite the fact that 75% of the equipment is in the household and only 25% on the farm proper. Fruit farms in general are at low ebb in activity in the winter, and the owners in this case have left the farm in charge of the hired man from January to March for the past three years and lived in the city. This results in the low readings occurring in these months. Since the consumption would probably not exceed 90 kw.-hrs. in any of these months, the important part of the curves would not be materially affected by this change of residence.

With the steady increase in bulk use from year to year (see Table 5 and Figure 7), there have been corresponding declines in the net rate paid up to 1929 and 1930, when the limit of the sliding-scale schedule of this company appears to have been approached. Despite this fact, it is interesting to note that the volume was still on the increase in 1930. No change in the scheduled rates for this farm occurred during the 6 year period, so that all declines in net rate shown in Figure 7 are due to increasing volume of use. In the spring of 1931 the company was purchased and became a part of a large system, and more favorable rates were put into effect.

Electricity an Incentive to Modernize Home.

That the coming of electricity stimulates the farm to modernize has been observed in a great many instances. In this case to provide heat in the kitchen to compensate for any lack of use of the wood range the owner's interest in furnace equipment was aroused and resulted in the installation of heating equipment for the entire house. The availability of a dependable supply of water brought about the discarding of an outside toilet and the installation of a complete modern bathroom with septic tank disposal system. Before the house refrigerator equipment even was settled upon, the fact that one eye-sore, the dilapidated ice-house, could be eliminated was viewed with much interest. While the old windmill was still permitted to stand, it is no longer in use. Even the old sad irons seem to have little usefulness except as door stops. In general there is a distinct air of sprucing up about the place and in the mode of living as a result of having electricity installed.

In reviewing their experience late in 1930, the housewife remarked, "There is but one appliance that we use but little, and that is our table-stove. We would not be without it, but we seem to eat toast faster than that can toast it, so we do all the slices at one time with the broiler unit in the range." This viewpoint shows the complete utilization that the equipment has developed. A satisfactory agreement as to which of several items of equipment were most useful could not be reached.

Very little difficulty was experienced with any of the equipment during this six-year period. The brine tank of the refrigerator developed a leak in one of the seams which necessitated a $15 expenditure for

repairs. The flat iron, automatic heat control type, was found to be too slow in heating to keep up with the rapid rate with which this woman irons, and replacement with another style is planned. Low voltage conditions existed for a time on this extension, but were corrected by rewiring the line with heavier copper.

FARM NO. 6 (POULTRY)

Description. Three-man farm. Family of three adults, two children. Ten room brick house. Hay and stock barn, garage, main laying house, and 20 brooder houses and shelters. 180 acres of flat, sandy loam, of which 30 are tillable. Located one mile from town. 2,500 laying hens, 20,000 to 25,000 broilers, 20,000 day old chicks, 2 horses, 1 cow, 1 delivery car, 1 pleasure car, modern machinery, 9,000 egg incubator using coal hot water heat. Transformer of 7.5 K. V. A.

Equipment. Light and Power Circuit Equipment: House lights, 34 outlets; Barn and Poultry Lights, 30 outlets; Washing machine; Waffle iron; Heating pad; Vacuum cleaner; Water pump; Radio.

Heat circuit equipment: Kitchen range; Household refrigeration; Flat iron.

Distribution of Equipment Costs

The load on Farm No. 6, one of the two poultry farms under test, resolved itself into largely one of a household nature—80% of the total number of appliances and 81% of the total cost for equipment being so utilized.

Making up the 19-20% used on the farm proper, there were but three items—poultry lamps, the water pump and water heater. The last two items are given a position of each performing half duty for the house and farm work respectively.

Since poultry lights represent winter consumption, and water supply a more or less even load throughout the year, the only appliance reflecting the busy season of the farm was the hot water heater, which was used considerably for scalding fowl to be sold.

Likewise in the home, the equipment was used with an even tenure throughout the year with the exception of the hot water heater. The increase in consumption in the winter, due to house lights, was balanced by a somewhat greater demand for refrigeration in the summer. The kitchen range was the only cooking unit used and caused no particularly greater consumption of current in one season of the year than another. No large amount of canning was done.

From this situation the load curve for this farm would be expected to show a more or less flat contour or negative qualities as far as coming to a peak at any particular season is concerned.

From inspection of the curves in Figure 8, it will be seen that in the pre-experimental year of 1925 a very commonplace distribution of the load occurred, with the undesirable quality of being greater in winter than in summer.

For 1928 and 1929 a more or less even consumption throughout the year is evident with no consistently repeated tendencies of importance one way or the other. The year 1930 would undoubtedly have produced a similar curve, but failure of a test meter resulted in the loss of the true record.

The greater consumption and distinct peaks and depressions for the period of June, 1926, to October, 1927, were caused entirely by the

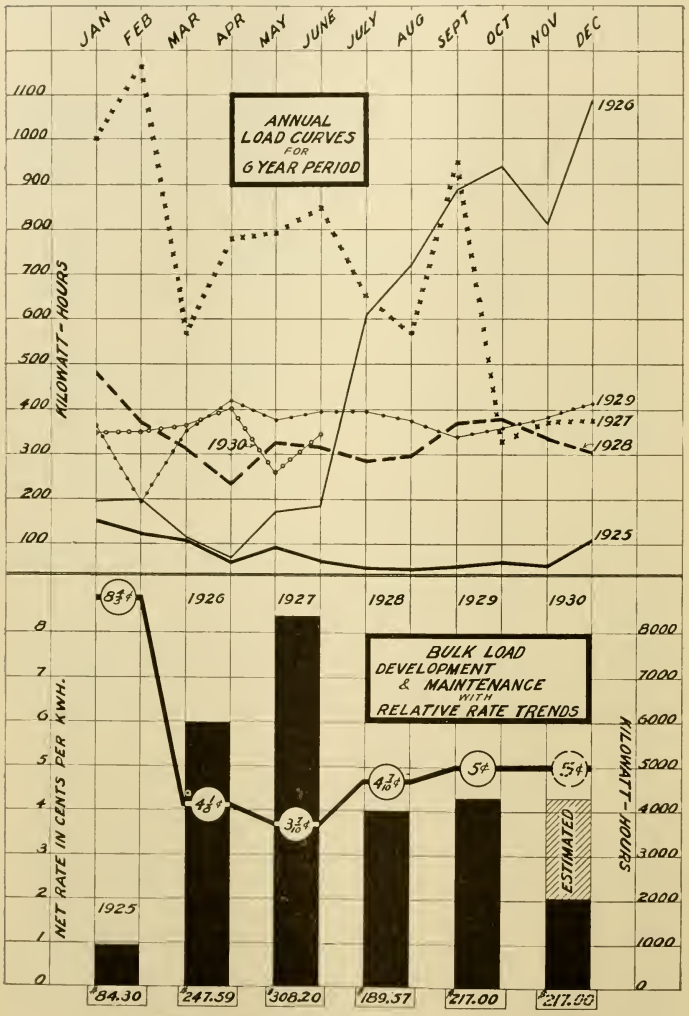

FIG. 8. *The annual characteristics and rate trend in the electric load on Farm No. 6.*

poor installation of a hot water heater which was placed in use and removed on these dates.

From the standpoint of bulk use the 500 to 800 per cent. increases of 1926-27 do not represent economical use of current as explained above. The greatest importance of these two years is to observe the effect on the net rate paid and its relation to volume of use. It will be seen that the rate dropped sharply from 8 4-5 cents per kw.-hr. to 4 1-8 cents, and then 3 7-10 cents, bringing the price down to a point where cost of operation registers for greater freedom of use.

The true volume for this farm, loaded as it is, is in the neighborhood of 4,000 kw.-hrs. per year as shown in Fig. 8, or an average of 335 to 362 kw.-hrs. per month. (See Table 6.)

During these last three years the reflex action of the rates as a result of decreased volume of use will be seen in the swing back to the 5 cents per kw.-hr. mark. Since there has been no change in rate schedule by the utility during this period, the record is an accurate and true index of the greater economy resulting from quantity use on rate schedules having sliding scales.

Sturdy Resistance of Farms to Adversities Indicated.

