A STUDY OF THE POWER SITUATION IN TEXAS

A THESIS SUBMITTED TO THE FACULTY OF
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Introduction

The ever increasing demand for power runs parallel with our industrial developement. Because of large power increases various studies are being made, some with a view to finding the controlling influences, others for determining the many social and economic causes and results involved. The wealth included in power producing machinery runs into a considerable per cent of the nations total wealth. "Machinery" is taken in a broad sense, of course.

This paper is a study of the influences surrounding the production and consumption of power in the state of Texas. Certain questions arise, as for example; how is the power produced, and by whom; what are the quantities relatively and in absolute numerical amount; what controls these quantities, if they are controlled by other than the economic of supply and demand. These and many other questions come up and an endeavor has been made to answer some of them here. Data are not available for long enough periods to allow of complete studies, but such as are to be had were used freely. Most of the material is taken from the government reports of the Bureau of Census. References to the Geological Survey and ~~and~~ other sources are shown in the bibliography.

It is regretted that time prevents the making of a study of this kind for the entire United States. In such

a study results and relationships would be forthcoming which are not now to be had when restricted to one state only. The author takes this opportunity to express his thanks to Dean P. F. Walker for suggesting this study and for valuable criticisms during its preperation.

Forrest E. Jones
Austin, Texas.

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Austin, Texas,

May 1st, 1923.

Dean P. F. Walker,

School of Engineering,

University of Kansas,

Lawrence.

My dear Dean Walker:

I have the pleasure to submit herewith a thesis on "A Study of the Power Situation in Texas". It is offered as the thesis required for the Degree of Mechanical Engineer as conferred by the University.

Yours very respectively,

Forrest E. Jones.

Forrest E. Jones,

Instructor Mechanical

Engineering, University of

Texas.

Texas is the largest of the states and, according to geographical classification, is in the West South Central group with Oklahoma, Arkansas, and Louisana. Some conception of the State's size can be gained by considering the length of its boundries. The boundry between Texas and Oklahoma is approximately 675 miles long. The Rio Grande river line is 1100 miles long, while the coast length is 1680 miles. The distance from the northeast to the southwest extremity is 960 miles, and the distance from the east to the west side of the state is 900 miles, approximately. The area of Texas is 265,896 square miles, almost all of which is land.

In covering such a large area Texas has many extnemes, which, although not unlike some other states, are when considered as a whole, somewhat striking. In the extreme western portion, in the neighborhood of El Paso, the rain fall is ten inches or less per year, while in the extreme eastern section the precipitation is 50 to 60 inches per year. It is not unnatural that this section of the state is conducive to rice growing. Parts of Texas are virtually desert, the Staked Plains of the northwestern part; yet others are very productive of cotton, wheat, garden truck and other crops, not to mention cattle. There are mountainous areas, and flat treeless tracts, as well as great timber producing sections.

Texas is an agricultural state and does not have industrial centers like those found in states such as Ohio or Illinois. However, industrial and power consuming centers are developing around some of the cities,---notably Dallas and Houston. The natural resources of the state are conducive to industrial developement. Texas has ranked near the top among the petroleum producing states for some years. The Bureau of Mines reported over a hundred refineries in the state on the first of January, 1921. Port Arthur alone has over 100,000 barrels of refining capacity. A large amount of lumber is produced. Texas has a greater lignite producing area than any other state, possibly greater than all other states combined. This is a resource for which one day there will be a great demand. Even at this writing, research is being made with a view to utilizing large quantities of this fuel in the generation of power.

In population Texas has increased from three per square mile in 1870, to 17.8 per square mile in 1920. In rank of states she went from 19th to 5th place during the same period. The increase from 1910 to 1920 was 19.7 per cent, and the population in 1920 was 4,663,228. There are four cities with a population of over 100,000, and 30 cities having a population of more than 10,000.

POWER

There are three sources of power in Texas to-day,

namely, steam power, wherein oil or coal is burned under a boiler; gas and oil engine power, in which fuel oil of all grades is used; and water power. Their importance is in the order given, which is to say that the most power is produced by steam and the least by water power. Although there are some fair sized rivers in Texas, stream flow conditions are such as to restrict any noteworthy hydro-electric projects.

LOCATION OF POWER STATIONS

The towns and cities having power stations of 100 kw. capacity or over are shown in table 1, supplemented by figure 1, where the stations are shown on the map of Texas. The table gives the total capacity of the station, including both alternating and direct current generators, whether driven by steam units or some other power; the type of prime mover; the fuel used; and, when possible, the connected load. Although some units may be stand-by installations, or discarded and seldom or never used, if they are connected to the boilers, or ready to operate, they are included. Most of the data are taken from the McGraw Central Station Directory. It is complete up to 1921 and is thought to be fairly reliable. Figure 2, besides showing the location of the stations and transmission lines, differentiates between the prime movers. The steam, water power, and internal-combustion engine stations are separated as shown. Classification as to

Table 1.

Location of Texas Power Plants With Capacities of 100 Kw. or Above

Town or City	Capacity of Plant Kw.	Prime Mover	Fuel	Power Load
Abilene	1,225	Int-comb.	Gas	1,137 kw.
Alice	175	Steam	Oil	150 "
		Int-comb.	"	
Alpine	340	" "	"	35 "
Alto	105	Steam		50 "
Amarillo	1,560	"	"	
Athens	150	"	Lignite	
Austin	2,250	"	"	
Baird	125	"	Gas	33 "
Ballinger	300	"	Oil	
Bastrop	125	"	Lignite	130 "
Bay City	150	"	Oil	
Beaumont	5,700	"	"	5,300
Beeville	200	"	"	
Bellville	115	Int-comb.	"	
Big Spring	450	" "	"	
		Steam		
Bowie	250	Int-comb.	"	89 "
Brady	180	" "	"	
Brenham	1,200	" "	"	
		Steam	Lignite	

Brownsville	600	Steam	Oil	
Brownwood	1,225	"	"	1,123 kw.
		Int-comb.	"	
Bryan	300	" "	"	250 hp.
Caldwell	105	" "	"	80 kw.
Calvert	150	Steam	Lignite	
Cameron	525	"	"	325 hp.
		Int-comb.	Oil	
Canadian	160	" "	"	150 "
Canyon	125	Steam	Coal	100 kw.
Cartharge	100	"	"	
Center	110	"		
Childress	250	"	Oil	
Cisco	525	"	Gas	
Clarendon	100	Int-comb.	Oil	
Claude	200	" "	"	
Clifton	185	" "	"	
Coleman	250	" "	"	85 "
		Steam	Gas	
College Station	550	"	Lignite	
Cooper	225	"	Oil	50 "
Corpus Christi	850	"	Gas	
		Int-comb.		
Corsicana	450			100 "
Crockett	225	Steam	Coal	60 "
Cuero	950	Steam Water wheel		

Dalhart	360	Steam	Coal	
Dallas	18,300	"	Oil	18,000 kw.
Dayton	150	Int-comb.	"	50 hp.
Del Rio	325	Steam	Coal	
		Water wheel		
Denton	610	Steam	Coal	300 kw.
		Int-comb.		
Donna		" "	Oil	210 "
Eagle Lake	132	" "	"	60 "
Eagle Pass	500	Steam	Coal	
Eastland	7,030	"	Gas	
El Campo	375	Int-comb.	Oil	
Elgin	125	" "	"	
		Steam	Lignite	
El Paso	10,700	"	Coal	
Farmersville	190	"		105 "
Fentress	160	"		
		Water wheel		
Floresville	140	Steam	Lignite	
		Int-comb.		
Fort Stockton	175	Int-comb.	Oil	25 "
Fort Worth	44,600	Steam	" Coal	24,498 "
Franklin	160	Steam	Lignite	
Fredericksberg	120	Int-comb.	Oil	
Freeport	1,000	Steam	"	
Gainsville	550	Int-comb.	" Gas	
Galveston	5,925	Steam	"	3,420 "

Gatesville	350	Int-comb.	Oil	
Georgetown	125	Steam	Lignite	
Gilmer	150	"	Coal	
GOldthwaithe	150	Int-comb.	Oil	40 kw.
Goliad	150	" " Steam	" "	40 "
Gonzales	850	"	Lignite	
Graham	150	" Int-comb.	Coal Oil	150 "
Grand Saline	150	Steam	" Lignite	
Greenville	600	"	Lignite	
Groveton	100	"	Wood,Oil	175 "
Halletsville	112	"	Lignite	37 "
Hamilton	100	" Int-comb.	Oil "	
Haskell	375	" " Steam	" "	300 "
Hearne	150	"	Lignite	100 "
Henderson	150	"	"	50 "
Hereford	150	"	Slack	300 "
Hico	150	"		176 "
Houston	24,200	"	Oil	29,907 "
Hubbard City	920	"	Lignite	
Huntsville	500	"	"	
Jacksonville	355	" Int-com.	Wood Oil	
Jacksboro	140	"		
Kenedy	112	" " "	Oil	
Kerville	230	" " "	" Lignite	
Kingsville	975	" " "	"	

Lagrange	150	Steam	Coal		
Lampasas	235	"	Lignite		
Laredo	3,250	" Int-c0.	Oil		
Leonard	150	" " "	"		
Livingston	100	Int-comb.	"		
Llano	150	Water wheel			
Lockhart	150	Steam			
Longview	380	" Int-comb.	" Lig.	821	kw.
Lubbock	350	" " "	Oil		
Lufkin	250	"	Wood		
McAllen	225	"	Oil		
Marfa	430	Int-comb.	"	300	"
Marlin	385	Steam	Coal		
Marshall	1,405	"	Gas	1,534	"
Mart	475	"	Lignite	250	"
Memphis	130	"	Oil	150	
Mexia	1,500	" Int-comb.	" Lig.		
Mineola	150	" " "	" "	30	"
Mineral Wells	975	"	Gas	250	"
Mt. Pleasant	275	"	Lignite	150	"
Nacogdoches	450	"			
Naples	100	" "	Oil	30	"
Navasota	420	"	Coal	125	"
New Braunfels	975	" " " Water wheel	Oil		
Orange	1,435	Steam	Oil		
Palestine	1,500	" Int-comb.	"		

Pearsall	125	Steam	Lignite	
Pharr	325	Int-comb.	Oil	
Pittsburg	175	Steam	Lignite	
Plainview	900	" Int-comb.	Oil	
Port Arthur	12,950	Steam	"	
Post	825	"	"	
Quanah	665	Steam "	"	
Ranger	490	Int-comb.	"	
San Angelo	685	Steam	"	
San Antonio	24,225	"	"	
San Benito	165	Int-comb.	"	
San Marcos	300	" " Water wheel	"	25 kw.
Santa Anna	125	Int-comb.	Gas	60 kw.
Scaly	174	" " Steam	Oil Coal	
Seguin	275	" Water wheel	"	
Shiner	150	Int-comb.	Oil	40 kw.
Smithville	400	Steam	Lignite	
Snyder	240	Int-comb.	Oil	
Sour Lake	250	Steam	"	
Spur	135	"	Coal	
Stamford	750	"	"	510 kw.
Strawn	200	Int-comb	Oil	
Sulphur Springs	310	Steam	Lignite	
Sweet Water	800	" Int-comb.	"	
Taylor	440	" " "	"	

Teague	280	Steam Int-comb.	Oil "	75 kw.
Temple	850	Steam		
Texas City	1,775	"	"	
Thurber	200	"	Gas	112 "
Tyler	960	" Int-comb.	Oil	
Uvalde	355	Int-comb.	"	
Vernon	200	Steam	"	
Victoria	800	"	"	
Waco	12,000	"	"	
Weatherford	400	"	Gas	425 kw.
Wellington	105	Int-comb.	Oil	
Wharton	230	" " Steam	"	
Whichita Falls	2,075	"	Gas	
Yoakum	725	" Int-comb.	Oil "	
Yorktown	425	" " Steam	" "	

size is shown in figure 1.

