PETROLEUM REFINING.

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The period covered by this report is the calendar year 1899. The statistics presented embrace the operations of every establishment in the United States engaged in refining crude petroleum. Establishments which purchase refined or partly refined oils, and mix or compound them with vegetable, animal, or other mineral oils for special purposes, are not considered in this report. The schedules of inquiries were prepared and the tables have been compiled in a manner as uniform as possible with those of the Eleventh Census.

The statistics of petroleum refining at the present census show that while the value of the product has increased 45.8 per cent over that of 1889, there has been a decrease in the number of establishments and the number of refineries. The reduction in the number of establishments has been due partly to the consolidation of two or more formerly independent concerns under one management, and partly to the abandonment and dismantling of a few comparatively small establishments, both being the natural result of the present tendency in industrial conditions.

The principal features of the statistics of petroleum refining in 1899, 1889, and 1880 are summarized in the following table:

Table 1.—COMPARATIVE SUMMARY: 1899, 1889, AND 1880.

	1899	1889	1880	Per cent of increase.	
				1889 to 1899	1880 to 1889
Number of establisments	[1] 67	[2] 94	86	[3] 28.7	9.3
Capital	$95,327,892	$77,416,296	$27,325,746	23.1	183.3
Land	$8,166,032	$7,886,668	(4)	3.5	.....
Buildings	$6,502,182	$6,403,994	(4)	1.5	.....
Machinery, tools, and implements	$39,565,389	$20,837,038	(4)	89.9	.....
Cash and sundries	$41,094,289	$42,288,596	(4)	[3] 2.8	.....
Wage-earners, average number	12,199	11,403	9,869	7.0	15.5
Total wages	$6,717,087	$5,872,467	$4,381,572	14.4	34.0
Miscellaneous expenses	$3,330,851	$2,069,268	(5)	61.0	.....
Cost of materials	$102,859,341	$67,918,723	$34,999,101	51.4	94.1
Value of products	$123,929,384	$85,001,198	[6] $43,705,218	45.8	94.5

[1] Exclusive of 2 idle establishments with aggregate capital amounting to $90,000.
[2] Exclusive of 7 idle establishments with aggregate capital amounting to $423,508.
[3] Decrease.
[4] Not reported separately at the census of 1880.
[5] Not reported at the census of 1880.
[6] In the report for 1880 the value of packages made at the refinery is not shown as a distinct item of product, and does not appear to have been included in the value.

The aggregate capital shows an increase in 1899 over 1889 of $17,911,596, or 23.1 per cent. The noteworthy increase is in the capital invested in machinery, tools, and implements, this portion of the capital showing an increase of $18,728,351. The value of the buildings shows an increase of $98,188, and land, an increase of $279,364, while that portion classed as cash and sundries, represented by the cash on hand, accounts and bills receivable, stock on hand, etc., shows a decrease of $1,194,307. The average capital per establishment in 1880 was $317,741, in 1889 it was $823,578, and in 1899 it was $1,422,804, a rise illustrating clearly the effect of the consolidations which have taken place during the last decade.

These figures represent, not the capital stock of the corporations engaged in the industry, but the value of the plants, together with the live or working capital.

It is interesting to note that while the total capital in 1899 shows an increase of 23.1 per cent over 1889, and the value of the products an increase of 45.8 per cent, the cost of materials increased 51.4 per cent. The prices of crude petroleum in 1899 were higher than in 1889, while the values of refined products, particularly illuminating oils, were generally lower.

Table 2 presents the statistics concerning idle establishments, by states, in 1899 and 1889.

Table 2.—CAPITAL, IDLE ESTABLISHMENTS: 1899 AND 1889.

State.	Year.	Number of establishments reporting.	Total.	Land.	Buildings.	Machinery, tools, and implements.	Cash and sundries.
United States	1899	[1] 2	$90,000	$20,250	$34,750	$35,000	.....
	1889	7	423,508	81,700	215,690	104,889	$21,229
California	1899	.....	.....	.....	.....	.....	.....
	1889	1	28,118	600	400	26,789	329
Ohio	1899	[1] 1	65,000	20,000	30,000	15,000	.....
	1889	2	12,600	800	2,700	9,100	.....
Pennsylvania	1899	.....	.....	.....	.....	.....	.....
	1889	3	372,790	79,800	204,590	67,500	20,900
Texas	1899	[1] 1	25,000	250	4,750	20,000	.....
	1889	.....	.....	.....	.....	.....	.....
West Virginia	1899	.....	.....	.....	.....	.....	.....
	1889	1	10,000	500	8,000	1,500	.....

[1] Practically abandoned.

There were 7 idle establishments in 1889, with a total capital of $423,508, while in 1899 there were but 2 idle

establishments, practically abandoned, with a total capital of $90,000.

The total number of refineries in operation in 1899, 1889, and 1880, by states, is shown in the following table:

TABLE 3.—COMPARATIVE SUMMARY: NUMBER OF REFINERIES, BY STATES; 1899, 1889, 1880.

STATE.	1899	1889	1880
United States	75	106	89
California	4	2	.....
Colorado	2	2	.....
Indiana	1	.....	.....
Kansas	1	.....	.....
Kentucky	.....	.....	1
Maryland	1	3	3
Massachusetts	.....	1	5
Maine	.....	.....	1
Michigan	1	.....	.....
New Jersey	6	5	2
New York	9	16	21
Ohio	9	15	18
Pennsylvania	39	58	33
Texas	1	.....	.....
West Virginia	1	4	5

The number of establishments shown in Table 1 does not represent the total number of refineries, for when two or more refineries, located in the same city or county, are operated by the same corporation, firm, or individual, they are counted by the Census Office as one establishment.

The petroleum refining industry for 1899 is confined to 12 states, and in 7 there are only one or two refineries. There are, therefore, but 5 states for which the statistics can be given separately without disclosing the operations of individual establishments. The number of refineries in each of these states is as follows: California, 4; New Jersey, 6; New York, 9; Ohio, 9; and Pennsylvania, 39. Colorado has 2 refineries, while Texas, West Virginia, Indiana, Kansas, Maryland, and Michigan have 1 each. Kentucky and Maine each reported an establishment in 1880, but none in 1889. Massachusetts had 5 in 1880, 1 in 1889, and none in 1899. Indiana, Kansas, Michigan, and Texas are included in the list in 1899, but not in 1889 or 1880. The number of refineries in Pennsylvania has decreased from 58 in 1889 to 39 in 1899; those in New York, from 16 to 9; in Ohio, from 15 to 9; in Maryland, from 3 to 1. The total number of refineries in the United States is shown to have decreased from 106 to 75, a loss of 31. Part of this decrease has been due to the consolidation, under one management, of two or more refineries which were conducted as separate concerns in 1889 and as one establishment in 1899.

At the Eleventh Census, the average number of persons employed during the entire year was called for, and also the average number employed at stated weekly rates of pay. At the Twelfth Census, the greatest and least numbers of employees were reported, and also the average number employed during each month of the year. The average number of wage-earners (men, women, and children) employed during the entire year was ascertained by using 12, the number of calendar months, as a divisor into the total of the average numbers reported for each month. This slight difference in the method of ascertaining the average number of wage-earners during the entire year, may have resulted in a variation in the number, and should be considered in making comparisons.

Table 4 presents a comparative summary of the number of employees by classes, with salaries and wages paid in 1899 and 1889.

TABLE 4.—NUMBER OF EMPLOYEES, BY CLASSES, WITH SALARIES AND WAGES PAID: 1899 AND 1889.

EMPLOYEES AND WAGES.	1899	1889
Proprietors and firm members	47	(1)
Salaried officials, clerks, etc.:		
Number	1,201	[2] 1,068
Salaries	$1,811,400	[2] $1,117,011
Wage-earners, average number	12,199	11,403
Total wages	$6,717,087	$5,872,467
Men, 16 years and over—		
Average number	11,935	10,885
Wages	$6,673,629	$5,786,737
Women, 16 years and over—		
Average number	66	2
Wages	$15,570	$622
Children, under 16 years—		
Average number	198	516
Wages	$27,888	$85,108

[1] Included with salaried officials, clerks, etc., in 1889.
[2] Includes proprietors and firm members, with their salaries; number only reported in 1899. (See Table 9.)

The figures show a large relative increase in the number of women employed and a decrease in the number of children. The number of children employed showed a decrease of 318, or 61.6 per cent. There appears to have been comparatively little change in the number of men employed in the administrative or clerical force, while in the wage-earners the number increased 9.6 per cent and the total wages 15.3 per cent.

Table 5 presents, in detail, a comparative summary of materials used in 1899, 1889, and 1880.

TABLE 5.—COMPARATIVE SUMMARY: MATERIALS USED; 1899, 1889, AND 1880.

MATERIALS USED.	1899	1889	1880	PER CENT OF INCREASE.	
				1889 to 1899	1880 to 1889
Total cost of materials	$102,859,341	$67,918,723	$34,999,101	51.4	94.1
Crude petroleum:					
Quantity (barrels of 42 gallons)	52,011,005	30,662,629	17,417,455	69.6	76.0
Cost	$80,424,207	$44,879,783	$16,340,581	79.2	174.7
Fuel, cost	$3,120,441	$2,275,468	$1,319,008	37.1	72.5
Acids, cost	$1,735,782	$1,530,065	$1,206,300	13.4	26.8
Packages bought, barrels, tin cans, and cases	$2,930,805	$4,340,274	$8,388,572	[1] 32.5	[1] 48.3
Coopers', carpenters', and tinners' materials	$8,220,928	$12,495,600	$7,576,055	[1] 34.2	64.9
Mill supplies	$228,926	(2)	(2)	.....	.....
All other materials, cost	$3,300,851	[3] $2,397,583	$168,585	37.7	1,322.2
Freight paid	$2,897,401	(2)	(2)	.....	.....

[1] Decrease.
[2] In 1889 and 1880 this item was not reported separately.
[3] Includes $127,205, the value of residuum and naphtha used as materials.

Crude petroleum is measured by barrels of 42 Winchester gallons; refined petroleum, by barrels of 50 gallons. The total amount of crude petroleum consumed by the refineries of the United States in 1899 was 52,011,005 barrels, as against 30,662,629 barrels in 1889 and 17,417,455 barrels in 1880, the amount used in 1899 being nearly three times that used in 1880, and 69.6 per cent more than that used in 1889. In 1880 the value of the crude petroleum used was a little less than $1 per barrel; in 1889 it was worth $1.46 per barrel; and in 1899 it was worth $1.55 per barrel. The total value of the crude petroleum consumed in 1899 was $80,424,207, as compared with $44,879,783 in 1889 and $16,340,581 in 1880.

The value of fuel used in 1889 was $2,275,468, and in 1899 amounted to $3,120,441, an increase of 37.1 per cent. The cost of acids used increased 13.4 per cent, from $1,530,065 in 1889 to $1,735,782 in 1899. The cost of packages and coopers' and tinners' materials purchased in 1899 was about one-third less than the same items reported in 1889. The value of "all other materials," including mill supplies (not reported separately in 1889), increased from $2,397,533 in 1889 to $3,529,777 in 1899.

Table 6 presents a comparative summary of the quantity and value of products, the average price per barrel, and the percentage of increase or decrease in quantities and values.

TABLE 6.—COMPARATIVE SUMMARY: QUANTITY, AND VALUE OF PRODUCTS; 1899, 1889, AND 1880.

PRODUCTS.	1899			PER CENT OF INCREASE.		1889			PER CENT OF INCREASE.		1880		
	Number of barrels.	Total value.[1]	Average price per barrel.	On quantity.	On value.	Number of barrels.	Total value.[1]	Average price per barrel.	On quantity.	On value.	Number of barrels.	Total value.[1]	Average price per barrel.
Burning oils	31,266,513	$82,244,961	$2.63	84.3	71.9	16,967,397	$47,842,537	$2.82	54.2	29.9	11,002,249	$36,839,613	$3.35
Residuum	596,615	688,455	1.15	[2]50.1	[2]44.3	1,194,967	1,235,490	1.03	421.5	315.3	229,133	297,529	1.30
Paraffin oils	1,606,788	3,987,037	2.48	134.6	31.9	684,849	3,022,048	4.41	761.8	640.7	79,465	408,023	5.13
Paraffin wax	774,924	7,791,149	10.05	220.3	168.2	241,951	2,904,902	12.01	.....	359.7	[3]7,889,626	631,944	.....
Reduced oils	[4]1,766,090	7,108,168	4.03	106.1	204.6	856,730	2,333,923	2.72	271.1	67.3	230,859	1,395,037	6.04
Naphtha and gasoline	5,615,554	15,991,742	2.85	70.7	124.7	3,290,462	7,115,388	2.16	119.0	140.3	1,502,181	2,961,561	1.97
Neutral filtered oils	608,185	2,256,626	3.71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
All other products[5]	.....	3,861,246	.....	.....	[2]81.2	.....	[6]20,546,910	.....	.....	1,653.9	.....	1,171,511	.....

[1] The cost of packages is included in the values reported for 1899, but it was not uniformly included in the reports for prior censuses. This should be considered in connection with the average cost per barrel and percentages of increase shown in the above table.
[2] Decrease.
[3] Pounds.
[4] Includes filtered cylinder oils and greases.
[5] Includes coke, carbon points, and black naphtha.
[6] Includes $15,258,054, the value of packages made at the refineries.

The principal products obtained by the distillation of crude petroleum are kerosene, benzine, gasoline, naphtha, heavy or lubricating oils, residuum, and, according as the crude oil has a paraffin or an asphaltic base, paraffin or asphalt. The qualities of crude petroleum and the qualities or specific gravities of the refined oils distilled from it are almost infinite in their variety. It has been found necessary to group these products somewhat arbitrarily, and no attempt has been made to carry this investigation into the manufacture of by-products, such as vaseline, candles, and compounds of various kinds. The classification of products differed somewhat at the Twelfth Census from that of either the Tenth or Eleventh. This has been the natural result of the development of the industry. In Table 6 the products reported at the three censuses have been grouped as nearly uniformly as possible, and when no approximately similar classification was possible the items have been included among all other petroleum products.

The total amount of refined products obtained in 1899, for which the quantities were reported, aggregated 42,234,664 barrels of 50 Winchester gallons. Of this amount, 25,171,289 barrels were illuminating oils, 6,095,224 barrels fuel oils, and 5,615,554 barrels naphtha and gasoline, these constituting the lighter distillates and the principal products both in amount and value. The total amount of crude petroleum produced in the United States in 1899, according to the reports of the United States Geological Survey, was 57,070,850 barrels of 42 Winchester gallons, of which 2,801,999 barrels were exported. The amount of crude oil reported as used by the refineries was 52,011,005 barrels, leaving 2,257,846 barrels added to stocks of crude oil or lost by leakage, fire, or other accident. The total quantity of refined products reported on the census schedules amounted to 42,234,664 barrels of 50 gallons, which would be equivalent to 50,279,361 barrels of 42 gallons. Deducting this from the 52,011,005 barrels of crude petroleum used, there is a difference of 1,731,644 barrels to represent the amount of "all other products."

Table 7 shows the total production of crude petroleum as taken from the reports of the United States Geological Survey, and the exports of crude and refined oils as obtained from the reports of the Bureau of Statistics of the Treasury Department.

TABLE 7.—PRODUCTION OF CRUDE PETROLEUM, AND EXPORTS OF CRUDE AND REFINED OILS, FROM 1889 TO 1899, INCLUSIVE, AND FOR 1880.

YEAR ENDING DECEMBER 31.	PRODUCTION.	EXPORTS.											
		Total.		Mineral, crude, including all natural oils, without regard to gravity.		Mineral, refined or manufactured.						Residuum, tar, pitch, and all other, from which the light bodies have been distilled.	
						Naphthas, benzine, gasoline, etc.		Illuminating.		Lubricating, heavy paraffin, etc.			
	Barrels of 42 gallons.	Barrels of 50 gallons.	Value.	Barrels of 50 gallons.	Value.	Barrels of 50 gallons.	Value.	Barrels of 50 gallons.	Value.	Barrels of 50 gallons.	Value.	Barrels of 50 gallons.	Value.
1899	57,070,850	19,020,488	$64,982,249	2,353,679	$5,957,829	358,080	$1,557,607	14,491,259	$48,466,200	1,386,584	$8,344,735	430,886	$655,878
1898	55,364,233	19,729,612	52,551,048	2,298,302	4,764,111	340,532	1,053,231	15,223,042	38,542,082	1,279,367	7,385,054	588,369	806,570
1897	60,475,516	19,885,954	59,057,547	2,429,774	5,020,968	268,606	994,781	15,918,390	46,229,579	1,024,566	6,478,479	244,618	333,740
1896	60,960,361	17,809,179	62,383,403	2,218,472	6,121,836	246,986	1,059,542	14,329,111	48,630,920	1,010,511	6,556,775	4,099	14,330
1895	52,892,276	17,690,041	46,660,082	2,225,705	5,161,710	296,024	910,988	14,297,183	34,706,844	868,379	5,867,477	2,750	13,063
1894	49,344,516	18,165,045	41,499,806	2,488,527	4,415,915	311,115	943,970	14,607,372	30,676,217	803,811	5,449,000	4,220	14,704
1893	48,412,666	16,084,424	42,142,058	2,234,070	4,567,391	346,080	1,074,710	12,844,796	31,719,404	648,657	4,738,892	10,821	41,661
1892	50,509,136	14,892,770	42,729,157	2,087,942	4,696,191	327,866	1,037,558	11,788,364	31,826,545	680,537	5,130,643	8,061	38,220
1891	54,291,980	13,478,111	46,174,835	1,934,456	5,365,579	228,500	868,137	10,628,902	34,879,759	666,205	4,999,978	20,048	61,382
1890	45,822,672	13,876,597	52,270,953	1,931,453	6,535,499	249,253	1,050,613	11,017,468	39,826,086	641,811	4,766,850	36,612	91,905
1889	35,163,513	13,614,108	53,293,299	1,703,793	6,134,002	279,688	1,208,116	11,035,393	41,215,192	558,065	4,638,724	37,169	97,265
1880	26,286,123	6,935,588	34,505,645	734,962	2,772,400	302,302	1,344,529	5,722,631	29,047,908	112,140	1,141,825	63,553	198,983

This table shows that out of the 42,234,664 barrels of petroleum products in 1899, 16,666,809 barrels (of 50 gallons), or nearly 40 per cent, were exported. In addition to the refined products, there were exported 2,801,999 barrels (of 42 gallons) of crude petroleum. The total value of the petroleum exports at ports of shipment in 1899 was $64,982,249. This was the largest value of export petroleum ever reported, although the quantity exported in 1899 was less than either 1897 or 1898.

Table 8 presents a comparative summary, by states, in detail, of the power, stills, storage, transportation, and other plant equipment for 1899 and 1889.

TABLE 8.—COMPARATIVE SUMMARY: EQUIPMENT OF PLANT, BY STATES; 1899 AND 1889.

STATES.	Year.	BUILDINGS.							POWER.						STORAGE AND TRANSPORTATION.							
		Cooper shops.	Tin shops.	Stills.			Agitators.	Chilling houses for paraffin.	Total horsepower.	Engines.		Electric motors.[1]	Other power (pumps,[1] etc.).	Presses.	Storage tanks.		Tank cars.	Tank wagons.	Barges.	Steamships or other tank boats.	Towboats or lighters.	Horses and mules.
				Heated by steam.	Heated by superheated steam.	Heated by fire.				Steam.[1]	Gas and gasoline.[1]				For crude petroleum.	For refined petroleum.						
		No.	No.	No.	No.	No.	No.	No.		No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
United States	1899	48	13	290	26	1,458	327	48	37,052	864	28	69	[2]194	510	257	2,869	957	99	14	7	1	167
	1889	31	20	217	61	997	306	39	36,281	545	.....	.....	.....	767	292	1,861	893	75	19	6	26	361
California[3]	1899	2	1	9	6	22	7	1	180	4	1	.....	20	2	12	62	77	.....	1	2	.....	2
	1889	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
New Jersey	1899	9	4	42	8	303	64	10	12,048	121	.....	27	129	123	32	497	140	.....	11	2	1	5
	1889	4	1	23	.....	188	52	6	11,036	220	.....	.....	.....	86	22	375	50	.....	1	5	14	.....
New York	1899	3	4	41	8	227	55	5	4,469	126	2	37	.....	53	18	576	.....	28	.....	.....	.....	18
	1889	6	10	56	3	260	72	7	8,372	77	.....	.....	.....	370	41	446	39	5	11	.....	7	115
Ohio	1899	5	1	32	1	189	53	8	2,491	65	.....	.....	.....	54	21	275	275	21	2	.....	.....	48
	1889	4	2	34	17	163	54	6	5,997	63	.....	.....	.....	174	28	172	357	19	2	.....	3	63
Pennsylvania	1899	25	2	106	8	414	113	21	13,328	470	25	5	[2]45	208	152	1,198	461	50	.....	3	.....	79
	1889	12	3	86	36	305	98	17	8,223	164	.....	.....	.....	133	161	707	351	34	1	.....	1	140
West Virginia[4]	1899	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	1889	4	1	8	.....	20	12	2	975	10	.....	.....	.....	2	16	18	.....	.....	1	.....	.....	4
All other states[5]	1899	4	1	60	.....	303	35	3	4,536	78	.....	.....	.....	70	22	261	4	.....	.....	.....	.....	15
	1889	1	3	10	5	61	18	1	1,678	11	.....	.....	.....	2	24	143	96	17	3	1	1	39

[1] Not separately reported in 1889.
[2] Including 1 refrigerating machine.
[3] In 1889 California had only 2 establishments, and was included among "all other states."
[4] In 1899 West Virginia had only 1 establishment, and was included among "all other states."
[5] Includes establishments distributed as follows: 1899—Colorado, 2; Indiana, 1; Kansas, 1; Maryland, 1; Michigan, 1; Texas, 1; West Virginia, 1; 1889—California, 2; Colorado, 2; Maryland, 2; Massachusetts, 1.

Table 9 presents a detailed statement of the statistics for the industry, by states, during the period covered by the present investigation. In cases where there were less than 3 establishments in any one state, they have been combined and reported among "All other states."

TABLE 9.—PETROLEUM REFINING, BY STATES: 1899.

	United States.	California.	New Jersey.	New York.	Ohio.	Pennsylvania.	All other states.[1]
Number of establishments	67	4	4	4	9	38	8
Character of organization:							
Individual	10	.....	.....	.....	.....	10	.....
Firm and limited partnership	15	.....	1	.....	1	12	1
Incorporated company	42	4	3	4	8	16	7
Capital	$95,327,892	$477,618	$23,332,426	$16,970,492	$10,912,818	$26,580,504	$17,054,034
Land	$8,166,032	$46,810	$3,011,007	$2,383,796	$856,225	$1,188,955	$679,239
Buildings	$6,502,182	$26,813	$1,695,020	$1,068,691	$928,690	$1,609,855	$1,173,113
Machinery, tools, and implements	$39,565,389	$315,987	$9,857,910	$6,771,064	$4,824,427	$9,865,515	$7,930,486
Cash and sundries	$41,094,289	$88,008	$8,768,489	$6,746,941	$4,303,476	$13,916,179	$7,271,196
Proprietors and firm members	47	.....	2	.....	2	40	3
Salaried officials, clerks, etc.:							
Total number	1,201	19	149	312	217	277	227
Total salaries	$1,811,400	$40,303	$301,071	$575,313	$234,209	$403,466	$257,038
Officers of corporations—							
Number	85	5	15	16	14	25	10
Salaries	$407,899	$17,500	$97,767	$100,700	$55,832	$84,650	$51,450
General superintendents, managers, clerks, etc.—							
Total number	1,116	14	134	296	203	252	217
Total salaries	$1,403,501	$22,803	$203,304	$474,613	$178,377	$318,816	$205,588
Men—							
Number	1,060	13	131	277	192	238	209
Salaries	$1,371,827	$21,803	$201,064	$464,945	$172,611	$312,085	$199,319
Women—							
Number	56	1	3	19	11	14	8
Salaries	$31,674	$1,000	$2,240	$9,668	$5,766	$6,731	$6,269
Wage-earners, including pieceworkers, and total wages:							
Greatest number employed at any one time during the year	14,316	60	3,247	3,204	1,227	4,084	2,494
Least number employed at any one time during the year	10,115	47	2,566	2,160	794	2,523	2,025
Average number	12,199	53	2,951	2,629	1,008	3,299	2,259
Wages	$6,717,087	$42,453	$1,768,768	$1,306,084	$551,692	$1,681,603	$1,366,487
Men, 16 years and over—							
Average number	11,935	53	2,930	2,612	965	3,142	2,233
Wages	$6,673,629	$42,453	$1,764,368	$1,302,942	$541,261	$1,660,397	$1,362,208
Women, 16 years and over—							
Average number	66	.....	.....	9	43	1	13
Wages	$15,570	.....	.....	$1,803	$10,431	$505	$2,831
Children, under 16 years—							
Average number	198	.....	21	8	.....	156	13
Wages	$27,888	.....	$4,400	$1,339	.....	$20,701	$1,448
Average number of wage-earners, including pieceworkers, employed during each month:							
Men, 16 years and over—							
January	11,999	54	2,842	2,556	992	3,261	2,294
February	12,147	52	2,953	2,676	963	3,233	2,270
March	12,192	51	2,903	2,581	1,035	3,260	2,362
April	11,959	51	2,911	2,560	969	3,223	2,245
May	12,064	50	2,987	2,724	939	3,159	2,205
June	11,786	52	3,029	2,518	892	3,215	2,080
July	11,694	53	2,960	2,541	909	3,123	2,108
August	11,942	53	2,845	2,809	926	3,110	2,199
September	11,867	57	2,890	2,761	955	3,074	2,180
October	11,946	54	2,979	2,659	973	2,987	2,294
November	11,921	52	3,055	2,513	997	2,984	2,320
December	11,703	53	2,819	2,449	1,031	3,072	2,288
Women, 16 years and over—							
January	67	.....	.....	6	49	1	11
February	82	.....	.....	6	62	1	13
March	78	.....	.....	11	53	1	13
April	60	.....	.....	10	36	1	13
May	49	.....	.....	9	29	1	10
June	52	.....	.....	12	27	1	12
July	39	.....	.....	10	13	1	15
August	63	.....	.....	11	38	1	13
September	76	.....	.....	10	51	1	14
October	81	.....	.....	8	60	1	12
November	70	.....	.....	5	50	1	14
December	75	.....	.....	8	50	1	16
Children, under 16 years—							
January	165	.....	17	8	.....	123	17
February	157	.....	20	8	.....	116	13
March	158	.....	21	8	.....	118	11
April	156	.....	23	8	.....	113	12
May	148	.....	24	8	.....	105	11
June	233	.....	23	8	.....	196	6
July	262	.....	18	8	.....	227	9
August	241	.....	24	8	.....	197	12
September	215	.....	20	8	.....	174	13
October	190	.....	21	8	.....	143	18
November	199	.....	19	8	.....	151	21
December	252	.....	20	8	.....	208	16
Miscellaneous expenses:							
Total	$3,330,851	$15,785	$551,211	$974,321	$620,061	$640,429	$529,044
Rent of works	$11,761	.....	$4,807	.....	$4,747	$2,027	$180
Taxes, not including internal revenue	$365,962	$3,261	$71,484	$142,423	$53,655	$42,580	$52,609
Rent of offices, insurance, interest, and all sundry expenses not hitherto included	$2,937,713	$12,524	$467,169	$831,898	$561,259	$588,608	$476,255
Contract work	$15,415	.....	$7,751	.....	$400	$7,264	.....
Materials used:							
Total cost	$102,859,341	$489,989	$26,710,213	$23,435,357	$6,177,048	$27,513,785	$18,532,999
Crude petroleum—							
Number of barrels of 42 gallons each	52,011,005	339,863	12,136,537	9,553,434	4,061,554	14,500,461	11,419,156
Cost	$80,424,207	$405,150	$19,599,909	$16,113,689	$4,495,890	$23,172,609	$16,636,960
Acids, alkalies, and sulphur	$1,735,782	$27,942	$462,541	$246,874	$231,336	$505,519	$261,570
Coopers' and carpenters' materials	$3,576,943	$3,998	$1,421,576	$1,240,070	$125,411	$672,406	$113,482
Tinners' materials	$4,643,985	$125	$1,257,600	$2,698,005	$151	$581,246	$106,858
Barrels, cases, and tin cans	$2,930,805	$5,277	$535,799	$866,794	$423,519	$638,808	$460,608
Fuel	$3,120,441	$35,621	$774,244	$501,119	$325,591	$726,282	$757,584
Mill supplies	$228,926	$50	$27,031	$131,637	$395	$39,594	$30,219
All other materials	$3,300,851	$1,826	$496,748	$1,482,986	$246,183	$908,478	$164,630
Freight	$2,397,401	$10,000	$2,134,765	$154,183	$328,572	$268,793	$1,088

[1] Includes establishments distributed as follows: Colorado, 2; Indiana, 1; Kansas, 1; Maryland, 1; Michigan, 1; Texas, 1; West Virginia, 1.

TABLE 9.—PETROLEUM REFINING, BY STATES: 1899—Continued.

	United States.	California.	New Jersey.	New York.	Ohio.	Pennsylvania.	All other states.[1]
Products:							
Total value	$123,929,384	$697,877	$29,649,460	$27,184,524	$8,396,977	$34,977,706	$23,022,840
Illuminating oils—							
Barrels of 50 gallons	25,171,289	45,849	6,232,612	5,423,440	1,387,150	7,276,712	4,805,526
Value	$74,694,297	$170,066	$18,831,325	$18,803,450	$3,449,427	$20,390,666	$13,049,363
Fuel oils—							
Barrels	6,095,224	84,240	1,321,518	891,400	614,631	1,161,435	2,022,000
Value	$7,550,664	$98,237	$2,226,939	$1,093,418	$629,548	$1,644,044	$1,858,478
Residuum—							
Barrels	596,615	20,229	615	24,906	146,628	73,511	330,726
Value	$688,455	$53,972	$1,077	$36,221	$224,819	$153,237	$219,129
Paraffin oils—							
Barrels	1,606,783	.....	313,672	587,778	176,212	262,620	266,501
Value	$3,987,037	.....	$802,585	$1,342,887	$481,378	$662,305	$697,882
Reduced oils—							
Barrels	676,163	2,052	39,128	23,427	146,801	425,539	39,216
Value	$1,669,287	$10,262	$80,586	$165,395	$167,147	$1,155,690	$90,207
Neutral filtered oils—							
Barrels	608,185	.....	366,049	13,750	4,270	223,864	252
Value	$2,256,626	.....	$1,298,799	$70,868	$25,630	$860,243	$1,086
Filtered cylinder oils—							
Barrels	517,787	.....	.....	153,696	4,580	359,349	162
Value	$2,984,264	.....	.....	$1,135,104	$27,480	$1,819,232	$2,448
Greases (lubricating, etc.)—							
Barrels	572,140	9,452	48,563	87,448	161,264	63,597	201,816
Value	$2,454,617	$20,840	$460,937	$76,377	$723,308	$231,119	$942,036
Naphtha and gasoline—							
Barrels	5,615,554	57,995	1,128,025	1,082,684	598,858	1,582,262	1,165,730
Value	$15,991,742	$201,209	$2,306,345	$2,880,988	$1,750,541	$4,687,560	$4,165,099
Paraffin wax—							
Barrels	774,924	.....	195,216	118,484	66,455	255,327	139,442
Value	$7,791,149	.....	$1,944,043	$1,199,635	$801,223	$2,244,836	$1,601,412
Coke, carbon points, and black naphtha	$176,281	.....	$41,585	$53,209	$12,594	$49,625	$19,268
Value of all other products	$3,684,965	$143,291	$1,655,239	$326,972	$103,882	$1,079,149	$376,432
Comparison of products:							
Number of establishments reporting for both years	64	4	4	4	9	37	6
Value for census year	$123,179,856	$697,877	$29,649,460	$27,184,524	$8,396,977	$34,747,306	$22,503,712
Value for preceding business year	$97,200,074	$667,033	$25,322,003	$21,829,158	$6,789,268	$25,924,852	$16,667,760
Power:							
Number of establishments reporting	60	3	4	4	8	35	6
Total horsepower	37,052	180	12,048	4,469	2,491	13,828	4,536
Engines, steam—							
Number	864	4	121	126	65	470	78
Horsepower	30,568	50	7,764	3,926	2,491	11,801	4,536
Other power—							
Number	291	21	156	39	.....	75	.....
Horsepower	6,484	130	4,284	543	.....	1,527	.....
Establishments classified by number of persons employed, not including proprietors and firm members:							
Total number of establishments	67	4	4	4	9	38	8
Under 5	8	.....	.....	.....	.....	7	1
5 to 20	19	2	.....	.....	1	15	1
21 to 50	21	2	1	.....	4	12	2
51 to 100	3	.....	.....	.....	1	1	1
101 to 250	6	.....	1	1	1	1	2
251 to 500	4	.....	.....	2	1	1	.....
501 to 1,000	2	.....	1	.....	1	.....	.....
Over 1,000	4	.....	1	1	.....	1	1

[1] Includes establishments distributed as follows: Colorado, 2; Indiana, 1; Kansas, 1; Maryland, 1; Michigan, 1; Texas, 1; West Virginia, 1.

COKE.

COKE.

By Edward W. Parker, *Expert Special Agent.*

The statistics presented in the accompanying tables refer primarily to the manufacture of coke during the calendar year 1899, with incidental reference to the statistics collected by the Tenth and Eleventh censuses, the former covering the fiscal year ending May 31, 1880, and the latter the calendar year 1889. As in the previous censuses, the report is limited to the product usually termed "oven coke" obtained from the distillation or combustion of bituminous coal in retorts, ovens, or pits. Ordinary gas-house coke, obtained as a by-product in the manufacture of illuminating gas from coal, is not considered.

At preceding censuses the coke included was manufactured almost exclusively for metallurgical purposes, but during the last ten years its use for domestic purposes has extended, and manufacturers now prepare it for domestic use by crushing and screening.

Since the taking of the Eleventh Census there has been another development of coke manufacture in this country for which no comparison can be made with previous censuses. This is the introduction of the retort or by-product coke oven, whereby the volatile constituents of the coal, other than gases consumed in the distillation process, are recovered. These constituents are wasted in ordinary beehive ovens. Three classes of by-product ovens, the Semet-Solvay, the Otto-Hoffman, and the Newton-Chambers, are now in successful operation in the United States. The first and second are retort ovens, the coal being distilled in a chamber heated from flues in which the gas obtained from the coal is burned. The process of coking is a distillation, rather than a combustion of the coal. The Newton-Chambers ovens are beehive ovens with apparatus for recovering the tar and ammonia contents of the coal, but consuming the gas during the process. In some instances, these by-product ovens make gases their primary product and coke their secondary product, but even then the coke produced is suitable for metallurgical purposes, and as no exact separation of the metallurgical and domestic coke is possible, the production from all the by-product coke ovens is considered in this report. The first ovens of the by-product class to be constructed in the United States were built at Syracuse, N. Y. They were completed in 1893, and produced in that year 12,850 short tons of metallurgical coke. At the close of 1899 the number of by-product ovens in existence in the United States was 1,020, and the amount of coke produced by them amounted to 906,534 short tons.

The total product of coke in 1899 from all the ovens included in this report amounted to 19,640,798 short tons, valued at $34,633,418, as compared with an output of 10,008,169 short tons, valued at $16,494,454, in 1889, and with 2,752,475 short tons, valued at $5,359,489, in 1880 (Table 8). The output in 1899 increased 9,632,629 tons, or 96.2 per cent over, that of 1889, and was more than seven times that of 1880. The value of the coke produced in 1899, as compared with that of 1889, shows an increase of 110.0 per cent, and, as compared with 1880, an increase of 546.2 per cent. The average price per ton obtained in 1899 was $0.11 (or 6.7 per cent) higher than that obtained ten years before, but $0.19 (or 9.7 per cent) less than that obtained in 1880. The increase in the productive capacity of the ovens now in use, as compared with those in the earlier censuses, is shown in the fact that the average yield of coke per oven in 1899 was 417 short tons, while in 1889 it was 306 tons, and in 1880, 283 tons. While the production has increased 96.2 per cent, the number of active ovens has increased only 44.3 per cent.

There has been an increase in the percentage yield of the coal in coke. This has been partly due to the introduction of the by-product ovens, which yield a larger percentage of coke than the ordinary beehive ovens; partly to improved practice in manipulation of the beehive ovens; and partly to the preparation of the coal itself, by washing or otherwise, before being charged into the ovens. In 1889 the amount of coal washed, as shown by the Eleventh Census, before being charged into the coke ovens, was 968,329 short tons, whereas in 1899 the total amount of coal washed was 4,276,517 short tons (Table 9).

The present tendency toward large industries under one management is illustrated in the statistics of coke production in 1899. The total number of tons of coke produced has increased 96.2 per cent (Table 8), and the value of all products has increased 115.7 per cent (Table 1), while the number of active establishments reporting for 1899 was only 23, or 10.6 per cent, more than the

number reporting for 1889. The amount of capital invested in the industry in 1899 was $36,502,679, as compared with $17,462,729 in 1889 and $4,769,858 in 1880. The increase of capital in 1899 over 1889 was $19,039,950, or 109.0 per cent. As compared with 1880, the capital invested in 1899 increased 665.3 per cent. The total amount paid in salaries and wages increased from $4,186,264 in 1889 to $7,883,032 in 1899, or 88.3 per cent (Table 6). The value of the coal tar, ammonia, and surplus gas obtained as by-products in retort or by-product ovens in 1899 amounted to $952,027 (Table 13), and the total value of all products for that year to $35,585,445 (Table 1).

The coking industry is usually carried on in direct connection with coal mining. In some instances the entire product of the mines, with the exception of coal used at the works or consumed by employees, is charged into ovens. In the preparation of this report, the mining of the coal used for coke has been considered as a separate industry and has not been included. Its value includes the cost of mining, but this is not stated in the wages or other expenses connected with the coking operations. In a few cases the coal is transported to a distant point, and there made into coke, one instance being in Wisconsin, where the coke is made from coal mined in the Connellsville region of Pennsylvania.

In cases where all the coal mined is charged into the ovens, the value assigned to it is based either upon the average selling value of coal in the same district, or upon the cost of production plus a percentage of profit on the mining operations. Where coke is produced by proprietors of blast furnaces, etc., for consumption in their own furnaces, none being sold, the value assigned to it is based upon the average for the vicinity, or upon the cost of production plus a percentage of profit on the coking operations.

Table 1 presents the principal features of the statistics relating to the manufacture of coke in 1899, 1889, and 1880, with the percentage of increase in each of the two decades. Only active establishments are included.

TABLE 1.—COMPARATIVE SUMMARY: 1899, 1889, 1880.

	1899	1889	1880	PER CENT OF INCREASE. 1889 to 1899.	1880 to 1889.
Number of establishments	[1] 241	218	126	10.6	73.0
Capital	$36,502,679	$17,462,729	$4,769,858	109.0	266.1
Land	$2,927,354	$1,405,342	(2)	108.3	.....
Buildings	$2,382,237	$869,725	(2)	173.9	.....
Ovens	$18,351,924	$10,817,624	(2)	69.6	.....
Machinery, tools, and implements	$5,927,702	$823,790	(2)	619.6	.....
Cash and sundries	$6,913,462	$3,546,248	(2)	95.0	.....
Wage-earners, average number	16,999	8,998	3,140	88.9	186.6
Total wages	$7,085,736	$4,072,632	$1,197,744	74.0	240.0
Miscellaneous expenses	$2,184,968	$394,784	(3)	453.5	.....
Cost of materials	$19,665,532	$11,509,737	$2,995,441	70.9	284.2
Value of products	[4] $35,585,445	[5] $16,498,345	$5,359,489	115.7	207.8

[1] Not including 1 penal institution.
[2] Not separately reported at the census of 1880.
[3] Not reported at the census of 1880.
[4] Includes the value of by-products amounting to $952,027.
[5] Includes the value of by-products amounting to $3,891.

Table 1 shows an invested capital of $36,502,679, which represents the value of lands, buildings, ovens, machinery, tools, and implements, and the live capital required to carry on the business, but does not include the capital stock of any of the corporations.

Table 2 presents, by states and territories, the number of active coke establishments in the United States during 1899, 1889, and 1880.

TABLE 2.—NUMBER OF ACTIVE ESTABLISHMENTS, BY STATES AND TERRITORIES: 1899, 1889, 1880.

STATES AND TERRITORIES.	1899	1889	1880	STATES AND TERRITORIES.	1899	1889	1880
United States	241	218	126	Montana	2	2	.....
				New Mexico	2	.....	.....
				New York	1	.....	.....
Alabama	15	19	3	Ohio	5	13	15
Colorado	9	7	1	Pennsylvania	89	98	89
Georgia	2	1	1	Tennessee	8	8	4
Illinois	1	2	1	Utah	1	1	.....
Indiana	1	3	1	Virginia	5	2	.....
Indian Territory	2	1	.....	Washington	2	1	.....
Kansas	8	6	.....	West Virginia	77	45	11
Kentucky	5	5	.....	Wisconsin	1	1	.....
Massachusetts	1	.....	.....	Wyoming	1	.....	.....
Missouri	3	3	.....				

Table 2 shows that in 5 states the number of establishments in 1899 was less than the number reported in 1889. In Illinois and Indiana the industry has shown an actual decline, the production in these states in 1899 being less than it was ten years before (Table 10). In Ohio, where the number of establishments has decreased in ten years from 13 to 5, the production in 1899 was a little larger than in 1889, the decrease in the number of establishments having been due to the abandonment of their ovens by a number of small concerns. The other states in which the number of establishments was less in 1899 than in 1889 are Alabama and Pennsylvania, in both of which the industry has shown marked advances; the decrease in the number of establishments being due principally to consolidations.

Table 3 presents a summary of the ovens in active establishments during 1899 and 1889.

TABLE 3.—COMPARATIVE SUMMARY, NUMBER OF OVENS IN ACTIVE ESTABLISHMENTS, BY STATES AND TERRITORIES: 1899 AND 1889.

STATES AND TERRITORIES.	Year.	OVENS. Total number.	Beehive.	Belgian or flue.	By-product.	Other styles.
United States	1899	47,142	45,680	.....	1,020	442
	1889	32,659	32,129	233	.....	297
Alabama	1899	5,206	4,872	.....	120	214
	1889	3,693	3,459	160	.....	74
Colorado	1899	1,221	1,185	.....	.....	36
	1889	872	672	.....	.....	200
Georgia	1899	350	350	.....	.....	.....
	1889	(1)	.....	.....	.....	.....
Illinois	1899	4	4	.....	.....	.....
	1889	(1)	.....	.....	.....	.....
Indiana	1899	12	12	.....	.....	.....
	1889	102	102	.....	.....	.....
Indian Territory	1899	130	130	.....	.....	.....
	1889	(1)	.....	.....	.....	.....
Kansas	1899	86	86	.....	.....	.....
	1889	52	52	.....	.....	.....
Kentucky	1899	290	290	.....	.....	.....
	1889	164	164	.....	.....	.....
Massachusetts	1899	400	.....	.....	400	.....
	1889	.....	.....	.....	.....	.....
Missouri	1899	12	12	.....	.....	.....
	1889	9	9	.....	.....	.....

[1] Included in "all other states and territories."

TABLE 3.—COMPARATIVE SUMMARY, NUMBER OF OVENS IN ACTIVE ESTABLISHMENTS, BY STATES AND TERRITORIES: 1899 AND 1889—Continued.

STATES AND TERRITORIES.	Year.	OVENS.				
		Total number.	Beehive.	Belgian or flue.	By-product.	Other styles.
Montana	1899	203	203	.....	.....	.....
	1889	(1)	.....	.....	.....	.....
New Mexico	1899	114	114	.....	.....	.....
	1889	.....	.....	.....	.....	.....
New York	1899	25	.....	.....	25	.....
	1889	.....	.....	.....	.....	.....
Ohio	1899	235	235	.....	.....	.....
	1889	462	462	.....	.....	.....
Pennsylvania	1899	26,920	26,565	.....	355	.....
	1889	21,405	21,338	48	.....	19
Tennessee	1899	1,727	1,727	.....	.....	.....
	1889	1,581	1,577	.....	.....	4
Utah	1899	104	104	.....	.....	.....
	1889	(1)	.....	.....	.....	.....
Virginia	1899	1,588	1,528	.....	60	.....
	1889	(1)	.....	.....	.....	.....
Washington	1899	90	90	.....	.....	.....
	1889	(1)	.....	.....	.....	.....
West Virginia	1899	8,231	7,979	.....	60	192
	1889	3,140	3,140	.....	.....	.....
Wisconsin	1899	120	120	.....	.....	.....
	1889	(1)	.....	.....	.....	.....
Wyoming	1899	74	74	.....	.....	.....
	1889	.....	.....	.....	.....	.....
All other states and territories	1899	.....	.....	.....	.....	.....
	[2]1889	1,179	1,154	25	.....	.....

[1] Included in "all other states and territories."
[2] Includes Georgia, Illinois, Indian Territory, Montana, Utah, Virginia, Washington, and Wisconsin.

The total number of ovens has increased in Alabama from 3,693 in 1889 to 5,206 in 1899, and in Pennsylvania from 21,405 in 1889 to 26,920 in 1899. The average number of ovens to an establishment in Alabama in 1889 was 194; in 1899 it was 347, or nearly double the number in 1889. In Pennsylvania the average number of ovens to an establishment in 1889 was 218, and in 1899 it was 302. For the entire United States the average number of ovens to an establishment increased from 150 in 1889 to 196 in 1899.

Table 4 presents the statistics relating to capital, and kind and number of ovens in idle establishments, by states and territories, for 1899 and 1889.

TABLE 4.—IDLE ESTABLISHMENTS, BY STATES AND TERRITORIES: 1899 AND 1889.

STATES AND TERRITORIES.	Year.	Number of establishments reporting.	Capital.	OVENS.			
				Total.	Beehive.	Belgian or flue.	Other styles.
United States	1899	14	$511,669	669	665	.....	4
	1889	28	444,488	1,247	1,142	65	40
Alabama	1899	1	20,000	90	90	.....	.....
	1889	1	19,000	76	76	.....	.....
Colorado	1899	3	17,900	22	18	.....	4
	1889	3	12,600	48	8	.....	40
Illinois	1899	2	83,700	126	126	.....	.....
	1889	1	50,000	102	102	.....	.....
Indiana	1899	.....	.....	.....	.....	.....	.....
	1889	1	1,800	9	9	.....	.....
Kansas	1899	.....	.....	.....	.....	.....	.....
	1889	1	5,136	16	16	.....	.....
Kentucky	1899	1	5,000	10	10	.....	.....
	1889	1	600	2	2	.....	.....
Montana	1899	1	244,000	100	100	.....	.....
	1889	.....	.....	.....	.....	.....	.....
New Mexico	1899	1	76,069	76	76	.....	.....
	1889	.....	.....	.....	.....	.....	.....
Ohio	1899	1	5,800	9	9	.....	.....
	1889	.....	.....	.....	.....	.....	.....
Pennsylvania	1899	4	59,200	236	236	.....	.....
	1889	15	317,297	884	819	65	.....
Tennessee	1899	.....	.....	.....	.....	.....	.....
	1889	2	16,050	58	58	.....	.....
West Virginia	1899	.....	.....	.....	.....	.....	.....
	1889	3	22,000	52	52	.....	.....

Table 5 presents a comparative summary of the number of ovens and the capital in idle and active establishments in 1899 and 1889.

TABLE 5.—CAPITAL, ACTIVE AND IDLE ESTABLISHMENTS: 1899 AND 1889.

	1899		1889	
	Active.	Idle.	Active.	Idle.
Number of establishments	[1]241	14	218	28
Number of ovens	47,142	669	32,659	1,247
Capital	$36,502,679	$511,669	$17,462,729	$444,488
Land	$2,927,354	$13,950	$1,405,342	$6,425
Buildings	$2,382,237	$62,800	$869,725	$48,723
Ovens	$18,351,924	$303,469	$10,817,624	$312,661
Machinery, tools, and implements.	$5,927,702	$131,450	$823,790	$44,791
Cash and sundries	$6,913,462	.....	$3,546,248	$31,883

[1] Not including 1 penal institution (see Table 15, note 1).

The percentage of idle to active ovens in 1889 was 3.8; in 1899 it was 1.4. In 1889 the capital invested in idle plants represented 2.5 per cent of the total capital; and in 1899 it was 1.4 per cent.

By far the greater portion of the coke manufactured in the United States is made in the ordinary beehive ovens, of which there were 45,680 out of a total of 47,142 active ovens reported for 1899, and 32,129 out of a total of 32,659 reported for 1889 (Table 3). In 1880 and 1889 coke was reported as made in pits or mounds, these being used principally for experimental purposes. In later years, however, it has been considered better practice to have the coal shipped, in some cases long distances, to points where the experiments can be made in either beehive or by-product ovens, in order that better information may be secured as to the oven most suitable for the manufacture of coke from that particular coal. For this reason we find that no pits or mounds are reported for 1899. The Belgian or flue ovens, reported separately in 1880 and 1889, are included among "Other styles" in 1899. No by-product ovens were in use ten years ago, whereas 1,020 ovens of this type were operated in 1899, and produced 906,534 tons of coke.

Table 6 presents the number of salaried employees and wage-earners, and their salaries and wages, for 1899 and 1889.

TABLE 6.—NUMBER OF EMPLOYEES, BY CLASSES, WITH SALARIES AND WAGES PAID: 1899 AND 1889.

EMPLOYEES AND WAGES.	1899	1889
Proprietors and firm members	48	(1)
Salaried officials, clerks, etc.:		
Number	915	161
Salaries	$797,296	$113,632
Wage-earners, average number	16,999	8,998
Total wages	$7,085,736	$4,072,632
Men, 16 years and over:		
Average number	16,932	8,942
Wages	$7,071,834	$4,064,118
Children, under 16 years:		
Average number	67	56
Wages	$13,902	$8,514

[1] Not reported separately in 1889, but, with their salaries, included in that year with salaried officials, clerks, etc.

Table 6 shows that the number of wage-earners has increased from 8,998 in 1889 to 16,999 in 1899, or 88.9 per cent. The total wages increased from $4,072,632 in 1889 to $7,085,736 in 1899, or 74.0 per cent.

TABLE 7.—QUANTITY AND VALUE OF COAL USED, BY STATES AND TERRITORIES: 1899, 1889, 1880.

STATES AND TERRITORIES.	COAL CONSUMED.						PER CENT OF INCREASE.			
	1899		1889		1880		1889 to 1899		1880 to 1889	
	Short tons.	Cost.	Short tons.	Cost.	Short tons.	Cost.	In quantity.	In cost.	In quantity.	In cost.
United States	30,157,829	$18,355,252	15,795,087	$11,110,700	4,360,110	$2,761,657	90.9	65.2	262.3	302.3
Alabama	3,028,472	2,596,718	1,789,047	1,755,876	67,376	75,314	69.3	47.9	2,555.3	2,231.4
Colorado	817,725	496,033	323,731	399,778	29,500	29,500	152.6	24.1	997.4	1,255.2
Indiana	.....	.....	16,428	16,156	1,500	2,025	.....	.....	995.2	697.8
Kansas	26,988	26,079	21,600	9,011	.....	.....	24.9	189.4	.....	.....
Kentucky	151,503	72,196	25,192	13,542	.....	.....	501.4	433.1	.....	.....
Missouri	5,320	2,256	8,485	3,118	.....	.....	[1] 37.3	[1] 27.6	.....	.....
Ohio	142,678	102,540	134,178	123,992	193,848	228,432	6.3	[1] 17.3	[1] 30.8	[1] 45.7
Pennsylvania	19,490,030	10,899,832	11,336,985	6,992,573	3,608,095	2,031,305	71.9	55.9	214.2	244.2
Tennessee	684,821	501,927	619,016	523,400	179,311	124,137	10.6	[1] 4.1	245.2	321.6
Virginia	994,635	523,979	.....	.....	.....	.....	.....	.....	.....	.....
West Virginia	3,792,825	1,874,960	1,025,885	686,570	148,480	135,944	269.7	173.1	590.9	405.0
All other states	[2] 1,022,832	1,258,732	[3] 494,540	586,684	[4] 132,000	135,000	106.8	114.6	274.7	334.6

[1] Decrease.
[2] Includes Georgia, Illinois, Indiana, Indian Territory, Massachusetts, Montana, New Mexico, New York, Utah, Washington, Wisconsin, and Wyoming.
[3] Includes Georgia, Illinois, Indian Territory, Montana, Utah, Virginia, Washington, and Wisconsin.
[4] Includes Georgia and Illinois.

Table 7 shows the amount and value of the coal charged into the ovens in 1899, 1889, and 1880, by states and territories, with the percentages of increase or decrease in quantity and cost.

The principal item of expense in the manufacture of coke is the cost of the coal charged into the ovens, this being the only raw material used. The value of the coal consumed is its value at the ovens, whether mined in the immediate vicinity or transported from a distance. The coal, which is crushed or washed before coking, is taken at its value after being prepared. The amount of coal used has increased 90.9 per cent, whereas its value has increased only 65.2 per cent in the last decade. This difference has been due in great part to improvements in mining machinery and methods and in underground haulage, which have decreased the cost of production.

Table 8 presents a summary showing the number of active ovens, pits, or mounds in 1899, 1889, and 1880, together with the amount of coal used, the amount and value of the coke produced, the average yield of coke per oven, the average value of coke at the ovens per ton, and the percentage yield of coal in coke.

TABLE 8.—NUMBER OF OVENS, AND QUANTITY AND VALUE OF COKE: 1899, 1889, 1880.

	1899	1889	1880	PER CENT OF INCREASE.	
				1889 to 1899	1880 to 1889
Ovens, active	47,142	32,659	9,738	44.3	235.4
Coal used, short tons	30,157,829	15,795,087	4,360,110	90.9	262.3
Coke produced, short tons	19,640,798	10,008,169	2,752,475	96.2	263.6
Total value of coke at ovens	$34,633,418	$16,494,454	$5,359,489	110.0	207.8
Average yield of coke per oven, short tons	417	306	283	36.3	8.1
Value of coke at ovens, per ton	$1.76	$1.65	$1.95	6.7	[1] 15.4
Yield of coal in coke, per cent	65.1	63.4	63.1	.....	.....

[1] Decrease.

The total value of the coke and its average price per ton represent the value of the coke at the ovens before any expenses of transportation, etc., have been added.

Table 9 presents a statement of the condition of the coal when charged into the coking ovens; that is, whether it was run-of-mine or slack, and whether it was washed or unwashed. This statement does not consider the crushing of run-of-mine coal, which is sometimes done before coking.

TABLE 9.—QUANTITY AND COST OF DIFFERENT CLASSES OF COAL USED: 1899 AND 1889.