The history of Farm No. 6 presents quite a different experience than occurred on any of the experimental group, with the exception of Farm No. 1—namely, an unexpected business collapse which it was impossible for the operator to foresee or prevent. Such happenings are not uncommon to farms in general, but since this was the only case among the seven under test, the effect of such a situation becomes of particular interest.

Hand in hand with the discarding of the hot water heater, an epidemic of chicken-pox was discovered in the flocks. The owner had one of two options: either to attempt to eradicate the disease (which spreads rapidly) while making an effort to carry on, or to clean out the entire stock of birds and then clean, fumigate and disinfect the entire layout. The latter course was decided upon as being the most effective and least disastrous, and by November of that year not a bird remained in the commercial pens.

While this collapse was in the business end of the farm, in which there were few electrical applications, it would be expected that sharp declines and irregularities would appear in the annual load curves, since production was at a standstill until the winter of 1928-29—over a year.

The heavy broken curve of 1928, covering this inactive period, shows, instead, only a gradual tapering off up to the low point in April, followed almost immediately with tendencies to recover which continued with still greater consumption in 1929. 1930 would undoubtedly have shown equally good progress had the record been completed.

During the non-productive year of 1928 a new four-story brooder house with central heating plant was completed and placed in operation with the fresh stocking of chicks the following winter. This additional capacity has been in use each year since.

In 1930 an attractive and complete roadside stand was placed in operation, serving lunches and dinners featuring chicken, vegetables, etc. This business was placed in operation late in the season, and the current consumed is therefore negligible until the 1931 season.

TABLE NO. 6.

FARM NO. 6.—*Kilowatt hours and current costs—five-year electrification period.*

Month	Kilowatt hours used.						
	Pre-electrification Period 1925	1926	1927	1928	1929	1930	Average Monthly
January	152	197	1,000	484	360	345	477.2
February	123	200	1,165	372	196	346	455.8
March	108	114	565	311	351	362	340.6
April	58	69	778	233	417	401	379.6
May	91	171	792	324	378	257	384.4
June	61	185	845	314	393	344	416.2
July	47	609	650	287	392		387.6
August	45	721	561	296	371		389.8
September	51	889	945	367	337		507.6
October	60	941	325	378	359		400.6
November	53	812	370	334	379		379
December	109	1,090	374	303	412		435.8
Yearly total	958	5,998	8,370	4,003	4,345	4,345	5,412.2
Ave. per month	79.8	499.8	697.5	335.6	362.1	362.1	
Daily ave.	2.6	16.43	22.9	11	11.9	11.9	
Ave. rate per kw.-hr.	.088	.041	.037	.047	.05	.05	
	Current costs.						
January	$12.75	$15.45	$35.45	$27.72	$18.31	$18.66	$21.39
February	7.51	16.60	41.36	13.38	11.37	19.25	18.24
March	9.02	10.66	20.29	16.46	19.65	18.47	15.76
April	5.23	6.12	26.00	12.28	23.39	20.05	15.51
May	7.15	14.28	26.09	15.95	20.78	12.65	16.15
June	5.42	15.45	27.76	14.64	20.44	14.46	16.36
July	5.12	21.27	22.46	12.47	18.20	15.51	13.25
August	5.20	24.02	19.46	12.68	15.07	12.74	12.73
September	5.60	29.22	40.94	15.79	13.38	17.49	17.48
October	6.24	30.80	13.45	16.67	15.14	13.72	13.71
November	5.60	27.18	16.54	15.72	18.80	13.97	13.97
December	9.46	36.54	18.40	15.81	22.47	17.11	17.11
Yearly total	84.30	247.59	308.20	189.57	217.00	194.08	
Ave. per month	7.025	20.63	25.68	15.80	18.08	16.17	
Daily ave.	.2309	.678	.84	.52	.59	.53	

Estimated as a total of 2290

FARM NO. 7

Farms in New England operating on a large scale are much more the exception than the rule. Small to medium-size farms predominate in a large degree. Farm No. 7 was, in 1925, just a good sized poultry

farm, but by 1930 it had developed to be one of the largest poultry plants in the state.

While it may be doubtful that this growth is due to the stimulus of electrification, the owner states that the farm would not have reached the position it holds today if it had not been served by electricity. Furthermore, the development and growth in this case has had a very marked and evident effect on other farms in the surrounding section.

The following description gives the conditions and size of business from 1925 to 1927:

Three to four-man farm. Family of five adults and one child. Twelve room house, three story poultry barn, machinery storage barn, four laying houses, 21 brooder houses, repair shop, pump house and ice house. 184 acres, of which 70 are tillable. 2,600 laying hens, 15,000 broilers, and an annual hatch of 20,000 chicks, 3 horses, 1 cow, 1 delivery truck, 1 pleasure car, modern machinery, 6,000-egg incubator using coal-hot water heat. 450 apple trees. Broilers and fresh eggs shipped to Boston and New York. Farm two miles from town. Buildings wired over 10 years without extra line cost. Transformer of 10 K. V. A.

Equipment. Light Circuit Equipment: Wiring house and buildings; House lights, 40 outlets; Barn lights, 20 outlets; Washing machine; Percolator; Curling iron; Toaster; Sewing machine motor; Radiant heater; Vacuum cleaner.

Heat Circuit Equipment: Kitchen range; Household refrigeration; Ironer; Hot water heater; Flat iron.

Power Circuit Equipment: Motor drive for water pump; Feed mixer and elevator.

In 1928, 80 acres were added to the farm, bringing the total to 264 acres. By this purchase the apple trees in bearing became 750-800 instead of 450. The hay tonnage developed to 100 tons a year. A 15,000-egg electric incubator was purchased and installed and the capacity of the original 6,000-egg machine (coal-hot water heated) was increased to 10,800 by the addition of another deck and added length. This produced a capacity of 25,800 chicks at a hatch. Two hatches with this equipment produced 50,000 baby chicks. 4,000 laying hens were carried and 20,000 broilers raised. The man power was increased to four full-time men.

In 1929 a new brooding plant (120′ x 32′) to accommodate 4,000 chicks was constructed, heated by hot water. The stock carried was increased to 75,000 baby chicks and 5,000 laying hens, but the broiler production remained at 20,000. During this year another 15,000-egg electric incubator was purchased, making the total capacity 40,800 chicks per hatch.

At the beginning of 1930 there were 6,500 laying hens but this number was later cut back to 5,000. The baby chick and broiler business remained the same as the previous year.

The capacity of the entire plant in 1931 was 165,000 baby chicks, 11,000 layers and 30,000 broilers. As compared with 1925 this represents over 300% increase in laying hens, 100% increase in broiler production and 725% increase in baby chicks hatched.

No additions to the foregoing listed household equipment have been made. The equipment added to the farmstead operations brings the total number of appliances up to 23 and consists of two 15,000-egg

electric incubators costing $1,695 each, a 1 h. p. combination table saw, band saw, and planer, worth $260, but secured second-hand for about one-fourth that amount, two electric hand saws at $40 each and a ½" portable hand drill at $37.50.

The total of this new equipment amounts to $3,582, all of which has been bought solely at the discretion of the owner. Up to March, 1927, the total investment was $3,075, but several changes have been made in the original layout, reducing this to $2,429. The ultra-violet ray equipment (medical type) was removed because of the practical difficulty of exposing a large number of groups of birds daily without either moving them or the light. The 5 h. p. utility motor was abandoned, and a tractor purchased instead, due to a standing demand charge on the motor, whether in use or not. The hay-fork hoist was exchanged for a more satisfactory type but is not now motor-operated. While the experimental feed mixer was not considered entirely satisfactory (largely from the standpoint of labor requirements) it has been in constant use for the past five years—a strong indication of the need for equipment of this type.

The original 20 lights in the barns and poultry pens were increased to 45 with the making of additional space on the third floor of the main barn. By raising the roof at the eaves on one side, an additional floor was obtained at nominal cost. This large barn now has four floors cut up into lighted pens in which poultry is kept—a method which is becoming more prevalent for utilizing the spacious New England type of barn for poultry raising. Large numbers of birds can thus be maintained in a compact space where they may be cared for with a minimum of labor. The lighting of hen pens is carried on from October 15 to about April 10.