Industrial power loads of the principal cities are given in table 2, where a comparison is made for the last three census years. Increases are very noticable in the case of Dallas, Houston and some others, while a few decreases are seen. This is shown graphically in figure 9. Some of the power is furnished by electric motors which take current from the stations of table 1. There is no relation between the "power load" of the latter table and that of the former.

Table 2.

Growth of Industrial Power in Texas

	Primary Horse Power		
	1909	1914	1919
Abilene		502	469
Amarillo		1,791	1,612
Austin	2,211	4,824	3,302
Beaumont	4,596	5,580	7,265
Brownsville	414	486	770
Cleburne	1,499	1,541	1,757
Corpus Christi			575
Cleburne			2,871
Dallas	13,808	15,517	23,197
Del Rio			183
Dennison	2,306	3,652	3,806
El Paso	3,396	6,778	10,848

Fort Worth	6,614	7,815	14,234
Galveston	3,633	8,939	7,643
Greenville			1,871
Houston	14,866	18,004	31,416
Laredo	353	530	584
Marshall	1,326	1,963	1,533
Palestine	1,209	1,302	1,960
Paris	2,489	2,220	3,788
Ranger			629
San Angelo	608	937	743
San Antonio	6,908	8,859	13,040
Sherman	2,150	2,366	4,314
Temple	1,616	1,566	1,841
Texarkana		2,669	3,519
Tyler	769	1,332	2,289
Waco	3,669	5,452	4,981
Wichita Falls		2,085	3,519

CLASSIFICATION OF STATIONS AND PRIME MOVERS

The latest available information on central stations is the Census Report for 1917. At that time there were 24 municipal and 230 commercial central electric stations, a total of 254 in the whole state. In these stations 551 primary power units were in use, having a total power of 184,829 hp. Statistics for these stations are shown in tables 3 to 6. The tables show that with more stations

Table 3.

Commercial and Municipal Central Electric Stations in Texas for 1917

	Commercial	Municipal
Number of stations	230	24
Number of units primary power	511	40
Horse power	177,134	7,695
Kilowatt-hours generated	306,610,912	10,643,373
Kilowatt-hours consumed	351,718,450	13,752,445
Number of motors served	14,627	707
Horse power	159,727	3,750
Number of customers served	181,434	13,714
Customers per station	789	572
Value of plant and equipment	$58,278,471	$1,753,943
Value per plant	253,500	73,000
Gross profit	1,613,683	174,414
Per cent on investment	2.77	9,95
Horse power per station	771	353
Horse power per unit	347	192
Units per station	2.22	1.66
Customers per unit	356	343
Ratio of station capacity to motor load	1.1	2.05
Motors per station	63.5	29.5
Kilowatt-hours per station	1,330,000	444,000
Kilowatt-hours per unit	600,000	266,000

Table 4

Classification of Power Units in Central Electric Stations in Texas for 1917

Steam engines	256
Horse power	46,943
Number under 500-hp.	249
Horse power	39,393
Number between 500 and 2000-hp.	7
Horse power	7,550
Steam turbines	55
Horse power	109,819
Number under 500-hp.	15
Horse power	4,193
Number between 500 and 2000-hp.	23
Horse power	19,234
Number between 2000 and 5000-hp.	9
Horse power	27,367
Number above 5000-hp.	8
Horse power	59,025
Total steam units	311
Horse power	156,762
Internal-combustion engines	214
Horse power	24,714
Water powers	26
Horse power	3,353

Table 5

Classification of Power Units in Commercial and Municipal Central Electric Stations in Texas for 1917

	Commercial	Municipal
Steam engines	232	24
Horse power	42,988	3,955
Number under 500-hp.	225	24
Horse power	35,438	3,955
Number between 500 and 2000-hp.	7	
Horse power	7,550	
Steam turbines	52	3
Horse power	107,269	2,550
Number under 500-hp.	14	1
Horse power	3,893	300
Number between 500 and 2000-hp.	21	2
Horse power	16,984	2,250
Number between 2000 and 5000-hp.	9	
Horse power	27,367	
Number above 5000-hp.	8	
Horse power	59,025	
Total steam units	284	27
Horse power	150,257	6,505
Internal-combustion engines	203	11
Horse power	23,774	940
Water powers	24	2
Horse power	3,103	250

Table 6.

Statistics of Central Electric Stations in Texas

	1907	1912	1917
Number of stations	218	253	254
Capacity of generators, kws.	48,558	84,564	133,917
Number of generators			543
Average capacity per generator			247
Current generated, kw-hrs.	75,829,108	149,008,819	317,254,285
Current used for power, kw-hrs.			124,804,664
Per cent used for power			34.2
Population served with current			1,640,041
Per cent of population served			36
Consumption of current for power per capita			76
Primary horse power	71,914	126,616	184,829
Number of units			551
Average size per unit, hp.			342
Number of motors served	4,228	8,444	15,334
Increase in per cent		50	45
Horse power of motors	18,634	50,869	163,477
Increase in per cent		63.5	69
Average motor size, hp.	4.52	6.04	10.65
Value of plants and equip.	$11,313,529	43,612,986	60,032,414
Average value	51,900	172,500	236,000

the commercial plants have also more units per station and greater power per unit. The commercial stations have over double the capacity of the municipal plants. Nevertheless the latter show a greater return on the investment than the former. Without complete information on the data in hand a definite answer to this situation is precluded. It may be that incomplete reports have been made to the government, or the system of accounting may be responsible. Public Service companies hesitate to give information which may influence the power rates they have made. Often the accounting in small city power plants is very loose. On the other hand the data covers a large number of plants, many of which are on the edge of bankruptcy, or, at least, operating at a very small profit. The average return may be thus cut down.

A classification of prime movers in central stations as to size, considering both the number of units and the power is shown graphically in figure 3. There are four groups, namely; those engines and motors having ratings under 500-hp; those between 500 and 2,000-hp; those between 2,000 and 5,000-hp; and those above 5,000-hp. All the internal-combustion engines, and water wheels, as well as a large number of the steam engines and turbines are included in the ifrst group. The largest number of units and the greatest total horse power are in the group. The second and third groups are about equally divided as to

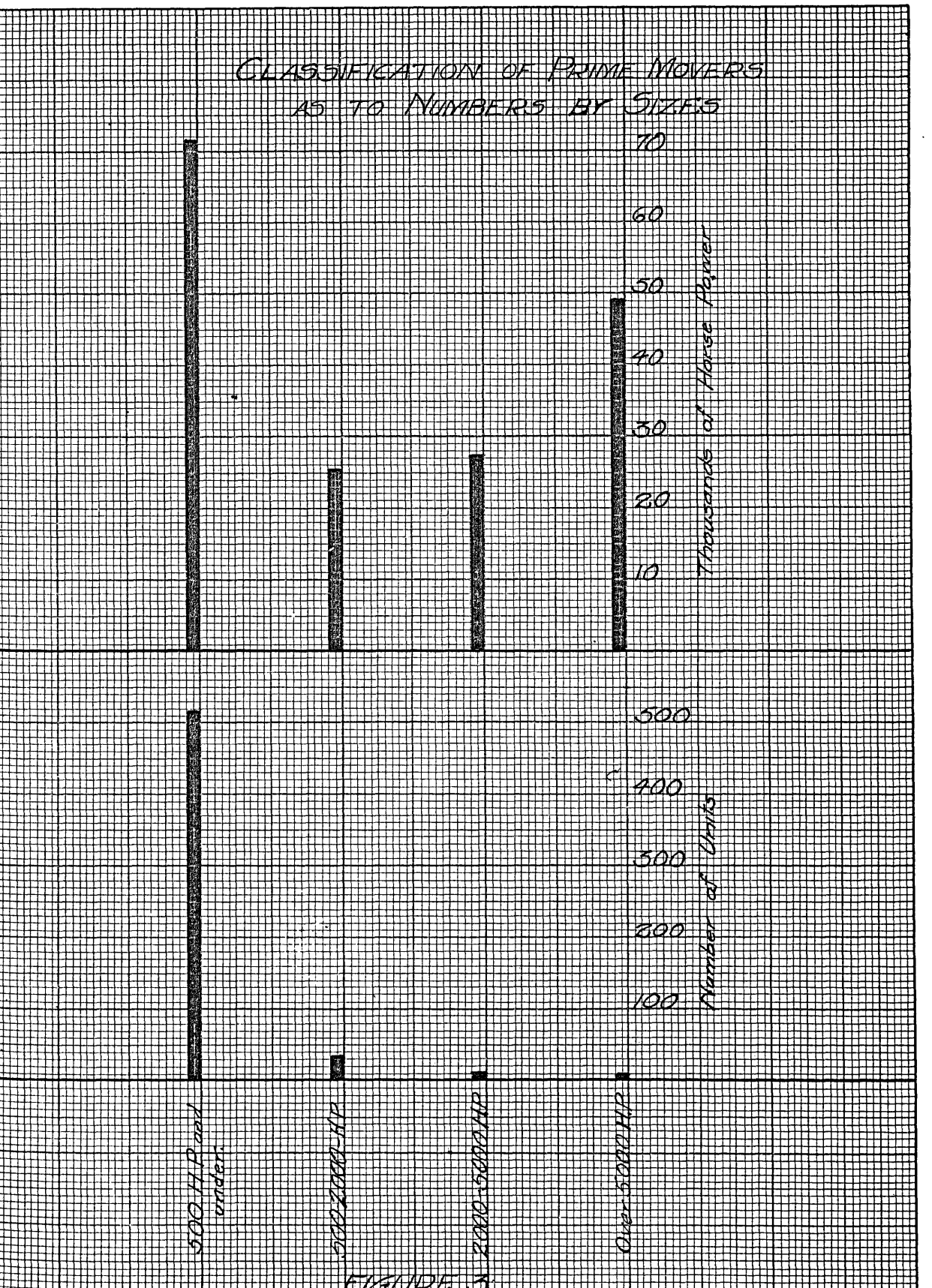

CLASSIFICATION OF PRIME MOVERS AS TO NUMBERS BY SIZES
70
60
50
40
30
20
10
Thousands of Horse Power
500
400
300
200
100
Number of Units
500 H.P and under
500-1000 H.P
1000-2000 H.P
Over 2000 H.P

