UNIVERSITY OF IDAHO
AGRICULTURAL EXPERIMENT STATION
Department of Agricultural Engineering

Rural Electrification Development In Idaho

By

HOBART BERESFORD

A summary of the cooperative studies on the relation of electricity to agriculture, as made by the Agricultural Experiment Station in cooperation with the Idaho Committee on the Relation of Electricity to Agriculture.

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CONTENTS

FOREWORD

The purpose of this bulletin is to summarize the cooperative investigations which have been made by the Idaho Committee on the Relation of Electricity to Agriculture and the University of Idaho Agricultural Experiment Station. Much of this cooperative work has been available in mimeographed progress reports which have reached a comparatively few of the people interested in the rural electric development in the state. It has been the purpose of the cooperative investigations to study the application of electricity to agricultural production and farm life; to find new ways and means of utilizing electric service on the farm for profit and convenience to the farmers, and thus by greater use make feasible the economic extension of rural lines into unserviced territory. This is the first Experiment Station publication dealing with the results of the studies which have been made and constitutes a record of the progress of the rural electric development in Idaho.

E. J. IDDINGS, *Director*,
Agricultural Experiment Station.

ACKNOWLEDGMENT

In addition to the individual acknowledgments which appear in the sections of this report, the author wishes to acknowledge the valuable suggestions made by members of the Idaho Committee on the Relation of Electricity to Agriculture; the Agricultural Experiment Station Staff; Dr. E. A. White, Director of the National Committee on the Relation of Electricity to Agriculture; and M. R. Lewis, formerly Head of the Department of Agricultural Engineering and Secretary of the Idaho C.R.E.A.

Thanks are given, for assisting in the collection of the data upon which the report is based, to D. A. Stubblefield, Superintendent of the Caldwell Substation; R. F. Johnson, Assistant Animal Husbandman; and Tom Maberly, former Herdsman (1925) of the Caldwell Substation Farm; as well as the meter department of the Caldwell office of the Idaho Power Company; R. S. Overstreet, Agricultural Engineer, Idaho Power Company; J. Earl Cress, who held the Rural Electrification Fellowship Appointment during two years of the work reported; and the equipment manufacturers who furnished appliances for the cooperative studies.

The author is grateful for the cooperation of the utility companies, the Bureau of Reclamation, and the Boise office of the United States Geological Survey in supplying the progress data reported in the rural survey.

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* In cooperation with the United States Department of Agriculture.

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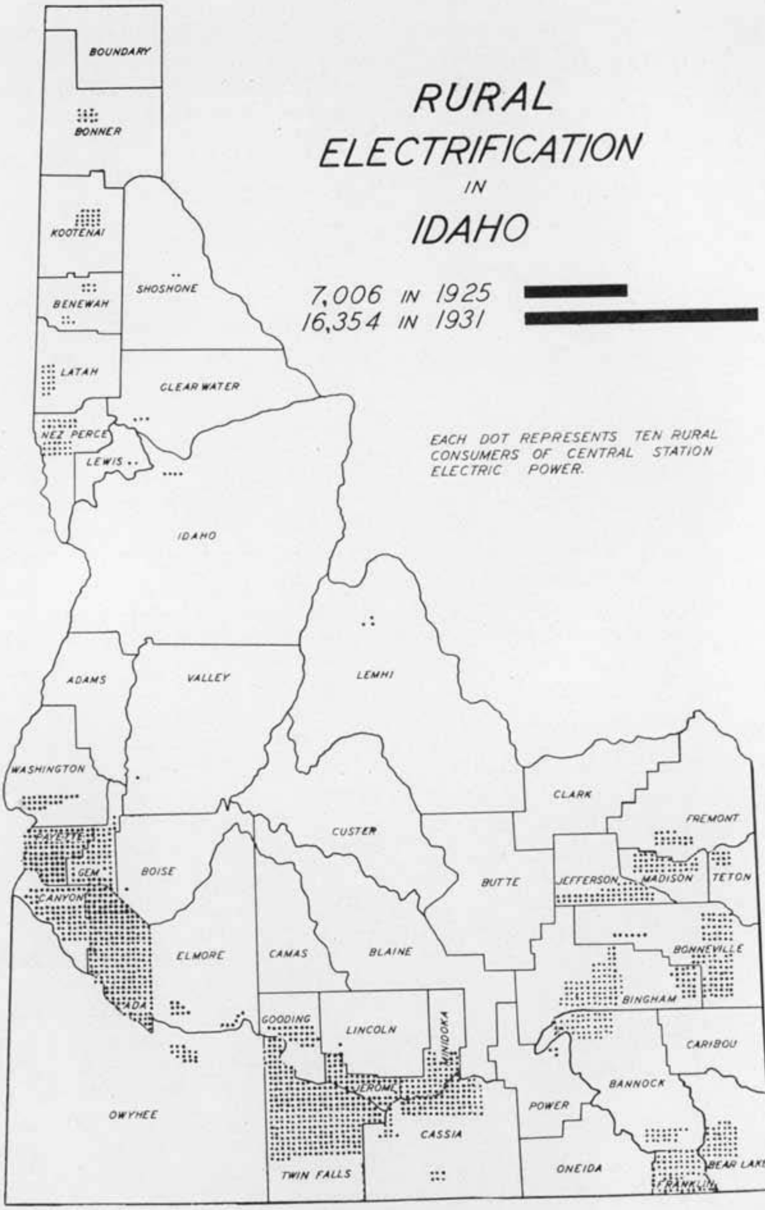
RURAL
ELECTRIFICATION
IN
IDAHO
7,006 IN 1925
16,354 IN 1931
EACH DOT REPRESENTS TEN RURAL CONSUMERS OF CENTRAL STATION ELECTRIC POWER.
BOUNDARY
BONNER
KOOTENAI
BENEWAH
SHOSHONE
LATAH
CLEAR WATER
NEZ PERCE
LEWIS
IDAHO
ADAMS
VALLEY
LEMHI
WASHINGTON
PAYETTE
GEM
CANYON
BOISE
CUSTER
CLARK
FREMONT
BUTTE
JEFFERSON
MADISON
TETON
ELMORE
CAMAS
BLAINE
BONNEVILLE
ADA
BINGHAM
GOODING
LINCOLN
MINIDOKA
CARIBOU
JEROME
POWER
BANNOCK
OWYHEE
CASSIA
ONEIDA
BEAR LAKE
TWIN FALLS
FRANKLIN

Rural Electrification Development in Idaho

By

HOBART BERESFORD[1]

The Progress of Rural Electrification in Idaho

The extensive use of electrical energy for irrigation pumping has made possible the early construction and wide penetration of Idaho's pioneer rural distribution lines. As early as 1925 the first report of the Idaho Committee[2] showed a total of 7,006 rural customers served by 1,259 miles of rural distribution lines. The past six years have shown a rapid increase in the use of electricity not only in the number of farms making use of central station service, but also in the increased application of electricity to agricultural production and to the convenience and comforts of rural living.

The chief source of electric power in Idaho is from water power developments, the majority of which are primarily used for irrigation purposes. According to the data compiled by the Boise office of the United States Geological Survey there are a total of 356,780 horsepower available from hydro-electric installations within the state. The stream from which it is supplied, the field number, the county, the location of the power plant, the installed capacity of the water wheels and generators, the head under which the water wheels operate, and the ownership of the installation are given in the tabulation on pages 6-10.

The potential power resources of Idaho are relatively large when compared to the present development. According to the United States Geological Survey, which at various times has published estimates on the water power resources of the United States by states, Idaho had on January 1, 1931, a total of 356,780 horsepower of installed water wheels. According to the estimates for the same date there are available, from the major streams which have been surveyed, a potential horsepower of between 2,190,500 horsepower and 3,770,800 horsepower based on the present flow and at 70 per cent efficiency for the installations. A table of estimates of horsepower available has been made for the Snake, Payette, Salmon, Clearwater, and Boise rivers. This estimate is given for the power development, with the present and with the regulated flow of the streams, available at 90 per cent, and 50 per cent of the time based on the over-all efficiency of 70 per cent.

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[1]Hobart Beresford, Agricultural Engineer for the Agricultural Experiment Station and Secretary and Project Director of the Idaho Committee on the Relation of Electricity to Agriculture.

[2]Progress Report of the Idaho Committee on the Relation of Electricity to Agriculture. May, 1926. M. R. Lewis, Secretary.

LIST OF WATER POWER DEVELOPMENTS IN IDAHO
(Compiled as of January 1, 1931, by the Boise office, United States Geological Survey)

STREAM	Field No. Idaho	County	Location of Power Plant	Installed Capacity: Water Wheels	Installed Capacity: Generators	Head, Forebay to Tailrace	Ownership
				H.P.	K.V.A.	Feet	
Bear River	38A	Bannock	(Old Grace plant) SW¼ sec. 21, T. 10 S., R. 40 E.	17,000	14,000	519	Utah Power & Light Co.
Bear River	38B	Bannock	(New Grace plant adj. old plant) SW¼ sec. 21, T. 10 S., R. 40 E.	49,500	36,666	525	Utah Power & Light Co.
Bear River	43	Franklin	NE¼ sec. 26, T. 13 S., R. 40 E. (Oneida plant)	45,000	33,510	145	Utah Power & Light Co.
Bear River	44	Bannock	(Cove plant) SW¼ NW¼ sec. 33, T. 10 S., R. 40 E.	10,500	8,333	94	Utah Power & Light Co.
Bear River	49	Caribou	(Soda plant) sec. 18, T. 9 S., R. 41 E.	20,000	About 15,000	80	Utah Power & Light Co.
Big Boulder Creek	53	Custer	NE¼ sec. 15, T. 9 N., R. 17 E.	450	300	380	Livingston Mines Corp'n.
Big Wood River	13	Blaine	(Bellevue plant) NE¼ sec. 26, T. 2 N., R. 18 E.	1,000	600	37	Peoples West Coast Hydro-Electric Corp'n.
Big Wood River	12	Blaine	(Hailey plant) SW¼ sec. 9, T. 2 N., R. 18 E.	400	400	24	Peoples West Coast Hydro-Electric Corp'n.
Big Wood River	18	Gooding	(Malad plant) NW¼ sec. 34, T. 6 S., R. 13 E.	7,500	5,500	125	Idaho Power Company
Birch Creek	9	Oneida	NW¼ SE¼ sec. 28, T. 12 S., R. 36 E.	360	250	510	Western States Utilities Co.
Boise River	17	Ada	(Barber plant) NW¼ sec. 32, T. 3 N., R. 3 E.	1,500	900	28	Operated by Western L. & P. Co. for Boise Payette Lumber Co.
Boise River	22	Ada	(Diversion Dam—Boise Project) SW¼ sec. 3, T. 2 N., R. 3 E.	3,000	[1]1,875	28	U.S. Bureau of Reclamation
Middle Fork Boise River	5	Elmore	On unsurveyed land 1½ miles east of Atlanta, Idaho	150	About 145	49	H. B. McGown
Canyon Creek	8	Shoshone	T. 48 N., R. 5 E.	160	100	?	Canyon Light & Water Co.

Cedar Creek	27	Custer	SW¼ sec. 2, T. 7 N., R. 24 E.	220	100	280	Mackay Light & Power Co.
Clearwater River	57	Nez Perce	SE¼ SW¼ sec. 28, T. 36 N., R. 5 W.	14,000	12,500	36	Inland Power & Light Co.
So. Fork Clearwater River	11	Idaho	(Grangeville plant) NE¼ sec. 30, T. 30 N., R. 4 E.	1,100	624	58-60	Inland Power & Light Co.
So. Fork Clearwater River	25	Idaho	NW¼ NE¼ sec. 6, T. 32 N., R. 4 E.	102	36	10	Kooskia Milling Co.
Cub River	39	Franklin	(High Creek plant) SW¼ sec. 34, T. 15 S., R. 40 E.	1,000	700	227	Utah Power & Light Co.
Deadwood River	59	Valley	NW¼ sec. 1, T. 13 N., R. 7 E.	425	375	200	Bunker Hill & Sullivan Mining Co.
Elk Creek	50	Idaho	Lot 4, sec. 15, T. 21 N., R. 7 E.	440	[2]400	430	Unity Gold Mines Co.
Georgetown Creek	37	Bear Lake	(Georgetown plant) SW¼ sec. 4, T. 11 S., R. 44 E.	300	225	159	Utah Power & Light Co.
Gold Run, East and Main Alder, and Tiger Creeks	3	Shoshone	Approx. sec. 6, T. 49 N., R. 5 E.	30	30	150	Adam Aulbach
Henrys Fork	2	Fremont	(Ashton plant) secs. 27 and 28, T. 9 N., R. 42 E.	9,150	5,800	46	Utah Power & Light Co. (Lease from F. A. Reid)
Henrys Fork	42	Fremont	(St. Anthony plant) SW¼ NE¼ sec. 1, T. 7 N., R. 40 E.	750	625	16-18	Utah Power & Light Co.
Kelly Creek	4	Shoshone	Sec. 15, T. 45 N., R. 5 E.	11	15	180	Avery Electric Light Plant
Lemhi River	33	Lemhi	(Upper plant) SE¼ sec. 5, T. 21 N., R. 22 E.	[3]250	200	17	Salmon River Power & Light Co.
Lemhi River	34	Lemhi	(Lower plant) NW¼ sec.5, T. 21 N., R. 22 E.	About 1,100	700	37	Salmon River Power & Light Co.
Lolo Creek[4]	10	Idaho	(Lolo plant) SE¼ sec. 14, T. 35 N., R. 2 E.	250	150	27	Inland Power & Light Co.
Meadow Creek[5]	60	Valley	(Meadow Creek plant) About SE¼ sec. 15, T. 18 N., R. 9 E.	100	75	420	United Mercury Mines Co.
Mill Creek	29	Shoshone	NW¼ sec. 34, T. 48 N., R. 5 E.	65	50	250	Mullan Light Co.

[1]About one-half power output furnished to Idaho Power Company for use of transmission lines in furnishing Minidoka Project with power.
[2]One 200-K.V.A. generator only in operation.
[3]Not in use.
[4]Abandoned in 1930; not included in the total.
[5]Added 1930.

LIST OF WATER POWER DEVELOPMENTS IN IDAHO (Continued)

STREAM	Field No. Idaho	County	Location of Power Plant	*Installed Capacity* Water Wheels	Generators	Head, Forebay to Tailrace	Ownership
				H.P.	K.V.A.	Feet	
Moyie River	6A	Boundary	NW¼ NW¼ sec. 14, T. 62 N., R. 2 E.	550	478	78	Village of Bonners Ferry, Idaho
Myrtle Creek[6]	6	Boundary	About sec. 19, 20, T. 62 N., R. 1 E.	250	150	250	Village of Bonners Ferry, Idaho
Payette River	16	Boise	(Horseshoe Bend plant) NW ¼ sec. 32, T. 7 N , R. 2 E.	3,300	1,500	24-36	Idaho Power Company
Payette River	54	Gem	Sec. 22, T. 7 N., R. 1 W.	14,200	10,000	85-92	U.S. Bureau of Reclamation
Lake Fork Payette River	55	Valley	NW¼ sec. 8, T. 18 N., R. 4 E.	250	38	52	T. E. Bennett, McCall, Idaho
North Fork Payette River	56	Valley	NW¼ sec. 25, T. 14 N., R. 3 E.	410	375	30	Peoples West Coast Hydro-Electric Corp'n.
South Fork Payette River	7	Boise	NE¼ sec. 9, T. 8 N., R. 5 E.	2,100	[7]1,530	40	Grimes Pass Power Co.
Paris Creek	41	Bear Lake	(Paris plant) SW¼ sec. 9, T. 14 S., R. 43 E.	1,180	800	390	Utah Power & Light Co.
Placer Creek	32	Shoshone	NE¼ sec. 34, T. 48 N., R. 4 E.	345	300	310-145	Northwest Light & Water Company
Potlatch River	24	Latah	NE¼ sec. 30, T. 37 N., R. 3 W.	[8]45	25	22	Juliaette Milling Co.
Rush Creek	1	Washington	SW¼ sec. 27, T. 16 N., R. 3 W.	310	200	520	Peoples West Coast Hydro-Electric Corp'n.
Portneuf River	40	Bannock	(McCammon plant) SW¼ NE¼ sec. 12, T. 9 S., R. 36 E.	[9]80	[9]60	12	Utah Power & Light Co.
East Fork South Fork Salmon River[9]	61	Valley	(Sugar Creek plant) About SE¼ sec. 34, T. 19 N., R. 9 E.	450	525	512	United Mercury Mines Co.
Snake River	20A	Power	(American Falls East Side plant) NE¼ sec. 31, T. 7 S., R. 31 E.	[10]41,500	[10]33,750	42-48.5	Idaho Power Company

Snake River	20B	Power	(American Falls Island plant) SE¼ sec. 30, T. 7 S., R. 31 E.	[11]2,000	[11]1,040	30-36	U.S. Bureau of Reclamation
Snake River	20C	Power	(American Falls West Side plant) NE¼ sec. 31, T. 7 S., R. 31 E.	[12]1,350	[12]500	42-48	U.S. Bureau of Reclamation
Snake River	30	Bonneville	NE¼ sec. 24, T. 2 N., R. 37 E.	3,200	1,800	18-22	Municipal Electric Plant, Idaho Falls
Snake River	58	Bonneville	Sec. 36, T. 3 N., R. 37 E.	1,800	1,500	21½	Municipal Electric Plant, Idaho Falls
Snake River	36	Bonneville	(Idaho Falls plant) SE¼ sec. 25, T. 2 N., R. 37 E.	3,400	2,400	14-18	Utah Power & Light Co.
Snake River	35	Bingham	(Shelley plant) SE¼ sec. 36, T. 1 N., R. 37 E.	350	250	40	Utah Power & Light Co.
Snake River	47	Minidoka	(Minidoka plant) NW¼ sec. 1, T. 9 S., R. 25 E.	13,500	10,000	48-49	U.S. Bureau of Reclamation
Snake River	14	Jerome	(Shoshone Falls plant) Lot 5, sec. 36, T. 9 S., R. 17 E.	16,500	12,600	200-206	Idaho Power Company
Snake River	15	Gooding	(Lower Salmon Falls plant) SW¼ sec. 2, T. 7 S., R. 13 E.	11,400	7,600	31-37	Idaho Power Company
Snake River	21	Owyhee-Ada	(Swan Falls plant) SE¼ sec. 18, T. 2 S., R. 1 E.	13,460	11,320	18-23.5	Idaho Power Company
Snake River	23	Baker, Ore.	(Oxbow plant) NW¼ sec. 9, T. 7 S., R. 48 E., W.M.	[13]12,400	[13]3,600	17-20	Idaho Power Company
Thousand Springs on Snake River	19	Gooding	(Thousand Springs plant) SW¼ sec. 8, T. 8 S., R. 14 E.	11,700	10,000	179-182	Idaho Power Company
Soda Springs Creek	31	Caribou	SW¼ sec. 6, T. 9 S., R. 42 E.	250	150	37	Municipal Electric Plant, Soda Springs

[6]Not used continuously; supplements Moyie River plant.
[7]Plant burned in 1923; one 500-K.W. generator unit reinstalled; no change to water wheel equipment previously in use. New units installed in April, 1928.
[8]Not in use.
[9]Added 1930.
[10]In June, 1927, installation was completed, comprising two new units—2 turbines of 9,000-H.P. each and two generators at 7,500-K.V.A. each.
[11]Used only for emergency purposes since 1927, and finally abandoned in 1930. Not included in total.
[12]Used only for emergency purposes since 1927.
[13]Rated capacity for 50-foot head; plant used as condenser large part of time.

LIST OF WATER POWER DEVELOPMENTS IN IDAHO (Continued)

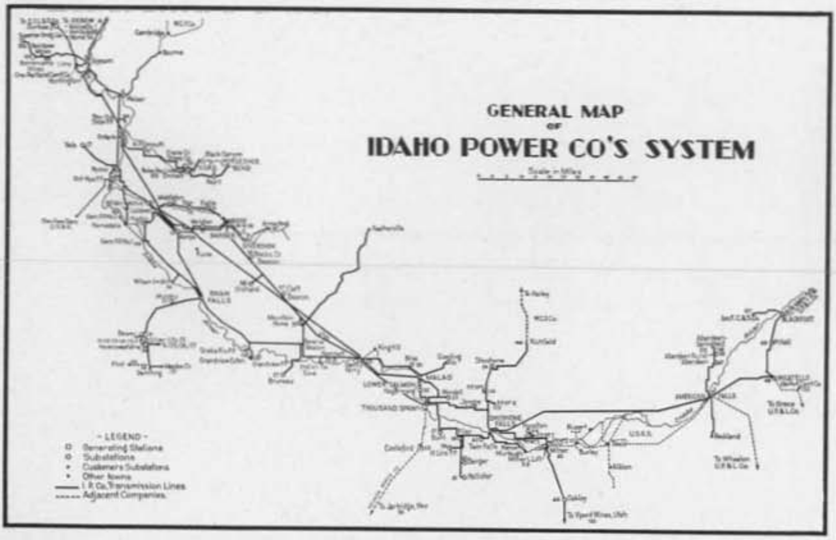
STREAM	Field No. Idaho	County	Location of Power Plant	*Installed Capacity* Water Wheels	Generators	Head, Forebay to Tailrace	Ownership
				H.P.	K.V.A.	Feet	
Spokane River	45	Kootenai	(Post Falls plant) SE¼ NE¼ sec. 4, T. 50 N., R. 5 W.	16,300	11,250	52	Washington Water Power Company
Stratton Creek	52	Valley	On unsurveyed land in about sec. 11, T. 13 N., R. 7 E.	200	About 185	508	Bunker Hill & Sullivan Mining Co.
Teton Creek	48	Lincoln (Wyo.)	Near Driggs, Idaho, T. 44 N., 118 W., 6th P. M. (plant in Wyoming)	252	150	140	Teton Valley Power & Milling Company
Warren Creek	51	Idaho	1 mile above Warren, Ida., T. 22 N., R. 6 E.	160	[14]150	195	Unity Gold Mines Co.
Whitebird Creek	46	Idaho	Sec. 14, T. 28 N., R. 1 E.	25	25	55	W. C. Hill
				356,780	263,245		

[14]Operated only in case of emergency.

POTENTIAL WATER POWER AVAILABLE FROM THE MAJOR STREAMS IN IDAHO[1]

Stream	*Horsepower at 70% efficiency* With Present Flow 90% Time	With Present Flow 50% Time	With Regulated Flow 90% Time	With Regulated Flow 50% Time
Snake River between Milner and Weiser	250,700	724,100	260,700	276,350
Snake River between Huntington and Lewiston	919,000	1,510,000	800,000	1,130,000
Payette River and tributaries	118,200	193,000	315,000	328,000
Salmon River, Stanley to Salmon	83,900	114,000	119,000	175,000
Salmon River, Salmon to mouth	590,500	778,600	685,400	872,800
Clearwater River Basin (40 sites only)	184,000	379,000		
Boise River Basin	44,200	72,100	55,400	83,900
	2,190,500	3,770,800	2,180,100	2,866,050

The following maps show the major power companies supplying service to the agricultural areas in Idaho.

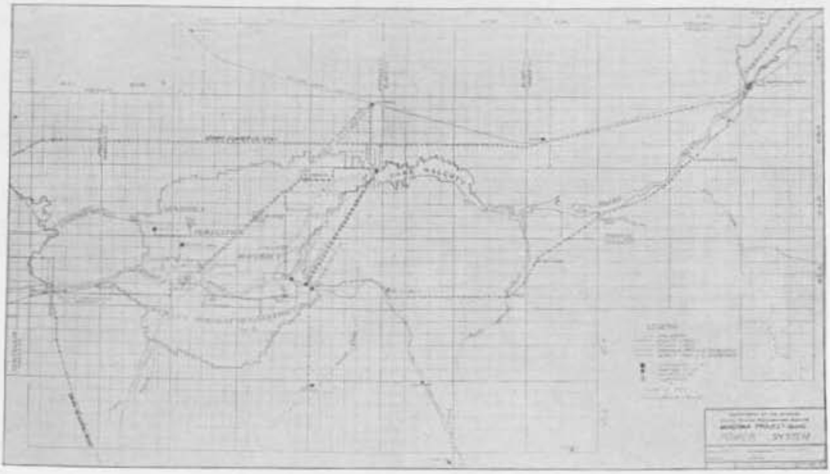


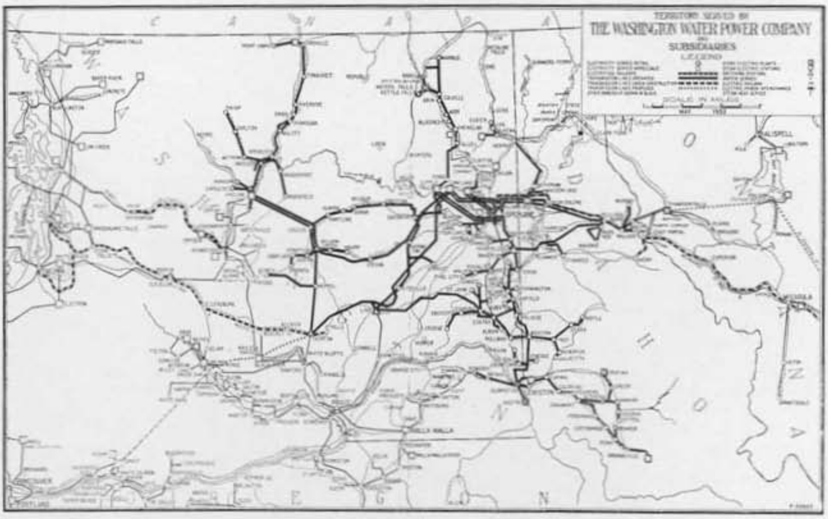
The total potential water power that will eventually be available in Idaho has not been definitely determined. It is entirely possible that between four and five million horsepower, available 50 per cent of the time, will be the ultimate figure reached when all the data on the streams throughout the state have been collected. In addition to the tabulated estimates which appear above, the Boise office of the Geological Survey reports that, "The Middle and South Forks of Salmon River have been surveyed but power and utilization reports for these streams have not been completed as yet."[2]

[1] Data furnished by the Boise office, United States Geological Survey, November 5, 1930.

[2] C. G. Paulsen, District Engineer, Boise office, United States Geological Survey, November 5, 1930.

The major rural electrification development in Idaho is located in the irrigated sections of the state, served by three inter-connected hydro-electric systems: namely, the Idaho Power Company, the Utah





Power and Light Company, and the Minidoka Irrigation Project of the Bureau of Reclamation. The development and sale of electric power from the hydro-electric plants on the Minidoka Project are incidental to the generation and use of electric power for irrigation. The farms on the Project receive their service from a group of mutual companies, who buy electric power at wholesale from the Bureau of Reclamation. In the northern part of the state a comparatively small area is served by the Washington Water Power Company and the

Pacific Power and Light Company, the Idaho property of the latter company having been transferred recently to the management of the Washington Water Power Company. In addition to the three major power companies and the Bureau of Reclamation properties there are nine minor companies included in the survey data compiled on page 15.