Twenty-seven additional lights were required in the new brooding houses. Seventeen of these (15 to 25 watts) are kept lighted all night —a method which has proven successful in contrast to using lights in the early morning or late afternoon for giving the birds greater daylight hours in winter. Having only a dim light, the birds go to roost to sleep, get up and eat or drink or exercise, as their mood happens to be, but at all times are able to see their way about. No ill effects of this method have as yet been discovered.

In the battery brooding room 4 lights are run day and night, using 40 watts in the daytime and 10 watts at night for each light. These were operated one year from September until June but, due to rate conditions, were cut down to February till June.

Twenty-five to 30 additional lights are also used to provide warmth for day-old chicks in the "live and grow" type brooder box. At a room temperature of 55° to 60° F. a 50-watt lamp on a flexible cord is placed in each box containing 50 chicks for the first week. For the following week or ten days this is reduced to 40 watts, after which the chicks are removed to regular brooding quarters, as these temporary brooding boxes fail to give sufficient head room after 15 to 20 days. The use of lamps in this manner provides the necessary heat for the chicks in each pen and also light so that they may move about freely.

Frosted globes are used, and where room temperatures are nearer 70° F., 40-watt bulbs are substituted for the 50-watt lamps the first week, followed by 25-watt.

Six service lights are also used in the grain room and general barns.

From the above it will be seen that lighting plays an unusually prominent part in the poultry business. From the 20 lights in 1927 the number increased by the end of 1930 to 107 lights. The average increase in layers, broilers and baby chicks was 375%. The increase in lights was about 400%; the relation between the number of lights used and the birds handled remained approximately constant. A greater number of lights and more current generally would be used, according to the owner, if a lower rate, commensurate with the amount now used and of a type applicable to rural service, were available.

The total electrical equipment outlay is now $6,012. This figure alone bespeaks the size of business which has been developed.

The analysis by circuits shows that the expansion of business has brought about some slight changes in the type of equipment employed. The light circuit lost 4% and the power circuit 2% in favor of the heat circuit, which was brought up 6% to a total of 30.4% as against 23.8% in 1926.

Looking through the cost distribution, however, a distinct change between 1926 and 1930 has taken place. The total investment in equipment for both the light and heat circuits in 1930 was about one-half that in 1926, and there was a jump from 39% to 69% in power circuit equipment. That the newly purchased equipment has been for farm work will be seen in that two-thirds of the equipment investment is on the farm and one-third in the house in 1930 as against 1926, when the advantage was slightly in favor of the household. This again indicates that the saturation point for the home is fairly definite, not particularly complicated, and may be reached as rapidly as the family wishes to make the necessary investment. Farm development, on the other hand, is not as quick, but has unlimited possibilities of expansion.

Table 7 and Figure 9 show that from the starting point in 1925 of 1,070 kw.-hrs. the load was built up in steady increments to 2,900 kw.-hrs. in 1928. The original average rate per kilowatt-hour of nearly 13 cents was apparently quickly affected in 1926, when it dropped to 9 3-5c. Actually, however, this was the result of the misapplication of the rate schedule, and in 1927 it returned to 10 3-5 cents. In 1928 the use of an additional 375 kw.-hrs. brought a reduction of but two-fifths of a cent per kw.-hr.

In this period when the consumption was nearly trebled (1,070 to 2,909 kw.-hrs.) the total decline in rate per kw.-hr. was 2.5 cents. Since it is probable that to small and average farms, which group predominates among rural customers, 3,000 kw.-hrs. a year could now be considered a very fair use of current, it appears that this particular rate schedule might not offer much inducement to a liberal use of current.

It has been pointed out in each of the previous farms that even after the experimental load building efforts of the project engineer had been suspended and the farms left to themselves, the use of current still continued to increase, or at least hold its own. In this case, with the

Table No. 7.

Farm No. 7.—*Kilowatt hours and current costs—five-year electrification period.*

Month	Kilowatt hours used. Pre-electrification Period 1925	1926	1927	1928	1929	1930	Monthly Average
January	134	235	305	262	275	1,008	417
February	103	204	263	259	664	1,204	518.8
March	89	108	201	259	832	1,455	571
April	49	64	182	254	782	1,319	520.2
May	45	86	162	219	654	1,175	459.2
June	45	78	168	224	584	666	344
July	32	275	232	183	264	254	241.6
August	40	292	246	308	358	372	315.2
September	44	233	217	276	332	413	294.2
October	75	240	181	196	400	315	266.4
November	139	119	178	188	829	478	358.4
December	275	209	195	281	1,018	1,623	665.2
Yearly total	1,070	2,143	2,530	2,909	6,992	10,282	4,971.2
Ave. per month	89.1	178.5	210.8	242.4	582.7	856.8	
Daily ave.	2.93	5.87	6.9	8.0	19.2	28.2	
Ave. rate per kw.-hr.	.1268	.0959	.106	.102	.072	.063	
	Current costs.						
January	$17.92	$28.70	$37.46	$32.70	$34.26	$82.30	$38.89
February	12.86	24.98	32.66	31.38	57.82	94.14	42.31
March	11.18	13.46	25.22	32.34	52.46	94.58	38.21
April	6.38	8.47	22.78	30.06	60.46	85.38	35.59
May	5.90	8.92	20.30	22.26	44.46	68.02	28.31
June	5.90	8.68	20.14	21.50	36.94	50.22	23.90
July	4.34	18.12	19.34	15.14	23.96	15.64	16.09
August	5.30	18.63	19.66	22.14	28.68	21.54	19.32
September	5.78	16.25	17.30	20.94	26.52	23.18	18.33
October	9.50	17.24	14.26	17.34	30.04	19.26	17.94
November	17.18	14.88	15.58	18.46	49.28	25.78	23.53
December	33.50	27.21	24.18	32.42	55.40	71.58	40.72
Yearly total	135.74	205.54	268.88	296.68	500.28	651.82	343.16
Ave. per month	11.31	17.12	22.41	24.72	41.69	54.32	
Daily ave.	0.37	.563	.737	.813	1.37	1.78	

exception of 1928, when infectious disease in the flock curtailed development, the tendency to develop the load unassisted is very evident. Much of the work of the first year's installations made necessary many fundamental changes in equipment which have later proven capable of providing the necessary service even under conditions of a large expansion of business. In other words, many appliances not only fill the immediate need, but provide reserve capacity for increased duty if needed.

In 1929 the very definite enlargement of plant and equipment raised the consumption to 7,000 kw.-hrs. or 133% over the year 1928. Nineteen hundred thirty showed a 50% increase over 1929, when over 10,000 kw.-hrs. was used. The reaction of the net rate to these two increases is seen in the reduction to 7 1-5 cents in 1929, followed by a drop to 6 3-10 cents. With the exception of 1929 when the decline in unit cost was significant, this particular schedule reacts to curtail rather than induce liberal use. Over and above this it appears that the entire range of this rate does not fit rural service, inasmuch as 10,000 kw.-hrs. per year, consumed by one unit, warrants a much better last block than 6 3-10 cents per kw.-hr.

Poultry Farm Characteristics Still Indefinite

While it appears that a very sizeable quantity load can be built up on poultry farms, the quality of this load, judging from the results obtained on this farm, is in direct contrast with what has come to be considered the agricultural load characteristic, i. e., a peak load in the summer months. A glance at the curves in Fig. 9 shows the sway-back original curve for 1925, followed by improvement in 1926-27-28 with a tendency to peak in July or August. That this tendency would merely be more accentuated as the load was increased was the preliminary conclusion held until 1928. This would hold true if the scale of operations had remained as described in Bulletin No. 228.

With the concentrated and specialized development of baby chick, egg and broiler production, all of which are cold weather operations, the balance maintained with routine farm production was upset, with the resulting shift in peak load to the winter months. The principal applications causing this peak are poultry lights—used increasingly as the daylight hours decrease—the change from coal to electric incubators and the brooding of broilers. Inasmuch as the big increase in stock comes at this time, the total equipment of the farm is also placed under a generally heavier load.