FIGURE 3

power, but the former has nearly three times more units than the latter. The last two groups are composed entire ly of steam turbines, and in the last, especially, is where the large size turbine makes itself felt. Of the whole group of prime movers in central stations only 1.45 per cent were above 5,000-hp, but this amount represented 31.9 per cent of the total power. There will no doubt be an increase in this value in the next census returns, because of the trend toward the larger central station. Larger units are now being installed at Austin, Dallas, San Antonio and other places. In the different groups the size per unit varies from 142 to 7,378-hp.

Steam units predominate over other types in the ratio of about 1.3 to 1, making 56.5 per cent of the prime movers steam units. Oil engines (including some gas engines) amount to 38.9 per cent of the total number. The remainder are water power installations. Two and fifty seven hundredths per cent of the steam units are turbines above 5,000-hp. This represents 37.7 per cent of the power of the steam units.

The water power installations are shown in table 7. Power and number of wheels on each river in the Gulf and Mississippi river basins are shown. The Guadalupe river has almost 65 per cent of the power and 35 per cent of the wheels. The water power out look in the state is not promising, there being practically no chance for any additional developement. Power developed by water is

Table 7.

Water Power Stations in Texas

Drainage Basins	Wheels	Horse Power
Gulf of Mexico	190	9,899
Mississippi river	5	67
Total	195	9,966
Rivers		
Guadalupe	69	6,447
Colorado	25	1,503
Neches	35	538
Brazos	13	448
Trinity	12	279
Sabine	24	263
San Antonio	6	215
Rio Grande	1	102
Pecos	2	68
Red	5	67
Nueces	3	36

shown in a later table and will be seen to be of little consequence. The location of powers of 100-hp. or over are shown in figure 2. The writer is indebted to Mr. C. E. Ellsworth of the U. S. Geological Survey, Austin, for the location of these stations. The data pretaining to the number of wheels and the power are taken from Water Supply Paper 234, pg. 38 to 41, of the U. S. G. S.

The use of internal-combustion engines -- oil engines-- in central stations is increasing. The table shows the total power to be 24,714-hp. The average power per unit is 115.5-hp. This is relatively small. The larger size units of the present day will no doubt increase this value in the next census. Many plants have semi-Diesel and low compression engines of small power. This also lowers the average size. According to Mr. L. H. Morrison in Power for March 21, 1921, there were 92 full Diesel engines in Texas central electric stations, with a total of 19,975-hp. Only 5.6 per cent of this power was in municipal stations. This makes an average size of 217-hp. The proximity of an oil supply makes this type of prime mover advantageous in Texas. The oil engine also serves as an auxiliary or stand by in many stations. A 1,250-hp. 2-cycle engine has recently been installed at Mexia.

Increases in power generation in central stations from 1907 to 1917 are shown in table 6. From 1912 to 1917 the number of stations increased only one, but power generated

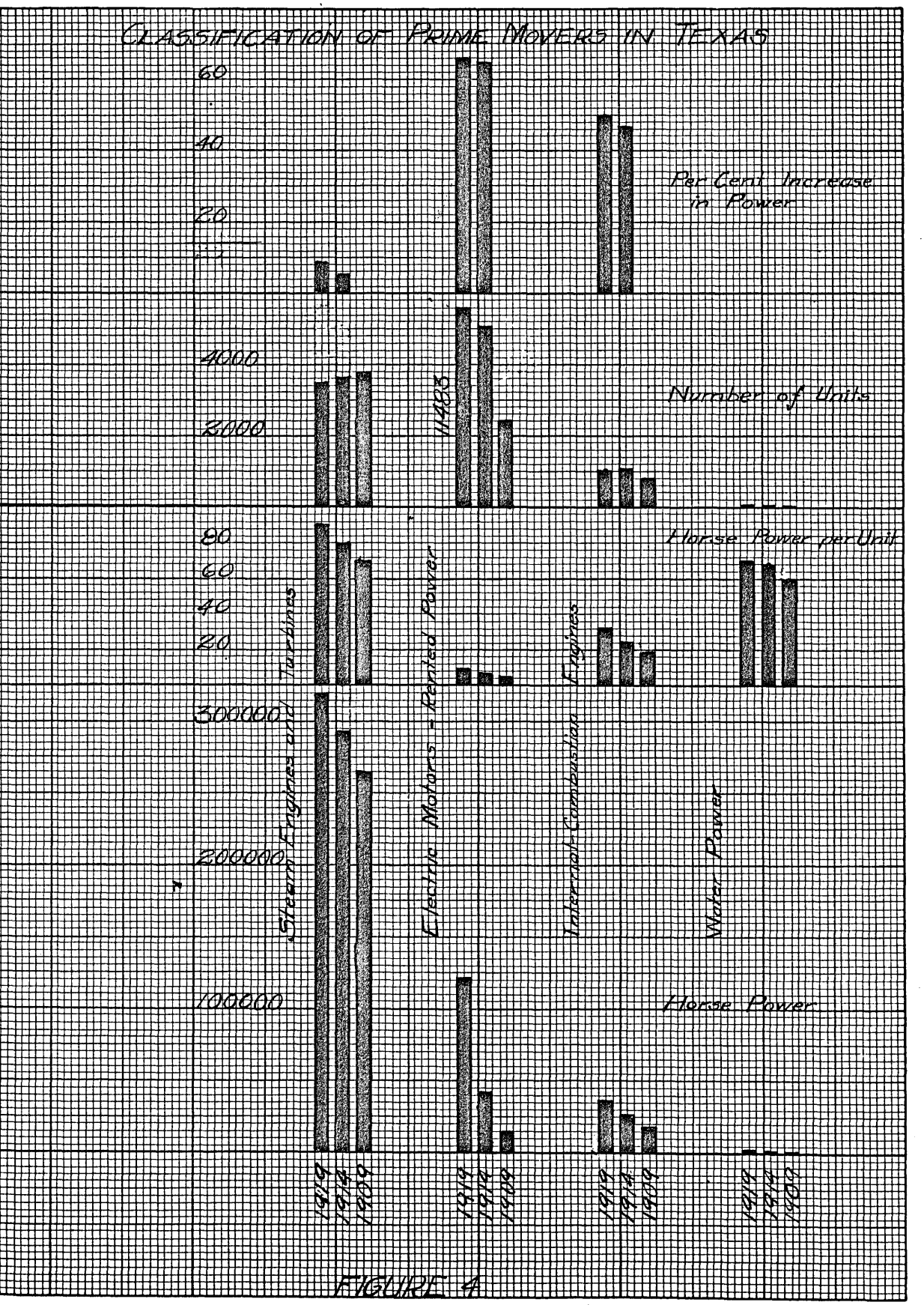

CLASSIFICATION OF PRIME MOVERS IN TEXAS
60
40
20
Per Cent Increase in Power
4000
2000
Number of Units
80
60
40
20
Horse Power per Unit
300000
200000
100000
Horse Power
Steam Engines and Turbines
Electric Motors - Rented Power
Internal-Combustion Engines
Water Power
1919
1914
1909

FIGURE A

increased 53 per cent, and station capacity increased 38.4 per cent. During the five years previous to 1917 motors increased 45 per cent in number and 69 per cent in power. This was brought about by the installation of larger motors and heavier loadings. This is shown by the increase in average motor size. Increase in value has been due mainly to increase in amount of equiptment.

PRIME MOVERS IN INDUSTRIES

The number and power of prime movers used in the industries of Texas as reported by the Census Bureau for 1919 are shown in the following table. The chart, figure 4, shown power statistics graphically for 1909, 1914, and 1919.

Table 8.

Prime Movers in Texas Manufacturing Industries

Prime movers	Number	Horse power
Steam engines	2,397	281,371
Electric motors	11,482	120,539
Internal-combustion engines	1,063	36,579
Water wheels	34	2,405
Total	14,977	440,894

Electric motors far out number all other prime movers. Those motors operated on current generated in the companys' own power plant are, of course, not included in the above number. The distribution shows that over 76 per cent of the prime movers were motors. This number represents only 36 per cent of the power, however. This is due to the

small average size. The numbers and power of motors are shown in the following table.

Table 9.

Number and Horse Power of Motors

	1909	1914	1919
Number of motors	2,443	5,275	11,483
Increase in per cent		53.7	54
Horse power	14,868	42,943	120,539
Increase in per cent		65.5	65.9
Horse power per motor	6.07	8.15	10.7

There has been an increase of about 54 per cent in motors every five years. The power has increased approximately 65 per cent in the same time. Motor size has increased 44 per cent in ten years.

The steam engine is foundin larger sizes but in less number than the motors. In fact the number of engines has decreased, but the power has increased. As may be expected this is largely due to the steam turbine. Turbine statistics are, unfortunately, not available for years other than 1919. Table 10 gives the steam engine statistics.

Table 10.

Numbers and Horse Power of Steam Engines and Turbines

	1909	1914	1919
Number of engines	2,955	2,541	2,298
Increase in Per cent		-16.3	-6.1
Number of turbines			99
Horse power of engines	249,535	262,200	248,653

Increase in per cent		4.83	7.07
Horse power of turbines			32,718
Average horse power per engine	85.5	103.3	108.2
Average horse power per turbine			331

The decrease in numbers and increase in power is quite evident. It is likely that, in addition to the turbine, a unit size increase of the steam engine is responsible for this.