CLASSES.	1899		1889		AVERAGE PRICE PER TON.		PER CENT OF INCREASE.	
	Tons.	Cost.	Tons.	Cost.	1899	1889	In quantity.	In cost.
Total	30,157,829	$18,355,252	15,795,087	$11,110,700	$0.61	$0.70	90.9	65.2
Run-of-mine or lump, unwashed	20,844,637	12,309,681	11,631,436	8,255,542	0.59	0.71	79.2	49.1
Run-of-mine or lump, washed	1,457,961	1,304,437	421,074	305,983	0.89	0.73	246.2	326.3
Slack, unwashed	5,036,675	2,966,800	3,195,322	2,333,597	0.59	0.73	57.6	27.1
Slack, washed	2,818,556	1,774,334	547,255	215,578	0.63	0.39	415.0	723.1

Of the coal used in the manufacture of coke in the United States during 1899, 74.0 per cent was run-of-mine, and 93.5 per cent of this mine-run coal was unwashed. Practically all the coal used in the Connellsville region of Pennsylvania (52.9 per cent of the entire coke product of the United States) is unwashed run-of-mine, the coal being charged directly from the mine, without preparation, into the ovens. Of the total

amount of coal used in 1899, 26.0 per cent was slack, and of the slack coal used, 35.9 per cent was washed. There has been a notable increase in the amount of slack coal washed before coking. The amount of unwashed slack coal used in 1899 was 57.6 per cent more than that used in 1889, whereas the amount of washed slack used in 1899 was over five times as much as that used ten years before, or an increase of 415.0 per cent.

Table 10 gives the rank of the states and territories in the production of coke, the tons of coke produced, and the percentage of total output for 1899, 1889, and 1880.

TABLE 10.—PRODUCTION AND RANK, BY STATES AND TERRITORIES: 1899, 1889, 1880.

STATES AND TERRITORIES.	RANK.			TONS OF COKE.			PER CENT OF TOTAL OUTPUT.		
	1899	1889	1880	1899	1889	1880	1899	1889	1880
United States	.....	.....	.....	19,640,798	10,008,169	2,752,475	100.0	100.0	100.0
Pennsylvania	1	1	1	13,245,594	7,372,653	2,317,149	67.4	73.7	84.2
West Virginia	2	3	3	2,278,679	612,645	95,720	11.6	6.1	3.5
Alabama	3	2	6	1,787,809	1,055,823	42,035	9.1	10.5	1.5
Virginia	4	6	.....	618,707	(1)	.....	3.2	(1)	.....
Colorado	5	5	7	503,543	199,638	18,000	2.6	2.0	0.7
Tennessee	6	4	4	380,525	356,964	91,675	1.9	3.6	3.3
Massachusetts	7	.....	.....	330,770	.....	.....	1.7	.....	.....
Ohio	8	8	2	83,878	75,826	109,296	0.4	0.8	4.0
Kentucky	9	12	.....	81,095	13,021	.....	0.4	0.1	.....
Montana	10	10	.....	56,376	(1)	.....	0.3	(1)	.....
Georgia	11	7	5	50,907	(1)	70,000	0.3	(1)	2.5
New Mexico	12	.....	.....	44,134	.....	.....	0.2	.....	.....
Wisconsin	13	9	.....	33,437	(1)	.....	0.2	(1)	.....
Washington	14	17	.....	30,372	(1)	.....	0.2	(1)	.....
New York	15	.....	.....	28,416	.....	.....	0.1	.....	.....
Utah	16	18	.....	26,881	(1)	.....	0.1	(1)	.....
Indian Territory	17	15	.....	24,339	(1)	.....	0.1	(1)	.....
Wyoming	18	.....	.....	15,630	.....	.....	0.1	.....	.....
Kansas	19	11	.....	14,476	13,910	.....	0.1	0.1	.....
Missouri	20	16	.....	2,860	5,275	.....	(2)	0.1	.....
Indiana	21	14	9	2,105	8,301	1,000	(2)	0.1	(2)
Illinois	22	13	8	265	(1)	7,600	(2)	.....	0.3
All other states[3]	.....	.....	.....	.....	294,113	.....	.....	2.9	.....

[1] Included in "all other states."
[2] Less than one-tenth of 1 per cent.
[3] Includes Georgia, Illinois, Indian Territory, Montana, Utah, Virginia, Washington, and Wisconsin.

There were 22 states in which coke was produced in 1899 as against 18 states in 1889, and 9 in 1880. At each census Pennsylvania has stood at the head of the coke-producing states, more than two-thirds of the total coke product of the United States being made in that state. But the proportion of her product to the total has decreased from 84.2 per cent in 1880 to 73.7 per cent in 1889, and 67.4 per cent in 1899. West Virginia, which was third in rank at the two preceding censuses, became second in importance in 1899; and Alabama, which was sixth in 1880 and second in 1889, now stands third. Ohio, which was second in 1880, had fallen to the eighth place in 1889, and held the same relative position in 1899. Virginia, which reported no coke product in 1880, was sixth in 1889, and fourth in 1899. Colorado, the only important coke-producing state west of the Mississippi River, now ranks fifth among the total number; and Tennessee, which stood fourth in 1880 and 1889, was sixth in 1899. Massachusetts, which had no coke product in 1880 or 1889, was seventh in importance in 1899. This was due to the establishment of 400 Otto-Hoffman ovens at Everett, near Boston. The coal from which this coke is made is brought from the Nova Scotia mines, and gas for domestic consumption is made the primary product. The coke product, however, while largely used as a locomotive fuel, is a metallurgical coke and is therefore included in the statistics of the present investigation.

Outside of the states mentioned, there was no state that produced as much as 100,000 tons of coke in 1899, or as much as 0.5 per cent of the total.

Of the 6 leading coke-producing states, 5 draw their coal supply from the coal fields of the Appalachian system. These 5 states in the order of their importance—Pennsylvania, West Virginia, Alabama, Virginia, and Tennessee—contributed 93.2 per cent of the entire product of the United States in 1899. The proportion of the product of the United States coming from this field (92.5 per cent in 1880; and 93.2 per cent in 1899) has remained almost the same for twenty years; the relative decrease in Pennsylvania since 1880 and in Tennessee since 1889 being about balanced by the increase in Virginia, West Virginia, and Alabama.

Table 11 presents a statement of the amount and value of coal used; and the amount and value of coke produced in 1899, 1889, and 1880; also the amount of coal in pounds necessary to produce a ton (2,000 pounds) of coke; and the value of the coal used to a ton of coke.

TABLE 11.—COMPARATIVE SUMMARY, RELATION OF COAL USED TO COKE PRODUCED: 1899, 1889, 1880.

ITEMS.	1899	1889	1880
Total coal used, tons	30,157,829	15,795,087	4,360,110
Total cost of coal	$18,355,252	$11,110,700	$2,761,657
Average cost of coal per ton	$0.61	$0.70	$0.63
Tons of coke made	19,640,798	10,008,169	2,752,475
Value of coke make	$34,633,418	$16,494,454	$5,359,489
Average value of coke per ton	$1.76	$1.65	$1.95
Quantity of coal per ton of coke (pounds)	3,070	3,156	3,168
Average cost of coal to ton of coke	$0.93	$1.11	$1.00

The amount of coal used in 1899 was 30,157,829 tons, yielding 19,640,798 tons of coke—indicating a loss in weight by the coking process of 34.9 per cent. The value of the coal used was $18,355,252, whereas the

value of the coke produced was $34,633,418, an increase of 88.7 per cent. In 1889 the loss in weight by coking was 36.6 per cent, and the increase in value was 48.5 per cent. The amount of coal necessary to make a ton of coke was less in 1889 than in 1880, and was reduced in 1899, as compared with 1889, indicating a greater efficiency in the coking operations.

Table 12 presents, by states and territories, the total amount of coal used and the coke produced in 1899 and 1889, together with the percentage of coal in coke in each state and territory in both years.

TABLE 12.—QUANTITY AND PERCENTAGE OF YIELD OF COAL IN COKE, BY STATES AND TERRITORIES: 1899 AND 1889.

STATES AND TERRITORIES.	1899			1889		
	Number of tons of coal used.	Number of tons of coke manufactured.	Per cent of yield in coke.	Number of tons of coal used.	Number of tons of coke manufactured.	Per cent of yield in coke.
United States	30,157,829	19,640,798	65.1	15,795,087	10,008,169	63.4
Alabama	3,028,472	1,787,809	59.0	1,789,047	1,055,823	59.0
Colorado	817,725	503,543	61.6	323,731	199,638	61.7
Indiana	.....	.....	.....	16,428	8,301	50.5
Kansas	26,988	14,476	53.6	21,600	13,910	64.4
Kentucky	151,503	81,095	53.5	25,192	13,021	51.7
Missouri	5,320	2,860	53.8	8,485	5,275	62.2
Ohio	142,678	83,878	58.8	134,178	75,826	56.5
Pennsylvania	19,490,030	13,245,594	68.0	11,336,985	7,372,653	65.0
Tennessee	684,821	380,525	55.6	619,016	356,964	57.7
Virginia	994,635	618,707	62.2	.....	.....	.....
West Virginia	3,792,825	2,278,679	60.1	1,025,885	612,645	59.7
All other states	[1] 1,022,832	643,632	62.9	[2] 494,540	294,113	59.5

[1] Includes Georgia, Illinois, Indiana, Indian Territory, Massachusetts, Montana, New Mexico, New York, Utah, Washington, Wisconsin, and Wyoming.
[2] Includes Georgia, Illinois, Indian Territory, Montana, Utah, Virginia, Washington, and Wisconsin.

By the yield of coal in coke is meant the percentage of the original weight of the coal that remains in the form of coke after the process of coking is complete. The statement shows that the yield of coal in coke in 1899 was 65.1 per cent, as compared with 63.4 per cent in 1889. The highest yield in both years is reported for Pennsylvania. The lowest yield in 1899 was in Kentucky (53.5 per cent), and in 1889, in Indiana (50.5 per cent). It must be stated in this connection (and the same statement should be made in regard to the amount of coal used in the manufacture of coke) that it is not possible to secure absolutely accurate information on this point, for the reason that, in many instances, the coal is not weighed before being charged into the ovens, and the amount as reported on the schedules is frequently estimated. The figures, however, may be taken as fairly representing the conditions.

Table 13 shows the quantity and value of by-products from retort or by-product ovens in 1899.

TABLE 13.—BY-PRODUCTS: 1899.

	Unit of measure.	Number.	Value.
Tar	Pounds	104,687,330	$207,952
Ammonium sulphate	Pounds	11,984,931	330,921
Ammonia liquor	Gallons	1,572,325	180,642
Surplus gas sold	Cubic feet	1,171,942,697	225,022
Unclassified	.....	.....	7,490
Total value	.....	.....	952,027

As previously stated, the introduction of retort ovens, whereby the volatile constituents of the coal consumed in the coking are saved, has been a development of the last decade, and no statistics of this kind are available for either 1889 or 1880. These by-products consist of tar, ammonia (as sulphate or ammoniacal liquor), and surplus gas. The gas which is consumed at the ovens in the distillation of the coke is not considered a marketable product, and no statement of value of this factor could be obtained in any way, as it is not measured. Nor does the investigation extend to the consideration of the products obtained from the coal tar as a raw material. The by-products of tar, ammonia, gas, etc., represent a total value of $952,027.

Table 14 presents the statistics of the coke-producing regions of Pennsylvania and West Virginia, divided, for the sake of convenience, into districts.

TABLE 14.—PENNSYLVANIA AND WEST

	DISTRICTS.	Rank according to number of tons of coke produced.	Number of establishments reporting.	Total capital.	Proprietors and firm members.	SALARIED OFFICIALS, CLERKS, ETC.		WAGE-EARNERS.	
						Number.	Salaries.	Average number.	Wages.
1	Pennsylvania	.....	89	$20,213,147	43	518	$481,133	9,283	$4,516,651
2	Allegheny Mountain	6	10	1,267,100	.....	52	53,027	450	172,509
3	Broad Top	14	4	158,096	.....	8	7,077	103	43,199
4	Clearfield-Center	12	5	153,585	1	9	5,200	140	57,635
5	Connellsville	1	39	14,642,004	24	370	348,924	6,647	3,405,285
6	Greensburg	13	3	150,500	.....	11	6,600	123	30,397
7	Irwin	11	4	397,410	.....	3	1,507	156	57,213
8	Pittsburg	3	7	1,805,071	14	22	21,290	512	262,615
9	Reynoldsville-Walston	4	6	802,104	.....	9	6,491	550	228,861
10	Upper Connellsville	5	11	837,277	4	34	31,017	602	258,937
11	West Virginia	.....	77	4,452,579	1	208	126,878	3,131	890,024
12	Flat Top	2	35	2,325,737	.....	106	66,126	1,849	445,789
13	Kanawha	10	7	479,964	.....	11	13,669	331	74,586
14	New River	9	16	558,861	1	34	23,941	333	113,796
15	Upper Monongahela	7	16	823,529	.....	36	15,380	332	142,977
16	Upper Potomac	8	3	264,488	.....	21	7,762	286	112,876

VIRGINIA, BY DISTRICTS: 1899.

MATERIALS USED.				Miscellaneous expenses.	PRODUCTS.				Per cent of yield of coal in coke.	Price of coke per ton.	
Total value.	Coal.		All other.		Total value.	Coke.		All other.			
	Quantity, short tons.	Value.	Value.			Quantity, short tons.	Value.	Value.			
$11,678,079	19,490,030	$10,899,832	$778,247	$1,227,259	$22,282,358	13,245,594	$22,039,151	$243,207	68.0	$1.66	1
609,580	773,543	536,513	73,067	71,894	1,058,302	506,340	1,018,540	39,762	65.5	2.01	2
131,936	161,196	120,698	11,238	6,450	199,953	107,258	197,895	2,058	66.5	1.85	3
132,508	198,110	131,040	1,468	9,224	234,527	130,865	234,527	.....	66.1	1.79	4
8,803,833	14,974,978	8,204,585	599,248	981,346	17,128,112	10,389,335	17,075,411	52,701	69.4	1.64	5
102,152	173,811	101,757	395	6,189	247,421	110,594	247,421	.....	63.6	2.24	6
96,106	223,457	90,364	5,742	8,416	197,694	133,085	197,694	.....	59.6	1.49	7
713,155	954,028	675,728	37,427	58,793	1,337,803	644,467	1,189,117	148,686	67.6	1.85	8
507,449	1,097,115	503,638	3,811	44,550	892,248	613,757	892,248	.....	55.9	1.45	9
581,360	933,792	535,509	45,851	40,397	986,298	609,893	986,298	.....	65.3	1.62	10
1,966,682	3,792,825	1,874,960	91,722	226,603	3,529,241	2,278,679	3,470,405	58,836	60.1	1.52	11
802,129	1,861,570	757,341	44,788	150,167	1,453,598	1,138,490	1,453,598	.....	61.2	1.28	12
166,908	323,506	154,978	11,930	14,483	364,148	190,337	364,148	.....	58.8	1.91	13
349,263	493,160	338,889	10,374	23,461	523,996	281,135	523,996	.....	57.0	1.86	14
345,057	607,796	335,686	9,371	33,899	655,141	362,872	596,305	58,836	59.7	1.64	15
303,325	506,793	288,066	15,259	4,593	532,358	305,845	532,358	.....	60.4	1.74	16

The division in Pennsylvania has been made as follows: The Allegheny Mountain district includes the ovens along the line of the Pennsylvania Railroad from Gallitzin to beyond Altoona on the eastern side of the Alleghenies. The Connellsville district is the one located in the well-known region of that name in western Pennsylvania, and covers the greater part of Westmoreland and Fayette counties from just south of Latrobe to Fairchance. The Upper Connellsville district includes the northern portion of the Connellsville basin lying just north of the Connellsville district proper. The Clearfield-Center district is contained in the two counties from which it derives its name. The Broad Top district is located in the Broad Top coal fields, and the Greensburg, Irwin, Pittsburg, and Reynoldsville-Walston districts include the ovens near the towns from which their names are derived.

West Virginia is divided into five coking districts known, respectively, as the Kanawha, the New River, the Flat Top, the Upper Monongahela, and the Upper Potomac. The first two are compact and continuous. They include the ovens along the Chesapeake and Ohio Railroad from Quinnimont to the western limit of the coal fields. The Flat Top region includes the ovens in what is known as the Pocahontas district, including the counties of McDowell and Mercer. The Upper Monongahela and the Upper Potomac regions embrace the ovens located in the northern part of the state along the headwaters of the two rivers from which they derive their names.

Table 15 presents a detailed statement of the statistics for the industry, by states and territories, during the period covered by the present investigation.

TABLE 15.—COKE MANUFACTURED, BY STATES AND TERRITORIES: 1899.

	United States.[1]	Alabama.	Colorado.	Kansas.	Kentucky.	Missouri.	Ohio.	Pennsylvania.	Tennessee.	Virginia.	West Virginia.	All other states and territories.[2]
Number of establishments	241	15	9	8	5	3	5	89	8	5	77	17
Character of organization:												
Individual	15	.....	.....	.....	.....	.....	.....	12	.....	.....	2	1
Firm and limited partnership	21	1	.....	2	.....	.....	.....	16	.....	.....	1	1
Incorporated company	205	14	9	6	5	3	5	61	8	5	74	15
Capital	$36,502,679	$3,855,379	$928,874	$44,267	$198,533	$1,850	$84,690	$20,213,147	$607,322	$1,252,377	$4,452,579	$4,863,661
Land	$2,927,354	$1,303,111	$27,700	$400	$1,900	$125	$4,100	$744,341	$144,412	$102,000	$90,416	$508,849
Buildings	$2,382,237	$78,751	$95,325	$1,057	$17,800	.....	$3,770	$1,501,105	$44,800	$94,600	$380,793	$164,236
Ovens	$18,351,924	$1,839,319	$726,572	$22,346	$135,650	$1,500	$62,745	$9,774,075	$319,000	$879,000	$2,918,889	$1,672,828
Machinery, tools, and implements	$5,927,702	$377,821	$36,810	$16,188	$30,428	$75	$9,345	$2,686,344	$66,840	$51,300	$646,701	$2,005,850
Cash and sundries	$6,913,462	$256,377	$42,467	$4,276	$12,755	$150	$4,730	$5,507,282	$32,270	$125,477	$415,780	$511,898
Proprietors and firm members	48	2	.....	4	.....	.....	.....	40	.....	.....	1	1
Salaried officials, clerks, etc.:												
Total number	915	43	19	4	8	.....	14	518	22	23	208	56
Total salaries	$797,296	$40,003	$26,779	$2,920	$5,600	.....	$18,760	$481,133	$14,281	$26,360	$126,878	$54,582
Officers of corporations—												
Number	171	11	1	.....	2	.....	3	93	6	1	50	4
Salaries	$213,927	$6,854	$500	.....	$2,000	.....	$8,600	$146,217	$6,390	$1,800	$35,956	$5,610
General superintendents, managers, clerks, etc.—												
Total number	744	32	18	4	6	.....	11	425	16	22	158	52
Total salaries	$583,369	$33,149	$26,279	$2,920	$3,600	.....	$10,160	$334,916	$7,891	$24,560	$90,922	$48,972
Men—												
Number	723	32	18	4	5	.....	7	414	15	22	158	48
Salaries	$574,158	$33,149	$26,279	$2,920	$3,000	.....	$8,200	$331,045	$7,711	$24,560	$90,922	$46,372
Women—												
Number	21	.....	.....	.....	1	.....	4	11	1	.....	.....	4
Salaries	$9,211	.....	.....	.....	$600	.....	$1,960	$3,871	$180	.....	.....	$2,600
Wage-earners, including piece-workers, and total wages:												
Greatest number employed at any one time during the year	20,245	1,953	586	41	148	4	77	10,864	547	912	3,816	1,297
Least number employed at any one time during the year	14,403	1,591	273	23	96	4	62	7,676	426	669	2,669	914
Average number	16,999	1,592	406	28	126	4	71	9,283	477	785	3,181	1,096
Wages	$7,085,786	$535,622	$226,454	$11,425	$47,806	$2,220	$32,710	$4,516,651	$127,539	$225,532	$890,024	$469,753
Men, 16 years and over—												
Average number	16,932	1,558	406	28	126	4	71	9,278	468	773	3,124	1,096
Wages	$7,071,834	$527,757	$226,454	$11,425	$47,806	$2,220	$32,710	$4,515,749	$125,469	$223,872	$888,619	$469,753
Children, under 16 years—												
Average number	67	34	.....	.....	.....	.....	.....	5	9	12	7	.....
Wages	$13,902	$7,865	.....	.....	.....	.....	.....	$902	$2,070	$1,660	$1,405	.....
Average number of wage-earners, including piecework, employed during each month:												
Men, 16 years and over—												
January	15,495	1,350	366	34	97	4	75	8,383	453	678	2,960	1,095
February	15,353	1,224	361	34	97	4	75	8,463	460	674	2,913	1,048
March	16,112	1,387	405	31	102	4	78	8,883	467	721	2,940	1,099
April	16,312	1,423	400	25	115	4	76	9,000	455	740	3,035	1,039
May	16,624	1,566	403	20	135	4	62	8,933	439	833	3,093	1,086
June	16,261	1,557	352	18	136	4	63	8,724	451	822	3,123	1,011
July	16,966	1,529	394	24	139	4	65	9,273	484	829	3,195	1,030
August	17,437	1,617	391	26	137	4	65	9,578	460	846	3,196	1,117
September	17,666	1,727	412	24	137	4	73	9,713	471	813	3,129	1,163
October	17,973	1,765	453	26	138	4	71	9,833	476	801	3,262	1,144
November	18,364	1,760	471	31	139	4	77	10,145	486	774	3,313	1,164
December	18,621	1,791	468	36	143	4	77	10,358	514	745	3,329	1,156

[1] Exclusive of 1 penal establishment in Tennessee, operating 100 beehive ovens with an output of 54,783 tons of coke, valued at $85,796. This institution also reports capital, $63,400, and materials used, $30,317, including 95,174 tons of coal costing $28,847.

[2] Includes establishments distributed as follows: Georgia, 2; Illinois, 1; Indiana, 1; Indian Territory, 2; Massachusetts, 1; Montana, 2; New Mexico, 2; New York, 1; Utah, 1; Washington, 2; Wisconsin, 1; and Wyoming, 1.

TABLE 15.—COKE MANUFACTURED, BY STATES AND TERRITORIES: 1899—Continued.

	United States.[1]	Alabama.	Colorado.	Kansas.	Kentucky.	Missouri.	Ohio.	Pennsylvania.	Tennessee.	Virginia.	West Virginia.	All other states and territories.[2]
Average number of wage-earners, including piecework-ers, employed during each month—Continued.												
Children, under 16 years—												
January	58	26	.....	.....	.....	.....	.....	4	9	12	7	.....
February	58	27	.....	.....	.....	.....	.....	4	8	12	7	.....
March	59	26	.....	.....	.....	.....	.....	4	10	12	7	.....
April	61	29	.....	.....	.....	.....	.....	4	9	12	7	.....
May	65	34	.....	.....	.....	.....	.....	4	8	12	7	.....
June	65	34	.....	.....	.....	.....	.....	4	8	12	7	.....
July	69	36	.....	.....	.....	.....	.....	3	10	12	8	.....
August	69	35	.....	.....	.....	.....	.....	4	10	12	8	.....
September	77	41	.....	.....	.....	.....	.....	6	10	12	8	.....
October	77	44	.....	.....	.....	.....	.....	6	10	12	5	.....
November	72	39	.....	.....	.....	.....	.....	6	10	12	5	.....
December	74	39	.....	.....	.....	.....	.....	6	10	12	7	.....
Miscellaneous expenses:												
Total	$2,184,968	$180,290	$38,446	$12,069	$7,393	$125	$2,924	$1,227,259	$24,736	$37,145	$226,603	$427,978
Rent of works	$167,695	.....	.....	$260	$50	.....	$220	$32,177	$3,940	$20,315	$107,390	$3,343
Fire brick, cement, etc., used in repairing ovens	$408,311	$55,938	$17,208	$95	$3,055	$75	$1,274	$232,825	$4,152	$8,650	$63,095	$21,944
Taxes, not including internal revenue	$261,079	$16,764	$628	$639	$720	$35	$780	$186,344	$1,169	$2,100	$18,897	$33,003
Rent of offices, insurance, interest, and all sundry expenses not hitherto included	$1,291,287	$74,916	$20,610	$11,075	$3,568	$15	$650	$763,057	$9,450	$6,080	$37,221	$364,645
Contract work	$56,596	$32,672	.....	.....	.....	.....	.....	$12,856	$6,025	.....	.....	$5,043
Materials used:												
Total	$19,665,532	$2,673,568	$527,558	$28,136	$75,234	$2,566	$138,296	$11,678,079	$522,966	$677,269	$1,966,682	$1,375,178
Coal used—												
Number of short tons	30,157,829	3,028,472	817,725	26,988	151,503	5,820	142,678	19,490,030	684,821	994,635	3,792,825	1,022,832
Cost	$18,355,252	$2,596,718	$496,033	$26,079	$72,196	$2,256	$102,540	$10,899,832	$501,927	$523,979	$1,874,960	$1,258,732
Fuel	$189,184	$6,240	$3,850	$1,622	$220	.....	$12	$122,156	$3,470	$3,080	$8,416	$40,118
Mill supplies	$200,215	$12,757	.....	.....	$826	.....	$500	$88,853	$7,658	$66,712	$7,850	$15,059
All other materials	$675,720	$13,479	$18,269	.....	$830	.....	$1,209	$503,261	$9,594	$13,673	$65,127	$50,268
Freight	$245,161	$44,374	$9,406	$435	$1,162	$310	$34,035	$63,977	$317	$69,825	$10,319	$11,001
Products:												
Total value	$35,585,445	$3,726,433	$1,213,561	$32,270	$161,454	$5,520	$255,129	$22,282,358	$764,890	$1,072,684	$3,529,241	$2,541,905
Coke—												
Number of short tons	19,640,798	1,787,809	503,543	14,476	81,095	2,860	83,878	13,245,594	380,525	618,707	2,278,679	643,632
Value	$34,633,418	$3,634,471	$1,212,101	$30,817	$161,454	$5,520	$255,129	$22,039,151	$764,890	$1,071,284	$3,470,405	$1,988,196
Tar—												
Number of pounds	104,687,330	15,437,230	282,000	.....	.....	.....	.....	35,044,280	.....	40,000	8,181,160	45,702,660
Value	$207,952	$28,428	$1,460	.....	.....	.....	.....	$64,429	.....	$150	$15,063	$98,422
Ammonium sulphate—												
Number of pounds	11,984,931	.....	.....	.....	.....	.....	.....	3,046,683	.....	50,000	.....	8,888,248
Value	$330,921	.....	.....	.....	.....	.....	.....	$78,999	.....	$1,250	.....	$250,672
Ammonia liquor—												
Number of gallons	1,572,325	371,130	.....	.....	.....	.....	.....	890,184	.....	.....	214,945	96,066
Value	$180,642	$63,534	.....	.....	.....	.....	.....	$61,073	.....	.....	$38,492	$17,543
Gas sold—												
Number of cubic feet	1,171,942,697	.....	.....	.....	.....	.....	.....	153,201,100	.....	.....	160,378,200	858,363,397
Value	$225,022	.....	.....	.....	.....	.....	.....	$32,669	.....	.....	$5,281	$187,072
Value of all other products	$7,490	.....	.....	$1,453	.....	.....	.....	$6,037	.....	.....	.....	.....
Comparison of products:												
Number of establishments reporting for both years	200	9	7	5	3	2	5	75	7	5	68	14
Value for census year	$32,335,445	$3,282,997	$1,154,281	$15,438	$88,755	$4,320	$255,129	$21,548,766	$762,236	$1,072,684	$3,241,770	$609,069
Value for preceding business year	$23,253,879	$2,487,727	$1,036,778	$9,330	$48,032	$1,050	$210,488	$14,983,787	$507,905	$719,616	$2,425,402	$823,764
Power:												
Total horsepower	36,229	692	240	50	136	.....	55	25,057	630	1,439	4,095	3,835
Owned—												
Engines—												
Steam—												
Number	350	13	5	1	4	.....	2	220	11	17	54	23
Horsepower	29,148	482	240	50	136	.....	55	21,513	605	408	3,224	2,435
Gas or gasoline—												
Number	2	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....
Horsepower	7	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....
Electric motors—												
Number	68	.....	.....	.....	.....	.....	.....	25	.....	1	2	40
Horsepower	1,462	.....	.....	.....	.....	.....	.....	532	.....	90	40	800
Locomotives—												
Number	84	7	.....	.....	.....	.....	.....	54	2	5	15	1
Horsepower	5,269	210	.....	.....	.....	.....	.....	2,817	25	941	[3]676	600
Other power (pumps)—												
Number	14	.....	.....	.....	.....	.....	.....	5	.....	.....	9	.....
Horsepower	343	.....	.....	.....	.....	.....	.....	188	.....	.....	155	.....
Establishments classified by number of persons employed, not including proprietors and firm members:												
Total number of establishments	241	15	9	8	5	3	5	89	8	5	77	17
Under 5	23	.....	1	7	1	3	2	4	1	.....	3	1
5 to 20	47	1	1	1	1	.....	1	21	.....	.....	18	3
21 to 50	78	1	4	.....	2	.....	2	23	2	.....	33	11
51 to 100	58	6	3	.....	1	.....	.....	23	3	2	19	1
101 to 250	27	7	.....	.....	.....	.....	.....	12	2	2	4	.....
251 to 500	5	.....	.....	.....	.....	.....	.....	4	.....	1	.....	.....
501 to 1,000	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Over 1,000	2	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....

[1] Exclusive of 1 penal establishment in Tennessee, operating 100 beehive ovens, with an output of 54,783 tons of coke, valued at $85,796. This institution also reports capital, $63,400 and materials used, $30,317, including 95,174 tons of coal, costing $28,847.

[2] Includes establishments distributed as follows: Georgia, 2; Illinois, 1; Indiana, 1; Indian Territory, 2; Massachusetts, 1; Montana, 2; New Mexico, 2; New York, 1; Utah, 1; Washington, 2; Wisconsin, 1; and Wyoming, 1.

[3] Includes 1 compressed-air locomotive.

GAS, MANUFACTURED.

GAS, MANUFACTURED.

By Arthur L. Hunt.

The statistics presented in the following tables embrace the operations of establishments engaged in the manufacture of gas, for sale, including the plants owned and operated by municipalities. They do not include reports from private plants which sell no gas. Table 1 presents the principal features of the statistics for the industry as returned at the censuses of 1850 to 1900, inclusive, with the percentages of increase for each decade.

Table 1.—COMPARATIVE SUMMARY, 1850 TO 1900, WITH PER CENT OF INCREASE FOR EACH DECADE.

	Date of census.						Per cent of increase.				
	[1] 1900	1890	[2] 1880	1870	1860	1850	1890 to 1900	1880 to 1890	1870 to 1880	1860 to 1870	1850 to 1860
Number of establishments	877	742	.....	390	221	30	18.2	.....	.....	76.5	636.7
Capital	$567,000,506	$258,771,795	.....	$71,773,694	$28,848,726	$6,674,000	119.1	.....	.....	148.8	332.3
Salaried officials, clerks, etc., number	5,904	[3] 1,864	.....	(4)	(4)	(4)	216.7	.....	.....	.....	.....
Salaries	$5,278,500	[3] $2,143,169	.....	(4)	(4)	(4)	146.1	.....	.....	.....	.....
Wage-earners, average number	22,459	12,996	.....	8,723	5,730	952	72.8	.....	.....	52.2	501.9
Total wages	$12,436,296	$8,499,625	.....	$6,546,734	$2,321,536	$390,684	46.3	.....	.....	182.0	494.2
Men, 16 years and over	22,446	12,952	.....	8,705	5,730	950	73.3	.....	.....	51.9	503.2
Wages	$12,431,234	$8,492,797	.....	(4)	$2,321,536	(4)	46.4	.....	.....	.....	.....
Women, 16 years and over	10	.....	.....	.....	.....	2	.....	.....	.....	.....	[5] 100.0
Wages	$4,256	.....	.....	.....	.....	(4)	.....	.....	.....	.....	.....
Children, under 16 years	3	44	.....	18	.....	.....	[5] 93.2	.....	.....	.....	.....
Wages	$806	$6,828	.....	(4)	.....	.....	[5] 88.2	.....	.....	.....	.....
Miscellaneous expenses	$14,769,022	$7,799,385	.....	(2)	(2)	(2)	89.4	.....	.....	.....	.....
Cost of materials used	$20,605,356	$14,087,087	.....	$10,869,373	$3,667,630	$503,074	46.8	.....	.....	196.4	629.0
Value of products	$75,716,693	$56,987,290	.....	$32,048,851	$12,016,353	$1,921,746	32.9	.....	.....	166.7	525.3

[1] Includes 15 establishments operated by municipalities, which are shown separately in Table 10.
[2] Not reported.
[3] Includes proprietors and firm members, with their salaries; number only reported in 1900. (See Table 9.)
[4] Not reported separately.
[5] Decrease.

Table 1 shows the remarkable growth which has occurred in the industry during the past half century. The first census at which the statistics of the manufacture of gas were returned, with sufficient accuracy and detail to justify a comparison, was that of 1850. In that year 30 establishments were reported, as compared with 877 in 1900, an increase of 847, or nearly thirtyfold. During the same period, the capital increased from $6,674,000 to $567,000,506; the number of wage-earners from 952 to 22,459; the total wages from $390,684 to $12,436,296; the cost of materials from $503,074 to $20,605,356; and the value of products from $1,921,746 to $75,716,693. The industry was not reported at the Tenth Census, and consequently no figures are available for the production of gas in 1880. During the decade from 1890 to 1900 the number of establishments increased from 742 to 877, or 18.2 per cent. This increase is more apparent than real, as the full number of establishments was not reported in 1890.[1] The indications are that the number of establishments engaged in the industry is not increasing to any considerable extent. This is made clearer when it is stated that 92 establishments from which reports were received in 1890 failed to make returns in 1900. Of this latter number 47, or over one-half, were not in operation, having been dismantled, closed indefinitely, or changed to electric plants. Of the 45 establishments remaining, nearly one-third now distribute natural gas; a few failed to make returns for census purposes; and 18 establishments that were reported separately in 1890 have since lost their identity through consolidation. The number of new establishments seems small when it is considered that of the 1,653 cities and towns in the United States having a population of 2,500 and over, there were 826 in which no gas was manufactured. Of the 1,244 cities and towns with a population of 2,500 and over in 1890, there were only 530 not enjoying gas privileges. Of the 877 establishments shown for the Twelfth Census, 269, or 30.7 per cent, were operated in connection with the generation of electricity, and it was reported in many cases that the production of gas was attended with an actual loss.

[1] Report on Manufacturing Industries in the United States at the Eleventh Census, 1890, Part III, Selected Industries, page 699.

The striking increase in capital—119.1 per cent—is found chiefly in the items of machinery, tools, implements, and equipment. It is due to the constant demand for new equipment required to provide for increasing service. This also explains, in part, the fact that the percentage of increase in the value of products, 32.9 per cent, is so much smaller than the per cent of increase in capital; another factor being the reduction in the price of gas during the past decade, which would reduce the percentage of increase in the value of products. Between 1890 and 1900 the quantity of gas sold by gas companies increased 83.7 per cent, which may be a more accurate indication of the increase in the production than that represented by 32.9 per cent, the increase in value. This is further illustrated by comparing the average capital and product per establishment in 1890 with those items in 1900. In 1890 the average capital per establishment was $348,749, and in 1900, $648,523, or an increase in the average capital per establishment of 86 per cent. The average value of products per establishment in 1890 was $76,802, while in 1900 it was $86,336, an increase in value of products per establishment of only 12.4 per cent.

Table 2 is a list of the localities, alphabetically arranged, from which returns were received for the manufacture of gas in 1900, together with the number of establishments reporting from each. Where two or more plants, controlled by the same corporation, firm, or individual, are located in the same city or town, they have been counted as one establishment.

TABLE 2.—NUMBER OF ESTABLISHMENTS IN EACH LOCALITY: 1900.

Aberdeen, S. Dak	1	Bath, N. Y	1	Canton, Ill	1	Columbia, Tenn	1
Adams, Mass	1	Baton Rouge, La	1	Canton, Ohio	1	Columbus, Ga	1
Adrian, Mich	1	Battle Creek, Mich	1	Cape May, N. J	1	Columbus, Ind	1
Akron, Ohio	1	Bay City, Mich	1	Carbondale, Pa	1	Columbus, Miss	1
Albany, N. Y	1	Bayshore, N. Y	1	Carlinville, Ill	1	Columbus, Ohio	1
Albion, Mich	1	Beatrice, Nebr	1	Carlisle, Pa	1	Colusa, Cal	1
Albion, N. Y	1	Beaver Falls, Pa	1	Carson City, Nev	1	Concord, N. H	1
Albuquerque, N. Mex	1	Belfast, Me	1	Cartersville, Ga	1	Connellsville, Pa	1
Alexandria, Va	1	Bellaire, Ohio	1	Carthage, Mo	1	Connersville, Ind	1
Allentown, Pa	1	Bellefontaine, Ohio	1	Catasauqua, Pa	1	Conshohocken, Pa	1
Alliance, Ohio	1	Bellefonte, Pa	1	Catskill, N. Y	1	Cooperstown, N. Y	1
Alpena, Mich	1	Bellevue, Ky	1	Cedar Rapids, Iowa	1	Corning, N. Y	1
Alton, Ill	1	Beloit, Wis	1	Centerville, Iowa	1	Cortland, N. Y	1
Altoona, Pa	1	Belvidere, Ill	1	Centralia, Ill	1	Coshocton, Ohio	1
Americus, Ga	1	Benton Harbor, Mich	1	Chambersburg, Pa	1	Cottage City, Mass	1
Amesbury, Mass	1	Bethlehem, Pa	1	Champaign, Ill	1	Council Bluffs, Iowa	1
Amherst, Mass	1	Beverly, Mass	1	Charleston, S. C	1	Covington, Ky	1
Amsterdam, N. Y	1	Biddeford, Me	1	Charleston, W. Va	1	Crawfordsville, Ind	1
Annapolis, Md	1	Big Rapids, Mich	1	Charles Town, W. Va	1	Creston, Iowa	1
Ann Arbor, Mich	1	Binghamton, N. Y	1	Charlotte, Mich	1	Cumberland, Md	1
Anniston, Ala	1	Birmingham, Ala	1	Charlotte, N. C	1	Dallas, Tex	1
Appleton, Wis	1	Bloomington, Ill	1	Charlottesville, Va	1	Dalton, Ga	1
Ardmore, Pa	1	Bloomington, Ind	1	Chattanooga, Tenn	2	Danbury, Conn	1
Arkansas City, Kans	1	Bloomsburg, Pa	1	Chelsea, Mass	1	Danielson, Conn	1
Arlington, Mass	1	Boonville, Mo	1	Chester, Pa	1	Dansville, N. Y	1
Asheville, N. C	1	Bordentown, N. J	1	Cheyenne, Wyo	1	Danvers, Mass	1
Ashland, Ohio	1	Boston, Mass	6	Chicago, Ill	4	Danville, Ill	1
Ashland, Pa	1	Bowling Green, Ky	1	Chico, Cal	1	Danville, Ky	1
Ashland, Wis	1	Braddock, Pa	1	Chicopee, Mass	1	Danville, Pa	2
Ashtabula, Ohio	1	Brattleboro, Vt	1	Chillicothe, Mo	1	Darby, Pa	1
Astoria, Oreg	1	Bridgeport, Conn	2	Chillicothe, Ohio	1	Davenport, Iowa	1
Atchison, Kans	1	Bridgeton, N. J	1	Chippewa Falls, Wis	1	Dayton, Ohio	1
Athens, Ga	1	Bristol, Pa	1	Cincinnati, Ohio	1	Decatur, Ala	1
Athol, Mass	1	Bristol, R. I	1	Circleville, Ohio	1	Decatur, Ill	1
Atlanta, Ga	2	Bristol, Tenn	1	Claremont, N. H	1	Dedham, Mass	1
Atlantic, Iowa	1	Brockport, N. Y	1	Clarksburg, W. Va	1	Defiance, Ohio	1
Atlantic City, N. J	1	Brocton, Mass	1	Clarksville, Tenn	1	Delaware, Ohio	1
Attleboro, Mass	1	Brownsville, Pa	1	Clearfield, Pa	1	Delphos, Ohio	1
Auburn, N. Y	1	Brunswick, Ga	1	Cleveland, Ohio	1	Denison, Tex	1
Augusta, Ga	1	Bucyrus, Ohio	1	Clifton Springs, N. Y	1	Denver, Colo	1
Augusta, Me	1	Buffalo, N. Y	1	Clinton, Iowa	1	Derby, Conn	1
Aurora, Ill	1	Burlington, Iowa	1	Clinton, Mass	1	Des Moines, Iowa	1
Aurora, Ind	1	Burlington, N. J	1	Clinton, Mo	1	Detroit, Mich	1
Baker City, Oreg	1	Burlington, Vt	1	Clyde, N. Y	1	Dixon, Ill	1
Bakersfield, Cal	1	Butte, Mont	1	Clyde, Ohio	1	Dover, Del	1
Ballston Spa, N. Y	1	Cadiz, Ohio	1	Coatesville, Pa	1	Dover, N. H	1
Baltimore, Md	2	Cairo, Ill	1	Cohoes, N. Y	1	Downington, Pa	1
Bangor, Me	1	Calais, Me	1	Coldwater, Mich	1	Dubuque, Iowa	1
Baraboo, Wis	1	Cambridge, Md	1	Colorado Springs, Colo	1	Duluth, Minn	1
Barnesville, Ohio	1	Cambridge, Mass	1	Columbia, Mo	1	Dunkirk, N. Y	1
Batavia, N. Y	1	Camden, N. J	2	Columbia, Pa	1	Duquoin, Ill	1
Bath, Me	1	Canandaigua, N. Y	1	Columbia, S. C	1	Easthampton, Mass	1

TABLE 2.—NUMBER OF ESTABLISHMENTS IN EACH LOCALITY: 1900—Continued.

Easton, Md	1	Gloucester City, N. J	1	Joliet, Ill	1	Manistee, Mich	1
Easton, Pa	1	Goshen, Ind	1	Kalamazoo, Mich	2	Mankato, Minn	1
East St. Louis, Ill	1	Goshen, N. Y	1	Kankakee, Ill	1	Mansfield, Ohio	1
Eau Claire, Wis	1	Grafton, W. Va	1	Kansas City, Kans	1	Marblehead, Mass	1
Eldorado, Kans	1	Grand Forks, N. Dak	1	Kansas City, Mo	1	Marietta, Ohio	1
Elgin, Ill	1	Grand Haven, Mich	1	Kearney, Nebr	1	Marinette, Wis	1
Elizabeth, N. J	1	Grand Island, Nebr	1	Keene, N. H	1	Marion, Ohio	1
Elkhart, Ind	1	Grand Rapids, Mich	1	Kenosha, Wis	1	Marlboro, Mass	1
Elkton, Md	1	Grass Valley, Cal	1	Kenton, Ohio	1	Marquette, Mich	1
Elmira, N. Y	1	Green Bay, Wis	1	Keokuk, Iowa	1	Marshall, Mich	1
El Paso, Tex	1	Greencastle, Ind	1	Kewanee, Ill	1	Marshall, Mo	1
Elyria, Ohio	1	Greenfield, Mass	1	Kingston, N. Y	1	Marshalltown, Iowa	1
Emporia, Kans	1	Greensboro, N. C	1	Knoxville, Tenn	1	Martinsburg, W. Va	1
Erie, Pa	1	Greensburg, Pa	1	Kokomo, Ind	1	Martinsville, Ind	1
Escanaba, Mich	1	Greenville, Mich	1	Laconia, N. H	1	Marysville, Cal	1
Eufaula, Ala	1	Greenville, Ohio	1	La Crosse, Wis	1	Massillon, Ohio	1
Eureka, Cal	1	Greenville, Pa	1	Lafayette, Ind	1	Matawan, N. J	1
Evanston, Ill	1	Greenville, S. C	1	Lambertville, N. J	1	Mattoon, Ill	1
Evansville, Ind	1	Hackensack, N. J	1	Lancaster, Ohio	1	Mauch Chunk, Pa	1
Excelsior Springs, Mo	1	Hagerstown, Md	1	Lancaster, Pa	1	Maysville, Ky	1
Exeter, N. H	1	Hamilton, Ohio	2	Lansing, Mich	1	Meadville, Pa	1
Fairfield, Iowa	1	Hamlet, N. C	1	Laporte, Ind	1	Mechanicsburg, Ohio	1
Fairhaven, Wash	1	Hannibal, Mo	1	Lasalle, Ill	1	Mechanicsburg, Pa	1
Fall River, Mass	1	Hanover, Pa	1	Latrobe, Pa	1	Media, Pa	1
Fargo, N. Dak	1	Harrisburg, Pa	1	Lawrence, Kans	1	Medina, N. Y	1
Faribault, Minn	1	Hartford, Conn	1	Lawrence, Mass	1	Memphis, Tenn	2
Farmington, N. H	1	Hastings, Nebr	1	Lawrenceburg, Ind	1	Mendota, Ill	2
Fayetteville, N. C	1	Haverhill, Mass	1	Leadville, Colo	1	Menominee, Mich	1
Fishkill Landing, N. Y	1	Haverstraw, N. Y	1	Leavenworth, Kans	1	Merchantville, N. J	1
Fitchburg, Mass	1	Hazleton, Pa	1	Lebanon, Ind	1	Meriden, Conn	1
Flemington, N. J	1	Helena, Ark	1	Lebanon, Ohio	1	Meridian, Miss	1
Flint, Mich	1	Helena, Mont	1	Lebanon, Pa	1	Michigan City, Ind	1
Florence, Ala	1	Hempstead, N. Y	1	Le Mars, Iowa	1	Middleboro, Mass	1
Fond du Lac, Wis	1	Henderson, Ky	1	Leominster, Mass	1	Middletown, Conn	1
Fort Dodge, Iowa	1	Hillsboro, Ohio	1	Leroy, N. Y	1	Middletown, N. Y	1
Fort Madison, Iowa	1	Hillsdale, Mich	1	Lewisburg, Pa	1	Middletown, Ohio	1
Fort Plain, N. Y	1	Hollister, Cal	1	Lewiston, Me	1	Milford, Mass	1
Fort Scott, Kans	1	Holyoke, Mass	1	Lewistown, Pa	1	Millville, N. J	1
Fort Smith, Ark	1	Honesdale, Pa	1	Lexington, Ky	1	Milton, Pa	1
Fort Wayne, Ind	1	Hoosick Falls, N. Y	1	Lexington, Mass	1	Milwaukee, Wis	1
Fort Worth, Tex	1	Hopkinsville, Ky	1	Lexington, Mo	1	Minneapolis, Minn	2
Fostoria, Ohio	1	Hot Springs, Ark	1	Liberty, Ind	1	Moberly, Mo	1
Framingham, Mass	1	Houston, Tex	1	Lima, Ohio	1	Mobile, Ala	2
Frankfort, Ind	1	Hudson, N. Y	1	Lincoln, Ill	1	Modesto, Cal	1
Frankfort, Ky	1	Huntingdon, Pa	1	Lincoln, Nebr	1	Moline, Ill	1
Franklin, Ind	1	Huntington, Ind	1	Lisbon, Ohio	1	Monmouth, Ill	1
Franklin, N. H	1	Huntington, N. Y	1	Litchfield, Ill	1	Monongahela, Pa	1
Frederick, Md	1	Huntington, W. Va	1	Little Falls, N. Y	1	Monroe, Mich	1
Fredericksburg, Va	1	Huntsville, Ala	1	Little Rock, Ark	1	Montgomery, Ala	1
Freehold, N. J	1	Huntsville, Mo	1	Lock Haven, Pa	1	Montpelier, Vt	1
Freeport, Ill	1	Hutchinson, Kans	1	Lockport, N. Y	1	Morris, Ill	1
Fremont, Nebr	1	Independence, Iowa	1	Logansport, Ind	1	Morristown, N. J	1
Fremont, Ohio	1	Independence, Mo	1	London, Ohio	1	Mt. Clemens, Mich	1
Fresno, Cal	1	Indianapolis, Ind	2	Long Branch, N. J	1	Mt. Holly, N. J	1
Frostburg, Md	1	Ionia, Mich	1	Lorain, Ohio	1	Mt. Joy, Pa	1
Gainesville, Fla	1	Iowa City, Iowa	1	Los Angeles, Cal	1	Mt. Pleasant, Iowa	1
Gainesville, Tex	1	Ipswich, Mass	1	Los Gatos, Cal	1	Mt. Sterling, Ky	1
Galena, Ill	1	Ironton, Ohio	1	Louisiana, Mo	1	Mt. Vernon, N. Y	1
Galesburg, Ill	1	Ishpeming, Mich	1	Louisville, Ky	1	Mt. Vernon, Ohio	1
Galion, Ohio	1	Ithaca, N. Y	1	Lowell, Mass	1	Murfreesboro, Tenn	1
Gallipolis, Ohio	1	Jackson, Cal	1	Lynchburg, Va	1	Murphysboro, Ill	1
Galva, Ill	1	Jackson, Miss	1	Lynn, Mass	1	Muscatine, Iowa	1
Galveston, Tex	1	Jackson, Tenn	1	Lyons, N. Y	1	Muskegon, Mich	1
Garden City, N. Y	1	Jacksonville, Fla	2	McKeesport, Pa	1	Nanticoke, Pa	1
Gardner, Mass	1	Jacksonville, Ill	1	Macomb, Ill	1	Nantucket, Mass	1
Geneseo, N. Y	1	Jamestown, N. Y	1	Macon, Ga	1	Napa, Cal	1
Geneva, N. Y	1	Janesville, Wis	1	Macon, Mo	1	Nashua, N. H	1
Georgetown, Ky	1	Jefferson City, Mo	1	Madison, Ind	1	Nashville, Tenn	1
Gettysburg, Pa	1	Jeffersonville, Ind	1	Madison, Wis	1	Natchez, Miss	1
Gilroy, Cal	1	Jersey City, N. J	1	Mahanoy City, Pa	1	Natick, Mass	1
Girardville, Pa	1	Jersey Shore, Pa	1	Malden, Mass	1	Nebraska City, Nebr	1
Glens Falls, N. Y	1	Johnstown, N. Y	1	Malone, N. Y	1	Neenah, Wis	1
Gloucester, Mass	1	Johnstown, Pa	1	Manchester, N. H	1	Negaunee, Mich	1

TABLE 2.—NUMBER OF ESTABLISHMENTS IN EACH LOCALITY: 1900—Continued.

Nevada, Mo		1
Nevada City, Cal		1
New Albany, Ind		1
Newark, N. J		1
Newark, Ohio		1
New Bedford, Mass		1
Newbern, N. C		1
New Britain, Conn		1
New Brunswick, N. J		1
Newburg, N. Y		1
Newburyport, Mass		1
Newcastle, Del		1
Newcastle, Pa		1
New Hartford, Conn		1
New Haven, Conn		1
New London, Conn		1
New Orleans, La		1
New Philadelphia, Ohio		1
Newport, R. I		1
Newport News, Va		1
Newton, Kans		1
Newton, Mass		1
Newton, N. J		1
New York, N. Y		13
Brooklyn borough	1	
College Point	1	
Coney Island	1	
Flushing	2	
Manhattan borough	6	
Rockaway Beach	1	
Stapleton	1	
Niagara Falls, N. Y		1
Niles, Mich		1
Norfolk, Va		1
Norristown, Pa		1
North Adams, Mass		1
Northampton, Mass		1
North Attleboro, Mass		1
Norwalk, Conn		1
Norwich, Conn		1
Norwich, N. Y		2
Norwood, Mass		1
Nyack, N. Y		1
Oakland, Cal		1
Oakpark, Ill		1
Oberlin, Ohio		1
Ocala, Fla		1
Ogden, Utah		1
Ogdensburg, N. Y		1
Omaha, Nebr		1
Oneida, N. Y		1
Oneonta, N. Y		1
Orlando, Fla		1
Oroville, Cal		1
Oshkosh, Wis		1
Oskaloosa, Iowa		1
Ossining, N. Y. (formerly Sing Sing)		1
Oswego, N. Y		1
Ottawa, Ill		1
Ottawa, Kans		1
Ottumwa, Iowa		1
Owego, N. Y		1
Owensboro, Ky		1
Ovosso, Mich		1
Paducah, Ky		1
Painesville, Ohio		1
Palatka, Fla		1
Palmyra, N. Y		1
Paris, Ill		1
Paris, Ky		1
Paris, Tex		1
Parkersburg, W. Va		1
Pasadena, Cal		1
Passaic, N. J		1
Pawtucket, R. I		1
Peekskill, N. Y		1
Pekin, Ill		1
Penn Yan, N. Y		1
Pensacola, Fla		1
Peoria, Ill		2
Perth Amboy, N. J		1
Peru, Ind		1
Petaluma, Cal		1
Petersburg, Va		1
Philadelphia, Pa		3
Phillipsburg, N. J		2
Phoenix, Ariz		1
Phoenixville, Pa		1
Pine Bluff, Ark		1
Piqua, Ohio		1
Pittsburg, Kans		1
Pittsburg, Pa		3
Pittsfield, Mass		1
Pittsfield, N. H		1
Pittston, Pa		1
Plainfield, N. J		1
Plattsburg, N. Y		1
Plattsmouth, Nebr		1
Plymouth, Mass		1
Plymouth, Pa		1
Pomona, Cal		1
Pontiac, Mich		1
Portage, Wis		1
Port Henry, N. Y		1
Port Huron, Mich		1
Port Jervis, N. Y		1
Portland, Me		1
Portland, Oreg		2
Portsmouth, N. H		1
Portsmouth, Ohio		1
Portsmouth, Va		1
Port Townsend, Wash		1
Pottstown, Pa		1
Pottsville, Pa		1
Poughkeepsie, N. Y		1
Princeton, Ill		1
Princeton, N. J		1
Providence, R. I		1
Pueblo, Colo		1
Putnam, Conn		1
Quincy, Ill		1
Quincy, Mass		1
Racine, Wis		1
Raleigh, N. C		1
Ravenna, Ohio		1
Reading, Pa		1
Red Bluff, Cal		1
Red Oak, Iowa		1
Red Wing, Minn		1
Reno, Nev		1
Rensselaer, N. Y. (formerly Greenbush)		1
Rhinebeck, N. Y		1
Rich Hill, Mo		1
Richmond, Ind		1
Richmond, Ky		1
Richmond, Va		1
Ripley, Ohio		1
Ripon, Wis		1
Riverside, Cal		1
Roanoke, Va		1
Rochester, Minn		1
Rochester, N. Y		1
Rockford, Ill		1
Rockland, Me		1
Rome, Ga		1
Rome, N. Y		1
Rushville, Ind		1
Rutland, Vt		1
Sacramento, Cal		1
Sag Harbor, N. Y		1
Saginaw, Mich		2
St. Albans, Vt		1
St. Augustine, Fla		1
St. Charles, Mo		1
St. Cloud, Minn		1
St. Helena, Cal		1
St. Johns, Mich		1
St. Joseph, Mo		1
St. Louis, Mo		2
St. Paul, Minn		1
Salem, Mass		1
Salem, N. J		1
Salem, Ohio		1
Salem, Oreg		1
Salina, Kans		1
Salinas, Cal		1
Salisbury, N. C		1
Salt Lake City, Utah		1
San Antonio, Tex		1
San Bernardino, Cal		1
San Diego, Cal		1
Sandusky, Ohio		1
Sanford, Fla		1
San Francisco, Cal		3
San Jose, Cal		1
San Leandro, Cal		1
San Luis Obispo, Cal		1
San Rafael, Cal		1
Santa Ana, Cal		1
Santa Cruz, Cal		1
Santa Rosa, Cal		1
Saratoga Springs, N. Y		1
Saugerties, N. Y		1
Savannah, Ga		1
Schenectady, N. Y		1
Schuylkill Haven, Pa		1
Scranton, Pa		1
Seattle, Wash		1
Sedalia, Mo		1
Selma, Ala		1
Seneca Falls, N. Y		1
Sewickley, Pa		1
Seymour, Ind		1
Shamokin, Pa		1
Sharon, Pa		1
Sharpsburg, Pa		1
Sheboygan, Wis		1
Shelbyville, Ind		1
Shelbyville, Ky		1
Shenandoah, Pa		1
Sherman, Tex		1
Shippensburg, Pa		1
Shreveport, La		1
Sidney, Ohio		1
Sioux City, Iowa		1
Sioux Falls, S. Dak		1
Smyrna, Del		1
Somersworth, N. H		1
Somerville, N. J		1
South Bend, Ind		1
Southbridge, Mass		1
Spartanburg, S. C		1
Spencer, Mass		1
Spokane, Wash		1
Springfield, Ill		1
Springfield, Mass		1
Springfield, Mo		1
Springfield, Ohio		1
Stamford, Conn		1
Staunton, Va		1
Sterling, Ill		1
Steubenville Ohio		1
Stevens Point, Wis		1
Stillwater, Minn		1
Stockton Cal		1
Stoneham, Mass		1
Stoughton, Mass		1
Streator, Ill		1
Stroudsburg, Pa		1
Sunbury, Pa		1
Superior, Wis		1
Syracuse, N. Y		1
Tacoma, Wash		1
Talladega, Ala		1
Tallahassee, Fla		1
Tamaqua, Pa		1
Tampa, Fla		1
Tarrytown, N. Y		1
Taunton, Mass		1
Taylorville, Ill		1
Terre Haute, Ind		1
Texarkana, Ark		2
Tiffin, Ohio		1
Toledo, Ohio		2
Tombstone, Ariz		1
Tonawanda, N. Y		1
Topeka, Kans		1
Towanda, Pa		1
Trenton, Mo		1
Trenton, N. J		1
Trinidad, Colo		1
Troy, N. Y		1
Troy, Ohio		1
Tucson, Ariz		1
Tyrone, Pa		1
Uniontown, Pa		1
Upper Sandusky, Ohio		1
Urbana, Ohio		1
Utica, N. Y		1
Vallejo, Cal		1
Valparaiso, Ind		1
Van Wert, Ohio		1
Vernon, Conn		1
Vicksburg, Miss		1
Vincennes, Ind		1
Vineland, N. J		1
Virginia City, Nev		1
Wabash, Ind		1
Waco, Tex		1
Wakefield, Mass		1
Wallawalla, Wash		1
Wallingford, Conn		1
Waltham, Mass		1
Wappingers Falls, N. Y		1
Ware, Mass		1
Warren, Ohio		1
Warsaw, Ind		1
Warsaw, N. Y		1
Washington, D. C		3
Washington, Ind		1
Washington, Iowa		1
Washington, N. C		1
Washington, Pa		1
Washington Court House, Ohio		1
Waterbury, Conn		1
Waterloo, Iowa		1
Watertown, N. Y		1
Watertown, Wis		1
Waterville, N. Y		1
Watkins, N. Y		1
Watsonville, Cal		1

TABLE 2.—NUMBER OF ESTABLISHMENTS IN EACH LOCALITY: 1900—Continued.