Dividing the equipment we find that group 1, having maximum use in winter, are lights—house, barn and poultry—water pump, feed-mixer, incubators and brooders (refer to Table 8). Group 2, having maximum use in summer, has shrunk to a relatively small number, viz, household refrigeration and booster service of the hot water heater.* The remaining equipment falls into Group 3, having generally negative qualities with but slight tendency to build up seasonally. The predominance of use of equipment in Group 1, is evident in this case, which makes self-explanatory the winter peak.

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*Up to 1928 a 5 h. p. portable motor was used for the hay hoist, wood sawing and like sundry chores. Due to the fact that a demand charge of $7.50 per month ($1.50 per h. p.) was continued in effect by the company regardless of infrequent and intermittent use, this equipment was discarded and a tractor purchased. Unless it is desired to keep large h. p. motors (over 2 h. p.) off the rural lines, this type of demand charge should go into the discard as being wholly unsuitable for rural use.

Equipment Trouble-free

The serviceability of electrical equipment for the farm has been demonstrated to be high if carefully selected. The repair costs to all household equipment are considerably under $5 for a 5-year period. In

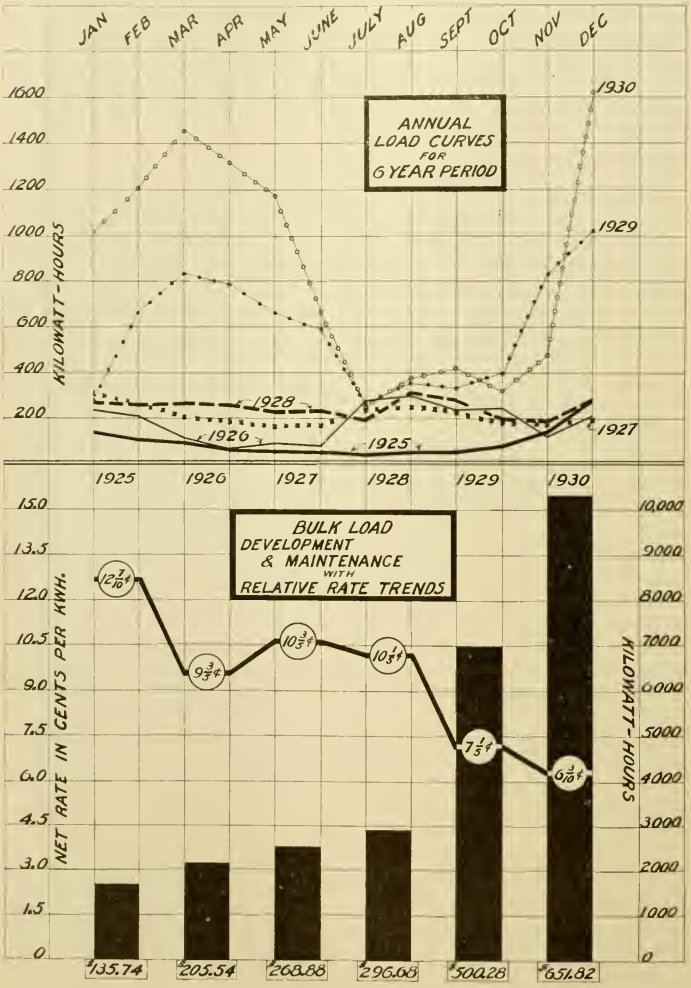

Fig. 9. *The annual characteristics, volume and rate trend in the electric load on Farm No. 7.*

the farmstead group, strictly electrical breakdowns of machines have been practically nil. Renewal of belts and secondary drive gearings have been necessary occasionally.

Failure of line service has continued to grow less and less. Storms, ice, snow and wind still present the greatest hazard, and this farm has suffered two losses of baby chicks in the incubators, 1,000 and 3,000 respectively, due to this cause. In one case the loss could have been partly avoided by proper management of the incubator at time of current failure, and steps are being taken to provide auxiliary means to overcome any other such occurrence.

While this farm has found work for electricity to do in very liberal amount and diversity of application, the possibilities are by no means exhausted. In 1931 an additional 16,000 egg electric incubator was installed operating with 1-10 h. p. motor and 3,600 watts heat.

THE ELECTRIC EQUIPMENT

The electrical appliances on these farms have proven satisfactory, economical and desirable in practically every instance. Sufficiently so that to those who may have a question as to what equipment is suitable for farm use, the foregoing pages may serve at least as a guide.

Applications of outstanding success are lights, water supply, household and dairy refrigeration, range, washing machines, flat irons, radio, shop equipment, milking machines, bottle brushes, cream separators (little used in this section, however), poultry lighting, incubators and fountain heaters. In addition to the above major operations, small equipment such as toasters, percolators, vacuum cleaners, sewing machines and the like have proven equally satisfactory. The above list is not intended to be complete, but comprises equipment with which this Station has experimented. It should also be pointed out that the type of appliance used was chosen with knowledge of the requirements to be met, rather than by indiscriminate purchase.

Following the above group there exists a number of applications which, carefully and properly selected and installed, can be depended upon to give satisfaction and practical results. The conditions surrounding this class of equipment require a higher degree of skill and experience than the first group, and they should, therefore, be handled by individuals well informed in this field. Among these are hot water heaters, portable motors for wood sawing, silo filling and hay hoisting, electric brooders and fruit sorters and graders.

Following the above is a large list of equipment which is more or less in the experimental or development stage. At intervals some one application becomes perfected and after a reasonable period is placed in the ranks of practical equipment. Appliances of this nature should be recognized as such, and where used to fill a given request the conditions surrounding them should be thoroughly explained. Any use of this class of equipment, more than in either of the two groups given above, requires, without exception, the most experienced personnel, if it is to be placed on farms by power companies while it is still in the experimental stage. The indiscriminate use of new material is of doubtful value to any of the parties concerned; a much more desirable

practice being to place one or two such applications on particular farms as a test where they may be closely observed and considered in the light of an experiment.

Growing Demand for Electrical Methods.

Notwithstanding the relatively large loads on these farms, there is not one in the experimental group that does not have under consideration additional electrical equipment or applications. On some farms the list includes a very considerable number of items. Some are awaiting more favorable personal financial conditions, lower rates or the correction of some local condition. All of them indicate particular interest in whether newly designed equipment has proved thoroughly practical for farm conditions and free from any possibilities of failure which would make their investment a loss.

This inclination to continue to increase their load by additional applications—without stress or suggestion from the project engineer—is of particular interest to any who, in the past, may have been inclined to wonder as to whether the farm would maintain or relinquish some of its load as the years progressed. The inclination to increase the load is well defined, and since practically no tendency in the opposite direction has been observed, there is considerable assurance that a well built farm load is a substantial fixture.

Uses for Electricity Not Exhausted—Dairying.

While electric current performs most of the important operations in the household, its uses in farm work are far from exhausted. Other applications which appear prominently for dairy farms are as follows:

Water Heaters and Utensil Sterilizers. In the dairy most washing and sterilizing are accomplished by coal-heated water and steam. The correct application of electric water heating for the home also constitutes an appreciable load not now connected. The regular chore and labor of building fires as well as cost of fuel make the possibility of automatic electric heating equipment worthy of investigation.

Furnace Control and Operation. Automatic electric operation of the house heating furnace would also relieve the men of the place of another responsibility and provide a more uniform temperature regulation.

Lighting. Flood lights and a search light are in many cases essential as protection at night from prowlers and thieves and are particularly important in the reduction of accidents in the farm yards at night.

Farm Shop. A complete farm shop is a much needed addition to any farm for the maintenance of plant and equipment.

Feed Mixing. A practical mixer for the home mixing of stock feeds would receive serious consideration by dairymen.

Silo Filling. The filling of silos by electric motor is frequently considered desirable, but may be best deferred until a new cutter is necessary, at which time one adapted to electric power can be secured.

Stock Tank Heaters. The heating of the stock watering tanks is now usually accomplished by coal. An electric heater would save much labor and reduce the fire hazard.

Poultry.

The possibilities of developing a much greater load on poultry farms can be visualized by the following operations:

Water Heating. (1) Correctly installed units for the house. (2) A unit to replace coal heaters in the poultry stock buildings for mixing mashes, scalding fowls, etc. (3) Electrically heated drinking fountains in the pens.