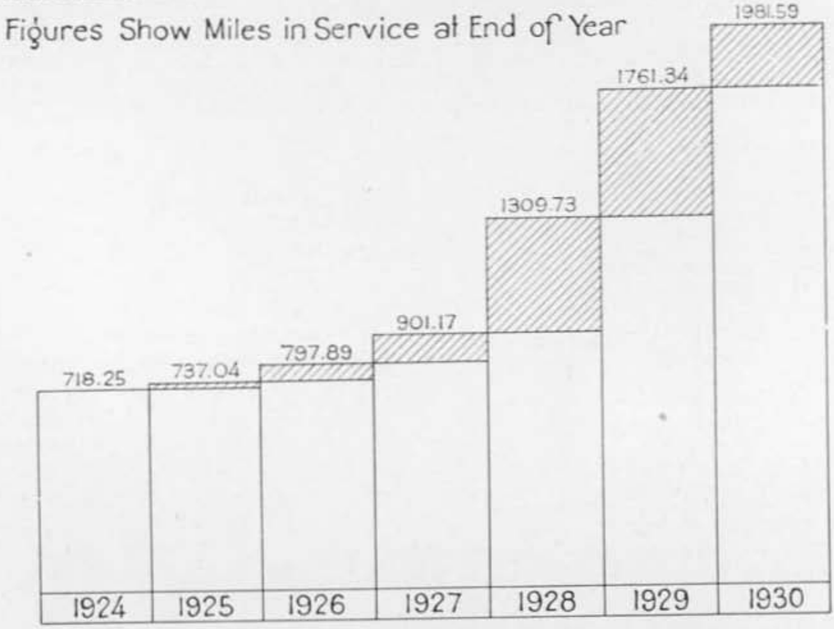
The generator capacity of the major public utilities operating in Idaho totals 221,250 K.V.A. in hydro-electric plants, and in addition there are 2,050 K.V.A. in steam plants and 4,750 K.V.A. in diesel or combination plants.[1]

During the period 1925 to 1931 the extension of rural lines has been confined chiefly to the irrigated area. A summary of the data secured from the companies mentioned above shows a total of 16,354 rural customers served by 3,010.974 miles of rural line. A reclassification of what constitutes a farm or other rural customer has decreased the total number of farms as previously reported by some of the companies. It has been recommended that all of the power companies use the United States Bureau of Census definition of a farm for the classification of their farm and other rural customers. This definition has been adopted by the National Electric Light Association and every effort has been made to secure this classification for the data reported from the various power companies in Idaho. The United States Bureau of Census definition of a farm is given as follows, "A farm is any tract of land three or more acres used mainly to produce agricultural products, or any place of three acres or less, where the owner or tenant devotes his entire time thereon to agriculture. Poultry and game raising, floriculture and horticulture, and similar pursuits fall within this classification." The National Electric Light Association has expressed further, "Farm service shall include all electrical service for lighting, heating, power, etc., used on farms as farms are defined by the United States Census Bureau, where such farms are located without the corporate limits of a corporate city, town, or village. The service to farms for irrigation where such service supplies electricity for pumping for the individual farm, will be considered as farm service. However, where an irrigation company or community pumping plant receives electrical service to furnish irriga-

[1] Electrical West, Volume 66, No. 2. February 1, 1931 (Record and Forecast, page 57).

tion water to more than one farm, such service will be considered as industrial irrigation service and be classified under the heading, 'Industrial Service'."

On the basis of the data reported above, during the past six years the number of rural customers receiving electric service has been doubled. In addition to the number of farms receiving central station electric service in Idaho, the power companies have reported other rural customers which have been grouped separately and in the final totals, for the purpose of showing the influence of all types of rural service on rural electrification progress resulting from the various uses of electricity in rural communities.



TOTAL MILES OF RURAL LINE IN SERVICE and Additions by Years

Courtesy of the Commercial Department, Idaho Power Company.

According to the latest census data[1] there are, in the regions within the state served by the power companies which maintain rural service lines, 30,000 farm units. On the basis of the number of farm units in these areas 43.7 per cent of the farms received electric service as of January 1, 1931. On the basis of the total number of farm units in the state[2] this is decreased to 31.4 per cent.

Of the total number of rural customers served in Idaho by the Idaho Power Company 7,637 come under the classification of farms according to the United States Bureau of Census and 3,072 fall under the classification of "other rural customers," the majority of which are residences

[1] Estimates based on the October 15, 1930, Preliminary Press Release, United States Bureau of Census.
[2] 41,678 total farms in Idaho. Preliminary Press Release, United States Bureau of Census, October 15, 1930.

not within corporate limits. The extension of rural service by this company is shown graphically on page 14, with the total number of miles of rural lines in service from 1924 to 1931 and the addition by years for the included period. This graph and the figures include the miles of line in service at the end of each succeeding year, including in the total of 1,981.59 miles, 207.31 miles of line located in eastern Oregon.

The kilowatt hour consumption of the Idaho farm customers of the Idaho Power Company for the past two years shows an increase of 237 kilowatt hours per customer.

IDAHO POWER COMPANY[1]

(Idaho farms exclusive of medium and high voltage power and irrigation)

Year	*Number of Customers*	*Yearly K.W.H. Consumption*
1930	7,187	1,747
1929	5,872	1,510
INCREASE	1,315 customers	237 K.W.H.

SURVEY DATA

FARM AND RURAL CUSTOMERS IN IDAHO

January 1, 1931

Company and Address	*Farm Customers*	*Other Rural Customers*	*Total Rural Customers*	*Miles of Rural Lines*
1. Canyon Light & Water Co., Burke, Idaho	5		5	3.5
2. Idaho Falls Municipal Plant, Idaho Falls, Idaho	61		61	
3. Idaho Power Company, Boise, Idaho	7,637	3,072	10,709	1,774.28
4. McCall Light & Power Co., McCall, Idaho	1		1	
5. Meadows Light & Power Co., Meadows, Idaho	7		7	2.75
6. Minidoka Project, Burley, Idaho	1,188	90	1,278	302
7. Mountain States Power Co., Sandpoint, Idaho	110		110	20
8. Murtaugh Light & Power Co., Burley, Idaho	62		62	20
9. Northwest Light & Power Co., Spokane, Washington	18		18	3.50
10. Salmon River Power & Light Co., Salmon, Idaho	17	16	33	1.444
11. Teton Valley Power & Milling Co., Driggs, Idaho	111		111	24
12. Utah Power & Light Co., Salt Lake City, Utah	3,228		3,228	727
13. Washington Water Power Co., Spokane, Washington	681	50	731	132.50
	13,126	3,228	16,354	3,010.974

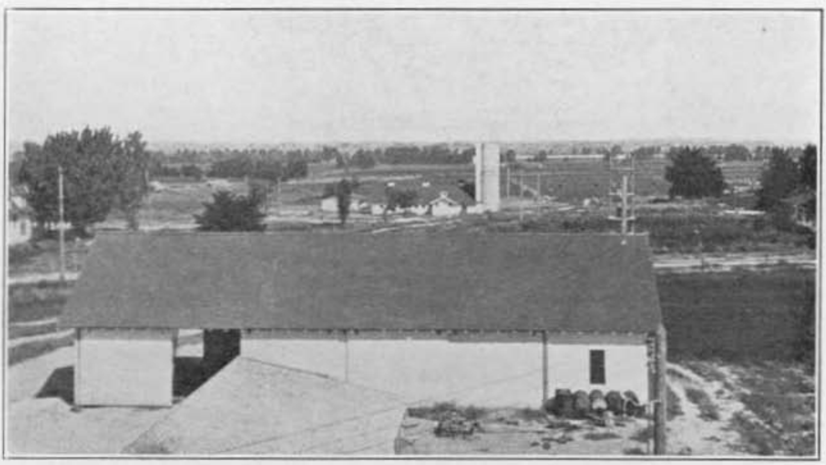
The acceptance of rural electrification by the farmer in Idaho is one of the indications of progress in agriculture in this state. Under the

[1]Courtesy of the Commercial Department, Idaho Power Company.

irrigation development, which includes 55 per cent of the agricultural land, the size of the farm unit has been influenced by the limited number of acres that could be handled by one irrigator. Electrifying the small irrigated farm promises to meet the competition of mass production made possible by the use of power machinery and larger field units found in other systems of farming.

The Idaho Rural Electrification Project

It has been the purpose of the Idaho Committee on the Relation of Electricity to Agriculture to cooperate with the College of Agriculture through its Experiment Station in an endeavor to determine the facts concerning the beneficial use of electricity for the development of the agricultural industry of the state. In June, 1925, the executive committee adopted a plan for the study of electricity as used on Idaho farms at that time. The data reported by this study give a basis for the measure of progress made in electrifying Idaho farms during the past six years. In August, 1926, plans for the demonstration and investigation of the use of electricity in agriculture were completed in the establishment of the Idaho Rural Electrification Project at the Caldwell Substation farm of the Agricultural Experiment Station. The farm, which has a total of 320 acres, is devoted to the study of various agricultural problems as they affect irrigation farming in southern Idaho, including experimental research projects in animal feeding, dairy production, and crop raising.



View of the Caldwell Substation Farm of the Idaho Agricultural Experiment Station

The Rural Electrification Project was planned originally to operate for three years and has played an important part in promoting statewide progress and in centering attention on rural electrification in Idaho. Equipment not anticipated in the first plans has been added and many of the projects increased in their scope. In addition to special tests of various types of equipment, the energy consumption and service rendered has been reported each month throughout the three-year period.

By the end of 1926 little progress had been made, due to the time required to secure the cooperation of the manufacturers of the electrically operated equipment being studied. Before the installations of electrical equipment were made, records were kept on the manual labor required for the operation of the dairy unit with the intention of comparing the data thus obtained with the operation of the same dairy under fully electrified conditions. The results of this study revealed that the use of the milking machine on a 20-cow herd saved 53½ hours of man labor per cow per year. The use of electricity in the dairy has included the design and construction of various types of dairy refrigerators and tests of the operation of electric sterilizers, motor-driven separators, and milking machines. The influence of mechanical equipment on the distribution of labor in dairy production has revealed the significance of electric service to the dairy farmer.

Farm power studies were made on a 10-horsepower motor applied to the feed grinding and silo filling work. The 10-horsepower motor proved to be larger than could be operated economically under average farm conditions and was replaced with a 5-horsepower portable motor which was entirely satisfactory for operating the various equipment. However, owing to the experimental work being done it has been found that a 7½-horsepower motor produces a more desirable distribution of labor and for that reason the 7½-horsepower unit has been selected as a satisfactory size for farms using power requirements similar to the Caldwell Substation.

The electric motor has been used for general belt power for grinding feed, filling silo, and hoisting hay. During the 1929 test of the 5- and 7½-horsepower motors for silo filling power, the importance of crew organization and management when small power units are used was strongly emphasized. Detailed study of the labor distribution, made by means of service recorder clocks located on the haulers' wagons, showed that when four teams were used the haulers were idle 3.12 minutes per ton; when five teams were used, they were idle 31.7 minutes per ton, and when six teams were used 51.7 minutes were lost. With a 7½-horsepower motor, silage was elevated 38 feet at the rate of 4.37 tons per hour. Under these conditions it required .97 kilowatt hours per ton.

The 5-horsepower motor was used for operating a mechanical hay hoist rigged to a boom derrick. The disadvantage of the electric hay hoist is found in the difficulty in moving wiring connections about the stack yard. This could be corrected by a well-planned underground distribution system.

Electric feed grinding has been one of the most satisfactory applications of this form of power to the belt-driven equipment. The feed grinding and hay chopping work is carried on in cooperation with the lamb and steer feeding experimental work conducted at the Station.

On the Caldwell Substation farm there are three residences, occupied by the superintendent, the dairy herdsman, and the farm irrigator.

These homes were included in the project and equipped with electric ranges, refrigerators, and various mechanical aids.

The laundry equipment was installed in a centrally located building and used by the three families on the station farm. Electric water heating was provided in the laundry unit and the residence of the superintendent.

Orchard Avenue Pumping Plant—No. 1 of the Pioneer Irrigation District

A study of the cost and effectiveness of pumping for drainage in the Boise valley has been one of the major cooperative projects of the Experiment Station and the Idaho Committee on the Relation of Electricity to Agriculture. Records of the water table secured from one hundred observation wells located in the territory drained by five deep well pumping outfits, have been kept during the irrigation season. Under certain conditions drainage by pumping has been very effective. Due to the shortage of storage water, the supplemental irrigation water resulting from the pumping has proved of special importance.

It is difficult to estimate just what influence the rural electrification project at the Caldwell Substation farm has had on directing the interest of our farmers to a widened distribution and increased use of electrical energy in agricultural production. The demonstrations and experimental work have, however, established the Caldwell Substation farm as a source of authentic and valuable information.

Electricity on the Farm

Wiring the Farm for Electric Light and Power Service

The first problem to be considered in the electrification of the Caldwell Substation was the planning and installing of the distribution system and the wiring of the three residences and the several farm buildings. The wiring job on the Substation farm is similar to the needs of farm wiring in general and the principles involved may be applied with modification to the individual farm. The first information required before the selection of the plans for the wiring system could be made was the present and anticipated use of electrical energy.

The farm residences and agricultural production units were considered individually and the total load estimated at approximately 40,000 watts. Due to the diversity of use of the various applications it was decided that 20-K.V.A., 2300-volt to 220-110-volt transformer would be adequate for the service required. The transformer was located on a two-pole rack at the edge of the roadway from which two main feeders of number four copper wire were run; one to the dairy unit, dead-ending at the concrete silo, and one to the feeding unit, dead-ending at the concrete silo which is located near the granary. The practice of dead-ending distribution lines on farm buildings is not recommended and was used only in view of the fact that the concrete silos were used for replacing two poles and the necessary guy wires, and are permanent fire-proof structures which permitted a reduction in the cost of the distribution system.

In spacing the poles the layout of the farmyard and the location of the buildings were considered. Whenever possible the poles were located on or near the fence lines or in the fence corners. The span between poles was kept between 175 and 200 feet, depending upon the convenience of the pole location. The branch circuits of the distribution system were constructed of number six and number ten wire. The circuit, supplying the power outlet and the lights in the feed yard, was made a three-conductor type to supply 220 volts for the motor and 110 volts for the lights. It would have been possible to reduce the cost of this circuit by using 220-volt light units, but the inconvenience of maintaining the yard lights at two voltages was believed to offset the additional expense of installation.

The load center, which is the position in the distribution system at which the average connected load would be located, is usually the most desirable location for the farm distribution panel. However, in locating the distribution panel on a farm, the convenience, safety, and permanence of the location should always be considered. In case of fire it would be desirable to have the service to the farm water supply independent of all of the farm buildings. This may be accomplished by utilizing the pump house for the location of the distribution panel, which should be housed in a fire-proof structure. In determining the load center, the connected load in watts is multiplied by the distance from the outlet to the transformer and the sum of the product thus secured is divided by the total number of feet of wiring required for the distribution. The value secured from this division gives the theoretical center which should be varied within reasonable limits to provide for the convenience and safety feature mentioned above.

A sketch of the floor plan for each building was made and the problem of wiring that building considered individually. The first question to decide was the approximate location of all of the lights, switches, convenience and power outlets. The selection of the type of wiring system included a consideration of the permanence and value of the buildings, the effect of the different methods of wiring on insurance rates, the service life, the utility of the system, and the original and upkeep cost. The location of the distribution panel for each building was determined by the convenience of the approach of the service to the building and the relation of the distribution panel to the working habits of the farm operators.

Although each residence and farm building proved to be an individual wiring problem, the general wiring scheme considered was the combination of the knob and tube tap system, supplemented with armored cable and flexible and rigid conduit. The use of flexible conduit and armored cable made it possible to run the circuits between partitions of the frame buildings, and the use of split knobs and tubes lowered the total cost of the wiring by allowing open work in the attics of the residences and in protected places in the farm buildings. The conduit system of wiring was used in the cellars, the laundry, the well house pump room, the milk house, and the barns, and for installations where the wires were unprotected or where they might be injured by the livestock or moving equipment.

The armored cable-type conductor was used in the granary, which was wired after the original wiring system was installed. It has been found that with the use of armored BX cable the reduction of the labor requirement for the installation tends to offset the difference in cost between the armored cable and the open type of wiring.

The wiring needs of each building were determined and the type of wiring selected; after which schedules of labor and material costs were obtained from reliable electrical dealers and contract bids for the complete wiring job were secured. The final contract was let with the reserve for the Experiment Station to purchase any of the required material they saw fit.

The residence lighting is provided by centrally located cluster fixtures

It is a good practice to confer with your electrical dealer when making your plans and thus take advantage of his experience in the selection of materials and his advice as to the proper installation of same.

The detailed plans of the circuits were not used for wiring the buildings. The electrician was informed as to the location of the outlets and was required to plan and lay out his own circuit. This method is usually the most satisfactory because of unforeseen difficulties encountered in trying to wire buildings on which the construction has been completed.

The size of the wire for the various loads should be specified and the location of the meter and distribution panel should be determined before the work of the wiring begins.

The service entrance to the residence was made through a weatherproof entrance fitting and the conduit located as close as possible to the distribution panel on the back porch. There are two main reasons for making the service entrance near the back porch; the first being the convenience and the economy in bringing the service to the distribution panel, and the second being the ease in which the circuits may be distributed from this position and the fact that the kitchen is usually near this location, which means that the most economical range or water heater circuit can be installed.

For lighting the farm buildings steel enameled reflectors were used

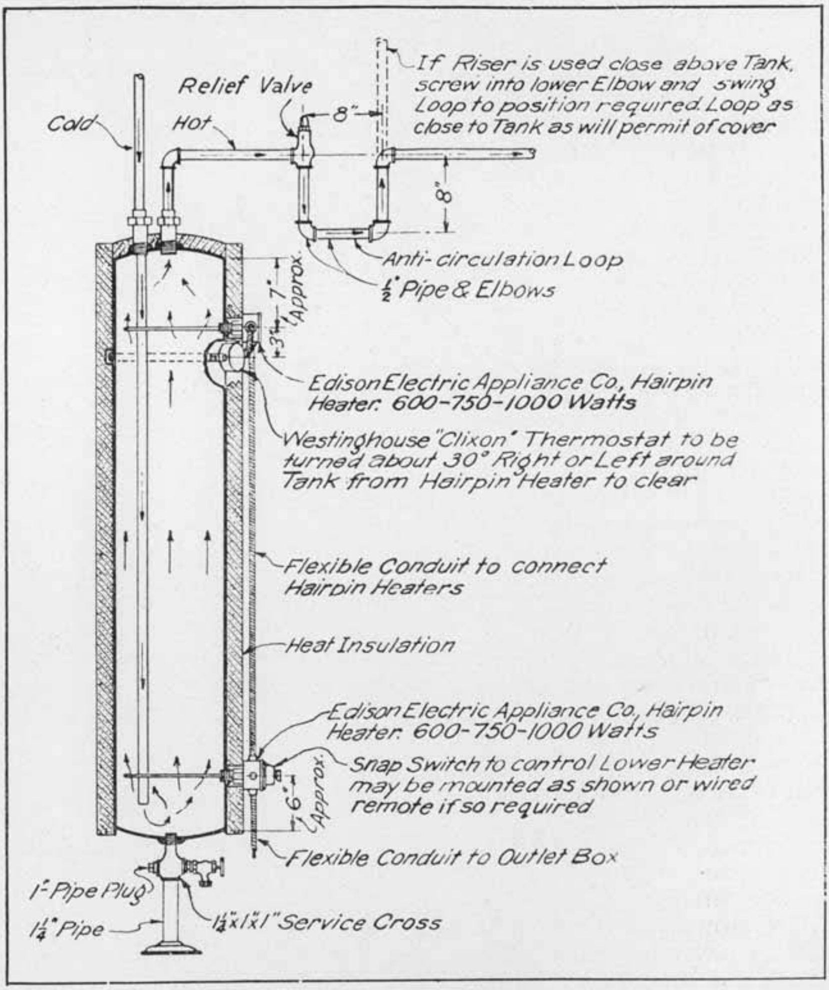
The three residences were wired with outlets for electric ranges, and service circuits were run for convenience outlets in all of the main rooms. The light circuits were provided with centrally located ceiling outlets for the fixtures, with wall switches controlling the most frequently used lights in at least two positions. (Three-way switches.)

The exposed power outlets are provided in weather-proof fittings

Steel enameled reflectors, known as R.L.M. type, were used on all of the light outlets in the farm buildings, and were located at the points of greatest convenience, depending upon the individual conditions. In general the lights were located symmetrically, and the distance between the units was kept approximately one and one-half times the height of the unit above the plane of work. A deep bowl steel reflector unit was placed at the top of the silo by means of conduit wiring, which included a switch located at the foot of the ladder.

Another feature of the wiring system is the yard lights which are located on the distribution system poles and controlled by switches located at convenient points of the chore route. Power outlets were provided for at the agricultural production units and the farm shop and granary. Whenever the outlets were located in an exposed position weather-proof fittings were used. All of the power outlets were supplied with 220-volt service and were 60-ampere capacity, which permitted the use of motors up to ten horsepower.

Every effort was made to keep the cost of the wiring low without sacrificing the quality of the materials, the workmanship, and the convenience and utility of the installations. The cost for the inside wiring averaged \$3.50 per outlet. The outside work averaged \$4.50 per outlet. This cost was increased due to the weather-proof power outlets previously mentioned.



Type of water heater installation selected for the laundry and dairy unit at the Caldwell Substation farm

ELECTRICITY IN THE FARM HOME

The use of electrical energy instead of human energy for doing the household work has resulted in a marked increase in the amount of equipment made applicable to the work of the housewife. The best type of equipment and its efficient utilization are factors which have warranted a study along these lines.

The washing and ironing on the farm constitutes one of the major household jobs and offers an excellent opportunity for reducing manual labor by mechanical and electrical aids. The Caldwell Substation farm is completely electrified and offers electric service to the wives of the farm employees. The washing and ironing equipment is centralized in a small building, and enables the equipment to be used by all three of the families residing on the farm. The operating time is thus increased to three times the normal operating period of the ordinary family washing and ironing equipment.

The most important development noted in this study is the adoption of a low wattage water heater and an insulated tank cover. Due to a change in the power company's policy with regard to the water heating service, an attempt was made to install equipment which would take advantage of a low rate and at the same time aid in giving better service to customers using electric ranges, without increasing the size of installation or distribution lines.

During the summer of 1929 a five-kilowatt circulating type water heater was replaced by two one-kilowatt immersion type water heating elements and the tank was insulated with a standard paper composition tank cover. One element was located in the top portion of the tank, and the other element in the lower section of the tank. Two "clix-on" type thermostats were used to hold the temperature of each element at 160° F.

Comparing the same periods of time, July, August, September, and October of 1928 and 1929, the new water heating installation has reduced the energy consumption to 61 per cent of that required when the five-kilowatt circulation type water heater and the non-insulated tank were in use. It has been difficult to determine the percentage of the saving attributed to the new heaters and the insulated tank. It is believed that both changes helped to reduce the energy consumption, due to the conservation of heat by the tank cover and the elimination of waste hot water.

The energy consumption of the heaters has varied between a minimum of 37 kilowatt hours and a maximum of 108 kilowatt hours per month during the three years' operation of the laundry equipment. The average for the period has been 73.6 kilowatt hours per month, during which time the three residences of the farm were occupied by fourteen persons.

The electric washing machine probably saves more time and effort with less consumption of electrical energy than any other appliance used by the housewife. The laundry is equipped with a popular make of a family size washer consisting of a corrugated tub fitted with a top agitator and a conventional type of rubber roll wringer. A study of the operation of this machine has shown that the pounds of clothes

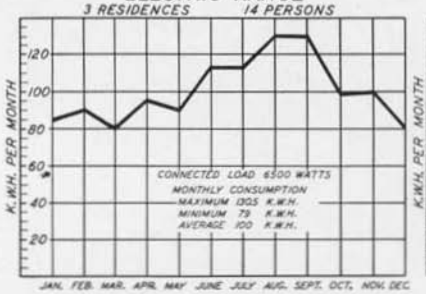
Electricity on the Farm

Three-year average — 1927-1928-1929 — Caldwell Substation farm

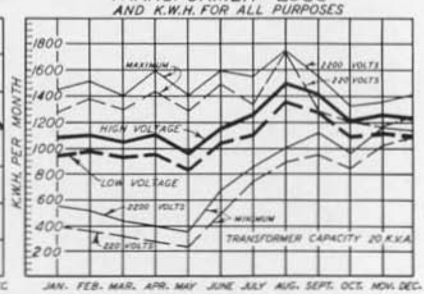
HOUSEHOLD WATER HEATER
2 YEARS AVERAGE ONLY 5 PERSONS

REFRIGERATOR
3 RESIDENCES 14 PERSONS

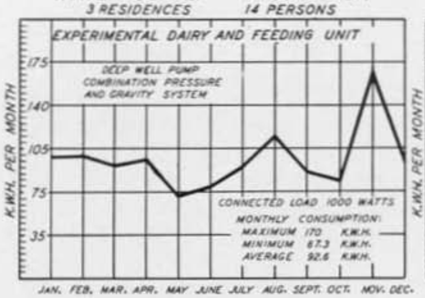
ELECTRIC RANGE
3 RESIDENCES 14 PERSONS



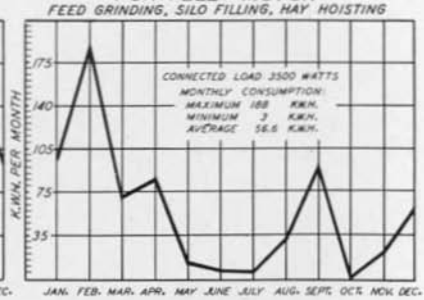
TRANSFORMER LOSS
AND K.W.H. FOR ALL PURPOSES



WATER SUPPLY 1 H.P. MOTOR
3 RESIDENCES 14 PERSONS



PORTABLE MOTOR
FEED GRINDING, SILO FILLING, HAY HOISTING



RESIDENCE LIGHTS
3 RESIDENCES 14 PERSONS

CONVENIENCE OUTLETS
3 RESIDENCES 14 PERSONS

washed per kilowatt hour varies over wide limits, depending upon the kind of clothes washed, the time required, temperature of the water, and the skill of the operator. The data secured have shown that one kilowatt hour washed from 51.7 pounds to 103.5 pounds (dry weight) of general household washing. Records taken during the summer months of 1929 show that the rate of washing depends upon the individual doing the work. The following table gives an example of the use of the electric washing machine at the Substation:

ELECTRIC WASHING MACHINE RECORDS

1929—Month	Washing Time in Hours	Clothes Washed Lbs. Dry Wt.	K.W.H.	Lbs./K.W.H
June	16.06	336.0	6.5	51.7
July	24.02	435.5	4.3	101.0
August	18.78	363.0	3.5	103.5
September	17.50	332.0	5.0	66.3
TOTAL	76.36	1466.5	19.5	322.5
Average per month	19.09	366.6	4.87	80.6

Individual Records

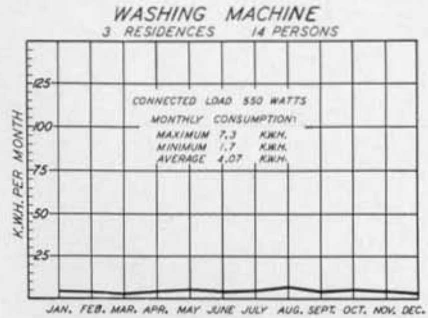
	Average Washing	Rate of Washing Lbs. per Hour
Residence No. 1	28.0 pounds	17.2
Residence No. 2	30.3 pounds	14.3
Residence No. 3	26.0 pounds	28.4
Average	28.1 pounds	19.9

A Sample Washing

Hot water required	16.5	gallons
*Energy for water heating	6	K.W.H.
Energy for washing machine	.4	K.W.H.
A tual operating time of washing machine	1	hour, 17 minutes
Pounds of clothes washed	22	pounds
Time cleaning up	15	minutes

* About one-half of the water was used.