Waukegan, Ill	1	Westfield, N. Y	1	Wilmington, N. C	1	Woonsocket, R. I	1
Waukesha, Wis	1	Westminster, Md	1	Wilmington, Ohio	1	Wooster, Ohio	1
Wausau, Wis	1	West Winfield, N. Y	1	Winchester, Va	1	Worcester, Mass	1
Waverly, N. Y	1	West Winsted, Conn	1	Windham, Conn	1	Wyncote, Pa	1
Waynesboro, Pa	1	Wheeling, W. Va	1	Windsor, Vt	1	Xenia, Ohio	1
Webster, Mass	1	White Plains, N. Y	1	Winfield, Kans	1	Yonkers, N. Y	1
Wellington, Kans	1	Wichita, Kans	1	Winona, Minn	1	York, Pa	1
Wellsville, Ohio	1	Wilkesbarre, Pa	1	Woburn, Mass	1	Youngstown, Ohio	1
West Chester, Pa	1	Williamsport, Pa	1	Woodbury, N. J	1	Ypsilanti, Mich	1
Westerly, R. I	1	Williamstown, Mass	1	Woodland, Cal	1	Zanesville, Ohio	1
Westfield, Mass	1	Wilmington, Del	1	Woodstock, Vt	1		

There were 827 cities and towns represented by the 877 establishments from which returns were received. Of the 877 establishments, 200 were in localities having less than 5,000 inhabitants; 260 in cities and towns having a population of from 5,000 to 10,000; 177 in cities of from 10,000 to 20,000; 47 in cities of from 20,000 to 25,000; 81 in cities of 25,000 and under 50,000; 43 in cities of 50,000 and under 100,000; 20 in cities of 100,000 and under 200,000; and 49 in cities of 200,000 and over. The most noteworthy feature indicated by the above figures is the fact that 460, or 52.5 per cent of the 877 gas plants from which reports were received, were in cities and towns of less than 10,000 inhabitants. This is more than fifteen times the total number of gas establishments in the United States in 1850. Further, of the 460 plants located in cities and towns of less than 10,000 inhabitants, 200, or 22.8 per cent of the entire number reported, were in localities of less than 5,000 inhabitants, showing that in matters of illumination a goodly number of the smaller towns enjoy the same privileges as the larger cities.

Table 3 presents, by states and territories, the number of active gas establishments from which returns were received in 1890 and in 1900, with the increase during the decade.

TABLE 3.—COMPARATIVE SUMMARY: NUMBER OF ACTIVE ESTABLISHMENTS, 1890 AND 1900, AND INCREASE DURING THE DECADE, BY STATES AND TERRITORIES; ARRANGED GEOGRAPHICALLY.

STATES AND TERRITORIES.	1900	1890	Increase.
United States	877	742	135
New England states	124	131	[1]7
Maine	9	11	[1]2
New Hampshire	13	13	.....
Vermont	7	8	[1]1
Massachusetts	68	72	[1]4
Rhode Island	6	7	[1]1
Connecticut	21	20	1
Middle states	242	213	29
New York	101	94	7
New Jersey	34	33	1
Pennsylvania	89	73	16
Delaware	4	4	.....
Maryland	11	7	4
District of Columbia	3	2	1
Southern states	122	85	37
West Virginia	8	3	5
Virginia	12	6	6
North Carolina	10	6	4
South Carolina	4	2	2
Georgia	12	11	1
Florida	11	7	4
Kentucky	17	14	3
Tennessee	11	8	3
Alabama	11	7	4
Mississippi	5	2	3
Arkansas	7	7	.....
Southern states—Continued.			
Louisiana	3	4	[1]1
Texas	11	8	3
Central states	290	221	69
Ohio	73	61	12
Michigan	38	27	11
Indiana	39	33	6
Illinois	53	36	17
Wisconsin	25	18	7
Minnesota	11	10	1
Iowa	26	19	7
Missouri	25	17	8
Western states	47	40	7
Montana	2	1	1
Wyoming	1	1	.....
North Dakota	2	2	.....
South Dakota	2	2	.....
Nebraska	9	9	.....
Nevada	3	2	1
Utah	2	1	1
Colorado	5	6	[1]1
Kansas	17	12	5
Arizona	3	2	1
New Mexico	1	2	[1]1
Pacific states	52	52	.....
Washington	6	4	2
Oregon	5	4	1
California	41	44	[1]3

[1] Decrease.

Table 3 indicates that in 8 states there has been a decrease in the number of establishments. This decrease is caused, as noted above, by the number of establishments reporting in 1890 that in 1900 were either abandoned or had lost their identity through consolidation. It will be observed from Table 3 that the greatest increase in number of establishments reported was in Illinois, which showed an increase of 17, followed by Pennsylvania with 16 additional plants.

Table 4 is a comparative summary of capital for 1890 and 1900, with the percentage of each item to the total, and the per cent of increase for the decade.

TABLE 4.—CAPITAL: 1890 AND 1900.

	1900		1890		Per cent of increase.
	Amount.	Per cent of total.	Amount.	Per cent of total.	
Total	$567,000,506	100.0	$258,771,795	100.0	119.1
Land	50,050,371	8.8	45,521,707	17.6	9.9
Buildings	58,486,472	10.3	35,048,435	13.5	66.9
Machinery, tools, and implements	376,790,335	66.5	153,830,910	59.5	144.9
Live assets, total	81,673,328	14.4	24,370,743	9.4	235.1
Raw materials on hand			2,654,254	1.0	
Stock in process of manufacture, and finished products on hand, including by-products	6,838,208	1.2	1,914,136	0.7	49.7
Cash, surplus, reserve fund, bills and accounts receivable, and all sundries not elsewhere reported	74,835,120	13.2	19,802,353	7.7	277.9

While in the majority of cases separate book accounts were not kept for the 269 establishments engaged in the production and distribution of gas in connection with electric light and power, an equitable division of the capital was made by the officials furnishing the information, so that the data may be accepted as fairly representing the capital engaged in the manufacture of gas.

The value of machinery, tools, and implements, including gas-making apparatus and machinery, gasholders, consumers' meters, mains and services, teams, tools, horses, wagons, and other accessories, constituted the principal item reported for capital in both years. In 1900 this item amounted to $376,790,335, or 66.5 per cent of the total capital, having increased $222,959,425, or 144.9 per cent, since 1890, when the corresponding value was $153,830,910. For the same period the value of land increased from $45,521,707 to $50,050,371, an increase of $4,528,664, or 9.9 per cent; and the value of buildings from $35,048,435 to $58,486,472, an increase of $23,438,037, or 66.9 per cent. But land and buildings, while showing an absolute increase, constituted a relatively smaller proportion of the total capital than in 1890. The land decreased from 17.6 per cent to 8.8 per cent, and the buildings from 13.5 per cent to 10.3 per cent, of all capital reported. A slight difference exists in the manner of reporting the live assets at the two censuses under comparison. In 1890 raw materials were separated from stock in process of manufacture and finished products, but in 1900 these items were combined.

Live assets, including raw materials, stock in process of manufacture, and finished products on hand, together with cash, surplus, reserve, bills and accounts receivable, and all other sundries, which amounted to $24,370,743 in 1890 and $81,673,328 in 1900, showed an increase of $57,302,585, or 235.1 per cent. The large increase over 1890 in the items of cash, surplus, etc., is due partly to the accumulation of profits which are held as a reserve fund.

These figures do not represent the capital stock of the establishments engaged in the manufacture of gas, but they stand for the actual value of the plants, together with the amount necessary for working capital. The returns indicate that to produce $1 of gross product required $3.47 of capital in 1850, $2.40 in 1860, $2.24 in 1870, $4.54 in 1890, and $7.49 in 1900.

The special schedule of inquiry for gas manufacture called for the amount of bonds issued by each company, and the rate of interest on the same; the amount of capital stock, preferred and common; and the amount of dividend paid during the year. Table 5 is a summary of amounts reported in reply to these inquiries.

TABLE 5.—BONDS AND STOCK: 1900.

Bonds:	
Amount issued	$192,669,181
Interest paid during the year	9,471,575
Stock issued:	
Total	376,035,803
Preferred	26,143,882
Common	349,891,921
Amount of dividend paid during the year	15,842,138

In 1900 the total capital stock was $376,035,803, as compared with $229,746,552 in 1890, an increase of $146,289,251, or 63.7 per cent, during the past ten years. Of the capital stock, $349,891,921, or 93 per cent, was common, and the remainder, 7 per cent, preferred stock. The total capital reported as actually invested, $567,000,506, exceeds the capital stock by $190,964,703. Several establishments reported that they issued no capital stock, and the companies operating both gas and electric plants reported it impossible to segregate the bonds and stocks so as to report the exact amount directly chargeable to the gas plant. In many instances, the amounts reported for the gas plant were unquestionably too small.

The schedule of inquiry for 1890 was the first which contained questions designed to show the cost of manufacture other than for wages and materials. The questions of the Twelfth Census relating to miscellaneous expenses were made as nearly uniform as possible with those of the previous census, and the returns are shown in Table 6 in comparison with those of 1890, together with the percentage of each item to the total, and the per cent of increase from 1890 to 1900.

TABLE 6.—MISCELLANEOUS EXPENSES: 1890 AND 1900.

	1900		1890		Per cent of increase.
	Amount.	Per cent of total.	Amount.	Per cent of total.	
Total	$14,769,022	100.0	$7,799,385	100.0	89.4
Rent, total	1,164,380	7.9	630,711	8.1	84.6
Of works	820,241	5.6			
Of offices	344,139	2.3			
Taxes, including royalties and special tax	3,577,037	24.2	2,227,122	28.5	60.6
Lamps and appliances purchased for sale	1,392,206	9.4			
Advertising, interest, insurance, repairs, and other sundry expenses	8,635,399	58.5	4,941,552	63.4	74.8

The amount paid for insurance, ordinary repairs, interest, advertising, etc., was the principal item of the miscellaneous expenses reported. This amount includes no allowance for depreciation, or for expense incurred for new equipment, extension of mains, etc. Interest in this item is not to be considered the same as the interest on bonds, shown in Table 5, but includes only the comparatively small sums paid for money or credit obtained from time to time during the year, incident to the conduct of the business. The next to the largest item of miscellaneous expenses was the amount paid for taxes.

Table 7 is a comparative summary of the cost of the different materials used in 1890 and 1900, with the percentage of each to the total cost of materials, and the per cent of increase from 1890 to 1900.

TABLE 7.—COST OF MATERIALS: 1890 AND 1900.

	1900		1890		Per cent of increase.
	Amount.	Per cent of total.	Amount.	Per cent of total.	
Total	$20,605,356	100.0	$14,037,087	100.0	46.8
Coal	7,164,472	34.8	8,797,851	62.7	[1]18.6
Coke	726,736	3.5	190,342	1.4	281.8
Oil	8,168,657	39.6	3,483,005	24.8	134.5
Water	204,402	1.0	(2)		
Natural gas	(2)		19,389	0.1	
Oxide of iron	(2)		51,936	0.4	
Lime	(2)		426,590	3.0	
Fuel	1,082,844	5.3	524,249	3.7	106.6
Mill supplies	149,439	0.7	(2)		
All other materials	2,395,430	11.6	543,725	3.9	340.6
Freight	713,376	3.5	(2)		

[1] Decrease.

[2] Not reported separately.

The total cost of materials used in 1900 was $20,605,356 as compared with $14,037,087 in 1890, representing an increase of $6,568,269, or 46.8 per cent. The quantities and values of the different materials used are presented in detail in Table 9, by states and territories.

Oil, crude and refined, was the largest single item of materials used in the manufacture of gas in 1900, its cost forming 39.6 per cent of the total cost of materials, as compared with 24.8 per cent in 1890. The relatively larger amount expended for oil in 1900 was due to the higher price of crude petroleum in 1900, and to the more extended use of oil for the purpose of enriching water gas, the manufacture of which has increased since 1890 much more rapidly than that of coal gas. This is evidenced by the fact that the cost of coal, which was the principal item of expense in 1890, forming 62.7 per cent of the cost of materials, was the second item of expense in 1900, forming but 34.8 per cent of the total. In 1890 coal gas formed 49.7 per cent of the value of products as compared with 38.1 per cent for water gas. The form of inquiry for 19 0 did not call for the amount of each variety of gas sold, and it is impossible to arrive at the exact proportion of each kind from the materials used, since hard coal, coke, and oil are all used in the manufacture of water gas; but the conclusion seems to be warranted that over 75 per cent of the gas manufactured during the census year was water gas.

A water-gas plant is, in several respects, more advantageously operated than other systems of gas production. Probably the chief advantage is the smaller expenditure for labor. Moreover, the illuminating power of the water gas is higher than that of coal gas.

The cost of oil and coal varies with the distance from the source of supply, and the quality used in different sections of the country also differs noticeably. Furthermore, in many instances, the materials used were bought delivered, and it was found impossible to separate the amount chargeable to freight. The number of gallons of oil used was given as 194,857,296, costing $8,168,657, an average per gallon of $0.042; the number of tons of coal consumed was reported as 2,487,287, costing $7,164,472, an average of $2.88 per ton. The figures

given make no allowance for material bought delivered. The number of bushels of coke, shown in Table 9, includes 2,733,034 bushels of by-product coke used by the plants reporting the same, for which no value is given. If this quantity be deducted from the total amount reported, it shows that 12,481,759 bushels of coke were purchased for $726,736, an average cost per bushel of $0.058. In this connection it should be stated that the number of gallons and cost of water, as given in Table 9, must not be taken as strictly accurate, inasmuch as some establishments reported the cost of water, but were unable even to approximate the number of gallons, while other establishments gave the number of gallons of water consumed, but stated that there was no cost attached to the same.

The total value of products, $75,716,693, as given in Table 1, for 1900, as compared with $56,987,290 for 1890, showed an increase of $18,729,403, or 32.9 per cent, during the past decade. The value of the principal product, gas sold, amounted to $69,432,582, an increase of $17,565,751, or 33.9 per cent, over the $51,866,831 reported for 1890. The value of by-products, $6,284,111, including $2,000,907 received from rents and sales of appliances, formed 8.3 per cent of the total value of products in 1900, and showed an increase of 22.7 per cent over the $5,120,459 reported in 1890. The by-products included tar, coke, and ammoniacal liquor, but the quantities and values of each were not reported separately.

The amount reported, $75,716,693, as the total value of all products, does not include the value of the gas and by-products consumed at the offices and works, the value of gas lost by leakage, nor does it include returns for several gas companies and so-called pipe-line companies which manufactured no gas, but purchased the same for distribution from gas manufacturing establishments.

The total quantity of gas sold for lighting and heating, as reported by the 877 gas establishments from which returns were received, was 67,093,553,471 cubic feet. In addition to this quantity the special report on the manufacture of coke at the Twelfth Census shows that there were 6 establishments manufacturing gas as a by-product, which they sold to gas manufacturers or to distributing companies to be resold for lighting and heating purposes. The total quantity of gas manufactured and disposed of in this manner was 1,171,942,697 cubic feet. A combination of this latter quantity with the quantity reported for gas companies shows that in 1900 the total quantity sold was 68,265,496,168 cubic feet, as compared with 36,519,511,510 cubic feet reported for 1890, an increase of 31,745,984,658 cubic feet, or 86.9 per cent. The gas manufactured and sold by coke companies was valued at $225,022, an average of $0.192 per thousand cubic feet, as compared with an average for the United States of $1.035 per thousand cubic feet for retort and water gas. In this connection, however, attention is called to the fact that the consumer does not receive gas for this price, as establishments using the by-product system do not sell directly to the consumer.

The average price of gas in 1890 was $1.42 per thousand cubic feet, while in 1900 the average price had fallen to $1.035 per thousand cubic feet, a decrease of $0.385, or 27.1 per cent. This average is computed from the totals of the whole number of establishments from which reports were received, and must not be assumed to be indicative of the price in any particular section of the country.

Table 8 shows the total quantity and value of gas sold, and the average price per thousand cubic feet in each state and in each group of states for 1900.

TABLE 8.—QUANTITY, VALUE, AND AVERAGE VALUE PER 1,000 CUBIC FEET OF GAS MANUFACTURED, BY STATES AND TERRITORIES; ARRANGED GEOGRAPHICALLY: 1900.

	Cubic feet.	Value.	Average value per 1,000 cubic feet.
United States	67,093,553,471	$69,432,582	$1.035
New England states	6,900,447,744	8,111,935	1.176
Maine	165,054,440	246,861	1.496
New Hampshire	212,670,047	300,478	1.413
Vermont	85,886,400	65,250	1.818
Massachusetts	4,673,442,791	5,356,801	1.146
Rhode Island	765,556,052	880,362	1.150
Connecticut	1,047,838,014	1,262,683	1.205
Middle states	37,956,880,522	33,632,901	.886
New York	20,741,546,599	19,857,722	.957
New Jersey	2,743,758,799	3,319,449	1.210
Pennsylvania	8,790,299,591	7,316,059	.832
Delaware	191,344,226	176,090	.920
Maryland	4,414,721,120	1,770,869	1.252
District of Columbia	1,075,210,187	1,192,712	1.109
Southern states	2,623,248,996	3,740,520	1.426
West Virginia	146,980,430	126,598	.861
Virginia	406,212,660	438,671	1.080
North Carolina	46,451,300	110,956	1.389
South Carolina	99,383,400	152,755	1.537
Georgia	451,946,212	558,182	1.235
Florida	78,022,877	154,290	1.977
Kentucky	447,352,340	574,627	1.285
Tennessee	344,411,892	476,214	1.383
Alabama	122,635,152	198,865	1.622
Mississippi	36,716,805	74,041	2.017
Arkansas	66,543,948	129,135	1.941
Louisiana	204,503,400	428,605	2.096
Indian Territory	.....	.....	.....
Southern states—Continued.			
Oklahoma	.....	.....	.....
Texas	172,088,580	$317,581	$1.845
Central states	19,751,747,257	19,199,651	.972
Ohio	3,440,297,822	3,263,940	.949
Michigan	1,127,095,479	1,224,724	1.087
Indiana	764,135,883	875,247	1.145
Illinois	9,392,071,196	8,478,773	.903
Wisconsin	1,192,222,406	1,202,019	1.008
Minnesota	752,851,693	979,004	1.300
Iowa	477,328,202	649,526	1.361
Missouri	2,605,744,576	2,526,418	.970
Western states	976,222,119	1,456,313	1.492
Montana	26,070,000	59,632	2.287
Idaho	.....	.....	.....
Wyoming	5,565,400	9,600	1.725
North Dakota	26,000,000	52,800	2.031
South Dakota	19,508,005	35,837	1.837
Nebraska	331,399,194	482,155	1.454
Nevada	4,873,900	21,934	4.500
Utah	31,000,000	36,022	1.162
Colorado	346,248,400	439,460	1.269
Kansas	173,812,220	290,588	1.672
Arizona	7,080,000	17,080	2.412
New Mexico	4,665,000	11,205	2.402
Pacific states	1,885,006,883	3,291,262	1.745
Washington	138,270,703	256,676	1.856
Oregon	67,658,000	150,442	2.224
California	1,679,078,180	2,884,144	1.718

Table 8 shows that the largest quantity of gas was sold in the Middle states, which consumed 37,956,880,522 cubic feet, or more than the combined product of the 4 other groups of states, and 56.6 per cent of the total quantity sold in the United States. The average price per thousand cubic feet was $0.886, which was less than that reported for any of the remaining groups. The state of New York, with 20,741,546,599 cubic feet, at an average price of $0.957 per thousand, used more than any other state, and more than the combined total of the other states in this group or all the states in any other group; its consumption constituted 30.9 per cent of the total for the United States. The group producing the least quantity was the Western States, with 976,222,119 cubic feet at an average price of $1.492 per thousand. The smallest quantity sold in any state or territory was 4,665,000 cubic feet, in New Mexico, at an average price of $2.402 per thousand.

The price per 1,000 cubic feet varied from $0.832 in Pennsylvania to $4.50 in Nevada. Proximity to the coal and oil producing districts gives to Pennsylvania the minimum average rate, while distance from source of supplies and limited transportation facilities are accountable for the high price in Nevada. These averages represent the price of all manufactured gas, both fuel and illuminating, as the quantity of each kind was not separately reported; this statement is necessary in order to obviate erroneous deductions. Idaho, Indian Territory, and Oklahoma have no gas plants.

The quantity of gas sold in New York city was 18,180,821,125 cubic feet, at an average price of $0.905 per 1,000, or $16,457,822 in the aggregate. This represents 27.1 per cent of the total quantity sold in the United States during the census year. In this connection it is interesting to note the quantity, value, and average price obtained in Chicago, Philadelphia, St. Louis, and Boston, which, after New York, are the largest cities in the United States, in the order named. The quantity sold for public use in Chicago reached 8,367,801,185 cubic feet, valued at $7,288,187, an average of $0.871 per thousand cubic feet. In Philadelphia 7,055,559,210 cubic feet sold for $5,372,774, an average of $0.761 per thousand. This is the lowest average price reported in any city. St. Louis consumed 1,607,230,800 cubic feet, valued at $1,494,616, an average of $0.93 per thousand cubic feet. In Boston there were 2,510,635,235 cubic feet of gas burned, with a value of $2,594,852, or $1.034 per thousand cubic feet.

HISTORICAL AND DESCRIPTIVE.

The history of the gas industry, not only of the United States but of the world, covers little more than a century. The possibility of manufacturing gas for illuminating purposes was investigated simultaneously in England and France in the latter part of the Eighteenth century—in England by William Murdock, in France by Philippe Le Bon—and it is still a question of dispute between the two countries as to which of these experimenters is entitled to the credit for this important discovery.[1]

The history of the gas industry in this country dates from 1806, at which time David Melville, of Newport, R. I., lighted his premises by means of coal gas which he had manufactured thereon. This took place nine years after the experiments in England. The apparatus first used by Melville was necessarily crude, but underwent improvements from time to time, until, in 1813, he secured a patent, and later used gas for the lighting of a cotton mill at Watertown, Mass. Gas was also used at about this time in a mill near Providence, R. I., and was employed in 1817 as an illuminant in a lighthouse. The growth of the industry was at first slow, but with the vast advance in the details of the construction and operation of gas plants, the improvement and development of special tools and appliances, and the increasing knowledge, gained by experience, of the laws of physics involved there came a much more rapid growth. As early as 1816 a company was chartered in Baltimore, Md., followed, in 1822, by the establishment of a plant in Boston, Mass. New York city adopted gas lighting in 1823, and two years later companies were formed in Brooklyn, N. Y., and Bristol, R. I. New Orleans was the next city to adopt gas, in 1835, twenty-nine years after Melville introduced the new illuminant in this country. A glance at the early history of these pioneer companies, as far as it is available, indicates a series of failures. Not only was it a difficult matter to secure the necessary capital to erect and operate a plant, but for some time the introduction of gas was strongly opposed on the ground that the erection of gas works and the distribution of the product endangered the health and lives of the inhabitants of the surrounding community. Opposition on this score was gradually overcome, however, and the different municipalities granted the petitioners the desired charters.

Gas as an illuminant has had several competitors, which, at the time of their appearance in the field, seriously threatened its existence. In the early days of the industry the gas manufactured had an illuminating value of about 15 to 17 candlepower. Compared with the light of candles or of the crude whale-oil lamps then in use, it was considered a wonderful illuminant. This superiority was soon threatened, however, by the introduction of kerosene and improved oil lamps, the general use of which interfered seriously with the rapid increase of the sale of gas. At this time, about 1870, gas was undoubtedly safer, but was still much higher in price per unit of light than oil lamps, and for this reason could not compete with kerosene. Its value for cooking and heating purposes had yet to be demonstrated.

[1] One Hundred Years of American Commerce, American Gas Interests, by Emerson McMillin, Volume I, pages 295–297.

These conditions would have retarded greatly the growth of the industry, had not the problem been solved by Du Motay and Lowe—the former a Frenchman, the latter an American—who, independently of each other, were carrying on experiments which were to result in the introduction of the so-called water gas. The investigations of both Du Motay and Lowe were conducted in this country, and the most important inventions affecting the manufacture of gas have been introduced here, so that the development of the water-gas industry is purely American. This gas is manufactured by a process in which hydrogen and the oxides of carbon, produced by the action of steam upon carbon at a high temperature, are mixed and then combined with richly carbureted gases, usually from petroleum, thus producing the power of illumination. The first plant using the Lowe process was erected at Phoenixville, Pa., in 1873. From that time until about 1880 this new process of making gas was vigorously opposed by coal-gas manufacturers. Gradually the opposition was overcome, and since 1880 many coal-gas makers have adopted the water-gas process, and the increase in the sales of water gas has been enormous. At present, although the exact figures are not available, the amount of water gas sold for public use is in the neighborhood of 75 per cent of the entire quantity of gas sold.

A few years after the introduction of water gas as an illuminant, a new rival appeared in the form of electricity, which, while it did not displace gas in general use, yet caused the manufacturer great uneasiness. However, the appearance of the electric light was not without its advantage to the gas interests, as it demonstrated to them the necessity of finding other uses for gas than those of illumination. The result was the introduction of gas stoves for cooking and heating purposes, the sales for which have increased enormously during the past decade. Gas engines also are growing in favor, on account of both economy and convenience. By far the most potent factor which is enabling gas to compete with electric light, and thus contributing to increase the consumption of gas, is the widespread use of the Welsbach—named for the inventor, Auer von Welsbach, of Vienna—or incandescent mantle, which develops an illuminating power of 20 candles per cubic foot. Its introduction gave a decided stimulus to the gas industry. Thus, although the use of electricity for lighting purposes is increasing much more rapidly than is that of gas, the consumption of gas also shows a marked increase.

Table 9, which accompanies this report, shows in detail the statistics relating to the manufacture of gas as returned by the 877 establishments reporting. The 15 plants controlled by municipalities are separately presented in Table 10.

TABLE 9.—GAS MANUFACTURE, BY

	STATES AND TERRITORIES.	Number of establishments.	BONDS AND STOCK.					
			Bonds.		Stock.			
					Amount issued.			
			Amount issued.	Amount of interest paid during the year.	Total.	Preferred.	Common.	Amount of dividend paid during the year.
1	United States	877	$192,669,181	$9,471,575	$376,035,803	$26,143,882	$349,891,921	$15,842,138
2	Alabama	11	897,000	51,040	1,408,300	.....	1,408,300	3,756
3	Arizona	3	.....	.....	65,500	.....	65,500	.....
4	Arkansas	7	406,000	14,850	407,350	.....	407,350	.....
5	California	41	3,421,500	118,442	22,934,050	23,500	22,910,550	1,159,952
6	Colorado	5	959,000	37,821	990,000	250,000	740,000	8,407
7	Connecticut	21	1,939,000	77,489	5,410,850	.....	5,410,850	284,043
8	Delaware	4	29,000	40,000	662,000	.....	662,000	70,760
9	District of Columbia	3	600,000	36,000	2,750,000	.....	2,750,000	405,000
10	Florida	11	191,300	12,305	737,000	9,100	727,900	.....
11	Georgia	12	1,943,500	73,310	2,692,590	760,540	1,932,050	41,672
12	Illinois	53	38,260,800	2,043,991	40,877,080	20,000	40,857,080	1,957,507
13	Indiana	39	3,969,033	225,583	4,323,900	32,500	4,291,400	90,930
14	Iowa	26	1,337,700	67,897	2,923,250	125,000	2,798,250	51,062
15	Kansas	17	691,550	38,033	1,091,900	71,900	1,020,000	25,620
16	Kentucky	17	871,366	40,891	4,728,866	7,500	4,720,866	196,407
17	Louisiana	3	127,000	5,720	3,850,000	.....	3,850,000	187,500
18	Maine	9	494,800	22,858	950,300	.....	950,300	40,877
19	Maryland	11	6,921,500	391,614	11,147,000	.....	11,147,000	438,960
20	Massachusetts	68	1,983,900	90,414	16,535,891	21,800	16,514,091	1,449,546
21	Michigan	38	6,815,600	341,013	8,039,675	.....	8,039,675	232,771
22	Minnesota	11	6,039,833	333,190	2,450,000	.....	2,450,000	121,500
23	Mississippi	5	110,000	900	324,100	.....	324,100	12,300
24	Missouri	25	15,067,500	758,042	17,066,500	2,500,000	14,566,500	388,723
25	Nebraska	9	1,980,000	105,105	4,640,000	1,300,000	3,340,000	103,500
26	Nevada	3	21,500	1,290	221,500	.....	221,500	3,000
27	New Hampshire	13	63,000	770	1,202,800	65,000	1,137,800	57,440
28	New Jersey	34	13,824,847	350,581	25,040,286	8,142	25,032,144	146,107
29	New York	101	55,452,916	2,762,463	117,030,516	15,538,400	101,492,116	4,054,211
30	North Carolina	10	315,000	12,317	477,000	35,000	442,000	7,500
31	Ohio	73	3,646,793	191,123	20,063,750	180,000	19,883,750	1,311,863
32	Oregon	5	1,023,500	61,645	1,064,250	.....	1,064,250	.....
33	Pennsylvania	89	17,791,610	853,415	37,464,529	5,138,000	32,326,529	1,936,262
34	Rhode Island	6	100,000	5,500	4,007,500	7,500	4,000,000	298,000
35	South Carolina	4	30,000	.....	933,500	.....	933,500	40,000
36	Tennessee	11	1,045,000	51,314	2,468,000	.....	2,468,000	92,911
37	Texas	11	703,833	42,230	1,814,170	.....	1,814,170	86,221
38	Vermont	7	76,000	4,060	335,000	.....	335,000	12,400
39	Virginia	12	648,000	41,314	1,195,875	.....	1,195,875	38,578
40	Washington	6	711,000	39,050	1,065,000	50,000	1,015,000	7,900
41	West Virginia	8	72,700	4,315	301,500	.....	301,500	11,132
42	Wisconsin	25	1,311,000	75,080	3,136,225	.....	3,136,225	455,820
43	All other states[1]	10	775,000	48,550	1,208,800	.....	1,208,800	12,000

[1] Includes establishments distributed as follows: Montana, 2; New Mexico, 1; North Dakota, 2; South Dakota, 2; Utah, 2; Wyoming, 1.

STATES AND TERRITORIES: 1900.

CAPITAL.						SALARIED OFFICIALS, CLERKS, ETC.						WAGE-EARNERS, INCLUDING PIECE-WORKERS.		
						Total.		Men.		Women.				
Total.	Land.	Buildings.	Machinery and gas-making apparatus, holders, mains, meters, teams, tools, horses, wagons, and other accessories.	Raw materials, and finished products on hand, including by-products.	Cash on hand, surplus, reserve fund (invested or otherwise), bills and unsettled ledger accounts receivable, and sundries not included in any of the foregoing items.	Number.	Salaries.	Number.	Salaries.	Number.	Salaries.	Greatest number employed at any one time during the year.	Least number employed at any one time during the year.	
$567,000,506	$50,050,371	$58,486,472	$376,790,335	$6,838,208	$74,835,120	5,904	$5,273,500	5,521	$5,113,217	383	$160,283	30,813	20,361	1
1,120,539	47,300	145,520	830,996	19,805	76,918	40	30,674	40	30,674	.....	.....	130	59	2
70,150	2,200	2,600	63,500	250	1,600	6	2,020	6	2,020	.....	.....	8	4	3
829,285	62,000	62,575	474,462	43,100	187,148	23	16,469	23	16,469	.....	.....	71	22	4
20,487,350	1,730,002	926,457	16,615,701	401,839	813,351	203	229,285	192	222,985	11	6,300	816	640	5
1,773,308	206,000	233,000	1,217,366	39,890	77,052	28	27,048	27	26,928	1	120	150	88	6
7,905,946	619,043	649,105	5,551,596	119,326	966,876	134	117,238	117	109,299	17	7,939	536	290	7
771,842	67,775	49,125	550,597	9,340	95,005	21	18,285	20	18,210	1	75	71	63	8
4,865,623	270,724	686,900	3,414,767	88,826	404,406	49	105,908	45	102,542	4	3,366	391	373	9
1,155,689	67,386	61,615	877,490	55,133	94,065	28	16,228	25	15,346	3	882	92	30	10
4,269,319	313,250	260,806	3,413,216	125,642	156,405	75	56,314	71	53,734	4	2,580	372	230	11
76,816,408	2,915,496	5,391,110	66,210,918	630,665	1,668,219	827	769,514	781	750,028	46	19,486	4,001	2,280	12
7,745,659	533,090	586,047	6,335,896	87,522	203,104	146	89,324	138	86,684	8	2,640	521	300	13
4,129,984	241,338	258,452	3,325,820	128,292	176,082	90	70,120	83	67,326	7	2,794	474	207	14
1,414,636	123,657	137,672	1,012,067	22,090	119,150	50	25,595	47	25,015	3	580	112	65	15
4,495,722	304,077	310,185	3,570,690	35,722	275,048	60	51,129	55	48,389	5	2,740	346	238	16
1,706,847	73,171	107,233	1,364,171	18,343	143,929	34	37,143	33	37,115	1	28	83	54	17
1,426,118	143,161	178,500	910,556	61,728	132,173	47	29,068	42	27,714	5	1,354	90	52	18
18,554,361	1,018,185	744,980	1,824,934	122,492	14,843,770	84	84,757	84	84,757	.....	.....	243	218	19
30,032,578	3,591,388	6,621,853	16,941,434	558,361	2,319,542	434	420,085	374	389,909	60	30,176	1,931	1,351	20
16,295,053	440,963	800,244	14,363,428	232,033	458,385	227	142,307	168	121,293	59	21,014	1,321	621	21
8,899,676	441,404	1,889,461	6,146,982	70,216	351,613	58	48,354	53	46,418	5	1,936	577	316	22
421,988	26,000	53,500	316,989	9,434	16,065	11	10,548	11	10,548	.....	.....	30	20	23
33,504,380	2,496,192	2,469,645	25,043,913	345,272	3,149,358	150	112,451	145	110,461	5	1,990	1,036	778	24
6,956,168	315,200	499,184	5,984,512	56,514	100,758	39	36,885	39	36,885	.....	.....	451	250	25
84,211	1,950	10,450	63,931	2,581	5,299	3	4,460	3	4,460	.....	.....	3	3	26
1,518,718	136,500	336,200	845,251	62,381	138,386	35	25,409	34	25,159	1	250	166	110	27
38,872,444	2,119,343	2,332,275	31,743,126	421,798	2,255,902	347	271,695	334	266,003	13	5,692	2,003	1,210	28
171,379,067	23,719,690	24,384,916	91,224,969	1,440,576	30,608,916	1,324	1,320,036	1,277	1,299,458	47	20,578	6,810	4,925	29
682,566	38,900	36,690	541,698	13,263	52,015	19	14,579	19	14,579	.....	.....	49	45	30
25,017,057	2,503,835	3,258,561	17,029,003	227,306	1,998,352	283	277,204	258	268,669	25	8,535	1,890	1,240	31
1,533,107	140,500	277,000	1,064,289	45,084	6,234	15	13,780	15	13,780	.....	.....	30	25	32
47,312,537	2,654,906	2,861,606	31,235,121	994,566	9,566,338	577	457,092	551	448,144	26	8,948	3,745	2,726	33
5,664,453	716,630	580,607	3,207,171	18,439	1,141,606	45	49,850	41	47,858	4	1,992	466	417	34
961,033	42,000	81,067	664,237	7,130	166,599	23	11,649	22	11,547	1	102	134	90	35
2,303,544	284,000	198,400	1,656,370	66,878	97,896	49	41,049	48	40,789	1	260	255	190	36
1,763,597	206,704	127,794	1,311,890	28,904	88,305	41	46,037	40	45,137	1	900	113	55	37
477,099	28,950	48,000	341,277	7,675	51,197	13	6,515	12	6,359	1	156	37	10	38
2,624,623	100,777	168,523	2,141,807	22,904	190,612	53	42,139	51	41,479	2	660	189	106	39
1,620,992	215,504	51,963	1,288,687	15,291	49,547	37	25,526	36	24,986	1	540	150	61	40
566,827	49,500	35,500	439,600	13,634	28,593	26	10,484	26	10,484	.....	.....	122	64	41
7,375,192	955,880	373,998	4,402,144	137,303	1,505,867	123	89,285	110	84,875	13	4,410	703	481	42
1,594,810	85,800	197,153	1,227,763	30,660	53,434	27	19,962	25	18,702	2	1,260	95	54	43

TABLE 9.—GAS MANUFACTURE, BY STATES

	STATES AND TERRITORIES.	WAGE-EARNERS, INCLUDING PIECEWORKERS—continued.								MATERIALS USED.			
		Total.		Men, 16 years and over.		Women, 16 years and over.		Children, under 16 years.			For gas making.		
												Coal.	
		Average number.	Wages.	Average number.	Wages.	Average number.	Wages.	Average number.	Wages.	Aggregate cost.	Total cost.	Tons.	Cost.
1	United States	22,459	$12,436,296	22,446	$12,431,234	10	$4,256	3	$806	$20,605,356	$16,264,267	2,487,287	$7,164,472
2	Alabama	75	31,611	75	31,611	.....	.....	.....	.....	51,010	29,709	22,642	28,143
3	Arizona	4	2,850	4	2,850	.....	.....	.....	.....	7,790	3,722	.....	.....
4	Arkansas	34	21,589	34	21,589	.....	.....	.....	.....	38,228	30,344	5,602	18,163
5	California	707	497,237	705	496,587	.....	.....	2	650	895,853	809,205	86,755	498,926
6	Colorado	109	54,051	109	54,051	.....	.....	.....	.....	122,839	63,523	24,160	28,481
7	Connecticut	354	231,102	354	231,102	.....	.....	.....	.....	362,248	315,720	62,328	191,494
8	Delaware	67	31,958	67	31,958	.....	.....	.....	.....	50,853	48,048	10,733	22,854
9	District of Columbia	382	202,796	382	202,796	.....	.....	.....	.....	363,939	345,635	31,691	100,970
10	Florida	47	24,108	47	24,108	.....	.....	.....	.....	41,324	30,895	2,733	11,085
11	Georgia	271	92,265	271	92,265	.....	.....	.....	.....	141,507	119,464	35,074	74,013
12	Illinois	2,371	1,305,670	2,371	1,305,670	.....	.....	.....	.....	1,990,547	1,722,198	100,902	234,719
13	Indiana	340	172,431	340	172,431	.....	.....	.....	.....	255,864	187,938	64,024	125,564
14	Iowa	226	118,307	225	118,151	.....	.....	1	156	203,961	156,159	24,774	65,926
15	Kansas	85	48,562	85	48,562	.....	.....	.....	.....	106,597	77,048	20,620	54,687
16	Kentucky	279	121,744	279	121,744	.....	.....	.....	.....	189,194	117,865	49,092	99,695
17	Louisiana	61	40,665	61	40,665	.....	.....	.....	.....	71,114	62,474	3,882	14,575
18	Maine	61	37,958	61	37,958	.....	.....	.....	.....	73,394	55,877	12,612	35,489
19	Maryland	237	136,980	237	136,980	.....	.....	.....	.....	481,013	400,769	28,378	99,684
20	Massachusetts	1,409	813,459	1,406	811,587	3	1,872	.....	.....	1,651,873	1,482,700	224,726	790,783
21	Michigan	658	293,976	657	293,672	1	304	.....	.....	298,321	176,459	72,901	114,540
22	Minnesota	375	168,558	375	168,558	.....	.....	.....	.....	303,868	235,824	41,218	117,499
23	Mississippi	24	9,164	24	9,164	.....	.....	.....	.....	16,743	13,052	3,621	9,122
24	Missouri	834	464,417	834	464,417	.....	.....	.....	.....	756,457	628,190	146,303	371,715
25	Nebraska	290	79,852	290	79,852	.....	.....	.....	.....	134,352	102,007	7,390	36,492
26	Nevada	3	2,680	3	2,680	.....	.....	.....	.....	9,383	2,250	715	1,496
27	New Hampshire	121	59,780	121	59,780	.....	.....	.....	.....	85,939	76,754	13,032	49,126
28	New Jersey	1,320	684,219	1,320	684,219	.....	.....	.....	.....	785,979	704,622	111,459	308,627
29	New York	5,381	3,676,712	5,379	3,675,892	2	820	.....	.....	5,866,549	5,223,064	370,943	1,829,567
30	North Carolina	47	14,256	47	14,256	.....	.....	.....	.....	37,370	19,064	5,272	10,357
31	Ohio	1,389	601,815	1,387	601,095	2	720	.....	.....	884,587	753,527	356,734	572,671
32	Oregon	28	18,764	28	18,764	.....	.....	.....	.....	52,704	44,125	7,288	38,706
33	Pennsylvania	3,144	1,506,266	3,143	1,506,146	1	120	.....	.....	3,150,655	1,253,270	269,280	553,082
34	Rhode Island	430	249,021	430	249,021	.....	.....	.....	.....	244,124	225,286	48,288	140,003
35	South Carolina	104	30,127	104	30,127	.....	.....	.....	.....	38,440	35,116	10,165	28,153
36	Tennessee	218	64,539	218	64,539	.....	.....	.....	.....	185,110	118,800	52,170	108,245
37	Texas	71	46,166	71	46,166	.....	.....	.....	.....	94,180	59,212	19,485	52,854
38	Vermont	15	7,837	15	7,837	.....	.....	.....	.....	20,191	18,225	1,173	6,088
39	Virginia	133	84,801	133	84,801	.....	.....	.....	.....	130,759	113,039	23,284	54,864
40	Washington	81	42,048	81	42,048	.....	.....	.....	.....	76,929	64,374	13,763	52,946
41	West Virginia	80	39,960	80	39,960	.....	.....	.....	.....	32,978	29,181	22,820	26,965
42	Wisconsin	532	268,459	531	268,039	1	420	.....	.....	321,047	241,243	70,968	150,084
43	All other states[1]	62	37,536	62	37,536	.....	.....	.....	.....	79,543	68,290	8,237	36,124

[1] Includes establishments distributed as follows: Montana, 2; New Mexico, 1; North Dakota, 2; South Dakota, 2; Utah, 2; Wyoming, 1.

AND TERRITORIES: 1900—Continued.

MATERIALS USED—continued.										
For gas making—Continued.										
Coke.		Oil.		Water.						
Bushels.	Cost.	Gallons.	Cost.	Gallons.	Cost.	Cost of fuel for boilers and retorts.	Cost of mill supplies.	Cost of all other materials, including purification supplies.	Amount of freight paid.	
15,214,793	$726,736	194,857,296	$8,168,657	1,250,862,092	$204,402	$1,082,844	$149,439	$2,395,430	$718,376	1
96,480	.....	25,000	864	2,144,200	702	1,777	669	1,880	16,975	2
.....	.....	98,353	3,527	190,242,000	195	767	75	125	3,101	3
62,731	795	152,785	9,978	4,986,000	1,408	1,158	514	1,100	5,112	4
39,939	6,141	5,911,751	299,488	3,203,300	4,650	38,680	2,132	22,830	23,006	5
206,228	11,327	735,040	23,336	855,000	429	17,041	1,206	1,344	39,725	6
130,702	6,488	2,589,084	113,932	32,766,699	3,806	23,642	1,201	14,422	7,263	7
3,573	.....	604,131	24,121	20,477,000	1,073	186	280	1,727	612	8
461,855	23,093	4,913,214	219,956	47,195,500	1,616	13,012	650	4,642	.....	9
.....	.....	376,545	19,443	389,062	367	3,995	469	2,679	3,286	10
.....	.....	949,879	44,416	7,900,448	1,035	6,398	645	6,112	8,888	11
5,328,721	376,563	38,611,335	1,098,486	119,002,938	12,430	120,695	43,678	19,466	84,510	12
336,349	13,694	1,575,809	46,193	13,309,429	2,487	25,983	2,246	14,835	24,862	13
148,440	16,671	1,714,447	69,723	27,348,838	3,839	13,230	685	5,625	28,262	14
36,999	2,698	482,448	18,289	2,403,800	1,374	10,161	1,041	6,809	11,538	15
98,719	4,820	358,591	12,048	4,198,750	1,302	2,973	143	14,491	3,722	16
135,500	11,344	898,716	36,106	.....	449	6,112	192	649	1,687	17
33,980	99	416,935	19,433	3,191,857	856	6,951	1,116	1,526	7,924	18
8,000	147	6,795,919	300,603	61,320,796	335	46,221	10,282	16,927	6,814	19
741,022	44,376	17,148,844	630,647	36,249,986	16,894	82,584	7,415	37,944	41,230	20
525,433	15,443	2,030,285	44,715	12,102,775	1,761	28,547	4,609	23,815	64,891	21
470,591	25,731	2,818,360	92,194	56,836,224	400	31,405	7,000	28,714	865	22
10,500	.....	98,127	3,595	1,870,219	335	943	282	642	1,824	23
829,857	6,176	6,757,240	241,665	87,132,380	8,634	23,074	1,903	74,837	28,453	24
3,600	.....	1,406,739	59,920	7,921,000	5,595	19,813	563	1,829	10,140	25
.....	.....	4,825	190	.....	564	.....	.....	210	6,923	26
4,562	274	640,643	26,487	4,263,434	867	5,063	211	2,792	1,119	27
192,148	2,884	10,504,542	384,051	36,633,608	9,060	37,226	8,989	7,359	27,783	28
1,740,803	17,264	55,355,504	3,288,342	202,348,250	87,891	349,359	27,217	176,708	90,201	29
42,460	1,270	209,257	7,397	10,000	40	1,814	241	3,687	12,564	30
1,888,366	68,148	3,029,683	105,783	58,681,186	6,925	32,477	2,839	42,556	53,188	31
.....	.....	105,261	4,771	1,080,000	648	3,748	134	1,972	2,725	32
498,630	17,946	19,846,645	669,934	137,481,542	12,358	55,647	10,253	1,811,294	20,191	33
30,000	.....	2,300,326	79,374	32,017,875	5,909	1,030	277	17,531	.....	34
215,754	.....	120,616	6,478	2,969,209	485	715	100	1,279	1,280	35
5,000	400	173,529	8,598	1,919,905	1,557	3,803	668	7,609	4,230	36
37,556	.....	206,442	5,047	1,936,000	1,311	8,968	364	2,264	23,372	37
9,000	720	245,288	10,821	203,000	601	1,137	95	200	534	38
123,533	10,399	1,078,131	46,735	11,188,857	1,041	3,874	636	2,518	10,692	39
107,750	8,590	31,305	2,259	2,391,000	579	299	172	575	11,509	40
23,550	325	28,375	1,008	9,555,500	883	386	288	2,063	1,110	41
509,402	23,638	3,126,954	66,565	3,750,775	956	47,554	7,549	6,726	17,975	42
77,060	9,272	380,393	22,139	1,383,750	755	4,396	400	3,117	3,340	43

TABLE 9.—GAS MANUFACTURE, BY STATES

	STATES AND TERRITORIES.	MISCELLANEOUS EXPENSES.						PRODUCTS.				
		Total.	Amount paid for rent of—		Amount paid for taxes, including royalties and special tax.	Amount paid for lamps and appliances purchased for sale.	Amount paid for insurance, ordinary repairs of buildings, machinery, tools, mains, lamps, and appliances, interest, freight, advertising, and all other sundry expenses.	Total value.	Gas sold.		All other products, including by-products, coke, tar, etc., sold.	Receipts from rents and sales of appliances.
			Works.	Offices.					Feet.	Value.		
1	United States	$14,769,022	$820,241	$344,139	$3,577,037	$1,392,206	$8,635,399	$75,716,693	67,093,553,471	$69,432,582	$4,283,204	$2,000,907
2	Alabama	54,396	.....	1,544	11,939	6,580	34,333	232,802	122,635,152	198,865	28,692	5,245
3	Arizona	5,091	200	300	1,087	1,021	2,483	18,450	7,080,000	17,080	170	1,200
4	Arkansas	24,458	.....	840	4,356	6,569	12,693	138,921	66,543,948	129,135	6,871	2,915
5	California	604,847	55,230	10,800	126,423	34,994	377,400	3,162,333	1,679,078,130	2,884,144	225,149	53,040
6	Colorado	100,136	.....	3,815	27,469	27,450	41,402	523,497	346,248,400	439,460	61,273	22,764
7	Connecticut	332,398	33,975	6,227	61,253	43,746	187,197	1,421,014	1,047,838,014	1,262,683	89,389	68,942
8	Delaware	21,034	.....	120	3,159	7,909	9,846	199,760	191,344,226	176,090	14,717	8,953
9	District of Columbia	66,637	300	2,328	44,888	4,271	14,850	1,220,391	1,075,210,187	1,192,712	23,091	4,588
10	Florida	54,445	136	1,386	6,547	8,324	38,052	170,297	78,022,877	154,290	5,563	10,444
11	Georgia	185,602	24,000	5,312	24,140	46,785	85,365	660,892	451,946,212	558,182	49,690	53,020
12	Illinois	1,046,945	2,127	56,496	404,568	67,264	516,490	8,774,053	9,392,071,196	8,478,773	231,925	63,355
13	Indiana	184,095	700	3,788	47,050	22,762	109,795	1,034,442	764,135,883	875,247	122,941	36,254
14	Iowa	259,017	.....	6,008	30,295	98,073	124,641	807,787	477,328,202	649,526	53,638	104,623
15	Kansas	40,651	100	2,237	10,395	3,121	24,798	325,465	173,812,220	290,588	30,248	4,629
16	Kentucky	194,579	60	882	83,945	4,353	105,339	670,804	447,352,340	574,627	90,395	5,782
17	Louisiana	104,234	.....	207	57,214	11,808	35,005	455,335	204,503,400	428,605	10,846	15,884
18	Maine	60,139	.....	1,007	14,237	12,927	31,968	285,055	165,054,440	246,861	28,329	9,865
19	Maryland	268,369	6,025	100	121,212	5,156	135,876	1,796,507	1,414,721,120	1,770,809	6,567	19,071
20	Massachusetts	1,147,205	40	36,329	315,907	41,377	753,552	5,868,864	4,673,442,791	5,356,301	381,108	131,455
21	Michigan	380,397	1,300	13,290	65,345	97,219	203,243	1,472,737	1,127,095,479	1,224,724	163,861	84,152
22	Minnesota	146,195	100	4,299	29,461	26,127	86,208	1,075,852	752,851,693	979,004	54,656	42,192
23	Mississippi	23,585	9,034	750	2,777	2,719	8,305	81,834	36,716,805	74,041	4,752	3,041
24	Missouri	256,572	850	10,313	83,686	18,209	143,514	2,877,102	2,605,744,576	2,526,418	332,825	17,859
25	Nebraska	135,182	1,250	5,416	29,411	37,497	61,608	524,852	331,399,194	482,155	3,399	39,298
26	Nevada	3,121	.....	.....	979	1,000	1,142	26,030	4,873,900	21,934	2,412	1,684
27	New Hampshire	129,992	45,206	2,237	14,732	21,763	46,054	355,794	212,670,047	300,478	27,692	27,624
28	New Jersey	1,074,887	163,488	13,514	146,719	325,023	426,143	3,767,751	2,743,758,799	3,319,449	123,289	325,013
29	New York	5,060,906	28,743	84,924	1,293,177	151,175	3,502,887	20,917,726	20,741,546,599	19,857,722	775,763	284,241
30	North Carolina	40,789	.....	918	5,094	12,246	22,531	129,747	46,451,300	110,956	6,381	12,410
31	Ohio	687,927	3,750	11,449	243,759	35,818	393,151	3,931,423	3,440,297,822	3,263,940	557,802	109,681
32	Oregon	23,262	.....	1,480	5,307	1,516	14,959	174,955	67,658,000	150,442	17,179	7,334
33	Pennsylvania	1,113,998	436,500	35,306	50,329	70,960	520,903	7,870,562	8,790,299,591	7,316,059	315,175	239,328
34	Rhode Island	212,872	.....	2,570	51,450	1,800	157,052	969,248	765,556,052	880,362	71,754	17,132
35	South Carolina	45,792	6,802	385	10,626	4,567	23,412	172,005	99,383,400	152,755	14,906	4,344
36	Tennessee	116,848	.....	1,348	50,760	11,148	53,592	572,490	344,411,892	476,214	76,175	20,101
37	Texas	56,080	150	2,261	17,190	9,309	27,170	379,613	172,088,580	317,581	46,552	15,480
38	Vermont	13,950	175	613	2,675	4,760	5,727	71,015	35,886,400	65,260	684	5,081
39	Virginia	78,832	.....	1,973	21,688	17,642	37,529	483,351	406,212,660	438,671	23,076	21,604
40	Washington	81,097	.....	1,990	9,901	38,883	30,323	315,993	138,270,703	256,676	17,465	41,852
41	West Virginia	19,238	.....	618	2,347	1,283	14,990	150,686	146,980,430	126,598	21,021	3,067
42	Wisconsin	263,896	.....	6,301	34,732	39,419	183,444	1,396,535	1,192,222,406	1,202,019	148,524	45,992
43	All other states[1]	49,326	.....	2,458	8,808	7,633	30,427	232,723	112,808,405	205,096	17,259	10,368

[1] Includes establishments distributed as follows: Montana, 2; New Mexico, 1; North Dakota, 2; South Dakota, 2; Utah, 2; Wyoming, 1.