Incubation. The replacement of incubators now operated by coal-heated hot water, by electric machines having higher efficiency, economy and labor-saving qualities.

Brooding. Electrically heated individual or battery brooders for from 5,000 to 25,000 broilers.

Feed Mixing. A feed mixer that will effectively mix grain either for scratch feed, mashes or to incorporate cod liver oil in the feed. (Such a mixer was partially developed by the Station on Farm No. 7.)

Poultry Pen Cleaning Equipment. Certain poultry diseases which have recently developed require the cleaning of houses or pens at frequent intervals as a control. To do this once every three days entails a very considerable cost for labor. A plan for doing most of this work with electricity as power has been suggested by one owner as having wide-spread use and economy features.

Yard and Building Searchlight. Safeguarding poultry at night, and inspecting buildings and grounds for prowlers and other disturbances is practical by the use of searchlights, or floodlights.

Ultra-Violet Irradiation. Ultra-violet ray producing lamps of the newly developed lamp-socket type to be used as a substitute for cod liver oil in the prevention or cure of disease.

Spray Equipment. Equipment that will spray paint, whitewash, insecticides and germicides would have great labor saving advantages.

Refrigeration. The killing, picking and dressing of poultry for at-the-door-sales develops serious interruption of the day's routine if done on a "when the customer calls" basis. Refrigeration provides storage facilities for a quantity killed at one time as well as for eggs and garden produce.

Just what load factor may be expected from poultry farms in general is not clearly established to the satisfaction of this Station. But two farms were under test, and with the abnormal conditions cited for Farm No. 6, deductions are perforce reduced to Farm No. 7. As has been pointed out, this farm presented opportunities for many applications, but a single case is not sufficient to furnish average data. It would appear essential to develop a larger group of poultry farms and plan for more concentrated effort in this field to provide the much requested and needed experimental data in poultry applications.

Fruit.

The total number of operations on fruit farms appears now from the limited data on hand, to be fewer than on dairy or poultry farms, and many of these require a large investment, the returns from which have not been clearly determined by the project thus far.

An Apple Grader and Sorter, such as was tested on the University fruit farm (results given in Bulletin No. 228, March, 1927), was seriously considered for the one fruit farm, and from the standpoint of operation and performance would have been entirely practical. The main questions were those of investment and the most economical method of marketing. These machines cost in the neighborhood of $1,000. While this might be out of the question for small producers, it appears possible that a community owned outfit would be desirable. No question of the merits of grading and sorting fruit for quality marketing is evident in any appreciable degree. Market conditions and marketing methods present some questions, however.

Motor Driven Cider Presses offer a method of disposal of culls and poor grade fruit where a market for cider or vinegar exists. While one of these presses has proved profitable on the college farm, their value on fruit farms in general in this section remains to be verified.

Spraying and Dusting Machinery, driven by electric motor instead of gas engine, offers difficulties in supplying the current to mobile equipment. In contrast to this is the method employed in the western fruit sections of installing the spray machinery in a central, permanent location and carrying the spray in underground pipe lines throughout the orchard. No specialized work has been done by the project as yet in this field.

Insect Trapping by electric lights, while still in the experimental stage at other Stations, offers possibilities in the control of pests and is a subject of great interest to the owners of fruit farms.

Refrigeration of Fruits. Experiments by the Horticultural Department at the university on the pre-cooling of fruit immediately after picking, by forced-draft refrigeration, show that apples so treated keep in quality condition much longer than those untreated. This experimental work has possibilities of future use on fruit farms. Refrigerated cold storage for fruit in place of the common storage heretofore generally used, also has potential possibilities. Two such storages are available for study by the project. The possibility of utilizing the "quick-freezing" method for preparing fruits for market opens another field of investigation not heretofore considered. The possibilities of these three uses of refrigeration could be considered either as individual applications on large fruit farms, or as a community project for a group of farms of smaller size.

Farm Shop. A motorized farm shop is of equal importance on fruit farms as on other types.

While the load characteristics and electrical applications on this fruit farm have proved desirable from all viewpoints, it is obvious that results drawn from but one case are of doubtful value as pertaining

to the utility and results from equipment on fruit farms in general. This fact, coupled with the evident need for the development of the additional applications mentioned, indicates that studies on a larger group of farms, particularly since fruit farming in New England is of considerable proportions, would be desirable.

Difficulty Experienced in Water Heating.

The circumstances surrounding the use of electric water heaters are worthy of mention since they emphasize two factors which are of great importance in the development of loads on farms: namely, (1) proper and careful installation, and (2) satisfaction and economy in use.

The heaters selected in these two cases were of a 30 gallon tank type of high quality, built by reliable manufacturers and of proven merit. During the ten months of use no difficulty of any kind was experienced with the heater equipment itself. The use of this device on two farms proved a positive failure due to faulty installation which resulted in abnormally high current consumption and corresponding costs. (It would be well to note here that the side arm booster type proved desirable and practical on two farms.)

The logical location for the heater was recognized as in the kitchen on Farm No. 1. This, however, was small, compact and offered no easy opportunity for placement. Since water drawing at this point is characterized by frequent short openings of the faucet, it would mean that unless the run of pipe were short there would be much wastage and lukewarm water delivered. The bathroom, however, was large and roomy with plenty of space for the heater. The mistake of selecting this location rather than in making the extra effort to provide room in the kitchen is evident in the results obtained. During the last six months of 1926, the heater averaged 191 kw.-hrs. per month, making an average bill of about $10.50 per month. In 1927 the average was 227 kw.-hrs. at $11.00 per month, with a maximum in June (planting season) of 407 kw.-hrs. at $18.30.

While the cost of operation of the electric heater was easily calculated and the cost of the coal method was more obscure (due to bulk buying of coal for all purposes) it was apparent to the operator that the cost of electric operation was excessive. Later checks of coal-heating units revealed the cost for coal to be more than this farmer expected, but still considerably under those experienced with the electric unit.

On Farm No. 6 a corner of a stairway would have placed the heater midway between the bathroom and kitchen sink with short direct runs to both points. This was discarded since it would partially block the stairway. No satisfactory location could be used in the kitchen or adjoining rooms. The only remaining possibility was the basement. This was under the main part of the house, and to reach the kitchen and bath the hot water had to traverse long runs of pipe in a cold, unexcavated foundation under the latter.

In operation these conditions developed very unsatisfactory results. While the heater tank was continually full of hot water, the pipe lines leading to the delivery faucets were filled with a large volume of cold water, so that in order to draw warm water the faucets had to be held

open until this had been discharged. The heated water itself was tempered considerably due to the long run of cold pipes so that lukewarm water was usually delivered except when large quantities were drawn. When the faucets were closed, the pipe lines were filled with heated water from the tank which, of course, cooled rapidly. At the same time so much water had to be drawn off before the warm arrived that the tank of the heater was constantly having its contents renewed with cold water which kept that unit working a large proportion of the time.

High current consumption, high electric bills, and lukewarm water as a result of faulty installation rather than inferior equipment caused this project to be a complete failure. In many cases of this kind such an experience (and the equipment or process in general is usually blamed) on the part of one farmer rapidly becomes common information in his community, and it is frequently impossible to get other farmers to even consider the same appliance for their own places.

Observation of similar occurrences on other farms demonstrates the unusual importance of proper installation of equipment at all times, but more particularly the first installation during the initial years of rural electric development in each community, in order that well designed equipment and processes developed for the rural field will not be unjustly condemned, thereby not only retarding the use of equipment which is economical to the farmer and revenue-producing to the utility, but also developing an artificial resistance factor which reflects on any legitimate electrical equipment which may be introduced. This is one of many reasons pointing to the importance for each utility to have at least one man in its organization well informed in rural problems, to safeguard its own and its consumers' interests.

SEASONAL USE

A factor which influences the type of load curve developed is the more or less inherent quality of some applications to produce greater consumption at one time of year than another, as a result more of seasonal or living conditions rather than activities in the work schedule. Dividing these into three groups (See Table 8) it has been found that those developing maximum current use in winter, Group 1, are the house, barn and poultry lights, which account for 20.5% of the total kw.-hr. load developed on the seven farms.