The energy consumption for the operation of the washing machine varied from a minimum of 1.7 kilowatt hours to a maximum of 7.3 kilowatt hours per month during the three-year period. The average for the entire record was 4.07 kilowatt hours per month, during which time the families using the laundry equipment were represented by fourteen persons.



The electric mangle has been used with success but it requires some practice before the operator becomes experienced and skillful in its operation. Uneven pressure of the cylindrical roller against the shoe has required the replacement of the cloth covering of the roll once in every two years. Such articles as pillow slips, sheets, etc., may be ironed with a considerable reduction in the time required by hand ironing. The following table is typical of the data secured on the operation of the 32-inch mangle at the Substation farm:

MANGLE OPERATION

1929—Month	Ironing Time in Hours	Clothes Ironed Lbs. Dry Wt.	K.W.H.	Lbs./K.W.H.
June	6.25	144.0	11.0	13.1
July	10.18	215.5	19.0	11.3
August	15.08	256.5	16.0	16.05
September	9.53	227.0	21.0	10.8
TOTAL	41.04	843.0	67.0	51.25
Average per month	10.3	210.7	16.75	12.81

A study of the energy consumption of the mangle shows that, due to the laundry building being inadequately heated, a seasonal use of the mangle resulted. The energy consumption varied from a minimum of 6.7 kilowatt hours to 30.3 kilowatt hours per month. The average for the entire period was 14 kilowatt hours per month, during which time the three families included an average total of fourteen persons.

The greatest use of electricity in the household has been for cooking which has varied on the combination coal and electric range in residence number one from a minimum of 33 kilowatt hours per month during the winter months to a maximum of 156 kilowatt hours per month during the summer. During the first two years of the records electric ranges were used also for all of the cooking in residences numbers two and three. During 1929 a change in the personnel at the Substation resulted in the removal of the range at residence number two, but in the summer and early fall months a small electric plate was used to supplement the coal range. The energy consumption of this plate was metered through the convenience outlet circuit and is not included in the records for the operation of the electric ranges. The average energy consumption for the electric ranges used by each of the three families during the three-year period varied from a minimum of 79 kilowatt hours to a maximum of 130.5 kilowatt hours per month. This record includes the combination coal and electric range (residence number one) which makes the monthly average for each of the three families 100 kilowatt hours per month.

Residence number three used much more energy for cooking than did residence number one with a maximum monthly kilowatt hour consumption of 220 and 181 respectively. The cooking for residence number one was for three adults and three children compared to a family of three small children and three adults in residence number three.

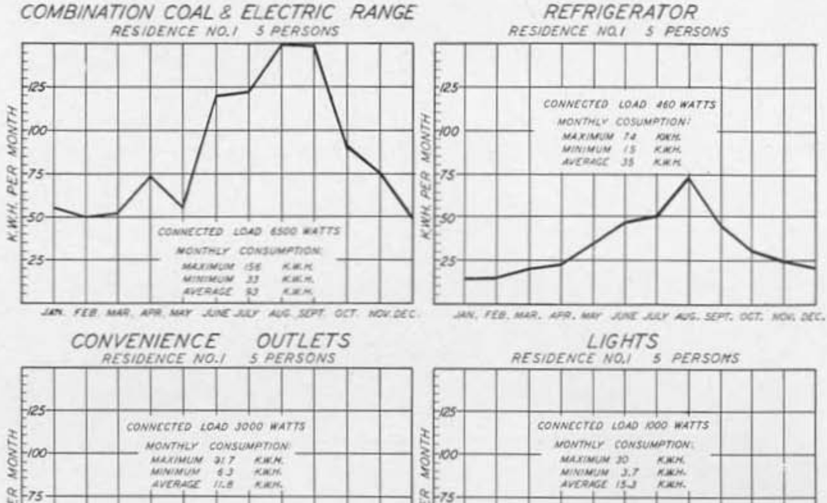
The change from the coal stove to the electric range usually requires new facilities for hot water. Several different types of water heating installations have been tried at the farm. One of the first installations consisted of a five-kilowatt immersion type heater in the circulating system, with a thermostat control. A 60-gallon range boiler was used for storing the hot water. Other installations were tried with two- and three-kilowatt heaters using a small three-gallon storage tank in connection with the circulating installation.

The three-kilowatt storage type of heater, with a capacity of 18 gallons, used in connection with the combination coal and electric range

ELECTRICITY IN THE HOUSEHOLD

Three-year average — Caldwell Substation farm

1927-1928-1929



in residence number one, shows a maximum of 60 kilowatt hours per month and an average of 26 kilowatt hours per month for the summer period between April and October.

Electric heaters have a heating efficiency of 100 per cent, while with the ordinary coal or oil stove there are many heat losses. Electric heat has several advantages over other forms in that it is much easier to concentrate, is more uniform, and is well adapted to automatic temperature and time control.

The electric refrigerator has been one of the most appreciated household appliances used in the farm home. On the Substation farm three seven cubic foot capacity refrigerators have been in operation during the past three years. There is very little difference in the energy required by the various makes of machines or in the total amount of energy required per year. Although two machines required minor service during the past year, the operation of the entire group has been satisfactory. During 1928 the average energy consumption on a monthly basis was 35.2 kilowatt hours, and during 1929 this average was increased to 37 kilowatt hours. The seasonal operation of the refrigerators shows the peak energy consumption in August, at which time the average for the individual machines was 70 kilowatt hours for both the 1928 and 1929 seasons.

There has been some variation in the energy required by the individual refrigerators, due largely to the location of the refrigerators in the house. In residence number one the machine is located on an inclosed back porch; in residence number two the refrigerator operates in an unheated pantry; and in residence number three the machine is located in the dining room. During the 1928 season the refrigerator in residence number three was located on an open porch, and had an average monthly energy consumption of 32 kilowatt hours. Locating the machine in the dining room increased the energy consumption from 32 to 40 kilowatt hours or 8 kilowatt hours per month. The increased convenience realized by having the refrigerator in the dining room more than compensates for the slight increase in the kilowatt hours consumed by the machine. A comparison of the winter and summer months shows that the average energy consumption was 3.3 kilowatt hours more during the summer.

The refrigerator at residence number one used a minimum of 15 kilowatt hours and a maximum of 74 kilowatt hours per month during the three-year period. The average monthly energy consumption was 35 kilowatt hours, which is typical of the operation of the three machines studied.

Minor household appliances have consisted of heating pads, glow heaters, curling irons, percolators, waffle irons, radios, vacuum cleaners, etc. These appliances have been operated from the convenience outlet circuits which were metered separately and show a minimum monthly energy consumption of 7.5 kilowatt hours and a maximum of 27.3 kilowatt hours per month for the three families during the three-year period.

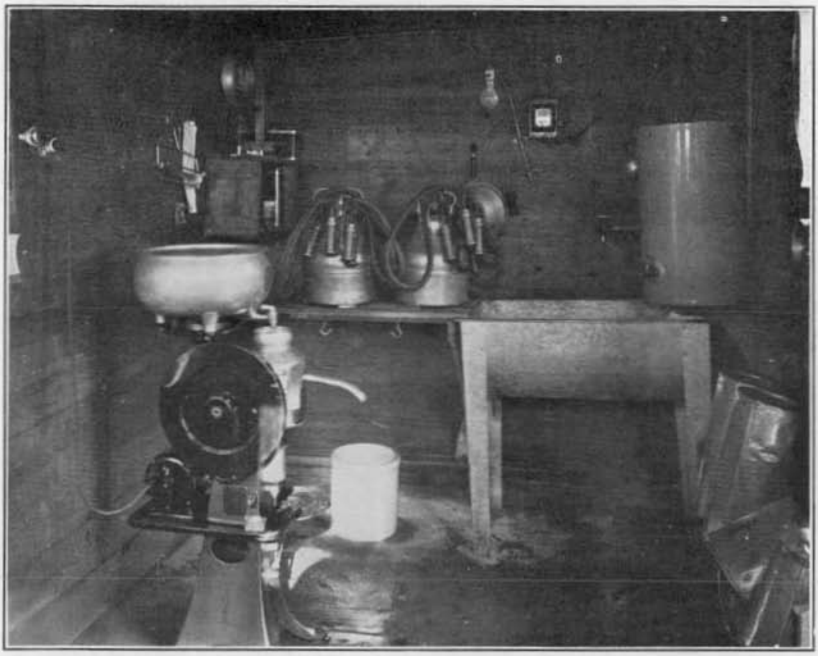
In residence number one the convenience outlet energy consumption reached a maximum during the winter months due to the use of the glow heater. The average for the three residences reached a maximum in the summer months as a result of the use of the electric plate in residence number two.

The lighting circuit energy consumption varied from 4.7 kilowatt hours to 22.4 kilowatt hours and averaged 12.7 kilowatt hours per month for the three residences during the three-year period. The variation in the use of electricity for lighting is shown by the graph to be inversely proportional to the hours of daylight throughout the year.

Electricity In the Dairy

The operation of the dairy unit at the Caldwell Substation has shown the importance of having a production unit of sufficient capacity to merit a reasonable return on the investment of labor and equipment.

During the past three years the dairy herd has been reduced from 20 head in 1927 to 19 head in 1928 and 11 head in 1929. When the herd is reduced to 11 cows, it is difficult to show a saving in either time or cost of production, although the benefits of the electrically operated mechanical equipment are appreciated by the operator. A change in



The "Idaho Farm Water Heater" and motor-operated separator assist in the time saving realized by the use of the milking machine in this farm dairy
—(Photo by Johnson & Son, Boise, Idaho.)

the methods of operating the dairy sterilizer alone increased the kilowatt hour consumption of energy from an average of 311 kilowatt hours per month in 1928 to 412.3 kilowatt hours per month in 1929. This increase of 101.3 kilowatt hours per month for sterilization represents approximately 20 hours of operation of a five-kilowatt element and is probably due to the manual control used in 1929 as compared to the automatic thermostat control used in 1927 and 1928.

For the three-year period two different sterilizers each used a five-kilowatt heater element, and averaged a minimum of 239 and a maximum of 391 kilowatt hours per month, averaging for the entire period 337 kilowatt hours per month. In addition to the sterilizing this equipment was used for heating the wash water at the dairy.

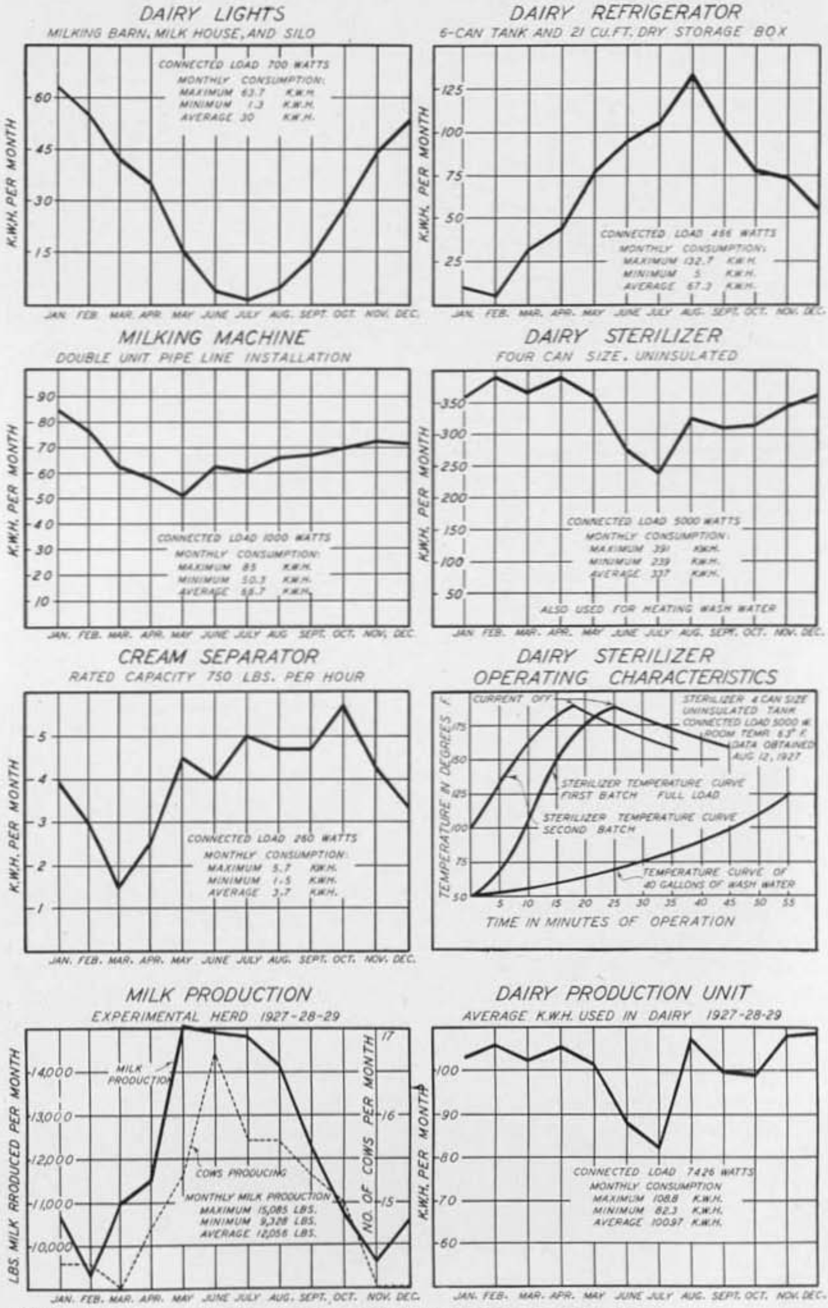
A test of a sterilizer, similar to the one formerly used on the Substation farm, which has been in operation on an 8-cow herd near Moscow, showed an average consumption of 133.3 kilowatt hours per month where the sterilizer was used twice daily for sterilizing only.

ELECTRICITY IN THE DAIRY[1]

Three-year average

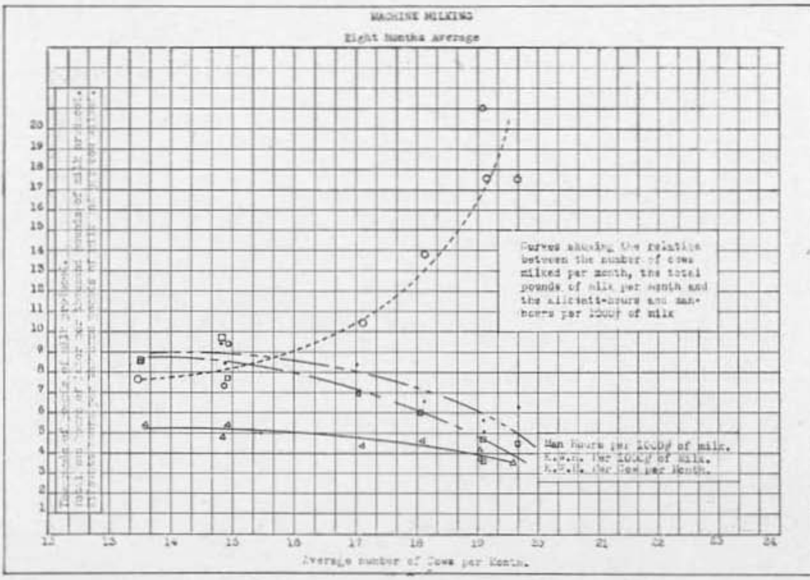
Caldwell Substation farm

1927-1928-1929



[1] Milk production records furnished by the Department of Dairy Husbandry.

The comparison of hand and machine milking in 1926 and 1927 showed a saving of 53.5 man hours of labor per cow when milking a 20-cow herd and was a saving of 47 per cent of the total labor required per cow.[1] Six man hours of labor were required per 1000 pounds of



Curves showing the relation between the labor distribution and dairy production

milk produced by machine milking as compared with 12 hours and 10 minutes per 1000 pounds of milk by hand milking. The time required for milking a cow twice a day averaged 18.9 minutes by hand and 10.1 minutes with the milking machine. As the number of cows in the herd decreased, the time required for milking them daily with the machine has increased from 10.1 minutes with 20 cows to 11.58 minutes when milking 9 cows.

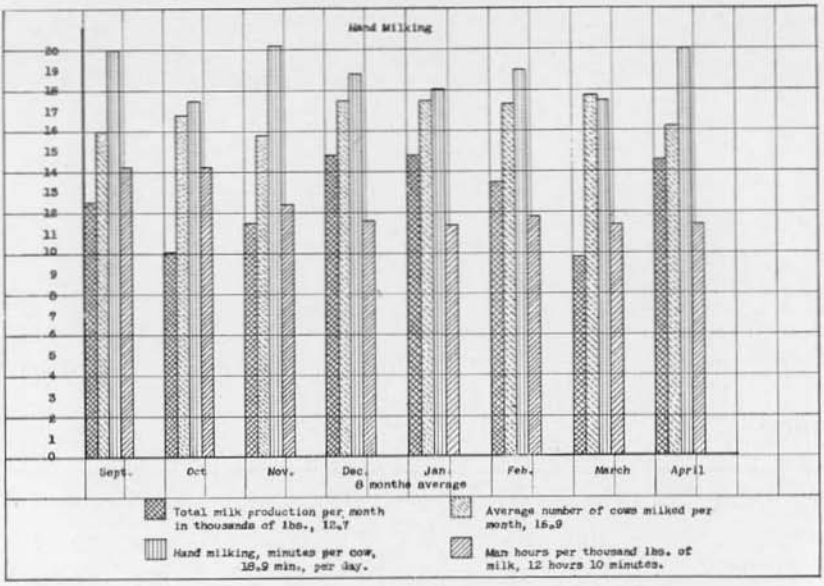
The average monthly energy consumption of the one-horsepower motor operating the compressor for the double unit pipe line milking machine was decreased from 75.7 kilowatt hours in 1928 to 53.4 kilowatt hours in 1929. However, the average kilowatt hours per cow per month was increased from 4.45 to 4.9 kilowatt hours, due to the change in the number of cows milked. The energy consumption for the three-year period varied from a minimum of 50.3 kilowatt hours to a maximum of 85 kilowatt hours and averaged 66.7 kilowatt hours per month.

The dairy refrigerator used on the Caldwell Substation is a farm-made unit consisting of a deep setting insulated concrete tank and a twenty-one cubic foot dry cold storage box.[2] The tank is used for the storage of cream in cans and the box for the storage of butter and milk

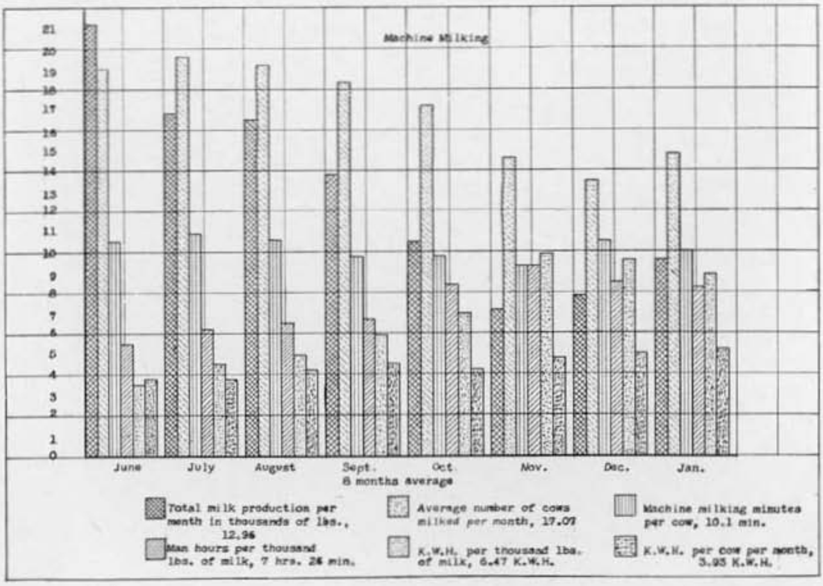
[1] The Effect of Mechanical Equipment on the Distribution of Labor in Dairy Production, by Hobart Beresford. Research Paper No. 69, Idaho Agricultural Experiment Station.

[2] Plans and bill of materials for the construction of this refrigerator may be secured upon application to the Department of Agricultural Engineering.

Graphs showing the relation between hand methods and machine methods for dairy production

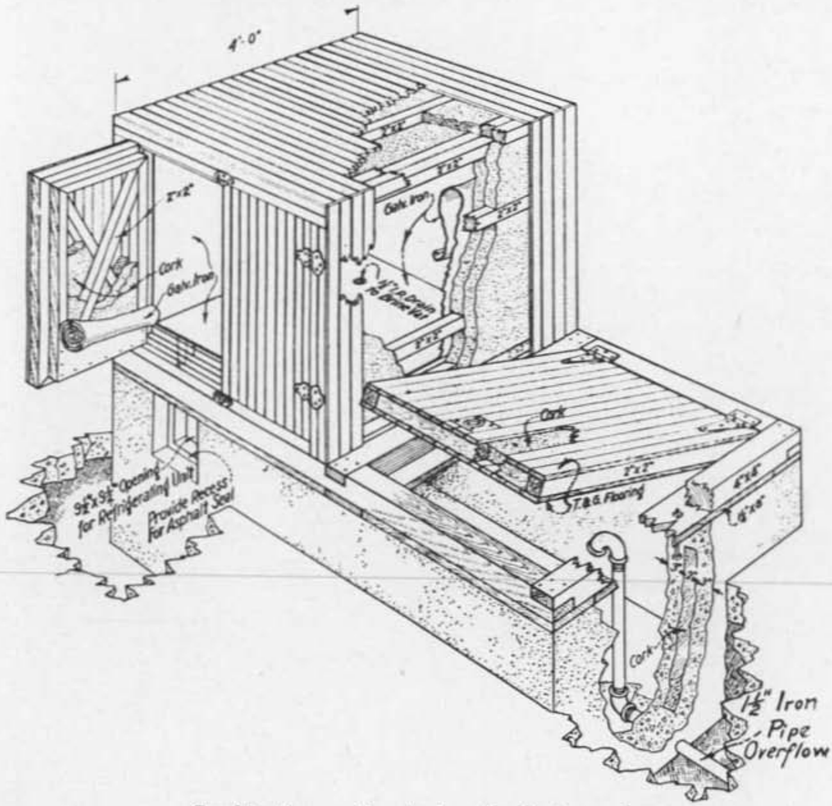


for household use. The box is insulated with a double layer of two-inch cork board. The compressor unit used with the refrigerator is a one-half horsepower model N Frigidaire. Water is used for the cooling medium in the tank and due to the contamination caused by milk and cream



spilling from the cans as they are placed in and out of the tank should be changed at least once a week.

The extension pipe for the drain extends 22 inches above the bottom of the tank. This provides a water level above the expansion coil in the tank and prevents flooding the cans. The expansion coil in the



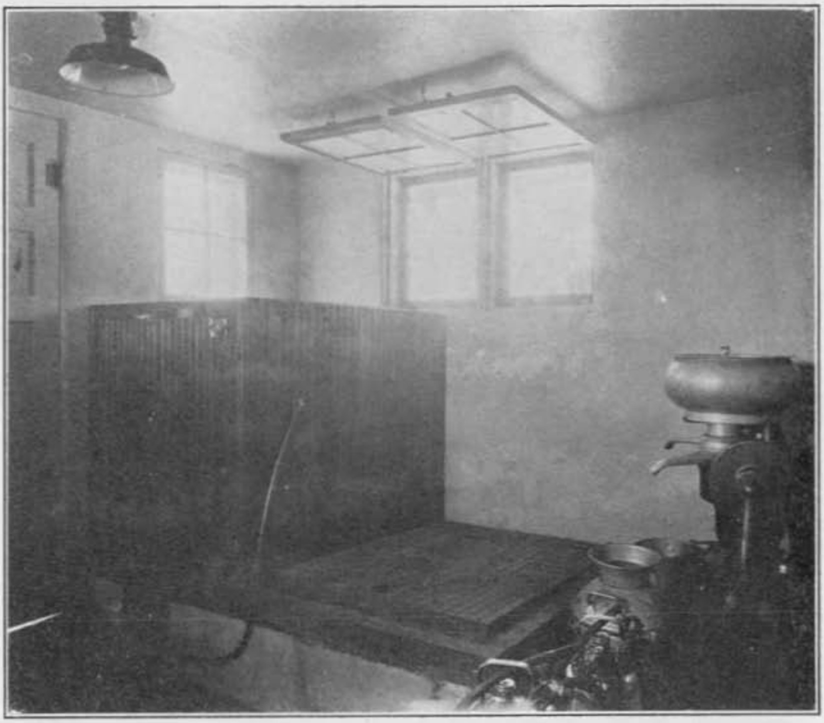
Combination cooling tank and cold storage box

cold storage box and the expansion coil in the tank are operated from the same compressor by means of a duplex temperature valve.

The temperature records show that the temperature in the tank is much more constant than the box temperature and averages 36° F. The average temperature in the box has been approximately 38° F. Records also show that outside temperatures or room temperatures have little effect on the temperature in the tank and the box, but do increase the operating time of the compressor and consequently the cost of cooling.

The three-year average for the operation of this refrigerator shows a minimum of 5 kilowatt hours per month and a maximum of 132.7 kilowatt hours per month which occurred each year during the month of August, and was due to the increase in both refrigerator load and room temperature. The average energy consumption for the three-year period was 67.3 kilowatt hours per month.