Separate data for gas, gasoline, and oil engines are not to be obtained and all are brought under the heading of internal-combustion engines. There are, however, probably more Diesel engines than any other of this type in industrial plants in the state. For example, there are over 26,000-hp. in oil pumping stations, 4,000-hp. in mills, and 5,000-hp. in ice plants.

Table 11.

Number and Horse Power of Internal-Combustion Engines

	1909	1914	1919
Number	802	1,101	1,063
Increase in per cent		27.2	-3.68
Horse power	15.745	28,300	36,579
Increase in per cent		46.5	50
Horse power per unit	19.6	25.7	34.4

The small carburetor engine (gasoline and kerosene) is so prevalent as to cut down the average engine size. The average size has increased 43.7 per cent in the last

ten years. Larger units have been installed, as shown by the decrease in numbers and increase in power. There is a general tendency toward the larger units in all the types of prime movers just studied. There will probably be a less unit increase in motors than in any of the other types due to the process of individual drive in industries, where the motor is usedso extensively.

PRIME MOVERS IN PRINCIPAL INDUSTRIES

In a study of this kind the question arises as to what the distribution of types of prime movers is among the industries. Where are motors especially used, and in what industries do steam engines predominate? These and other questions arise. Although the number of units is not available the power consumption, taken on the basis of connected load, is given in the following tables.

Table 12.

Primary Power in Classified Industries 1919

	Horse Power	Establi shments	Hp. per establmt
Mining and fuel	150,216	8,894	16.9
Food products	134,566	1,456	92.5
Building and house furnishing	121,373	1,029	118
Ice and cold storage	55,879	265	210
Metal products and construction	46,172	1,139	40.5
Miscellaneous	39,193	1,697	23
Clothing and textiles	14,859	74	201
Total	562,258	14,554	38.6

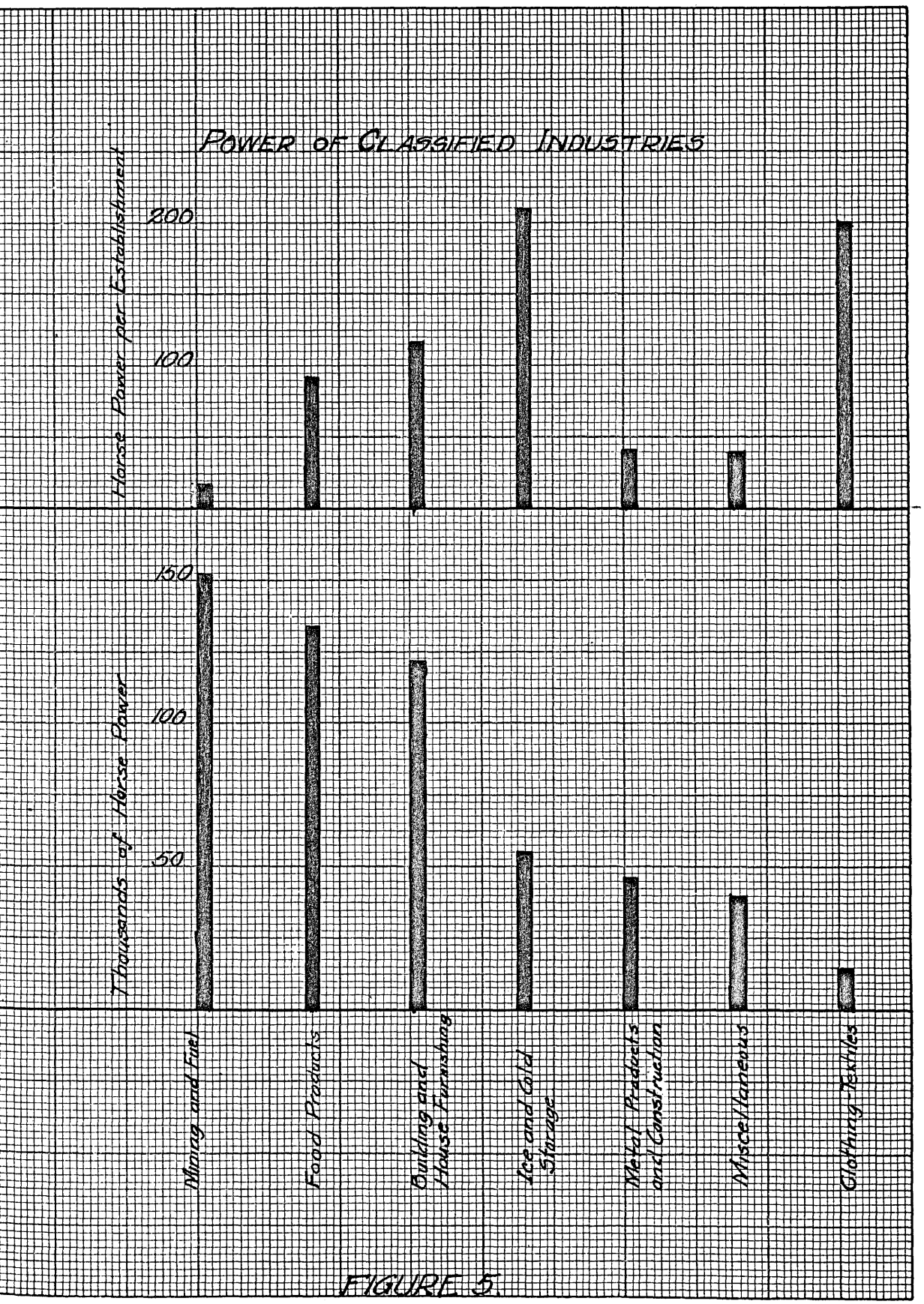

POWER OF CLASSIFIED INDUSTRIES
Horse Power per Establishment
200
100
Thousands of Horse Power
150
100
50
Mining and Fuel
Food Products
Building and House Furnishing
Ice and Cold Storage
Metal Products and Construction
Miscellaneous
Clothing Textiles

FIGURE 5.

Table 13.

Primary Power in Principal Industries for 1919

	Horse power	Establishments	Hp. per establishment
Automobile repairing	1,693	334	5
Box making (not cigar box)	5,682	19	300
Bakery products	2,792	610	4.6
Brick and tile	9,093	58	156.5
Rail road shops, electric	1,713	18	99
Rail road shops, steam	17,233	85	203
Cement	16,390	5	3,278
Chemicals	1,057	9	117
Confectionery and ice crm.	4,368	193	22.6
Cotton goods	14,210	15	948
Fertilizer	1,404	9	156
Flour and grist mills	23,854	222	107.3
Food products, miscls.	3,546	58	61.2
Foundry and machine shops	9,450	181	52.2
Furniture	1,846	22	84
Gas, artifical	3,622	25	144.8
Ice manufacturing	55,879	265	210
Malt liquors	4,476	6	746
Lumber and timber products	76,025	457	166
Lumber and planing mills	5.821	130	44.8

Marble and stone work	1,821	126	14.45
Matresses and spring beds	1,029	86	11.9
Mineral and soda waters	3,470	258	13.45
Oil and cotton seed cake	70,743	200	343.7
Paving material	1,567	11	142.4
Peanuts	1,257	9	138
Petroleum refining	27,543	39	706
Printing and publishing	8,017	1,073	7.47
Rice cleaning	7,998	14	571
Salt	1,656	3	552
Ship building	6,026	21	287
Slaughtering and meat packing	14,055	19	740
Wall plaster and composition flooring	1,715	3	571
Wood preserving	3,957	7	565

This classification has not been made arbitrarily, but with a view to segregating industries into allied groups. Centain deductions can then be made as to power uses and distribution. Incidentally by this means a detailed and complete study of industrial conditiond in the state could be made.

The number of establishments engaged in mining and fuel production includes 25 artificial gas plants, all mines and quarries, petroleum and gas wells and petroleum refineries. This accounts for the large number, which from a stand point of comparison can not be taken to exceed the number of establishments of all other groups, in as much as 98 per cent of the number are petroleum and gas wells. The number of refineries are some what variable, as in fact is petroleum production. For example, should crude prices advance more developement, or more intensive developement of producing fields, can be undertaken. The advance of crude price , or the decline in price of refined products, may result in the closing of a small refinery, or in some cases large ones. Other mining operations are confronted with the same conditions. There is nothing new or strange in this, and it is only mentioned here to call attention to the fact that power in this group is a variable quantity.

In as much as mining covers a wide field, and two important products are found in Texas, namely, coal and oil, a division of the group is shown, while data for refining and artificial gas are shown in other tables also.

Table 14.

Classification of Primary Power Used in Mining 1919

Number of coal mines	42
Number of other mines	39
Number of petroleum and natural gas wells	8,749

	Pet. and gas wells	Coal mines	Other mines
Total primary horse power	107,549	6,037	15,375
Steam engines			
Number of engines	2,174	76	204
Horse power of engines	58,988	5,190	8,789
Average power per engine	27.2	68.2	43.2
Steam turbines			
Number of turbines		1	5
Horse power of turbines		100	2,600
Average power per turbine		100	520
Internal-combustion engines			
Number of engines	1,734	11	84
Horse power of engines	47,186	752	2,302
Average power per engine	27.2	68.2	27.4
Electric motors			
Number of motors	64	3	62
Horse power of motors	1,375	95	1,684
Average power per motor	21.5	32	27.2

Almost all the power of both steam and internal-combustion engines is used by petroleum and natural gas production. Although not available for purposes of comparison this total power can be divided into two separate groups, namely; that power which has to do with drilling, or bringing the oil or gas to a state where it is "available"; and the other power which is necessary to pump the product to the refinery or an intermediate location, which is usually the case. Prime movers in the first group are in almost every instance reciprocating steam engines; and internal-combustion engines usually constitute the second group. If this reasoning be sound apparently more wells were being drilled than were completed and "on the pump" when the data was compiled. However, several wells are often pumped with a single engine of small power. This will account to some degree for the differences in number and power of the two types. Electrification of oil fields has been accomplished in some places. In this case motors often replace the internal-combustion engine. Motors are occasionally used for drilling also. In an electrified field internal-combustion engines often drive the generators. These engines are relatively large, while the pumping engines are small. In studying the figures in the table it should be remembered than a producing gas well can not be charged with any power (usually).

A little closer analyzation of power conditions in coal mines than in oil and gas production is possible. Steam engines, of course, predominate. The average power per unit is 68.3-hp. The eleven internal-combustion engines average the same amount. Electric motors are little used. The average power per mine is 144 hp., indicating the use of more than one unit in a mine.