Those working heavily in the summer, Group 2, are the combination range,* hot water heater, house refrigerator, large portable motors for hay hoisting, wood sawing and concrete mixing, and the dairy refrig-

*The combination range is believed more certain to produce a greater electrical load, and that load is more certain to be a summer one, than where a standard range is used in conjunction with a coal or wood range. Where this latter is the case, local conditions and individual characteristics play a more important part, as will be seen in the cases of Farms Nos. 5 and 7. In one case the electric range is a summer load, and in the other a neutral or year-around load. Where a standard range does all the cooking as on Farms 1 and 6, it becomes a positive year-around load. Such is also the case with water heaters. Installed alone they are used throughout the year. If used as booster heaters, they tend toward maximum use in summer.

TABLE No. 8.—*The effect of equipment having seasonal use on annual kilowatt-hour load.*

		Dairy Farms				Fruit Farm	Poultry Farms		Ave. % of Total Load
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	
Group I—Winter	House Lights	16.4 %	5.5% (1)	17 %	12.3%	25.4% (1&2)	8.86%	15.14 %	14.3%
	Barn Lights	1.1 %	1.5%	7 %	2.5%				3.0%
	Poultry House Lights						3.96%	26.8 %	15.3%
	Group Total	17.5 %	7 %	24 %	14.8%	25.4%	12.8 %	42 %	20.5%
Group II—Summer	Refrigerator	6.88%	13 %		(3)	15.0%	9.55%	13.68 %	11.6%
	Milk Cooling	13.3 %	28 %		21.3%				20.8%
	Combination Range (4)			8 %	47.6%	(7) 30.8%			28.8%
	Water Heater			3 %				6.32 %	4.6%
	Portable Motor	.72%						1.5 %	1.1%
	Group Total	20.9 %	41 %	11 %	68.9%	45.8%	9.55%	21.5 %	31.2%
Group III—Neutral	Clothes Washer	.39%	3.0%	1.0%	0.6%	13.0%	.42%	1.03 %	2.7%
	Flat Iron	1.23%		2.5%		8.9%	2.33%	3.48 %	3.6%
	Ironer				2.1%				2.1%
	Water Pump	9.19%		1.5%	2.8%	6.9%	5.04%	11.73 %	6.2%
	Standard Range	(5) 33.28%					(5) 69.8 %	11.53 %	38.2%
	Milking Machine	16.54%	40 %	5.9%	9.3%				17.9%
	Cream Separator	.95%							0.95%
	Feed Mixer							8.45 %	8.45%
	Farm Shop		5.0%					.003%	2.5%
	Battery Charger				(6) 1.5%				1.5%
	Dish Washer			1.0%					1.0%
	Bottle Brush		1.0%						1.0%
	Milk Cooling Pump		3.0%						3.0%
	Group Total	61.6 %	52.0%	65 %	16.3%	28.8%	77.59%	36.5 %	48.3%

(1) Includes flat iron
(2) Includes barn lights.
(3) Combination household and dairy refrigeration room.
(4) Side-arm type—booster service.
(5) Used for all cooking.
(6) Radio.
(7) Standard range used with wood stove.

erating system. These account for 31.2% of the total current used. The remaining equipment is more nearly inclined to have neutral qualities throughout the year, although it usually has a tendency to show somewhat greater use in summer. This Group 3 is most important to consider as a bulk load producer and uses 48.3% of the total load of the seven farms.

Considerable variation will be observed in the group totals for the different farms in Table 8. These are accounted for in the make-up of the load, and the various methods employed as described in the previous pages.

Annual Power Factor on Rural Lines.

From the above it appears that well equipped farms on rural lines have much to commend them from the utility standpoint. Nearly 50% of the annual load has approximately a straight-line power factor. Of the two possible tendencies to produce a peak demand, the greatest, 31.2%, occurs in the summer months when urban and industrial loads are low. The remaining 20.5%, comprising principally lighting, of necessity comes on the system in the cold months. The desirable part of the load is, therefore, approximately 80% of the total. Since about one-half of the Group 3 average total of 48.3% would occur in the summer, this added to the regular summer load of Group 2 of 31.2% would make a total of 55.2%, which might be classed as very desirable from the annual power factor standpoint. The curve of a power company's urban load is characterized by high peaks in the winter, early spring and late fall, and a depression in late spring, summer and early fall. The rural load is peaked at this very time of depression.

The tendency of the rural load is, therefore, to dovetail with the urban and produce a total production curve for the company that has that valuable characteristic of approaching equal volume the year around.

If farmstead and field operations were eliminated so that only the household operations were electrified, the load would bear similar characteristics to that of the city household, as the requirements of these two types of homes have been found to be similar.

It, therefore, appears that unless the field and farmstead operations are properly developed, a valuable feature of the rural load will be lost, and it will contribute only as increasing the total output without improving its character.

Among these field and farmstead operations is found that element of use which produces the high summer peak on rural lines. Due to the fact that many of these operations require investigation before successful operation can be obtained, or are not as attractive to sales agencies as the more easily satisfied household requirements, it appears that this field of use is worthy of particular and continued attention. Experience indicates that such procedure would be of great interest to the farm owners as well, as the operations concerned are those which annually cause trouble in the extra short-season labor requirement. Operation by electricity would, in most cases, make the labor difficulty of little importance.

In this connection it should be observed that all the farm homes in this group are exceedingly well equipped (with the exception of Farm No. 2) and somewhere near the saturation point. On the other hand, the amount of equipment in use in the farm operations is probably representative of present-day developments but is still a long way from its end point. Since electricity used in the farm operations usually develops into a summer load, the annual power factor on rural lines should improve as time goes on over the percentages given above.

RATES, DEMAND CHARGES, METERING, SERVICE ENTRANCES, ETC.

Any detailed study of rates has been outside the scope of this experimental work. Constant contact and observation of this field in general, however, has made it evident that the consideration of rates particularly designed for rural use will be of increasing importance.

New England's rural territory is distinctive in that its residents fall into somewhat different classifications than in agricultural territory in other parts of the country. They may be classified as follows:

(a) 1. Farmers. (a) large. (b) medium. (c) small.
2. Rural residents (12 months)
3. Stores and commercial units.
4. Village service—road and street lights, town halls, churches, schools, etc.

(b) 5. Summer non-residents (3 to 5 months)
6. Country Clubs, recreational summer camps, sports clubs. (Limited seasonal use)

The above grouping naturally divides itself into two general types of service; namely, (a) yearly service for farms, rural residents and villages, and (b) short-term service for non-residents and clubs. Whereas these two groups may be served from the same rural lines, it is evident that the class of service suggests separate rating schedules accord-

TABLE No. 9.—(1) *Stores, Sales and Population in Small City and* (2) *Rural Area.*

State	Stores in Small City and Rural Area				Population in Small City and Rural Area	
	Sales (000) Omitted	% of Tl. Sales	Number	% of all Stores	Number	% of Total Population
Mass.	$210,955	10	9,651	18	744,933	18
N. H.	67,253	36	3,255	50	234,831	50
Maine	172,280	56	7,791	70	569,413	71
Conn.	175,132	23	6,741	30	525,145	33
R. I.	21,540	7	1,090	11	85,904	12
Vermont	110,886	73	4,391	85	306,200	85

(1) Domestic Commerce Bulletin Vol. IX, No. 11, April 10, 1932, United States Dept. of Commerce, Washington, D. C.

(2) Under 10,000 population.

ing to whether the use is seasonal or annual. Many companies have already applied special ratings for summer residents, clubs and camps.

Classes 1, 2, 3 and 4 make up the usual customers of rural lines and are, therefore, of immediate concern in considering rates. It would appear that there is little question of the necessity for separate consideration of Class 4, village service, and such arrangements are being made by many companies. Likewise Class 3, stores and commercial enterprises, are usually treated in a different manner. That these are of considerable importance will be seen by an inspection of Table 9.

While the differing qualities of the last four divisions are fairly evident and are usually subject to special schedules, the dividing line between Classes 1 and 2, farmers and rural residents, is much more difficult to make. Several companies in this territory have attempted to apply the definition of a farm, as set forth by the Census and U. S. Department of Agriculture in their effort to separate one group from the other. No very great difficulty is experienced in doing this as far as large and medium-sized farms is concerned, but to distinguish between small farms and rural residents is many times impossible.