Additional refrigeration work has been the construction of a cold storage box for storing cases of bottled milk on a commercial dairy near

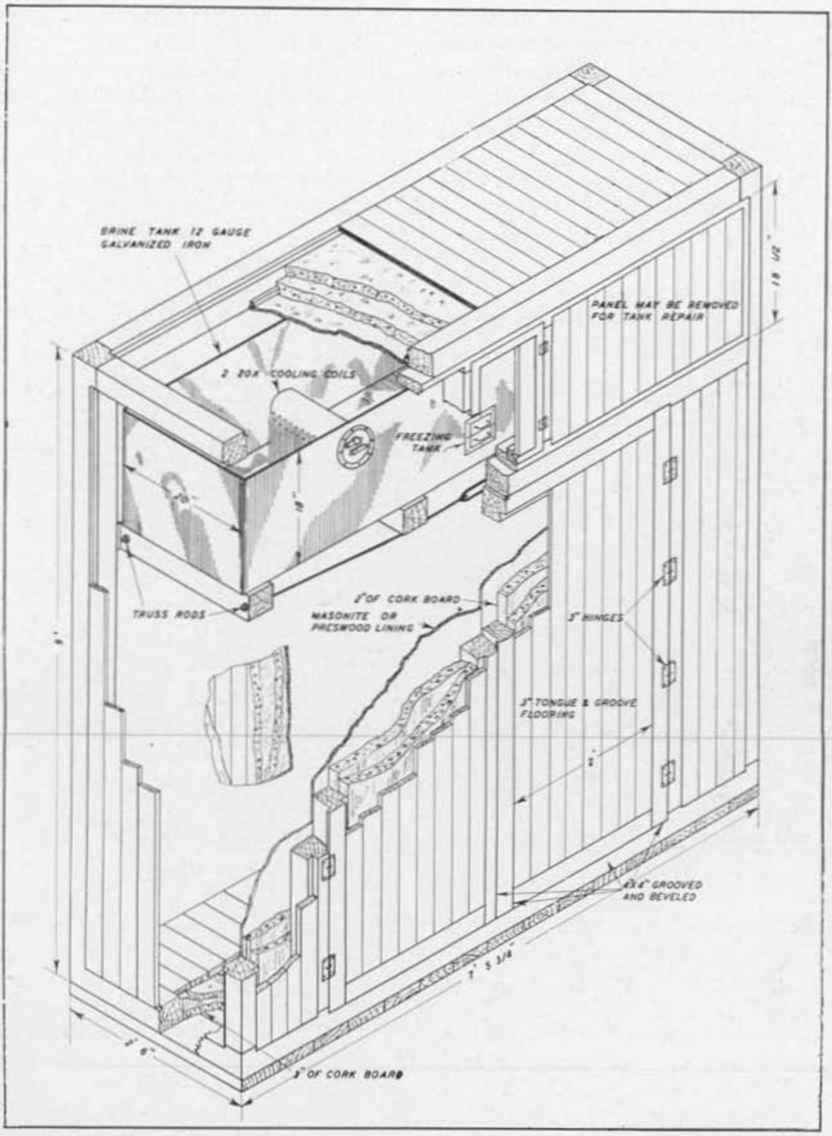


Interior of milk house at the dairy production unit, Caldwell Substation

Moscow. This box was built into a dairy milk room as a part of the room, the design being such that with a few alterations it could be constructed as a portable unit.[1]

The frame of the refrigerator is built from 4x4-inch Douglas fir. The box is insulated with three inches of cork board in the floor, and two inches in the walls and ceilings. The brine tank has a capacity of 130 gallons, which allows two gallons of brine for each gallon of milk cooled during the 24-hour period. The compressor used with this box is a one-half horsepower model N Frigidaire air-cooled unit operating on 110 volts. Two Frigidaire No. 20X refrigerating coils are used in the front face of the tank and a compartment for freezing ice cubes is built into the lower midsection. The top of the tank is rigidly braced by a frame made from 1½-inch angle irons and insert holes for brine inlet and outlet pipes are provided in the front. For convenient repair the tank may be removed through the top door way. A one-fourth

[1]Plans and bill of materials for the portable unit may be secured upon application to the Department of Agricultural Engineering.

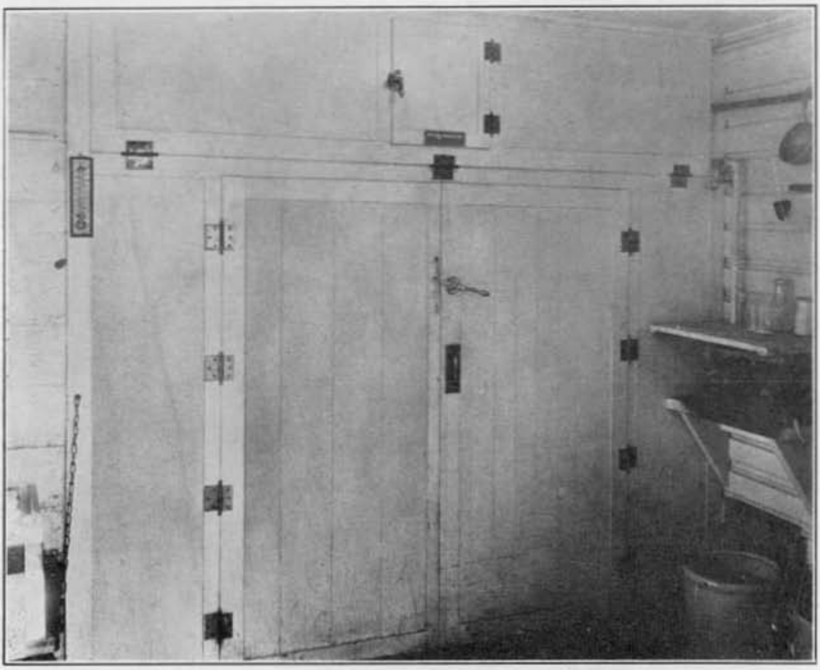


Cold storage box used for the storage of bottled milk, employing brine tank and surface type of cooler

horsepower 110-volt motor operates a centrifugal pump which circulates the brine through the lower portion of a surface type milk cooler. It was found that the 4x4 beam was not sufficient to carry the weight of the brine without sagging. This defect was corrected by using a one-half-inch truss rod bolted through the outer 4x4 tank support. The rod was adjusted from the inside of the box until the tension prevented any sag of the beam upon the lower doors.

During a test of this equipment the operating time of the compressor was secured by a service recorder clock which recorded the daily operating periods on paper dials and the temperature records were made by recording thermometers. One thermometer was placed in the box on a shelf midway between floor and ceiling, and the other thermometer was placed on a shelf in the milk room. The energy consumption was measured by a kilowatt hour meter.

The temperature in the box remained below 40° F. except for short intervals which were caused by the changes in the refrigerator load and in the opening and closing of the doors. Temperature fluctuations were more frequent during the day. The average temperature in the box



Cold storage box for commercial dairy installation located near Moscow

during the entire month was 37° F. The chart of the room temperature resembles a rough sine curve, the lowest part of which occurred around 6:00 A.M., while the highest point came some time between 1:00 P.M. and 5:00 P.M.

The operation of the compressor was generally for periods of four to nine hours of continuous operation. The operation time decreased as the outdoor temperature decreased. The total operating time of the compressor during the month of October, 1929, was 341 hours, giving an average daily operation of 11 hours and a total energy consumption of 173 kilowatt hours.

The refrigerator is used to cool the milk and cream for the dairy and food supplies for the family. The average amount of whole milk cooled per day is 17 cases (12 quarts per case) and 50 pint bottles. In addition to the milk, 1½ gallons of cream and 5 gallons of skim milk are cooled each day. The milk from the morning milking is stored in bulk until 10:00 o'clock in the morning, at which time it is bottled and returned to the refrigerator. The milk from the evening milking is bottled at once and stored over night. Thus the use of the refrigerator makes it possible to deliver all of the milk by a single morning delivery.

All of the milk is pre-cooled to below 40° F. before it is placed in the refrigerator or bottled. The pre-cooler consists of a surface type cooler, one-half of which is cooled by well water and the other half by brine pumped from the refrigerator brine tank by a small centrifugal pump operated by a one-fourth-horsepower motor.

Silo Filling

Electric motors for furnishing silo filling power have been the subject of a great deal of discussion during the last few years. The first recommendations based on tests of short duration have been found by actual field trials to be unsuited to western conditions. Former filling rates and cutting speeds recommended for the 5-horsepower motor left such a small margin of reserve power that with slight variations in the adjustment of the cutter or the rate of feeding disastrous results were produced.

In an effort to determine the best method of utilizing the portable electric motor for silo filling, power tests were carried on at the Caldwell Substation farm during the past four years. These tests have consisted in using electric motors during the regular silo filling period and operating the outfit with the usual silo filling crew. In 1926 the 10-horsepower motor was compared with the 10-20 tractor. The remaining tests have been of the 5- and 7½-horsepower motors combined with a study of the crew organization and labor distribution required for effectively utilizing the small motor for silo filling work.

Silo filling with electric motor power

The 5- and 7½-horsepower motors were used during 1927 to furnish power for filling two silos with a total of 99.15 tons, elevated to an average of 40 feet, at a rate of 4.32 tons per hour. The corn used for the silage was grown under irrigation on the Substation farm, in fields averaging one-half mile distance from the silos, which were located at the dairy unit and the experimental feeding pens at the farmstead.

The corn was cut with a horse-drawn binder, the plan being to keep not more than one-half day's cutting ahead of the haulers. Four to six teams were used for hauling, each man unloading his own load at the cutter, while two additional men assisted in loading in the field. All of the corn was weighed over a Fairbanks platform scale and the time required for obtaining the wagon weights was included in the loading and hauling time. The empty wagon weights were checked daily for any variation that might occur due to change in men or condition of equipment. One man fed the cutter and another operated the distributor in the silo. For the 1929 season the man in the silo operated the distributor from the top of the silo, which necessitated all of the silo doors being sealed in place before the filling operation started. Most silos need special care in order to obtain an air-tight seal at the doors and joints. The use of a clay mortar in the door cracks or building paper over the entire door are common methods employed.

Several methods of handling the silage in the silo have been attempted at the Caldwell Substation during the past four years. It is difficult to interpret the results, due to the fact that variation in the quality of the corn from year to year may have had some influence on the resulting quality of the silage. In 1927 an attempt was made to cut down the man hours required by eliminating the man in the silo except for the last ten or twelve feet of filling, at which time the silage was distributed by tramping in the usual manner. The theory of this procedure was that the effect of the tramping would be negligible compared to the weight of the silage, and was borne out by the amount the silage settled after the filling. However, the silage did not keep as well, due to an apparent separation of the heavier and lighter parts of the fodder. The slices of ears had a tendency to pile up on the outside, leaving irregular pockets for the lighter material. More than the usual amount of spoilage occurred and as a result it is not recommended to attempt to get along without a man operating the distributor either in or from the top of the silo.

The effect of the electric motor on the size and management of the crew required for silo filling has been found to be one of the most important phases of the motor's utilization. It has been difficult to give up the idea of having the neighbors in when the silos are being filled and as a result the majority of the crews have been too large.

A detailed study of the effect of the various numbers of haulers was made during 1929 by means of an automatic recorder clock known as "Servis Recorder." This device consists of a clock movement which carries a waxed paper disc upon which is left a record of the operation of any machine to which the mechanism is attached. The chart is turned at clock speed by the clock movement, but the recording stylus leaves its record only during the period of operation. These clocks were mounted on the haulers' wagons and the silage cutter. The records thus obtained were checked with the time keeper's record and used in computing the time lost. When four haulers were used the best distribution of labor was secured and resulted in only 3.12 minutes of idle time per ton of fodder hauled, as compared with 51.7 minutes of idle time per ton of fodder when six teams were used. With a crew of four haulers, two loaders, one binder, one feeder, and one man in the silo, 45.23 tons of corn were hauled on an average of one-half mile. This corn was cut and elevated on an average of 40 feet at a rate of 4.52 tons per hour, using the 7½-horsepower motor for power. The labor charge was two man hours per ton with an energy charge of .95 kilowatt hours per ton.

The total average for the 1929 tests was slightly less than the 1927 tests, at which time the best results obtained thus far were secured. The wide variation in the results obtained from the use of the electric motor for silo filling power for the Caldwell Substation may be explained by the following recommendations which are based on actual experiences responsible for the variations mentioned.

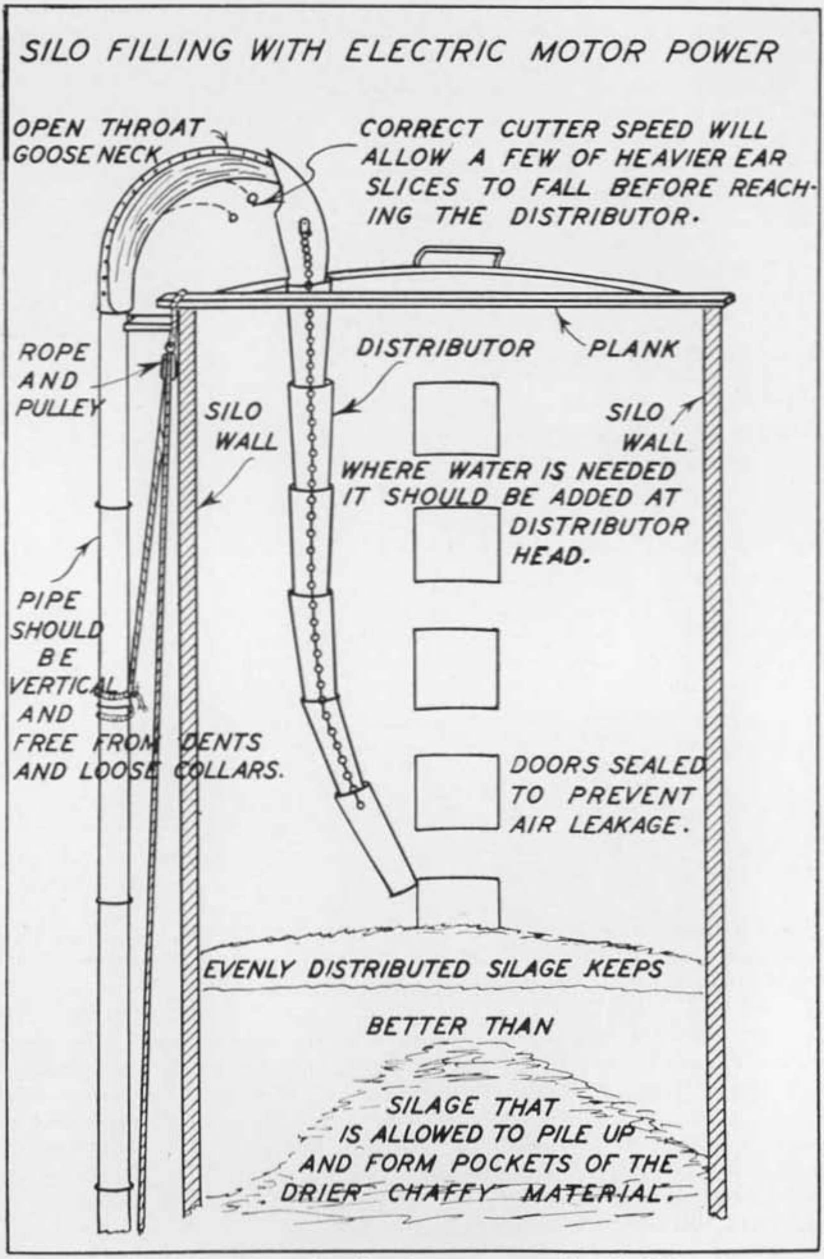
SUMMARY OF SILO FILLING TESTS

Year of Test	1926		1927	1928	1929
Tons of silage	42.29	33.42	121.38	54.58	99.15
Elevation in feet	42.00	38.00	40.00	42.00	40.00
Gasoline or K.W.H. per ton	1.99	1.8	.899	1.24	1.11
Rate of cutting in tons per hour	4.86	4.30	4.45	2.15	4.33
	Tractor	Motor	Motor	Motor	Motor
Size of motor or engine	10-20	10 h.p.	5 h.p.	5 h.p.	7.5 h.p.
Size of cutter throat, ins.	5½x11	5½x11	4½x10	4½x10	4½x10 6⅜x12¾
No. of knives	3	3	2	3	2-3
Cutter speed, R.P.M.	800	800	530-580	554-620	412-655
Average length of cut, ins.	½	½	½	½	½

During 1926 the tendency was to operate the cutter at a higher rate of speed than was needed to secure the elevation required. In addition to this tendency, considerable experimental work was carried out on the effect of dull knives and variation in the length of cut. These trials contributed materially to the low cutting rate and the high energy requirement per ton. The tests showed that there was a definite tendency to increase the energy requirement (approximately .2 kilowatt hours per ton) as the length of the cut was decreased from one inch to one-half inch. The effect of sharpening the knives lasted from three to four hours, after which the dulled knives increased the energy consumption as much as .25 kilowatt hours per ton and decreased the rate of cutting approximately one-fourth ton per hour. These tests also indicated that knives should be sharpened at least twice a day.

The required cutter revolutions per minute were found to vary with the elevation, the diameter of the blower, and the condition of the fodder and elevating pipe. Under certain conditions the heat of the sun's rays was found to cause the corn juice to gum the inside of the elevating pipe, resulting in an increase of power requirement. The most efficient operating speed for the cutter was that which just elevated the fodder without blowing over the top more rapidly than was necessary to secure the required lift. This condition was determined by noting the velocity of the silage in the open throat goose neck just before it entered the distributor. When the revolutions per minute of the cutter were reduced to the point where a few of the heavy ear slices fall before reaching the distributor head the minimum speed was reached.

Loss of power due to faulty transmission with an attempt to use too short and too narrow a belt was experienced in 1928. It was diffi-



Suggestions for using electric motor power for silo filling cult with the short belt to maintain the correct tension, resulting in both a loss of power and bearing trouble due to excessive pressures. The thermo fuse equipment supplied on the portable single phase motors also caused trouble by not permitting momentary overloading required for the operation of the silage cutter. For this reason thermo fuse equipment is not suited to the portable motors which are intended for silage cutter operation.

Poor voltage regulation was experienced for the first time during the 1929 silo filling work. During peaks a drop to 180 volts occurred at 11:00 A.M. and 5:00 P.M. on the first day of the trials. This condition was attributed to the fact that the rural line supplying the Substation farm had been loaded with several electric ranges during the past year. To correct the condition the transformer taps were moved to a higher voltage, although this is not as desirable as having sufficient line capacity to prevent voltage fluctuations. Rural transmission and distribution lines must be planned for the future if lasting satisfaction and the greatest possible development in the application of electricity to agriculture is to be realized.

RECOMMENDATIONS FOR USING THE ELECTRIC MOTOR FOR SILO FILLING POWER

Methods

If the electric motor is used for power, it is possible to fill a silo with the usual ranch crew, thus making the job a regular farm operation instead of an emergency demanding several additional hands and exchanging work with all of the neighbors. Three or four haulers can handle four to six tons of fodder per hour, depending upon the length of the haul; and the man feeding the cutter can easily take care of the motor. The equipment, including the silo doors, can be set up before the filling starts, thus saving one man's time for the field crew. The best results are obtained by having a man direct the cut fodder in such a way that even distribution and uniform settling is secured. The additional settling of the material resulting from the increased filling period makes up for the packing effect obtained by having more than one man in the silo throughout the job.

Service and Wiring

When planning for silo filling with an electric motor, locate the transformer as near the silo as will be convenient for the rest of the farm wiring system. Be sure the transformer furnishing the service has sufficient capacity for the motor load desired, and that the use of the range or other farm power equipment will not overload the wiring system or transformer during the hours of operation. It is very important that the wiring system from the transformer to the motor be large enough to carry the required current (never less than No. 6 copper wire), and that the distance from motor outlet to motor be kept within the limit for the size of wire used. The wiring from the motor outlet should be armed with either metal or rubber, having all connections taped and the wires strung out of the way of the men and teams.

The Motor

Overload and low voltage protection are essential for the operation of the electric motor for silo filling power. This is because the variation in load imposed on the motor by uneven feeding of the cutter produces very high momentary currents in the feed wires and motor windings. The new thermal type fuse will not stand these currents and for this reason the magnetic type of protection is recommended. The portable motor is ideal for silo filling power, although good results have been obtained by mounting the stationary type of motor on a truck or simple skids.

If it is desired to cut and elevate the silage forty feet or over at the rate of more than five tons per hour, a 7½-horsepower motor is recommended. With a thirty-to thirty-five-foot elevation the five-horsepower motor is capable of from five to eight tons per hour, provided a suitable silage cutter is used and the unit operated as recommended above.

Do not neglect the lubrication of either motor or cutter. However, the time to care for the motor is while it is at rest, because filling the oil cups while in operation will cause them to overflow and waste oil when the motor stops.

It is essential, when the small 5-horsepower motor is used, that all the power available be transmitted to the silage cutter. If a flat belt is used a 50-foot 6-inch 4-ply rubber belt is recommended; if a shorter belt is used it is difficult to keep it tight and there is an increased danger

Combination "V" and flat belt drive tests at the dairy silo, University farm

of producing excessive bearing pressure. A small block and tackle (wire stretcher) used between the motor skids or truck and an anchor stake is a convenient method of keeping the belt tight.

The "V" belt drives are well adapted to silo filling work, especially where close quarters demand the use of a short belt.

The Silage Cutter

The silage cutter should be in good repair, with shear plate and knives kept sharp and in adjustment. It is a good plan to have an extra set of knives and change to sharp knives every half day. A maximum clearance of one-eighth inch between blower blades and housing is recommended. The frame should be leveled when setting up the cutter in order to operate the main shaft and bearing on an even keel. Machines equipped with anti-friction bearings of the ball or roller type, as a rule require less power to operate and are less difficult to maintain in correct adjustment than machines equipped with plain bearings.

The cutter speed required depends chiefly upon the diameter of the blower and the height to which the fodder must be elevated. The higher the silo the faster the blower blades must travel, and the greater the diameter of the blower the fewer the revolutions per minute required for obtaining the same blower blade speed. The most efficient operating speed of the blower will be that which elevates the fodder without blowing over the top more rapidly than is necessary to secure the required lift, and at the same time provide a factor of safety which will prevent excessive plugging of the blower pipe. The correct cutter speed for electric motor power will allow some of the heavy ear slices to fall from the open throat of the goose neck before reaching the distributor head.

Even feeding is essential to the successful use of a 5- or 7½-horsepower electric motor for silo filling power

As the elevation required is reduced, the cutter speed may be lowered and the rate in tons per hour increased. The elevating pipe should be set up as nearly vertical as possible, anchored securely to the silo and cutter, and be free from dents or poorly fitting collars. A rope and pulley or block and tackle should be provided for raising the blower pipe, and will be found convenient for lifting the pipe from the cutter should plugging occur. The small size cutters have the advantage of being difficult to overload or choke by excessive feeding. The large silage cutters may be used with the five-horsepower motor, provided they are operated at the correct speed and the feeding rate is maintained to correspond to the power furnished by the motor. They have the advantage of being easier to feed for hay chopping, and the disadvantage of making it easy to overload the motor.

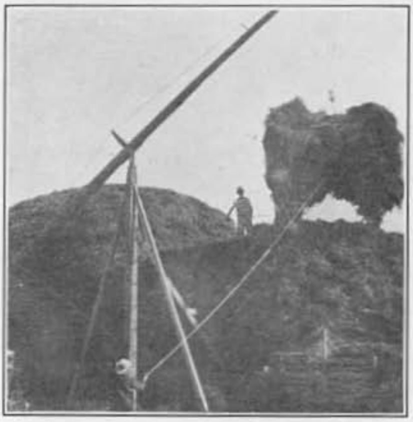
Adding Water to the Silage

It takes much less power to pump water over the top of the silo than it does to elevate it through the cutter and blower pipe. It is good practice to admit the water (when water is required) at the distributor pipe in order to mix it with the fodder. The best silage is produced when the cut fodder has sufficient moisture in it to exclude the air, thus preventing excessive molding and spoilage.

HAY HOISTING

The use of the electric motor and mechanical hoist for handling hay in Idaho was noted first in 1925 during a survey of the uses of electricity in agriculture. The application was found on the Dewey Brothers ranch, which was supplied with electric service from the Minidoka Project. A drum type hoist for handling the hay was used in a large stock barn, the power being supplied by a 10-horsepower portable motor.

During 1927 a short test of a similar hoist and a 2-horsepower motor was made on the Caldwell Substation farm. The hoisting outfit consisted of a double drum commercial hoist mounted on the base of a large boom derrick equipped with steel cable and pulleys.



The saving in time by the use of a motor operated hay hoist depends largely upon the crew organization and management.

Tests conducted during the three years, 1927, 1928, 1929, have included a study of labor distribution and the effect of using various combinations of slings and the jackson fork.

The effect of using one sling per load as compared with two slings per load was found to reduce the time required for unloading approximately one-half, or from 6.9 minutes to 3.5 minutes. This reduction was from 11.8 per cent to 7.6 per cent of the total time required for the haying operation.

During the three years of work a total of 203.79 tons of alfalfa were hoisted on an average of 16.4 feet at an average energy consumption of .237 kilowatt hours per ton.

HAY HOISTING TESTS

	Tons of Hay	K.W.H.	Estimated Height
1927	29.31	6.5	20 feet
1928	64.69	16.0	16 feet
1929	109.79	25.8	13.3 feet
TOTAL	203.79	48.3	49.3 feet
Average	67.93	16.1	16.4 feet

The results of the tests show that the electric motor may be used with success provided a suitable hoist is used. The cost of the energy used in hoisting hay is a minor consideration, when compared to the investment in the equipment which may be sufficient to determine the economy of this application. Another consideration is the wiring facilities required where hay is stacked and the frequent change of the derrick location complicates the wiring service to the portable motor. Hay hoist installations are best adapted to permanent locations such as stock barns where large amounts of hay are handled during the season.

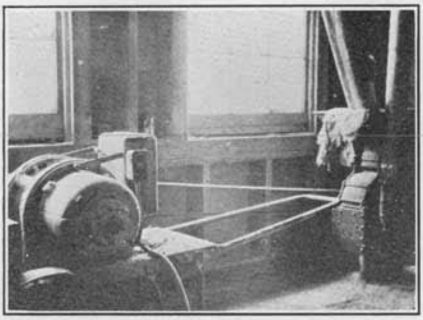
FEED GRINDING AND FORAGE PROCESSING

Considerable interest has been shown by the stock farmers and poultrymen of Idaho in the use of electrical power for feed grinding.

A small burr mill driven with a 3-horsepower motor has been used with satisfactory results by several farmers. There has been the disadvantage of a high labor charge due to the small capacity of the burr type mill and the fact that it usually requires constant attention. However, the advantage of farm grinding, which eliminates the trips to town and fits into the farmer's labor distribution by grinding for a few hours each week, has brought about a continued increase in this practice.