AND TERRITORIES: 1900—Continued.

POWER.												ESTABLISHMENTS CLASSIFIED BY NUMBER OF EMPLOYEES.									
Owned.																					
		Engines.				Water wheels.		Electric motors.		Other power.											
		Steam.		Gas or gasoline.																	
Number reporting power.	Total horsepower.	Number.	Horsepower.	Number.	Horsepower.	Number.	Horsepower.	Number.	Horsepower.	Number.	Horsepower.	Total number.	Under 5.	5 to 20.	21 to 50.	51 to 100.	101 to 250.	251 to 500.	501 to 1,000.	Over 1,000.	
639	32,016	1,609	31,165	18	250	4	33	40	219	22	349	877	264	400	107	52	26	16	8	4	1
10	124	12	109							1	15	11	2	6	3						2
2	21	2	21									3	2	1							3
6	107	8	107									7		5	2						4
24	1,199	49	1,084	4	42			1	8	2	65	41	19	15	2	3	1	1			5
2	225	11	225									5	1	3			1				6
18	801	49	751	1	10			1	5	3	35	21	5	8	3	4	1				7
3	76	7	76									4	3			1					8
2	405	12	405									3		1	1			1			9
11	168	14	168									11	5	3	3						10
9	307	24	307									12	2	7	1		2				11
40	3,471	119	3,250	2	35			6	94	1	92	53	11	23	8	7	3			1	12
30	654	52	649							1	5	39	14	19	3	2	1				13
17	379	28	369							1	10	26	8	12	3	2	1				14
15	154	20	139			1	15					17	4	12	1						15
12	343	19	343									17	3	12	1			1			16
2	139	8	139									3		2		1					17
7	511	15	511									9	1	7	1						18
10	469	23	469									11	5	5				1			19
50	4,217	150	4,212					1	5			68	16	28	11	7	5		1		20
25	502	43	498	1	4							38	9	21	5	1	1			1	21
10	838	28	832					2	6			11	4	4	1			2			22
5	58	6	55					1	3			5	2	2	1						23
14	1,298	58	1,293			1	5					25	10	11		2		1	1		24
5	1,063	13	1,063									9	3	4	1			1			25
												3	3								26
8	163	14	163									13	4	6	2	1					27
29	1,509	82	1,449	4	30			2	30			34	7	17	4	2	1		3		28
71	6,401	285	6,212	4	120	1	1	26	68			101	33	38	12	7	4	5	1	1	29
6	68	7	68									10	5	5							30
53	1,387	121	1,342	1	5						40	73	19	40	8	1	3		2		31
2	16	3	16									5	3	1	1						32
72	3,091	154	3,036							3	55	89	36	35	12	3	1	1		1	33
5	353	32	353									6	1	1	2	1		1			34
3	33	3	33									4		3			1				35
8	234	31	234									11	4	3	1	3					36
7	130	14	123	1	4					6	3	11	1	7	3						37
7	67	7	58							4	9	7	3	4							38
10	206	21	206									12	1	7	4						39
2	13	2	13									6	2		2	2					40
4	60	3	40								20	8	3	4		1					41
16	681	50	669			1	12					25	7	13	3	1		1			42
7	75	10	75									10	3	5	2						43

TABLE 10.—ESTABLISHMENTS OWNED AND OPERATED BY MUNICIPALITIES: 1900.

	United States.	Kentucky.	Massachusetts.	Michigan.	Minnesota.	Missouri.	Nebraska.	Ohio.	Virginia.	West Virginia.
Number of establishments	15	1	3	1	1	1	1	2	4	1
Capital:										
Total	$1,734,592	$40,000	$223,924	$15,470	$162,775	$5,600	$3,250	$268,082	$775,491	$240,000
Land	$97,069	$230	$34,521	$1,000	$6,667	$100	$1,000	$9,851	$20,700	$23,000
Buildings	$160,709	$1,785	$31,958	$2,000	$4,166	$500	$1,000	$23,000	$81,300	$15,000
Machinery and gas-making apparatus, holders, mains, meters, teams, tools, horses, wagons, and other accessories	$1,393,648	$37,125	$133,008	$12,000	$120,583	$5,000	$1,000	$231,441	$673,491	$180,000
Raw materials and finished products on hand, including by-products	$6,805	$460	$5,816	.....	$179	.....	.....	$350	.....	.....
Cash on hand, surplus, reserve fund (invested or otherwise), bills and unsettled ledger accounts receivable, and sundries not included in any of the foregoing items	$76,361	$400	$18,621	$470	$31,180	.....	$250	$3,440	.....	$22,000
Salaried officials, clerks, etc.:										
Total number	51	1	7	1	2	1	1	7	17	14
Total salaries	$35,710	$912	$2,279	$500	$1,500	$780	$500	$6,365	$17,784	$5,090
Men—										
Number	50	1	6	1	2	1	1	7	17	14
Salaries	$35,586	$912	$2,155	$500	$1,500	$780	$500	$6,365	$17,784	$5,090
Women—										
Number	1	.....	1	.....	.....	.....	.....	.....	.....	.....
Salaries	$124	.....	$124	.....	.....	.....	.....	.....	.....	.....
Wage-earners (men, 16 years and over):										
Greatest number employed at any one time during the year	328	6	79	1	38	1	1	26	90	86
Least number employed at any one time during the year	134	5	12	1	13	1	1	13	40	48
Average number	174	6	18	1	18	1	1	18	50	61
Wages	$107,007	$2,748	$4,424	$660	$4,528	$360	$420	$10,428	$51,407	$32,032
Miscellaneous expenses:										
Total	$60,182	$3,821	$6,491	$583	$9,923	$305	$1,650	$4,868	$23,400	$9,141
Amount paid for rent of—										
Works	$1,250	.....	.....	.....	.....	.....	$1,250	.....	.....	.....
Offices	$1,045	.....	.....	.....	$335	.....	.....	.....	$710	.....
Amount paid for taxes, including royalties and special tax	$11,816	$481	.....	$40	.....	$156	.....	$489	$10,650	.....
Amount paid for lamps and appliances purchased for sale	$3,547	.....	$473	$100	$2,764	.....	$200	$10	.....	.....
Amount paid for insurance, ordinary repairs of buildings, machinery, tools, mains, lamps, and appliances, interest, freight, advertising, and all other sundry expenses	$42,524	$3,340	$6,018	$443	$6,824	$149	$200	$4,369	$12,040	$9,141
Materials used:										
Aggregate cost	$148,262	$7,460	$15,619	$1,190	$9,925	$1,152	$1,310	$23,724	$67,791	$20,091
For gas making—										
Total cost	$128,677	$7,424	$6,619	$950	$8,760	$912	$1,175	$22,048	$62,526	$18,263
Coal—										
Tons	40,254	2,802	1,997	.....	655	730	.....	4,524	14,805	14,741
Cost	$81,074	$6,662	$5,299	.....	$3,367	$912	.....	$11,713	$35,432	$17,689
Coke—										
Bushels	71,350	.....	.....	.....	.....	.....	.....	71,350	.....	.....
Cost	$2,952	.....	.....	.....	.....	.....	.....	$2,952	.....	.....
Oil—										
Gallons	1,138,053	12,700	17,251	20,000	144,187	.....	19,583	284,121	621,836	18,375
Cost	$44,404	$762	$1,303	$900	$5,393	.....	$1,175	$7,203	$27,094	$574
Water—										
Gallons	18,185,557	500,000	92,700	500,000	.....	.....	.....	1,200,000	7,142,857	8,750,000
Cost	$247	.....	$17	$50	.....	.....	.....	$180	.....	.....
Fuel for boilers and retorts	$5,482	.....	$803	$240	$876	.....	$110	$1,367	$1,820	$266
Mill supplies	$2,173	$10	$1,645	.....	$29	$25	$15	$25	$328	$96
All other materials, including purification supplies	$6,347	$26	$2,969	.....	$260	$215	$10	$284	$1,117	$1,466
Amount of freight paid	$5,583	.....	$3,583	.....	.....	.....	.....	.....	$2,000	.....
Products:										
Total value	$501,027	$15,046	$46,070	$6,060	$34,526	$6,706	$3,975	$58,638	$235,969	$94,037
Gas sold—										
Feet	484,952,120	12,715,100	26,543,000	1,843,390	25,310,000	4,126,000	1,825,000	74,635,620	230,376,160	107,577,850
Value	$450,996	$12,715	$39,000	$5,801	$30,979	$6,406	$3,650	$52,657	$224,396	$75,392
All other products, including by-products, coke, tar, etc., sold	$45,312	$2,331	$7,060	.....	.....	$300	.....	$5,971	$11,573	$18,077
Receipts from rents and sales of appliances	$4,719	.....	$10	$259	$3,547	.....	$325	$10	.....	$568
Power:										
Number of establishments reporting power	10	1	2	.....	1	.....	.....	2	3	1
Number of engines (steam)	18	1	2	.....	3	.....	.....	5	7	.....
Total horsepower	236	6	13	.....	55	.....	.....	37	105	20
Establishments classified by number of employees:										
Total number	15	1	3	1	1	1	1	2	4	1
Under 5	5	.....	1	1	.....	1	1	.....	1	.....
5 to 20	4	1	1	.....	.....	.....	.....	1	1	.....
21 to 50	4	.....	.....	.....	1	.....	.....	1	2	.....
51 to 100	2	.....	1	.....	.....	.....	.....	.....	.....	1

THE UTILIZATION OF WASTES AND BY-PRODUCTS IN MANUFACTURES.

THE UTILIZATION OF WASTES AND BY-PRODUCTS.

WITH SPECIAL REFERENCE TO THE DECADE OF 1890-1900.

By Henry G. Kittredge.

Nothing in the arts of manufacture is more indicative of economic efficiencies than the utilization of products that have been rejected as wastes or residues in the industrial processes. The acme of industrial economy is the profitable employment of every atom of material in whatever form it may be presented or however obtained. Every particle of an organic or inorganic substance has a useful part to play in contributing to human necessities or pleasures, and when it performs no function toward some useful end, or remains dormant, it shows that the ingenuity and enterprise of man have not reached their fullest development or that the arts of the laboratory have not revealed all the secrets of nature. The refuse of today is a source of profit to-morrow; and this has been going on for years and probably will be going on for years to come, notwithstanding that even now there is little that is thrown aside as absolutely useless except as it may be utilized in the economies of nature. New revelations and new uses are constantly being found for substances of all kinds, whether in their original forms, or in their changed forms due to outside agencies. The world's increment of wealth is largely dependent upon finding new and more economical uses for materials, however exalted or humble they may be in the industrial scale, and especially the elevation of the humble to a higher plane of appreciated usefulness. If a thing is unused for man's enjoyment it is because it has not yet found its place of utility.

The signification of the word waste is given by different authorities as follows:

Rubbish; trash. Rejected as unfit for use. Refuse; hence of little or no value; useless. Stuff that is left over, or that is unfitted or can not readily be utilized for the purpose for which it was intended; overplus, useless, or rejected material; refuse, as paper scraps in a printing office or bindery, or shreds of yarn in a cotton or woolen mill.—*Century Dictionary.*

Something of little or no account or value, as the refuse of cotton or silk.—*Worcester's Dictionary.*

That which is of no value; worthless remnant; refuse; especially the refuse of cotton, silk, or the like.—*Webster's Dictionary.*

The refuse of a factory or shop; as a broken or spoiled casting; the refuse of wool, cotton, or silk resulting from the working of the fiber; paper scraps of an office, printing office, etc.—*American Encyclopedia Dictionary.*

Something rejected as worthless or not needed; overplus or useless stuff; especially the refuse of manufacturing process or industrial art.—*Standard Dictionary.*

In addition to the foregoing may be added the following views of economists:

By-products may be considered as a special case of joint-products; that in which one of the joint-products is of relatively small value. This incident does not invalidate the general theory that the prices of joint-products are such that (1) the supply of each commodity just meets the demand; (2) the net advantages of the producer are equal to those of any other occupation between which and the occupation under consideration there exists industrial competition.—*Dictionary of Political Economy, edited by R. H. Inglis Palgrave, Vol. I, page 197.*

Residual and waste products (by-products) may be defined as those materials which in the cultivation or manufacture of any given commodity remain over and which possess or can be brought to possess a market value of their own apart from the value of the article from whose manufacture or in connection with whose cultivation they have resulted. In this way, straw is a residual or by-product resulting from the cultivation of grain. J. E. Cairnes, Some Leading Principles of Political Economy, 1884, page 128, refers to them as "excessory products" and defines them as commodities which are produced, not separately but as parts of a common industry, and of which the most obvious examples are mutton and wool, beef, tallow, and hides, gas and coke, and the like.—*Dictionary of Political Economy, edited by R. H. Inglis Palgrave, Vol. III, page 291.*

Charles Babbage in his "Economy of Machinery and Manufacture," London, fourth edition, 1835, page 11, paragraph 9, refers to the employment of waste products, such as the hoofs of horses and cattle, and other horny refuse, in the production of prussiate of potash, and also to the re-use of old iron and old tinware.

The consumption of soap and paper, the quantity of letters exchanged, the extension of public libraries and the use made of them, etc., are often taken as a measure of the actual degree of civilization of a nation. An extensive and refined use made of the waste materials of industry and housekeeping might be considered with equal right as a measure of the degree of industrial development and capability. It would also scarcely be possible to find in the processes of manufacture and in agriculture an instance which shows to the same extent the really creative force of science and the characteristic tendency of a nation to economize, as its endeavor to keep, like nature, entirely within the circle of reproduction.—*Archduke Regnier, president of the Imperial Commission, Vienna International Exhibition for 1873.*

A nation's industrial greatness and wealth in the world's competition are definitely related to the skillful application of waste or residual materials in the arts and manufactures. The profits of industry are contingent upon the extent of the successful employment as materials of the by-products or wastes of industry. Success is oftentimes dependent on the superior utilization of that which is lowly in the scale of materials, so that it shall perform the functions of that which is more costly in a manner to satisfy the purpose for which the manufactured product is intended. There is nothing without an economic value for some purpose, if not in the industry in which it first appears, in some other where it can be turned to a profitable account. But while prevention of waste is of the highest importance in any process of manufacture, prevention of by-products is not always in the line of economy, rather it may be in the line of inexcusable waste. The valuable character of by-products is exemplified in the coal-tar products, from which exquisite colors and perfumes are obtained that minister to the caprices and pleasures of man, as well as to his needs. Matter that is the most unattractive, the most base, or the most offensive in its properties oftentimes contains the elements of the greatest usefulness and beauty.

Probably no science has done so much as chemistry in revealing the hidden possibilities of the wastes and by-products in manufactures. This science has been the most fruitful agent in the conversion of the refuse of manufacturing operations into products of industrial value. "Her magic wand has only to touch the most noisome substances and the most ethereal essences, the most heavenly hues, the most delicate flavors and odors instantly arise as if by magic." Chemistry is the intelligence department of industry.

Dr. Lyon Playfair said in one of his lectures:

> Chemistry, like a prudent housewife, economizes every scrap. The clippings of the traveling tinker are mixed with the parings of horses' hoofs from the smithy or the cast-off woolen garments of the poorest inhabitants of a sister isle, and soon afterwards, in the form of dyes of the brightest blue, grace the dresses of courtly dames. The bones of dead animals yield the chief constituent of lucifer matches. The dregs of port wine, carefully rejected by the port-wine drinker in decanting his favorite beverage, are taken by him in the morning as Seidlitz powders to remove the effects of his debauch. The offal of the streets and the washings of coal gas reappear carefully preserved in the lady's smelling bottle or are used by her to flavor blanc manges for her friends. This economy of the chemistry of art is only an imitation of what we observe in the chemistry of nature. Animals live and die; their dead bodies passing into putridity, escape into the atmosphere, whence plants again mold them into forms of organic life; and these plants, actually consisting of a past generation of ancestors, form our present food.

For nearly a century the world's main supply of soap depended on soda, which was obtained as a product of the sulphuric-acid industry.[1] Notwithstanding soap was known to the ancients, it was regarded even in the middle ages as a luxury, and when it was not readily obtained, the lack of cleanliness was concealed by fine clothes and by perfumes. The soda industry being brought to a standstill in France during the French Revolution, the national convention of that country appealed to the chemists to discover some method for making soda from common salt, which had been shown by Du Hamel, in 1736, to contain the same base as soda. About forty years thereafter, Scheele found that caustic soda could be obtained from salt by the action of lead oxide; but the production of soda by chemical processes was unimportant from an industrial standpoint until Le Blanc secured results that gave to the world one of its principal industries. His discovery was based upon the treatment of chloride of sodium with sulphuric acid, forming hydrochloric acid and sulphate of soda. The hydrochloric acid was regarded as a by-product of so little value that it was allowed to pass off into the air, to the great detriment of vegetation in the neighborhood. To remedy this evil the English Government took action against the soda works to compel them to condense the acid and keep it out of the way, and this led indirectly to the discovery that hydrochloric acid could be used as a valuable agent in the bleaching industry, which, however, was at that time far from having attained its present height of development. For use in this way it was found necessary to employ some agent to decompose hydrochloric acid, so that chlorine could be obtained from it, and the best agent was found to be the binoxide of manganese, which the acid dissolves, setting free a part of the original chlorine of the acid or of the salt and forming manganous chloride. Previous to about forty years ago this latter product was allowed to go to waste, and it was not until the demand for manganese oxide was so great and the price so high that a reclamation of the spent manganese was looked upon as desirable, that this was accomplished, adding greatly to the resources of the chlorine industry for bleaching.

The choicest perfumes that are placed upon the market are no doubt obtained from oils and ethers extracted from flowers; but there are many others which are artificially made, many out of bad-smelling elements. The fusel oil obtained in the distillation of spirits has an odor that is peculiarly disagreeable, yet it is used, after treatment with proper acids and oxidizing agents, in making the oil of apples and the oil of pears; and the oil of grapes, and the oil of cognac are little more than fusel oil diluted. Oil of pineapple is best made by the action of putrid cheese on sugar, or by distilling rancid butter with alcohol and sulphuric acid. One of the most popular perfumes has for one of its essential ingredients material which is obtained from the drainings of cow houses, though it may be obtained at a less cost from one of the products of gas tar, out of which is also obtained the oil of bitter

[1] Prof. H. B. Cornwall in Chautauquan, vol. 20, page 419.

almonds, so largely consumed in the manufacture of perfumed soap and confectionery.[1]

The refuse of cities throughout the civilized world is now generally collected and disposed of for sanitary reasons, though in many instances it is utilized to good advantage for industrial purposes. The collection of this refuse has been made only within a comparatively few years, but is now carried on systematically, being more or less self-supporting and advantageous from an industrial point of view. Formerly this refuse was simply accumulated and disposed of by burning, or casting into streams or onto waste land. Now, bones, glass, rags, iron, paper, and other articles are separately collected and sold. Old tin cans are used (1) for the recovery of solder, (2) for the recovery of the tin, and (3) for remelting in the manufacture of steel or iron. The waste heat from furnaces, into which the inflammable refuse is thrown, may be utilized for steam purposes in operating engines for electric lighting and power. The city of Glasgow, Scotland, obtains waste heat from such furnaces equivalent to nearly 9,000 horsepower per day of ten hours for power for manufacturing purposes.[2]

The food wastes of New York city are disposed of by what is known as the Arnold utilization process, which is, briefly, steam digestion and a separation of the cooked product into greases and fertilizer fillers. The greases are all, or nearly all, shipped abroad and, it is believed, refined and separated into several grades, such as "glycerin, red oil, lard oil, and inferior grades." It is not known that refineries in this country are as yet able to handle what is known as garbage grease, as the secret of the trade seems to be held abroad. The solids after being dried and screened are sold to the various manufacturers of "complete fertilizers," and by them made up into grades which seem to be particularly adapted for use in the cotton belt.

The process of utilization employed in New York is as follows: The garbage is delivered on the scows located along the water front and towed to a place of final disposition, which is at an average distance of about 25 miles from the dumps. It is there unloaded and placed immediately in steam-tight digesters and treated by steam under pressure varying from 30 to 80 pounds for about eight hours, the vapors of cooking being condensed and not permitted to reach the outer air. The cooked matter is then discharged from the digester into receiving tanks, and from the receiving tanks goes to presses, where the grease, together with a greater part of the water, is separated from the solids. The remainder of the moisture is taken from the solids in either steam or hot-air dryers. The grease and water are run into tanks or traps, and after gravity separation the grease is skimmed off, partially cleansed, and barreled for shipment. The solids taken from the dryers are put through screens, where metals, bones, crockery, etc., are separated from the fertilizer filler proper. This filler is then cooled and bagged, and is then ready for shipment. The tailings from the screens go on the dumps. There is left then only the water which has been separated from the grease; this is evaporated to the consistency of a thick sirup, and as much of this sirup as can be so used is mixed with some of the solids before drying. This admixture with the evaporated "stick" produces a better grade of fertilizer filler than that which comes from the dryers without treatment

IRON AND STEEL INDUSTRY.

The economic uses of furnace slag have been greatly developed within the last few years. Formerly this slag was carted away from the furnace and disposed of in the most available place, as so much refuse material, hardly worth the cost of carting. It was considered an incumbrance of the smelting works, of no account except to fill up gullies and ravines, or to be thrown into the sea, if such a disposition could be made of it. Within very recent years it was estimated that the cost of removing this waste slag from the furnaces of England was no less than $2,500,000 annually. The amount of slag made by the iron furnaces of Great Britain is certainly immense. A considerable portion of this waste is now put to some profitable use as a substitute for artificial porphyry in the construction of buildings and for street pavements. Paving stones are made from it for the streets of Metz, Brussels, and Paris, of a quality sufficiently durable to stand heavy traffic. Mr. T. Egleston, in a paper read in 1872 before the American Institute of Mining Engineers, on the uses of blast-furnace slag, described a process by which, at a small cost, good bricks may be made of it, and a cement equal to the best Portland cement.

In an article contributed by F. Luermann to the Engineering and Mining Journal, in 1898, it is stated that bricks manufactured from granulated blast-furnace slag are preferable, as building material for dwelling houses, to those made directly from fluid slag, since the former are porous, while the latter, being impermeable to air and steam, would cause the aqueous vapor exhaled by the occupants to condense on cold days, and thus render rooms damp and unhealthy. Good bricks may be produced from granulated slag mixed with dust from slag which has crumbled in the air, but the hardening process is rather slow. It is stated that slag brick is quite as strong as ordinary brick, while it may be heated, without injury to its strength, to a temperature at which carbonate of lime begins to decompose. Slag brick appears to be particularly adapted to the construction of chimneys, for lining limekilns, and for boiler setting. The manufacture of slag brick is carried on in Russia, and it is stated that the brick made there possesses strong hydraulic properties capable of

[1] Lord Playfair in North American Review, vol. 155, page 565.
[2] Journal of State Medicine, vol. 5, page 501.

withstanding high and low temperatures, weighs less than stone, and requires less mortar when laid. Its tensile strength is about 312 pounds; its crushing strength, 1,250 to 5,600 pounds per square inch, according to the time of hardening.[1]

At the Karl-Emil Hutte, in Koniginhof (Bohemia), bricks are said to be made from the cinder produced in a coke furnace smelting an oolitic impure clay ironstone. The slag is run from the cinder notch into water, where it is granulated to a gray-colored sand. It is then mixed in a mill with milk of lime and pressed into bricks, which must be left for eight days to harden before they will bear transporting. The bricks are made to stand a pressure of 256 pounds per square inch, though they are guaranteed only to carry two-thirds of this amount. The whole width of the brick should withstand a load of 5 tons.[2]

In a paper read very recently by Edwin C. Eckel, before the American Society of Civil Engineers, on slag-cement manufacture in Alabama, it was said:

> American technical literature contains little upon the subject of slag cements. This is the more curious as the matter would seem to be of considerable importance to engineers. For whatever the value of slag cement may be as a structural material, the industry has become fairly well established in this country, at least six factories being at present in operation, and I believe that all the plants are in a comparatively prosperous condition. The materials used in the manufacture of slag cement are blast-furnace slag and slaked lime. Two slag-cement plants are now in operation in Alabama, both being located in the vicinity of Birmingham, in close proximity to large supplies of both lime and slag of proper composition.

Slag-cement works have been established in a number of European countries, but probably the greatest development has been reached in Germany. It was stated in a communication to the Architectural Association of Berlin, in 1892, that there were then in that country ten slag-cement factories, with an annual production of 600 tons. About this time the Maryland Steel Company intrusted R. W. Mahon with an investigation of the slag from their blast furnaces to determine its value for cement making, and laboratory experiments were made which became the subject of a paper that was read before the chemical section of the Franklin Institute, in 1893. The result of these experiments was to answer the question affirmatively whether it was possible to make from slag a cement. The slag used was the refuse of Mediterranean ores and an ore mined in the island of Cuba. The limestone came from a point near the city of Baltimore.

It has been found that an admixture of prepared slag with cement adds to its tensile strength in the end, but is apt to have the effect of slightly lowering the initial strength of the cement; i. e., the resistance to tension and compression which the cement acquires within, say, from one to seven days. This defect, however, says A. D. Elbers in the Engineering and Mining Journal of 1897, can be overcome by treating the prepared slag with an aqueous solution of sodium carbonate, rendering it so efficient that a suitable admixture of it with Portland cement is apt to raise the tensile strength of the latter from 50 to 100 pounds per square inch.

Thomas or basic slag is now used by fertilizer manufacturers in large quantities instead of imported phosphate rock, especially in Germany, where the total consumption of basic slag in 1896 was estimated at 800,000 tons. During the same year there were 83,765 tons of this slag imported into Germany, while the exports, chiefly to Belgium, were 134,257 tons.[3]

Reference is made in the Journal of the Society of Chemical Industry, 1897, to the recovery of tin from spent tin baths by the treatment of the oxide of tin with hydrochloric acid in the presence of metallic tin. The process is also utilized for the recovery of tin from the waste liquors of the dyehouse containing tin in solution. From such waste solutions the tin is precipitated by means of lime, sodium carbonate, sulphuric acid, sodium sulphate, etc. The oxides are digested in concentrated hydrochloric acid. As long ago as 1861, Messrs. Edward and Charles Kuhn, chemists of Sechsbaus, near Vienna, took out a patent for producing pure tin, good weldable iron, ammoniac, prussian blue, and some minor products from the waste clippings of white iron.[4] A firm at Manchester, England, utilizes the tin from waste tinned iron (scrap tin) in the manufacture of stannate of sodium.

A very important innovation in the metallurgical industry in Germany is the utilizing of the waste gases of blast furnaces for working gas engines. That the waste gases can now be made serviceable in their entire heating capacity by a rational burning in gas engines, is one of the most important steps that have been recently made in science in its adaptations to practical technics. What this improvement means, economically, is seen by a theoretic calculation according to which this use yields a profit of $1.25 per ton of pig-iron production, which means for Germany alone, where the utilization of these waste gases is made, a gain of over $10,000,000 on her entire wrought-iron production.

Gas machines for utilizing these gases were introduced into Germany about 1898. Good results were reported from all quarters, which lead to the belief that this is a material advance in the development of an important gas-machine industry. So confident are those who are interested in it, that blast furnace gas engines of large dimensions have already been erected at different places in that country. An establishment at Donnersmarck may be particularly mentioned as having erected a gas dynamo of 600 horsepower. The managers calculated that if the quantity of gases which hitherto, when burning

[1] Journal Society of Chemical Industry, vol. 17, page 1049.
[2] Journal Society of Chemical Industry, vol. 16, page 144.
[3] Engineering and Mining Journal, May 8, 1897.
[4] Waste Products and Undeveloped Substances, P. L. Simmonds.

under boilers, produced 1,000 horsepower in round figures, be used for burning in gas-power machines, the production would be increased to about 2,700 horsepower.

To utilize these gas engines to their greatest advantage it has been thought that electricity would have to be employed. The electric transmission of power acts as an auxiliary, which is regarded as an incalculable advantage, notwithstanding the loss of about 20 per cent in energy. The Cockerill Company, of Serainty, Belgium, with the cooperation of Mr. E. Delamare-Deboutteville, is said to be first to solve successfully the problem of the direct utilization of blast-furnace gases as a source of energy. Since 1895 a gas engine of this kind has been in operation at the works of this company, and their 600-horsepower single-cylinder gas engine exhibited at the Paris Exposition of 1900 attracted a great deal of attention from those interested in the metallurgical industry.[1]

In the fiscal year 1900 there were imported and entered for consumption into the United States, for remanufacture only, 26,307.46 tons foreign waste and refuse, scrap iron and steel.

LUMBER AND TIMBER PRODUCTS.

Nearly all of the formerly waste products of lumber and timber are now turned to some utility, and some of the new products thus formed are of considerable value. Of this latter class may be mentioned sawdust, which was formerly considered an absolute waste material, and was allowed to float down the stream or was thrown into a heap where it could be most conveniently disposed of. French cabinetmakers have found a way of preparing this material which gives it a value far above that of solid timber by a process that has been in vogue for at least twenty-five or thirty years, combining the use of the hydraulic press and the application of intense heat. By this process the particles of sawdust are formed into a solid mass capable of being molded into any shape and of receiving a brilliant polish, and possessing a durability and a beauty of appearance not found in ebony, rosewood, or mahogany. This product is known as "Bois durci." Artificial woodwork therefore seems to have a promising future. Alum, glue, and sawdust, kneaded with boiling water into a dough, and pressed into molds when dried, is hard and capable of taking on a fine polish. Ornaments of great beauty can be made from it very closely resembling carved woodwork.[2]

The production of acetic acid, wood naphtha, and tar from sawdust is one of the latest enterprises in Norway. A factory has been started at Fredrikstad capable of distilling 10,000 tons of sawdust in a year. It also manufactures charcoal briquettes, which are exported to the Netherlands. The acids are chiefly placed on the German market, while the tar is mostly consumed at home. The factory is said to be the first of its kind erected in that country.[3] According to an English patent of 1897, sawdust may be so prepared as to be noninflammable, and then applied to jacketing of boilers and other purposes.

In the Journal of the Society of Chemical Industry, for 1898, is described a series of experiments for obtaining alcohol from either coarse or fine sawdust, without affecting the yield. It was found that pine sawdust as compared with fir sawdust was superior as yielding a purer alcohol. It was also found that a high yield of sugar was obtained from birch sawdust, the yield of sugar being about 30.8 per cent of the quantity of birch wood used. The quantity of alcohol obtained from 220 pounds of air-dried sawdust (20 per cent water) was 7 to 8 quarts. The quality of the alcohol distilled from the fermented liquid was said to have been excellent, and the preliminary experiments indicated that the trifling impurities found in it could be readily removed.[4]

A patent taken out in England in 1896 for utilizing certain waste products of wood describes a process of constructing or manufacturing a product resembling wood from a mixture of sawdust or wood refuse and certain quantities of gums, resins, or other suitable agglutinants, either in a dry state or dissolved, the compound being subjected to pressure at a temperature sufficiently high to soften or melt the gums or resins.

According to the United States census of 1900 the amount of sawdust used in the clay and pottery industry of this country cost $19,687, or 0.17 per cent of the total cost of all the materials used.

The utilization of wood pulp in the manufacture of paper is not new, but its increased use is very marked, as will be seen by comparing the statistics of the census of 1890 with those of 1900, in the amount of raw materials used in the manufacture of paper. Early in 1826 the brothers Cappucino, paper makers of Turin, discovered a means of supplying the need for paper-making material, caused by the scarcity of rags in the fabrication of paper, by substituting the thin bark of the poplar, willow, and other kinds of wood. The good quality of the paper made from this material was recognized by the Academy of Sciences, after an examination of the manufactured product, and so important was the discovery considered that the King granted the brothers an exclusive privilege for ten years for the manufacture of paper from ligneous materials.[5] In 1833 a patent was granted in England to J. V. Desgrand for making paper and pasteboard from wood reduced to a state of paste. Poplar wood was thought at that time the best for this purpose, as it had been in Italy twelve years

[1] Journal of the Society of Arts, vol. 48, page 850.
[2] Waste Products and Undeveloped Substances, P. L. Simmonds, page 217.
[3] Journal Society of Chemical Industry, vol. 17, page 81.
[4] Journal Society of Chemical Industry, vol. 17, page 1154.
[5] Waste Products and Undeveloped Substances, P. L. Simmonds.

previous. A patent was granted in 1855 to William Johnson for improvements in the application of various substances containing wood fiber, as the bast, or inner bark, of the lime tree, the willow, birch, and alder, to the manufacture of wood paper pulp. At the London International Exposition of 1862 Wurtemberg contributed several samples of paper made from wood pulp mixed with rags, the proportion of the former varying from 10 to 80 per cent; and the paper was reported to be serviceable although of a low grade. The wood was simply rubbed down into pulp against the periphery of a wheel, prepared with a rough face. At the Paris Exposition, 1867, was to be seen in action a large machine of 50 horsepower for making wood pulp for paper. Only white woods were thought to be available for this purpose.

There is no limit to the range of wood suitable for paper making, though the pine family is most suitable for this purpose, and invention has been mainly directed to methods for reducing wood to a suitable condition for use in paper manufacture. The first method of preparing pulp from wood was to reduce the wood to thin shavings, which were soaked in water for a week or more, then dried, and then ground to powder by a crushing mill of some kind. This powder was mixed with rags to form a pulp, in which condition it was suitable for converting into paper. The principal defect in this method was the production of a very short fiber. Chemically produced pulp was resorted to as better preserving the natural fiber of the wood. The chief objection against it was its cost, but this has now been largely, if not entirely, overcome and the industry placed upon an economical basis.

The value of pulp wood entered for consumption in the United States for the fiscal year 1900 was $1,109,139.11; the wood pulp entered for consumption during the same period was as follows:

	Pounds.	Value.
Mechanically ground	70,222,823	$491,889.36
Chemically bleached	20,112,995	478,456.00
Chemically unbleached	90,207,760	1,436,052.36
Total	180,543,578	2,406,397.72

The utilization of the needle-shaped leaflet of the pine tree, either alone or in combination with some other fiber, as cotton, for example, has frequently been attempted with more or less success to produce an article of commercial value for textile or other purposes. Near Breslau, in Silesia, there have been erected factories that convert the pine leaves into what is called "forest wool," for wadding. Other factories have been erected in other parts of Europe for a similar use of these leaflets, as in Sweden, Holland, and France. The products made from these pine-tree leaflets have been exhibited at a number of expositions, where they attracted more or less attention as furnishing suitable material for stuffing mattresses and articles of furniture in place of horsehair, for manufacture into hygienic fabrics for medical use, and for articles of dress, such as inner vests, drawers, shirts, chest preservers, etc. In the preparation of the textile material an ethereal oil is produced, which is employed as a curative agent and oftentimes as a useful solvent. Some attempt has been made of late in the state of Oregon to make use of these leaflets by reducing them to a fibrous condition suitable for mixing with cotton, to be spun into yarn for weaving.

PAPER MANUFACTURE.

In the utilization of waste products there is a close relation between the manufacture of paper and that branch of the lumber and timber industry which reduces wood to a fibrous pulp. In fact, paper has always been made chiefly by the utilization of waste materials obtained from the vegetable world, such as rags, old rope, straw, etc. But there was a smaller quantity of cotton rags and other cotton substances used in 1900 than 1890, and a very much smaller quantity of such substances as manila stock, rope waste, etc. On the other hand, there was an increased use in 1900 over 1890 of such materials as straw, old waste paper, and particularly of wood pulp made either by a mechanical or a chemical process.

The best variety of fiber obtained from wood is that produced by chemical means, which renders the wood free from the resinous matter found in wood prepared by grinding. If resin is left in the fiber, it resists strongly the action of the bleaching agents, causing the paper to become yellow after a time. There are two processes chiefly in use for the chemical preparation of the wood fiber—the caustic soda and the bisulphite processes—the latter being much more widely employed than the former. There is another process, known as the Franke process, which uses bisulphite of lime. The efficacy of the bisulphite process is explained by Cross and Bevan, to the effect that the chief agency is the hydrolytic action of sulphurous acid, aided by conditions of high temperature and pressure. This process yields a large amount of pure fiber, preserving its original strength, which is not the case when the caustic soda process is used.[1] German chemists have found that an organic substance containing sulphur can be obtained from waste sulphite liquor in different ways, and the product has been proved to be similar by a corresponding amount of sulphur contained therein.[2]

From a sanitary, as well as industrial point of view, the recovery of the sulphite liquor as a waste from wood-cellulose factories is worth the attention and ingenuity of inventors. A prize of 10,000 marks was offered in Germany in 1894 for the best and most suc-

[1] Industrial Organic Chemistry, 3d edition, Sadtler.
[2] Journal of Society of Chemical Industry, vol. 17, page 596.

cessful method of treating waste sulphite liquors so as to prevent the pollution of the streams into which these liquors ran.

There has as yet been evolved no satisfactory application of the waste liquors from the bisulphite process.[1] Evaporation and combustion involve large losses of sulphur. A more complete regeneration of the sulphur has been the subject of a series of German patents, but the processes are inefficient through neglect of the actual state of combination of the sulphur, viz, as an organic sulphonate. The process of V. B. Drewson consists in heating with lime under pressure, yielding calcium monosulphite (with sulphate and lignone complex in insoluble form). The sulphite is redissolved as bisulphite by treatment with sulphurous acid. This process, however, is relatively costly and yields necessarily an impure lye. It has been proposed to employ the product as a food stuff both in its original form and in the form of benzoate, but its unsuitability is obvious from its composition. A method of destructive distillation has been patented in Germany, but Prof. H. Seidel, of Germany, has investigated the process and finds that the yield of useful products is much too low for its economical development. Fusion with alkaline hydrates for the production of oxalic acid is also excluded by the low yield of the product.

A number of German patents have been taken out for the recovery of the organic matter from waste sulphite liquor and for the production of useful products therefrom. Many of these patents have for their object the extraction of a tannin material as size for paper. By this latter process the solution containing tannin (simply waste lye) is added to the pulp in a beating engine, and, when well mixed, a solution of gelatine is added, the result being an insoluble coating of tannin size upon the fibers. In a later patent the addition of resin size is recommended. According to a German patent of 1891, a means of osmosis is proposed for obtaining a purer form of tannin suitable for tanning hides.

In the opinion of Prof. H. Seidel, the application of the waste liquors from the bisulphite process to tanning purposes appears promising from the fact that 28 per cent of the dry residue is removed by digestion with hide powder. This application, however, he says has been extensively investigated, but without practical success. Various uses are suggested by the viscosity of the evaporated extract. As a substitute for glue in joinery work, in bookbinding, etc., it has proved of little value. It is applied to some extent as a binding material in the manufacture of briquettes, and also as a substitute for gelatine in the petroleum industry.

According to Dr. L. Gottstein, Breslau, Germany, the isolation from the waste waters of the bisulphite process of a suitable tanning material for use in the leather factories has not been so successful as was at first expected; and the attempts to make alcohol, acetic acid, and oxalic acid have not given satisfactory results. He says, too, that all the attempts to produce usable material by the dry distillation of the solid residue from the liquor have also failed. The daily production in Germany of about 1,000 tons of sulphite pulp means about ten or twelve times that amount of liquor, having from 9 to 10 per cent solid residue, giving about 1,000 tons as the daily production of this substance. It is on the average about one-fifth inorganic and four-fifths organic in composition.

A German patent has been granted for the production of a dressing compound for textile material, which the inventor calls "Dextron." The liquor is neutralized, and then concentrated by means of evaporation and saturated with magnesium sulphate. The solution of this salt throws out, in the form of a scum upon the surface, the so-called dextron, which is collected, dried, and ground. The material, it is said, can be largely used in the place of dextrin. It contains tannin and possesses antiseptic properties, and is sold chiefly to cotton-weaving mills and calico printers.

Prof. H. Seidel's application of soda salt from the lignone sulphonic acid as a reducing agent in chrome-mordanting wool and woolen goods is claimed to be successful in practice, and its industrial development shows, it is said, satisfactory progress. The product is known as ligno-rosin. Dr. Gottstein, in a recent address, observes that sodium lignin-sulphonic acid (ligno-rosin) as a substitute for tartaric or lactic acid for mordanting wool plays, in proportion to the great amount of sulphite liquor produced, a very small role in its utilization.

Waste liquors from the sulphite boiling process contain in solution about 50 per cent of the weight of the dry wood. It is probable that, with the further development of the sulphite process, methods will be worked out by which this large amount of waste material may be utilized. The most obvious direction for such methods will be toward the preparation of glucose, alcohol, and oxalic and pyroligneous acids.[2]

A process (patented) has been communicated by Mr. W. Trippe, of Esson-on-the-Rhur, Germany, relating to the treatment of waste liquors from the manufacture of sulphite cellulose.[3] The lyes are inspissated in the usual manner by evaporation, though their inspissation is carried beyond the usual consistency of sirup, and is effected without the addition of any reagents calculated to promote the elimination of the solid compounds of sulphur. By the time the sirupy mass has been brought to contain only about 20 per cent of water, the sulphur compounds of the lye begin to decompose, yielding mainly sulphurous acid, and also, secondarily, some other volatile compounds of sulphur, such as mer-

[1] H. Seidel.

[2] The Chemistry of Paper Making, Griffen & Little, 1894.

[3] Paper Trade Review, July 5, 1901.

captanes, mercaptides, and the like. These gasiform products which, if desired, may be drawn off, may be utilized in a variety of ways, say in the manufacture of sulphurous acid, sulphuric acid, or compounds of such acids, or, if desired, in the production of sulphur and other sulphur compounds. The moment decomposition begins, a froth forms on the surface of the liquor, as a result of the first escape of gas, in the form of bubbles. The formation of froth discontinues after a resistant skin has developed on the surface. This is blown or distended, and hinders the rapid escape of the gases, thereby retarding the progress of the decomposition.

The physical effect—and also the chemical change—may be expedited by additions of organic substances capable of checking the formation of the resistant skin already mentioned. Among such substances may be mentioned the different varieties of pitch and similar tar products, resin, carbohydrates, hydrocarbons, glues, organic acids, and the ethers of such acids. These additions of organic matter are particularly effective when made in the form of solutions, the preferable solvents to be employed being benzine, petroleum, and other hydrocarbons or their derivatives. In order to expel the sulphur compounds, inspissation should be carried on to a point at which there shall remain behind a mass of paste which while hot (or warm) is, indeed, plastic and kneadable, but which, when allowed to cool, becomes hard and brittle and can be broken up or pounded into fragments, like resin, for example. Inspissation may be carried on even beyond this point, until there remains a perfectly dry, sandy residue. It is a somewhat remarkable fact that this residue still retains the viscous or adhesive property which it had been observed to possess in those forms in which alone it has been hitherto known to occur. The only forms in which, until the present time, the mass was known to be adhesive was the liquor, sirupy form, either cold or warm, and the kneadable form which the mass assumes when cold.

The residue, if not evaporated right down to desiccation, forms, while yet warm, a moldable mass or paste, which, however, has lost none of its adhesive qualities; and this adhesiveness subsists both when the residue is moistened, as it would in the case of glue, and when it is heated, as in the case of resin or pitch, so that it may immediately be used as a substitute for any of these substances. The development of these qualities may be favored by superadding to the mass, while yet in the process of formation, such other substances as are capable of increasing its adhesiveness; the nature of such additions, of course, depending upon the particular purpose which the adhesive mass is intended to serve. Among such substances, in addition to the organic compounds already referred to as agents for the prevention of skin formation, are the various albuminoids, albuminates, terpenes, resins, and tar products.

As a result of these additions, the residue will more closely resemble such adhesive substances as resin, pitch, or the like; but if the residue is readily soluble in water, the additions will be apt to diminish its adhesive property. Where the residue is treated with a view to its employment as a substitute for glue, resins, or the like, it is expedient to determine the degree of inspissation beforehand, with due regard to the qualities which the residue in its final form is desired to possess. Where, for example, it is to be used as a substitute for glue, inspissation should not be carried on as far as it would have to go if a substitute for resin were required.

As the residue has been freed from sulphur compounds, it is not only perfectly harmless to vegetation, but is fitted for use as manure, or as an addition to manure, by reason of the assimilable organic substances and of the lime in a finely divided state which it contains. Where, on general grounds or from local considerations, this treatment of the residue—which, economically speaking, is unobjectionable—is not deemed desirable, it may immediately be used as fuel; in which case the mineral ingredients of the lyes—in particular calcium or magnesium—should preferably be eliminated either before or during the process of inspissation, it being immaterial what particular mode of elimination is adopted.

A process of utilizing waste sulphite liquor and product therefrom has been very recently invented by Alexander Mitscherlich, of Freiburg, Germany, and patented in the United States.[1] The process is chiefly intended to collect these liquors and utilize their properties so as to yield products of increased commercial value, and extend their usefulness to various purposes other than the manufacture of paper pulp. The process is based upon the previous removal of the inorganic constituents of the spent liquor by an addition of lime and the subsequent separation of the organic bodies by dialysis or osmosis. A new article of manufacture also obtained from the spent liquors is a tanning agent.

A process of obtaining an adhesive substance from sulphite liquors suitable for sizing and mordanting was the subject of a patent in 1895.[2]

The use of a neutralized solution of the bisulphite waste waters free from the lime precipitates, as water for field irrigation, has proved a failure.[3] The gummy liquor stops the pores of the ground, preventing filtration, and rendering the leached waters from fields on which it is used dark and ill smelling. On this account the storage of the liquor in cemented basins is not to be recommended, since, on standing, the basins became leaky and the surrounding water contaminated.

As to the durability of paper produced wholly or partially from wood cellulose, opinions are still divided, some holding that rag substitutes should never be used

[1] United States patent No. 681241.
[2] United States patent No. 550712.
[3] Dr. L. Gottstein, Breslau, Germany.

for paper that is intended to remain in good condition for long periods. In the case of unbleached cellulose and ground wood no doubt seems to exist, as these materials are known to deteriorate rapidly. The question of durability, therefore, it would seem, can be definitely decided only by a series of systematic experiments extending over a long period of time.

A writer in the Journal of the Society of Chemical Industry for August 31, 1896, makes some comment on the durability of paper made from wood pulp, to the effect that pulp prepared by grinding wood contains ligneous and other incrusting matter, and the composition is similar to that of the wood itself. Paper made from this pulp turns brown, and becomes brittle and rotten when exposed to the action of light and air for any length of time. Pure wood-cellulose fibers are not affected by light or air, hence it is assumed that the above results are owing to the presence of the incrusting matters. Paper made from brown pulp is less sensitive to light, since the incrusting matter is partly removed by steaming and lixiviating. Cellulose made from wood by boiling with soda stands the action of light and air without turning brown, although it undergoes a change of another kind.

Some years ago blotting paper was made by an American firm from soda wood cellulose, but it was admitted by the makers that after a time the paper lost its absorbing qualities and in a few years it became rotten, the fibers becoming again incrusted. A test of blotting papers several years old confirmed this view. From this and other observations, it is suggested that certain cellulose pulps are liable to return by degrees into the state of the original ligneous fiber. Whether papers made of sulphite fiber will remain unaffected in the course of years, is as yet uncertain, although some paper makers assert that sulphite fiber is as suitable for documents as is rag fiber.

An English patent has been granted to W. J. Ward, Manchester (English patent 15986, September 8, 1900), for the manufacture of waterproof paper, also mineral oil, grease, soap, and the like. According to this patent the spent liquor from the sulphite treatment of wood is evaporated down to 30° Tw., with a definite proportion of sodium or potassium bichromate. It is then treated with more bichromate in a steam-jacketed pan, while paraffin, wax, or the like, previously melted with 2 or 3 per cent of tallow, or 1 per cent of boiled linseed oil, is mechanically incorporated. Finally the product is mixed with the paper pulp in the beaters at a temperature not exceeding 80° F. A mineral grease or soap is obtained in a similar way by removing the calcium salts from the spent liquor and adding 50 per cent or more of mineral oil, with 1 or 2 per cent of tallow, instead of the wax.

The recovery of soda is a valuable side product in the manufacture of paper. The alkaline liquors in which rags and other paper-making material had been boiled were at one time allowed to run to waste. This is no longer permitted in economically conducted mills, as the alkali can be recovered in the form of a carbonate, by the evaporation of the waste liquors and the ignition of the residues, after which this carbonate can then be causticized and prepared for renewed use. The soda, during the process of boiling with the paper-making materials, takes up a large amount of noncellulose fiber constituents, such as resin, coloring matter, and silica. These on evaporation and ignition become either carbonate or silicate.[1]

A patent was taken out in 1893 (United States patent No. 492927) for the manufacture of paper board, box board, and the like from old newspapers or other similar printed white paper. In the manufacture of the article preference was given to printed newspaper or other printed paper possessing the characteristic properties of the ordinary paper upon which newspapers are printed on account of its cheapness, its freedom from size, and its softness. Old copies of newspapers or the overissues can be bought up at low rates and utilized for this purpose. A new article made is a paper board manufactured from old newspapers ground to a pulp and having the permanent particles of the printers' ink minutely subdivided and uniformly distributed throughout it so that a smooth and even tint is imparted to the board.

According to the present census 356,193 tons of old waste paper were consumed in paper manufacturing, and crude paper stock, fit only to be converted into paper, was imported and entered for consumption in 1890–1900 to the value of $3,261,407.21.

SLAUGHTERHOUSE PRODUCTS.

Slaughterhouses furnish a multitude of by-products which are utilized on a commercial scale of some importance. The products of the gray brain matter of calves are now employed in the treatment of affections of the nervous system,[2] known under different names, as, for example, neurasthenia (nervous debility; nervous exhaustion), agoraphobia (a dread of crossing open spaces, city parks, etc.), chorea (nervous disease; St. Vitus's dance), psychosis (mental disorder; insanity).

It was not until 1870 that the preservation of pork and beef products was practically carried further than the air-drying and salt-pickle curing of hams, bacon, mess pork, and dried and corned beef. The customary practice at that time of shipping the cattle from the West to the eastern markets, to be there slaughtered, entailed a heavy shrinkage in weight, and other losses. It was about this time that there was a commercial

[1] Industrial Organic Chemistry, by Sadtler; Text-Book of Paper Making, by Cross and Bevan.
[2] Journal Society of Chemical Industry, vol. 17, page 738.

demand from glue manufacturers for a part of the slaughtered offal, the disposition of which had become a source of expense, and a demand from fertilizer manufacturers for such parts as were not wanted by the glue maker opened the way for a utilization of by-products, which was greatly facilitated by the introduction of a system of ice refrigeration and transportation. This made it possible to slaughter live stock in the West and ship the edible portions to the consumer at distant points, allowing the conversion of the offal at the point of slaughter into by-products, such as soap, glue, fertilizers, etc., thus saving the cost of transportation as part of the live animal.

The blood from slaughtered animals has long been utilized for the production of albumen, for the use of the calico printer, the tanner, the sugar refiners, and others. The bones of animals are used for a score of different purposes; those coming from the cooked meat are boiled, and the residual fat and gelatin are extracted; the former is used in the manufacture of soap, and the latter, for various objects, as transparent coverings for chemical preparations, etc.[1]

The bones from the feet of cattle are used in the manufacture of toothbrush handles, knife handles, chessmen, and for whatever purpose ivory is used, since the hard bone takes a very high polish. The knuckles from these bones are cut off and used in the manufacture of glues and for fertilizer. The tip of horns is sawed off, and the horn is split and pressed out into a flat plate under heat and pressure. These plates are used in the manufacture of combs, backs of brushes, large buttons, etc. The tip of the horn is made into mouth pieces for pipes and various other articles. The horn scrap is used for fertilizer.

Hoofs are sorted into three grades: White hoofs, which are sent to Japan and there used in the manufacture of various ornaments; striped hoofs, which are worked up into buttons and horn ornaments; and black hoofs, which are used in the manufacture of cyanide of potassium for gold extraction, and also ground up to make fertilizer for use of florists, grape growers, and others.

Neat's-foot oil is extracted from the feet, and various oils are taken from different portions of the animals. These all have a high commercial value.

A patent was granted in 1898 to Alexander Mitscherlich, of Germany (United States patent No. 602237), for a process and apparatus for converting bones at a small cost into useful adhesive matters; at the same time certain fermentable substances which can be used for producing alcohol and phlegma (distiller's wash) are by-products of the process. The process consists essentially in dissolving waste bony matter, such as horns, hoofs, hair, and the like, and precipitating this solution by the tanning principle found in the lyes obtained in the manufacture of sulphite cellulose.

[1] Good Words, vol. 17, page 156.

A valuable branch of the utilization of fat of beef and hogs is the manufacture of substitutes for butter, toward which experiments have been made with more or less promising results within the last thirty years. In 1870 a French chemist found that carefully washed beef suet furnished a basis for an excellent substitute for dairy butter. Since then a large industry has grown up in the manufacture of such articles as butterine and oleomargarine.

An important article obtained from fat is glycerin, which is brought into commerce as refined or distilled glycerin, or as an element in glycerin soaps, toilet preparations, roller compositions, etc. Glycerin was once a waste article produced in the manufacture of candles from palm oil. It was found necessary to abstract this substance, as it caused an unpleasant smell when the charred end of the wick went out. This substance was at first allowed to float off into the river, the loss per week at some factories being estimated as high as $2,000. This loss has been eliminated since the valuable qualities of the by-product have been ascertained. The application of glycerin in medicine, and for technical purposes, has made it important to extract and purify this article whenever possible, and now its value, in relation to other fat constituents, is great.

The two methods of saponification by which glycerin has been obtained on a large scale, are the processes of Wilson and Payne of decomposing the fats by superheated steam and after distillation, and the lime autoclave process of Milly.[2]

Dr. S. P. Sadtler, in the third revised edition of his work on organic chemistry, says:

> It is obvious that in soap making, as numerous quantities of the fats are decomposed, corresponding quantities of the glycerin go into the spent lyes. It is only very recently that it has been attempted to recover this glycerin, and no perfectly satisfactory process seems as yet to have been adopted. More practical, in the opinion of those qualified to judge, seems to be the idea recently put forward to deglycerinize all fats before saponifying them. The process of Michaud Freres, of Paris, realizes this idea very successfully.