Anyone living in or on the edge of rural territory is quite apt to keep varying amounts of stock such as chickens, a cow or a horse, a pig or two, etc., and for this reason lays claim to the right to be served on the rural rate. These same families may derive a considerable income from employment in the nearby town, either steadily or intermittently, or they may carry on some small-scale farm operations at the same time as a side line.

It would appear that to separate these two groups by an analysis of occupation is difficult and unsatisfactory. On the other hand, many companies feel that such a separation should be made and corresponding rate schedules applied on the basis that special rural lines are built, primarily for farm use, and that quantity consumption warrants lower unit cost. While in the past rural consumption has been low in quantity per month, it appears probable that in the future it may raise itself considerably. Of importance in this is the inducement of a lower rate with increased use which a farm of any proportions can reasonably attain, but which might be unusual for a customer in the rural resident class to develop.

In order to avoid the necessity of making a division between these two classes, it is suggested that they be thrown together in one rate, starting with the rural resident as the base unit and separating the rate structure so that only the actual putting of electricity to work in farm operations of appreciable size will bring the consumer into that position of securing the low block charges. In other words, the distinguishing element would be that, having exceeded a certain minimum (which would be the rural resident's approximate maximum), the customer automatically establishes himself as an operating farmer and is eligible to lower priced farm rates. This method would throw small farms (apparently non-operating) and rural residents together in the first brackets of the rate, from which they may emerge into the next lower cost brackets by developing their farm operations to such a point as will place them, without doubt, as active operating farms.

Essential Qualities of Rural Rate Forms.

The true farm customer represents, from the utility standpoint, a combination of home and business enterprise, both carried on on the same premises and served by one electrical service entrance. Roughly the farm represents a combination of residential and power service—a condition not generally found in other classes of utility business. For this reason it warrants special attention.

Due to the close proximity of the two parts of this combination it is difficult to distinguish where one ends and the other begins. Dairy utensils may be washed by the housewife in the kitchen. She may also hatch and brood the farm flock of chicks. The man of the house may secure all hot water from the kitchen for stock purposes, etc.

While a certain amount of the electrical usage is very evidently purely residential, the other part is distinctly a power load. This power load should be given consideration from the standpoint that the current is to be used in a business, the products of which are largely sold on a wholesale basis. In other words, it appears to be a fair assumption that if a farm sells its products wholesale it should purchase the ingredients on somewhat the same basis to show reasonable profits and continuity of business.

From the above it is evident that the farm rate should represent a combination of residential (retail basis) and power (wholesale basis) usage. Here again is the perplexing question of what proportion of each should be incorporated. The answer to this, under present conditions, probably could be obtained only through study of power company billings, including a large number of subscribers. From the experience of the experimental group it would be expected that the use of current on the average farm is somewhat equally divided between house and farm operations at present, but it should be borne in mind that the saturation point in the home is fairly definite, whereas the limits of use in farm operations appear now to be many times that of the home. Since large bulk use is desired and necessary to produce the proper return on line investment, as well as to justify lower rate steps, it would seem that a farm rate structure should have a predominant part devoted to the power (wholesale) basis, at least after the initial higher block or blocks in order to induce more liberal use in the field where it can actually take place and needs more stimulation.

Rates

Several different forms of rates have been in effect on the experimental farms and, as has been stated before, these are not all entirely suited to the agricultural business. For the most part they have been more or less temporary until such time as experience indicated the proper procedure.

Area Basis.

One form of rate, more or less common of recent years and known as the area rate, bases the minimum charge and subsequent scale on the square foot of area enclosed in the house and other buildings. Satis-

factory as this may be for urban residential use, it may not be a sufficiently accurate criterion upon which to base the demand charge for rural customers, although various area rates are applied in a variety of ways.

In applying this method to farms, most companies eliminate from their calculations such space as attics, cellars, halls, closets and other little used space, and secure their net area from the major rooms. In the case of the outbuildings, it is difficult to establish a uniform scale that adequately fits the variety of conditions existing. A small barn or out-building may be given a one-room rating, and a large barn may be considered as the equal of two or three rooms.

In general the underlying principle is that the size of buildings is the index to the electrical demand to be expected. This, in practice, may not work out to be generally true in which case it usually results in discrimination against the small farmer who happens to be burdened with too generous a layout of buildings, but who is in reality doing only a small or medium amount of business and may have a small family.

For the large farmer, whose house is well utilized either with a good sized family or with housing his hired help, and who is making actual use of his many buildings, such a basis is fair and accurate, but only in those cases, large or small, where the buildings *happen* to be in proportion to the scale of operations is this area method an accurate index.

By far the greater number of New England farm layouts are of that generous, substantially built and long lasting type, of a generation or more ago when families were large, when children remained on the farm and worked and, when a farmer's affluence was indicated by the size and character of buildings sheltering his family, stock, feed and equipment.

In subsequent years these properties have changed hands, and the farm business in New England has undergone an adjustment to changing times and conditions. The ruggedly constructed buildings that still stand are frequently only partly used. A large farm house may have only two or three occupants who use only a part of the total space—the rest being "closed off" and not in use. A large barn may have only a few stanchions out of the total filled and many out-buildings standing idle. It is evident that any unnecessary discrimination against the small operator who is already over-taxed—many times with too much upkeep and overhead from these same buildings—is in opposition to the prevailing situation. Another difficulty is the formation of a satisfactory rule of thumb for applying this rate basis to the ever varying conditions of one farm and another. It is frequently evident that one building should be included in the scale on one farm and the same building on another should not—all of which is very difficult of satisfactory explanation, no matter how just the cause.

In general the experience on this project indicates that the area basis is a doubtful index for farms, may not develop to be equitable in a certain percentage of cases, and while it may have merit over previous methods for general use is probably not the ultimate form to be desired.

Complicated Rate Structure.

Another form of rate structure that has been used in the rural field is one in which the costs of all items entering into the generation of the current and its delivery to the customer form the basis of a very complicated formula for arriving at the cost per kilowatt hour.

Such a rate as this is practically impossible of explanation to the average layman, and is, therefore, apt to be a continual cause of discussion and comment. It has been observed that the simplest form of rate structure is the most desirable and is frequently commended for this quality.

Demand Charges on Portable Motors.

An instance of this kind was referred to under Farm No. 7, and, as already suggested, a charge per motor h. p. per month is to be discouraged. Motors of 5 h. p. are at present used intermittently and at infrequent intervals.

Suggested Method of Establishing Demand.

Of the many possible methods of establishing the rating basis or demand of a farm, there seems to this investigator no more logical, accurate and simple method than to employ the K. V. A. factor of the transformer serving that farm. For example—a 1 K. V. A. transformer is required for a certain farm. 1 K. V. A., representing the capacity of the transformer, also represents the demand the utility is required to maintain for the farm, which can also be expressed in the form of a demand charge in dollars and cents. By developing a scale of demand ratings for various size transformers the demand charge is immediately available without detailed study of the farm, its buildings, conditions, etc.

This method appears to have much to commend it. The size of transformer hung would correspond as nearly as possible to the estimated or actual load of the farm in the interests of economy. No greater load than this capacity (eliminating over-load capacity) could be used continuously by the farm. This would also represent the maximum demand the utility would have to supply. No other characteristics or conditions on the farm such as acres, stock, buildings, etc., would be involved. The problem is thus restricted to just the electrical load characteristics and a classification of the individual as farmer, rural resident, etc., so that the corresponding rate could be applied. Transformer capacities would appear on the work-orders so that they would be readily accessible without farm inspections, etc. Where two or more farms are served from one transformer, the K. V. A. capacity may be divided between them according to connected load, demand meter readings, or a similar method of adjustment.

While disadvantages may show up in this method, several utilities who have employed it for a year or two have reported none to date. From the agricultural standpoint it reduces the possibilities of discrimination to a minimum.

Metering.

Various methods of metering farms have been found to have a corresponding variety of results. During the first year of the experimental work, all the farms were served on a two or three meter basis covering respectively, light, heat and power service. Early in the second year one company changed to the single meter basis with combination rate and other companies have since adopted the same plan.