Manufacturers have sensed the farm feed grinding problem and in the past few years farm equipment markets have offered small hammer mill grinders especially adapted to the use of electric power and automatic operation. Hammer type mills are not injured by running empty nor does foreign material or wear appreciably affect their operation or efficiency. The capacity and power requirement is determined largely by the rate of feeding and by the kind of material being ground. This and the above mentioned characteristics make the hammer type mill well adapted to automatic grinding.

Small burr mills are likely to require frequent replacement of burrs. They require more or less attention unless all foreign material is removed from the grain and the feeding and burr adjustment is carefully maintained. Running the mill empty should be avoided in order to protect the burrs from injury. The burr type of mill is satisfactory for medium and coarse grinding. It requires a small space and the investment cost is comparatively low.



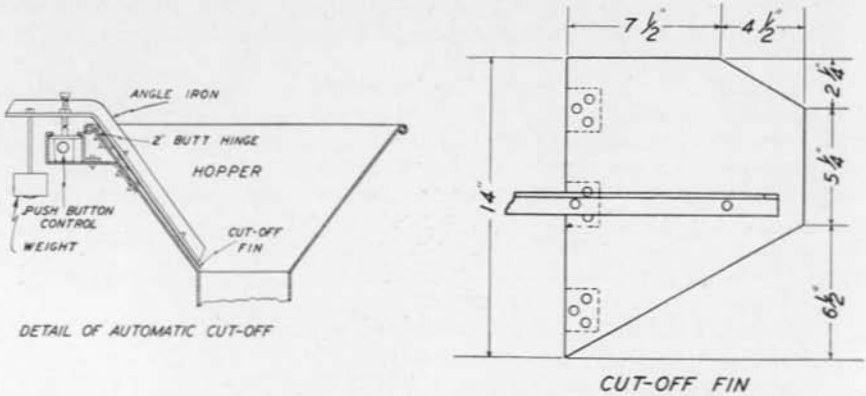
Portable 5-horsepower motor and small hammer mill grinder

The experimental feeding work conducted at the Caldwell Substation during the past three years has included the use of electric motor power for operating farm feed miles for the grinding of feed and the processing of alfalfa hay. This has included special tests of various types of grinders as well as the grinding and chopping of much of the materials used in the experimental feeding work.

The use of the 10-horsepower motor for feed grinding during 1926 indicated that few farmers would have year-around jobs for this size of motor. For this reason the 3-, 5-, and 7½-horsepower motor units have been tried on a variety of mills in an effort to find practical and economical combinations of equipment.

For most of the grinding work the hammer type mill has been selected because it has been found to be well adapted to electric motor operation and automatic control. Automatic and semi-automatic feed grinding promises to cut down the labor required for the grinding operation and to develop the use of small motor units which from the investment and operating standpoint is desirable both to the farmer and to the electric service companies.

A simple device for obtaining semi-automatic feed grinding operation consists of a pressure fin hinged to form a sub-wall of the feed hopper of the mill. When the supply of unground grain in the hopper is exhausted the lack of grain pressure on this fin allows the weight on the end of the fin arm to push against the button of the remote control starter for the motor.



Detail of control device used for automatic feed grinding

For operation the outfit should be set up where a predetermined supply of grain can be fed into the hopper. The grinder must be equipped with a ground feed elevator, or mounted over a receiving bin that will take care of the ground feed. The grinders equipped with agitators in the feeder throat are best adapted to automatic operation. After the outfit is once started and the feeding rate adjusted to the capacity of the power of the motor, further attention is unnecessary if proper balance between the ground feed bin and the grain supply has been maintained. When fine grinding is required a dust collector is used in connection with the blower type of elevator. The grinder should be used without the blower attachment for hammer mill speeds below 3,000 r.p.m. and electric motors of less than 5 horsepower.

Using the 5-horsepower motor for chopping alfalfa hay

The experimental feeding work has required the grinding of grains and the chopping and grinding of alfalfa hay. The rate of grinding and energy requirement for such material as barley has varied from 456 pounds per hour requiring 11.4 kilowatt hours per ton when a 3-horsepower motor was used to 2,150 pounds per hour requiring 11.54 kilowatt hours per ton when a 10-horsepower motor was used. For grinding barley with the 5- and 7½-horsepower motors the rate varied from 765 pounds per hour to 937 pounds per hour, and the energy consumption varied from 10.42 kilowatt hours to 15.58 kilowatt hours per ton. The reason for the apparent increase in energy consumption for the 7½-horsepower motor as well as the relatively small increase in rate of grinding was probably due to the semi-automatic control which was in the development stage during the trials upon which these data are based.

Grinding beans with the 5-horsepower motor showed a slightly lower rate of grinding—666 pounds as compared with 765 pounds. The energy consumption was also lower and averaged 8.57 kilowatt hours per ton.

Grinding alfalfa hay which had been chopped gave an average rate of 678 pounds per hour when using the 10-horsepower motor and a three-sixteenth-inch screen. The use of a one-fourth-inch screen and the 5-horsepower motor gave a grinding rate of 815 pounds per hour.

Chopping alfalfa hay in one-half inch cuts using the fly-wheel knife type silage cutter gave a chopping rate of 1,988 pounds per hour with an energy consumption of 10.76 kilowatt hours per ton when a 10-horsepower motor was used. When the 5-horsepower motor was used for chopping hay, 873 pounds per hour were obtained requiring an energy consumption of 6.86 kilowatt hours per ton. The cost of grinding and chopping hay depends upon the amount of grinding the farmer will have during the season and the number of bushels or tons of material to which the investment and depreciation charge for the grinding equipment may be distributed.

It was estimated that 160 hours of operation per year would meet the grinding requirements on the average farm when the 5-horsepower motor and the medium size hammer mill grinder were used. This estimate has been increased to 240 hours of operation per year for the 3-horsepower outfit. The number of hours of operation has been decreased when the 7½- and 10-horsepower motors were used for grinding the average amount of grain, due to the increased capacity of the equipment obtained by the larger power units. This condition shows that the larger motors should not be considered for farm power units except where more than the average amount of grinding or other power application will be required.

The service life of feed grinders and electric motor equipment has been taken at 15 years for estimating the costs of grinding, during which period the motors are expected to operate on other farm jobs.

The motor and machinery costs have been computed on the estimates based on actual farm operation and are shown in table form on page 48. These costs have been used for arriving at the average costs per ton appearing in the feed grinding and forage processing tables. The total average costs for grinding grain range from $1.47 per ton for the 10-horsepower motor to $2.57 per ton for the 3-horsepower motor, where the labor charge is calculated at $0.40 per man hour and the cost of energy is $0.03 per kilowatt hour.

The costs for grinding chopped alfalfa hay with the hammer type of mill ranged from $1.60 per ton for the 5-horsepower motor to $2.21 per ton for the 10-horsepower motor.

FEED GRINDING AND FORAGE PROCESSING; MACHINERY AND POWER COSTS
Estimated Service Life, 15 Years

Equipment	Cost New	Days Used per Yr.	Days and Hours for Grinding	Depreciation and Interest		
				Per Yr.	Per Day 8 Hrs.	Per Hr.
Electric motor 3 horsepower	$125.00	40 days	30 days 240 hours	$13.60	$0.34	$0.042
Electric motor 5 horsepower	$175.00	30 days	20 days 160 hours	$19.04	$0.634	$0.079
Electric motor 7.5 horsepower	$250.00	25 days	15 days 120 hours	$27.20	$1.088	$0.136
Electric motor 10 horsepower	$325.00	20 days	10 days 80 hours	$35.36	$1.768	$0.221
Hammer mill Small No. 1	$100.00	25 days	25 days 200 hours	$10.88	$0.435	$0.054
Hammer mill Medium No. 2	$150.00	20 days	20 days 160 hours	$16.32	$0.816	$0.102
Hammer mill Large No. 3	$200.00	15 days	15 days 120 hours	$21.76	$1.45	$0.18
Silage cutter Small	$250.00	15 days	5 days 40 hours	$27.20	$1.813	$0.226
Silage cutter Medium	$325.00	10 days	3 days 24 hours	$35.36	$3.536	$0.442

Chopping alfalfa hay with the medium size cutter and a 5-horsepower motor averaged a cost of $2.93 per ton, and with the 10-horsepower motor the cost was $1.79 per ton. The cost for chopping alfalfa hay with the 10-20 tractor averaged $2.82, or approximately the same as for the 5-horsepower motor.

Commercial chopping rates, at the time this work was done, varied from $2.00 to $3.00 per ton. It should be noted that the costs of chopping or grinding alfalfa hay are largely determined by the condition of the hay and the rate at which the operation is carried on. The fineness modulus[1] for the chopped hay ranged between 3.0 to 3.5 and the moisture content varied from 10 to 20 per cent.

For the grain ground the fineness modulus varied from 2.1 to 2.3 and the moisture content varied from 10 to 15 per cent.

During the period over which the feed grinding and forage processing data were obtained the feeding material was used for the experi-

[1]Fineness modulus or index system for expressing and comparing feed grinding results was developed by the Rural Electrification Division of the American Society of Agricultural Engineers.

FINENESS TESTS—PROCEDURE

Fineness determined on sample oven dried at 100° C. to constant weight.
Size Sample—Grain, 250 grams; forage, 100 grams.
Screens—Tyler Standard 8-inch. Size, ⅜-inch and Nos. 4, 8, 14, 28, 48, and 100.
Shaking—On Ro-Tap shaker; 5 minutes.
Fineness—To be recorded as the accumulative percentages of material retained on the several screens, beginning with the coarsest.

The fineness modulus or index shall be the sum of the percentages of material coarser than each of the screens in the series named above, divided by one hundred (100).

FEED GRINDING AND FORAGE PROCESSING

Grinding Equipment

Manufacturer: Fairbanks Morse Co.
Type: Stationary Hammer.
Screen: $\frac{3}{16}$-inch perforation.

Name: "All Purpose Feed Mill."
Size: 14-inch diam., 17¾-inch length.
Elevator: None. Speed: 3,000 r.p.m.

Motor H.P.	Operation and Material	No. of Trials and Date	Weight in Pounds and Tons	Time Required and Crew	Energy Consumption	Rate of Grinding, lbs. and tons per hr.	Average Cost Per Ton				
							Labor at $0.40 per hr.	Energy at $0.03 K.W.H.	Mill	Motor	Total
10	Grinding barley	4 trials 1926-1927	11,940 lbs. 5.97 tons	5 hrs. 38 min. 2 men	69 K.W.H.	2,150 lbs. 1.075 tons	1.88 man hrs. $0.75	11.55 K.W.H. $0.346	$0.167	$0.205	$1.468
7.5	Grinding barley	30 trials 1930	37,081 lbs. 18.54 tons	39 hrs. 35 min. 1 man part time[1]	289 K.W.H.	937 lbs. 0.468 tons	2.13 man hrs. $0.85	15.58 K.W.H. $0.467	$0.384	$0.29	$1.991
5	Grinding barley	4 trials 1927	5,272 lbs. 2.63 tons	6 hrs. 8 min. 1 man	23 K.W.H.	860 lbs. 0.43 tons	2.33 man hrs. $0.93	8.74 K.W.H. $0.262	$0.418	$0.183	$1.693
10	Grinding chopped alfalfa[2]	2 trials 1927	3,835 lbs. 1.91 tons	2 hrs. 37 min. 2 men	31 K.W.H.	678 lbs. 0.339 tons	1.36 man hrs. $0.54	16.2 K.W.H. $0.486	$0.531	$0.651	$2.208

[1]Semi-automatic.
[2]One-fourth inch screen perforation.

FEED GRINDING AND FORAGE PROCESSING

Grinding Equipment

Manufacturer: I. B. Rowell Co.
Type: Swinging Hammer.
Screen: ¼-inch perforation.

Name: "Whip-it No. 1."
Size: 13¾-inch diam., 16-inch length.
Elevator: Blower. Speed: 3,000 r.p.m.

Motor H.P.	Operation and Material	No. of Trials and Date	Weight in Pounds and Tons	Time Required and Crew	Energy Consumption	Rate of Grinding, lbs. and tons per hr.	Average Cost Per Ton				
							Labor at $0.40 per hr.	Energy at $0.03 K.W.H.	Mill	Motor	Total
5	Grinding barley	20 trials 1928-1929	76,980 lbs. 38.49 tons	100 hrs. 33 min. 1 man part time[1]	401 K.W.H.	765.58 lbs. 0.382 tons	2.61 man hrs. $1.044	10.418 K.W.H. $0.31	$0.141	$0.206	$1.701
3	Grinding barley	2 trials 1927	171.5 lbs. .0857 tons	23 min. 1 man	0.9 K.W.H.	439.6 lbs. 0.219 tons	4.55 man hrs. $1.82	10.5 K.W.H. $0.315	$0.246	$0.191	$2.572
5	Grinding chopped alfalfa	1 trial 1927	2,250 lbs. 1.12 tons	2 hrs. 46 min. 1 man	11 K.W.H.	815.2 lbs. 0.407 tons	2.46 man hrs. $0.984	9.82 K.W.H. $0.294	$0.132	$0.194	$1.604
5	Grinding beans	1 trial 1928	2,100 lbs. 1.05 tons	3 hrs. 9 min. 1 man	9 K.W.H.	666.66 lbs. 0.333 tons	3 man hrs. $1.20	8.57 K.W.H. $0.257	$0.162	$0.237	$1.856

[1]Semi-automatic.

FEED GRINDING AND FORAGE PROCESSING

Chopping Equipment

Manufacturer: International Harvester Co.
Type: E. Fly-wheel, 3-knife.
Length of Cut: ½-inch.

Name: "McCormick-Deering."
Size: 11x5½=60.5 sq. in., throat 16½ in. length.
Elevator: Blower. Speed: 655 r.p.m.

Motor H.P.	Operation and Material	No. of Trials and Date	Weight in Pounds and Tons	Time Required and Crew	Energy Consumption	Rate of Grinding, lbs. and tons per hr.	Average Cost Per Ton				
							Labor at $0.40 per hr.	Energy at $0.03 K.W.H.	Mill	Motor	Total
5	Chopping alfalfa hay	4 trials 1929	10,110 lbs. 5.05 tons	10 hrs. 43 min. 2 men	23.5K.W.H.	944.8 lbs. 0.472 tons	4.23 man hrs. $1.692	4.65 K.W.H. $0.139	$0.936	$0.165	$2.932
10	Chopping alfalfa hay	3 trials 1927	10,445 lbs. 5.22 tons	5 hrs. 15 min. 2 men	56 K.W.H.	1,989.5 lbs. 0.994 tons	2.01 man hrs. $0.804	10.72 K.W.H. $0.3216	$0.444	$0.221	$1.79
Tractor 10-20	Chopping alfalfa hay	4 trials 1929	11,745 lbs. 5.87 tons	9 hrs. 43 min. 2 men	78.67 lbs. gasoline	1,209.5 lbs. 0.604 tons	3.307 man hrs. $1.322	13.4 lbs. gas $0.402	$0.731	$0.365	$2.82

FEED GRINDING AND FORAGE PROCESSING

Chopping Equipment

Manufacturer: Gehl Brothers Co.
Type: A. Fly-wheel, 2- or 3-knife.
Length of Cut: ½-inch.

Name: "Gehl".
Size: 10x4¾=47½ sq. in., throat 13 in. length.
Elevator: Blower. Speed: 530 r.p.m.

Motor H.P.	Operation and Material	No. of Trials and Date	Weight in Pounds and Tons	Time Required and Crew	Energy Consumption	Rate of Grinding, lbs. and tons per hr.	Average Cost Per Ton				
							Labor at $0.40 per hr.	Energy at $0.03 K.W.H.	Mill	Motor	Total
5	Chopping alfalfa hay	1 trial 1928	2,620 lbs. 1.31 tons	3 hrs. 2 men	9 K.W.H.	873.3 lbs. 0.436 tons	4.58 man hrs. $1.832	6.87 K.W.H. $0.206	$0.518	$0.181	$2.737

mental feeding work carried on under the direction of the Department of Animal Husbandry.[1] The lamb feeding investigations are reported in detail in the Experiment Station Bulletin No. 176.[2]

A summary of the lamb feeding work based on the data in this bulletin is given as follows:

SUMMARY OF LAMB FEEDING
Feeding: 68-pound Feeder Lambs
1927-1928 1928-1929
Two-Year Average
(Whole barley fed with alfalfa hay)

	Whole Hay	Chopped Hay	Ground Hay
Average daily gain	.28 lbs.	.27 lbs.	.271 lbs.
Average daily ration (hay)	3.10 lbs.	2.44 lbs.	1.97 lbs.
Average hay consumed	2.16 lbs.	2.08 lbs.	1.94 lbs.
Per cent of hay wasted	30.1 %	13.8 %	1.8 %
Hay required to produce 100 lbs. gain	1104.6 lbs.	911.3 lbs.	742.1 lbs.

The comparison made of the long hay versus chopped, and ground hay is summarized by the investigators as follows:[3]

"For fattening lambs, the preparation of alfalfa hay by chopping or grinding is an operation that has its greatest value through the reduction of refused hay. Where livestock is being 'roughed' through the winter, hay refused by fattening lambs can be utilized. The average of two years' results comparing long, chopped, and ground hay shows that with the finer preparations the amounts of refused hay are correspondingly decreased. . . . Lots fed on long hay refused 30.1 per cent, chopped hay 13.8 per cent, and ground hay 1.8 per cent. . . . Another factor in favor of chopped or ground hay is the ease with which it may be handled.

"The results show that chopping or grinding hay does not increase the amount of hay actually consumed by the lamb. After deducting the amount of waste hay from the total, the amount consumed per lamb is: long hay, 2.16 pounds per day; chopped hay, 2.08 pounds per day; ground hay, 1.94 pounds per day. When it is desirable to feed large amounts of hay, and the waste hay can be used by other livestock, there may be an advantage in long hay. Average daily gains made by lambs are not increased by chopping or grinding. The amount of hay required for 100 pounds gain is lowered, but due to the cost of chopping and grinding, the total cost of producing 100 pounds gain is not materially affected, except in the case of high priced hay."

The comparative value of chopped and whole hay for feeding steers also has been investigated at the Station farm by the same group. During the period 1919 to 1925 between two to five carloads of steers

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[1] R. F. Johnson is Assistant Animal Husbandman with the Experiment Station. E. F. Rinehart is Extension Animal Husbandman and Associate Animal Husbandman with the Experiment Station. C. W. Hickman is Animal Husbandman with the Experiment Station. The Caldwell Substation, under the general supervision of Superintendent D. A. Stubblefield, provided the feed and other facilities for animal feeding investigations. Grinding and power equipment was provided at the Caldwell Substation through the cooperation of the Idaho Committee on the Relation of Electricity to Agriculture and the Department of Agricultural Engineering.

[2] Lamb Feeding Investigations, University of Idaho, Agricultural Experiment Station, Department of Animal Husbandry, Bulletin No. 176, February, 1931, by R. F. Johnson, E. F. Rinehart, and C. W. Hickman.

[3] Quoted from Agricultural Experiment Station Bulletin No. 176, Lamb Feeding Investigations.

have been fed each year. The experimental rations employed have included whole and chopped hay alone and a combination of grain and silage with the whole and chopped hay.

A SUMMARY OF ALL CATTLE FED[1]
Caldwell Substation
1919 to 1925
Six-Year Average
(Alfalfa hay supplemented with varying silage and grain rations)

	Whole Hay	Chopped Hay	Saving by Chopped Hay
Average daily gain	1.51 lbs.	1.63 lbs.	Gain 4.2%
Average hay fed per 100 lbs. gain	2038.00 lbs.	1759.00 lbs.	Hay 16 %
Average silage fed per 100 lbs. gain	1022.00 lbs.	869.00 lbs.	Silage 18 %
Average grain fed per 100 lbs. gain	315.00 lbs.	321.00 lbs.	Grain 9 %

During the period of the feed grinding work the experimental feeding of steers has included the comparison of whole, chopped and ground hay, fed alone and the same rations supplemented with barley.

A SUMMARY OF FEEDING TWO-YEAR-OLD STEERS[2]
Caldwell Substation
1926-1927 1927-1928 1928-1929
Three-Year Average
(Whole barley fed with alfalfa hay two years, alfalfa hay fed alone one year)

	Whole Hay	Chopped Hay	Ground Hay
Average daily gain	1.57 lbs.	1.82 lbs.	1.87 lbs.
Average daily ration (hay)	23.453 lbs.	23.05 lbs.	23.60 lbs.
Average hay consumed	21.07 lbs.	22.07 lbs.	23.60 lbs.
Per cent of hay wasted	10.3 %	4.6 %	0.0 %
Hay required to produce 100 lbs. gain	1613.00 lbs.	1339.00 lbs.	1057.00 lbs.

The average daily gain for the chopped and ground hay was one-fourth pound greater during the three years than the daily gain for the whole hay. Owing to the wastage of 10.3 per cent for the whole hay, 4.6 per cent for the chopped hay, and 0 per cent for the ground hay, the lots receiving the chopped hay consumed one pound of hay per day more than the lots receiving whole hay.

The difference between the chopped hay and ground hay consumption was 1½ pounds in favor of the latter. Hay required per 100 pounds of gain gave a difference of 556 pounds between the ground hay and whole hay; 274 pounds between the chopped hay and whole hay; and 322 pounds between the ground hay and chopped hay.

When the chopped or ground hay was fed alone it was found that there was a superior finish as well as an increase in gain and a reduction in the amount of feed required per 100 pounds of gain. The most economical gain is credited to the chopped hay, owing to the greater cost of grinding.

Relative to the feeding of chopped and ground hay, R. F. Johnson, in charge of the experimental feeding work at the Station, stated:[3]

[1]Based on data furnished by the Department of Animal Husbandry.
[2]Based on data furnished by the Department of Animal Husbandry.
[3]Forage Processing and Experimental Feeding Results. Paper given by R. F. Johnson at the Rural Electrification Short Course, University of Idaho, January 17, 1931.

"Precautions necessary in feeding chopped and ground hay include care to be used in changing from long hay to either of these other forms. Animals very often are subject to bloat and impaction and the hay should therefore be fed sparingly and at frequent intervals until the animals are accustomed to the new preparation. In chopping hay it is also essential that the hay should be dry and that the chopping or grinding be done in dry weather. Any wet hay chopped in a pile and covered over will usually spoil and becomes unfit for feed."

One of the objections to the use of chopped hay and ground hay is the cost of preparation. The lowest costs obtained for the trials reported were $1.60 per ton for grinding chopped alfalfa with a 5-horsepower motor unit, and $1.79 per ton for chopping alfalfa hay with a 10-horsepower motor. These values give a total of $3.39 for the ground hay as compared with the custom rate of $3.00 per ton. With improved equipment the double labor charge could be reduced, thereby bringing the total cost of the farm operation below the custom charge.

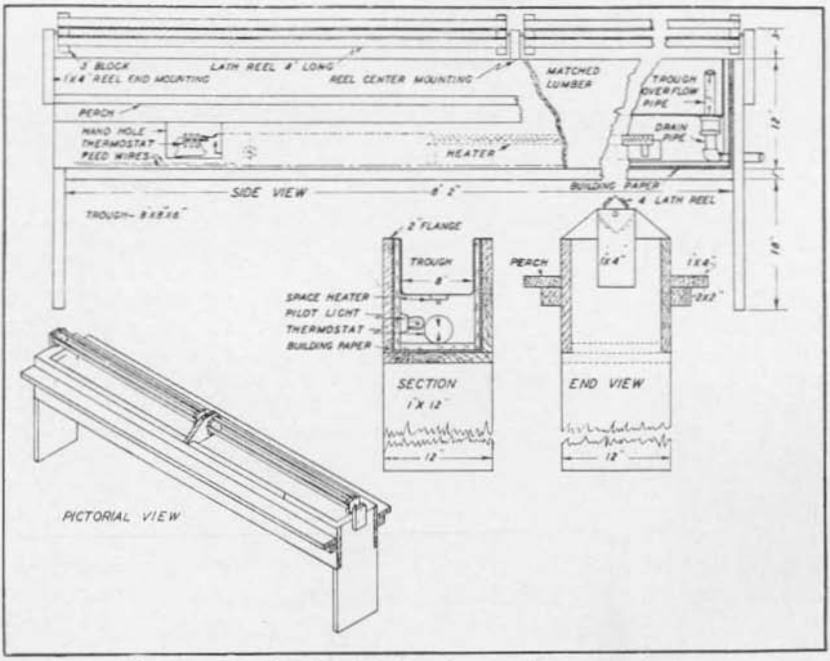
The costs for chopping alfalfa hay varied from $1.60 to $2.90 per ton with the 5-horsepower unit. This wide variation is due chiefly to the difference in the hay being chopped and the condition of the cutter. It should be noted that the labor charge attributed to the chopping operation is the greatest single item of cost and could be materially reduced if a system could be worked out whereby the chopping is a part of the harvesting operation. The problem to be solved is the development of economical equipment with sufficient capacity to handle the hay as it comes from the field.

Stock Tank and Poultry Water Heaters

The heating of stock and poultry drinking water during the winter months is considered a necessity, especially for fattening livestock, for dairy cattle, and for high producing flocks.

One of the outstanding applications of electricity to poultry water heating has been made by Loy H. Lee of Middleton, Idaho. Mr. Lee used a galvanized trough 8 feet long, 8 inches wide, and 6 inches deep with a 2-inch flange around the top edge. One 345-watt space heater, controlled by means of a thermostat that had been discarded for incubator use, was placed in an air-tight box underneath the trough which just filled the upper part of the box. The construction of this box and trough is clearly shown in the drawing. An overflow drain was provided in one end of the trough by means of a screw-in pipe, which when removed permitted easy cleaning. A great deal of time and labor could be saved by providing the water supply through an automatic float valve.

Trials were made to determine at which temperature the most water would be consumed with the most satisfactory resulting egg production. It was found that for the first few days more water was used at 50° F. than when the trough was maintained at 40° F.; but when the birds became accustomed to the warm water the consumption dropped back to the same amount consumed at the lower temperature. For this reason it was decided that there was little advantage in maintaining the drinking water at above 40°F., inasmuch as there was no apparent

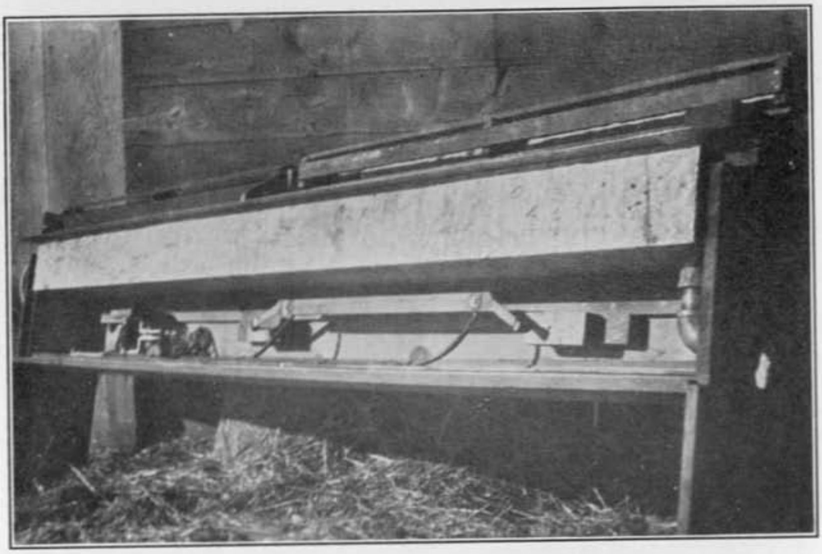


Construction details of the Lee type poultry water heater

effect on the egg production from the flocks. A comparison of the pens receiving water between 40° and 50° F. and the pens receiving water in which ice was allowed to form gave an egg production record of 20 per cent increase in favor of the pens receiving the warm drinking water.