A suggestive invention was patented in 1898 (Letters Patent No. 602725) for the recovery of glycerin from tank waters, that of utilizing of the waste products of slaughterhouses and rendering establishments. Tank water, as is well known, is a by-product of rendering establishments produced in cooking, under pressure, the scraps of meats, bone, sinews, lungs, intestines, and other nitrogenous matter containing more or less fat; such cooking being continued for several hours, until the substances in the tank are decomposed to a great extent and the fat liberated. A large part of the nitrogenous matter remains in solution in the liquid produced from the solids introduced into the tank and from the condensed steam. The fats rise to the surface, while the undissolved matter, to a great ex-

[2] Industrial Organic Chemistry, Sadtler.

tent, settles to the bottom of the tank. The liquid lying between the fat and the solids, or "tankage," in the bottom of the tank is known as "tank water." After the fat has been skimmed off, the water is drawn off from the tankage and disposed of in various ways. This tank water was for many years discharged into the sewers, although it is known to contain valuable nitrogenous matter, and even at the present day it is thus disposed of in almost all houses of small capacity.

There was imported into the United States for the fiscal year 1899–1900, crude and refined glycerin to the value of $2,128,670.50.

Red bone marrow is a valuable by-product of the slaughterhouses. The marrow found in young animals has the most active properties, and is obtained from the finer medullary substances of the rib bones of young cattle, and contains less fatty principles than that derived from the long bones, and must be extracted immediately after the animal has been killed, else molecular death of the marrow ensues. It unites with the unaltered proteids of the blood, and is of the highest nutritive value. Finely comminuted calves' ribs, being richest in bone material, are selected from recently killed animals and macerated or digested in chemically pure glycerin for several days, until extraction is complete. The medullary glyceride is then strained or filtered off for immediate use as a palatable preparation. This product stimulates the formative processes and increases the rate of production of the red blood corpuscles.

Gelatin, or, in its lower grades, glue, is a by-product of the slaughterhouse, as the bones of animals contain on an average nearly one-third of their weight of organic constituents, which may be extracted by boiling and converted into gelatin or glue. This, though inferior in adhesive power to that prepared from animal skins, is of much commercial value. The soft bones of the head, shoulders, ribs, legs, and breast, and the bony core of the horns of horned cattle, and especially deer's horns, yield a larger quantity of gelatin or glue than the hard thigh bones and the thick parts of the vertebra, which are principally composed of calcium phosphate and require a more prolonged treatment to extract the gelatin-making constituents.[1] The most important gelatin-yielding material is the hide of animals, obtained from the trimmings of ox, sheep, and calf skins, the refuse of the beam house, and scraps which have been softened and the hair removed by liming to get them in condition for boiling. The epidermis and the underlying fat tissue are not valued as glue stock. For gelatin, calves' hides are the most valuable, forming a special article of commerce after being limed and dried.

The following statistics pertaining to the manufacture of glue are from the 1900 census:

	Total number of pounds.	Made from hide, trimmings, etc., fur, or neat's-foot stock.	Made from bone or bone liquor.
		Pounds.	*Pounds.*
Glue establishments	34,984,448	29,036,901	3,109,165
Slaughtering establishments	34,516,761	12,780,832	20,183,562
United States	69,501,209	41,817,733	23,292,727

	Made from cattle, hogs, etc.	Made from fish skins and waste.	Made from other materials.
	Pounds.	*Pounds.*	*Pounds.*
Glue establishments	66,666	2,731,156	40,560
Slaughtering establishments	1,282,367	270,000	.....
United States	1,349,033	3,001,156	40,560

The value of imports of hide cuttings, raw, and all other glue stock and hide rope entered for consumption in the United States during the fiscal year of 1899–1900 was $1,207,572.03, and the value of imports of glue was $526,544.05.

Slaughterhouse by-products that are utilized include—

- Gelatin,
- Glue,
- Fertilizers,
- Hair,
- Curled hair,
- Bristles,
- Blood,
- Neat's-foot oil,
- Bones,
- Horns,
- Hoofs,
- Glands and membranes, out of which are obtained—
  - Pepsin,
  - Thymus,
  - Thyroids,
  - Pancreatin,
  - Parotid substances,
  - Suprarenal capsules, etc.,
- Soap stock,
- Glycerin from tallow,
- Brewer's isinglass,
- Albumen,
- Hides,
- Skins,
- Wool,
- Intestines.

WOOLEN INDUSTRY.

The woolen industry furnishes a number of materials formerly regarded as waste, that are now utilized in the industry itself and for pharmaceutical and other purposes. The principal articles of waste are rags and wool-grease. The former is reconverted into wool and used the same as the original raw material, while the latter is employed in other industries. The sheep obtains from the soil of the pastures upon which it feeds a considerable portion of potash, which, after circulating through the system of the animal, is excreted with other matter from the skin and becomes attached to the

[1] Industrial Organic Chemistry, by Sadtler.

wool. This excretion is known by the French as "suint," and oftentimes constitutes, together with the dirt that is mixed with it, two-thirds of the weight of the fleece. Formerly the suint was allowed to go to waste when the wool was cleaned; and even now a large portion of it that is taken from the fleece is allowed to go to waste with the wash waters. There is a disposition at present, however, to recover the grease from the wash waters and use it for industrial purposes. At first, attention was directed to the saving of suint for the purpose of obtaining the potash and potash salts contained in it, and with this object a special industry was established in the wool districts of France and Belgium for converting it into commercial products, which were exhibited at the several industrial expositions in Europe, and especial mention was made of them at the Paris Exposition of 1867, many of them receiving silver medals.

The encrusting matters attached to wool, besides the dirt, consist of wool fat, which is soluble in ether, and wool perspiration, which is soluble in water. The wool fat and the wool perspiration are together embraced under the name of the "yolk" of the wool. The wool fat is a mixture of a solid alcoholic body, cholesterine, together with iso-cholesterine, and the compounds of these bodies with several of the fatty acids. These free higher alcohols are soluble in boiling ethyl-alcohol, while the compounds they form with the fatty acids are insoluble in alcohol but soluble in ether. Wool perspiration consists essentially of the potassium salts of oleic and stearic acids, and possibly other fixed fatty acids, also potassium salts of volatile acids, like acetic and valerianic, and small quantities of chlorides, phosphates, and sulphates.[1] Thus it will be seen that the yolk of wool contains many elements of recognized value in arts and manufacturing.

When the potash salts are evaporated and ignited, they yield a product of potassium carbonate, and it is estimated that 2,200,000 pounds of this product is saved from the wool wash waters of the mills and scouring establishments of France and Belgium. When the yolk is submitted to dry distillation it yields a residue containing carbonate of potash, nitrogenous carbon of great value for the manufacture of yellow prussiate of potash. According to M. Chandelon, 2,200 pounds of raw wool may furnish 300 quarts of yolk solution of 1.25 specific gravity, having a value of $3.75, while the cost of extraction does not exceed 60 cents.[2]

It is only within comparatively recent years that volatile solvents have been used for extracting the yolk from wool. By far the greater quantity of wool is still cleansed by the old process of scouring with alkalis and washing in a rapid current of water. The volatile-solvent process, however, is coming into use, though now confined chiefly to establishments where large quantities of wool are cleansed. The great cost of the plant for cleansing wool by this method confines it to large establishments. Various volatile solvents can be used, such as fusel oil, ether, petroleum naphtha, and carbon disulphide. When these solvents are used they have to be followed by washing with water, as, while they dissolve fatty matters, they do not take up the oleates, etc., of the wool perspiration. The treatment of wool by these means is now confined to petroleum naphtha, and, as now conducted, according to the best methods in vogue, is found to be not only practicable but remunerative, both in the saving of a valuable product and in leaving the wool in an excellent condition for the various processes of manufacture.

In 1897 a bill was presented to the English Parliament, from the Bradford district, relating to the treatment and disposal of "suds" from the wool washbowls in combing sheds. At that time considerable interest was attached to a process which had been introduced at the works of Messrs. William Scaife & Co., wool combers, Laisterdyke. The process is described as exceedingly simple and apparently successful. The suds, after being run off from the washing bowl, are allowed to stand for about half an hour in a settling tank, to permit the sand and solid matter to fall to the bottom. The liquor is then pumped into a tank, very much like a washbowl, in the bottom of which is a system of pipes through which compressed air is forced. About one gallon of sulphuric acid is added to every 700 gallons of suds before the "blowing" begins. The violent aeration of the liquor which ensues quickly brings the grease to the surface in the form of a thick foam or froth, and a set of boards, carried on an endless chain, scrapes this off and carries it away over one end of the tank. The blowing is continued as long as any froth arises, which is just as long as there is any grease left in the water. The foam, which contains only about 5 per cent of water, is treated just as the magma, obtained in the usual way by precipitation, is dealt with—by pressure in a steam press.[3]

Within the past five or six years, several methods for cleansing wool, and for the recovery of the grease, etc., from the wash liquors, have been introduced into England and on the continent, that have attracted considerable attention and comment from scientific journals. At the works of Thomas Biggart, of Dalry, Ayrshire, the recovery of grease and potash from the wash liquor is effected in the following manner: The suds from the first scouring bowl, containing about nine-tenths of the grease and potash, after standing about twelve hours to insure deposition of the sand, are evaporated in a pan until the liquid attains a sirupy consistency. The resultant liquid is then cooled in

[1] Industrial Organic Chemistry, 3d edition, Sadtler, page 306.
[2] Industrial Organic Chemistry, 3d edition, Sadtler.
[3] Public Health Journal. 1897.

shallow iron trays, and the grease which collects on top is removed at intervals. The semiliquid residue is then calcined in a brick oven and the heat produced from it is used to assist in the evaporation. A crude carbonate of potash is thus produced, which, after being completely carbonated, is boiled to dissolve out the potash salts. The solution is then concentrated to 100° Tw., the potassium sulphate and chloride crystallizing out on cooling. The potassium carbonate and grease obtained are sold.

In a recent type of machine—that of Emile Richard-Lagerie, of Roubaix, France—the wool is subjected successively to the action of liquors of diminishing strength, the last being clear water. The liquors, after having passed through the wool, are pumped into tanks for redistribution until they attain a density of 1.07, when they are evaporated and the residues calcined for the manufacture of potassium carbonate. Each machine is capable of dealing with about eight tons of wool per 24 hours.

The grease is extracted from the suds at the works of Alf. Matte & Co., Roubaix, by a mechanical process of "battage." The suds are, by means of a rotary agitator, beaten into a froth, which carries the fatty matters to the surface. These are skimmed off into conduits by a mechanical scraper, and are forced by a steam extractor into a wooden tank in which they are heated to 60° C. and treated with sulphuric acid in the proportion of 1 pound to 100 gallons. The acid is then removed by washing and the grease is filter-pressed.

In the establishment of Thomas Fox, Wellington, Somerset, the soapy liquors are led into 6 acidifying tanks and treated with sufficient acid to liberate the fatty acids. These on separating, together with the wool fat, are drained on sawdust filters. They are afterwards taken off and purified by distillation for conversion into soap again. The dilute acid from the acidifying tanks is pumped into intermediate storage tanks for further settlement, after which it flows into the precipitation tanks and is treated with the general waste waters from the works, by aluminoferric, sulphate, and lime.[1]

There has been a patent granted in England (No. 20433, October 29, 1895) for improvements relating to removing, recovering, or separating certain constituents from the suint and obtaining certain valuable products therefrom. The solvent employed in this process for treating the wool is a heavy petroleum oil (specific gravity, 0.837 to 0.878) at a temperature of 120° F. On cooling the resultant liquid to about 70° F. the cholesterol of the suint separates out as a heavy deposit, while the glycerides remain in solution. This solution is found to be an efficient agent in scouring the wool, leaving it in a condition suitable for the subsequent carding, etc. The wool is treated with the petroleum oil in an ordinary wool-scouring bowl fitted with pressure rollers. One-half to one gallon of solvent is employed for each pound of wool. After about twenty minutes' action the greater part of the liquid is drawn off, and the operation is repeated if necessary. The wool is then treated with water or neutral soap, rinsed, pressed, and dried. After filtration the liquid is cooled, the deposit is removed, and the clear solution used again. This solution may also be employed as a lubricant or for use on leather, and since it contains no free fatty acids, it would seem to be better adapted for either purpose than the analogous mixture of degras and petroleum oil.

Among the most valuable improvements in treating wool fat and producing products therefrom are those covered by a United States patent (No. 539386) recently granted to William D. Hartshorne, of Methuen, Mass., and Emile Maertens, of Providence, R. I. By the methods employed by these inventors 5 resultant products are obtained from wool fat. The object of the invention is to more thoroughly separate or divide wool fat into products possessing different properties and characteristics, so that the constituent parts of the wool fat, when obtained in a comparatively pure isolated state, are in the best form to be put to the various uses to which each is best adapted. This separation is considerably affected by temperature and by concentration of the solution from which and by which they are extracted. The fat products obtained are applicable to the following uses: (1) As a base for ointments and other pharmaceutical and toilet preparations on account of its penetrating, lubricating, and softening qualities. (2) As a leather and belt dressing, and, when freed from resinous matter, as a lubricant in conjunction with certain lubricating oils. (3) As a lubricant for wool and other animal fibers. This can be used to advantage to increase the specific gravity and viscosity of certain lubricating oils.

The inventors refer to wool fat as chemically a mixture or combination of cholesterin or its isomers or allied substances or alcohols with various fatty acids of resinous matters, and sometimes of such matters in a free state. The exact chemical relationship of these as they exist in the original wool fat on the sheep is, in the opinion of the inventors, very complex, and probably has never been accurately determined, and in the nature of the case may be indeterminable.

A number of patents have been granted of late years for cleansing wool by some solvent process. Among the important ones are those based upon the patents of Emile Maertens, of Providence, R. I., all of which relate to methods of treating wool and refining wool fat. The apparatus employed relates essentially to the economical removal and saving of the solvent adhering to the materials after their extraction, and particularly to the economical and safe treatment of wool with volatile solvents.

[1] Journal Society of Chemical Industry, vol. 15, page 47.

The process employed for degreasing wool is that of treating the wool in close digesters with the volatile solvents until a complete extraction is effected. One of the principal features of the process is the employment of compressed gas as a forcing or motive power to circulate the solvent through the wool under treatment. It is used to press the liquid solvent out of the wool as well as to blow out of it such solvent as has not been removed by pressure. It is also used as a heat-carrying medium to the wool and as a solvent vapor-carrying medium from the wool. It is furthermore used as an atmosphere wherein to carry on the extracting operation, both for covering the solvents in the reservoirs and for taking the place of the solvent removed from any part of the apparatus, and thus prevents the ignition of the solvent vapors by any electric or other spark which might accidentally be communicated to it; and since the gas is always moved in a closed circuit, it prevents the loss of solvent vapors, and can be used repeatedly without limit. It may be explained that the gas referred to by the inventor is an inert gas, or one which does not form explosive compounds with the vapors of the solvent used or with atmospheric air.

The great importance and growing appreciation of the solvent process of cleaning wool and preparing it for dyeing and spinning permits of special and more extended observations. Scientists and technical experts who have studied the wool fiber are unanimous in the opinion that it should be freed from its fat by means of volatile solvents, and not by the use of soapy and alkaline solutions, as has been heretofore the universal practice.

The earlier attempts to carry on the process of degreasing wool by means of volatile solvents were none of them successful from a commercial standpoint, although the rationality of the process was fully demonstrated in almost every instance by the superior condition of the wool thus treated. The problem was a very complex one to solve, requiring considerable mechanical engineering skill, knowledge of the wool fiber, of chemistry, due regard for the healthfulness and safety of the operation, and the blending of all these requisites into a system, the result of which would show a saving which could be expressed in dollars and cents.

In 1895 a plant for treating wool by the "solvent process" was put in operation by the Arlington Mills, of Lawrence, Mass., and was the first plant of its kind in the world that was commercially and technically successful. This plant has the capacity of degreasing 50,000 pounds of wool every ten hours, and has been run to its full limit ever since it was started. After an experience of six years with the solvent process, the Arlington Mills are now building a new plant to treat wool by this process which will have the capacity of degreasing from 200,000 to 250,000 pounds of wool every ten hours.

The saving effected by the "solvent process" to establishments that degrease and work their own wool for worsted purposes can be expressed in round numbers as averaging 2 cents per pound, figured on the greasy wool. This saving is made in the cost of the soap, which is entirely dispensed with by the new process; in a greater yield of the wool fiber since none of it is dissolved by soap and alkali; in a larger proportion of top to noil, because the wool, being free from any felting, cards and combs freely without breaking of the fibers or the making of nibs; in a larger production on cards, combs, drawing, and spinning machinery; in the superior softness and appearance of the finished product; in the wool fat recovered, and in the potash recovered. The cost of the degreasing operation, including labor, solvent, power, interest, depreciation, etc., is, it is estimated, more than covered by the soap saved.

The average amount of fat taken out of such wools as are worked in the United States is 15 per cent, which at the minimum price of 3 cents per pound represents 45 cents on every 100 pounds of wool degreased, and if to this is added also the value of the carbonate of potash recovered from the rinsing waters, which on an average amounts to 25 cents net per 100 pounds of greasy wool treated, we have 70 cents as the average minimum value of the by-products recovered from every 100 pounds of raw wool, or seven-tenths of a cent per pound of wool treated.

It is safe to say that from two to three million dollars worth of wool fat and potash are run down the streams and wasted annually in the United States. If this wool fat instead of being wasted were recovered, refined, or separated into its constituent parts, its value would increase at lease fivefold, and its uses would multiply. As the freighting expenses from some wool-producing districts to the mills or wool stores are often as high as 2 cents per pound, and average more than 1 cent per pound, for that part of the wool clip which is consumed in the Eastern and Middle states, and as the average shrinkage of the wool clip is 60 per cent, and and some wools shrink as high as 80 per cent, it will readily be seen that in some cases these freight charges amount to 10 cents per pound on the clean wool, and that they average 2½ cents per pound on clean wool. By establishing degreasing plants at the principal Western shipping points, millions of dollars worth of wool fat and potash could be recovered annually, and from 60 to 80 per cent of the freight charges, amounting to several millions of dollars more could also be saved. Such a plan, if it were feasible, would have the further advantage of putting the wool upon the market absolutely clean, free from further shrinkage, and in the most perfect condition for working. In having wool cleaned at the shipping points, some system of grading or sorting the wool according to its qualities would

necessarily have to be established in order to meet the requirements of manufacturing.

More progress has been made in the United States in the practical employment of the solvent process than in any other country. Plants have been recently erected in Belgium and Saxony, but not on so large a scale as exist in this country. The chief opposition to them is that of first cost, and the revulsion of manufacturers to to the giving up of old methods. The cost of erecting a suitable plant is undoubtedly a serious obstacle in the employment of the solvent process, and to bring the process within the scope of the industry this obstacle may have to be removed.

The application of wool grease in the leather industry is familiar. Some experiments performed in Europe and described in the Journal of the Society of Chemical Industry in its issue of February 28, 1898, in "stuffing" a number of samples of leather with a mixture of wool grease and tallow, showed that the neutral wool grease penetrated the leather better than other fats of the same consistency; that it left no sticky touch or ill odor; and that, in the case of chrome-tanned leathers especially, it gave a very good color.

Wool grease under the name of "degras" is very largely used for stuffing leather. The term "degras," as employed in the trade in the United States, and as used in paragraph 279 in the customs tariff—where it is spoken of as brown wool grease—applies to grease extracted from the wool of sheep. In general use, however, the term "degras" is applied to oils and greases used by tanners without any special distinction, including what is known as "sod oil." Sod oil and wool grease have entirely different constituents as well as characteristics, and hence should be easily distinguished. Wool grease is extracted from the wool of sheep. Sod oil is expressed or extracted from leather which has been curried with oils, particularly fish oils. Sod oil has no relation to wool grease in its derivation, but is related to it in its use; that is, for the currying of leather. Sod oil contains a resinous substance (not a resin) known as degras former, which is characteristic of sod oil. No other oil or grease (and this includes wool grease which is, scientifically speaking, an animal wax and not a grease at all) contains this degras former, which is therefore characteristic of sod oil.[1] Originally sod oil was called degras. Later, the term "degras" was made by the American oil trade to embrace wool grease, and was adopted less extensively by the English. The term has therefore come to embrace two substances, dissimilar in constitution, source, and chemical constants.

The amount of degras that was imported and entered for consumption into the United States for 1899-1900 was 13,263,480 pounds, valued at $285,486.47, duties paid.

The most useful by-product of the woolen industry is undoubtedly woolen rags that may be reconverted into wool. Before these rags were used for this purpose, they were either thrown upon the waste heap to become manure or collected and used for the production of prussian blue and an inferior grade of paper. No waste of this kind is now permitted, but every woolen rag, in whatever form it may appear, unless completely worn out, is reused in manufacture, to appear again in clothing. Such rags are used and reused until there is absolutely nothing left of them that can be utilized, when they are mixed with hoofs, horns, and the blood from slaughterhouses, and melted with wood ashes and scrap iron for material out of which the beautiful prussian blue is made.[2]

Shoddy has been a part of the woolen manufacture since about the beginning of the Nineteenth century, and its use is one of the necessary developments of the art of manufacturing, as, were it not for the supply from this source, there would not be a sufficient amount of raw material to meet the demands for clothing, except at very much increased prices over those that exist to-day.

Shoddy is not woolen rags ground to powder, but rags that are picked, leaving a good staple suitable for spinning. Some of the most substantial goods that are made, doing serviceable work for a number of years, contain a proportion of shoddy mixed with wool.

The largest amount of shoddy is utilized in the woolen industry of Great Britain; next to which comes that of the United States, where, in 1900, about 75,000,000 pounds were consumed, mostly in the manufacture of woolen fabrics, very little going into worsted fabrics, and that little placed upon the back of the goods, the worsted appearing upon the face. Practically all of the shoddy that is made in the United States comes from American rags. Only 314,597 pounds of wool waste were imported and entered for consumption into the United States for the year ending June 30, 1900. Very little of this consisted of rags, and still less of shoddy.

In recent years none but all-wool shoddy has been manufactured. During the Civil War and prior thereto much of the shoddy for low-grade goods consisted of that made from rags with more or less cotton in them, especially in the warp. The improvement in the manipulation of rags, particularly those that contain more or less vegetable matter, as cotton, is due to the methods of destroying the vegetable material by means of acids and high temperature, both of which are necessary. These methods come under the general head of what is known in the trade as "carbonizing," which

[1] Erastus Hopkins. Journal of the American Chemical Society June, 1900.

[2] Lord Playfair.

term applies strictly to the destruction of vegetable substances without essentially affecting the manufacturing qualities of the wool fiber. The shoddy thus produced goes under the general trade term of "extract," meaning simply that the wool fiber is extracted from its impure mixtures.

The acid commonly employed in carbonizing rags and making "extract" is sulphuric acid, in which the rags are allowed to soak for a short period of time and then subjected to a heat of from 200° to 210° in a close chamber, when the rags are removed and the acid neutralized by an alkaline bath, after which they are dried and shaken, the latter process converting all of the vegetable matter into dust. The rags, thus left with nothing but pure wool, are then sorted, picked in a machine known as the "shoddy picker," and otherwise treated in the same manner as original "all-wool" rags. The shoddy, or extract, that is thus made is absolutely clean and free from all deleterious matter, without the slightest possibility of conveying disease germs, and, in this particular, is freer than the wool obtained from many countries in the tropical and semitropical parts of the world. There is a process of carbonizing rags in which the dry system rather than the wet system (that of submerging the rags in a sulphuric acid bath) is employed. The acid used for dry carbonization is generally hydrochloric. There have been several patents taken out for the treatment of the rags by this process.

In 1896 an English patent was issued for an improved apparatus for carbonizing rags by the hydrochloric acid process, which, if allowed to act on the rags when perfectly dry, does not alter their color. Where the retention of color is essential the process is a valuable one, as by the wet process the colors are destroyed. By means of this improved apparatus the rags are placed in a perforated drum fitted radially with arms which do not reach quite to the center. A hollow shaft, which is heated in an adjacent chamber by means of furnace gas, enters at one end. Compressed hot air is allowed to enter the chamber containing the drum with the rags, either by way of the hollow shaft and through the rags or from the outside into the space surrounding the drum. In this manner the rags are perfectly dried. After the drying, hydrochloric acid is allowed to drop slowly from a funnel through the heated part of the hollow shaft into the drum, where it carbonizes the cotton in the rags.[1]

Preparation of acetone oil and ketones from wool washings is referred to in some of the European scientific journals.[2] A process is suggested for this purpose by making use of the volatile fatty acids contained in the liquid obtained by washing wool. The dry calcium salts of the volatile fatty acids thus obtained are distilled in the usual way, the yield being a mixture of ketones.

[1] English patent 25703. 1896.
[2] Review of Chemical Industries, 1898.

COTTON MANUFACTURING INDUSTRIES.

In the manufacture of cotton very little waste remains unutilized, but there have been great improvements of late in the methods for its more successful utilization for refabrication instead of being simply used for carpet linings, wadding, and batting. Nearly all cotton rags, and the same may be said of the linen rags, constitute valuable materials for the manufacture of paper. It is very difficult to destroy by mechanical means the physical identity of the cotton fiber. P. L. Simmonds, in his "Waste Products and Undeveloped Substances," goes so far as to remark that—

> In this utilizing age it can not reasonably be expected that a waste product, such as rags, which have been proved to possess a length of staple, when broken up, sufficient for the spinning of common stuff, will be much longer permitted to find its way exclusively to the paper mill. Like flock and shoddy, linen and cotton rags will be taken more and more from the paper maker, and raw vegetable fibers will have to be sought for or cultivated.

A large portion of the waste made in cotton mills, that is, such waste as has too short a staple for spinning, is used for such articles as batting and wadding. From this material 10,567,700 pounds of batting and wadding, valued at $864,016, were made during the census year of 1900.

COTTONSEED OIL INDUSTRY.

Closely allied to cotton manufacturing is the cottonseed oil industry, in which there has been a great revolution within late years in the utilization of the cottonseed, in obtaining most valuable commercial by-products, that were at one time allowed to go to waste with the seed in the form of manure. Cottonseed was a garbage in 1860, a fertilizer in 1870, a cattle food in 1880, and a table food and many things else in 1890.[3]

The manufacture of cottonseed oil and all of its resultant by-products furnishes one of the best examples of the development of a business based upon the utilization of a waste product.

The seed of the cotton plant, of which cotton oil is the fatty ingredient, was for many years a waste product of the cotton field. The first cotton-oil mill was established in 1837, but for many years after the business did not amount to much; in fact, the real advances in this industry have been made in the past twenty years, with the greatest development in the last ten years. Prior to the advent of the oil mill and during the interval of its development cottonseed was used in some localities as a fertilizer. Later on it was used to a certain extent as a cattle food; but the main proposition seems to have been how to get rid of the seed with the least trouble, and, in fact, laws were passed in certain states making it a punishable offense for ginners within certain limits of towns to allow cottonseed to lie around and rot, or to dump it into streams.

It is computed that as late as 1870 only 4 per cent of the seed produced (from a cotton crop of 3,011,996

[3] F. G. Mather, Popular Science Monthly, vol. 45, page 104.

bales) was utilized in the oil business. In 1890 this had increased to 25 per cent of the seed on a crop of 7,472,511 bales, and in 1900 it was 53 per cent on a crop of 9,645,974.

According to the census of 1900, the value of the entire cottonseed crop was 13.8 per cent of the total value of the cotton crop, including the value of the seed, while the value of the products from the manufacture of all the seed produced would have been 20.4 per cent of the total value of the cotton crop.[1] Thus it will be seen that the full benefit of the cottonseed product to the planting and commercial interests of the South is not yet fully realized; not within $26,000,000 on the size of a crop equal to that in the census year of 1900. The seed which is not worked up in the oil mills is used for fertilizing, feeding, and planting. It has been unquestionably demonstrated that for feeding and fertilizing purposes the product of the cottonseed, after expressing the oil, has a greater economical value than does the whole seed, so that eventually the entire seed crop will be worked through the cotton-oil mills, with the exception of the amount reserved for planting.

The seed-cotton is brought from the fields to the ginneries, and there the fiber is removed, leaving adhering to the seed a short fiber, known as linters, the removal of which is the first process through which the seed passes in the oil mill, after the seed has been cleaned of trash, bolls, etc.

Cottonseed as it comes to the mill has a waste, due to sand, trash, etc., amounting to from 1 per cent to 3 per cent. The clean seed consists of about 2 per cent of linters, 48 per cent of hulls free from lint, and 50 per cent meats. These figures vary with different seasons and different localities, but they show the average of a number of localities and seasons.

The process of separating the different component parts of the seed is practically a continuous one. At the mills the seed is received into large houses and there distributed by means of conveyors and elevators to different parts of the shed or to the mill proper. All seed is thoroughly cleaned of bolls, trash, nails, etc., before going to the delinting machines. These consist of fine revolving saws closely set together, which tear off the short fiber left on the seed as it comes from the regular cotton gin. This product of the oil mill, known as linters, varies considerably as to quality and the quantity obtained, depending upon the seed worked. The average amount of linters taken from a ton of cleansed seed is from 20 to 30 pounds. It is of fairly good color and is used largely in the making of mattresses, felt hats, pillows, etc.

The seed, after passing through the delinting machines, is run through the hullers, which cut the seed so that when dropped upon the shakers and passed through the beaters the meats are thoroughly separated from the hulls. A ton of seed yields about 1,000 pounds of hulls. Perhaps one of the greatest developments in the business during the past few years is the utilization of these hulls for cattle food. Previously they were considered a great nuisance around the mills, and in order to get rid of them the mills used them for fuel, the ashes being utilized for fertilizers, as they contain a large amount of potash. The feeding of the hulls is being recognized more and more every day, and from this has come a demand which has resulted in the baling and shipping of the hulls to great distances from the source of their production. There have also been developed, although not to any great extent as yet, processes for removing the fiber from the shell of the hull and making a fine paper stock from it, utilizing the bran in making mixed cattle food.

The separated meats pass from the shakers to rolls, where they are crushed, and from there they pass to cookers, where they are cooked to break up the oil cells. The cooked meats are then inclosed in camel's-hair mats and placed in hydraulic presses and subjected to a pressure of 2,000 to 4,000 pounds. The resultant crude oil is then pumped into settling tanks and certain impurities are allowed to settle out. The residue left in the press, after expressing the oil, is in the form of a hard cake. This is a most valuable by-product of cottonseed oil and amounts to about 725 pounds per ton of seed. The cake, either in the form of cake or after having been ground into meal (known as cottonseed meal), is used largely as a cattle food, or in the form of meal directly as a fertilizer, or as the principal ingredient in many prepared fertilizers. It is the best cattle food and fertilizer of any of the vegetable-oil cakes produced.

Mr. W. J. Booker, in "Flour and Feed," gives the following statement, based on a report of Prof. E. N. Jenkins, of the Connecticut State Experimental Station, showing the relative value of nitrogen, phosphoric acid, and potash contained in wheat bran, corn meal, linseed-oil meal, and cottonseed meal:

	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
2,000 pounds wheat bran contains	47.4	60.2	32.0
2,000 pounds corn meal contains	29.0	12.8	8.0
2,000 pounds linseed oil meal contains	106.0	38.8	20.2
2,000 pounds cottonseed meal contains	134.6	60.6	35.8

Taking the nitrogen at 17 cents per pound, phosphoric acid at 6 cents per pound, and potash at 4½ cents per pound (all of which are low valuations) gives the following as the manurial values:

	Per ton of 2,000 pounds.
Wheat bran	$13.03
Corn meal	6.04
Linseed oil meal	21.55
Cottonseed meal	28.04

In feeding, the animal retains from 5 per cent to 20 per cent of the above elements, so that, taking 20 per cent from the above values, and taking wheat bran at $22 per ton, corn meal at $24 per

[1] Manufactures, Part III; Report on Cottonseed Products.

ton, linseed oil meal at $28 per ton, and cottonseed meal at $27 per ton, after deducting the cost of the manure, it costs to feed—

	Per ton.
Wheat bran	$11.57
Corn meal	19.16
Linseed oil meal	6.45
Cottonseed meal	4.56

It will be seen from the foregoing that cottonseed meal contains, by a large percentage, a greater amount of nitrogen (protein) than any other food. It is, in fact, the most concentrated, cheapest, and most nutritious of foods, and in feeding, mixing it with bran, middlings, hulls, or other feeds, it produces an ideal cattle food. The tendency of the times is toward more scientific feeding, and the utilization of cottonseed meal, with its high percentage of flesh-forming properties, makes a great advancement over the old method of feeding the whole seed.

The foregoing products are all incidental to the production of crude cottonseed oil. The crude oil is allowed to stand in settling tanks for a number of hours, and is then ready for the refining process. There is obtained from a ton of seed approximately 275 pounds of crude oil. The oil varies in quality considerably, depending upon the condition of the seed and the locality from which it comes. It will vary in color from a light brown to a deep black. It contains varying proportions of red coloring matter and free fatty acids, depending upon the care with which the seed has been handled and the oil produced. The free fatty acids will vary from 0.4 per cent to as high as 30 per cent, but the average is in the neighborhood of 2 per cent.

The real advancement of the last twenty years in the cotton-oil industry has been made by the refinery. While there have been many improvements in the machinery of the crude oil mills, the process is to-day practically what is was many years ago, but when we turn to the refinery, the tremendous strides which have been made in the improvement of the refining methods result in a product so superior to the article produced years ago, that industries utilizing the oil, on account of this improvement, can use greater quantities of the oil than ever before.

Crude cottonseed oil, after its first process of refining, comes out in the shape of a clear, brilliant, yellow oil, known as summer yellow oil, having a specific gravity at 15° Centigrade of .92. Owing to the deterioration of the seed and to inferior methods of manufacture, all crude oil does not produce yellow oil of the same grade. The trade has classified summer yellow oil as choice, prime, off, and soap oil, the difference in these grades being in the color and flavor. Choice oil is a light lemon-colored oil, without any suggestion of red, and is mild and neutral in flavor. Prime oil is slightly darker in color and sweet in flavor, without any seedy flavor. These two grades are used for edible purposes. The off and soap grades of oil are reddish in color and the flavor is very poor, due to bad seed, mustiness, etc. This oil is used for mechanical and soap purposes.

As intimated before, the amount of the different grades of oil produced depend largely upon the condition of the seed. It has varied from about 85 per cent to 35 per cent of choice and prime oil, and from 15 per cent to 65 per cent of off and soap oil.

With the improved refining methods of the past ten years has come increased demand and use for refined cottonseed oil. Summer yellow oil forms an important basis for a number of different products after being submitted to various processes, such as bleaching it to make it white and pressing it to extract the stearin.

One of the principal uses and development of cottonseed oil contingent upon the improvements in refining methods in the past decade is that of the manufacture of lard compound—a mixture of lard, oleo stearin, and refined cottonseed oil—making a most palatable and economical food. Another product of cotton-seed oil, white cottolene, is a mixture of oleo stearin and specially processed cottonseed oil, marking, perhaps, the highest development of cotton oil as a food product.

Cotton oil is also used in the making of salad oils, packing sardines, in the oleomargarine industry, for miners' burning oil, cathedral burning oil, tempering oil, oil for heavy tool-cutting machines, mixing with putty, and, while not exactly a drying oil, yet for rough painting the crude oil can be and is used to a considerable extent. The cheapness of cotton oil compared with other fats, as well as its excellent soap-making properties, has caused it to be largely used by soap makers, both in America and abroad. It is also used in the manufacture of washing powders. Cottonseed oil is used to-day to a great extent by bakers. It is also used as a substitute for olive oil. Chemists and physicians now recognize cotton oil as a high-class food product.

In the refining process there is produced a loss amounting on an average to about 10 per cent of the crude oil. This forms an important by-product of the cotton-oil industry. This substance is known as soap stock, or foots. It has a fat acid content of from 40 per cent to 50 per cent, and is composed of free oil, coloring matter of the crude oil, and soap caused by saponification in the process of refining. It is used in making wool-scouring soaps and cheap grades of laundry soaps. It makes a most excellent soap. There is also produced from this substance glycerin, candle stock, olein, still pitch, etc. The number of uses of this last, though by no means least, by-product of the cotton-oil industry emphasizes the many uses to which this oil and its various products are put. It is of course impossible here to elaborate upon these, or even to fully enumerate them.

It should be borne in mind in dealing in or describing cottonseed products that in no two seasons are the con-

ditions exactly alike, and the quality and quantity vary so much, that it makes it a constant study and a most interesting business.

THE LEATHER INDUSTRY.

In the making of leather very little is allowed to go to waste. In 1896 a patent (No. 13,096) was granted in England for making leather-board material, suitable for being pressed into form for decorative and other purposes, or for use in substitution for leather floor cloth and the like, the waste of leather alone being used. Waste fibrous material and the wax, oil, albuminous and extractive matter derived from cottonseed and shell are made into a pulp, boiled together with silicate of soda, and the whole precipitated by the addition of milk of lime. The alkaline liquor is then drained off from the precipitate. Waste leather or other animal substance is separately treated with sulphurous acid, and then added and thoroughly mixed with the first-obtained pulp, together with tanning agents or chromium compounds. The mass is then made into boards, or pressed or molded as desired.

Among the side products of the tanning of leather may be mentioned the following: Spent tan and tan liquors; waste liquors containing lime salts; scrap and skin for glue manufacture; hair, sold for cheap blanket and cloth manufacture, or for use with lime in plaster; scrap for glue manufacture, and refuse washings. These side products are obtained in the conversion of softened hides into finished sole-leather sides.

Degras, which has been referred to in connection with the woolen industry as being obtained from wool grease, is also a by-product of great value in the leather industry, and a great demand for this material for currying purposes has led to the manufacture of it as a special industry. In this process the skins are treated exactly as in the manufacture of chamois leather, being used repeatedly until no longer capable of taking up the oil. The supply from this source is not sufficient for the demand, hence an artificial degras is sometimes made from oleic acid, fat, and a little lime soap to which some tannic acid has been added.[1]

Scraps of leather are now converted by means of a special apparatus into boot and shoe heels, as well as other things, such as inner soles, etc. Some of the small bits of leather are utilized for what is called "shoddy leather," which is made by reducing the bits to a pulp by grinding, and by maceration and conversion into solid "sides" of leather by pressure. This is used to a considerable extent as inner soles for shoes and boots. If leather scraps can not be used for any better purpose, they are utilized in the manufacture of glue.[2]

[1] Industrial Organic Chemistry, 3d edition, S. P. Sadtler, page 335.

[2] Waste Products and Undeveloped Substances, P. L. Simmonds.

THE DYEING INDUSTRY.

There are many by-products used in the dyehouse and in the dyeing industry which have contributed largely to the great progress that has been made in manufacturing within the last one or two decades. Of these by-products the most conspicuous and valuable are those obtained from coal tar or gas tar, which, not many years ago, was a waste material difficult to get rid of. It could not be thrown into streams because of its polluting the waters, nor could it be disposed of by burial because of its destructive effect upon vegetation, and had to be disposed of by burning.

These by-products have now become of the highest value, not only for the production of exquisite dyes, but for medicines and disinfectants, and for the production of a saccharine substance several hundred times sweeter than sugar. The list of uses to which these materials can now be converted is a long one. Naphthalene, one of the products of gas tar that was formerly a troublesome waste, choking gas pipes and otherwise making itself obnoxious, is now one of the most valuable substances for the preparation of dyestuffs. The manufacture of alizarin, an artificial preparation of the by-products of tar, has destroyed the madder industry of Europe, or practically so. The aniline by-product of gas tar is a most productive source of coloring matter, its derivatives being almost without number, and producing every shade of color imaginable. By means of a synthetic process, certain constituents of coal tar can be combined for the production of artificial indigo equal in all respects to natural indigo, at a cost that makes it an article of much commercial value. Naphtha is a well-known product of coal tar used in dissolving gums, resinous substances, etc., india rubber and gutta-percha, and for many other purposes. Perhaps the most important products of this tar are benzol, from which aniline colors are obtained, naphthalene, and anthracene, from which alizarin and purpurin are obtained.

The primary object of the coal-tar color industry has been to supplant dyewood extracts by artificial products. The manufacture of synthetic indigo is perhaps the highest attainment yet reached in this line, one involving great scientific research of immense commercial and industrial importance to textile manufacturing. It is thought by chemists that the greatest promise of ultimate success in supplanting dyewoods lies in the development of the azo-dyes as completely as artificial alizarin has supplanted madder. For most purposes, more especially for the dyeing of cotton, the dyewoods may already be dispensed with, since artificial substitutes give superior results and are more easy of application.[3]

Where dyewoods are used, large quantities of them remain after the coloring matter has been extracted and

[3] Chem. Zeit., 20, 53–54.

are thrown away as useless, though this is not carried on to so large an extent now as was formerly the case. In France and in some other of the European countries, this apparently useless product is mixed with tar refuse and formed into compressed cakes for fuel. It is said that a large factory at Havre made at one time such utilization of their spent dyewoods. This firm produced about 120 tons of agglomerated wood per month. The product was distinguished by the relatively small quantity of coal tar (25 to 30 per cent) which they used, as well as by the low price at which they were able to sell it as compared with other artificial wood fuel. They produced also pyrolignite of iron and wood acids, but afterwards gave into other hands the utilization of the waste residues of their manufacture, as it tended to interfere with their principal product.[1]

Before 1870, after concentrating the coloring matter from the dyewoods, less than a dollar per ton could be obtained for the exhausted wood as a combustible, and in most cases it was thrown away as an absolute waste, so far as any use could be made of it for industrial purposes. The rational application of applied science turned this waste into a useful product. M. Chaudet, an ingenious chemist at Rouen, began to utilize this waste in a practical way, and obtained from the exhausted dyewoods various products of a commercial value. One of the most important was a paper pulp obtained by separating the incrusting substances. These, in their turn, combining with the chemical agents by which they were extracted, furnished a useful soda soap adapted to use in cotton printing. It is stated that some of the residual deposits, resulting from the exhausted campeachy and fustic woods, can be utilized in steam boilers for preventing calcareous deposits. The researches of Chaudet led him to discover that the wood of the chestnut and the beach yielded almost colorless mordants, preferable in many respects to those obtained from the ordinary dyewoods. It is claimed that the spent bark of tanneries submitted to a hydraulic press might be employed with equal advantages as an economical fuel and the derivatives made by distillation usefully applied.[1]

The waste liquors in indigo dyeing are capable of being saved and reused. It is reported that at the works of the Pincroft Dyeing and Printing Company, Adlington, Lancashire, England, the waste liquors containing indigo in suspension are passed into precipitation tanks, receiving on the way between 10 and 15 grains of lime per gallon. The precipitated indigo is raised by an ejector from the bottom of the tanks and blown into the different vats to be used again.[2]

During the fiscal year ending June 30, 1900, there were imported and entered for consumption in the United States coal-tar colors and dyes to the value of $4,792,103.09, upon which duties were paid to the amount of $1,437,630.93.

The production of ammonia from animal matter is insufficient to meet the wants of the present day. Fortunately the deficiency of the supply from this source is met by an inexhaustible supply from the vegetable world, or from the plant life of former periods. In the bituminous coal fields and in the deposits of brown coal is stored up an unlimited supply of nitrogen capable of being converted into ammonia, which is now obtained incidentally in the production of illuminating gas, of coke, and of animal charcoal, the supply depending upon the extent of these industries. This is likely to prove something of an industrial embarrassment, as the consumption of ammonia has grown enormously during the last thirty-five or forty years, while on the other hand the manufacture of illuminating gas, upon which the main portion of the supply of ammonia depends, has been seriously affected by the introduction of electricity for illumination, and is likely to be further affected.

Coke production combined with the saving of the by-products is an established industry in Europe, and is increasing in the United States. The question, Will it pay to gain the by-products of the manufacture of coke? is no longer pertinent. The answer to this question has been practically solved in the affirmative. Coke production is the basis of the tar-color industry, and will further the growth of the soda industry based on the ammonia process. But it is not advocated that the production of coke should be only for the gain of ammonia; the higher yield of coke, the recovery of the tar, with the daily increasing demand for the same, and the gain of the ammoniacal water are the inducements held out by the new methods of production.[3]

A new and interesting development in the chemical industry of the United States is the utilization of the sulphuretted hydrogen gas developed as a by-product in the refining of asphaltum at the California Asphaltum Company's works at Ventura, Cal. The gas is burned to sulphurous anhydride in the usual manner, and the product of the combustion conveyed to the lead chambers. Owing to the method of its production, the gas is of a high degree of purity, and the acid produced is also of a high grade. At present the output amounts to 10 tons per day when the works are running at their full capacity. Sulphuric acid is made on a large scale at one other plant, while the manufacture of bluestone and boracic acid, carbonic acid, epsom salts, magnesia, and numerous other products is now carried on. The state of California has great natural resources upon which to base an important chemical industry, and its geographical position gives it an

[1] Waste Products and Undeveloped Substances, P. L. Simmonds, page 219.

[2] Journal of the Society of Chemical Industry, January 31, 1896.

[3] Dr. Bruno Terne's address before the chemical section of the Franklin Institute, Philadelphia, October 20, 1891.

advantage in suppying certain markets of the Pacific slope, so it is probable that such an industry will grow up there when the transportation problem is settled.[1]

SILK.

There is a large amount of waste made in the manufacture of silk which at one time was considered of comparatively little value. Now the reworking of waste silk has become an important and profitable industry. At the Dublin Exposition of 1865, a concern of Milan, Italy, showed some silk waste carded by hand and power, and spun into yarn, that attracted a great deal of attention, and was the subject of interesting comments in the technical journals of that time. Silk-waste carding, however, was not an altogether new industry in Italy at that period, as there were then 10 or 12 manufacturers, employing upward of 2,000 men, women, and children, engaged in this occupation, with an annual production estimated at about 400,000 pounds. At the Paris exposition of 1867 the attention of the French jury was drawn to some exhibits in this line that were made at that time, and interesting mention was made of them in its report.

STARCH INDUSTRY.

There are a number of by-products produced in the manufacture of starches from cassava, potato, corn, wheat, and rice. By-products in the manufacture of rice starch are the rice hulls, which are used mainly as fuel and packing material, but are also ground up and used for the adulteration of spices and the higher grade feed stuffs. As a food product they are of little value, on account of their indigestibility and excessive amount of fiber. Pure rice starch is not made to any great extent, the rice flour being generally sold as rice starch.

Wheat starch is generally made by one of two processes: (A) Wheat flour is made into a dough and the starch washed out in suitable machines, the gluten conglomerating and separating as a tenacious, sticky mass. This is dried and forms the wheat gluten of commerce. It is used as a food article or as a mixing product to raise the percentage of proteids in low-grade feeds. Its utilization is still in its infancy, and its application to the arts is in the experimental stage. (B) Wheat flour is allowed to sour or ferment, and then the starch is separated mechanically on starch runs, the gluten being taken off as a thin fluid, which is generally not recovered. If recovered, it is dried and gives a product similar to that made in process A.

The cassava-starch industry is confined to Florida. The manufacture is still in the experimental stage, and no reliable data are at hand.

For potato starch the potatoes are peeled and ground and the starch washed out and separated by mechanical processes. The by-product is potato slop, which is used as a cattle food in the immediate vicinity, in a wet condition. The potato and cassava industries are of small importance.[2]

Corn starch.—About five-sixths of the starch manufactured in the United States is made from corn, the daily maximum consumption being about 180,000 bushels, yielding 2,500,000 pounds of starch and 4,000,000 pounds of glucose or sugar. From a manufacturing standpoint the kernel consists of four parts: Starch, gluten, germ, and bran, of which the gluten, bran, and germ are by-products. These by-products are separated by mechanical means, the process being somewhat as follows: Corn is soaked in moderately warm water for from twenty-four to sixty hours, to which a very small amount of sulphurous acid has been added to prevent fermentation and to loosen the intercellular tissue between the starch and gluten cells. The excess of soak water is then run off and the wet corn ground in such a way that the germs are loosened without being cut up or broken. The whole mass is then run into separators, where the free germs are floated off as wet germs. These are dried in suitable driers, then ground to a flour and the oil extracted by hydraulic pressure, leaving the corn oil cake as a by-product. This product forms one of the staple cattle foods, and contains about 24 per cent protein and 10 per cent fat. The nutritive and digestible properties are very high. Ground oil cake is known as germ oil meal. The average production is about 2 to 2½ pounds per bushel. Over 50 per cent of it is exported.

The corn mass, free from the germs, is then ground very fine and run over bolting-cloth sieves. Here the bran of the corn is separated and remains on the sieves. The product that remains in the bolting-cloth sieves is pressed, and, combined with about 50 per cent of water, is sold for immediate consumption. It is known by various names, as "glucose food," "slop," "corn food," "sugar food," etc. It heats and quickly deteriorates in the wet condition, but can be preserved for a time during hot weather by salting. This same product dried is known as "corn bran," "dried glucose," or "sugar food," or some fancy name. The food is easily digested and competes directly with wheat bran. Its composition is about 11 per cent protein and 3 per cent fat. Mixed with the gluten meal described below, it forms gluten food. The yield per bushel is about 4½ pounds.

The substance passing through these sieves, mentioned above, is a mixture of starch and gluten. The starch is separated by gravity from the gluten, the mixture being run over long level planes, as starch tables, runs, or gutters, where the starch settles out as a firm mass and the gluten passes away at the ends. This gluten is settled and gives what is termed wet gluten. The starch taken from the tables is used as

[1] The Engineering and Mining Journal, 1899.

[2] Bulletin No. 58, Department of Agriculture: The Manufacture of Starch from Potatoes and Cassava, by H. W. Wiley, Ph. D.

the raw material for the manufacture of the various grades of commercial starches, or it is treated with acid and converted into the various grades of glucose or grape sugars. The wet gluten pressed and dried forms gluten meal, the composition of which is, protein 38 per cent, fat 3 per cent, and starch 40 per cent. This is one of the richest and best food products on the market. The nutritive value is very high, and the factor of digestibility ranges from 92 to 96 per cent. The yield per bushel of corn is about 5½ pounds. The gluten meal is treated for the recovery of its starch, and gives two new products, a concentrated food stuff, characterized by the large amount of proteids (60–70 per cent) it contains, and a maltose sirup. This food stuff is suitable for human consumption, and also for raising the percentage of proteids in foods that have a small amount of these substances. When the wet bran and the wet gluten are mixed in the proportions as obtained from the original corn and the mixture dried, the resulting food is known as gluten. This is the most common food product in the starch and glucose industry, and represents about 80 per cent of the food output. Its feeding value is very high and its digestibility above 90 per cent. Its composition is about 28 per cent protein and 3 per cent fat.

Corn oil cake and gluten meal are exported extensively. The bran and gluten food is used almost exclusively in the United States. The production per bushel of corn is about 12½ pounds of food, giving a maximum daily production of from 1,200 to 1,300 tons, valued at $25,000.

OLD RUBBER.

Old rubber as a waste material is a thing of the past. Nothing containing rubber is discarded, but is utilized in some form of commercial utility. One thing that formerly rendered rubber comparatively valueless was because of its being vulcanized, which rendered it of little use for remanufacture, due to the fact that it could not be remelted for mixing with new gum because of the sulphuric treatment it had received. This difficulty is now overcome, and the old rubber is blended with the new in certain proportions with good results, enabling the manufacturer to reduce materially the price of his goods. Old rubber can be utilized, however, without being mixed with new material, by being steamed, passed between rollers, and in this softened condition applied to a strong, coarse fabric, or used for such purposes as stiffening the heels of boots.

In 1890 (United States Patent No. 420,820) a patent was granted to N. C. Mitchell, of Philadelphia, for a process of restoring rubber, with special reference to the treatment of rubber waste, such as old boots and shoes, for the purpose of recovering therefrom the rubber as a marketable product. By this process the old stock, after being ground between rolls and freed from foreign matters, such as metal, sand, and fiber, is exposed to the action of heat, preferably steam heat, for the purpose of devulcanizing and desulphurizing the rubber. The steam acts mainly in softening the rubber and has but little effect in removing the sulphur. The inventor of the process discovered that desulphurization may be effected by mixing with the rubber small quantities of sulphide of calcium previous to the treatment with steam. When calcium sulphide is used alone, a very high degree of heat is required to effect desulphurization, which high degree of heat dries the rubber to an injurious extent. It is therefore desirable to mix with the calcium sulphide some substance which will keep the rubber in a moist condition. For this purpose heavy petroleum is used, usually in the proportion of 7 pints of the mixture of petroleum and sulphide calcium to 200 pounds of rubber scrap. Seven pints of the fluid contain one-fourth of a pound of the sulphide.

BREWERIES.

A patent was taken out in England in 1897 (Patent No. 3900) for a process to utilize the solid refuse of breweries, distilleries, starch and sugar factories, and the like. In the process described the refuse is treated with soda lye, and the pulp produced mixed with different kinds of finely powdered resins. The lye is then washed out with water, the remaining water is pressed out, and the residual mass is dried in a vacuum drying apparatus and finally pressed in molds while warm. The material is then claimed to be ready for use as laths, panels, wall coverings, etc.

The exhausted mash-ton grain in breweries is used for cattle food, and, while containing too much protein to be used alone, it is regarded as a most valuable food when mixed with hay. The amount of dry grains produced in breweries in the United States is estimated at 300,000 tons a year, and is all sold for cattle feed. Some breweries collect the carbonic-acid gas, that results in the process of fermentation, for soda water. There are consumed in the neighborhood of 50,000,000 pounds of hops annually in the United States in the manufacture of beer. These hops when they become exhausted are a veritable waste, and are buried or thrown on the refuse heap.

TIN AND MUSSEL SHELLS.

Among the materials used in the production of buttons are the remnants of the sheets of tin plate from which the bottoms and caps of cans for blacking and other boxes have been cut. After the button blanks have been punched from these tin remnants, the scraps which are left are made into sash weights. Another article that was considered of little or no value ten years ago is the fresh-water mussel shell, which is now extensively used in the manufacture of buttons. These shells were used in the button industry of the United States in 1900 to the amount of 4,830,112 pounds at a cost of $238,046.

GLASS.

Broken glass is now being utilized in the manufacture of artificial stone as a building material, which has been tested in France with apparent satisfaction. The material is known as ceramic stone. The broken glass is first ground to a powder, and then devitrified by passing it through two furnaces, the second at a very high temperature, when the pasty mass is pressed, thereby acquiring form and solidity.[1]

ASHES, ETC.

An artificial stone is said to be made in Germany of sifted ashes, potash, and other alkaline carbonates, gypsum, and slaked lime. It is said that this stone is not affected by atmospheric conditions. This mixture of sifted ashes and other materials is mixed with diluted sulphuric acid and hydrated sulphate of lime, forming potassium sulphate, which dissolves, leaving a plastic mass of gypsum to be molded by compression into the desired forms. To remove any alkali that may remain in the stone, it is immersed in a solution of alum acidified with sulphuric acid; the alum is decomposed and alumina formed, and this still further hardens the stone.[2]

CORN PITH.

Among the uses of waste products may be mentioned the application of the pith of the cornstalk to naval and military uses for the protection of vessels, forts, or other structures from the injurious effects of collision, projectiles, or otherwise. Efforts have been made from time to time, for many years, for some means of readily and effectually closing openings made in the hulls of vessels by collisions or projectiles. Different substances have been proposed, and some have been adopted, that have proved more or less serviceable.