Mines other than coal employ more power than the latter by about 60 per cent. The nature of the processes used is largely responsible for this. Steam engines again exceed with oil engines next. Turbines are found only in the larger sizes.

The second group of food products includes those industries making food products and those of a closely allied nature. Some of the individual members of the group are shown in other tables, where similar data are given. The group as a whole has the power per establishment well above the average. Some members of the group require as high as 350-hp. per plant, but such establishments as bakeries bring the average down. The average for bakeries and confectioneries is 5 to 22-hp. respectively. Table 13 shows this data. The small establishments exceed the large in point of numbers by about 50 per cent. The extent to which the small establishments use electric motors is shown in the table, where all forms of rented power are included under the heading of "electric motors", the power other

Table 15.

Horse Power of Prime Movers in Principal Industries

1919

	Steam engines	Steam turbines	Internal comb. engines	Electric motors
Automobile repairing	34		431	1,228
Box making (not cigar box)	1,671	2,000	4	2,007
Bakery products	698	5	153	1,929
Brick and tile	8,001	5	206	881
Rail road shops, electric	4,000		3	1,310
Rail road shops, steam	8,056		565	8,112
Cement	125	4,500	6,400	5,365
Chemicals	291			766
Confectionery and ice cream	1,079		350	2,939
Cotton goods	4,785		800	8,625
Fertilizer	405			999
Flour and grist mills	8,296		5,694	9,036
Foods products miscellaneuos	1,743		279	1,524
Foundry and machine shops	1,815	40	1,157	6,438
Furniture	618	40	14	1,174

Gas, artifical	1,877	1,194	125	416
Ice manufacturing	42,694	1,933	5,664	5,378
Malt liquors	3,340		850	286
Lumber and timber products	71,587	2,047	173	2,175
Lumber and planing mills	2,674	100	408	2,639
Marble and stone work	190		518	1,113
Matresses and spring beds	6		82	941
Mineral and soda waters	1,141	1,118	231	973
Oil and cotton seed cake	47,551	1,375	5,885	14,932
Paving material	917		150	491
Peanuts	250		295	712
Petroleum refining	2,767	10,375	2,700	11,701
Printing and publishing	905	5	702	6,502
Rice cleaning	6,103		420	1,475
Salt	990	433	33	200
Ship building	2,062	690	547	2,727
Slaughtering and meat packing	9,657			4,398
Wall plaster and composition flooring	190		675	850
Wood preserving	3,767	169	21	

than from electric current is negligable. In the case of the two industries mentioned 67 to 70 per cent of the power used is from electric motors. Flour and grist mills use 38 and oil mills only 21 per cent of electric power. This is to be expected from thelatter since steam is used in the process. A few mills, however, employ electric motors through out with a small boiler for the process steam. The bulk of the internal-combustion engines of this group are found in cotton seed oil mills and flour mills. More water power is to be found in this group than in others. Included in this are not only wheels and turbines on rivers but also water motors using water furnished from city mains. Seventy six per cent of all water power is in the second group.

The building and house furnishing group includes lumber production, marble and stone work, furniture, and so on. The lumber industry is the largest in the state in point of power. Most of the timber producing land is in the eastern section of the state. Here most of the mills are to be found, and the fuel used is largely mill refuse. Many of the mills are small affairs. This industry has 22.5 per cent of the establishments of the group and 62.6 per cent of the power. Cement manufacture is the other industry in the group which has a creditable amount of power. There are only five plants in Texas but the nature of the process requires a large amount of power per establishment.

The group ranks third in power produced by internal-combustion engines. One of its members, cement manufact-

ure, is the largest single user of this type of power. The group heads all others in the power of steam engines and turbines. The lumber industry is responsible for 75 per cent of this, where 94 per cent of the power is generated with reciprocating steam engines. The group ranks third in the use of electric motors.

Ice and cold storage is shown as a group and also as an individual industry with a consequent duplication. This is for the sake of completeness only. As regards prime movers in the industry reciprocating steam engines rank first, internal-combustion engines second, electric motors third, and steam turbines fourth. The raw water system of refrigeration has made it possible to use prime movers other than steam economically. Also the perfection of the high speed ammonia compressor has been a great aid in the use of motors, oil or gas engines. Probably about 11,000-hp. are in raw water plants in Texas. More than half of this amount are internal-combustion engines. The average plant load is 210 hp. This is the largest of any group. Taking it as an industry, however, the amount is about medium.

Power consumption has increased in the industry rather rapidly. During the five years previous to 1914 the increase in total power was 26.8 per cent, and the increase from 1914 to 1919 was 24.4 per cent. During this time steam engines increased 12 per cent, internal-combustion engines 64 per cent, and motors 88 per cent. The latter will probably not have such a phenominal increase in the next

CLASSIFIED PRIMARY POWER USED IN PRINCIPAL INDUSTRIES IN TEXAS FOR 1919

FIGURE 6

five years, although both oil engines and electric motors will probably increase at the expense of steam engines. Plant location will play a large part in the final selection of the type of prime mover. When rates permit of their use electric motors are more desirable. Proximity to coal or oil supply will often be the deciding factor as to the final selection of the prime mover.

"Metal products and construction" includes foundries, machine shops, automobile repair shops, and similar enterprises. Although there are over a thousand such industries in the state, they are, with few exceptions, small institutions. The group is next to the lowest in rank of power per establishment, as well as total power. From this it would be concluded that the group is relatively unimportant. Power required by an industry or a group of similar industries is indicitive of the relative inportance and size within the boundries considered. This rule can not be followed blindly, but is often a criterion. A notable exception is mining, and farming. Data for the groups' industries are shown in table 15, and graphically in figure 6.

Miscellaneuos industries for which individual statistics are not available, and those which do not fall naturally into a group are included under this heading. A large number of establishments are included, which have an average power per plant of 23-hp. The power per individual indus-

try in the group ranges from 7.5 to 117-hp. for printing and publishing and chemicals respectively

The group lowest in rank as regards power use is "clothing and textiles". In as much as Texas produces more cotton than any other state it is to be expected that this group will increase in importance. In fact it is a little surprising that such little textile manufacturing is carried on in Texas. In the group are found clothing manufacture of both men and women and all "cotton goods". Most of the power is supplied by electric motors, signifying that the establishments are often small. Steam engines rank next. (A textile mill is now being erected at New Braunfels which will use water power). Steam turbines or water power are not to be found in the group. The average power of the "cotton goods"industry is 950-hp. This brings the average of thegroup up to 201-hp.

POWER PRODUCTION

A previous discussion of commercial and municipal central stations relative to production of current has been given, but only in so far as to classify prime movers and stations. This will be supplimented with additional data, and studied with a view to determining any underlying causes affeceting power distribution on the time basis, if possible. Statistics pertaining to power production and industrial power requirements have not been collected for a sufficient length of time to allow very accurate estimations. Some profit can be gained froma study of that in hand, however.

Table 16.

Coal and Lignite Used for Producing Electric Power in Texas

Quantities in short tons.

	1919	1920	1921	1922
January	[illegible]	21,428		20,561
February	25,330	20,959		15,491
March	33,963	22,636		16,274
April	26,618	19,839	21,800	16,378
May		18,532	18,458	16,621
June		20,280	18,426	17,097
July	29.269	22,650	19,314	25,510
August		19,783	19,240	24,676
September	24,511	18,125	17,728	19,105
October	26,696	18,223	18,479	18,637
November		18,590	18,220	17,516
December		20,259	17,281	21,777

Table 17.

Natural Gas Used for Producing

Electric Power

in Texas

Thousand cubic feet.

	1919	1920	1921	1922
January		54,980		119,407
February	173,695	57,669		152,510
March	179,760	60,469		156,413
April	177,778	72,815	121,393	177,574
May		95,409	113,918	176,624
June		187,515	124,987	209,417
July	114,148	165,873	135,336	246,317
August		154,267	140,864	279,193
September	58,717	163,984	126,948	281,199
October	55,798	122,116	125,600	270,337
November		135,651	131,456	260,084
December		143,344	132,828	227,183

Table 18.

Fuel Oil Used for Producing Electric Power in Texas

Barrels of 42 gallons.

	1919	1920	1921	1922
January		241,993		256,108
February	170,905	223,973		219,773
March	181,397	239,174		239,901
April	178,003	224,234	222,699	219,277
May		229,633	245,192	238,482
June		219,327	247,221	238,595
July	188,691	245,716	260,988	240,357
August		241,586	282,779	266,265
September	214,285	258,559	278,444	279,168
October	240,135	269,295	275,543	282,478
November		254,253	255,327	274,659
December		249,150	256,169	279,663

Table 19.

Thousands of Kilowatt Hours of Electric Power Produced by Fuels in Texas

	1919	1920	1921	1922
January		55,622		64,604
February	43,070	49,814		56,708
March	47,616	53,590		61,117
April	44,816	51,280	57,031	58,602
May		48,094	59,994	63,100
June		52,549	61,139	64,385
July	45,537	55,911	63,971	67,935
August		57,409	66,574	72,067
September	47,582	60,981	66,377	73,777
October	43,499	64,072	66,702	76,883
November		61,986	63,330	75,912
December		63,284	63,955	77,968

Table 20.

Thousands of Kilowatt Hours of Electric Power Produced in Texas by Water Power

	1919	1920	1921	1922
January		74		432
February	266	231		389
March	284	380		369
April	305	299	305	355
May		310	372	379
June		310	360	358
July		316	364	182
August	191	359	408	219
September	61	332	409	208
October	71	491	237	209
November		492	375	208
December		431	432	187

The capacity of the commercial stations is 132,000-kw. and that for the minicipal stations is 5,725-kw. The per cent of load carried per unit on a full load full time basis is 27.6 and 21.2 for the commercial and municipal stations respectively. The production is respectively 587,000 and 22,170-kw. hrs. So the commercial stations carried 96.5 per cent of the load and maintained a 6.4 per cent greater load factor. The average monthly production was 26,438-kw. hrs. in 1917. This can be compared with similar data for other years. The U. S. Geological Survey has compiled data giving the kilowatt hours produced by water power, and fuels; such as coal, natural gas, and fuel oil. The returns are for public utility stations, and those furnishing power to electric rail ways with productions over 10,000 kw. hrs. per month. The data covers about 95 per cent of the power produced in the state by such stations, and so can be considered characteristic. Curves and tables both show this information. Water power production is low as has been intimated before, and is compared with that produced with fuels in figure 8.