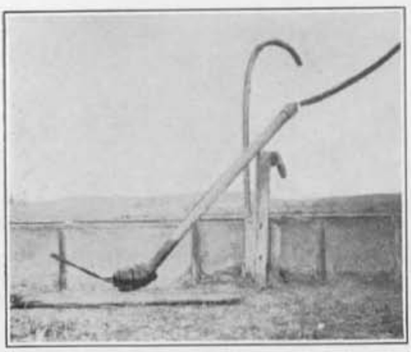
View of poultry water heater installation

An average of 15 gallons of water was consumed per day where the temperature of the drinking water was maintained at between 40° and 50° F. This was 20 per cent more than the same flock required when the water was allowed to remain at a freezing temperature. During the days that the temperature of the poultry house averaged 18° F. the heating element was required to operate 20 hours out of every 24 in order to keep the drinking water at the required temperature. The average energy consumption for a 30-day period was 3 kilowatt hours per day. A maximum of 6 kilowatt hours per day was used during the coldest weather (room termperature 18° F.). The advantage of the thermostatic control, as used in connection with this poultry water heater, is that the temperature of the drinking water never exceeds 50° F., even though the water in the trough were lowered to within an inch or less of the bottom. This is not the case when the



Showing poultry water heater with the side of the box removed

small stove type water heater is used, for as the amount of the water decreases, the temperature rises until rapid evaporation occurs and there is danger of having the drinking water too warm. If the humidity in the poultry house is increased as a result of the drinking water being maintained at too high a temperature, excessive dampness may occur to the extent of being detrimental to the flock. The disadvantage of the thermostat is the additional expense which makes its use impractical except on the large watering troughs.



Original stock tank water heater at the Aberdeen Substation

For the small pans or pails, the immersion or clamp-on heaters are more convenient. If these heaters are to be used in connection with insulated pails or troughs, a 100-watt element will prove satisfactory for maintaining four to five gallons of water at a temperature increase over the atmosphere of approximately 40° F. This means that for the very cold weather, less water can be handled by a given heating element if the 40° to 50° F. range is to be maintained.

An early application of stock tank water heating by means of elec-

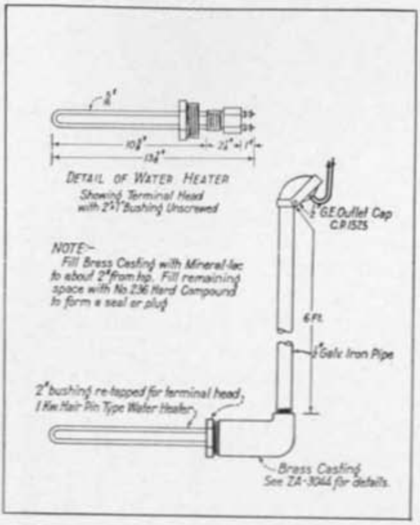


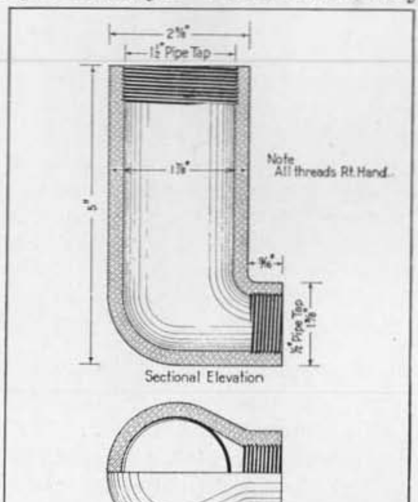
Diagram of immersion type stock tank heater

trical equipment occurred on the Aberdeen Substation of the Agricultural Experiment Station of the University of Idaho. Mr. A. E. McClymonds, Superintendent of the Substation farm, reports that the first installation was made in 1925 with a 750-watt immersion type heater. This heater was used in a 250-gallon galvanized stock tank for heating between 100 and 125 gallons per day in the fattening lamb pens during the winter months. For a 12 months' record of this stock tank water heating installation, the average energy consumption per month was 256.75 kilowatt hours, during which time it was estimated that 40,000 gallons of water was kept well above freezing temperature.

The water tank in which this heater was used supplied the lamb feeding unit on the experiment station farm, and in regard to the satisfaction secured from the service rendered by the equipment, Mr. McClymonds says: "I think it is a very successful method of heating water and the lambs certainly appreciate the warm water; in addition it also saves a lot of chopping of ice, which is necessary where no water heater is used."

There has been sufficient interest since the first installation of the immersion stock tank heater, which was made up of standard pipe fittings, to warrant the manufacturing of a special fitting, which is shown in the detailed drawings.

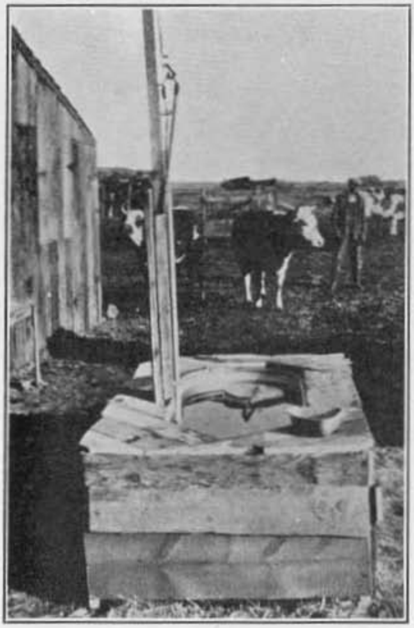
It has been possible, by the use of a single brass casting, to reduce the cost of the installation and decrease the danger of short circuits due to leakage of the pipe fittings formerly employed. The space within the brass casting has also been sealed with a special insulating compound which aids in forming a water-proof seal.



Sectional view of brass casting used for improving stock tank heater

It is recommended, where the heaters are installed in galvanized iron tanks, that the tank be grounded, and that the feed wires to the heater circuits be protected from injury by the livestock.

ELECTRICITY IN POULTRY PRODUCTION



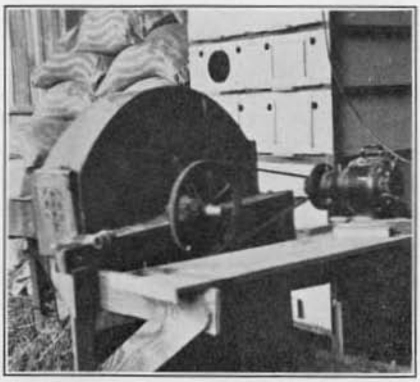
Installation of stock tank heater and insulated tank

Electrical aids in poultry production have a wide influence on the development of the poultry industry in southern Idaho. Lighting, incubation, brooding, water heating, and feed preparation are a few of its many uses which contribute to a saving of human labor and a lowering of production costs.

The use of electricity for lighting farm flocks in Idaho is important because in this latitude the short days are unfavorable to egg production. Longer days during the late fall and winter induced by the use of artificial lighting will mean greater feeding by the laying flock and result in an increased egg production.

Recommendations for lighting equipment and schedules appear in Extension Bulletin No. 75, Housing Farm Poultry.[1]

"The use of a 100-watt lamp and a steel enamel reflector designed for a 60-watt lamp, . . . gives a combination that places the lamp bulb far enough below the rim of the reflector to allow the light to spread into the far corners of the the house. The use of the higher wattage lamps produces more than double the intensity of light, due to the higher efficiency of the large lamps and means that the cost of operation is less in proportion to the amount of light secured. Tests show that reflectors concentrate the light to the floor area where it is most effective and that the use of the standard commercial equipment, known as the R.L.M. Dome Reflector, is a paying investment."



Small motors reduce labor and save time for the busy poultry man

In regard to the lighting schedule the following recommendation is made:[2]

"Lighting in the morning is one of the simplest and most com-

[1]The manuscript and drawings for this bulletin were prepared by Pren Moore, Poultry Specialist in the Extension Division; C. E. Lampman, Professor of Poultry Husbandry and Poultry Husbandman of the Experiment Station; Frank E. Moore, Assistant Poultry Husbandman of the Experiment Station; Hobart Beresford, Professor of Agricultural Engineering and Agricultural Engineer of the Experiment Station.

[2]Quoted from University of Idaho Extension Bulletin No. 75. Housing Farm Poultry.

mon practices. The lighting schedule is started early in the fall and each day the use of the light extended to meet the decrease in natural daylight. The switch controlling the light circuit may be operated by means of an alarm clock or the feed wires arranged to permit the location of the switch in the poultryman's sleeping quarters or wherever it will be most convenient. Night feeding of grain is usually practiced with the early morning lighting. The disadvantage of this method lies in the fact that the birds are awakened and brought down from the roosts into the cold house.

"With morning and evening lighting it becomes necessary to provide some means of dimming the lights for the evening turn-off in order that the birds may find the roosts without confusion. This may be accomplished by means of a resistance or the use of a parallel series circuit, either of which decreases the intensity of illumination by reducing the voltage or pressure at which the electrical energy is supplied to the lamps. . . . Evening lighting alone has the advantage of a warmer house for the greater part of the bird's activity. The disadvantage is that it usually does not fit into the poultryman's schedule quite as well as the morning or twice-a-day method. The evening lunch system uses the least amount of light; however, it involves night work and the use of a dimming control.

"Regardless of the practice of lighting followed, it should be remembered that the use of the light is for the purpose of bringing the birds off of their roosts and increasing the length of their active day. The results obtained from the use of artificial light for controlling the time of the egg-producing period of the hen depend largely upon the living conditions, feeding, and management. In the use of any method of poultry lighting it is very important that any change in the schedule for lengthening or reducing the active period of the bird be limited to not more than fifteen minutes each day. If absolute regularity and consistency are not practiced in the use of lights, the endeavor becomes a dangerous experiment instead of a benefit. Poultrymen who regulate their lighting schedules according to the body weight and general physical condition of their flocks have had greater success than those who depend upon a season or clock schedule. In general light should not be used on breeding pens until after the birds have had a suitable rest between their regular production periods."

Electric incubators used by commercial and farm units vary from 50- to 15,000-egg capacity and are common in Idaho's poultry industry. Summarizing the cooperative tests made on electric incubators at the University of Idaho by the Departments of Poultry Husbandry and Agricultural Engineering,[1] it was found that in comparison the cost of heating by oil or by electricity was not materially different. In every instance the use of electricity reduced the labor costs where similar capacity incubators were compared. The total costs of operating large capacity machines were practically the same, regardless of the source of heat energy.

[1]Reported in the Second Progress Report of the Idaho Committee on the Relation of Electricity to Agriculture, by M. R. Lewis, Hobart Beresford. Tests supervised by R. T. Parkhurst, formerly Professor of Poultry Husbandry, University of Idaho.

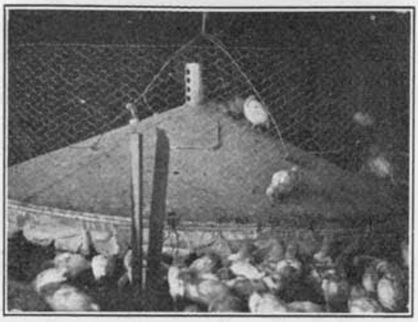
The electric machines of small capacity operated at a lower cost than the small capacity oil machines. The fertility of the eggs included in this test was of greater significance in the cost per chick hatched than the cost of the heat energy whether obtained from oil or electricity.

The electric incubators were more cleanly and safer from the standpoint of fire risk, in addition to the advantage of the saving in labor and heating energy costs.

The electric brooder is a device that makes use of heating elements which transfer heat to the chick compartment of the brooder by means of one or all three of the methods of heat transfer known as radiation, convection, and conduction. In the radiant type of brooders the elements operate at a glowing temperature, to which the chick compartment is directly exposed. The wattage required for this type of element ranges from two to three watts per chick, depending upon the climate and the protection afforded by the brooder house. The fire risk from the glow or radiant heat type is slightly greater than from the non-glow or the black heat type, especially where a combustible litter is used. The brooders which depend upon radiation from non-glowing elements are usually equipped with a low and curtained hover. Special ventilating devices are required, due to the low hover, which by necessity reduces the size of the chick compartment. The operation of this type of brooder usually costs less than the same size of glowing type. The watt capacity per chick is slightly less, being determined by the climate. The brooders which depend upon convection (that is, the movement of warm air) for the heat transfer to the chick compartment may use the glowing or non-glowing type of element, and usually heat a part or all of the incoming air.

The ventilator should be readily adapted to changes in the weather in order that the air flow may be controlled to correspond with the difference in temperature within the brooder and the brooder house. Tests show that approximately seven square inches of brooder floor area per chick should be allowed. This means that a 500-chick capacity brooder should be from 66 to 67 inches in diameter, although this recommendation varies with the breed and the age of the chick. The smaller the space required the less heat will be used, and proper ventilation will become more difficult as the area is reduced. The operation of an electric brooder should not be attempted in drafty or damp brooder houses.

The hover type of electric brooder may be suspended from the ceiling by means of a rope, two pulleys, and a sand pail or bag. If a bag is used, a close woven grain sack will be found more satisfactory than the ordinary gunny sack, because the chickens will have no trouble in picking holes in the gunny sack and letting the sand out. When the chicks are first placed under the brooder, the temperature should be regulated between 95° and 98° F., being sure that the thermometer bulb is on the level with the baby chicks when the reading is taken. A circular pen of sheet metal or hinged boards about twice the diameter of the hover will be found a convenient means of encouraging the baby chicks to find the warmth of the hover and prevent floor draft. Nearly all of the brooders are provided with lamps for the purpose of attract-



The hover type of electric brooder used in tests to determine electric brooder recommendations

ing the chick. These lamps are also of great convenience for attracting the chickens under the hover.

Brooders vary mainly in their operating costs and the dependability of operation. Well constructed and well insulated brooders which provide for adequate ventilation will in general be more satisfactory than those depending upon curtains, crowding the chicks, or restricted ventilators for their heat conservation. There are many brooders on the market that will give satisfactory results, provided they are properly operated; but with the hover type brooder the brooder house floor and protection from drafts are of utmost importance. The brooder manufacturers have provided instructions for the operation of their equipment, although circumstances may occur in the operation which are not discussed. The comfort of the chick should decide what adjustment should be made when instructions prove inadequate.

Tests were made on four electric brooders for the purpose of determining their operating characteristics under southern Idaho conditions. The brooders were operated in four shed type brooder houses formerly used with the underheat furnace type of hover. The houses were all of similar construction and design, and provided with sand floors which had been thoroughly dried out by building a fire in the underheat furnace before the tests were started.

One of the early hatches of chicks was placed under the brooders early in April. Due to receiving a higher per cent of the hatch than was expected, it was necessary to place more chickens under the large hover than were recommended by the manufacturer. The records secured indicate that for a five-week brooding period under southern Idaho conditions a maximum energy consumption of from 40 to 60 kilowatt hours per hundred chicks may be expected.

The chief advantages of the electric brooder are the reduction in labor required for caring for the chicks, due to the ease in which the hovers are raised and lowered; the relief from handling fuel, starting fires, or trimming wicks; and the decreased fire hazard. Another distinct advantage is that as soon as the chicks begin to feather out the hover may be raised and small roosts placed underneath for the purpose of training the baby chicks to roost.

Pumping for Drainage and Supplemental Irrigation[1]

In Idaho the continual application of irrigation water has made it necessary to construct extensive drainage systems to protect irrigated lands, upon which as much as the total value of the land may have been invested in water delivery systems, improvements, and preparation of the land for irrigation. In general this drainage has been attempted by the use of deep open or by closed tile drains. Since the early drains were constructed, it has become apparent that the results have not been as satisfactory as was expected. In certain sections the drainage systems have checked the rise of ground water, but the excessive application of water to the higher areas still overtaxes the natural underground and artificial drainage systems, and more areas are becoming waterlogged each year.

True conservation of water can be accomplished if the accumulation of water underneath the farm lands can be removed at a place where it can be utilized for irrigation, rather than being wasted away from the land. Pumping the excess water to the surface with deep well pumps of large capacity serves the double purpose of relieving the land of its excess ground water and at the same time providing additional water for irrigation.

The available supply of irrigation water is limited by nature and must be used more efficiently if it is to serve larger areas of land and thus extend agriculture in Idaho by means of irrigation. Drainage by artificial channels and by the natural underground means often results in a return flow on the lower reaches of the streams. This return flow is in many instances more than sufficient to irrigate the adjacent lands, while a shortage of water may exist upon the upper reaches of the streams. In addition, the water developed from the drains, as well as the water stored in the soil below the level of the drains, is not being utilized under the present system. Pumping from deep wells for the purpose of drainage and the recovery of irrigation water has the advantage of flexibility, as the wells can be placed in wet areas where their discharge may be effectively utilized and the whole system need not be installed at once. The use of the wells eliminates the unsightly open ditch which takes extensive areas of valuable lands out of production and demands a yearly expenditure for maintenance due to the caving in of the banks and the growth of vegetation.

The study of the cost, effectiveness, and methods of pumping for drainage and supplemental irrigation were undertaken to obtain further and definite information concerning the possibility of using deep wells for irrigation and drainage under Idaho conditions.

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[1]Credit is given the following men for their cooperation in this study:

W. G. Sloan, Consulting Engineer and specialist in drainage pumping, Boise, Idaho, provided data upon the logs, development, and casing of the wells, and maps of the territory in which the wells are located.

John May, Superintendent of the Pioneer Irrigation District, furnished the information relative to the operation of the pumps.

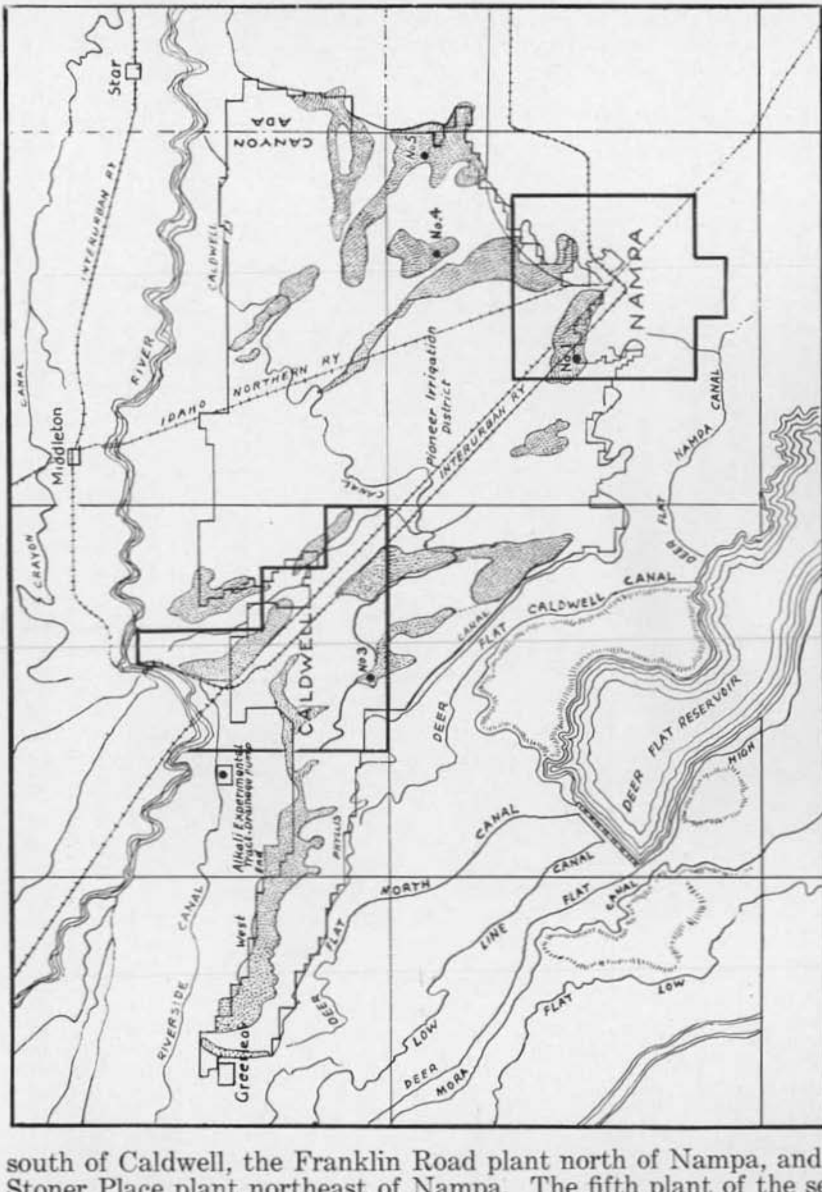
R. S. Overstreet, Agricultural Engineer for the Idaho Power Company, supplied the power cost data.

J. C. Marr, Associate Irrigation Engineer, United States Department of Agriculture, Boise, Idaho, assisted in and supervised the installation of the observation wells and the collection of much of the data.

Mark R. Kulp, Irrigationist of the Agricultural Experiment Station, University of Idaho, assisted in the preparation of the report.

E. H. Neal, formerly Irrigationist of the Agricultural Experiment Station, University of Idaho, assisted in the preparation of the report.

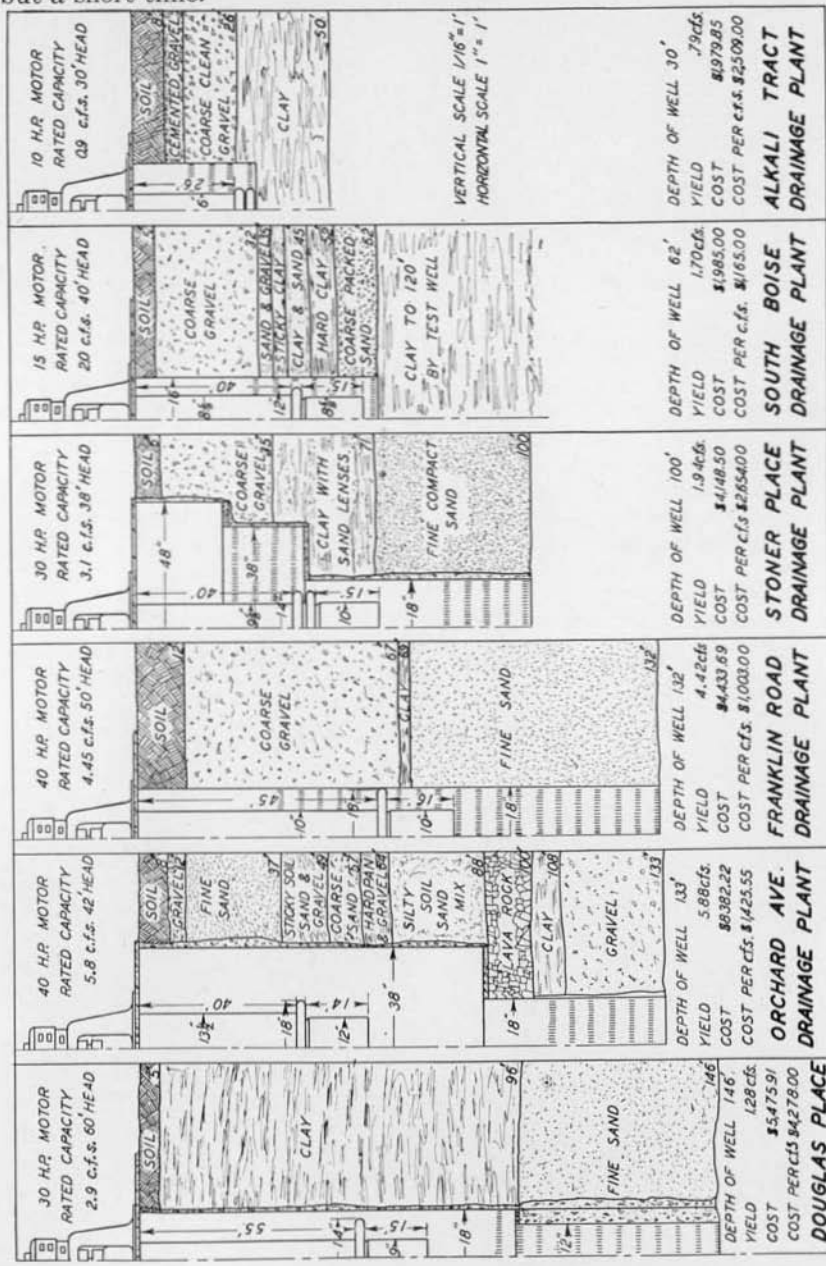
Six deep well drainage plants were studied during the season of 1929. These included four plants of the Pioneer Irrigation District, namely the Orchard Avenue plant west of Nampa, the Douglas Place plant



Map Showing Location of Drainage and Waterlogged Areas in the Pioneer Irrigation District[1]

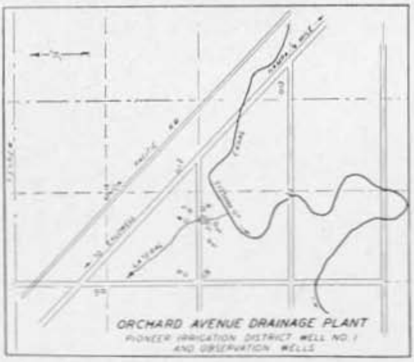
[1] Map by W. G. Sloan and John May, 1928.

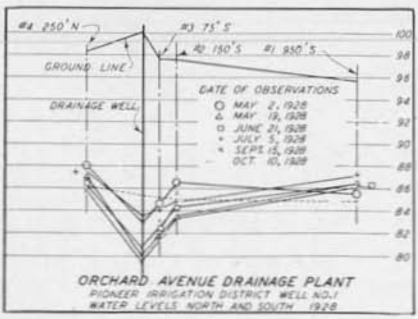
south of Caldwell, the Franklin Road plant north of Nampa, and the Stoner Place plant northeast of Nampa. The fifth plant of the series was the South Boise plant of Ada County Drainage District No. 3 located in South Boise. The sixth well was the drainage plant located upon the alkali reclamation tract west of Caldwell upon which studies are being made by the Agricultural Experiment Station of the University of Idaho and the United States Department of Agriculture. This plant was included in the studies although it had been in operation but a short time.