Masses of cork or other light material have been used, extending to the water line of the vessel, so that in the event of the place being pierced by shot, no more water could enter than would fill the place traversed by the shot, and thus the buoyancy of the vessel would be but slightly interfered with. The amorphous cellulose of the cocoanut has been used with advantage as a barrier or cushion to protect vessels, forts, and other structures. The discovery that a material can be prepared from the pith of cornstalks, which possesses in a high degree all the qualities desired, was made by Mark W. Marston, of Philadelphia.[3] He found that this substance had a capacity to absorb water or moisture of over twenty times its own weight, which exceeds the absorptive capacity of any known substance capable of like uses. Further, the rapidity with which the water is absorbed by this substance is said to be greater than that shown by any other; thus a compressed body of this material will absorb water to fully one-half its capacity, or ten times its weight, almost as soon as water is brought into contact with it. The inventor found that if the substance were dried after being saturated, it substantially returned to its former condition and acted as before on again being wet.

GLYCERIN.

In the manufacture of soaps a large portion of the glycerin contained in the oils and fats employed passes into the salty lye which is left at the end of the operation. A method has been suggested[4] for recovering from this waste, glycerin in a sufficiently pure condition for commercial purposes, ready for use without further treatment. The method employed consists in first treating the lye with an acid to neutralize partially the free alkali of the solution, and then to add sulphate of iron or sulphate of aluminum to complete the neutralization, and the precipitate is filtered or otherwise separated out. Evaporating is then employed to crystallize out the salt, and finally the resultant liquid is distilled to obtain the glycerin.

The wash resulting from the distillation of wine, molasses, beet root, and, speaking generally, from any alcoholic fermentative, contains glycerin, which is formed during the alcoholic fermentation at the expense of the sugar. A process of recovering the glycerin from these residues is a recent invention of a Frenchman.[5] The process consists in concentrating the wash by evaporation and treating it with an agent to neutralize the free acids contained therein, then subjecting the wash thus treated to the action of steam to carry off the glycerin contained therein, and finally condensing the glycerin. Aside from obtaining glycerin from the residues left from the distillation of wines and similar materials may be mentioned other by-products, such as ammonia, tars, and salts. A process for the utilization of distillers' wash is the subject of another French invention patented in this country.[6]

PRINTERS' INK ROLLERS.

There are now improved means of utilizing waste portions of printers' ink rollers, which have heretofore possessed but little commercial value, for the recovery of glycerin from the residuum of a process of distillation.[7]

POWDERED MILK.

The manufacture of powdered milk has become in late years an industry of considerable importance. The main difficulty heretofore has been that milk could not be shipped to countries where it was scarce, owing to

[1] Journal of the Society of Chemical Industry, vol. 16, page 44.
[2] English patent 20612. 1897.
[3] United States patent No. 534611. 1895.
[4] United States patent No. 458647. 1891.
[5] United States Letters Patent No. 631396. 1899.
[6] Letters Patent No. 669812. 1901.
[7] United States patents Nos. 635821 and 649169.

the fact that even in the condensed form it would keep but a short time. In very hot climates it is almost impossible to use condensed milk, as, after a can is opened, it has to be consumed almost immediately. Condensed milk also contains a large percentage of sugar and water, which add to the expense of freight. In powdered milk there is no water and absolutely no foreign matter, no chemicals being used in the process of manufacture. The product is made from sweet skimmed milk, by a process of simple evaporation. Not until lately, it is believed, has a milk powder been manufactured which would remain soluble, owing to the action of the heat upon the albumen, but in the process now in use the heat is so regulated that there is obtained a perfectly soluble product with almost no odor, and by adding the required amount of hot water a perfect skim milk is obtained. This solution may be precipitated by rennet in the same way that ordinary skim milk is precipitated, or, if allowed to stand for some time, it will sour in the same manner.

CORN OIL.

Corn oil is a valuable by-product of breweries, distilleries, and starch works. It is adapted for illuminating purposes, and the claim is made that it may be advantageously used for dressing wool, and also as a machine oil, and in the manufacture of soap. It might, in certain cases, be applicable as a lubricant, its low acidity and little tendency to deposit solid matter or to "gum" being properties that recommend it for this purpose. Donard and Boulet, at their works at Bapaume-Les Rouen, France,[1] have treated during the last seven years about 28,000,000 pounds of corn cake, from which 7,700,000 pounds of oil were extracted. Corn oil is the most valuable product obtained from the corn kernel in the manufacture of starch, being worth more than the main products—starch, glucose, or grape sugar. Corn oil can be treated with sulphur (vulcanized), giving a product similar to rubber, which is used to mix with rubber for the manufacture of all kinds of rubber goods. The oil itself is used in paints. It is a nondrying oil, very stable, and does not become rancid. The characteristic taste and smell are eliminated through refining. Seventy-five to 80 per cent of this oil made in the United States is exported.

The maximum daily production of corn oil in the United States is about 275,000 pounds, worth $16,000. The value of the by-products, feed and oil is about 20 cents per bushel of corn.

[1] Journal of the Society of Chemical Industry, vol. 16, page 550.

PATENTS IN RELATION TO MANUFACTURES.

PATENTS IN RELATION TO MANUFACTURES.

By Story B. Ladd.

The discoverer of new products of value in the arts and the inventor of new processes or improved machines, adds to the public wealth, and his right to the product of his brain is now recognized by the laws of all civilized nations.

The patent system of England had its origin in royal grants, to favored subjects, of monopolies in trade or manufacture. The evils arising therefrom became most oppressive during the reign of Elizabeth, under whom the most common articles of consumption were subjects of monopolies. In 1603 James I, upon his accession, rescinded all such exclusive privileges restricting domestic commerce, the foreign commerce still remaining under the control of the great merchant companies. Finally, in 1623, the statute against monopolies was enacted, which, sweeping away all monopolies, granted—

> The sole working or making of any manner of new manufactures within this realm, to the true and first inventor and inventors of such manufactures, which others at the time of making such letters patent and grants shall not use, so as also they be not contrary to the law nor mischievous to the State, by raising prices of commodities at home or hurt of trade or generally inconvenient.

Patents were early construed by the English courts with a leaning against them; but in the course of time, through a series of judicial decisions, the law was broadened and expanded. Prior to the nineteenth century, the number of patents granted in England was comparatively few, and, as in the United States, it is only within the last half century that the number of patents has assumed large proportions. The number of patents granted in the six reigns preceding that of George III was only 540 in eighty-five years, or an average of a fraction over six per year. At intervals of fifty years the number of patents granted in England during the year were as follows:

1650	None.
1700	2
1750	7
1800	96
1850	523

Prior to the adoption of the Federal Constitution, patent rights in this country rested upon the statute of James I, and the rights and remedies recognized by the common law before the enactment of said statute. A few patents for inventions were granted by the provincial governments of the American colonies, and by the legislatures of the states, prior to the adoption of the Federal Constitution, though it should be remembered that during the colonial period invention was stifled by the fixed purpose of Great Britain to prevent and suppress manufactures in the colonies and to foster and encourage manufactures at home.

McCulloch, in his Commercial Dictionary, says it was a leading principle of England, in her colonial policy, "to discourage all attempts to manufacture in the colonies such articles as could be provided for them by England."

Bancroft, in his history, says that England in her relations with other countries sought a tariff for the protection of her manufactures, while "in the colonies she prohibited industry. Every branch of consumption was, as far as practicable, secured to English manufacturers; every form of competition in industry in the colonies was discouraged or forbidden."

The following summary of the early patented inventions, so far as data concerning them is obtainable, will be of interest in a study of the growth of inventions in this country:

MASSACHUSETTS.[1]

YEAR.	Inventor.	Invention.	Term.
1641	Samuel Winslow	Method of making salt.	10 years.
1646	Joseph Jenks	Scythe	14 years.
1652	John Clark	Saving wood and warming houses at small cost.	3 years; extended during his life.
1656	John Winthrop (son of Governor Winthrop).	Method of making salt.	20 years.

[1] Reports of Commissioner of Patents, 1849–1850.

The grant of 1641 appears to have been the first made by any of the colonies for an invention, though it is by no means certain that the method was an invention. It may have been an importation of a process, as in many cases special privileges were granted to secure the establishment of new industries in the colonies. If this is the case, the patent to Joseph Jenks of 1646 is the first patent granted to an inventor in America.

NEW HAMPSHIRE.[1]

YEAR.	Inventor.	Invention.	Term.
1786	Benj. Dearborn	Printing press	14 years.
1787	Benj. Dearborn	Hand engine for throwing water.	14 years.
1787	Benj. Dearborn	Balance or scales	14 years.
1788	Oliver Evans	Elevator for flour mills	14 years.
1788	Oliver Evans	Hopper boy for flour mills	14 years.
1788	Oliver Evans	Steam carriages	14 years.
1789	Oliver Evans	Elevator	7 years.
1789	Oliver Evans	Hopper boy	7 years.
1791	John Young	Chimney	14 years.

[1] Reports of Commissioner of Patents, 1849–1850.

No patent for an invention was granted by the provincial government of this colony. In the patents to Oliver Evans of 1788 and 1789, the state reserved the right to abolish the exclusive privilege upon the payment of £2,000; and the grant to John Young in 1791 provided that the state patent should be void in case a patent was obtained from the General Government that covered the state, this being subsequent to the United States patent act of 1790.

CONNECTICUT.[1]

YEAR.	Inventor.	Invention.	Term.
1717....	Edward Hinman.....	Making molasses from cornstalks.	10 years.
1718....	John Prout et al.....	Making linseed oil.....	20 years.
1719....	John Prout et al.....	Making linseed and rape oil.....	20 years.
1722....	Ebenezer Fitch.....	Slitting mill	15 years.
1725....	Richard Rogers	Making duck	7 years.
1728....	Samuel Higley and Joseph Dewey.	Making steel.....	10 years.
1740....	Thomas Fitch et al ...	Making steel.....	15 years.
1741....	Samuel Willard et al..	Making potash.....	10 years.
1747....	Thomas Darling.....	Making glass.....	20 years.
1753....	Jabez Hamlin et al ...	Flax dressing.....	15 years.
1766....	Abel Buell	Method of grinding and polishing crystals and stones.	(2)
1783....	Benjamin Hanks.....	Self-winding clock.....	14 years.

[1] Reports of Commissioner of Patents, 1849-1850.
[2] He had been convicted of forgery, but was restored to all liberties and privileges on account of his invention.

NEW YORK.[1]

YEAR.	Inventor.	Invention.	Term.
787....	John Fitch	Steamboat	.....

[1] Reports of Commissioner of Patents, 1849-1850.

Patents were also granted to Fitch in New Jersey, Pennsylvania, and Delaware. James Rumsey contested the claim of Fitch to the invention of the steamboat and sought to secure a patent in New York as well as in Pennsylvania. Among the records in the case appears the following indorsement from George Washington:

I have seen the model of Mr. Rumsey's boat, constructed to work against stream, examined the powers upon which it acts, been eyewitness to an actual experiment in running water of some rapidity, and give it as my opinion (although I had little faith before) that he has discovered the art of working boats by mechanism and small manual assistance against rapid currents; that this discovery is of vast importance, may be of the greatest usefulness in our inland navigation; and if it succeeds, of which I have no doubt, that the value of it is greatly enhanced by the simplicity of the works, which, when seen and explained, may be executed by the most common mechanic.

Given under my hand at the town of Bath, county of Berkeley, in the state of Virginia, this 7th of September, 1784.

GEORGE WASHINGTON.

PENNSYLVANIA.[1]

YEAR.	Inventor.	Invention.	Term.
1717....	Thomas Masters.....	Cleaning, curing, and refining Indian corn.	14 years.
1717....	Thomas Masters.....	Weaving in a new method palmetto, chip, and straw for covering hats and bonnets.	14 years.

[1] Reports of Commissioner of Patents, 1849-1850. These were patents granted by the Crown and recorded in Pennsylvania.

MARYLAND.[1]

YEAR.	Inventor.	Invention.	Term.
1785....	James Rumsey	Steamboat	10 years.
1787....	Oliver Evans	Elevator	14 years.
1787....	Oliver Evans	Hopper-boy	14 years.
1787....	Oliver Evans	Steam carriage.....	14 years.
1787....	Robert Lemman	Carding and spinning machine..	14 years.

[1] Reports of Commissioner of Patents, 1849-1850.

It is not clear to whom is due the credit for the clause in the Constitution which vested in Congress power—

To promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries.

This clause was not in the original draft of the Constitution presented to the convention by Mr. Pinckney, May 29, 1787. In the record of the debates of the convention appears the following for August 18, 1787:[1]

In convention, Mr. Madison submitted, in order to be referred to the committee of detail, certain powers, as proper to be added to those of the general legislature. * * * To secure to literary authors their copyrights for a limited time. * * * To encourage, by premiums and provisions, the advancement of useful knowledge and discoveries.

On the same day Mr. Pinckney submitted certain propositions, among which was the power "to grant patents for useful inventions," also "to secure to authors exclusive rights for a certain time."

On the 5th of September the committee reported five clauses which it was proposed to incorporate in the Constitution, the fifth being the patent and copyright clause as it appears in the Constitution.

The germinating principle of this clause of the Constitution has vitalized the nation, expanded its powers beyond the wildest dreams of its fathers, and from it more than from any other one cause has grown the magnificent manufacturing and industrial development which we to-day present to the world.

In the discharge of the duty thus laid upon Congress, the organic patent act of April 10, 1790, was passed.

The early workings of this act are interestingly described in the Patent Office Gazette, as follows:[2]

By act of April 10, 1790, the first American patent system was founded. Thomas Jefferson inspired it, and may be said to have been the father of the American Patent Office. He took great pride in it, it is said, and gave personal consideration to every application that was made for a patent during the years between 1790 and 1793, while the power of revision and rejection granted by that act remained in force. It is related that the granting of a patent was held to be in these early times quite an event in the history of the State Department, where the clerical part of the work was then performed.

It is a matter of tradition, handed down to us from generation to generation by those who love to speak of Mr. Jefferson and his virtues and his eccentricities, that when an application for a patent was made under the first act he would summon Mr. Henry Knox,

[1] Elliot's Debates, vol. 5, page 439.
[2] Official Gazette, U. S. Patent Office, September 24, 1877.

of Massachusetts, who was Secretary of War, and Mr. Edmund Randolph, of Virginia, who was Attorney-General, these officials being designated by the act, with the Secretary of State, a tribunal to examine and grant patents, and that these three distinguished officials would examine the application critically, scrutinizing each point of the specification and claims carefully and rigorously. The result of this examination was that during the first year a majority of the applications failed to pass the ordeal, and only three patents were granted. In those days every step in the issuing of a patent was taken with great care and caution, Mr. Jefferson seeking always to impress upon the minds of his officers and the public that the granting of a patent was a matter of no ordinary importance.

In 1793 a new patent act was passed, which, with certain amendatory acts, remained in force until the act of 1836, when the patent system, virtually as it exists to-day, was established. Prior to 1836 there was no critical examination of the state of the art preliminary to the allowance of a patent application. Since the act of 1836 there have been various enactments, modifying and improving the law in matters of detail; in 1839 an inventor was given the right to use his invention prior to applying for a patent therefor, for a period not exceeding two years; in 1861 the term for a patent, which had been fourteen years, was increased to seventeen years, and extensions were prohibited except as to patents granted prior thereto, and in 1870 the patent law was revised, consolidated, and amended; but in its salient features the patent system of to-day is that of the law of 1836.

Speaking in 1884, on a bill for the reorganization of of the Patent Office, Senator Platt, of Connecticut, said:

To my mind the passage of the act of 1836 creating the Patent Office marks the most important epoch in the history of our development—I think the most important event in the history of our Government from the Constitution until the Civil War. The establishment of the Patent Office marked the commencement of that marvelous development of the resources of the country which is the admiration and wonder of the world, a development which challenges all history for a parallel; and it is not too much to say that this unexampled progress has been not only dependent upon, but has been coincident with, the growth and development of the patent system of this country. Words fail in attempting to portray the advancement of this country for the last fifty years. We have had fifty years of progress, fifty years of inventions applied to the everyday wants of life, fifty years of patent encouragement, and fifty years of a development in wealth, resources, grandeur, culture, power which is little short of miraculous. Population, production, business, wealth, comfort, culture, power, grandeur, these have all kept step with the expansion of the inventive genius of the country; and this progress has been made possible only by the inventions of its citizens. All history confirms us in the conclusion that it is the development by the mechanic arts of the industries of a country which brings to it greatness and power and glory. No purely agricultural, pastoral people ever achieved any high standing among the nations of the earth. It is only when the brain evolves and the cunning hand fashions labor-saving machines that a nation begins to throb with new energy and life and expands with a new growth. It is only when thought wrings from nature her untold secret treasures that solid wealth and strength are accumulated by a people.

When the Japanese Government was considering the establishment of a patent system, which was created by their patent act of March 1, 1899, they appointed Mr. Korekiyo Takahashi a special commissioner and sent him to the United States to gather the data obtainable in regard to our patent system as practiced at that date.

Mr. Takahashi was in Washington several months, diligently prosecuting his investigations. The Commissioner of Patents directed that the officers should give him every facility within their power in aiding him to facts within their knowledge, and also presented him with a copy of every publication, circular, notice, etc., ever issued by the office, in so far as available at that time.

The examiner of designs at that date, Dr. P. B. Pierce, gives a most interesting narration of Mr. Takahashi's many interviews with him. Near the end of these interviews, one day the examiner said to him: "Mr. Takahashi, I have answered many questions asked by you; would you object to answering a single question which I would like to put to you?"

The Japanese commissioner at once intimated his readiness to grant any favor that might be requested.

"Well," said the examiner, "I would like to know why it is that the people of Japan desire to have a patent system?"

"I will tell you," said Mr. Takahashi. "You know it is only since Commodore Perry, in 1854, opened the ports of Japan to foreign commerce that the Japanese have been trying to become a great nation, like other nations of the earth, and we have looked about us to see what nations are the greatest, so that we could be like them; and we said, 'There is the United States, not much more than a hundred years old, and America was not discovered by Columbus yet four hundred years ago;' and we said, 'What is it that makes the United States such a great nation?' And we investigated and we found it was patents, and we will have patents."

The examiner, in reporting this interview, added: "Not in all history is there an instance of such unbiased testimony to the value and worth of the patent system as practiced in the United States."

The demonstration thus given the commercial world during the last half century of the effect of beneficent patent laws has led to their modification in all the chief industrial countries, and the salient feature of our system—a preliminary examination as to novelty and patentability prior to the grant of a patent—has in late years been incorporated into the patent systems of many foreign countries, as, for instance, Austria, Canada, Denmark, Germany, Japan, Norway, Russia, Sweden, and Switzerland.

The following tables and data aim to show the cooperative relation of patents and manufactures:

Table 1 shows the total number of patents issued to the citizens of the several states and territories from 1790 to 1899, inclusive, grouped according to decades and with the patent rank for each period, in comparison with the population, rank of the states and territories for the census year ending each period, and with the manufacturing rank of the states and territories for each census year, beginning with 1850.

TABLE 1.—COMPARATIVE TABLE SHOWING STATES AND TERRITORIES RANKED ACCORDING TO NUMBER OF ACCORDING TO GROSS VALUE

	STATES AND TERRITORIES.	1800—1790 TO 1799 INCLUSIVE.			1830—1800 TO 1829 INCLUSIVE. 3 DECADES.				1840—1830 TO 1839 INCLUSIVE.			1850—1840 TO 1849 INCLUSIVE.			
		Patents.		Population rank.	Patents.			Population rank.	Patents.		Population rank.	Patents.		Manufacturing rank.	Population rank.
		Number.	Rank.		Number.	Average per decade.	Rank.		Number.	Rank.		Number.	Rank.		
1	Alabama				9	3	21	15	17	21	12	52	16	26	12
2	Alaska														
3	Arizona														
4	Arkansas							28			25	1	31	33	26
5	California													16	29
6	Colorado														
7	Connecticut	24	4	8	480	160	4	16	377	4	20	313	5	5	21
8	Dakota														
9	Delaware	1	12	17	24	8	18	24	16	22	26	24	25	25	30
10	District of Columbia			19	90	30	13	25	54	14	28	75	13	29	33
11	Florida							26			27	2	30	32	31
12	Georgia	5	10	12	24	8	18	10	26	19	9	32	23	22	9
13	Hawaii														
14	Idaho														
15	Illinois							20	5	24	14	82	12	15	11
16	Indiana			21	21	7	19	13	38	17	10	49	18	14	7
17	Indian Territory														
18	Iowa										29	20	26	27	27
19	Kansas														
20	Kentucky			9	70	23	14	6	76	12	6	51	17	13	8
21	Louisiana				17	6	20	19	22	20	19	53	15	24	18
22	Maine	(2)		14	[3]125	125	5	12	264	6	13	84	10	9	16
23	Maryland	9	7	7	255	85	6	11	248	7	15	207	6	7	17
24	Massachusetts	44	2	[3]5	816	272	2	8	711	2	8	720	3	2	6
25	Michigan				3	1	23	27	16	22	23	49	19	17	20
26	Minnesota													36	36
27	Mississippi			20	8	3	21	22	22	20	17	13	27	28	15
28	Missouri				4	2	22	21	6	23	16	42	20	10	13
29	Montana														
30	Nebraska														
31	Nevada														
32	New Hampshire	8	8	11	126	42	11	18	179	9	22	83	11	11	22
33	New Jersey	18	5	10	166	55	8	14	128	11	18	188	7	6	19
34	New Mexico													35	32
35	New York	39	3	3	1,680	560	1	1	1,594	1	1	1,759	1	1	1
36	North Carolina			4	66	22	15	5	46	16	7	33	22	20	10
37	North Dakota														
38	Ohio			18	145	48	10	4	281	5	3	433	4	4	3
39	Oklahoma														
40	Oregon													30	34
41	Pennsylvania	67	1	2	752	251	3	2	709	3	2	776	2	3	2
42	Rhode Island	3	11	16	112	37	12	23	64	13	24	63	14	12	28
43	South Carolina	3	11	6	59	20	16	9	35	18	11	28	24	23	14
44	South Dakota														
45	Tennessee			15	30	10	17	7	53	15	5	35	21	18	5
46	Texas											12	28	31	25
47	Utah													34	35
48	Vermont	7	9	13	214	71	7	17	146	10	21	114	8	21	28
49	Virginia	14	6	1	155	52	9	3	195	8	4	91	9	8	4
50	Washington														
51	West Virginia														
52	Wisconsin								1	25	30	5	29	19	24
53	Wyoming														
54	Unknown	5													
55	Officers in the Army and Navy								5			3			
56	Citizens residing abroad														

[1] This table is prepared from the table of "patents granted to citizens of the United States, by years and states, 1790 to 1890," accompanying the report of the Commissioner of Patents for 1891, and from the annual reports of the Commissioner of Patents to date. The Patent Office tables showing the number of patents issued to citizens of the United States by states and territories include both patents and designs, and it is not practicable to separately report by states and territories the patents for inventions and the patents for designs. It is also to be noted that for certain years prior to 1875 the Patent Office state tables include reissues; and for the years 1875 and 1876 trade-marks and labels were included along with patents, designs, and reissues. In the report for 1877 and for subsequent years the Patent Office state tables include patents and designs only. The table therefore is only to be used for purposes of state comparison.

PATENTS ISSUED DURING EACH DECADE, WITH POPULATION RANK, 1800 TO 1900, AND MANUFACTURING RANK OF PRODUCTS, 1850 TO 1900.[1]

1860—1850 to 1859 inclusive.				1870—1860 to 1869 inclusive.				1880—1870 to 1879 inclusive.				1890—1880 to 1889 inclusive.				1900—1890 to 1899 inclusive.				
Patents.		Manufacturing rank.	Population rank.	Patents.		Manufacturing rank.	Population rank.	Patents.		Manufacturing rank.	Population rank.	Patents.		Manufacturing rank.	Population rank.	Patents.		Manufacturing rank.	Population rank.	
Number.	Rank.			Number.	Rank.			Number.	Rank.			Number.	Rank.			Number.	Rank.			
108	24	25	13	134	28	29	16	412	30	32	17	639	32	27	17	933	30	30	18	1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	51	(4)	1	52	49	51	2
.....	.....	.....	.....	.....	.....	46	46	8	46	47	44	84	45	48	48	140	47	42	49	3
16	32	34	25	27	38	38	26	205	37	37	25	626	33	37	24	895	31	38	25	4
94	26	7	26	1,100	12	16	24	3,112	10	12	24	5,043	11	12	22	6,288	10	12	21	5
.....	.....	.....	38	59	34	39	41	224	35	31	35	1,113	26	28	31	2,175	19	27	31	6
1,139	5	5	24	3,872	6	8	25	6,491	6	7	28	8,177	7	10	29	8,291	7	11	29	7
.....	.....	.....	42	5	40	47	45	41	42	41	40	467	37	.....	.....	.....	.....	.....	.....	8
64	29	26	32	161	26	27	35	376	31	28	38	366	38	35	42	384	42	37	46	9
273	13	30	35	879	17	33	34	1,509	17	34	36	1,859	20	32	39	1,946	21	35	42	10
17	31	35	31	39	37	37	33	98	38	38	34	295	39	39	32	601	38	40	32	11
149	21	20	11	274	25	22	12	703	26	22	13	1,201	23	25	12	1,218	26	26	11	12
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14	51	41	48	13
.....	.....	.....	.....	3	41	44	44	16	45	45	46	65	46	46	45	193	44	50	47	14
769	6	8	4	5,049	5	6	4	9,746	5	4	4	15,839	4	3	3	19,936	3	3	3	15
462	8	10	6	2,191	8	11	6	3,853	8	10	6	5,854	10	11	8	6,114	11	8	8	16
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25	48	49	(4)	113	49	51	39	17
120	22	24	20	1,403	11	18	11	3,088	11	19	10	3,931	12	17	10	4,141	13	17	10	18
3	35	31	33	114	30	30	29	704	25	24	20	2,290	16	18	19	2,613	17	16	22	19
199	19	15	9	578	20	17	8	1,409	18	17	8	2,148	19	16	11	2,098	20	18	12	20
163	20	22	17	374	22	23	21	878	24	25	22	909	29	26	25	1,169	28	22	23	21
266	15	14	22	1,098	13	12	23	1,516	16	15	27	1,466	21	19	30	1,381	25	21	30	22
408	9	12	19	1,061	15	14	20	2,225	14	13	23	2,691	14	14	27	2,763	16	14	26	23
2,808	2	3	7	8,370	2	3	7	14,312	3	3	7	19,115	3	4	6	18,718	4	4	7	24
238	16	17	16	2,107	9	9	13	3,852	9	9	9	6,866	8	8	9	7,635	8	10	9	25
11	33	32	30	313	23	25	28	1,107	19	16	26	2,265	18	13	20	3,530	14	13	19	26
98	25	28	14	149	27	34	18	486	28	36	18	523	34	38	21	616	37	39	20	27
215	17	11	8	1,052	16	5	5	3,051	12	8	5	5,889	9	7	5	7,333	9	7	5	28
.....	.....	.....	.....	5	40	41	43	24	43	43	45	194	42	42	44	685	36	34	44	29
.....	.....	39	39	46	36	36	36	303	33	33	30	1,047	27	20	26	1,756	22	19	27	30
.....	.....	.....	41	47	35	28	40	213	36	42	43	161	43	47	49	109	50	52	52	31
357	11	16	27	876	18	15	31	1,087	20	18	31	1,342	22	22	33	1,190	27	24	36	32
641	7	6	21	2,423	7	7	17	5,802	7	6	19	9,151	6	6	18	9,837	6	6	16	33
(1)	.....	37	34	1	43	43	37	18	44	44	41	104	44	45	43	132	48	47	45	34
5,791	1	1	1	17,906	1	1	1	29,942	1	1	1	38,693	1	1	1	37,519	1	1	1	35
88	27	21	12	134	28	26	14	493	27	29	15	665	31	31	16	781	34	28	15	36
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(5)	.....	43	41	347	43	45	41	37
1,596	4	4	3	5,942	4	4	3	9,973	4	5	3	14,484	5	5	4	15,248	5	5	4	38
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	50	46	173	45	46	38	39
.....	.....	33	36	93	32	35	38	255	34	35	37	515	36	30	38	846	33	36	35	40
2,499	3	2	2	7,766	3	2	2	15,991	2	2	2	19,938	2	2	2	22,705	2	2	2	41
272	14	13	29	1,092	14	10	32	1,944	15	14	33	2,615	15	15	35	2,444	18	15	34	42
70	28	27	18	85	33	32	22	332	32	30	21	520	35	36	23	486	40	32	24	43
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(5)	.....	41	37	539	39	44	37	44
113	23	19	10	289	24	20	9	1,039	21	21	12	1,184	24	23	13	1,478	24	25	14	45
61	30	29	23	118	29	31	19	1,008	23	27	11	2,275	17	24	7	3,247	15	23	6	46
.....	.....	38	37	3	42	42	39	58	39	39	39	217	41	40	40	406	41	43	43	47
309	12	23	28	694	19	21	30	1,008	23	23	32	975	28	34	36	758	35	33	40	48
381	10	9	5	483	21	19	10	1,037	22	20	14	1,160	25	21	15	1,655	23	20	17	49
4	34	36	40	12	39	40	42	47	40	40	42	243	40	29	34	1,034	29	29	33	50
.....	.....	.....	.....	112	31	24	27	466	29	26	29	678	30	33	28	862	32	31	28	51
215	18	18	15	1,589	10	13	15	2,426	13	11	16	3,910	13	9	14	5,076	12	9	13	52
1	36	.....	.....	1	43	45	47	45	41	46	47	45	47	44	47	147	46	48	50	53
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	54
18	.....	.....	.....	63	.....	.....	.....	87	.....	.....	.....	113	.....	.....	.....	182	.....	.....	.....	55
.....	.....	.....	.....	.....	.....	.....	.....	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	56

[2] For purposes of patent comparison for the first decade, the population of Maine and Massachusetts should be combined, for though the population of Maine was separately taken, the patents issued are credited to Massachusetts. This change makes Massachusetts rank 4 in population, North Carolina 5, while Tennessee, Rhode Island, Delaware, Ohio, District of Columbia, and Mississippi are each advanced one grade.

[3] Number issued subsequent to 1820, when Maine was set apart from Massachusetts.

[4] The population of Alaska, 32,052, and Indian Territory, 180,182, not included in general report in 1890. Indian Territory would have ranked 42 in population, and Alaska 51.

[5] See Dakota for patents for the decade of 1890.

The manufacturing states have ever been the leading states in the matter of patents, and it will be noted that the patent rank approximates to the manufacturing rank, as a rule. This is shown by the following table:

TABLE 2.—PATENTS AND MANUFACTURES.

YEAR.	Number of states and territories compared.	Number of equal rank.	Number one point apart.	Number two points apart.	WITHIN TWO POINTS OF EQUAL RANK.	
					Number.	Per cent.
1850	35	5	10	5	20	57.1
1860	35	4	12	6	22	62.9
1870	46	10	11	7	28	60.9
1880	47	14	13	8	35	74.5
1890	47	12	9	5	26	55.3
1900	52	9	5	14	28	53.8

New York, though third in population and patent rank for the first decade, has since been first in both, as well as in manufactures. The states from which patents are reported for the first decade comprise all of the original thirteen states with the exception of North Carolina and Vermont; although Maine was a part of Massachusetts, its population was separately reported in the census of 1800, but all patents therefrom were credited to Massachusetts. There doubtless were a considerable number of patents from Maine during this period, as the state for the first decade following its admission ranked fifth in patents, while only twelfth in population.

As the great Middle and Western states were settled they developed manufactures, and also took rank as patent states. Ohio early took high rank, being exceeded in 1850 only by New York, Pennsylvania, and Massachusetts in number of patents and volume of manufactures, and by the two former states in population, but it has since been crowded to fifth place in patents and manufactures, and fourth in population, by Illinois, which now ranks third.

The period from 1840 to 1850 shows a partial stagnation in patent growth. For the decade of 1840 there were 1,741 patents granted to the New England states, while in the decade of 1850 there were but 1,377, a falling off of 21 per cent, though Massachusetts shows a slight gain. For the next decade, that of 1860, the New England states show a renewal of patent activity, the number of patents issued being 5,151, or an increase of 274 per cent, slightly greater than the growth of the country at large.

Subsequent to 1850 the states all show a steady patent growth until the decade of 1890, when a falling off in the number of patents issued appears in Maine, Vermont, and Nevada. A decrease in the number of patents for Maine and Vermont, as well as for Nevada, is also shown in the 1900 decade; likewise a falling off in New Hampshire and Rhode Island, with a slight decrease in Massachusetts; while a reduced number of patents is also shown for New York, South Carolina, and Kentucky. Though Connecticut shows a slight increase for 1900, it is but 1.4 per cent, while the increase for the country at large for the decade is 15.02 per cent. On the whole, the New England states show a retrograde movement during the last decade with respect to patents. It is not to be assumed, however, that the number of patents is necessarily a true gauge of the manufacturing activity of a state, for one controlling patent for a new product for which there is a demand, or for a radical improvement in processes or machinery pertaining to a leading industry, is a larger factor in the development of manufactures than a large number of patents for subordinate or trifling inventions. Nevertheless, in general, the number of inventions and patents therefor becomes a gauge of the manufacturing activity and growth of a district, a manifestation of the intelligence and thought employed in manufacturing, and of the striving after better results and products, cheaper processes, and tools and appliances that will reduce the labor cost. This effort results in the expansion of existing manufactures and the creation of new industries in a greatly increased ratio.

The first patent granted by the General Government was to Samuel Hopkins, July 31, 1790, for an improvement in pot and pearl ash manufacture. The last patent granted for the year 1889, at the close of the first hundred years of patent issues, was to Wilhelm Dreyer, No. 418,664, of December 31, 1889, for an electro-magnetic typesetting machine. These two patents are suggestively symbolical of the progress of the century in invention and manufactures—the first akin to the primitive industries of a new country and the last serving the exacting demands of a highly organized industrial system.

The total number of patents issued during this century of invention was 428,621.

A comparison of the leading manufacturing states shows that there is, on the whole, an approximate parallelism between inventive activity and manufacturing growth. Table 3 illustrates this point, the 10 states leading in manufacturing rank for the censuses of 1860 to 1900, inclusive, being ranked in parallel columns according to per cent of increase in number of patents over the preceding decade, and according to per cent of increase in gross value of products over the preceding census year.

TABLE 3.—COMPARATIVE TABLE OF THE TEN STATES LEADING IN MANUFACTURES AT EACH CENSUS YEAR, RANKED ACCORDING TO PER CENT OF INCREASE IN NUMBER OF PATENTS AND PER CENT OF INCREASE IN GROSS VALUE OF PRODUCTS: 1860 TO 1900.

NUMBER.	1860		1870		1880		1890		1900	
	Patents.	Manufacturing.	Patents.	Manufacturing.	Patents.	Manufacturing.	Patents.	Manufacturing.	Patents.	Manufacturing.
1	Ind	Ill	Mich	Mo	Mo	Ill	Mo	Ill	Wis	N. J.
2	Ill	Ind	Ill	Mich	N. J	Ind	Mich	Mo	Ill	Ind.
3	Va	Ohio	Mo	Ill	Pa	N. J	Ill	Wis	Mo	Wis.
4	Mass	N. J	R. I	R. I	Ill	N. Y	Wis	Mich	Pa	Ill.
5	Ohio	Pa	Ohio	Pa	Mich	Ohio	N. J	Ohio	Mich	Pa.
6	Conn	Conn	N. J	N. J	Ind	Mich	Ohio	Pa	N. J	Ohio
7	N. J	Va	Conn	Ohio	Mass	Conn	Mass	N. Y	Ohio	Mich.
8	N. Y	Mass	Pa	Mass	Ohio	Mass	N. Y	Mass	Ind	N. Y.
9	Pa	N. Y	N. Y	N. Y	Conn	Pa	Conn	N. J	Mass	Mo.
10	Cal	Cal	Mass	Conn	N. Y	Mo	Pa	Conn	N. Y	Mass.

Indiana, which appears in the columns for 1860, 1880, and 1900, was below the tenth rank in 1870 and 1890. Likewise Rhode Island only appears in the comparison for 1870, California falls below the tenth rank after 1860, and Connecticut drops out in 1900. In the case of the younger states the relative growth in patents and manufactures is in many cases very large, but the 10 states of the highest manufacturing rank are assumed to be states which, at the time, had already reached a stage of substantial development. In some cases the states fall into parallel positions—as, for example, Rhode Island, New Jersey, and New York, in 1870; and in 17 cases they are but one removed from a uniform rank. Thirty-nine cases, or 78 per cent, are within 3 points of parallelism. It will be noticed that the greatest relative growth both in inventions and in manufactures has been in the Western states, except that in the present census New Jersey holds the ranking position in the rate of increase of manufactures among the 10 leading states.

In 1860 Indiana ranked first in rate of patent growth, the increase over the decade of 1850 being 843 per cent, while Illinois ranked first in rate of growth in manufacturing products, the increase over 1850 being 248.3 per cent. In 1870 Michigan ranked first in rate of patent growth, with an increase of 785 per cent, and Missouri first in growth of manufactures, with an increase of 393.5 per cent. In 1880 Missouri led in rate of patent growth, with an increase of 194 per cent, and Illinois in manufactures, with an increase of 101.8 per cent. In 1890 Missouri again leads in rate of patent growth, with an increase of 91 per cent, and Illinois leads in rate of manufacturing growth, with an increase of 119 per cent. In 1900 Wisconsin leads in rate of patent growth, with an increase of 30 per cent, and New Jersey in manufactures, with an increase of 72.5 per cent.

The anomalous position of Missouri in 1880, with respect to this table—first in rate of patent growth and last in manufacturing growth (see also Pennsylvania)—is apparently due to the omission in the Tenth Census of inquiries in regard to certain industries, which specifically affected the total volume of products of this state. As reported, Missouri actually shows a decrease of 19.8 per cent in its gross value of products for 1880, in comparison with 1870, the only one of the 10 states of highest manufacturing rank showing a decrease, while the manufacturing growth of Pennsylvania for the same period shows but 4.6 per cent increase.

Table 4 is a comparative table showing the growth in number of patents issued during each decade to citizens of the United States and to citizens of foreign countries.

TABLE 4.—COMPARATIVE TABLE SHOWING, BY DECADES, THE GROWTH OF PATENTS ISSUED TO CITIZENS OF THE UNITED STATES AND TO CITIZENS OF FOREIGN COUNTRIES.

	PATENTS.		DESIGNS.		PATENTS AND DESIGNS.							
								To citizens of the United States.		To citizens of foreign countries.		
	Number.	Per cent of increase.	Number.	Per cent of increase.	Number.	Per cent of increase.	Per cent of designs.	Number.	Per cent of increase.	Number.	Per cent of increase.	Per cent of total number.
Prior to July 28, 1836	9,957											
July 28, 1836, to January 1, 1840	1,464											
Prior to 1840	11,421				11,421			11,372		49		
Decade of 1850	5,516		257		5,773		4.45	5,611		162		2.81
Decade of 1860	19,661	256.44	925	259.92	20,586	256.59	4.49	20,276	261.18	310	91.36	1.51
Decade of 1870	71,818	265.28	2,627	184.00	74,445	261.53	3.53	72,513	257.63	1,932	523.23	2.60
Decade of 1880	124,751	73.70	7,757	195.28	132,508	77.99	5.85	126,550	74.53	5,958	208.39	4.50
Decade of 1890	195,454	56.68	7,986	2.95	203,440	53.53	3.92	189,938	50.09	13,502	126.62	6.64
Decade of 1900	221,502	13.33	12,502	56.55	234,004	15.02	5.34	210,921	11.05	23,083	70.96	9.86
Total prior to 1900	650,123		32,054		682,177			637,181		44,996		6.60

This table shows the growth in number of patents for inventions, number of design patents, and the per cent of increase of each per decade, and the total number of patents for inventions and designs for each decade, beginning with 1850, issued to citizens of the United States, and also to the citizens of foreign countries, with the several percentages of increase; and also a column showing the per cent of patents issued to alien inventors for each decade.

The tables given in the annual reports of the Commissioner of Patents of the number of patents issued to citizens of foreign countries include patents for inventions proper and patents for designs. The number of patents for designs issued to citizens of foreign countries is relatively less than the number of patents for designs issued to citizens of the United States; but it is not practicable to ascertain the per cent of patents for inventions to alien inventors, apart from design patents, without an inspection of all design patents issued. The per cent of design patents issued, however, is so small that the percentages of total number of patents and designs issued to citizens of foreign countries as given would approximate to the percentages of the number of patents for inventions proper issued to citizens of foreign countries, though the former would be greater.

For example, an examination of the design patents issued in 1900 shows that 3.07 per cent of the design patents were issued to citizens of foreign countries, while the number of patents for inventions and designs issued to citizens of foreign countries for the decade of 1900 is 9.86 per cent. Taking 3.07 per cent as an average for the number of design patents issued to aliens for the decade of 1900, and computing the per cent of patents for inventions proper issued to citizens of foreign countries for this decade, it gives 10.25 per cent, as against 9.86 per cent for patents for both inventions and designs. The same relative increase in ratios will probably hold good for former decades.

The growth in the number of patents granted in the United States to citizens of foreign countries is a striking feature, and shows the high esteem in which this country is held by the world at large as a field for the exploitation of inventions. Since 1860 the number of patents issued to citizens of foreign countries has increased in a much greater ratio than the number of patents to citizens of this country. For the decade of 1870 the increase in number of patents to citizens of the United States over the preceding decade was 257.63 per cent, while for foreigners it was 523.22 per cent; for the decade of 1880 the increase to citizens of the United States was 74.52 per cent, and to foreigners 208.39 per cent; for the decade of 1890 the increase to citizens of the United States was 50.09 per cent and to foreigners 126.62 per cent; and for the decade of 1900 for citizens of the United States the growth was 11.05 per cent, while for foreigners it was 70.96 per cent. The per cent of patents to citizens of foreign countries with respect to the total number of patents issued during the several decades is as follows: For the decade of 1850, 2.81 per cent; for 1860, 1.15 per cent; for 1870, 2.6 per cent; for 1880, 4.5 per cent; for 1890, 6.67 per cent; and for 1900, 9.86 per cent.

The per cent of patents to foreign inventors has more than doubled during each period of twenty years since 1860.

In the years 1898, 1899, and 1900 there was an abnormal increase in the number of patents issued to foreign inventors, owing to the act of March 3, 1897, which went into effect January 1, 1898, and barred the grant of a patent for an invention first patented in a foreign country where the application for the foreign patent had been filed more than seven months prior to the filing of the application for a patent in this country. The effect of this enactment was to cause a rush to get in applications prior to January 1, 1898, for inventions patented abroad; and these applications were worked through and appear as patents in the years immediately following. In 1897, 9.36 per cent of the patents issued were to foreign inventors. In 1898 the foreign patents increased to 12.4 per cent, in 1899, to 13.02 per cent, and in 1900, to 13.18 per cent, as the result of the said act of March 3, 1897; while in 1901 the foreign patents fell off to 8.32 per cent by reason of the abolishment of the right to secure patents in this country of inventions long patented abroad. For the first quarter of 1902 the number of patents issued to foreign inventors is 11.93 per cent of the total number issued, showing a continuance of the increase in growth of patents granted to foreign inventors.

The majority of these foreign patentees are citizens of the great manufacturing countries; four-fifths of them are from England, France, Germany, and Canada, the number from the latter country being largely augmented by reason of her proximity to the United States. For the last decade the patents to foreign inventors were distributed as follows:

COUNTRY.	Number of patents.	Per cent.
Canada	3,135	14.0
England	7,436	32.0
France	2,163	9.0
Germany	5,788	25.0
All other countries	4,561	20.0
Total to citizens of foreign countries	23,083	100.0

This marked growth in the number of patents to aliens is explained by the very liberal features of our patent system. Foreigners stand here on an equal footing with citizens of this country, and they are neither subjected to restrictions in the matter of annuities or taxes payable after the grant of a patent, nor required to work an invention in this country to maintain it in force, as is the case in most foreign countries.

Moreover, the thorough examination made by our Patent Office as to the novelty of an invention prior to the allowance of an application for a patent—an examination that includes not only the patents and literature of our own country bearing on the art or industry to which the invention relates, but the patents of all patent-granting countries and the technical literature of the world—and the care exercised in criticising the framing of the claims has come to be recognized as of great value in the case of inventions of merit, and hence the majority of foreign inventors patenting in this country take advantage of this feature of our patent system, and secure the action of the Patent Office on an application for a patent before perfecting their patents in their own and other foreign countries, taking due precaution to have their patents in the different countries so issued as to secure the maximum term in each, so far as possible. This practice holds now in the case of probably nine-tenths of the alien inventions patented in this country.

The working of an invention has never been required under our patent laws, though in most foreign countries, with the exception of Great Britain, an invention must be put into commercial use within the country within a specified period or the patent may be declared void. In the case of patents for fine chemicals and like products, which require a high order of technical knowledge and ability for their inception and skilled workmen for their manufacture, the effect of this requirement, that the industry must be established within the country, has been most salutary in building up chemical industries within the home country, to some extent at the expense of other countries where the working of a patent is not obligatory. This shows most strongly in the case of carbon dyes and in the patents for chemicals of the class known as carbon compounds, which includes numerous pharmaceutical and medicinal compounds of recent origin, aldehydes, alcohols, phenols, ethers, etc., and many synthetic compounds, as vanillin, artificial musk, etc.

There were issued prior to January 1, 1902, 1,196 patents in the Patent Office class of "carbon dyes" (bleaching and dyeing), of which number 622 were issued during the decade of 1900. Of these 622 patents, 609, or 97.91 per cent, were to foreign inventors, chiefly to German, French, and Swiss chemists. Only 2.09 per cent were to chemists of this country. In the Patent Office class of "carbon compounds" (chemicals), 532 patents were issued prior to January 1, 1902, of which number 312 were issued during the decade of 1900. Of these 312 patents, 281, or 90.1 per cent were to foreign inventors, German chemists largely preponderating, less than 10 per cent being to American chemists.

The manufacturing side of the case, so far as carbon dyes are concerned, is reflected in the imports of "coal-tar colors and dyes," which, for the ten years 1891 to 1900, aggregate $28,483,393.

The growth in the imports of "coal-tar colors and dyes," 1890 and 1900, and the countries furnishing the same, is shown by the following table:

TABLE 5.—IMPORTS: COAL-TAR COLORS AND DYES.

FROM—	1890	1900
Austria-Hungary		$8,309
Belgium	$8,999	21,037
France	69,899	32,905
Germany	1,398,902	3,822,162
Netherlands		32,748
Switzerland	166,777	740,992
United Kingdom	141,018	230,287
Other countries	1,958	1,632
Total	1,787,553	4,890,072

The countries furnishing the patentees are the countries which have furnished the imports. In contrast with the above, the value of the artificial dyestuffs manufactured in this country for the census year 1900 is $52,648, making an aggregate for the imports and home product for 1900 of $4,942,720, of which the home product is 1.07 per cent of the total. This is a close approximation to the per cent of the patents in this line of industry issued to our own chemists—2.09 per cent.

Data in regard to the home manufacture and imports of fine chemicals corresponding to the Patent Office class of "carbon compounds" (chemicals) is not so specifically obtainable; but, as may be expected, the facts, so far as they can be deduced, show a larger home production, in harmony with the somewhat larger number of patents to domestic inventors. The imports of "chemicals, drugs, and dyes, all others (dutiable)" for 1900 were $6,530,037, of which, as in the case of coal-tar colors and dyes, the greater portion came from Germany, the United Kingdom, France, and Switzerland.

The following table shows the imports of the same for 1890 and 1900:

TABLE 6.—IMPORTS: CHEMICALS, DRUGS, AND DYES, ALL OTHERS (DUTIABLE).

FROM—	1890	1900
Austria-Hungary	$100,502	$85,033
Belgium	40,180	105,158
France	430,439	572,178
Germany	1,861,080	3,145,254
Switzerland	56,601	140,697
United Kingdom	1,947,191	1,942,549
All other countries	239,228	539,168
Total	4,675,221	6,530,037

The manufactures of fine chemicals for the census year 1900 amounted in value to $4,206,744, making an aggregate of $10,736,781 for the imports and home products for 1900, of which total the home product is 39.18 per cent, while the per cent of patents to American chemists in the class of carbon compounds (chemicals) is 9.94 per cent. It should be observed, however, that the chemicals comprised in the above class of

imports were reported in the census group under fine chemicals and are not comparable in all particulars with the Patent Office classification of carbon compounds (chemicals).

This phase of our patent system calls for serious consideration. The great chemical houses of Germany, with their highly trained chemists working along special lines, and with the manufacture of new compounds fostered by the requirement that an invention must be worked in Germany to an adequate extent within three years after being patented, have held their patents in this country to protect their market, with the result that at the expiration of the patent term the trade is in the hands of the foreign manufacturers, and the equipment, trained workmen, and chemists are all abroad contributing to the building up of foreign manufactures, instead of aiding in our own development.

The patent systems of Switzerland and Japan, of which the former went into force November 15, 1888, and the latter March 1, 1899, were established after a study of the patent systems of all nations, neither country having formerly granted patents. In both countries a patent becomes void when, without good reason, the invention has not been put into use within the country within a specified time from the grant of the patent.

Tables 7 and 8 illustrate the per capita growth and rank of the states and territories with respect to patents and manufactures.

TABLE 7.—SHOWING NUMBER OF PATENTS ISSUED TO CITIZENS OF THE UNITED STATES FOR EACH CENSUS YEAR, 1840 TO 1900, WITH THE RATIO OF POPULATION TO EACH PATENT GRANTED, AND WITH THE STATES RANKED ACCORDING TO RATIOS.

STATE.	1840		STATE.	1850		STATE.	1860		STATE.	1870	
	Patents issued.	One to every—		Patents issued.	One to every—		Patents issued.	One to every—		Patents issued.	One to every—
United States	449	38,017	United States	973	23,835	United States	[1]14,510	6,972	United States	[2]12,677	3,042
Massachusetts	77	9,451	District of Columbia	11	4,699	District of Columbia	49	1,532	Connecticut	739	727
Connecticut	24	12,916	Connecticut	57	6,505	Connecticut	237	1,942	District of Columbia	174	757
Rhode Island	8	13,604	Massachusetts	141	7,053	Rhode Island	77	2,268	Massachusetts	1,448	1,006
District of Columbia	3	14,571	New York	300	10,324	Massachusetts	472	2,608	Rhode Island	197	1,103
Maryland	25	18,801	Rhode Island	14	10,539	New York	1,278	3,037	New York	2,962	1,480
New York	129	18,829	New Hampshire	22	14,453	Vermont	67	4,703	New Jersey	474	1,912
Pennsylvania	78	22,103	Pennsylvania	152	15,209	New Jersey	135	4,978	Colorado	18	2,215
Vermont	11	26,541	New Jersey	24	20,398	New Hampshire	58	5,622	Pennsylvania	1,481	2,378
New Hampshire	10	28,457	Ohio	90	22,004	Pennsylvania	513	5,665	California	216	2,594
Delaware	2	39,043	Delaware	4	22,883	Ohio	340	6,881	Vermont	123	2,687
Ohio	31	49,015	Maryland	25	23,821	California	54	7,037	Ohio	982	2,714
Maine	10	50,180	Vermont	12	26,177	Illinois	226	7,575	New Hampshire	111	2,868
New Jersey	6	62,218	Indiana	21	47,067	Maine	73	8,607	Michigan	401	2,953
Michigan	3	70,756	Maine	12	48,597	Michigan	75	9,988	Illinois	835	3,042
Missouri	3	127,901	Illinois	16	53,217	Maryland	64	10,735	Delaware	39	3,206
Kentucky	6	129,971	Virginia	19	74,824	Florida	13	10,802	Indiana	452	3,718
Virginia	7	177,114	Louisiana	6	86,294	Indiana	111	12,166	Maryland	206	3,791
Alabama	3	196,918	Florida	1	87,445	Louisiana	57	12,421	Oregon	22	4,133
South Carolina	3	198,133	Wisconsin	3	101,797	Wisconsin	62	12,514	Maine	139	4,510
Tennessee	4	207,302	Texas	2	106,296	Iowa	52	12,979	Wisconsin	223	4,626
Georgia	2	345,696	Kentucky	8	122,801	Nebraska	2	14,420	Nevada	9	4,721
Louisiana	1	352,411	Michigan	3	132,551	Georgia	73	14,483	Iowa	203	5,740
North Carolina	2	376,709	Missouri	5	136,409	Missouri	75	15,760	Minnesota	70	6,281
Illinois	1	476,183	Tennessee	7	143,245	Virginia	101	15,805	Louisiana	111	6,549
			South Carolina	4	167,127	Mississippi	42	18,841	Nebraska	16	7,687
			Georgia	5	181,237	Delaware	5	22,443	Kansas	46	7,922
			Iowa	1	192,214	Tennessee	46	24,126	Missouri	210	8,197
			Arkansas	1	209,897	Minnesota	7	24,575	Wyoming	1	9,118
			North Carolina	3	289,680	South Carolina	26	27,066	Kentucky	143	9,238
			Mississippi	2	303,263	Texas	21	28,772	West Virginia	47	9,405
			Alabama	2	385,811	Kentucky	39	29,633	Virginia	110	11,138
						North Carolina	26	38,173	Tennessee	109	11,546
						Alabama	24	40,175	Georgia	81	14,619
						Arkansas	6	72,575	Mississippi	50	16,558
						Kansas	1	107,206	Texas	48	17,054
									North Carolina	54	19,840
									South Carolina	35	20,160
									Montana	1	20,595
									Washington	1	23,955
									Alabama	36	27,694
									Florida	5	37,550
									Arkansas	11	44,043
									New Mexico	2	45,937
									Utah	1	86,786

NOTE.—Line separating the states above from those below the average ratio for the United States.

[1] Includes 3 patents granted to the United States Army

[2] Includes 7 patents granted to the United States Army, 1 to the United States Navy, and 17 to citizens of the United States in foreign countries.

TABLE 7.—SHOWING NUMBER OF PATENTS ISSUED TO CITIZENS OF THE UNITED STATES FOR EACH CENSUS YEAR, 1840 TO 1900, WITH THE RATIO OF POPULATION TO EACH PATENT GRANTED, AND WITH THE STATES RANKED ACCORDING TO RATIOS—Continued.