CLASSIFICATION AS TO FUEL USED

Naturalgas, oil, and coal are all more or less extendively used. Gas can hardly be utilized in sections very distant from the producing fields, on account of the transportation charges. Nevertheless it is used extensively in the producing territory. The supply may not last for any great length of time. The quantities of oil and gas cover

that used in internal-combustion engines and under boilers. Fuel oil is very extensively used in large as well as small plants, see table 1. In this state transportation charges operate to the exclusion of coal over oil, although a large amount of power is generated with coal and lignite. Lignite, with a heating value on the wet basis of 9,500 B.t.u., is scattered over a large portion of Texas. The otherwise nearest coal fields are in Oklahoma. Both technical, as regards the difficulty of burning lignite, and economic problems must be solved before a solid fuel can be used. The plant at El Paso is about the farthest removed from refineries or oil fields, of any of the large plants, and oil is used there.

As an aid in comparing the amounts of current produced with the different fuels figure 7 has been plotted. The actual amounts of current produced by both water power and fuels is also shown for different years by months. The seasonal variation of current demand is usually plain as wellaas the yearly increase. Especially in the case of fuel oil it will be seen that the peak occurs between October and August. Cotton ginning season is at this time and is responsible in a large part for the shape of the curves. The peak load for natural gas for 1921 and 1922 is at about the same time. The use of this fuel is very erratic, due to new wells coming in with a consequent over supply of gas. The exceptional use of gas in 1922 helped to elevate the power production curve for the same year as shown in figure

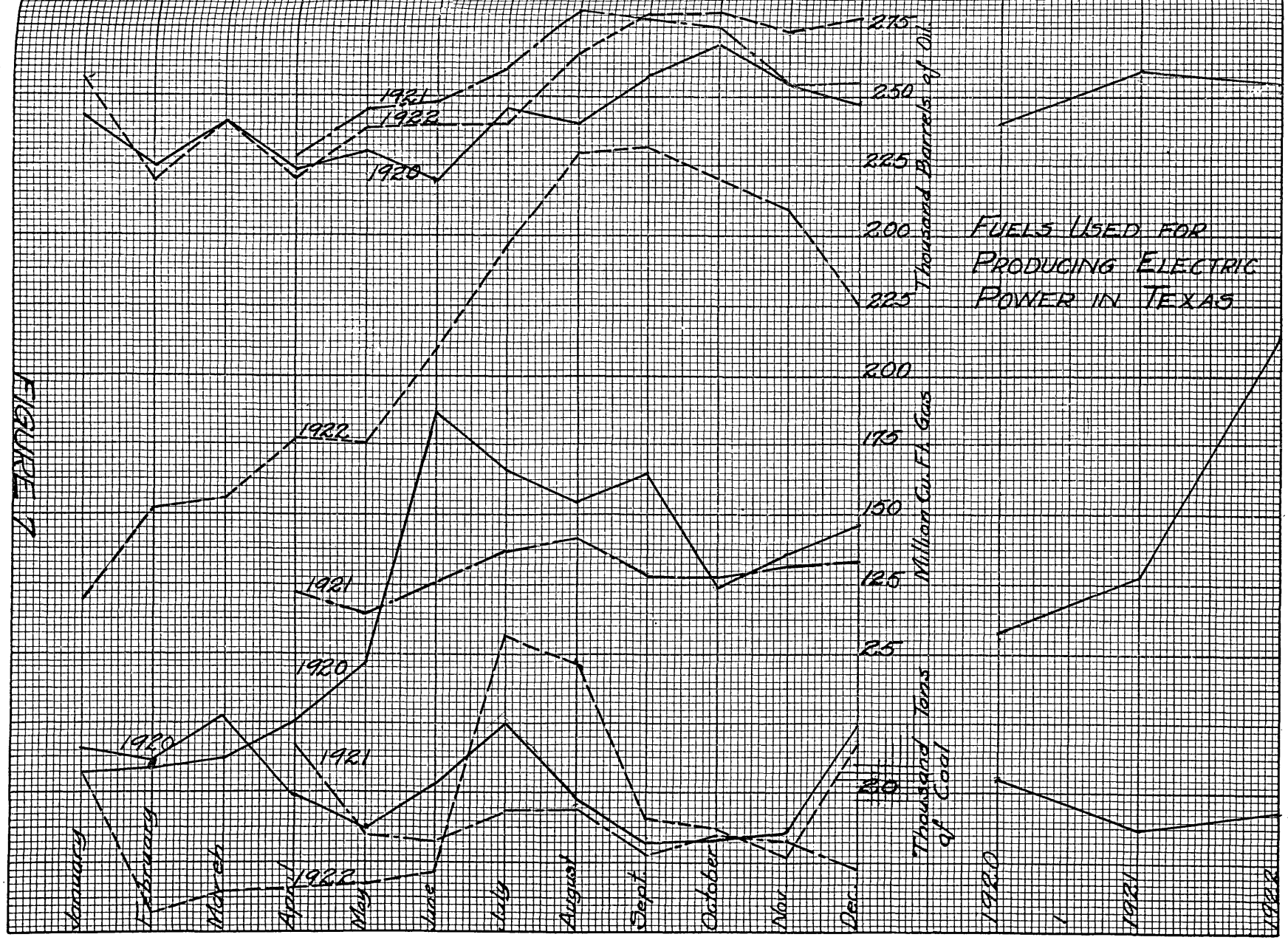
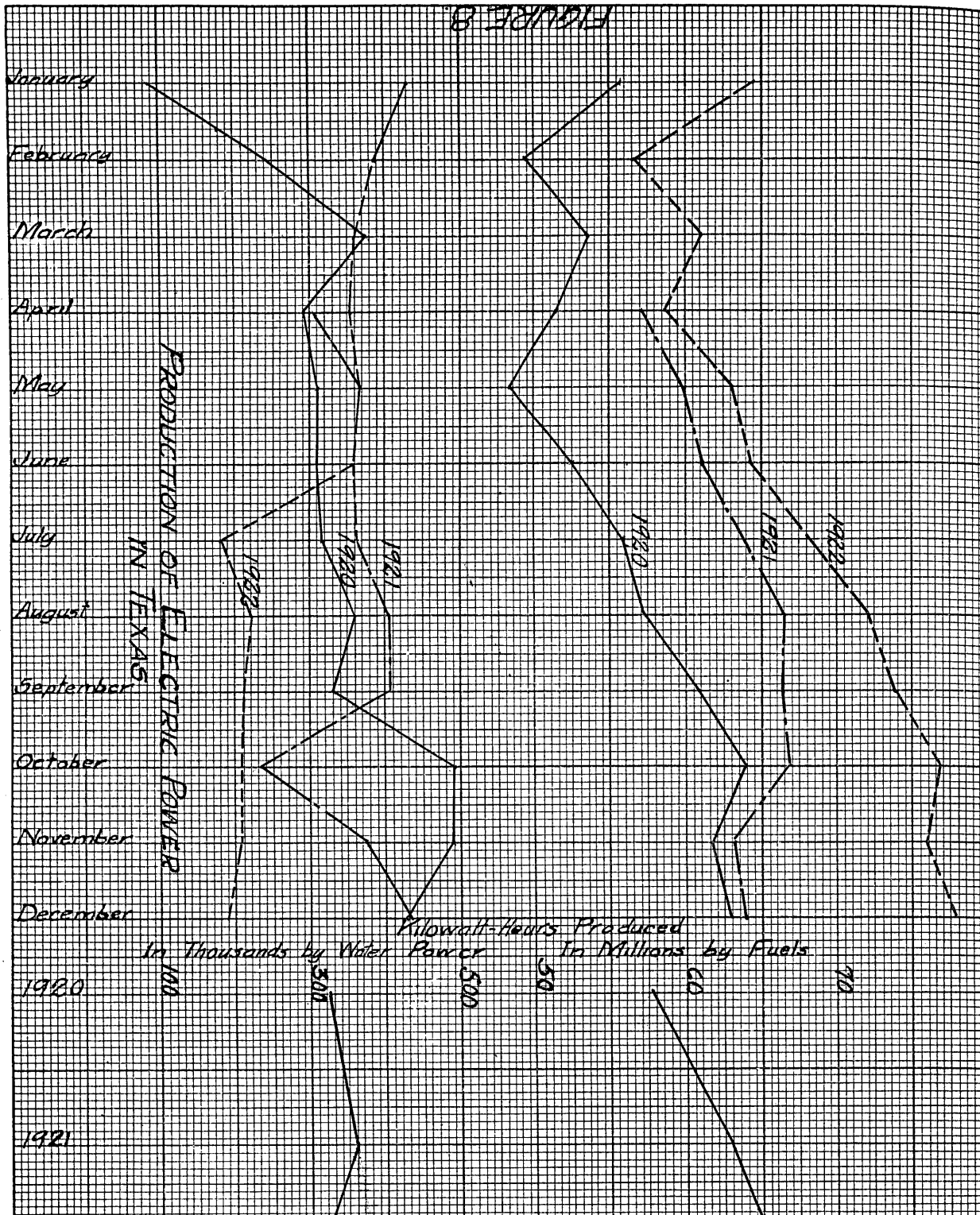

FUELS USED FOR PRODUCING ELECTRIC POWER IN TEXAS
Thousand Barrels of Oil
Million Cu. Ft. Gas
Thousand Tons of Coal
1922
1921
1920
2.75
2.50
2.25
2.00
225
200
175
150
125
25
20
January
February
March
April
May
June
July
August
Sept.
October
Nov.
Dec.
1920
1921
1922

FIGURE 17


PRODUCTION OF ELECTRIC POWER IN TEXAS
January
February
March
April
May
June
July
August
September
October
November
December
1920
1921
1922
1920
1921
1922
Kilowatt-Hours Produced
In Thousands by Water Power
In Millions by Fuels
300
500
50
60
70
Average Monthly Production
Kilowatt-Hours

7. Had it not been available some other fuel would probably have been used. The use of coal seems to be variable also and acts as a sort of stabelizer for oil, although it is not to be infered that a shift is made from one fuel to the other at will. Some plants burn both at the same time. It should be noted that the oil and gas curves have the same general shape for the various years. The curves showing the average amount of fuel used during 1920, 1921 and 1922 in figure 7 are in reality parts of those at the top of figure 8. These are a summation of the former with different units and scales. A large fuel consumption represents a large power production.