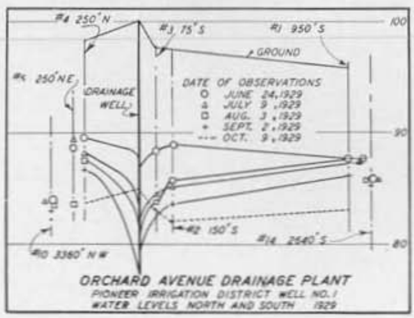


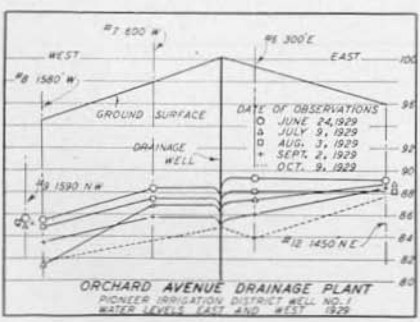
Pump and Well Data

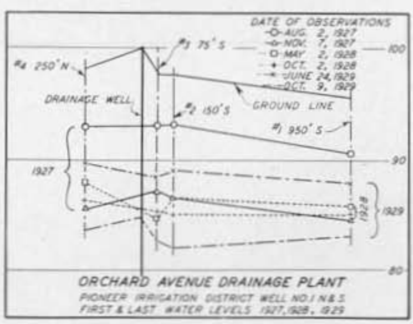
Observation wells for the measurement of changes in the ground water level were installed in May, 1929, by placing two lines of wells at right angles through each of the pumping plant locations. These wells were placed approximately one hundred feet, two hundred feet, six hundred feet, twelve hundred feet, twenty-two hundred feet, and forty-five hundred feet from the plants. An observer measured and recorded the depth of ground water each month. Each of the pumping plants, except the one in South Boise, was equipped with water measuring devices from which the discharge was recorded whenever the observer visited the plant. The discharge of the South Boise plant was determined by the aid of a current meter. The horsepower input to the pump motors, the kilowatt hours of electrical energy used, and the costs were obtained from the Idaho Power Company. The kilowatt demand was graphically recorded for the Orchard Avenue plant. For the other plants the kilowatt demand was taken by the Idaho Power Company as the rated horsepower of the motor and was necessarily taken at that value in the calculation of the hours of operation of each plant. The depreciation upon the plants was figured at 5 per cent and the interest at 6 per cent of the total cost.











ORCHARD AVENUE DRAINAGE PLANT
No. 1 of the Pioneer Irrigation District

The Orchard Avenue drainage plant, located about one mile west of Nampa, was the first drainage well installed in the Boise valley. This well was constructed under contract for the Pioneer Irrigation District in the fall of 1927. The plant was operated from May 1 to October 1 for the season of 1929. During one time, when the water was not needed for irrigation purposes, the pump was not operated for 84 hours; and at another time it remained shut off for 92 hours due to power line difficulties. No stops were made for repairs and no special attendant was required.

POWER COSTS FOR THE ORCHARD AVENUE DRAINAGE PLANT

Season of 1927—100-H.P. Motor

Date	K.W.H.	Net
August 6-September 19	10,180	$ 208.55
September 19-October 1	45,650	705.70
TOTAL	55,830	$ 914.25

Season of 1928—40-H.P. Motor

Date	K.W.H.	Demand H.P.	Net
May 1-May 22	7,500	40	$ 119.15
May 22-June 23	24,100	40	241.00
June 23-July 23	23,500	40	238.00
July 23-August 21	22,448	45	242.50
August 21-September 24	27,440	45	267.45
September 24-October 1	4,704	45	53.90
TOTAL	109,692		$1,162.00

Season of 1929—40-H.P. Motor

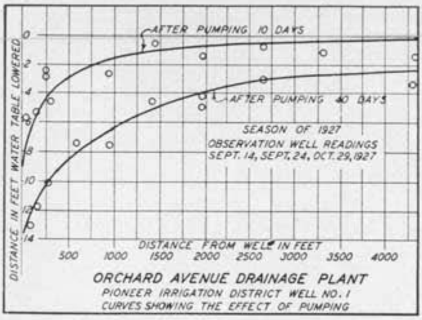
Date	K.W.H.	Demand H.P.	Net
May 17-June 21	21,360	45	$ 253.85
June 21-July 19	23,632	47	252.30
July 19-August 20	23,520	48	253.70
August 20-September 19	24,416	48	258.20
September 19-October 21	19,760	39	217.35
TOTAL	112,688		$1,235.40
Less Tax Exemption			209.19
Net Cost			$1,026.21

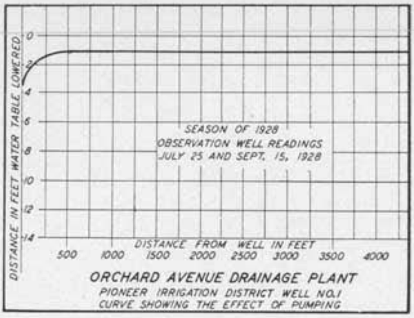
The equipment used in 1927 was deemed unsuitable and was replaced in May, 1928, by the present pump and a 40-horsepower motor. On the basis of an estimated yield[1] of 1,466 acre feet for the 1929 season, the power cost of $0.70 per acre foot was obtained.

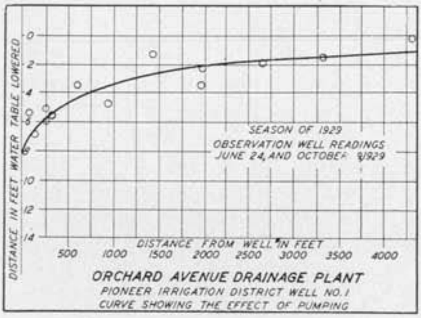
The drainage effect produced by the operation of the Orchard Avenue plant during the 1927 season is shown graphically by means of two curves which have been plotted from data obtained from the tables of observation well readings made on September 14, September 24, and

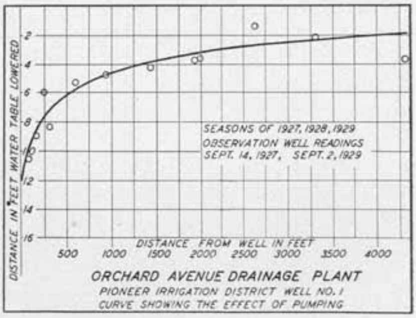
[1] The estimated yield of 1,466 acre feet is based upon an over-all plant efficiency of 47.8 per cent. Pumping plant tests were made in September, 1930.

Orchard Avenue plant during efficiency tests made in 1930









October 29 of that year. These curves represent the effect of 40 days of continuous operation of the plant. The first curve shows the distance in feet the ground water was lowered during the first ten days of the run. The second curve indicates that the water table was lowered about three feet at a maximum distance of 4,300 feet from the well at the end of 40 days of pumping. Similar data for the 1928 season show that for a continuous operating period from July 25 to September 15 the water table was lowered from one to two feet at an average distance of 300 feet from the well.

During the 1929 season the pumping plant was operated from May 1 to October 1. The first observation well readings were made on June 24 and the last on October 9. Data obtained from these readings have been used for plotting the curve showing the distance in feet the ground water was lowered during 1929. At an average distance of 1,500 feet from the well the ground water was lowered from two to three feet.

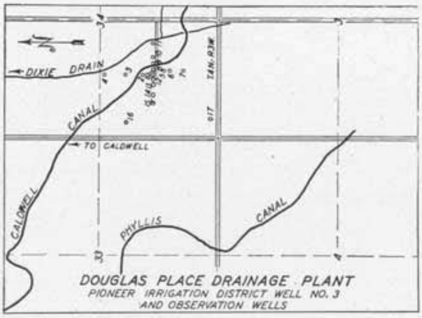
A curve has been prepared showing the accumulative drainage effect as indicated by the observation well readings made on September 14, 1927, and September 2, 1929. The drainage effect produced by the three seasons' pumping has been satisfactory. The water table was substantially lowered over an area of 640 acres and slightly decreased over an additional 640 acres during the 1928 and 1929 pumping seasons. This has been done at a lower first cost than would have been required for the construction of a system of gravity drains to protect the same area, and in addition at least half of the area has been more effectively drained. In addition to the drainage benefit, the water pumped has been used for irrigation purposes.

Douglas Place Drainage Plant

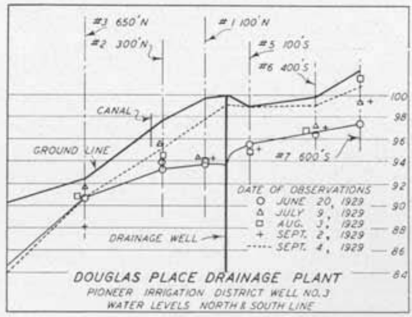
No. 3 of the Pioneer Irrigation District

The Douglas Place drainage plant of the Pioneer Irrigation District is located south of Caldwell on the South Tenth avenue road. This well was constructed during the spring of 1928 and was drilled without putting down a test hole, with the result that the size and type of casing is not suited to the underground conditions. The well as first constructed had an 18-inch stovepipe type casing sunk to a depth of 203 feet with the following log: soil, 0 to 5 feet; clay, 5 to 96 feet; fine sand, 96 to 146 feet; and clay from 146 to 203 feet. The casing collapsed at the 132-foot level, but was later cleared and 50 feet of shop perforated 12-inch casing was installed above the 146-foot level, below which the well is now sanded up. A hole was bored along the side of the 18-inch casing and an attempt was made to develop a gravel wall by feeding down ¼- to 1½-inch gravel. Thirty-five cubic yards of gravel were used in 1928, to which six cubic yards were added during 1929. The output of the well has been increased by this operation and by continuous pumping from 0.6 to 1.3 cubic feet per second.

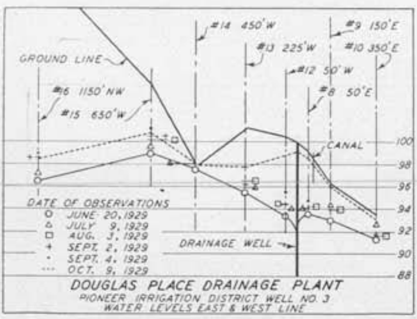
This plant was in operation from the 22nd of January until the 1st of October, 1929. The first cost and the cost of operation are both excessive, as the construction and development of the well has been expensive due to the experimental work required. The use of a large capacity pump and the resulting drawdown of 60 feet effects the cost of operation. The yield of this well has been 1.3 cubic feet per second. The amount of water removed during the period of operation is estimated at 603 acre feet. A curve showing the distance the water table was lowered between November 20, 1928, and September 4, 1929, indicates that there is a slight reduction in the ground water table over an area of about 35 acres. After closing the plant down on October 1, the ground water rose rapidly to the surface both at the well and throughout the entire area.



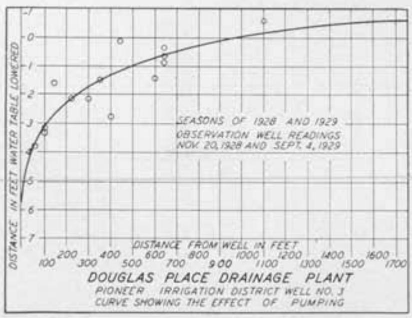
DOUGLAS PLACE DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO. 3 AND OBSERVATION WELLS



DOUGLAS PLACE DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO. 3
WATER LEVELS NORTH & SOUTH LINE



DOUGLAS PLACE DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO. 3
WATER LEVELS EAST & WEST LINE



DOUGLAS PLACE DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO. 3
CURVE SHOWING THE EFFECT OF PUMPING

These results indicate that deep-seated artesian water underlies the area and is responsible for the waterlogged condition and the poor drainage effect. The possibility of relieving this condition by drainage pumping is suggested by the results obtained thus far, and indications are that a more continuous operation of the plant would further relieve the artesian pressure.

The original 18-inch well yielded a large stream of water until the casing collapsed. After the 12-inch casing was inserted, the annular space between the two casings undoubtedly became packed with sand and the resulting double-cased, sand-packed condition reduced the efficiency of the well until its yield was reduced to 0.6 second feet with more than a 60-foot drawdown. The increase in yield which occurred as gravel was fed down along the side of the outer casing is believed to show the suitability of the gravel-wall principle to this condition, but there appears to be no remedy for the faulty casing of the present well. It is concluded that a new well of the gravel-wall type will yield sufficiently under these conditions to relieve the artesian pressure and that the drawdown will be much less than at present.

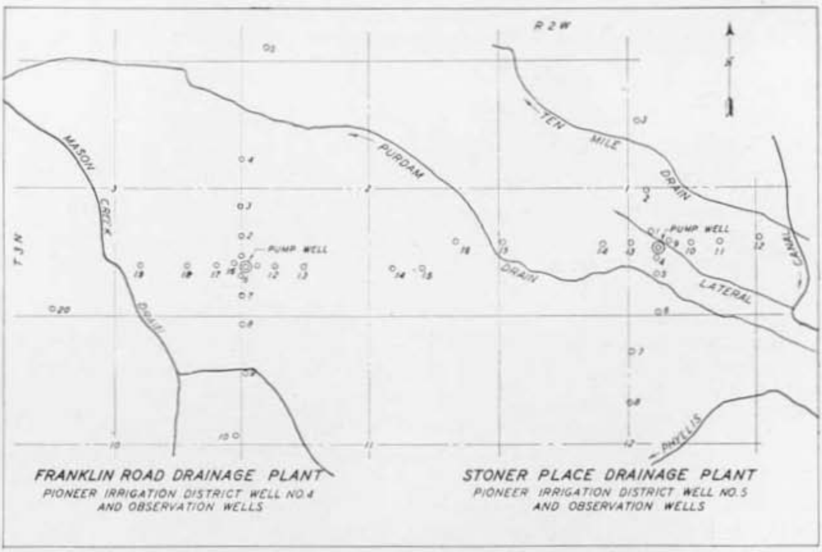
POWER COSTS FOR THE DOUGLAS PLACE DRAINAGE PLANT

Season of 1928—30-H.P. Motor

Date	K.W.H.	Demand H.P.	Net
May 11-May 21	30	30	$ 22.60
May 21-June 21	430	30	70.00
June 21-July 20	2,200	30	84.25
July 20-August 9			
August 9-October	Equipment moved to Nampa		
October-November			
November 17-December 21	11,430	30	111.15
TOTAL	14,090		$ 288.00

Season of 1929—30-H.P. Motor

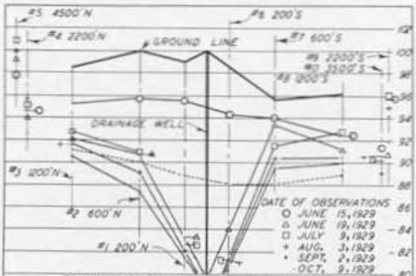
Date	K.W.H.	Demand H.P.	Net
January 22-February 22	12,560	30	$ 116.80
February 22-March 22	11,470	30	111.35
March 22-April 22	13,560	30	121.80
April 22-May 22	13,610	30	122.05
May 22-June 24	16,300	30	135.50
June 24-July 20	12,610	30	164.05
July 20-August 21	13,070	30	166.35
August 21-September 20	10,050	30	151.25
September 20-October 22	3,880		93.40
TOTAL	107,110		$1,182.55
Less Tax Exemption			$ 198.85
Net Cost			$ 983.70



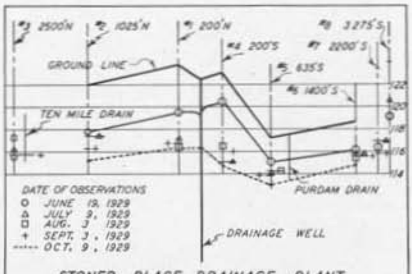
FRANKLIN ROAD DRAINAGE PLANT

No. 4 of the Pioneer Irrigation District

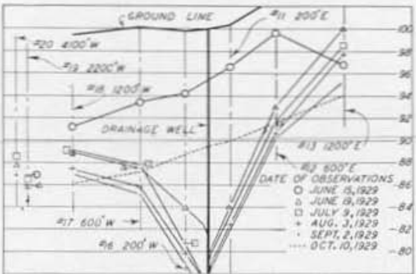
The Franklin Road drainage plant is located on the Franklin Road two miles north of Nampa. The well was drilled during 1928 and is equipped with a stovepipe type casing. The cost of power per acre foot pumped at this plant is somewhat higher than for the Orchard Avenue plant due to the higher lift required to deliver the water to a nearby irrigation ditch. The results from drainage have been fair, but the excessive use of irrigation water has complicated the determination of the drainage effect. The amount the water table was lowered between June 15 and September 2, 1929, has been shown graphically by the curve plotted from the data obtained from the observation well readings. At a distance of 1,200 feet from the well, a 4-foot decrease in the water table is shown.



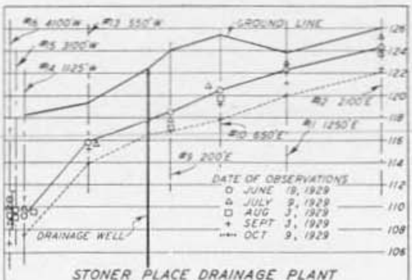
FRANKLIN ROAD DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO.4
WATER LEVELS NORTH & SOUTH LINE



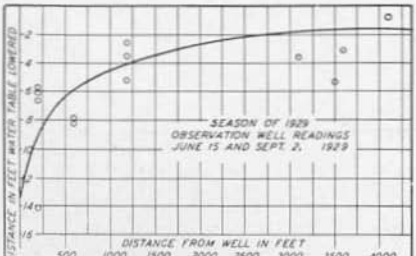
STONER PLACE DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO.5
WATER LEVELS, NORTH & SOUTH LINE



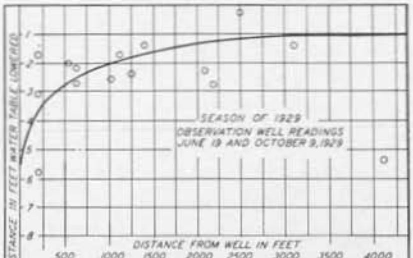
FRANKLIN ROAD DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO.4
WATER LEVELS EAST & WEST LINE



STONER PLACE DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO 5
WATER LEVELS EAST & WEST LINE



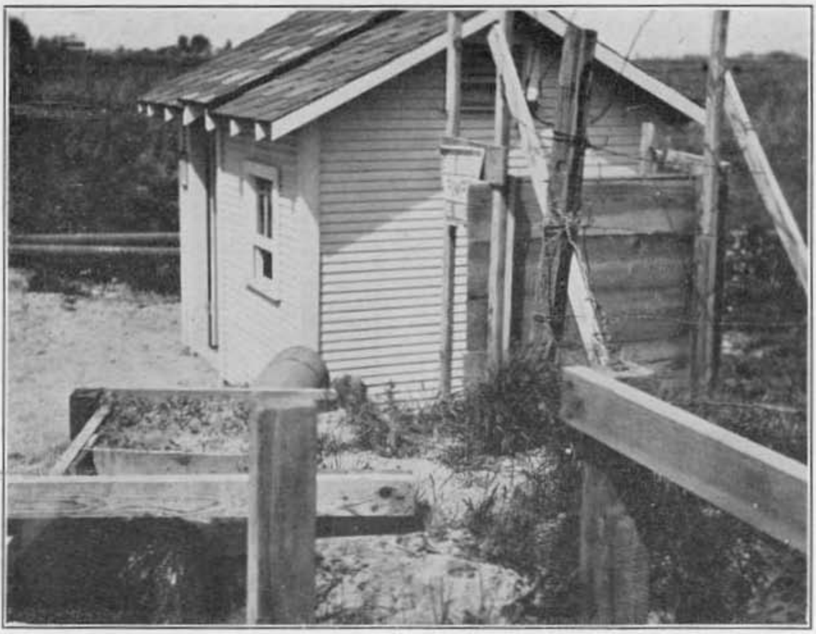
FRANKLIN ROAD DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO.4
CURVE SHOWING THE EFFECT OF PUMPING



STONER PLACE DRAINAGE PLANT
PIONEER IRRIGATION DISTRICT WELL NO.5
CURVE SHOWING THE EFFECT OF PUMPING

The discharge of this plant varies, according to the Sparling acre foot meter, from 4.11 to 4.44 second feet. The high discharge is probably correct, since temporary cut-offs of power may account for the lower yields. The discharge for the season of 1928 was calculated at

4.42 second feet. The lift was not determined during 1929, due to the absence of an air line. The lift during 1928 was measured as 45 feet, which includes an extra lift of about 5 feet from the pump to the ditch.



The Franklin Road drainage plant showing discharge pipe

POWER COSTS FOR THE FRANKLIN ROAD DRAINAGE PLANT

Season of 1928—40-H.P. Motor

Date	K.W.H.	Demand H.P.	Net
July 21-August 17	20,630	40	$ 214.70
August 17-September 22	22,880	40	234.90
September 22-October 1	5,825	40	65.25
TOTAL	49,335		$ 514.85

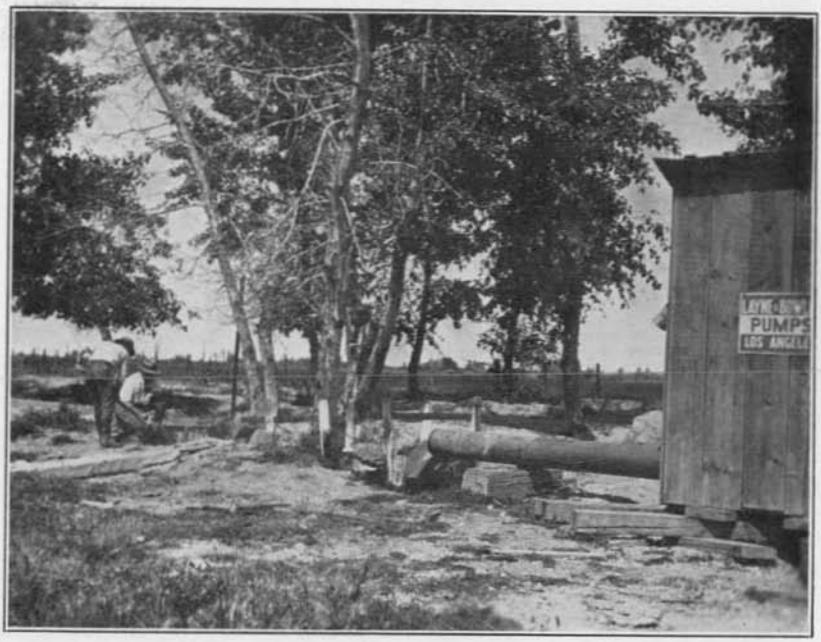
Season of 1929—40-H.P. Motor

Date	K.W.H.	Demand H.P.	Net
May 17-June 20	17,300	40	$ 226.45
June 20-July 20	19,650	42	222.65
July 20-August 20	22,350	40	232.25
August 20-September 20	22,140	40	231.20
September 20-October 1	7,140	40	74.60
TOTAL	88,580		$ 987.15
Less Tax Exemption			164.45
Net Cost			$ 822.70

Stoner Place Drainage Plant
No. 5 of the Pioneer Irrigation District

The Stoner Place drainage plant is located about one and one-half miles east of the Franklin Road plant and was installed in the fall of 1928. The well is of the gravel-wall type and has developed a low yield of 1.94 cubic feet per second, due to the pump discharging for two minutes out of each three, running empty the third minute. It is planned to install an additional length of pump column, placing the pump deeper in the well as a means of correcting this difficulty.

The pump was started May 17 and was run intermittently during the first part of the season. It is estimated that a total of 248 acre feet of water were pumped. The drainage effect is fair, considering the limited quantity of water developed.



Stoner Place drainage plant during efficiency tests made in 1930

A better yield of water may be obtained from this well with further development, thus satisfying expectations. So far, however, the Stoner Place drainage well has been disappointing in yield and serves to emphasize the need for research in well construction and development.

Power Costs for the Stoner Place Drainage Plant
Season of 1928—30-H.P. Motor

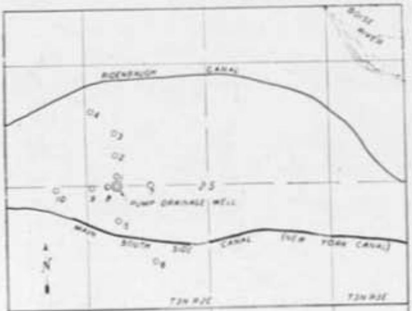
Date	K.W.H.	Demand H.P.	Net
August 17-August 24	4,410	36	$ 45.90
August 24-September 22	17,530	36	190.70
September 22-October 1	5,290	36	57.40
Total	27,230		$ 294.00

Season of 1929—30-H.P. Motor

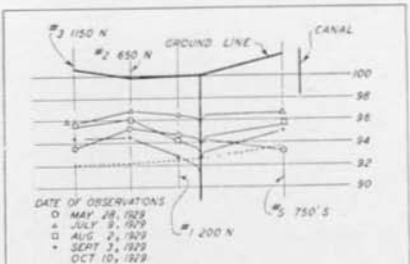
Date	K.W.H.	Demand H.P.	Net
May 17-June 12	11,110	36	$ 141.95
June 12-July 22	8,080	25	131.65
July 22-August 21	8,010	25	131.30
August 21-September 20	5,710	25	119.80
TOTAL	32,910		$ 524.70
Less Tax Exemption			61.09
Net Cost			$ 463.61

SOUTH BOISE DRAINAGE PLANT

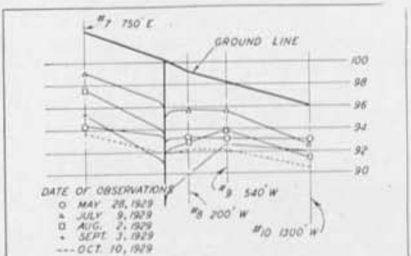
Ada County Irrigation District No. 3



SOUTH BOISE DRAINAGE PLANT
ADA COUNTY IRRIGATION DISTRICT NO. 3
WELL NO. 1 AND OBSERVATION WELLS



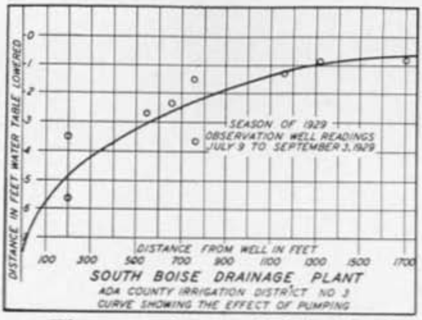
SOUTH BOISE DRAINAGE PLANT
ADA COUNTY IRRIGATION DISTRICT NO. 3
WATER LEVELS NORTH & SOUTH LINES



SOUTH BOISE DRAINAGE PLANT
ADA COUNTY IRRIGATION DISTRICT NO. 3
WATER LEVELS EAST & WEST LINES

The South Boise drainage plant was installed in the spring of 1929 and is located in South Boise, 500 feet north of the large canal supplying the Boise Project. The well is of the stovepipe casing type, and has a yield of 1.7 cubic feet per second as measured by a current meter. The cost of $1,165.00 per second foot of yield for this plant ranks second lowest among those studied. The cost of pumping during the 1929 season has been higher than is necessary due to the intermittent operation of the pump.