STATE.	1880		STATE.	1890		STATE.	1900	
	Patents issued.	One to every—		Patents issued.	One to every—		Patents issued.	One to every—
United States	[1]12,655	3,963	United States	[2]24,103	2,598	United States	[3]22,935	3,327
Connecticut	610	1,021	Connecticut	937	797	District of Columbia	251	1,110
Massachusetts	1,339	1,382	District of Columbia	235	980	Connecticut	755	1,269
Rhode Island	205	1,349	Massachusetts	2,096	1,068	Massachusetts	1,745	1,608
District of Columbia	116	1,531	Rhode Island	273	1,266	Rhode Island	264	1,623
New York	2,802	1,814	New Jersey	1,112	1,299	New Jersey	1,020	1,847
New Jersey	518	2,184	New York	4,585	1,308	New York	3,788	1,919
California	349	2,478	Illinois	2,152	1,778	Colorado	278	1,941
Nevada	24	2,594	California	640	1,888	Illinois	2,439	1,977
New Hampshire	111	3,126	Pennsylvania	2,641	1,991	California	732	2,029
Pennsylvania	1,324	3,235	Ohio	1,762	2,084	Ohio	1,718	2,420
Illinois	943	3,264	Michigan	980	2,187	Pennsylvania	2,564	2,458
Ohio	917	3,488	New Hampshire	172	2,189	Michigan	773	3,132
Michigan	450	3,638	Colorado	184	2,240	Washington	163	3,179
			Montana	53	2,494	Montana	76	3,202
Maryland	229	4,083						
Vermont	76	4,372	Wisconsin	634	2,661	Maryland	318	3,736
Wisconsin	276	4,766	Indiana	670	3,272	New Hampshire	107	3,847
Indiana	359	5,511	Vermont	101	3,291	Nevada	11	3,849
Iowa	285	5,700	Delaware	51	3,304	Iowa	561	3,978
Delaware	23	6,374	Missouri	809	3,312	Oregon	103	4,015
Maine	101	6,425	Minnesota	379	3,435	Indiana	625	4,026
Missouri	337	6,434	Maine	192	3,443	Wisconsin	508	4,078
Minnesota	114	6,849	Maryland	297	3,510	Missouri	750	4,142
Wyoming	3	6,930	Nevada	12	3,813	Minnesota	417	4,200
Oregon	22	7,944	Oregon	82	3,826	Utah	58	4,772
Colorado	24	8,097	Kansas	352	4,054	Idaho	33	4,902
Kentucky	170	9,698	Arizona	14	4,259	Vermont	69	4,980
Kansas	96	10,376	Iowa	437	4,375	Maine	134	5,183
Texas	147	10,828	North Dakota	40	4,568	Nebraska	203	5,253
West Virginia	52	11,893	Nebraska	225	4,706	Kansas	276	5,328
Washington	6	12,519	Washington	64	5,459	Wyoming	17	5,443
Montana	3	13,053	South Dakota	59	5,573	Delaware	30	6,158
Louisiana	66	14,242	Utah	30	6,930	Oklahoma	64	6,224
Utah	10	14,396	Idaho	12	7,032	North Dakota	48	6,649
Nebraska	31	14,594	Texas	308	7,258	Arizona	18	6,830
Virginia	99	15,274	Kentucky	252	7,376	South Dakota	56	7,171
Idaho	2	16,305	Wyoming	8	7,588	West Virginia	121	7,924
Dakota	8	16,397	Florida	51	7,675	Florida	66	8,008
Florida	15	17,966	West Virginia	95	8,029	Texas	373	8,173
Arkansas	44	18,239	Louisiana	137	8,165	Kentucky	235	9,137
Tennessee	82	18,810	Virginia	177	9,299	Virginia	200	9,271
Georgia	77	20,028	New Mexico	16	9,600	Louisiana	140	9,869
Arizona	2	20,220	Tennessee	180	9,820	Tennessee	203	9,954
Alabama	62	20,363	Georgia	165	11,135	Georgia	172	12,886
South Carolina	39	25,528	Arkansas	95	11,876	Arkansas	99	13,248
Mississippi	39	29,015	Alabama	103	14,690	Alaska	4	15,898
North Carolina	36	38,882	South Carolina	75	15,349	Alabama	95	19,249
New Mexico	2	59,783	Oklahoma	4	15,459	Mississippi	74	20,963
Indian Territory	1	(4)	North Carolina	74	21,864	New Mexico	9	21,701
			Indian Territory	8	22,523	Indian Territory	18	21,781
			Mississippi	55	23,447	Hawaii	7	22,000
						North Carolina	82	23,095
						South Carolina	47	28,517

NOTE.—Line separating the states above from those below the average ratio for the United States.

[1] Includes 6 patents granted to the United States Army, and 3 to the United States Navy.
[2] Includes 9 patents granted to the United States Army, and 9 to the United States Navy.
[3] Includes 10 patents granted to the United States Army, and 8 to the United States Navy.
[4] Not reported.

TABLE 8.—SHOWING GROSS VALUE OF PRODUCTS PER CAPITA FOR EACH STATE FOR EACH CENSUS YEAR, 1850 TO 1900, WITH STATES RANKED ACCORDING TO PRODUCTS PER CAPITA.

1850		1860		1870		1880		1890		1900	
United States.	$43.94	United States.	$59.98	United States.	$109.76	United States.	$107.06	United States.	$149.67	United States.	$170.90
Oregon	168.24	Rhode Island	233.14	Rhode Island	512.61	Rhode Island	376.68	Rhode Island	412.44	Rhode Island	429.52
Massachusetts	158.61	Massachusetts	207.58	Massachusetts	380.08	Massachusetts	353.96	Massachusetts	396.69	Connecticut	388.39
Rhode Island	149.90	California	179.62	Nevada	373.50	Connecticut	298.21	Connecticut	332.78	Massachusetts	369.01
California	134.91	Connecticut	178.04	Connecticut	299.68	New Jersey	224.89	New York	285.37	New Jersey	324.76
Connecticut	127.07	Washington	121.35	New Hampshire	223.18	New Hampshire	213.20	Pennsylvania	253.29	New York	299.33
New Jersey	81.40	New Hampshire	115.27	Pennsylvania	202.13	New York	212.62	New Jersey	245.39	Pennsylvania	291.19
New York	76.71	New Jersey	113.54	New Jersey	186.78	Pennsylvania	173.92	Illinois	237.47	New Hampshire	288.32
New Hampshire	72.85	Pennsylvania	99.83	New York	179.16	Delaware	139.93	New Hampshire	227.79	Illinois	261.24
Pennsylvania	67.07	New York	97.63	Delaware	134.31	Illinois	134.79	Delaware	222.99	Delaware	245.69
Maryland	56.68	Delaware	88.16	Maine	126.81	California	134.40	California	176.64	Montana	234.56
Dist. of Columbia	52.05	Dist. of Columbia	72.08	Montana	121.12	Maine	123.02	Ohio	174.74	Maryland	204.16
Delaware	50.79	Maine	60.79	Missouri	119.80	Maryland	114.21	Dist. of Columbia	170.72	California	203.95
		Maryland	60.74	Washington	119.02	Ohio	108.91	Maryland	164.85	Ohio	200.22
Maine	42.29			California	118.87					Colorado	190.53
Missouri	35.66	Oregon	56.74			Wisconsin	97.50	Minnesota	147.51	Maine	183.39
Ohio	31.66	Ohio	52.02	Ohio	101.20	Minnesota	97.42	Wisconsin	147.34	Wisconsin	174.39
Wisconsin	30.43	Vermont	46.45	Michigan	99.99	Vermont	94.36	Maine	144.75	Arizona	173.39
Michigan	28.09	Michigan	43.60	Maryland	98.08	Michigan	92.07	Michigan	132.72	Dist. of Columbia	171.02
Vermont	27.29	Kansas	40.65	Vermont	97.37	Missouri	76.27	Oregon	132.05		
Utah	25.59	Wisconsin	35.89	Illinois	80.96	Indiana	74.81	Missouri	121.14	Vermont	167.75
Kentucky	22.10	Missouri	35.35	Wyoming	77.37	Colorado	73.38	Washington	119.55	Washington	167.52
Virginia	20.82	Illinois	33.63	Oregon	75.64	Dist. of Columbia	66.90	Vermont	115.36	Indiana	150.26
Illinois	19.42	Kentucky	32.82	Wisconsin	73.21	Oregon	62.55	Indiana	103.46	Minnesota	149.97
Indiana	18.94	Virginia	31.73	Colorado	71.56	Montana	46.88	Colorado	103.06	Michigan	147.44
Iowa	18.48	Indiana	31.70	Dist. of Columbia	70.56	Kentucky	45.78	Nebraska	87.86	Nebraska	135.04
Louisiana	13.09	Utah	22.35	Idaho	69.85	Iowa	43.73	Kansas	77.23	Missouri	124.09
South Carolina	10.54	Louisiana	22.02	Indiana	64.63	Washington	43.27	Kentucky	68.18	Kansas	117.06
North Carolina	10.48	Nebraska	21.06	West Virginia	54.53	Wyoming	43.22	Iowa	65.41	Oregon	111.24
Tennessee	9.70	Iowa	20.70	Minnesota	52.56	Idaho	38.99	Virginia	53.36	Louisiana	87.71
Minnesota	9.59	Minnesota	19.61	Nebraska	46.66	West Virginia	36.97	Louisiana	51.68	West Virginia	78.05
Georgia	7.82	North Carolina	16.80	Kentucky	41.35	Nevada	35.00	West Virginia	50.74	Utah	76.66
Florida	7.64	Tennessee	16.21	Iowa	38.97	Virginia	34.23	Florida	46.56	Iowa	73.76
Alabama	5.87	Georgia	16.01	Louisiana	33.24	Kansas	30.96	Utah	42.86	Kentucky	72.00
Texas	5.50	New Mexico	13.36	Kansas	32.32	Utah	30.04	Montana	41.61	Virginia	71.70
Mississippi	4.80	South Carolina	12.24	Virginia	31.31	Nebraska	27.91	Tennessee	40.94	Florida	69.64
New Mexico	3.90	Alabama	10.98	Tennessee	27.22	Louisiana	25.75	Wyoming	39.00	Alaska	66.85
Arkansas	2.56	Texas	10.89	Utah	27.00	Tennessee	24.04	Georgia	37.51	Tennessee	53.17
		Florida	10.74	Georgia	26.35	Georgia	23.63	Alabama	33.86	North Carolina	50.12
		Mississippi	8.33	Florida	24.95	Florida	20.58	Texas	31.51	Georgia	48.12
		Arkansas	6.61	Arizona	19.20	Dakota	17.56	South Carolina	27.73	Wyoming	46.48
				North Carolina	17.75	South Carolina	16.81	North Dakota	27.52	Alabama	44.15
				New Mexico	16.22	Arizona	15.29	North Carolina	24.95	South Carolina	43.83
				Texas	14.07	North Carolina	14.36	Nevada	24.15	Texas	39.17
				South Carolina	13.97	Texas	13.02	Arkansas	20.08	Nevada	38.83
				Alabama	13.08	Alabama	10.74	South Dakota	17.28	Arkansas	34.45
				Dakota	12.59	New Mexico	10.71	Idaho	16.54	South Dakota	30.46
				Mississippi	9.85	Arkansas	8.42	Arizona	15.89	North Dakota	28.77
				Arkansas	9.56	Mississippi	6.64	Mississippi	14.51	New Mexico	28.70
								New Mexico	9.87	Mississippi	26.06
								Oklahoma	2.92	Idaho	24.85
								Alaska	1.83	Oklahoma	17.78
								Indian Territory	1.33	Hawaii	16.23
										Indian Territory	9.67

NOTE.—Line separating states above from those below the average per capita for the United States.

Table 7 shows the number of patents issued to citizens of the United States for each census year, 1840 to 1900, with the ratio of population to each patent granted, and with the states ranked according to ratios. The average number of citizens per patent for each census year is shown, and the line of separation between the states which were above the average for the United States from those below the average for each census year is indicated.

Table 8 shows the gross value of products per capita for each state for each census year, 1850 to 1900, with the states ranked according to products per capita, and the line of separation of the states which were above the average per capita for the United States from those below the average is indicated.

A comparison of these two tables brings out the cooperative relationship of patents and manufactures, and their mutual development.

The District of Columbia ranks abnormally high in the patent table on account of the location therein of the Patent Office and the number of inventors it draws to Washington. It should not be considered in making state comparisons. Leaving out of consideration the District of Columbia, Connecticut has ranked first in patents per capita since 1850, Massachusetts being first in 1840. These states, with Rhode Island, have been the three ranking states for each census year.

Table 8 shows for California and Oregon a high standing per capita for the decades of 1850 and 1860, prior to transcontinental railway communication, when the Pacific coast had the protection of long ocean travel in favor of its own manufactures and as a stimulus to their development. For the decade of 1870, following the opening of the Union Pacific Railway, manufactures for California and Oregon show a decrease, though Nevada, on account of its phenomenal mining development during this period, ranks third. Considering solely the states subject to normal manufacturing growth, the table shows that, as in the case of patents, the three states of Massachusetts, Rhode Island, and Connecticut head the list for all decades per capita, Massachusetts being first in 1850 and Rhode Island first for each census year following, with Massachusetts second for 1860 to 1890, inclusive, and Connecticut second in 1900.

The growth and diffusion of inventive talent through-

out the country is shown by the changes in the number of population per patent for the United States, for each census year, and by the numbers of patents for the states of both highest and lowest rank for each census year. For example, in 1890 the ratio for the country at large, 1 to 2,598, outranks the highest ratio of 1850, 1 to 4,699; and the ratio for the state of lowest rank, per capita, in 1890—Mississippi with 1 to 23,447—is ahead of the average ratio for 1850—1 to 23,835.

The growth in products per capita is manifest. In 1900 the average for the United States, per capita, exceeds that of the state of highest rank for 1850. The figures for 1870 have not been reduced to compensate for the premium on gold then prevailing.

Table 9 shows the number of patents (not including designs) in force at the beginning of each calendar year from 1850 to 1900.

TABLE 9.—NUMBER OF PATENTS FOR INVENTIONS ISSUED DURING EACH CALENDAR YEAR, AND NUMBER OF LIVE PATENTS AT THE BEGINNING OF EACH CALENDAR YEAR.[1]

YEAR.	Number of patents issued during the year.	Number of live patents.	YEAR.	Number of patents issued during the year.	Number of live patents.
1850	884	6,987	1869	12,957	73,824
1851	757	7,769	1870	12,157	85,005
1852	890	8,099	1871	11,687	94,910
1853	846	8,474	1872	12,200	104,022
1854	1,759	8,928	1873	11,616	112,937
1855	1,892	10,251	1874	12,230	120,551
1856	2,315	11,673	1875	13,291	128,547
1857	2,686	13,518	1876	14,172	141,157
1858	3,467	15,714	1877	12,920	155,200
1859	4,165	18,714	1878	12,345	168,011
1860	4,363	22,435	1879	12,133	177,737
1861	3,040	26,252	1880	12,926	186,408
1862	3,221	28,795	1881	15,548	195,325
1863	3,781	31,428	1882	18,135	206,048
1864	4,638	34,244	1883	21,196	218,041
1865	6,099	38,034	1884	19,147	230,360
1866	8,874	43,415	1885	23,331	237,204
1867	12,301	51,433	1886	21,797	247,991
1868	12,544	62,929	1887	20,429	256,831

[1] Extended patents are included, but no account has been taken of the limitation of the terms of patents by reason of prior foreign patents.

TABLE 9.—NUMBER OF PATENTS FOR INVENTIONS ISSUED DURING EACH CALENDAR YEAR, AND NUMBER OF LIVE PATENTS AT THE BEGINNING OF EACH CALENDAR YEAR[1]—Continued.

YEAR.	Number of patents issued during the year.	Number of live patents.	YEAR.	Number of patents issued during the year.	Number of live patents.
1888	19,585	265,103	1895	20,883	332,886
1889	23,360	273,001	1896	21,867	341,424
1890	25,322	284,161	1897	22,098	351,158
1891	22,328	297,867	1898	20,404	360,330
1892	22,661	307,965	1899	23,296	365,186
1893	22,768	317,335	1900	24,660	370,347
1894	19,875	325,931			

Patents issued prior to 1861, when the term was fourteen years, could in certain cases be extended, and the extended patents have been taken into account in the computation. Patents limited by reason of prior foreign patents have been given their full terms, as it is impossible to ascertain the dates when they expired without an examination of each patent and the dates of antedating foreign patents therefor.

The change in the patent term from fourteen to seventeen years shows in the large increase in the number of live patents in force on the first of January for the years 1876, 1877, and 1878. For the last seventeen years the yearly issues have averaged a little less than 22,000 per year, and hence the increase in the number of live patents is less for the later years.

Table 10 draws comparisons between patents and manufactures, and shows the increase in the number of patents issued and the number of live patents for each decade, 1850 to 1900, with percentages of increase; the growth in manufactures for each census year, with percentages of increase; and the ratios of live patents to capital, number of wage-earners, cost of materials, and gross value of products, respectively, for each census year, with percentages of ratios on the basis of 1850.

TABLE 10.—COMPARATIVE TABLE OF PATENTS AND MANUFACTURES: 1850 to 1900.

YEAR.	PATENTS.						MANUFACTURES.					
	Number issued during the decade.	Increase.	Per cent of increase.	Number of live patents.	Increase.	Per cent of increase.	Number of establishments.	Capital invested.	Number of wage-earners.	Wages.	Cost of materials used.	Gross value of products.
1850	5,516	.....	.....	6,987	.....	.....	123,025	$533,245,351	957,059	$236,755,464	$555,123,822	$1,019,106,616
1860	19,661	14,145	256.4	22,435	15,448	221.1	140,433	1,009,855,715	1,311,246	378,878,966	1,031,605,092	1,885,861,676
1870	71,818	52,157	265.3	85,005	62,570	278.9	252,148	2,118,208,769	2,053,996	775,584,343	2,488,427,242	4,232,325,442
1880	124,751	52,933	73.7	186,408	101,403	119.3	253,852	2,790,272,606	2,732,595	947,953,795	3,396,823,549	5,369,579,191
1890	195,454	70,703	56.7	284,161	97,753	52.4	355,415	6,525,156,486	4,251,613	1,891,228,321	5,162,044,076	9,372,437,283
1900	221,502	26,048	13.3	370,347	86,186	30.3	512,254	9,817,434,799	5,308,406	2,322,333,877	7,345,413,651	13,004,400,148

YEAR.	MANUFACTURES—continued. Per cent of increase.						RATIOS OF LIVE PATENTS TO CAPITAL, NUMBER OF WAGE-EARNERS, COST OF MATERIALS, AND GROSS VALUE OF PRODUCTS, WITH PERCENTAGE OF RATIOS ON BASIS OF 1850.							
	Establishments.	Capital.	Wage-earners.	Wages.	Materials.	Products.	Capital.	Per cent.	Wage-earners.	Per cent.	Materials.	Per cent.	Products.	Per cent.
1850	.....	.....	.....	.....	.....	.....	1 : $76,320	100	1 : 137	100	1 : $79,451	100	1 : $145,858	100
1860	14.1	89.4	37.0	60.0	85.8	85.1	1 : 45,012	59	1 : 58	42	1 : 45,982	58	1 : 84,059	58
1870	79.6	109.8	56.6	104.7	141.2	124.4	1 : 24,919	33	1 : 24	18	1 : 29,274	37	1 : 49,789	34
1880	0.7	31.7	33.0	22.2	36.5	26.9	1 : 14,969	20	1 : 15	11	1 : 18,223	23	1 : 28,806	20
1890	40.0	133.9	55.6	99.5	52.0	74.5	1 : 22,963	30	1 : 15	11	1 : 18,166	23	1 : 32,983	23
1900	44.1	50.5	24.9	22.8	42.3	38.8	1 : 26,509	35	1 : 14	10	1 : 19,834	25	1 : 35,114	42

*

The ratios show that up to 1880 patents developed, numerically, at a faster rate than manufactures, the capital, cost of materials, and gross value of products keeping pace with each other, while fewer wage-earners were required in successive census years in comparison to the capital invested, cost of materials, and value of products. Since 1880 the capital, cost of materials, and value of products of the manufacturing returns have increased at a faster ratio than the patents, while the number of wage-earners show a lesser ratio, indicating that, along with patent growth, the capital invested, cost of materials, and value of products per wage-earner employed has increased for every decade. The efficiency of improved machinery and processes, the use of cheaper materials, and the utilization of former waste products results in the employment of more capital, the handling of more material, and the turning out of more products per wage-earner with each succeeding decade.

In comparison with Table 10, which relates to manufactures in general, there is presented the following comparative Table 11, for sewing machines and attachments therefor, an industry which, founded on patents at the middle of the last century, and held practically as a close monopoly by reason of dominating patents for a long period, has now passed beyond the control of fundamental patents, and has become a normal manufacturing industry. It is taken as typical of an industry created by patents.

TABLE 11.—COMPARATIVE TABLE OF PATENTS AND MANUFACTURES FOR SEWING MACHINES AND ATTACHMENTS: 1850 to 1900.

YEAR.	PATENTS.						MANUFACTURES.					
	Issued during the decade.	Increase.	Per cent of increase.	Live patents.	Increase.	Per cent of increase.	Number of establishments.	Capital.	Wage-earners.	Wages.	Cost of materials used.	Gross value of products.
1850	11			11								
1860	379	368	3,345	386	375	3,409	75	$1,427,750	2,297	$1,094,796	$648,312	$4,255,820
1870	952	573	151	1,232	846	219	49	8,759,431	7,291	5,142,248	3,055,786	14,097,446
1880	2,327	1,375	144	3,087	1,855	151	106	12,501,830	9,553	4,636,099	4,829,106	13,863,188
1890	2,807	480	21	4,264	1,177	38	59	16,043,136	8,837	4,750,324	3,502,173	12,823,147
1900	2,018	[1]789	[1]28	[1]3,956	[1]308	[1]7	58	18,739,459	10,635	6,213,938	7,809,796	18,314,419

YEAR.	MANUFACTURES—continued.						RATIOS OF LIVE PATENTS TO CAPITAL, NUMBER OF WAGE-EARNERS, COST OF MATERIALS, AND GROSS VALUE OF PRODUCTS, WITH PERCENTAGE OF RATIOS ON THE BASIS OF 1860.							
	Per cent of increase.													
	Establishments.	Capital.	Wage-earners.	Wages.	Materials.	Products.	Capital.	Per cent.	Wage-earners.	Per cent.	Cost of materials used.	Per cent.	Value of products.	Per cent.
1850														
1860							1 : $3,699	100	1 : 6.0	100	1 : $1,680	100	1 : $11,025	100
1870	[1]33.8	514.1	218.9	371.4	371.6	231.9	1 : 7,110	192	1 : 5.9	100	1 : 2,480	148	1 : 11,443	104
1880	118.4	42.7	31.0	9.8	58.0	[1]1.7	1 : 4,050	110	1 : 3.1	53	1 : 1,564	93	1 : 4,491	41
1890	44.3	28.3	[1]7.5	2.5	[1]27.5	[1]7.5	1 : 3,762	102	1 : 2.1	36	1 : 821	49	1 : 3,008	27
1900	[1]1.7	16.8	20.3	30.8	123.0	42.8	1 : 3,737	101	1 : 2.7	46	1 : 1,974	118	1 : 4,630	42

[1] Decrease.

The table shows the number and increase in number of patents pertaining to sewing machines and attachments issued during each decade, 1850 to 1900, with per cent of increase, and the number of live patents in this industry for each census year, with the increase and per cent of increase; and, with respect to manufactures, the number of establishments, capital invested, wage-earners, wages paid, cost of materials, and gross value of products, with the percentages of increase or decrease for each census year. In harmony with Table 10, there is also shown the ratios of live patents to capital, number of wage-earners, cost of materials, and gross value of products, respectively, for each census year, with percentages of ratios on the basis of 1860.

The first sewing machine patent was granted to J. J. Greenough, February 21, 1842, No. 2466. The patent to Elias Howe, jr., in 1846, for the eye at the point of the needle, made the sewing machine a practical success. It has been estimated that the four-motion feed patent earned $32,000,000 for its owners, a larger amount probably than any other patent issued prior to the Bell telephone patent. It was issued in 1850 for a term of fourteen years, and twice extended for terms of seven years, making twenty-eight years in all. By means of it the sewing-machine combination virtually held a monopoly of the industry during its lifetime. On its expiration in 1878 a marked increase appeared in sewing-machine inventions.

A practical sewing machine was nearly perfected by Walter Hunt in 1838, but upon the protest of his wife against it, on account of its effect upon tailors and sewing women, he suppressed it.

A presentation of the industries which are based upon patented inventions—either inventions which have

created new industries or inventions which have revolutionized old industries—would include almost all of the manufacturing industries of the present day. The difficulty in the way of such a presentation lies in the selection and elimination of the industries which, as now practiced, are not indebted to patents, rather than in the selection of the industries which are based upon patents, either those which are now in force or those which have expired and been added to the common stock of the world's industrial knowledge.

There are many extensive industries which are entirely the creation of patents, and can be readily differentiated from the great mass of manufactures; for example, certain industries based upon chemical inventions and discoveries, as oleomargarine, which now employs $3,023,646 of capital, and supplies products to the value of $12,499,812; glucose, which uses $41,011,345 of capital, and gives products to the value of $21,693,656; wood pulp, which, starting with the ground wood pulp patent of Voulter in 1858, and following with the soda fiber and sulphite fiber processes, is now the chief material employed in paper manufacture, with products aggregating $18,497,701; high explosives, which, starting with the nitroglycerin patent of Nobel in 1865, now includes dynamite, the pyroxylin explosives, and smokeless powder, with products aggregating $11,233,396; while the electrical industries, which now touch all fields of industrial activity, power and transportation, lighting and heating, electro-chemical processes, telegraphy and telephony, employ directly and indirectly capital extending into the billions, and are the creation of patents. The rubber industry was insignificant prior to the discovery by Charles Goodyear of the process of vulcanization, while now the products in the shape of rubber and elastic goods and rubber boots and shoes amount to $93,716,849. Bicycles and tricycles employ $29,783,659 of capital, with products valued at $31,915,908. Manufactured ice employs $38,204,054 of capital, with a return in products of $13,874,513.

Phonographs and graphophones, starting in 1877, now show the use of $3,348,282 of capital, and products to the value of $2,246,274. Photography, including the manufacture of materials and apparatus as well as the practice of the art—all the outcome of invention—is now represented by 7,706 establishments, with a combined capital of $18,711,339, and products to the value of $31,038,107. The manufacture of sewing machines employs $18,739,459 of capital, and supplies products to the value of $18,314,490. The manufacture of typewriters and supplies, within three decades, has become an industry that employs $8,400,431 of capital, and gives products to the value of $6,932,029. These are but examples of what may be considered as patent-created industries.

If we attempt to enumerate the industries which, existing prior to the period of patent growth, have been revolutionized by inventions, a catalogue of all of the old industries is virtually required. The returns for the manufacture of agricultural implements for the present census show 715 establishments, with a capital of $157,707,951, giving employment to 46,852 wage-earners, who received $22,450,880 in wages, and manufactured products to the value of $101,207,428; and, in the entire range of agricultural implements and machines now manufactured, every one, from hoe or spade to combined harvester and thrasher, has been, either in the implement or machine itself, or in the process of manufacture, the subject of a patented improvement which has produced a new or better article, or cheapened the cost of manufacture.

The great iron and steel industry as it exists to-day is the product of countless inventions which permeate every branch thereof, and include many revolutionizing inventions, as, for example, the Bessemer process. The blast furnaces, rolling mills and forges and bloomeries, reported at the present census comprise 668 establishments, with a capital of $573,391,663, employing 222,490 wage-earners, with $120,820,276 paid in wages, and supplying products to the value of $803,968,273. A prohibition of the use of the patented inventions of the last half century would stop every one of these establishments.

The same may likewise be said of the textile industry, the manufactures of leather, of lumber, chemicals, etc., and the railway system in its entirety, from the rail to the top of the smokestack, and from the pilot to the rear train light or signal, is an aggregation of American inventions.

Without attempting to touch upon the industries which have been revolutionized or expanded by patents, Table 12, which follows, aims to show the growth of industries which have sprung from patents, so far as the returns of the present and preceding censuses permit of the industries being reported and compared. This table shows the progressive growth through the several decades of these selected industries, the decade when they were severally first reported as separate industries, and their expansion in succeeding decades. It will be understood, however, that in many cases an industry existed prior to its appearance as a separately reported manufacture, but was merged during its infancy with other manufactures.

TABLE 12.—COMPARATIVE SUMMARY OF INDUSTRIES DEVELOPED FROM INVENTIONS: 1850 TO 1900.

	1850			1860			1870		
	Number of establishments.	Capital.	Products.	Number of establishments.	Capital.	Products.	Number of establishments.	Capital.	Products.
Electrical apparatus and supplies	[1] 2	$3,750	$5,100	4	$16,500	$59,000	(2)	(2)	(2)
Nitroglycerin							3	$39,500	$225,700
Galvanizing							9	206,000	796,326
Ice, manufactured							4	434,000	258,250
Photographic apparatus							10	245,400	831,975
Photographic materials				12	198,000	468,280			
Photography				249	417,250	1,090,647	1,090	1,995,280	3,643,887
Sewing machines and attachments				87	1,474,450	4,253,206	49	8,759,431	14,097,446
Stereotyping and electrotyping				41	126,500	286,300	36	1,033,200	1,075,080
Wood pulp							8	191,000	172,350
Total			5,100			6,257,433			21,101,014

	1880			1890			1900		
	Number of establishments.	Capital.	Products.	Number of establishments.	Capital.	Products.	Number of establishments.	Capital.	Products.
Bicycles and tricycles				27	$2,058,072	$2,568,326	312	$29,783,659	$31,915,908
Electrical apparatus and supplies	76	$1,509,758	$2,635,036	189	18,997,337	19,114,714	580	83,130,943	91,348,889
Electrical construction and repairs							1,162	5,438,087	15,907,420
Electroplating	221	865,898	1,975,700	313	2,051,134	3,121,642	422	1,460,692	3,007,455
Explosives:									
Nitroglycerin								(3)	783,299
Gun cotton	21	1,601,625	2,453,088	32	3,929,503	4,600,272		(3)	486,773
Dynamite								(3)	8,247,223
Smokeless powder								(3)	1,716,101
Fire extinguishers, chemical	3	400,000	204,693	9	405,733	195,834	17	136,933	217,833
Galvanizing	21	671,450	1,884,695	27	1,301,973	2,957,143	28	1,775,770	2,470,703
Glucose	7	2,255,000	4,551,212	7	5,991,023	7,756,686	8	41,011,345	21,693,656
Ice, manufactured	35	1,251,200	544,763	222	9,846,468	4,900,983	787	38,204,054	13,874,513
Oleomargarine	15	1,680,300	6,892,939	12	634,532	2,988,525	24	3,023,646	12,499,812
Pens, fountain and stylographic				15	142,265	351,775	23	590,629	906,454
Phonographs and graphophones				(2)	(2)	(2)	11	3,348,282	2,246,274
Photographic apparatus	10	90,800	104,305	25	362,834	624,342	48	1,849,724	2,026,063
Photographic materials	5	63,000	142,000	45	1,172,640	2,121,387	105	3,668,026	5,773,325
Photography	1,287	3,131,895	5,935,311	3,105	7,804,532	15,488,324	7,553	13,193,589	23,238,719
Photolithographing and photoengraving				89	1,134,873	2,071,580	204	1,999,921	4,226,106
Registers, car fare	1	300,000	6,600	7	74,725	141,320	5	104,408	80,865
Registers, cash				5	292,150	1,281,500	13	5,137,965	5,594,500
Rubber belting and hose	2	265,000	1,085,000	17	5,270,068	5,512,840	18	5,493,885	6,169,044
Rubber boots and shoes	9	2,425,000	9,705,724	11	17,790,970	18,632,060	22	33,667,533	41,089,819
Rubber and elastic goods	93	6,284,187	14,518,924	[4] 139	13,703,787	18,708,917	202	39,304,853	52,627,030
Sewing machines and attachments	106	12,501,830	13,863,188	59	16,043,136	12,823,147	58	18,739,459	18,314,490
Stereotyping and electrotyping	45	536,000	724,689	81	1,332,129	2,183,909	140	2,389,215	3,772,025
Typewriters and supplies				30	1,421,783	3,630,126	47	8,400,431	6,932,029
Wood pulp:									
Ground	50	1,898,450	2,256,946	82	7,455,449	4,627,796		(5)	4,433,699
Soda fiber								(5)	3,612,602
Sulphite fiber								(5)	10,451,400
Total			69,504,813			136,403,148			395,663,958

[1] Electro-magnetic instruments.
[2] Not separately reported.
[3] Capital not separable from explosives in general.
[4] Rubber, vulcanized, included in "all other industries" in 1890.
[5] Capital not separable from paper and wood pulp.

There is presented in the appendix hereto a review of the patent growth of the industrial arts for the period included between the years 1871 and 1900, inclusive, as shown by the leading and typical inventions in the several departments of the industrial and mechanical industries. The closing decades of the nineteenth century have witnessed the most extraordinary development of manufactures and commerce known in our history. Industrial demand and invention go hand in hand. They act and react, being interdependent. Any change in industrial conditions creating a new demand is at once met by the invention of the means for supplying it, and through new inventions new industrial demands are every year being created. Thus through the process of evolution the industrial field is steadily expanding, and a study of the inventions for any decade will point out the lines of industrial growth for the succeeding decade.

PATENT GROWTH OF THE INDUSTRIAL ARTS: 1870 TO 1900.

The expansion of the industrial arts under the stimulus afforded by the patent system is best set forth by a plain recital of facts. No single year will so well illustrate this as a more expanded view over a period of years. The industrial arts are a growth; inventions do not limit themselves in their bearings to so short a period as one year, therefore it is here attempted to give a more extended survey of the advances in the practical arts during the period of thirty years last past, not because that period is marked off by any special epochs in the arts, but because it is a convenient though arbitrary period with reference to the arrangement of facts, and has proved to be a period extraordinarily prolific in invention throughout the world.

The difficulty in selecting material is obvious, and some unfortunate inferences may be derived from the method of treatment adopted.

It is recognized that many imperfections must be apparent in any attempt, however studied and sincere, to truly set forth in brief space this vast array of facts; but to avoid mere generalization on the one hand and mere cataloguing of all patents on the other, it was determined to select, as the tangible proofs of the various propositions of the text, certain typical patents which illustrate the various stages of growth in the different arts.

When the number of patents in a class or subclass are given, all granted prior to January 1, 1902, are included.

No attempt has been made in this history to be guided in the selection of examples by the decisions of the courts. By following these, selection might have been made of many patents which are commercially valuable, but which are not as pointed illustrations of industrial advance as those which have been selected are believed to be.

AGRICULTURE.

(1) Farming, including those agencies by which agricultural products in their raw condition are obtained from the earth.

(2) Farm products, including the preparation of such products for the market without essential change in their character.

FARMING.

Plows and Cultivators.—In this class 11,825 patents have been granted. A notable evolution in tilling the soil is the use of disks that penetrate the earth and revolve in contact therewith. In the breaking of prairie land, cutting disks are harnessed to steam motors and are adapted to break up at one operation a wide strip of ground. In the class of steam plows, the patents to Newsom, 349,807, September 28, 1886, and Brown, 424,265, March 25, 1890, are of this class. Two hundred and twenty-three patents have been issued for steam plows.

In breaking plows, Underwood, 177,668, May 23, 1876, is among the first to employ the disk plow; while the plow of Atkins and Roberts, 543,118, July 23, 1895, illustrates the advance made in the art.

A type of the disk hand-wheel plow is illustrated in the patent to Ruggles, 422,161, February 25, 1890.

Another important type, which has received considerable attention since 1870, employs a gang of plows arranged to plow back and forth, without turning like the well-known hillside plow. Unterlip, 301,306, July 1, 1884, and Fay, 536,949, April 2, 1895, show such machines designed for horsepower; while Sack's, 386,162, July 17, 1888, is a heavier machine for use with steam power.

The history of the wheeled plow shows a gradual improvement. The patents to Hasbrook, 138,329, April 29, 1873; Casaday, 466,945, January 12, 1892; and Sater, 501,607, July 18, 1893, show this. In this subclass 1,423 patents have been issued.

Electricity is beginning to be employed in the art of tillage, as is shown in the patent to Roberts, 509,556, November 28, 1893. This is analogous to steam plows in its heavy multishared construction, designed for plowing large tracts of level ground.

Among the later patents in wheeled plows is one to Davis, 657,862, September 11, 1900, a frameless plow which in this form is new in the art. The patent to Waterman, 629,733, July 25, 1899, in contrast shows a plow provided with a frame, guide or steering wheels, jointly coupled disk colter, cushioned levers, and spring-lifting device. In wheeled cultivators an advance seems to have been made in cultivating a number of rows of growing crops. Machines for this purpose are illustrated in the patents to Davis, 576,039, January 26, 1897, and 609,611, August 23, 1898.

Among the first of the disk cultivators is one shown in the patent to Mallon, 206,185, July 23, 1878, a revolving cultivator, and a later one is found in the pat-

ent to Lindgren, 531,200, December 18, 1894, a riding cultivator, having an arched axle to pass over the rows of growing crops and cultivate on both sides of the row at the same time, adjusting mechanism to regulate the throw of the soil to or from the plants, and adjustable dragbars suspended by a universal joint, and lifting levers. The patent to Jones, 542,339, July 9, 1895, shows a cultivator adapted to work 3 rows at the same time.

Much attention has been given in recent invention to the hammock cultivator, so called by reason of its swing construction, by which the blades can be easily turned to one side or another of a row to avoid the accidental plowing out of the hills of corn or other crops. Among these patents are those to Sobey, 578,502, March 9, 1897; Brunnemer, 631,415, August 22, 1899; Hastings, 629,162, July 18, 1899; and Beall, 659,885, October 16, 1900. The two last-named patents are provided with weight compensating mechanism, whereby the swing frame is balanced and the weight of the tongue minimized.

Unusual activity has been shown in the disk plow inventions. Among these may be cited Brunnemer's patent, 644,318, February 27, 1900, as an up-to-date single-disk plow, while the patent to Gatling shows a gang of 8 disks coupled to a motor. In hand plows the patent to Allen, 618,316, January 24, 1899, illustrates one of a type having the draft applied low. This type of plow is in great favor with extensive truck gardeners.

Cultivators for specific purposes are now constructed for cultivating beets, spinach, cane, cotton, potatoes, and other plants. The patent to Gatling, 651,659, June 12, 1900, illustrates a machine for the cultivation of cotton and corn, while the patent to Whitbeck, 642,398, January 30, 1900, shows a device especially adapted for the cultivation of potatoes.

The potato-harvesting devices now largely in use consist generally of wheeled machines provided with a digging plow, a conveyor mechanism, assorting screens, and bagging devices. The leading patents are Smethurst, 520,902, June 5, 1894, and Jackson, 539,432, May 21, 1895.

Four distinct types of cotton choppers have gradually evolved—the reciprocating, illustrated by Summers, 573,369, December 15, 1896; the scraper or horizontal cutter, shown in 637,382, November 21, 1899, to Gills; the wheel spacer, illustrated in Taylor, 635,205, October 17, 1899; and the revolving chopper, seen in the patent to Blaschke, 651,523, June 12, 1900.

Harrows and Diggers.—Probably the most noteworthy patent issued in this class is one granted to Garver, March 26, 1878, reissue 8,142, of a patent obtained in 1869, for a curved spring tooth. This patent nearly revolutionized the harrow industry.

Garver's patent was followed by one to Nishwitz, 262,975, August 22, 1882, for a harrow comprising two ranks of oppositely curved trailing teeth, an implement especially popular in foreign countries. In 1886, August 17, a patent, 347,745, was granted to Stoddard for a harrow comprising two gangs of concavo-convex disks attached to a frame and capable of horizontal adjustment. These three distinct types of harrows have superseded largely all prior devices in that class.

In patents 600,658 to 600,663, inclusive, March 15, 1898, E. E. Whipple claims to be the first to have invented means in various forms for supporting pivoted-tooth-bar harrows in a plane elevated above the ground by a wheeled attachment, whereby the frame of the harrow can be supported in a given horizontal plane when the teeth are in or out of operative engagement with the soil, and at the same time the harrow may be left free to move above the plane of the support without interfering with the operation of the wheeled attachment. Other forms of apparatus for the same purpose are patented to the same inventor—609,980, 609,981, and 610,115, August 30, 1898; 611,160, September 30, 1898; and 636,371 and 636,477, November 7, 1899.

Patents 636,878, 637,190, and 637,192, November 14, 1899, to Whipple, show floating harrows of the "weeder" type, the weeder frame being held within certain limits of downward movement, but free to rise; and in these patents, as well as in 637,191, the connection between the harrow and the wheeled support is far in advance of the harrow teeth, permitting free lateral swing of the harrow frame. Sharp, 589,797, September 7, 1897, shows devices connected with the gang frame and the support of a pivoted gang disk harrow, operated by the end thrust of the gang to apply a downward pressure to the gang at one end. Hallock received patent 600,782, March 18, 1898, for a weeder tooth having a slender cylindrical lower end and having the upper end flat and reenforced by an overlaid spring. Macphail received patents 631,046 and 631,048, August 15, 1899, for a harrow spike tooth sprung into a split tubular tooth bar, to be held thereby. Ryder, 585,941, July 6, 1897, shows harrow teeth and supporting wheels supported at right angles on rocking tooth bars, so that as one device is thrown out of operation the other is thrown into operation. Naylor, 625,793, May 30, 1899, shows associated rocking tooth bars adapted to bring spike and spring teeth either into alternate or simultaneous operation. Hopkins, 618,098, January 24, 1899, and Evans, 655,924, August 14, 1900, show means for cutting the stalks of weeds near the surface of the ground, said means adapted to be freed from clogging by periodic release from engagement with the supporting frame, and by rotation.

Patents to Nash, 648,466, May 1, 1900, and Zimmerman, 653,635, July 10, 1900, show means of pulling up potato plants by their tops, to clear the rows for the subsequent operation of potato diggers. Russell, patent 639,618, December 19, 1899, shows interlocking corrugated reels, adapted to pull weeds, especially flax.

Berg, patent 635,642, October 24, 1899, shows a roller, and Wood, 649,093, May 8, 1900, shows a drag-bar, adapted to lay grain so as to protect it from injury by high winds.

Seeders and Planters.—In the class of seeders and planters the substitution of the force feed for gravity feed marked an important step. The feed devices usually consist of a cylinder having a smooth and a fluted part working in a cup through a rose or ring beneath the hopper, with provision for adjustment, to graduate the flow of seed, the smooth portion acting as a cut-off. The patents to Bushnell, August 29, 1876, 181,521, and Riter, November 9, 1880, 234,335, illustrate this subclass.

The shoe drill has largely superseded the common hoe drill, especially in the far West. A series of shoes are pivoted to the frame, extend beneath the seedbox, and are provided with springs for depressing or raising the shoes. The patents to Christman & Munn, 497,864, May 23, 1893, and Schopp & Liese, 513,060, January 16, 1894, are good examples.

Lister plows and planters are so important in the art that nearly every manufacturer has one of special make. They consist of a double moldboard plow that clears away the earth, followed by a drill tooth that cuts a furrow and delivers and covers the seed. See as examples: Lindgren, 364,829, June 14, 1887, and Waterman, 385,738, July 10, 1888.

In planters for corn, cotton, and potatoes it has become desirable to have machines that are susceptible of conversion from a hand to a check row or drill device. The patents to Lynch, 376,534, January 17, 1888, and Scofield, 509,453, November 28, 1893, illustrate the combined machine.

The desirability of combining in one machine devices whereby three distinct operations of discharging seed is possible, viz, check rowing, drilling, and hand dropping, is illustrated in patents to Kaylor, 555,319, February 25, 1896; Lindgren, 577,437, February 23, 1897; Dooley, 593,295, November 9, 1897; and Haworth, 602,903, April 26, 1898. The substitution of rimless wheels, the teeth of which take into the ground for operating the dropping devices, for the staked check-row cord, appears to be growing in favor. See as illustrations patents to Jarmin, 630,891, August 15, 1899; Bettendorf, 635,838; and Burt, 662,912, December 4, 1900. Little or no change has been made in the devices for dropping cottonseed since the advent of the delinting devices, which remove the fuz, and the seed can be manipulated the same as other seed. The advent of the seeder attachment to ordinary forms of cultivators whereby the missing hill may be "replanted" with the first cultivation of the growing corn appears to be important. See patents to Flagg, 615,-835, December 13, 1898; Shedenhelm, 652,524, June 26, 1900; and Mitchell, 664,663, December 25, 1900. Devices for distributing coarse fertilizer whereby, after a vehicle is loaded a belt or endless belt is used to convey the load to a feeding cylinder as in patents to Kemp, 632,124, August 29, 1899, and Oppenheimer, 648,519, appear to be growing in favor.

Regarding the "force feed," devices for feeding seed, to judge from the special improvements, as in patents to Ham, 564,424, July 21, 1896; Heath, 629,994, August 1, 1899; and Sester, 642,534, January 30, 1900, the art is gradually growing. The devices for centrifugally scattering seed from an attachment that is substituted for the end board of an ordinary farm wagon and also carried by the operator, as in patents to Morse, 557,010, March 24, 1896; Ziegenhorn and Guingrich, 635,836, October 31, 1899; Stevens, 657,797, September 11, 1900; Eltzroth, 579,049, March 16, 1897; Taylor, 619,055, February 7, 1899; and Rinderknecht, 649,953, May 22, 1900, apparently are regarded as useful devices, to judge from the number of applications filed and patents granted.

Among important patents in transplanters are those issued to Pitt, 516,745, March 20, 1894, and Stevens & Swart, 519,460, May 8, 1894. These dig the plant trench, distribute the fertilizer, set the plant, pack the earth, and water the plant automatically.

A novel device was patented by A. M. Rivero y Aguiar, 552,449, December 31, 1895, for planting sugar cane. In this a plow digs the trench, a knife cuts the cane into proper lengths, which drop into the trench and are covered by scraping blades at the rear of the machine.

Harvesters.—In this class 11,228 patents have been issued. In 1871 some of the essential features of the modern harvester had already been invented, and some experimental machines had been tested in the field; but farmers were then using nothing more than the ordinary mowing machines and reapers, from which the grain was raked in gavels and bound by men who followed the machine. Since that time the art of harvesting grain has been revolutionized by the invention and introduction of the automatic self-binding machines. The patents to Locke, 149,233, March 31, 1874, and 121,290, November 28, 1871, show a wire-binding attachment for harvesters, under which a great many machines were built, and which continued in use until the development of the twine binder. The patents to Gordon, 152,481, June 30, 1874; 169,258, October 26, 1875; 194,817, September 4, 1877; and 151,967, June 16, 1874, show the Gordon wire binders, which competed in the market with those of Locke. The patent to M. L. Gorham, 159,506, February 9, 1875, was probably the first twine binder to operate successfully in the field, and was considered a pioneer invention by the court in the recent case of the McCormick Harvesting Machine Company *v.* C. Aultman & Co., 73 O. G., 1899. Almost all the twine binders built in this country have been built under one of two patents—one to H. A. & W. M. Holmes, 210,533, December 3, 1878,

and the other to Appleby, 212,420, February 18, 1879. The patent to Howe, 456,825, July 28, 1891, shows a sheaf carrier, which established a type now in general use. Great numbers of these attachments have been built, and this is one of the most valuable patents which has been granted in recent years. The patents to Smith, 233,035, October 5, 1880, and 298,249, May 6, 1884, show a spring-lifting device or counterbalance for the cutting apparatus of a mowing machine. Such devices are in general use at the present time. The patent to Beck, 468,382, February 9, 1892, shows a rotary hay tedder, which is now largely manufactured, and which created considerable interest among manufacturers and farmers.

At the Atlanta Exposition a cotton harvester was shown which created a great deal of interest and is said to have been very successful. This machine is found in patent 542,794, Campbell, July 16, 1895.

In the last few years perhaps the most important development has been in machines for harvesting corn, and in mowers and lawn mowers propelled by steam or other motive power. Several of the leading manufacturers are now producing the former machines on an extensive scale as compared with anything previously done, and the latter have come into much more general use during the past few years than ever before. Examples of corn-harvesting machines may be seen in the patents to Peck, 466,512, January 5, 1892, reissue 11,492, May 7, 1895; Pridmore, 611,078, September 20, 1898; Sharp, 614,064, November 8, 1898; Whitney & Steward, 619,377, February 14, 1899; Farrall & Maul, 657,215, September 4, 1900; and Steiner, 656,675, August 28, 1900. The patent to Ellis & Steward, 577,105, February 16, 1897, is an example of what has been done in the other class.

In California and other states where the grain is ready for thrashing as soon as it is cut, there is in general use a thrasher and a harvesting machine of the header type mounted on a single platform, and the heads of grain are carried directly from the harvester by elevators into the thrashing machine, from which the thrashed grain is delivered into bags, and is then ready for shipment. Combined harvesters and thrashers have been known since 1836, but they have been much improved and are now built on a much larger scale. Good examples of this class are shown in patents to Matteson, 333,533, January 5, 1886, and to Berry, 374,339, December 6, 1887. In this subclass 91 patents have been issued.

Trees, Plants, and Flowers.—In the class trees, plants, and flowers 1,225 patents have been granted. In hedge training several inventors seem to have attained considerable success, especially Michael Neil and Wesley Young, to whom about a dozen patents have been issued. See patent to Young, 185,616, December 19, 1876, and Neil and Young, 208,755, October 8, 1878.

The most important improvements in the cultivation of plants since 1873, such as the introduction of the beetles called ladybirds, and other natural enemies, to destroy the aphis, and the use of kerosene emulsion for a similar purpose, have either not been patented at all or not under this art.

The most noteworthy inventions of late years are those of the Germans, Nobbe and Hiltner, Caron, and Hartleb, for bacterial fertilization of the soil; but the American patents, excepting that to Nobbe and Hiltner, belong to the year 1901. Patent to J. Fuchs, 565,384, for the destruction of phylloxera and microbes by electricity is important, if it proves practically successful.

STOCK, INCLUDING PATENTS REFERRING TO THE RESTRAINT, FEEDING, AND PROTECTION OF ANIMALS.

Bee Culture.—In this class 1,049 patents have been issued. The first movable comb frame for beehives was patented to Langstroth, 9,300, October 5, 1852, and improvements thereon, disclosing simple and effective means for holding removable comb frames in the hive, were patented to Heddon, 327,268, September 29, 1885; to Shuck, 329,341, October 27, 1885; and to Dazenbaker, 547,164, October 1, 1895.

The first artificial comb foundation was made in Germany about 1842. An effective improvement thereon is the employment of a wire support embedded in the foundation, and patented to Hetherington, 208,595, October 1, 1878, reissued November 11, 1879, 8,962. An artificial honeycomb was made prior to 1853, and on January 29, 1889, 397,046, to Aspinwall, was patented one of wood, from which the honey may be separated in a centrifugal machine, and on August 30, 1892, 481,578, to Mason and Moskovitz, was patented an improved process for making a honeycomb from wax.

Incubators.—The art of hatching chickens by artificial means was practiced in Egypt for thousands of years with considerable success. Machines with this end in view were patented in this country prior to 1871, but very rarely with any positive degree of success. The reason for their failure arose from the operator's ignorance of the degree of heat and amount of moisture requisite. The British patent to Cantelo, 11,102, February 25, 1846, and the United States patents to Hoffman, 4,978, February 20, 1847, and Guerin, 3,019, March 30, 1843, are among the earliest types of incubator employed in this country and England. Following these tentative constructions, the most important innovation was made by Rosebrook, 271,991, February 6, 1883, who successfully regulated the temperature by a thermostat and electric circuit, and Halstead, 267,422, November 14, 1882, who devised an egg-turner and moisture system. Campbell, 372,115, October 25, 1887, provided for the independent regulation of water and air temperatures, thereby greatly enhancing the effectiveness of the incubator.

Later improvements in details have been made, such as those shown in patents to Kutz, 599,145, February 15, 1898; Nix, 597,242, January 11, 1898; and Newsome,

614,493, November 22, 1898; while Brown, 662,347, November 20, 1900; and Markwell, 663,916, December 18, 1900, relate to improvements in brooders. There have been 190 patents issued in this class.

Fences.—Probably the most important patent in the class of fences issued since 1873 is that of Glidden, 157,124, November 24, 1874, for a barbed wire. This differs from former inventions in barbed wires in having the barb formed of a wire coiled around the longitudinal fence wire instead of having it formed of a perforated plate strung on the fence wire.

The patent granted to Winsor, 151,260, May 26, 1874, for a railway gate, was the first United States patent for a crossing guard of the common type. The patent to Toulmin, 397,880, February 12, 1889, was the first automatic railway gate operated by an electric motor, and Lidback, 345,239, July 6, 1886, was the first mast gate divided for the purpose of avoiding overhead wires. The first automatic device for closing hatches in case of fire is to Reynolds, 135,728, February 11, 1873.

Many specific improvements have been granted in fencing fabrics, which may be illustrated by Kitselman, 606,421, in the mesh, and Willix, 605,570, in the stayed, type of fabric. Perry, in 576,069, shows the first electrically welded fence fabric.

Much activity has been shown in the class of concrete metal-reenforced posts: Matthews, 607,258, illustrates one of this type of posts.

PREPARATION OF FARM PRODUCTS.

For the treatment of grain products we have, in succession, thrashing, flour milling, and baking devices, malting devices, and all those devices which by subsequent treatment aid in transforming the malt into fermented and spirituous liquors.

Thrashing.—Four thousand nine hundred and sixty-seven patents have been issued in this class. The power cornsheller, the counterbalanced straw shaker, and the automatic band-cutting and grain-feeding attachment for thrashers appear to be the most notable, of which the following are fair representatives: 247,338, Gillet, September 20, 1881; 250,248, Huber & Strobel, November 29, 1881; 327,587, Piatt, October 6, 1885; and 624,023, Heine, May 2, 1899.

For separating the thrashed grain from the straw, and the disposal of the straw by pneumatic means, see patent 569,298, Outram, October 13, 1896.

Flour Milling.—This art has been wholly transformed since 1870 (1) by the almost complete substitution of the roller mill for the disk mill or burr, of which a pioneer and representative is shown in 182,250, Wegmann, September 12, 1876; (2) by the introduction of the so-called middlings purifier—a flat bolt or shaker in an inclosing case, through which passes an upward draft of air, lifting the bran specks and fuzz from the shaken material, of which a representative type is seen in 164,050, Smith, June 1, 1875; (3) the disastrous flour-dust explosions at Minneapolis in 1877–78 caused the development of the dust collector for withdrawing from the milling machinery and from the interior air of the mill the suspended particles of flour dust, the ignition of which caused these explosions. Thus the air is cleared for use in the delicate operations for producing the finest flour and for respiration, and the mill may be kept closed and comfortable in the cold seasons. The collector at first took the form of a filtering diaphragm, of which a representative is seen in patent 213,151, March 11, 1879, to Washburn. Later the dust collector has for its essential principle the vortical or rotatory air current, which, it is claimed, masses and precipitates fine particles impossible to arrest by means of a filter, however fine. Example, 403,362, Morse, May 14, 1889.

The gyrating flat bolt has received attention, especially as to the circulating brushes and other cloth cleaners. See 644,484, Wilson, February 27, 1900.

Bread and Cracker Machines, etc.—Among the machines which reduce the whole wheat berry to a thread-like or shredded form (shredded wheat) may be mentioned those covered by patents to Perky, 571,284, November 10, 1896, and 614,338, November 15, 1898.

A number of patents have been granted to Corby for working and shaping dough. No. 629,239, July 18, 1899, covers a process in which the dough is drawn out into sheet form from the main mass, such drawn-out portion being combined with the main mass, and the drawing out continued until the desired homogeneity is reached. Under 640,097, December 26, 1899, cool air is blown into the dough while it is being mixed. It is claimed that the air not only makes the mass light, but hastens the action of the yeast.