POWER PRODUCTION BY FUELS AND BY WATER POWER

For the years shown there is a general increase in power production by fuels starting from about May and continuing to the peak near the month of October. The amounts of current produced with water power has a tendency to follow the shape of the curves above. This is shown in the curves for 1920 and 1921 from March to September. It would appear that in this period all the current demanded was supplied and that from July to December 1922 river conditions prevented a full power output. A dry period was in fact experienced at this time. Practically no new load can be taken on by the water plants because of the unreliability of the source. The size of the wheels has determined the nature and extent of the load to a large extent. The load is usually local street lighting and small motors.

FIGURE 9

Abilene
Amarillo
Austin
Beaumont
Brownsville
Cleburne
Corpus Christi
Corsicana
Dallas
Del Rio
Denison
El Paso
Fort Worth
Galveston
Greenville
Houston
Laredo
Marshall
Palestine
Paris
Ranger
San Angelo
San Antonio
Sherman
Temple
Texarkana
Tyler
Waco
Wichita Falls

POWER STATISTICS FOR PRINCIPAL TEXAS CITIES

200 400 — No. of Establishments
10 20 30 — Thousands of Horse Power
50 100 150 — Population in Thousands
50 100 — H.P. per Establishment
2000 4000 6000 — Capital per H.P.
2 4 6 — H.P. per Person Engaged

Table 21.

Power Statistics of Manufactures in Texas

Cities for 1919

Cities	No. mfgs.	Persons engag.	Capital empld.	Primary hp.	Cap. per hp.	Per. per hp.	hp. per estab.
Abilene	22	194	582,000	469	1,241	.415	21.3
Amarillo	42	613	1,049,000	1,612	650	.380	38.4
Austin	91	1,037	4,306,000	3,302	1,305	.314	36.3
Beaumont	70	4,558	65,731,000	10,390	6,330	.439	148.4
Brownsville	18	156	340,000	700	442	.203	42.7
Cleburne	33	1,246	2,501,000	1,757	1,425	.720	53.2
CorpusChristi	20	158	1,021,000	575	1,778	.275	28.7
Corsicana	40	729	5,907,000	2,871	2,057	.253	71.8
Dallas	457	10,677	42,270,000	23,197	1,826	.461	50.7
Del Rio	6	105	267,000	183	1,460	.573	30.5
Denison	42	1,217	1991,000	3,806	524	.320	90.6
El Paso	208	4,777	14,775,000	10,848	1,363	.441	52.1
Fort Worth	229	5,505	24,084,000	14,234	1,693	.387	65
Galveston	118	1,904	10,668,000	7,643	1,395	.249	64.7
Greenville	29	260	3,180,000	1,871	1,665	.139	64.5
Houston	383	12,126	49,646,000	31,416	1,580	.386	82.2
Laredo	30	363	684,000	584	1,171	.622	19.4
Marshall	24	1,815	9,147,000	1,533	5,960	1.185	63.9
Palestine	17	1,187	2,061,000	1,960	1,053	.605	11.5
Paris	52	1,164	3,808,000	3,788	1,005	.307	72.9
Ranger	17	237	894,000	629	1,420	.377	37
San Angelo	30	202	401,000	743	540	.275	24.7

San Antonio	318	8,708	22,580,000	13,040	1,728	.667	42
Sherman	53	1,089	9,392,000	4,314	2,177	.255	815
Temple	45	566	2,044,000	1,841	1,111	.307	409
Texarkana	38	963	3,085,000	3,519	878	.273	926
Tyler	33	863	1,858,000	2,289	812	.377	693
Waco	134	1,795	6,657,000	4,981	1,338	.360	37
Wichita Falls	69	1,236	15,945,000	3,519	4,538	.351	51

Classified Primary Power Used in Principal Cities in Texas For 1919

1 inch = 4000 H.P.

Total Primary Power Including Water Power

Steam Engines and Turbines

Electric Motors = Rented Power

Internal-Combustion Engines

Abilene
Amarillo
Austin
Beaumont
Brownsville
Cleburne
Corpus Christi
Corsicana
Dallas
Del Rio
Denison
El Paso
Fort Worth
Galveston
Greenville
Houston
Laredo
Marshall
Palestine
Paris
Ranger
San Angelo
San Antonio
Sherman
Temple
Texarkana
Tyler
Waco
Wichita Falls

Standby steam and oil engine plants are used to furnish any deficite in power demand. The total power usedin these years is combined with similar data for plotting a curve shown with other curves in figure 11. The steady and continued increase is very incouraging as regards power production. The value of manufactured and agricultural products increase at very nearly the same rate as kilowatt hours developed.

POWER CONSUMPTION

The primary power used in the principal cities of Texas is shown in table 21. The power consumed in the industries is shown in figure 5. All the cities with a population of 10,000 or over, with the exception of Port Arthur, are shown in table 21. This city is not included, as statistics for it would disclose individual operations. Four items are given in the table, namely; primary power; the number of persons employed in the manufactures per horse power used; capital per horse power; and the amount of power per establishment. This data along with the number of manufactures and population are shown graphically in figure 11. Population and power appear to run hand in hand with a ratio of about 4 to 7.5 persons per horse power for the larger cities, those above 20,000 population, and 40 to 50 for those below this figure. It will also be seen that capital per horse power, with a few notable exceptions, is fairly constant. The nature of the manufactures will have a large influence on this ratio, however. Horse power per establishment, though not so fixed as the other does not vary to a great

FIGURE III

POWER STATISTICS FOR TEXAS

Population

Agricultural Products

Manufactured Products

Power of Manufactures

Power Generated by Central Stations

Population Millions

Value of Products Million Dollars

Thousands of Horse Power

Average Kilowatt-hours per Month Millions

1900

1905

1910

1915

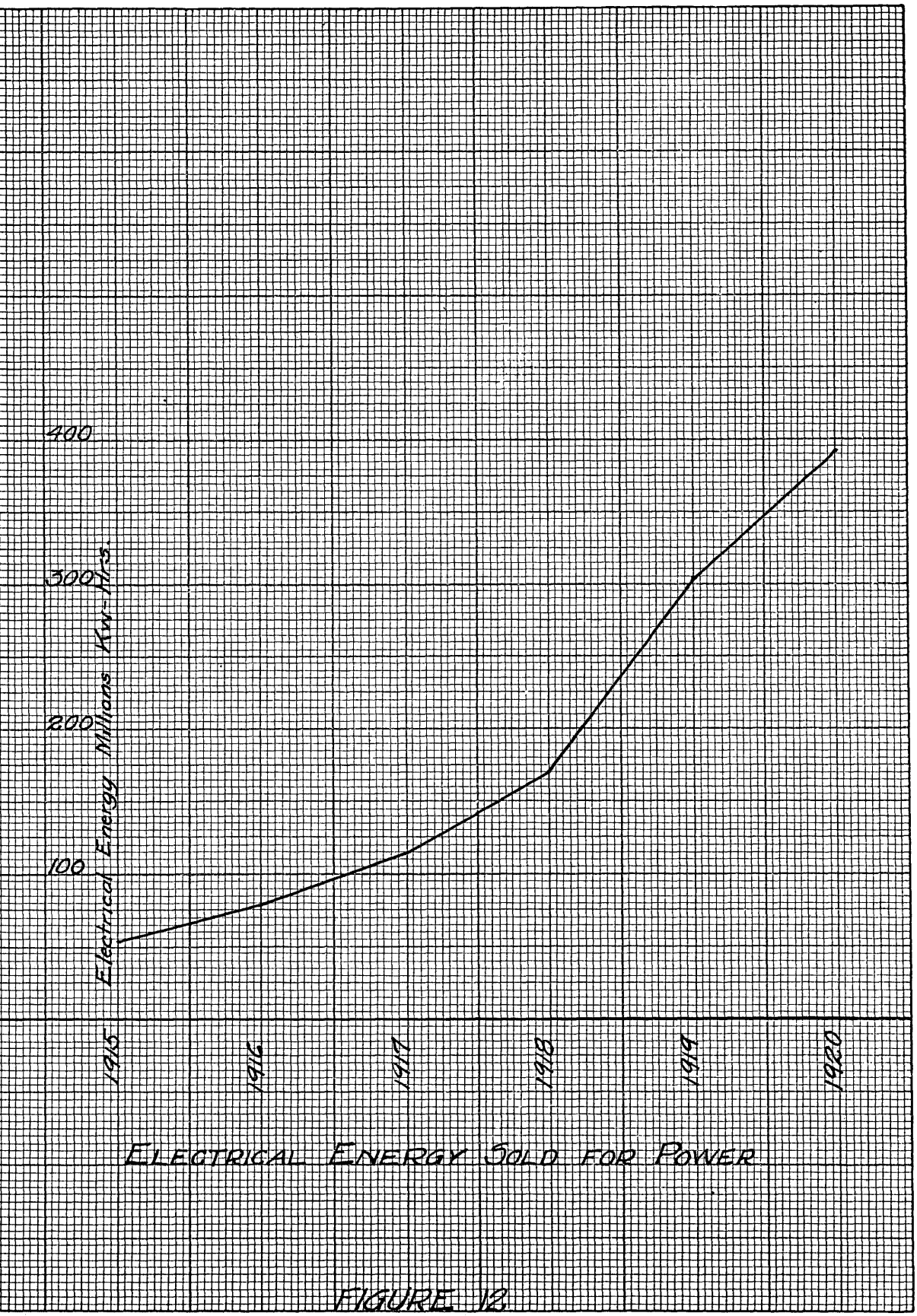
1920

1925

extent, and for the larger cities remains within fairly fixed limits. The ratio is approximately one horse power per establishment per 1,500 to 3,000 persons. The power per person employed is variable depending on the type of industry and local conditions. The relation of power to population over several years is shown in figure 11. The population curve and that for horse power of manufactures are almost parallel. The power usedin the principal cities is shown in graphical form in figure 10. In large centers, such as Fort Worth, Dallas, and Houston are found the greatest steam and electric motor powers. The large use of motors is to be expected where central stations are present. The relative importance of a city as in industrial center is shown in the amount of total horse power consumption.