The full influence of the operation of this plant is not shown clearly by the records of the observation wells, owing to the fact that the work of installing the wells was started late in May, and consequently the condition of the water table before the pumping was started is not recorded. The ground water during the midsummer of 1928 is reported to have been at the surface in the vicinity of the pumping plant. The distance the water table was lowered between July 9 and September 3, 1929, has been shown graphically by a curve prepared from the data obtained from the observation well readings made on those dates. At a distance of 750 feet from the well, the water table was lowered from 2 to 3 feet. The limit of the



SOUTH BOISE DRAINAGE PLANT
ADA COUNTY IRRIGATION DISTRICT NO 3
CURVE SHOWING THE EFFECT OF PUMPING

drainage effect seems to be at about 1,250 feet from the well. The landowners are well satisfied with the drainage effect, but hope to reduce the cost of pumping through a more continuous operation of the plant. The water pumped from this well was used for irrigation, but full benefit of the water was not realized due to a faulty delivery system.

The experience of this district shows the necessity for careful management if a pumping installation is to operate at the lowest cost.

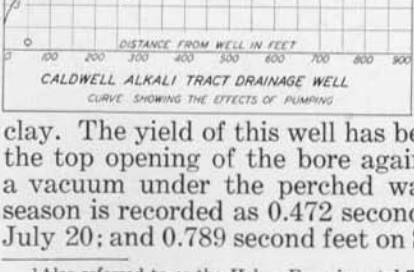
POWER COSTS FOR THE SOUTH BOISE DRAINAGE PLANT

Season of 1929—15-H.P. Motor

Date	K.W.H.	Demand H.P.	Net
May 22-June 4	230	15	$ 24.10
June 4-July 3	670	15	57.50
July 3-August 6	6,210	15	95.30
August 6-September 5	10,410	15	116.30
September 5-October 2	6,700	15	91.30
TOTAL	24,220		$ 384.50
Less Tax Exemption			44.96
Net Cost			$ 339.54

CALDWELL ALKALI TRACT DRAINAGE PLANT

The Caldwell Alkali Tract drainage plant was installed during the summer of 1929 on the Alkali Experimental Tract[1] one mile west of Caldwell, upon which experimental work in reclamation of alkali lands is being conducted by the Agricultural Experiment Station of the University of Idaho and the Bureau of Public Roads of the United State Department of Agriculture. The pump was installed for the special purpose of attempting drainage of a perched water table that occurs in the soil close to the surface over the greater portion of the experimental tract.



CALDWELL ALKALI TRACT DRAINAGE WELL
CURVE SHOWING THE EFFECTS OF PUMPING

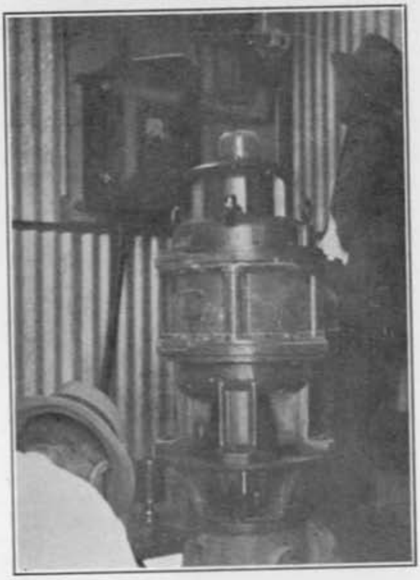
This well also is of the stovepipe type, but is only 30 feet deep, being bottomed on a deep layer of clay. The yield of this well has been increased considerably by sealing the top opening of the bore against the entrance of air, thus creating a vacuum under the perched water surface. The yield for the 1929 season is recorded as 0.472 second feet on July 9; 0.667 second feet on July 20; and 0.789 second feet on September 18. The latter increase was

[1]Also referred to as the Helms Experimental Tract.

made after the plant had been idle for 21 days, and after a pump and motor of lower rated capacity had been installed.

The cost of the yield based on the September reading of 0.789 second feet is $2,506.00 per second foot. This high cost is partially due to the expenditure on test holes before the driling of the main well was started.

The drainage effect is not definitely indicated by the observation wells which, owing to the impervious nature of the soil, did not function properly, particularly at wells Nos. 5, 9, 13, 15, 16, and 31. The record of the water level is probably recorded most accurately by the reading taken from well No. 33, which is one of the older group, and shows that between the dates of July 8 and September 26, 1929, the water table was lowered 2.7 feet.



Pump house interior showing vertical type of motor installation

Perched water has been present during the entire season in a duplicate system of shallow wells (four feet deep). Lowering the ground water has not materially affected this condition, which is due to an impervious soil stratum immediately below the surface layer. Here an unusual condition occurs, in which any water applied to the ground surface is prevented from reaching the ground water table and is held in a perched condition until evaporated or used by the plants. Obviously no method of drainage would prove effective under these conditions, and the only possible remedy lies in a correction of the physical structure and chemical composition of the soil.

POWER COSTS FOR THE CALDWELL ALKALI TRACT DRAINAGE PLANT

Season of 1929—10-H.P. Motor

Date	K.W.H.	Demand H.P.	Net
July 7-July 19	222	15	$ 23.00
July 19-August 20	693	15	57.50
August 20-September 19	137	15	57.50
September 19[1]-October 19	269	10	42.50
TOTAL	1,321[2]		$ 180.50
Less Tax Exemption			$ 2.45
Net Cost			$ 178.05

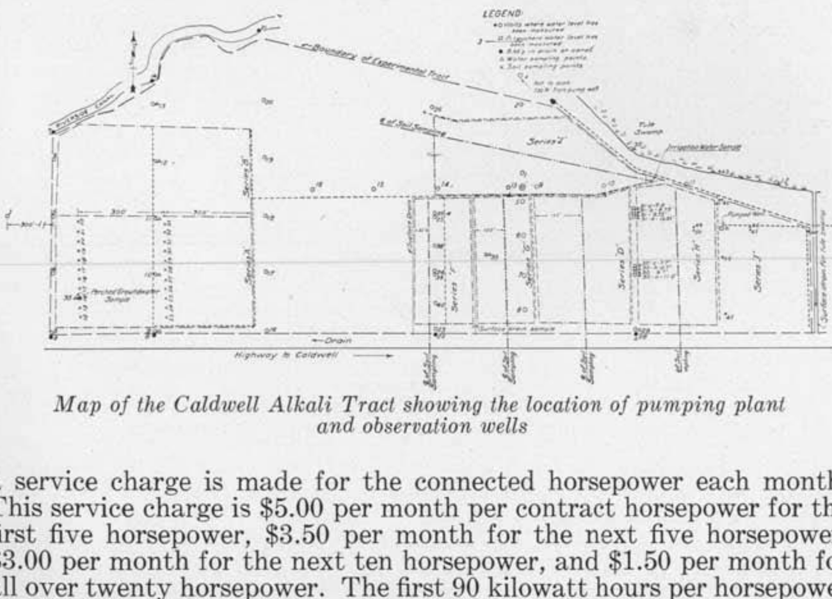
RESULTS OF STUDY

The studies of these plants indicate that to obtain a maximum yield and lost cost the development should be planned by a skill-

[1]Motor changed to 10 H. P. on September 23.
[2]Total kilowatt hour consumption inaccurate due to defective meter.

full and experienced engineer. Properly designed pumps of the requisite capacity are essential for obtaining the best results. There appears to be a tendency to install pumping equipment of greater capacity than the yield of the well warrants. This could be avoided if the wells were developed before the final pumping equipment were selected. The question of economical yield and drawdown for any given well is a difficult problem and depends upon the value of the pumped water and the accuracy of measuring the limits of the effect of the drainage produced.

The costs per acre foot of water pumped for each of the wells could be reduced if the operation were more continuous and for a longer period. In terms of cost per acre foot the overhead charges of interest and depreciation upon the pumping machinery and the well are from 40 to 80 per cent of the operating costs. The total amount of the interest and depreciation charges are fixed, but the costs per unit of water pumped can be reduced by lengthening the period of operation. The power for operation of the pumps is purchased under a rate by which



Map of the Caldwell Alkali Tract showing the location of pumping plant and observation wells

a service charge is made for the connected horsepower each month. This service charge is $5.00 per month per contract horsepower for the first five horsepower, $3.50 per month for the next five horsepower, $3.00 per month for the next ten horsepower, and $1.50 per month for all over twenty horsepower. The first 90 kilowatt hours per horsepower per month is included in the service charge. The next 90 kilowatt hours per horsepower are at the rate of 1½ cents per kilowatt hour, with all additional energy at the rate of ½ cent per kilowatt hour. Further provision is that the total charge for the irrigation season of any year shall not be less than $22.50 per horsepower of the highest contract horsepower during the season. Under this rate any motor that is connected to a line carries a service charge regardless of the number of days of operation during the month. The 90 kilowatt hours per horsepower included in the service charge are sufficient to operate the motor at its rated capacity for five days. The 90 kilowatt hours at 1½ cents will operate the motor for an additional five days. For the balance of the month the cost of energy at ½ cent per kilowatt hour materially reduces the operating charge.

Taking for example a 25-horsepower motor operating under this rate, the service charge amounting to $80.00 includes a sufficient number of kilowatt hours to operate the motor at its rated capacity for a period of five days. The cost of energy at the end of ten days is $113.75, or $33.75 for the second five-day period of operation. The bill amounts, at the end of 30 days, to $158.75. The cost of operation during this last 20 days of the month is $45.00.

The lowest power cost per acre foot of water pumped is obtained by operating the pump as continuously as possible. If the connection and disconnection for the electric service are not made on the regular meter reading dates, the first and last monthly charges of the season are billed on a pro rata basis which depends upon the number of days the service is connected.

The cost for power per acre foot of water pumped during 1929 was from $0.70 to $1.87. The Orchard Avenue drainage plant with $0.70, the South Boise drainage plant with $0.72, and the Franklin Road drainage plant with $0.93, have the lowest cost per acre foot of the plants studied. The 1929 costs include the deduction for tax exemption allowed upon hydro-electric power plants and equipment used in irrigation pumping in Idaho.

The observation well measurements show that for the pumping plants where the least amount of drainage effect was noted, the ground water level at between 100 to 200 feet from the well remained at within 6 to 8 feet of the ground surface, while the distance to the water in the drainage well during the pumping period varied from 30 to 60 feet. The loss of head in getting the water into the well is a serious problem and affects both the yield of the well and the cost of operating the plant.

The lack of success resulting from the drainage of open channels and the difficulty encountered in attempting to measure the results of the drainage by pumping probably are due to the presence of ground water under pressure. The wet areas showed no definite rule of occurrence due to the lack of uniformity in depth and character of the soil and subsoil. Under such conditions pumping from wells which have been located in the waterlogged areas lowers the water table more than is possible by means of open drains.

In addition to the need for more effective drainage than is being secured with the open channel drains, there is a need for an additional water supply to supplement the existing water rights in the late summer and in the years of water shortage. These conditions have emphasized the importance of the supplemental irrigation water developed by the drainage pumping plants.

In the Boise valley it is estimated that from 150,000 to 200,000 acre feet of water can be obtained each year by pumping from wells, with the possibility of pumping additional water in years of water shortage. With a carefully planned installation of electrically operated deep well pumps on the lower lands, this water could all be reclaimed and used on adjacent lands, thus freeing the gravity water for use on other lands higher up the river. The ground would then serve as a reservoir and conserve the water until its withdrawal during the irrigation season.

The lowest power cost for the several drainage plants during the 1929 season was $0.70 per acre foot of water where the lift was 35 feet. This cost is low: first, because of the moderate pumping lift; second, because of continuous use which made available the lowest possible unit power charge; and third, because of the moderate charge made for the electric service. Other power costs for 1929 vary from this cost of $0.70 to $1.87, or an average of $0.99 per acre foot of water pumped. The above costs are determined from estimates of the total amount of water pumped, based upon pumping plant efficiencies determined in 1930.

The cost of interest, depreciation, and taxes, when computed at 14 per cent of the capital investment per acre foot of water pumped, varies from $0.59 to $2.34, or an average of $0.93 per acre foot of water pumped during 1929.

No overhead, supervision, or maintenance was figured in the costs, as these wells are an integral part of an irrigation and drainage system. This system uses direct flow and reservoir storage water in gravity distribution for irrigation and open gravity drains for drainage in addition to the drainage wells which provide additional irrigation water.

The unit cost of an acre foot of water, including power, interest, depreciation, taxes, repairs, and lubricants, has steadily decreased from $3.49 per acre foot in 1927, when only one well was pumped for a part of the season, to $2.50 in 1928, and $1.99 in 1929[1] as the result of the better wells delivering larger amounts of water at lower cost. The unit cost for all wells for three years was $2.30 per acre foot of water pumped.

Drainage of this district by means of open ditches previously cost about $11.00 per acre. Approximately 19,000 acre feet of reservoir storage cost $370,000.00, or a capital investment of about $19.47 per acre foot. Using these figures as a basis, the following comparison may be made:

Reservoir Storage Water Per Acre Foot	
Interest, depreciation and taxes on capital investment of $19.47 at 9 per cent	$1.75
Maintenance and repair	.02
Cost at reservoir outlet	$1.77
Less 25% regulation and conveyance loss equals .75 acre feet delivered for $1.77 or 1 acre foot delivered for	$2.36

Water Pumped from Drainage Wells Per Acre Foot	
Interest, depreciation and taxes on capital investment of $8.57 at 14 per cent	$1.20
Power	1.05
Repairs and lubricants	.04
	$2.29
Credit for drainage of ½ acre for each acre foot of water pumped ½ of 6% on $11.00	.33
Total cost of pumped water	$ 1.96

Reservoir storage on the Snake River costs much less than in the Boise valley, but the unit cost of pumped water should be further reduced through the perfection of the system and the use of more economically located and equipped wells.

[1]The 1929 costs include the deduction for tax exemption allowed upon hydro-electric power plants and equipment used in irrigation pumping in Idaho.

PUMPING FOR DRAINAGE UNIT COSTS

Drainage Well	Years	Yield in Acre Feet	Power[1] Cost	Power Cost per acre ft.	Capital Invest-ment	Capital Investment per acre ft.	Interest, De-preciation, Taxes per acre ft.	Repairs and Lubricants	Repairs and Lubricants per acre ft.	Total Cost per acre ft.
Orchard Avenue Pioneer Number 1	1927	599	$ 914.25	$1.526	$ 8,382.22	$13.99	$19.59			$3.485
	1928	1,395	1,162.00	.833	8,382.22	6.01	.841	$ 8.40	$0.006	1.680
	1929	1,466	1,026.21	.700	8,382.22	5.72	.801	8.40	.006	1.507
	3 yrs.	3,460	3,102.46	.897	25,146.66	7.27	1.018	16.80	.005	1.920
Douglas Place Pioneer Number 3	1928	79	$ 288.00	$3.646	$ 5,475.91	$69.32	$ 9.705	$ 8.40	$0.106	$13.457
	1929	603	983.70	1.631	5,475.91	9.08	1.271	18.40	.031	2.933
	2 yrs.	682	1,271.70	1.865	10,951.82	16.06	2.248	26.80	.039	4.152
Franklin Road Pioneer Number 4	1928	494	$ 514.85	$1.042	$ 4,433.69	$ 8.98	$ 1.257	$ 8.40	$0.017	$ 2.316
	1929	887	822.70	.928	4,433.69	5.00	.700	193.52	.218	1.846
	2 yrs.	1,381	1,337.55	.969	8,867.38	6.42	.899	201.92	.145	2.013
Stoner Place Pioneer Number 5	1928	206	$ 294.00	$1.427	$ 4,148.50	$20.14	$ 2.820	$ 8.40	$0.041	$ 4.288
	1929	248	463.61	1.869	4,148.50	16.73	2.342	8.40	.034	4.245
	2 yrs.	454	757.61	1.669	8,297.00	18.28	2.559	16.80	.037	4.265
South Boise Ada County Irrigation District 3	1929	471	$ 339.54	$0.721	$ 1,985.00	$ 4.21	$ 0.590	$ 8.40	$0.018	$ 1.329
All Wells	1928	2,174	$2,258.85	$1.039	$22,440.32	$10.32	$ 1.445	$ 33.60	$0.015	$ 2.499
All Wells	1929	3,675	3,635.76	.989	24,425.32	6.65	.931	237.12	.067	1.987
All Wells	3 yrs.	6,448	6,808.86	1.056	55,247.86	8.57	1.200	270.72	.042	2.298

NOTE.—The Caldwell Alkali Tract well was not included on account of the electric current meter not functioning.

[1]1927-1928, without tax exemption.

The 1929 costs include the deduction for tax exemption allowed upon hydro-electric plants and equipment used in irrigation pumping in Idaho.

Chemical analyses of samples of water taken from the drainage pumping plants during the 1928 season showed the concentration of alkali salts to be less than was found in the surface drainage water. The re-use of the water developed by the drainage plants has in every instance been satisfactory for irrigation.

After the extensive installation of drainage wells eventually lowers the water table to where drainage is effected through the areas by pumping, the question arises as to whether or not additional pumping would continue to lower the water table to a point where the power costs for pumping would be prohibitive. Theoretically it would be possible to balance the output from the pumping plants to the input of the basin being drained, thereby maintaining a constant pumping cost.

Under the doctrine of appropriation, the legal status of water developed by pumping in Idaho is not fully settled. An application for a water right upon each well studied in this report has been made to the State Department of Reclamation as a means of protecting the right to the use of such water.

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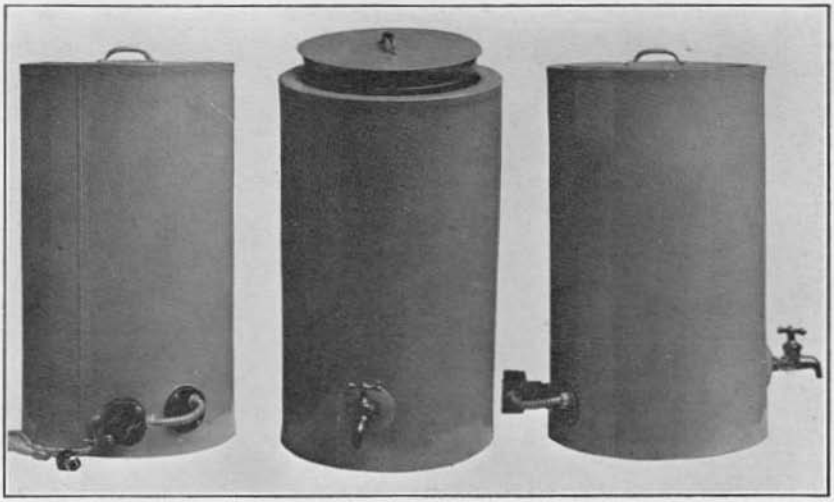
New Uses and Methods for the Application of Electricity to Agriculture

Each year adds many new uses and methods for the application of electricity to agriculture in Idaho. Improvement in old uses and a more economical application have resulted in saving human labor and reducing production costs. The following new uses and methods are a few of the outstanding developments.

"The Idaho Farm Water Heater"

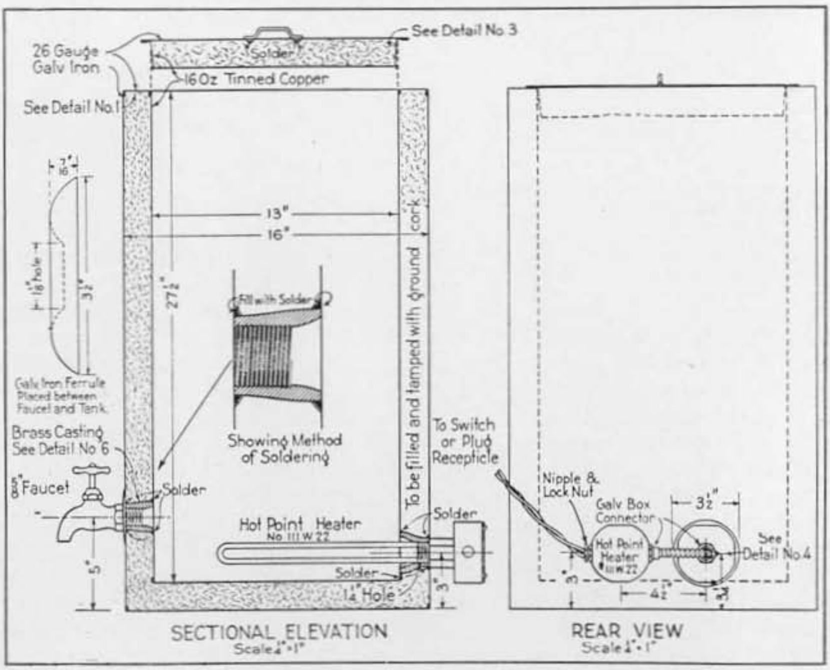
The problem of furnishing a convenient and economical supply of hot water for the farm kitchen and dairy has been met in southern Idaho by the development of a 15-gallon cork insulated tank heated by a one-kilowatt immersion type heater. This heater may be controlled by a thermostat or by a manually operated switch, depending upon the service requirements.

The first work on the "Idaho" type of farm water heater was done in the summer of 1928 when an attempt was made by the Twin Falls Division of the Idaho Power Company to replace the reservoirs found on the kitchen coal and wood stoves common to that territory. Meet-



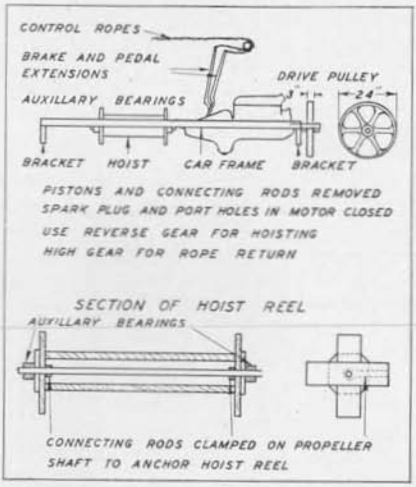
View of the "Idaho Farm Water Heater," showing the location of the heating element, thermostat and faucet

ing the requirement for hot water in the farm kitchen where water was not supplied under pressure meant there would be less resistance to the sale of electric ranges. Galvanized iron was used for the construction



Sectional view of the 15-gallon capacity "Idaho Farm Water Heater" of the first tank, but the life of this material proved unsatisfactory and the present design uses a tinned copper lining and brass pipe fitting in order to prevent rusting. The outside shell of the tank is made from 26-gauge galvanized iron and the 1½-inch space between the inner and outer walls is filled with ground cork insulating material.

A one-kilowatt immersion type heater, usually controlled by a thermostat, is used for heating the 15 gallons of water. When the thermostat is used, it is located in a recess provided in the insulated cover; or if omitted, the current is controlled by a manually operated switch. The tank is filled through the top which is provided with an insulated cover similar in construction to the rest of the tank. The hot water is drawn from the bottom of the tank through a compression bib located about two inches above the heating element. This location of the outlet allows an automatic protection for the heating element, insuring a maximum service life and economical operation of the unit.



Details of the "Farm-Made Hay Hoist," utilizing a Model T Ford motor and transmission

Over 500 of these water heaters were sold in southern Idaho during 1928-1929. Most of the units were placed in farm kitchens, although they have been found convenient for heating water in the dairy, in the shop, and in fact wherever hot water is needed on the farm.

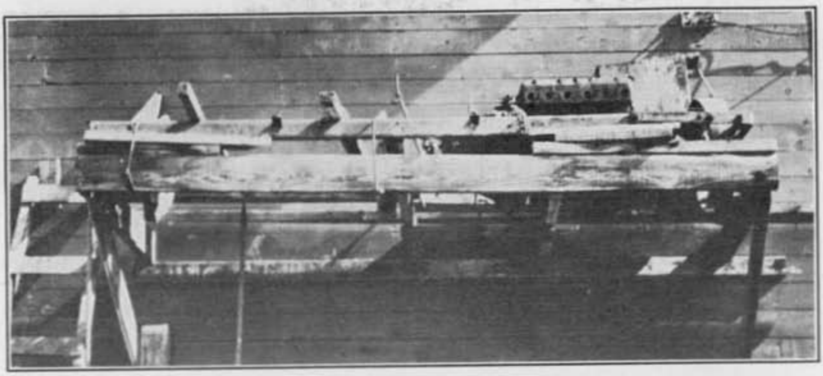
The interest the "Idaho Farm Water Heater" is creating has been recognized by one of the leading manufacturers of electrical equipment, who now offers the "Idaho Electric Water Heater" as one of its latest models.

FARM-MADE HAY HOIST

Hay hoisting with electric motor power has been the subject of a great deal of discussion during the last few years. The usual difficulty presented by this application of electricity to agriculture has been the extreme seasonal use of relatively expensive equipment. The annual interest and depreciation charges on the hoist, in almost every instance, have been more than the cost of the energy used for power.

The idea of using a Model T Ford transmission for obtaining an inexpensive and satisfactory hay hoist is credited to Mr. Frank J. Bruins of Boise, Idaho. This hoist utilizes a Model T Ford motor and frame as shown in the diagram.

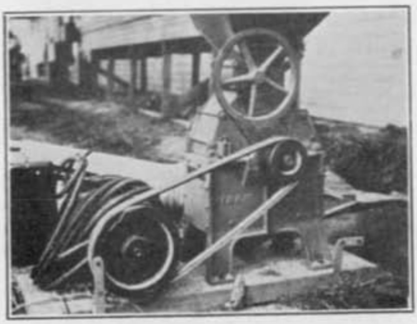
For hoisting work the unit is driven by a 3-horsepower electric motor, the reverse gear being used for the load and the high gear for the rope return. The hoist may be mounted on the side of the barn where it is convenient to step from the load of hay to the hoist frame and thus one operator may take care of the hoist and hay fork.



Hay hoist mounted on the side of the barn by means of brackets

"V" Belt Drives for Farm Motors and Equipment

"V" belt drives have helped solve the problem of driving farm machine equipment with electric motors, and although the development of the different type of drives is not new, its use on farm equipment and machinery is comparatively recent.



A small hammer mill feed grinder equipped with "V" belt and drive

These drives provide the compactness and efficiency of direct-connected motors and at the same time furnish a flexible and economical method of power transmission.

Operating "V" belts in small diameter groove pulleys and on large diameter flat pulleys is a combination that promises greater convenience and flexibility for the use of the portable farm motor in the future.

Electric Lamb Docker

An electrically heated lamb docking blade has been developed by brazing a 2-inch width tip to the standard heating element of a 550-watt soldering iron. It has been found that in service this instrument maintains a sufficiently high temperature to sear the flesh properly during the amputation, thus avoiding the use of a forge or blow torch, which accompanied the former practice.

There is, in addition to the convenience obtained by this electrically heated docking blade, a reduction in the labor required for the docking operation.