The multi-meter plan has been found to have several drawbacks from the standpoint of farmer and utility alike. To the farmer it means that to secure the proper economic results heating appliances and power appliances must be wired back to the proper circuit at the meter board, regardless of whether the equipment requires special wiring or not. This on farms where the operations may be spread over quite an area, means added expense of installation and sometimes refusal to use equipment for this reason only. Where the appliance makes a heavy demand, special wiring is necessary under any condition, but for smaller units the multi-meter system tends to restrain the free use of equipment rather than to induce it. The single-meter combination rate eliminates this difficulty by reducing special wiring to a minimum. It also tends toward simplicity—always an advantage.

To the utility the multi-meter method, over the single meter has several disadvantages. The investment in meters and their service requirements are doubled or trebled. Costs of reading and accounting are increased. Three rates instead of one must be worked out and maintained. Greater possibilities of mistakes in accounts exist. It also becomes necessary, under this method, to classify operations as to whether they are of a light, heat or power nature. For example, an electric incubator may use 1,500 to 3,000 watts in heating elements, and also involve a ¼ h. p. motor in continuous operation. While this would be classed as a heating appliance and connected to the heat meter, we are then confronted with the question of rate on that meter: is it designed for household or combination use? If it is not economical for that particular use, shall it be made an exception and subject to special conditions?

From the experience of the past seven years it is very evident that there is very much to commend the single-meter combination rate plan and very little to commend the multi-meter system.

Service Entrances.

During the first few years of the experiment there were relatively few occasions where 220-volt service was of any consequence; most equipment of that time was found to be satisfactory on 110 volts. During the last two or three years, however, it has become more and more apparent that the active farm will develop uses that require this type of service. On the dairy farm hot water heaters (in which speed is a factor) and sterilizers are best operated from 220 volts. Likewise, some heating equipment on the poultry farm may be best served in this way. Long runs to pump houses are not uncommon and frequently may be best handled with 220 volts.

In view of these possibilities, it would seem to be wise policy and an economy for both farmer and utility to provide entrance service equipment of sufficient size to permit of the drawing in of a three-wire service later on, even if it is not done at the outset. The increased cost of large conduit and three-pole equipment is not great as compared to the removal and replacement of small two-wire entrances which may be found to have insufficient capacity. This should not be considered a hard and fast rule for all rural customers, and judgment would have to be exercised as to what individual active farms show promise of developing sufficient load. Several experiences of this nature have shown that difficulties in the future can be thus avoided as well as an ultimate saving made for the farm customer.

CONCLUSIONS

The electric load on the seven test farms has shown two characteristics. The dairy farms have, for the five-year period, repeatedly registered a distinct peak during the summer months, usually May to October. Poultry farms, on the other hand, appear to develop their maximum load in the cold months. There is, presumably, a third type of farm load which has a more or less even loading effect throughout the year.

In Figure 1 (See front cover) is shown the composite load curves for the four dairy farms (which are also representative for general purpose and stock farms) and the fruit farm for the five-year period; the two poultry farms are not included since the type of load curve developed is not comparable. The center white band is the average of all readings for these five farms for the five-year period, and is considered representative of a well developed rural load, of particular significance in which is the peak load in midsummer. For the characteristics of poultry farm loads the reader is referred to Farm No. 7 in the preceding pages.

A well defined tendency to increase the use of electricity over a period of years has been observed with little or no indication of reducing the consumption as a result of financial stress, farm business reverses or the expiration of guarantees on new line extensions. This should assure power companies of the substantial qualities attached to rural development.

A substantial load is possible in the home of an active farm and may be placed on the line with the least sales resistance and service difficulty of any of the equipment which a farm can use. The relying on this type of farm load alone will, however, yield an annual power factor on rural lines similar to that already placed on generating stations by urban loads and cannot be relied upon to bring in a peak load during the summer months when the urban demand on generating equipment is at low ebb.

To insure the development of a summer peak load on rural lines, the greatest net results will be obtained from refrigeration, ranges, booster water heaters, and by electrifying operations connected direct-

ly with the field operations, thereby reflecting in the current consumed the increased activities occurring on farms at this season of the year.

In 1925, before the project began activities, the lowest average use was 36 kw.-hrs. per month, and the highest was 280 kw.-hrs. The average 1925 monthly consumption for the seven farms was 141 kw.-hrs. The higher amounts occurred on those farms which had had current for an appreciable period, and the lowest amount was for Farm No. 5, a new user of current.

By 1930 this average had increased to 428 kw.-hrs. per month or an average increase over 1925 of 203%. The smallest user had increased to 131 kw.-hrs. per month and the largest to 856 kw.-hrs.

From the standpoint of annual consumption the oldest electrified farm, No. 2, maintained a practically constant load throughout the whole period—varying only between a 13% increase and a 3% decrease. The greatest development occurred in the midst of experimental activities when a maximum increase of 853% was made on one farm.

More nearly the normal increase is obtained from an average of the five-year period which amounted to 228% for all the farms—the range being from 0% to 466% increase. Since these farms are somewhat above an average of all farms in progressiveness and activity and their original 1925 use of current was, therefore, higher than the same average class, it appears that an increase in bulk load of several hundred per cent. should be attainable on average farms in the next decade.

The loads developed on the test group have resulted from an average concentration of 65% of the equipment in the home and 35% on the farm, both from the standpoint of number of operations and the proportionate cost of appliances. Where heavy loads occurred in the home and little was done in the farm operations, negative annual load qualities developed. Where the reverse was the case, a summer peak usually appeared in good relief.

Since the requirements of rural electrification are distinctly different from those of other divisions of the electrical industry's activities and the connecting of the large potential load requires specialized and experienced attention, it would seem advisable to place this section of the business in the hands of a rural service man or department, according to the size of operations. It is believed that the investment made in lines and the assuring of adequate future revenue will warrant specialized attention.

SUMMARY

The general utility, efficiency, economy and satisfaction derived from the use of electricity for a large number of light, heat and power operations on the seven experimental farms have been well established. Criticisms and objections to the equipment and methods have been rare.

The analysis of total load developed by all the experimental farms shows 31.2% to be very desirable, 48.3% desirable and 20.5% undesirable in the effect on the power factor of central stations.

The better quality of electric load on farms, i. e. developing the greatest kw.-hr. use in mid-summer, is particularly influenced by such factors as: a greater balance of use on the farm than in the home; the use made of refrigeration in the house and for milk and other products; the use of the combination range, booster type water heaters and portable motors. This type of equipment accounted for 31.2% of the total current used over the five year period.

Equipment developing 20.5% of the total load, and concentrated in the winter, comprised lighting and poultry farm appliances such as incubators and brooders.

That part of the load having negative qualities, i. e. contributing even bulk without seasonal characteristics, is responsible for 48.3% of the total and comprises the largest number of appliances (see table 8).

During the height of experimental activities a maximum increase in current used of 853% was made on one farm over previous records.

The average increase in kw.-hr. consumption for all farms ranged from 0% to 466% but averaged 288% for the five year period.

The average concentration of equipment was 65% in the household and 35% on the farm.

In 1925, 36 kw.-hrs. to 280 kw.-hrs. was the range in monthly consumption with an average of 141 kw.-hrs. By 1930 the average of all farms had reached 428 kw.-hrs.

The farm electric load is continuing to steadily and normally increase rather than decrease.

The limits of use in the farm home are easily discerned, but the development of electric power in farm operations is considered as being only well started.

Dairy and fruit farms have shown the most desirable characteristics from the standpoint of quality of load.

Serious difficulties with equipment have been relatively few.

Increased volume of use has, in most cases, benefited the farm operator by making him eligible to lower rates.

The trend of the scheduled rates of the utilities has progressed steadily in a downward direction.

Standing demand charges per h. p. on portable motors have been found to discourage their use.

Single meters with combination rates have proven more desirable to farmer and utility alike than the multi-meter method.

Signs of the financial depression were hard to discover in the current consumption. These farms were affected, but apparently the effects were not transmitted to the electrical usage.

The requirements of rural service are such that both utilities and farmers are placed in the most desirable relationship when the development of this field is placed in the hands of an individual experienced in agricultural matters.

The advent of electricity has been observed to be a great stimulus to a higher scale of living on the farm.