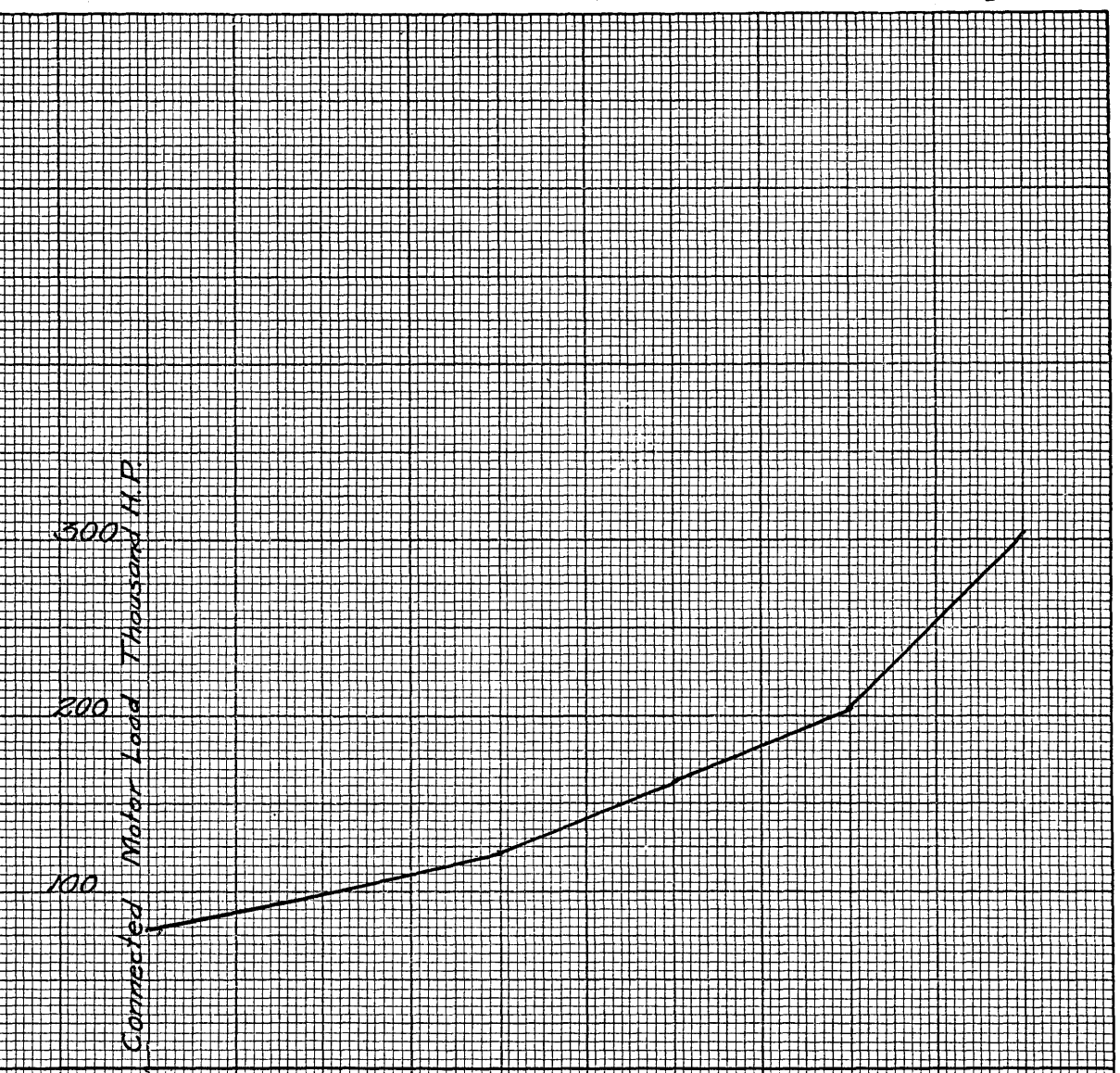
In 1919 171 power laundries were in Texas. These consumed a total power of 5,918-hp. The average power per plant was then 34.6-hp. Some internal-combustion engines and electric motors were used, but the bulk of the power was from steam engines.

Irrigation is assuming a good deal of importance in some parts of the state. In 1920 there were 1,369 irrigation plants in operation. A total of 80,511-hp. was employed, which averages 58.8-hp. per plant. Although a classification of prime movers is not available, it is known that a large per cent of the total is internal-combustion engines.



ELECTRICAL ENERGY SOLD FOR POWER

FIGURE 12



POWER OF ELECTRIC MOTORS IN TEXAS

FIGURE 13

The following table gives the consumption of electrical energy and the connected motor load and number of motors served from 1915 to1920 inclusive.

Table 22.

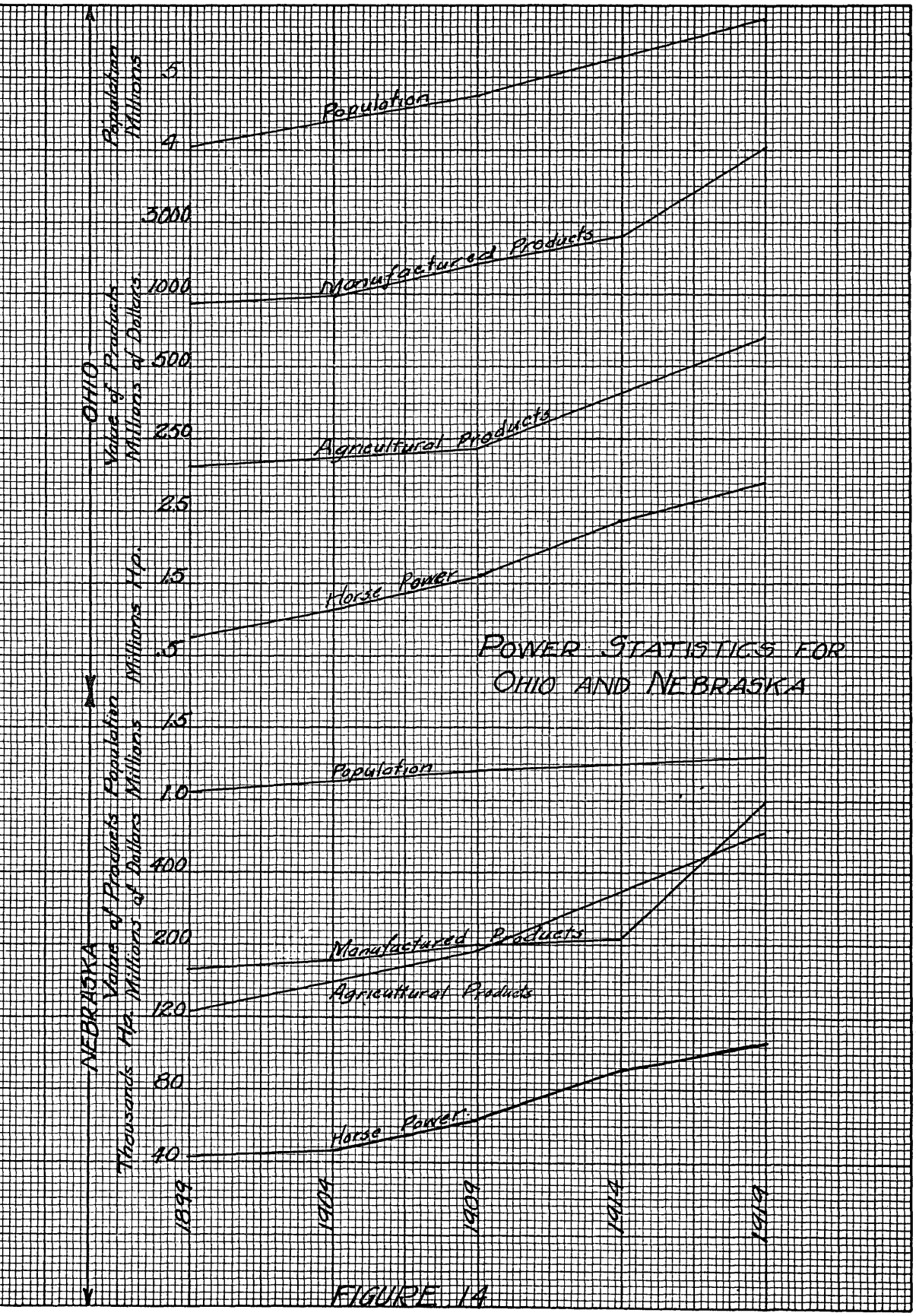
Consumption of Electrical Energy in Texas

Year	Motors Served	Connected load horse power	Total electrical energy sold kw.hrs.
1915	11,900	81,000	54,800,000
1916	13,600	100,100	79,200,000
1917	14,500	123,200	114,500,000
1918	16,900	170,200	170,800,000
1919	19,500	209,700	304,000,000
1920	21,500	308,500	391,000,000

During this time the increase in energy sold was 86 per cent and connected motor load increased 44.6 per cent. The estimated population increase in the same time was 9.2 per cent. This makes a ratio of power increase to population increase of 9.3 to 1. The above table is taken from the Jan. 1st, 1921, number of Electrical World and is given here as a suppliment to the preceeding data. Figures 12 and 13 shown curves for the power and motor increase.

COMPARISON OF THE TEXAS SITUATION WITH THAT IN OTHER STATES

Data for Nebraska and Ohio covering power of industries, value of manufactured and agricultural products, and population are shown graphically in figure 14 for the years 1899 to 1919 inclusive. As in the case of Texas, power



POWER STATISTICS FOR OHIO AND NEBRASKA

FIGURE 14

increases at almost the same rate as population considering the twenty year period. Moreover the value of manufactured products increases at nearly the same rate ,in the three states. Although the value of agricultural products has fallen off somewhat it is not marked, and its curve slopes in much the same way as the curve for the manufactured products. Of course, war prices have had a great deal to do with the shape of the "value" curves. Power consumption in Nebraska has increased at a greater rate than population and, on the whole, than value of manufactured products. Value of agricultural products and power consumption have increased at nearer a like rate than the above. These two states are taken for comparison in as much as they are representative of most states. Ohio has a large population and large number of manufactures, while Nebraska has a population smaller than Texas, with the value of manufactured and agricultural products nearly equal but lower than that for Texas. Should a similar study be made for all the states no doubt some striking relations would be found. Probably a definite relationship exists between power consumption and population.

END

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TEXAS

N

SCALE OF MILES

0 50 100

CENTRAL STATIONS

LEGEND

SIZE OF STATIONS

100	TO	500	HORSE	POWER
500	"	1000	"	"
1000	"	2000	"	"
2000	"	5000	"	"
ABOVE		5000	"	"

FIGURE 1

F.E.J. 5123

TEXAS

N

SCALE OF MILES

0 50 100

CENTRAL STATIONS

LEGEND

- STEAM ○
- OIL OR GAS ⊕
- WATER △
- STEAM & WATER ⧋
- OIL OR GAS & WATER ⧋
- STEAM & OIL OR GAS ⊕
- STEAM, OIL OR GAS & WATER ▲
- TRANSMISSION LINES ——

FIGURE 2

F.E.J. 5123