A number of patents have been granted on machines for coating candy with chocolate, in which the operation is performed on a large scale. An example may be seen in 618,234, Panoulias, January 24, 1899. Patent 635,137, Kennedy, October 17, 1899, covers a machine for molding popcorn bulbs, this patent being representative of a number which have been granted in the last few years.

Vegetable Cutters and Crushers.—Apparently the most prominent improvements have been in machines for seeding raisins in large quantities, and in improvements in stalk and cane cutters, of which the following are representatives: 543,834, La Due, July 30, 1895; 548,009, Ross, deceased, October 15, 1895.

ALCOHOL.

In the class of alcohol 1,267 patents have been granted. Advances within the last thirty years are recorded as follows:

The most noteworthy patent in the class is that to Villon, 608,652, August 9, 1898, relating to the synthetical production of alcohol from acetylene. Other noteworthy patents are those to Sauer, 576,510, Feb-

ruary 2, 1897, and to Gumboldt, 616,838, December 27, 1898. Sauer's patent relates to the production of various kinds of wine from malt by the aid of properly selected grape ferments, and Gumboldt's patent relates to the solidification of alcohol.

The work of Pasteur in this field, begun in France after the war of 1870, resulted in an important United States patent for yeast—Pasteur, 141,072, July 22, 1873. Penninton, 215,287, May 13, 1879, made an improvement in methods for selecting proper ferments and excluding improper ones.

Pasteur's work resulted also in improved processes for aging and preserving alcoholic liquors by destroying deleterious ferments. See patent 126,722, Luquet et al., May 14, 1872; 136,741, Luquet, March 11, 1873; 194,324, Bersch, August 21, 1877.

Takamine, in using as ferments koji, moto, and moyashi, different forms of mold, and proposing to entirely do away with malt in the manufacture of beer and whisky, made a noteworthy departure. See Takamine 411,231, September 17, 1889; 525,819, 525,820, 525,821, 525,822, 525,823, 525,824, and 525,825, September 11, 1894.

In the manufacture of malt, a patent for pneumatic malting was granted as long ago as 1865, patent 49,768, Kreusler, September 5, 1865, but little appears to have been done till the important improvements in this line were devised in 1881. See Galland's patent, 241,958, May 24, 1881. Since this date there has been much improvement in this system of malting. An important improvement in means for stirring malt during germination was granted in 1890, patent 440,850, Saladin, November 18, 1890. The processes in the manufacture of alcoholic liquors have in the past thirty years assumed a scientific aspect.

For half a century the beer industries have recognized the importance of artificially injecting carbonic acid gas into the beer immediately after the first fermentation, to supplant the secondary fermentation and its attendant delay and for preventing impurities which always accompany delay, patent 538,086, April 23, 1895, Schneible, seems to have been the first to disclose the correct principles.

FIBERS.

Brakes and Gins.—Prior to 1871 inventions in this art were mainly directed to perfecting the structure of the primary gin.

In the development of the cotton gin several inventors have contributed to the further perfection of its elements. See, for instance, the patents for roller gins, 655,167 and 655,168 to Prior, 616,761 to Baskin, 633,994 to Evans, 681,194 to Chapin; and for saw gins, 608,729 to Swenson, and 631,293 to Gardner.

Only the long staple fiber was secured, leaving the cottonseed covered with a short fiber which, with the seed, was regarded as a waste product. To reclaim this short fiber and secure the seed in condition for use have been the main endeavors of inventors during the last twenty years. These objects have been attained by the delinter, one of the first practical forms of which appeared about 1883. See patent to Taylor, 276,305, April 24, 1883. Since that time 114 patents have been granted on improved forms of this device, resulting in the perfected delinter of to-day, which reclaims both the short fiber and the seed in condition for use, the former as wadding and the latter as a valuable cattle food. See patents to Thomas, 503,103, August 8, 1893; to Burnham, 523,655, July 31, 1894; to Faulkner, 538,870, May 7, 1895, and 546,270, September 10, 1895.

Later patents: 565,793, to Pollard; 597,123, to Rosamond; 651,919, to Cockrell; 659,840, to Baxter; and 672,068, to Pollock, present marked types.

Another advance of large practical importance has been the introduction of pneumatic feed devices for gins, whereby the cotton can be fed at once from the wagon to a series of gins. See patents to Munger, 308,790, December 2, 1884; to Elam et al., 414,762, November 12, 1889; to Gammons, 500,804, July 4, 1893. In this subclass 91 patents have been granted.

The production of a machine capable of decorticating commercially the stems of ramie or china grass (Boehmeria tenacissima) presents a difficult but attractive problem to inventors. The industrial importance of such a machine would be great. For typical patents, see 580,635, to Burrows & Radclyffe; 630,408, to Reinshagen; 635,345, to Packer; 637,824, to Pratt; and 690,817, to Allison.

Machinery for treating wet flax in the field to adapt it to coarse uses, as for twine, is shown in patent 692,936, to Smith.

Machinery for decorticating fleshy leaves of the agave and the like has also attracted a great deal of attention, but no markedly new types have been evolved.

Cotton Presses.—The attention of cotton growers throughout the South has been directed within the last few years to new means for baling cotton. The old commercial rectangular bale seems destined to be supplanted by that made into cylindrical form, of much greater density, substantially fireproof, and more convenient for handling. Several early patents were granted, notably that to Mead, 5,235, August 14, 1847, for a roller press intended to form cotton into a uniformly dense mass as it is gathered by small increments around a spindle; that to North, 5,632, June 13, 1848, for a roller press forming a bale by pressing the cotton into the space between several rollers; that to Workman, 331,932, December 8, 1885; that to Evans, 366,943, July 19, 1887; and that to Brady and Brady, 378,570, February 28, 1888, wherein also rollers are used, but it was not until February 10, 1891, that a patent was granted to Brown, 446,128, which presented the idea of first forming the cotton into a sheet or bat and then causing the same to be rolled into cylindrical

form, each layer thereof being subjected to pressure as it is wound upon the spindle. Following this latter mode of forming the bale, several patents have been granted, each of which contains salient features. A patent was issued to Bessonette, 492,132, February 21, 1893, for a press comprising an upright framing carrying an upper stationary and a lower movable roll and a positively driven core located between them. In later Bessonette patents the core is driven from the rolls, and under such patents the first commercial cylindrical bales were formed. Several other patents were granted to the Bessonettes for presses resembling in general features those alluded to and forming a bale in substantially the same way: 508,909, November 21, 1893; same, reissue, 11,422, June 19, 1894; 530,000, November 27, 1894; 530,001, November 27, 1894; and 541,418, June 18, 1895. On December 5, 1893, several patents were granted to Graves, numbered, respectively, 510,385, 510,386, 510,387, and 510,388, disclosing as their distinctive feature a weighted endless belt, within the loop or bight of which the bale is formed layer upon layer. On September 10, 1895, a patent, 546,009, was granted to Graves for a cylindrical cotton bale and method of making the same, which covers broadly a cylindrical cotton bale formed of a bat wound spirally, layer upon layer, the bale being of great and substantially uniform density throughout, and covers also the method of forming such bale. Attempts are being made to form rectangular bales of superimposed layers, each being subjected as laid to heavy pressure, and patents have been issued thereon, notably that to Murray, 532,386, January 8, 1895, and while the presses are more complicated than those used to form cylindrical bales, it is claimed that the resulting bale has all the advantages of the cylindrical one.

The folded bat press has been further improved, as shown in patents to Mallett, 607,063, July 12, 1898; Deane, 629,716, July 25, 1899; Taylor, 655,998, August 14, 1900; McLean, 655,000, July 31, 1900; and Mallett, 661,349, November 6, 1900.

In each of these presses the cotton is taken in a bat from the gin compressor between rolls and led to the baling chamber, where it is folded back and forth and kept under pressure until a rectangular bale of sufficient size is formed.

Later improvements in the volute type of press are shown in patents to Fordyce, 616,457, December 27, 1898; Swenson, 574,121, December 29, 1896; and 591,304, October 5, 1897; Bessonette, 603,250, May 3, 1898; Dyer, 604,028, May 17, 1898; Swenson, 557,089, March 24, 1896; Griffin, 558,171, April 14, 1896; and 562,180, June 16, 1896.

The objection to a cylindrical or volute baling press is that it has to be stopped at intervals to remove the finished bale and start a new bale. This objection is largely overcome by the devices of patents 562,180 and 604,028, in which a double press is shown and the cotton fed alternately on one side and the other, the feed being shifted as soon as the bale is completed, so that the machine is continuously in operation.

A third form of press practically dates from the year 1897, and likewise treats a bat of cotton, compressing it before or at the time that it is applied to the bale. In this press the cotton instead of being wound in a volute or folded is formed into a helix, as shown in patent to Lowry, 661,475, November 6, 1900. The bat of cotton is fed under great pressure through a rotating head, an example of which is shown in Lowry, 581,601, April 27, 1897, and pressed against the cotton already in the baling chamber. It will be seen that this press may be made continuous by constantly feeding the cotton and severing it into bales of suitable size as it emerges from the baling tube. Other examples and improvements of this form of press are shown in the Lowry patents, 581,600, April 27, 1897; 645,728, March 20, 1900; 662,457, November 27, 1900; and 630,374, August 8, 1899.

The advantages which are derived from the types of presses shown in the above-cited patents are that the press is adapted to be used on the plantation where the cotton is grown, that but one compression is required, and that the cotton is made into such a highly condensed mass, equaling in density ordinary woods, that it does not readily burn or smolder.

An important branch of this art relates to the extracting of oil from flax and other oleaginous seeds, and examples of presses designed for this purpose are seen in the patents to Eiston, 631,286, August 22, 1899; and Bisbee, 660,718, October 30, 1900.

FRUITS AND FOODS.

Drying.—Nearly all of the patents relating to drying or evaporating fruit fall within one of three classes: First, those in which the trays of fruit are placed upon stationary ledges within a heated chamber; second, those in which the trays of fruit are placed within a heated chamber and raised or lowered step by step by mechanical means farther away from or toward the source of heat as the drying progresses; third, those in which the fruit is placed in imperforate steam-jacketed pans. These three types of fruit driers form, under the present classification, the bases of the subclasses, driers, shelf and tray, elevator and pan, and boiler, respectively. Patents representing all of these types of driers were issued previous to 1871. The subsequent patents represent development in the direction of improvement in details of form, ventilation, method of regulating heat, or moving the trays, but without marked change in structure or advance in efficiency.

Preserving.—The necessity of preventing disease and of keeping foods has brought into general use during the last thirty years a class of devices called sterilizers, an example of which is found in 149,256, Shriver, March 31, 1874. In some of these the receptacles in

large numbers are placed within the chamber, and by devices operated from the outside, the cans or bottles are opened and shut while within the steam-filled devices. See 524,629, Popp et al., August 14, 1894.

By treating starchy matters with the substances containing diastase a partial transformation is effected, which will materially shorten or assist its digestion, and this fact has been largely made use of in the preparation of soluble foods. See 375,601, Carnrick, December 27, 1887; malted milk, 278,967, Horlick, June 5, 1883; lactated food, 344,717; Boynton et al., June 29, 1886.

Great activity has been shown in malted foods and in flaked foods. Clowes, 579,739, mixed with flour or dough a malt flour containing cytase; Horlick, 627,119, has a dry food containing the extracts of malt, whole wheat, and peptonized beef, with chocolate or cocoa if desired; 651,776, Bourdeau, malted flaked food in "thin, crisp flakes."

Kellogg, 670,283, presents Protose, a vegetable substitute for meat, made from gluten and peanuts; Cochran, 610,258, separated the pith from the fibrous part of bagasse and made the latter a nutritious food for cattle, thus utilizing a waste product; Bernstein, 603,165, made a substitute for eggs from coagulated milk albumen and uncooked casein, "preferably reduced to a powder;" Babillion, 643,032, improved condensed milk by removing from it a substance which if left therein "assumes a reddish color and gives the milk a disagreeable odor."

LIQUIDS.

Under this title will be treated devices for utilizing the juice of sugar cane and beets, cottonseed oil, and oxidizing oils.

Sugar.—The principal improvements have been in revivifying boneblack, 509,460, Weinrich, November 28, 1893; in centrifugal machines for refining sugar, 506,230, Haubtman, October 10, 1893; in defecating by chemicals and heat, 531,460, Deming, December 25, 1894; in evaporating pans, by spreading the liquid in a film and subjecting it to countercurrent of heated gas, as in centrifugal evaporators, 444,945, Theisen, January 20, 1891; in separating starch and converting it into glucose, 187,881, Manbre, February 27, 1877; and in the strontium process for making sugar, 260,327, Scheibler, June 27, 1882.

Among later improvements are Kassner, 628,985, for recovering sugar from molasses as lead sucrate; and Claassen, 664,465, for details in the process of boiling sugar juices in vacuo. In the subclass of vacuum pans are Harvey, 643,794, and Joslin & Schmidt, 603,087.

Starch.—An advance is the production of what are known now as "thin boiling starches," i. e., starches which give a solution as thin when cold as when hot, so that garments may be starched in the cold. This is done chemically, by partially converting the starch, as in Duryea, 658,105.

Cottonseed Oil.—This is an important product. It was formerly made by steaming the seed and expressing the oil. This process has been superseded by extraction processes, by aid of volatile solvents, which are afterwards separated from the oil by distillation. Patent 397,792, to Forbes and Leder, February 12, 1889, is an important patent in this line.

Oxidizing Oils.—The art of oxidizing oils for the manufacture of linoleum and oilcloth had its commercial origin in a patent granted to Walton, 153,867, August 4, 1874. Prior to this date oil had been vulcanized for a similar purpose, but a great impetus to the art was due to the substitution of chloride of sulphur for pure sulphur as the vulcanizing agent. Sommer's patent, 451,531, May 5, 1891, shows this.

TOBACCO.

In this class 3,100 patents have been issued, and advances have been made in the following subclasses: Cigar machines, endwise-moving filler; leaf treating, stemming; cigar machines, apron, stationary rolling table.

In the subclass endwise-moving filler cigar machines, which includes machines for making cigarettes by the continuous process, the patent setting forth the primary invention is that to Hook, November 7, 1876, 184,207. Before this cigarettes were made singly by hand or singly, in the same way, by machines. That patent was for a machine which made continuous cigarettes of indefinite length, to be cut into separate cigarettes, in which tobacco was fed to a ribbon of paper as it was drawn from a spool, the edges passing over a gummed wheel. Thence the paper passed into a trough, which gradually curved the paper from a flat condition into a tube by a tube-forming die, the edges being made to adhere. Further advance was made in the Emery patent, 216,164, June 3, 1879, in which the tobacco rod was formed by an endless belt and tube, and forced by the belt through the wrapping means, and subsequently carried by the same belt to the cutting means. The Bonsack machines, 238,640, March 8, 1881, and 247,795, October 4, 1881, were improvements upon the Emery belt machine, the main difference being that the belt which underlies paper and filler passes with both through the wrapping mechanism. The patent to Hardie, 429,031, May 27, 1890, known as the Elliott machine, was a departure from the usual manner of making the filler rod and wrapping it, the filler being formed on an endless carrying belt in a reciprocating trough and the wrapper folded by means of wheels over the same carrying belt. The Bohls patent, 445,036, January 20, 1891, formed the rod of tobacco by still another means—endless side-forming chains, working face to face between upper and lower belts, the wrapper being folded by stationary or moving folding means. The patent to Baron, 543,840, August 6, 1895, employs means differing from preceding machines. In the former machine,

compressing wheels form the filler into a thick, grooved band, while in the latter patent the compressing wheels work face to face over a plain endless belt and are adapted to make elliptical cigarettes. A later improvement is Baron, 555,417, February 25, 1896.

Gilliland, 639,677, December 19, 1899, shows a machine of the same general structure, in which certain of the operating parts are different. Hudson, 587,826, August 10, 1899, and 587,828, August 10, 1897, relate to a machine and process for making a cigarette of that type in which the ends of the paper are tucked in around the tobacco, as in the case of certain handmade cigarettes.

A machine for making the well-known elliptical cigarette is shown by Campbell, 579,422, March 23, 1897.

In cigar machines, which include mechanism for making all-tobacco cigarettes, a departure was made by the patent to Bauer, 473,108, April 19, 1892, particularly in the automatic oscillating means for feeding the wrappers, the pasting means, and in feeding the charges of tobacco one by one, whereby speed was attained. This machine was followed by the patent to Moonelis, 514,238, February 6, 1894, which automatically fed the wrapper to the rolling means by a reciprocating and dropping mechanism. Subsequently a patent was granted to Williams, 548,688, October 29, 1895, in which certain movements were effected by suction, the whole working automatically.

Improvements relating to rolling are shown by Bunn, 566,058, August 18, 1896, and 579,859, March 30, 1897, each of which relates to a machine in which the rollers are composed of short sections to adapt them to fit various forms of bunches.

A series of patents, including those to Patterson, 654,178, July 24, 1900, and Tyberg, serial numbers from 654,195 to 654,203, July 24, 1900, is devoted to a machine for making cigars in which hand labor is largely obviated. In this device the tobacco leaf for forming the wrapper is placed on a suitable support, to which it is held by pneumatic pressure, where it is cut to the shape of the wrapper required and automatically transferred to the wrapping machine. Bunches for forming cigars are automatically fed to the wrapping machine, which is of a type closely following the movements of the fingers of the cigar maker in making a cigar. The wrapper is inserted in the rolling device and wrapped around the bunch and the completed cigar is then discharged.

In leaf treating, a radical departure from all existing machines was made in the patent to Guerrant, 494,254, March 28, 1893. This was the first machine to tear the leaf from the stem by seizing the stems as the leaves were carried along. Since this the following patents have been granted, each working on a different principle from that of Guerrant and from each other, viz, Fries, 534,147, February 12, 1895, which crushes the stem; Cochrane, 538,660, May 7, 1895, and 546,843, September 24, 1895, which have stripping rollers or rotary devices covered with card clothing; and Underwood, 543,143, July 23, 1895, which has means for retarding the leaf while the stems are drawn therefrom.

Later improvements are shown in patents to Underwood, 591,436, October 12, 1897, and 661,199, November 6, 1900, and Williams, 662,212, November 20, 1900. In the first two patents the leaf is fed stem first between the stripping rolls until it is gripped by gripper rolls by which it is drawn through, the stripper rolls operating to separate the body of the leaf from the stem. In the Williams patent is shown a machine which cuts out the entire central vein and stem, and books the half leaves.

The patent to Mills, 614,618, November 22, 1898, shows a vending machine adapted to vend cigars from an original package, thus complying with the revenue laws.

ANIMAL PRODUCTS.

Artificial Butter (*Oleomargarine*).—This manufacture was first patented to Mége, 146,012, December 30, 1873.

An important improvement is the patent to Poppe, 658,529, September 25, 1900, which covers a product derived from natural butter for aromatizing artificial butter.

Butchering.—Improvements for handling animals in slaughtering are illustrated in the patents to Hurford, 541,278, June 18, 1895, and Lowry, 627,265, June 20, 1899.

For cleaning and cutting up of fish by power machinery, see patent 645,682, Letson & Burpee, March 20, 1899.

Dairy.—The principal patents in this class relate to churns, the treatment of milk, and cow milkers. In the first of these subclasses invention has largely concerned itself with combined churns and butter workers, in which cream is first churned to form butter and then by certain changes in the mechanism the butter is worked. Examples of this type of device are found in patents to Fargo, 583,143, May 25, 1897; Penn & Brown, 600,168, March 8, 1898; and Virtue & Deeg, 634,074, October 3, 1899.

Roth, 657,621, September 11, 1900, shows a cheese cutter with means for readily cutting off sections of any desired weight.

Patents to Philips, 609,461, August 23, 1898, and Salenius, 648,798, May 1, 1900, show, respectively, a process for separating cream from milk by causing the milk to fall in drops into a body of water, and a process of pasteurizing and cooling milk.

In cow milkers the tendency has been toward the adoption of pneumatic means. As early as 1860 several patents were granted for milkers operated by air pumps, and also many mechanically operated. The patents to Hoover et al., 474,830, May 17, 1892; Harvey et al., 547,255, October 1, 1895; and Condron, 655,200, August 7, 1900, show the former type, and the patents to

Shiels, 513,624 and 513,625, January 30, 1894, and 654,331, July 24, 1900; and Von Bechtolshiem, 678,231, July 9, 1901, show highly developed devices of the same type, in which the vacuum is made to increase and decrease, or pulsate. The patents to Horlyck, 459,582, September 15, 1891, and to Fay, 510,964, December 19, 1893, exhibit well-developed machines of the second type—those in which the tubes are mechanically contracted by pressure plates.

Extracting Wool Fat.—Within the last decade the extraction process has been used with great advantage in extracting wool fat from wool, grease from garbage, and linseed oil from linseed. Two important patents were granted to Maertens in 1895 for extracting wool fat and separating it into its constituents, 545,900, September 10, 1895, and 539,388, May 14, 1895, and improvements thereon were patented to him August 1, 1899, 630,293, and October 30, 1900, 660,758.

Oils, Fats, and Glue.—In this class 2,247 patents have been granted. Glycerin was for many years made by the Tilghman process, according to which fat was decomposed by water or steam at a high temperature. This process is now superseded. All glycerin is now made from soap underlye, which was formerly a waste product. The first patent for a process for doing this was granted to Babbitt, September 13, 1870, 107,324, but the process was not greatly improved until the process of distilling glycerin by the aid of reheated and expanded steam was devised in 1894 and disclosed in patent to Van Ruymbeke, 522,132, June 26, 1894.

Aylsworth, 666,636, January 29, 1901, decomposes glycerides by subjecting the same, in conjunction with heat and alkali, to a high mechanical pressure.

Wilson, 567,210, September 8, 1896, removes the liquid elements from garbage and similar material, after the same has been cooked, by subjecting the material on all sides to the action of compressed air.

CHEMISTRY.

BLEACHING AND DYEING, CHEMICALS, FERTILIZERS, MEDICINES, AND ELECTRO-CHEMISTRY.

Bleaching and Dyeing.—In this class 2,293 patents have been issued. In dyeing, the original methods were confined to dipping machines and the use of stencil-plate patterns in press dyeing. The saturation of sand by a dye and its application to fabrics by an air blast is a modern method, and is disclosed in 223,019, Vaughan, December 30, 1879. Continuous circulation, by vacuum or pressure through cops placed on perforated spindles, all in the same vessel, of fluids in one or both directions, for bleaching, dyeing, drying, or oxidizing, is disclosed in 368,715, Graemiger, August 23, 1887; 479,383, Young & Pearn, July 19, 1892; 411,504, Klauder, September 24, 1889; 509,351, Maertens, November 21, 1893; 509,431, Graemiger, November 28, 1893; 387,540, Richmond, August 7, 1888, and in skein dyeing, elaborate devices for moving the skeins through the dye are shown in 505,984, Haslam, October 3, 1893; 437,173, Corron, September 30, 1890, reissue 10,973, Delahunty, December 11, 1888; 345,892, Gillet, July 20, 1886.

The most important recent invention in this class is undoubtedly the process of mercerizing, which was foreshadowed by Mercer in 1844 and attained its first commercial success as the result of the patent to Thomas and Prevost, 600,826, March 15, 1898. This patent described the production of a silky gloss on long-stapled cotton, by saturating it with an alkaline fluid under tension. All the novelty of the foreign patents of these inventors has been denied in favor of the British patent to Lowe, 20,314, of 1889. The process has attained an extraordinary commercial development.

Carbon dyes are now the most important, and will probably soon be the only dyes in use, 1,196 patents on them having been granted since they were introduced. Artificial alizarin, 95,465, Greabe, October 5, 1869; anilin black, 38,589, Lightfoot, May 19, 1863; alizarin black, 379,150, Bohn, March 6, 1888; artificial indigo, 259,629, Baeyer, June 13, 1882; the azo colors, 210,054, Roussin, November 19, 1878; and the processes for making colors on the fiber, 241,661, Holliday, May 17, 1881, are important.

The manufacture and use of artificial indigo has steadily increased, and it is evident that the cultivation of indigo, like that of madder, is doomed to speedy extinction. Patents to Heumann, 617,651 and 617,652, October 1, 1899, are important in this art. The dyes made by heating various synthetic substances with sulphur and sodium sulphide have become very numerous and successful. Vidal, 594,105, November 23, 1897, and Green & Meyenberg, 641,587, January 16, 1900, are examples of this class of dyes.

Chemicals.—In this class 2,395 patents have been issued. There has been a decided activity since 1896 in the improvement of methods and apparatus in making the so-called heavy chemicals. A notable illustration is in making sulphuric anhydrid by the contact method. Of the several patents granted, that of United States patent, 652,119, Knietsch, June 19, 1900, is important in that it points out the necessity of a proper regulation of the temperature of the contact material.

Apparent advances have been made in utilizing air for preparing ammonia (150,007, Du Motay, April 24, 1874) and cyanides (526,592, Vautin, September 25, 1894). Reichardt & Bueb, 607,881, July 26, 1898, devised a process for making cyanides from waste lyes from beet-root molasses by distillation at high temperatures. Ammonia has also been obtained from the same waste product by a process patented to Sternberg, March 31, 1896, consisting in subjecting the waste lyes to incandescence in presence of a contact body. The carbides of the alkali metals reacted on by nitrogen at suitable

temperatures have been patented as a means of making cyanides. See United States patent, 623,709, April 25, 1899.

Peroxides of barium (calcium, 267,551, Marchand, November 14, 1882, and hydrogen and sodium, 494,757, Castner, April 4, 1893) are now widely used as oxidants. The recovery of soda (387,613, Wrinkle, August 7, 1888) from crude natural soda of Nevada, Utah, and California, attracted attention.

The chemical purification of water for municipal supplies has received attention, the chief object being to automatically supply the water with chemicals and to use the power of the flowing water for actuating the necessary devices. Patents to Gaillet, 563,660, July 7, 1896, and Koyl, 653,010, July 3, 1900, indicate the trend in this art. Aluminium and ferric salts and finely divided metals used in filtering (350,679, Hyatt, October 12, 1886) diminish the difficulty in water purification on a large scale.

In the class of carbon compounds (chemical) the synthetic perfumes, like artificial musk (536,324, Baur, March 26, 1895) and vanillin (487,204, Fritz, Ach, November 29, 1892) have been entirely developed within the last thirty years.

In addition to artificial musk, vanillin and geraniol receive the most attention. The later patents are generally for improvements in detail rather than for pioneer inventions. Of a more original character the Tiemanns patents, 583,719 and 583,720, June 1, 1897, for aromatic ketones, may be noted.

Of a more important character are the patents for artificial camphor to Nagel, 582,221, May 11, 1897, and to Thurlow (British), 14,754, of 1900, worked very successfully at Niagara.

A synthetic adhesive gum made from cellulose is described in patent to Cunningham et al., 637,090, November 14, 1899, and a process of recovering adhesives and other substances from the sulphite liquor of wood-pulp manufacture in patent to Mitschevlich, 681,241, August 27, 1901.

Patent to Gentzsch, 657,696, September 11, 1900, covers a process of raising the melting point of resins and waxes by heating them to a high temperature in conjunction with water and certain salts and oxides.

Fertilizers.—In this class 725 patents have been issued. The disposal of tankage has attracted the attention of inventors to methods of utilizing this waste product. The treatment with precipitants (146,285, Shaw, January 6, 1874) absorbents, and by filtration and evaporation (324,103, Gibson, August 11, 1885) have each been tried.

The treatment of basic slag from iron furnaces, in order to put the phosphoric acid of the slag into condition for assimilation by growing plants, is disclosed in the following patents: Rocour, 284,674, September 11, 1883; Thomas, 301,406, July 1, 1884; Twynam, 361,656, April 19, 1887; Reece, 450,254, April 14, 1891.

Medicines.—In this class 1,746 patents have been issued. The introduction into the materia medica of synthetic chemical substances, which are either patented or controlled by trade-marks, seems to indicate that, although the substances are already numerous, they are to become still more numerous and more complex. Prominent among these are the following, now become well known: Antipyrin, 307,399, Knorr, October 28, 1884; aristol, 446,875, Messinger et al., February 24, 1891; dermatol, 495,497, Liebrecht, April 18, 1893; ferratin, 505,986, Marfori et al., October 3, 1893; haemol, 541,933, Kobert, July 2, 1895; ichthyol, 318,662, Schröter, May 26, 1885; lanolin, 271,192, Braun et al., January 23, 1883; lycetol, 514,632, Stoehr, February 13, 1894; orexin, 428,286, Paal, May 20, 1890; phenacetin, 400,086, Hinsberg, March 26, 1889; saccharin, 319,082, Fahlberg, June 2, 1885; salol, 350,012, Von Nencki, September 20, 1886; sulfonal, 396,526, Baumann, January 22, 1889.

In this class of more recent date we have notably the patent of Carnrick, 587,278, for protonuclein, a nutritive and antitoxic preparation; Behring, 606,042, for diphtheria antitoxin, "by means of which people may be immunized against diphtheria and people suffering from diptheria may be cured;" Klever, 608,612, for an ointment base, known generally as "Vasogen" (Coblentz' Newer Remedies), quite fully patented abroad; Pertsch, 628,489, for a local anæsthetic, ethyl chlorid carrying cocaine; Schwickerath, 637,355, for a new soluble compound of nuclein and mercury; Jolles, 641,017, for a process of making ferruginous nuclein from the blood of animals, by which the greatest quantities of assimilable iron can be introduced into the organism; Landmann, 649,938, for a process of obtaining tuberculous toxin, which the patentee calls "fractional exhaustion;" Berlioz, 664,377, for guaiacolated serum, a normal animal serum containing a glycerin solution of guaiacol phosphite. Rohmann & Liebrecht, 575,277, give us a solid compound of silver and casein as a powder which forms a substitute for nitrate of silver, which has found a place in the art of medicine.

For treating diseases a movement is in the direction of appliances for subjecting the patient to an atmosphere of hot air at an extremely high temperature, pains being taken to keep the air dry and to carry off the moisture resulting from perspiration. See Sprague, 601,684, April 5, 1898, and 654,185, July 24, 1900.

Electro-Chemistry.—The commercial use of electrolysis to effect or modify chemical changes may be said to have been entirely developed within the last twenty-five years. Electro-chemical methods are now employed for the production of a large number of elements, such as the alkali and alkaline earth metals, copper, zinc, aluminum, chromium, manganese, the halogens, phosphorus, hydrogen, oxygen, and ozone; various chemicals, including the mineral acids, hydrates, chlorates,

hypochlorites, chromates, permanganates, disinfectants, alkaloids, coal-tar dyes, and various carbon compounds; white lead and other pigments; varnish; in bleaching, dyeing, and tanning; in extracting grease from wool; in purifying water, sewage, sugar solutions, and alcoholic beverages. The present low price of aluminum, reduced from $12 per pound in 1878 to 35 cents at the present time, is due to its production by electrical methods. Among the earliest successful processes is that of Cowles brothers, described in patents to Cowles and Cowles, 319,785, June 9, 1885, and 324,658, August 18, 1885, in which a mixture of alumina, carbon, and copper is heated to incandescence by the passage of a current, the reduced aluminum alloying with the copper. This has now been superseded by the Hall process, patent 400,766, April 2, 1889, in which alumina dissolved in fused cryolite is electrolytically decomposed. Practically all the copper now produced, except that from Lake Superior, is refined electrolytically by substantially the method of Farmer's patent 322,170, July 14, 1885. All metallic sodium and potassium is now obtained by electrolysis of fused hydroxides or chlorides, as set forth in patents 452,030, May 12, 1891, Castner, and 541,465, June 25, 1895, Vautin. The production of caustic soda, sodium carbonate, and chlorin by the electrolysis of brine is carried on upon a large scale and will probably supersede all other methods. Nolf's process, patent 271,906, February 6, 1883, and Castner's, 528,322, October 30, 1894, employ a receiving body or cathode of mercury, alternately brought in contact with the brine undergoing decomposition and with water to oxidize the contained sodium. Craney, patent 520,257, May 22, 1894, employs an iron-wire gauze cathode, in contact with water, but separated from the brine by a sheet of asbestus.

Patent 579,317, March 23, 1897, Constam et al., discloses a process of making percarbonates, for bleaching purposes, and which decompose water at ordinary temperatures with an evolution of oxygen and carbonic acid.

Patent 649,565, May 15, 1900, Acker, relates to a process of manufacturing alkali and a hologen gas which has gone into extensive public use in the production of caustic soda.

Chlorates are also manufactured by the thousand tons by the electrolysis of chlorides. Gall and De Montlaur, patent 492,003, February 21, 1893, separate the electrodes by a diaphragm, subsequently conveying the contents of the negative compartment into the positive. Gibbs and Franchot, 493,023, March 7, 1893, remove the hydrogen cation by copper oxide. See also Gibbs, 665,426, January 8, 1901.

Carborundum, or silicide of carbon, is largely superseding emery and diamond dust as an abradant. It is produced by Acheson, patent 492,767, February 28, 1893, by passing a current of electricity through a mixture of silica and carbon. Calcium carbide, heretofore a rare compound, can now be cheaply produced by the action of an electric arc on a mixture of lime and carbon, as described by Willson, patent 541,138, June 18, 1895. It is used in the manufacture of acetylene gas.

Patent 597,880, January 25, 1898, Horry, shows a continuously operating furnace for making calcium carbide.

The question of electroplating iron vessels with copper instead of sheathing them by thin plates is attracting attention. Suitable methods and apparatus are described by Crane, patent 498,707, May 30, 1893. Metallic tubes, especially of copper, are produced by Elmore's method, patent 442,428, December 9, 1890, in which the copper is condensed by a burnisher while it is undergoing electro-deposition on a rotating mandrel.

Hermite, in patent 294,619, March 4, 1884, produces a hypochlorite suitable for bleaching or disinfecting by the electrolytical decomposition of sodium chloride; Frölich, in patent 487,390, December 6, 1892, uses an ozone apparatus consisting of a dielectric plate, independent electrodes on one face, and a metallic plate on the opposite side of and at some distance from the dielectric; Worms and Balé, in patent 361,249, April 12, 1887, describe a process in which they place green hides and tanning liquor in a drum and simultaneously rotate and pass electricity through the drum.

Batteries.—There are 847 patents granted for various forms of secondary batteries. Storage batteries or accumulators, as now practically employed, date from the patents of Faure, 252,002, January 3, 1882, and Brush, 266,090, October 17, 1882, and 276,155, April 24, 1883, a paste of active material, lead oxide, being applied to the lead electrodes, which are used in a dilute solution of sulphuric acid.

Among primary batteries, that of Lalande and Chaperon, patent 274,110, March 20, 1883, which employs copper oxide as a depolarizer and an alkaline solution, is noteworthy. There are 978 patents for primary batteries.

DENTISTRY.

In this class 1,695 patents have been issued. Some of the leading inventions in dentistry relate to bridge work. After the teeth are destroyed by decay, the roots are utilized to support at several points a metallic bridge, upon which a set of teeth is secured. Leading patents are Low, March 3, 1885, 313,434, and March 15, 1881, 238,940; Richmond, May 22, 1883, 277,933; Carr, April 27, 1897, 581,335, and June 1, 1897, 583,565; and Chaffin, April 5, 1898, 601,703.

Many improvements have been made also in the way of procelain crowns to be attached to single roots after the natural crown of the tooth is removed, some of which are shown in patents to Gates, March 1, 1881, 238,382; Low, January 17, 1888, 376,603; Baird, June 13, 1899, 626,779; and Dunn, June 27, 1899, 627,920.

Other improvements in single teeth have been in the ways of securing them to the dental plate without the baking in of platinum pins, which was very expensive. See patents of Foster, July 12, 1898, 607,231; Page, April 17, 1900, 647,865; and Robinson, August 21, 1900, 656,267.

In the way of hand pieces, improvements lie in the direction of enabling the operator to secure and release the tool rapidly with one hand and by a single motion. Leading patents are Keller, 462,409, November 3, 1891, and Brooks, 504,704, September 12, 1893. Also many improvements relate to making one hand piece serve both as a plugger and as a drill. See patent of Case & Shaw, July 11, 1899, 628,524. The hand piece to be used at various angles has been improved by the insertion of a ball-and-socket joint. See patent of Brown, July 5, 1898, 606,755.

Instruments for slitting and removing gold crowns or caps have been improved (Lanterman, May 23, 1899, 625,401), and also instruments for accurately aligning the abutments or securing caps for bridge work (Le Cron, August 14, 1900, 655,933).

In dental engines the more important inventions are in the way of constructing the usual treadle-operated drills so that the various parts may fold up under the operating chair. See patent of Campbell, October 13, 1891, 461,146.

ENGINEERING, ELECTRICITY, AND TRANSPORTATION.

Engineering and transportation are arts which are often intimately related and mutually reliant. Electricity, which is a branch of engineering in its broadest sense, stands in close relation to the transportation art also.

ENGINEERING.

Bridges.—In this class 1,059 patents have been issued. The iron cantilever truss bridge is a product of comparatively recent invention. The St. Louis and other bridges across the Mississippi and the Poughkeepsie bridge across the Hudson are good examples of this, which may be found detailed in patents to Bender, Latrobe, and Smith, 141,310, July 29, 1873; Eads, 142,378–142,382, inclusive, of date September 2, 1873; and Clarke, 504,559, September 5, 1893.

The construction of the Chicago drainage canal and of the Chicago River improvements stimulated invention in the line of bascule bridges. See patents to Vent, 652,201, June 19, 1900; Waddell, 661,113, November 6, 1900; and Keller, 685,767, November 5, 1901.

Excavating and Dredging.—In this class 2,708 patents have been issued. In the dipper system important inventions, looking to better mastery of very hard material and quick movements of the bucket, are exhibited in patents to Osgood, 196,378, October 23, 1877, and 297,287, April 22, 1884, and King, 460,973, October 13, 1891. In dredging by the hydraulic system, i. e., severing or disintegrating the material by a cutter and pumping it up in suspension in water and similarly forcing it through pipes to a distant point of discharge, important inventions appear in patents 185,600, December 19, 1876; 277,177, May 8, 1883; 300,333, June 10, 1884, all to Von Schmidt et al.; 318,859, May 26, 1885, and 484,763, October 18, 1892, both to Bowers. The Bowers system has been applied in battery fashion by Bates' patent, 545,762, September 3, 1895, and is largely employed by the Government.

The system of dredging by clam-shell dredges has been improved by the direct application of fluid pressure to close the bucket, examples of such construction being shown in patents 198,957, January 8, 1878, to Symonds; 514,788, February 13, 1894, to Symonds, and an example of differential application of the power in patent 11,476, reissue, March 5, 1895, to Pless.

Inventions for the excavation of clay, and for piling and burning it in a crude state for ballast for railways, are important to railways which traverse areas where clay is plentiful and gravel is lacking. Such inventions are shown in patents to Davy, 389,551, September 18, 1888; Davy and Butler, 413,361, October 22, 1889; Butler, 491,765, February 14, 1893.

The dressing of railroad beds by machinery mounted on the work train has been largely improved. See patents to Doddridge, 549,188, November 5, 1895, and 634,166, October 3, 1899, and McElvaney, 631,654, August 22, 1899.

Sinking shafts through quicksands by artificially freezing the sand is a distinctly new idea, for which have been granted patents to Poetsch, 300,891, June 24, reissued as 10,541, December 9, 1884; and 371,389, October 11, 1887, to Smith.

In wheeled scoops for excavating and removing earth very great activity has existed, and the output of them has been immense. Patents to Hubbard, 332,532, December 15, 1885; Hubbard, 359,537, March 15, 1887; Rathbun, 401,658, April 16, 1889; Brooks, 481,160, August 23, 1892; Deevy, 506,212, October 10, 1893, reissued 11,468, January 29, 1895; Kilborn, 513,464, January 23, 1894, are good examples of progress in this line.

In machines for finishing and repairing roads the activity and advance has been as great as in the last-mentioned class. Patents to Pennock, 270,693, January 16, 1883, and 315,541, April 14, 1885; Taft, 315,184, April 7, 1885; Taft, 341,609, May 11, 1886; Fleming, 433,780, August 5, 1890; Holland, 484,429, October 18, 1892; Kimball, 491,565, February 14, 1893; Bunnell, 511,997, January 2, 1894, show good examples of these inventions.

An improvement in deep sewer construction, by which the minimum of obstruction to the street is effected, the work being largely performed below the surface, is that of Coyle, patent 518,394, April 17, 1894.

Hydraulic and Pneumatic Engineering.—In this class

1,585 patents have been issued. The balance locks for canals, of Dutton, are intended to provide ease and rapidity of action, and are receiving world-wide attention. His patents are 457,528, August 11, 1891; 557,564, April 7, 1896; and 665,414, January 8, 1901.

The pneumatic caissons of Eads and of Flad are referred to as illustrations of advance in this art. Patents to Eads, 123,002, January 23, 1872, and 123,685, February 13, 1872, and Flad's patent, 303,830, August 19, 1884, are comprehensive applications of the same principles.

The bear-trap canal lock gate as improved by Du Bois, patents 229,682, July 6, 1880, and 236,488, January 11, 1881, and by Jones, 552,063, December 24, 1895, is a signal advance.

The timber dry dock is now apparently superseding the old expensive stone dock. See Simpson, 204,689, June 11, 1878; Simpson and Simpson, 347,895 and 347,896, August 24, 1886. Haupt's dike or jetty is shown in patent 380,569, April 3, 1888. Allenwood's hydraulic giant for washing down gold-bearing hills is shown in reissue patent 8,037, January 15, 1878.

Steam pile drivers are shown in patents to Loomis, reissue, 7,586, April 3, 1877, and Skinner, 273,904, March 13, 1883.

The Greathead tunneling shield, patent 360,959, April 12, 1887, exhibits an advance.

The plans proposed by the Pennsylvania Railroad of connecting Jersey City and the boroughs of Brooklyn and Manhattan by tunnels under the Hudson and East rivers has resulted in the submission to the office of a great variety of processes and appliances, all contemplating the peculiar difficulty which is met in the case of the Hudson, viz, a very soft bed, which has hitherto defied the pneumatic system. One patent which is reported to have the approval of the engineers of the railway, viz, is that of Jacobs, 690,960, January 14, 1902.

Iron Buildings.—In this class 914 patents have been issued. Patents to Coffin, 477,925, June 28, 1892; Larimer, 485,870, November 8, 1892; Stearns, 495,070, April 11, 1893; Cornell, 523,425, July 24, 1894, record innovations in edifices consisting of a steel skeleton and tile casing. Green, in his patent, 466,033, December 29, 1891, presents a marked improvement in book stacks for public libraries. Patents to Kinnear, 382,092–382,094, inclusive, May 1, 1888; Kinnear, 443,322–443,324, inclusive, December 23, 1890; Northrop, 301,260, July 1, 1884; and Northrop, 330,915–330,917, November 24, 1885, mark advance in interior wall and ceiling finish of embossed sheet metal. A similar valuable improvement is the metal facing of exterior walls of buildings, for which patents 381,000, April 10, 1888, Determann; 433,217, July 29, 1890, Sagendorph; 483,163, September 27, 1892, Pruden; 520,137, May 22, 1894, Deslauriers, have been granted.

Caisson work, as applied in setting foundations for the modern "tall building," has been practically improved by Washington. See patents 633,298, September 19, 1899, and 655,532, August 7, 1900.

The evolution of the "tall building" has induced extensive study of means and methods for obtaining the maximum strength and stability with the minimum of weight, and of space occupied. Constructions (*a*) in concrete and metal are found in patents to Jackson, 621,091, March 14, 1899; Norcross, 596,534, January 4, 1898; and Orr, 644,939 and 644,940, March 6, 1900; (*b*) in tile and metal, in 650,072 and 650,073, to Buente, May 22, 1900, and 663,060, December 4, 1900, to the same.

The tile and metal principle is being applied in the construction of very large fireproof grain elevators. This is a great step in advance. See patents to Johnson, 664,323, December 18, 1900, and 683,441, 683,442, 683,443 to Cooley, October 1, 1901.

The same or even greater necessity exists to make the partitions of the "tall buildings" light, thin, and strong. This has been done (*a*) in metal wired concrete by Orr, patents 550,801, December 3, 1895; 675,403, June 4, 1901; 681,728, September 3, 1901; and Himmelwright, 681,700, September 3, 1901, and (*b*) in tile, by Orr, 598,481, February 1, 1898; Liebau, 564,205, July 21, 1896; and Bell, 640,526, June 2, 1900.

Masonry.—In this class 1,111 patents have been issued. The invention of J. C. Goodridge for strengthening bridge piers and the like with beton work is set forth in patents 193,865, August 7, 1877, and 271,234, January 30, 1883.

Armored or metal-reinforced concrete has been exploited in arch bridges by Thacher, patent 617,615, January 10, 1899; in abutments by Stowell and Cunningham, 629,477, July 25, 1899; in arches, girders, and building blocks, by Melber, 660,518, October 23, 1900, and 672,175 and 672,176, April 6, 1901; and in sewer construction by Parmley, 696,828, April 1, 1902.

Railways.—In this class 11,387 patents have been issued. The wear plate to arrest the destruction of the wooden tie by the rail is a most valuable improvement, and is that of Servis, patents to whom are 249,407, November 8, 1881; 294,816, March 11, 1884; 524,868, August 21, 1894. In street railways the girder rail, supported upon metallic box chairs, has supplanted the flat rail upon a wooden stringer. Patents 316,995, to Moxham, May 5, 1885; 442,175, to Entwisle, December 9, 1890; 493,386, to Read, March 14, 1893, show this. Patents for metallic railway ties are 401,949, April 23, 1889; 478,058, June 28, 1892; and 487,733, December 13, 1892, to Hartford.

A tie plate setter and fastener which is mounted on wheels and travels along the rails under which it places the tie plates is shown in patent 567,232, Greenshield, September 8, 1896.

As regards the joining of railway rails, the common fish plate or angle-bar joint was never broadly covered by patent. The Fisher joint, a bridge joint, has been largely used. See patents 214,032, April 8, 1879; 313,067,

March 3, 1885; 439,497, October 28, 1890; and 466,095, December 29, 1891, to Fisher. The union of rail ends by fusion—i. e., by casting an iron jacket about the joint under conditions involving a surface fusion of the wrought metals—is disclosed in patent 545,040, August 20, 1895, Hoffman and Falk. The spring-rail frog at the intersection of the crossing rails makes the main track practically continuous, and is shown in patents 213,204, March 11, 1879, Johnston; and 217,536, July 15, 1879, Jackson. For a spring-rail frog a hardened insert is set into a lateral bend in the fixed wing rail, as in patent 611,331, Parsons, September 27, 1898.

Intersecting portions of frogs and crossings are subjected to double wear. Hardened inserts are used at these points to withstand the wear. A hardened plate for a rigid-frog structure is shown in patent 623,578, Stockwell, April 25, 1899.

In railway switches the rising and falling points of the Duggan patents constitute an innovation. These patents are 330,878, November 24, 1885; 405,020, June 11, 1889; 433,934, August 12, 1890. The Snow switch stand yields to let a train trail through the points, when misplaced, without breakage, and is disclosed in patents 507,245, October 24, 1893; 299,176, May 27, 1884; 300,911, June 24, 1884; 367,862, August 9, 1887; 375,900, January 3, 1888, to Snow; and 428,029, May 13, 1890, to Weir and Goldsmith. The spring applied directly to the tiebar of the switch for the same purpose is presented in patents 164,398, June 15, 1875, Rowe; 211,541, January 21, 1879, Ainsworth; and 289,677, December 4, 1883, McCall. The horse-tread switch device for street railways enables the driver to shift the switch without leaving the car by driving one horse over a yielding plate, and is shown in patents 213,325, March 18, 1879, Douglass; and 522,782, July 10, 1894, Clouser. These are equally adapted to be operated by a depressible foot on an electric car. An elaborate pneumatic system of controlling switches and signals is shown in patents 520,812 and 520,813, June 5, 1894, and 545,750 and 545,830, September 3, 1895, all to Thomas, jr.

A train-order signal device for a locomotive sounds an alarm as the locomotive approaches a stopping point, and follows it up with an application of the air brakes if the engineer does not answer the call. See patents 617,232, De Wallace, January 3, 1899, and 623,503, De Wallace, April 18, 1899. Patent 385,066, June 26, 1888, Parsons, exhibits a means for insuring the passage of wheels with worn or false flanges. Improved signals and devices for interlocking them with associated switches are disclosed in patents 230,418, July 27, 1880, Jackson; 322,283, July 14, 1885, Hambay; 408,616, August 6, 1889, Hambay; 416,162, December 3, 1889, Hambay; and 429,193, June 3, 1890, Hambay.

Switch and signal mechanism adapted to be operated through a cycle of movements and having a minor system of return signaling from each switch or signal to the operating station indicates the set positions of the same and insures their operation in proper order: Dodgson, 647,482 and 647,483, April 17, 1900. Means for assembling the operating levers of a complex plant of switches and signals in a single cabin and interlocking them are shown in patents 226,499, April 13, 1880, Cummings; 230,200, July 20, 1880, Saxby; 240,054, April 12, 1881, Tilden; 273,681, March 6, 1883, Harper; 317,137, May 5, 1885, Johnson; 342,907, June 1, 1886, Hambay; 406,213, July 2, 1889, Hambay; 472,393, April 5, 1892, Pfeil; and 503,530, August 15, 1893, Dutton.

The difficulty of disposing of a heavy fall of light snow along a railway track has resulted in the production of power-driven machines which gather up the snow, compress and separate it into briquettes or blocks. Patent 641,803, Shirreffs, January 23, 1900, shows track cleaners.

A roller coaster of the "flip-flap" or "loop-the-loop" type is shown in patent 609,164, Prescott, August 16, 1898.

The moving stairway, patent 602,008, Halle, April 5, 1898, shows an inclined belt on which the passenger steps and at the same time grasps the moving hand railing. In patent 629,289, Dodge, July 18, 1899, moving steps are provided.

Patents for cable grips in the class of railways are shown in the following: 129,130, July 16, 1872, Hallidie; 157,385, December 1, 1874, Eppelsheimer; 173,329, February 8, 1876, Paine; 176,136, April 18, 1876, Hovey; 179,086, June 20, 1876, Hallidie; 195,505, September 25, 1877, Hallidie; 262,126, August 1, 1882, Root; 286,163, October 2, 1883, Root; 271,727, February 6, 1883, Miller; 332,933, December 22, 1885, Miller; 339,322, April 6, 1886, Robertson and Jonson; 347,935, August 24, 1886, Hovey; 371,095, October 4, 1887, Paine; 372,930, November 8, 1887, Robertson; 424,619, April 1, 1890, Robertson.

Patent 228,055, Gilbert, May 25, 1880, is for an elevated railway.

The Leslie centrifugal snow plow began a line of improvements, instances of which are exhibited in the following patents to Leslie: 317,809, May 12, 1885; 338,759, March 30, 1886; 380,809, April 10, 1888; 391,903, October 30, 1888; 391,904, October 30, 1888; and 438,008, October 7, 1890.

CONVEYING AND HOISTING.

Under this title are included patents referring to conveyers, clutches, cranes and derricks, elevators, pulleys, and store service.

Conveyers.—In this class 1,796 patents have been issued. A most important advance in the handling and storage of coal is shown by the patents to Dodge, 408,957, August 13, 1889; 443,605, December 30, 1890; 453,966, June 9, 1891; 503,409, August 15, 1893; 539,250, May 14, 1895.

The immense steam-generating plants of to-day require mechanical stoking, and that demands the most

efficient appliances for passing coal. This we find illustrated in patents to Dodge, 565,334, August 4, 1896, and 667,975, February 12, 1901; Hunt and King, 631,718, August 22, 1899; Frith, 620,298, February 28, 1899, and 690,518, January 7, 1902.

Also in the transfer of ore or coal from the vessel to the docks, the element of time has led to the application of high power to the lifting of immense bulks and weights at once. See patents to Hoover and Mason, 679,475 and 679,505, July 30, 1901. The same conditions call for mechanical appliances to gather the material from the remoter parts of the ship's hold to below the hatches. Hand shoveling is too slow and expensive. See patents to Hulett, 606,720, July 5, 1898, and 679,967, August 6, 1901.

Again, the same conditions have led to the dumping of coal or ore direct from the car into the hold of the vessel—patents to Hulett (reissue), 11,494, May 7, 1895, and with a minimum of breakage in the process, patent to McMyler, 558,200, April 14, 1896; the latter result aided by an intermediate step. See patent to Hulett, 631,717, August 22, 1899. But the coaling of ships is apparently done most expeditiously by what is known here as the rotary tipple, or in England as "the oscillating tippler." See, as instances of this type, patents to Long, 560,727, May 26, 1896, and 651,371, June 12, 1900.

An important development in the art of conveying and stacking straw is shown in the patents 297,561, April 29, 1884, and 467,476, June 19, 1892, to Buchanan; 424,433, March 25, 1890, to Ross; and 537,691, April 16, 1895, and 569,504, October 13, 1896, to Landis. Patent 545,013, August 20, 1895, to Dodge, is most interesting as showing the application of the air blast for general conveying purposes. While a trough is shown, the material hardly touches the trough, but rests upon a film of air.

The mechanical distribution of grain to all parts of the grain car has received large attention. See patents to Phillips and Hunt, 570,880, November 3, 1896; Reynolds, 614,891, November 29, 1898; and Skillin, 619,799, February 21, 1899.

Clutches and Gears.—In the class of clutches 1,314 patents have been issued. Although throughout the class of clutches there have been important improvements, yet the only radical advance in the art is manifested in the magnetic and fluid forms. Prior to 1880 there was no magnetic clutch. In 1881 a British patent, No. 200, was granted to one Imray, which shows the first attempt in this line. This was followed by the United States patent to Veeder, 439,213, October 28, 1890, and that to McLaughlin, 432,209, July 15, 1890, wherein are disclosed magnetic or electric clutches acting to produce a positive binding frictional contact. Willans, in his patent, 473,042, April 19, 1872, went a step further by producing a clutch which performs all the functions of a clutch, but without the usual frictional contact. Hence in the later form there is absolutely no wear of the clutch parts, since there is no contact. There have been 19 patents issued for magnetic clutches. The first fluid clutch of which there exists any record is that patented to Brayton, 235,732, December 21, 1880. Instead of relying upon the constantly decreasing power of mechanical elements to create frictional contact a fluid under pressure is employed. This principle was developed by Hartness, 541,483, June 25, 1895. See also Stone, 663,396, December 4, 1900.

In the Stone patent the power is transmitted from one shaft to another by expanding a split ring carried by one shaft within a flange carried by the other. The expansion of the split ring is effected by means of an hydraulic cylinder and piston coupled to one end of a pivoted lever, the ends of the split ring being connected to the lever by links arranged on opposite sides of the pivot. Another form of clutch is shown in Rogers & Chadwick, 659,379, October 9, 1900. In this device the driving and driven elements are coupled by means of a split ring, spread by a lever arranged to be acted on by a cam on the driving shaft. The following peculiarities will be noticed in this device:

The driven element can travel faster than and independently of the driving element;

That increased speed of the driven element automatically uncouples the parts, and coupling will be again effected by reduction of speed of the driven element to that of the driver;

That reversing the motion of the driving shaft when the driven element is moving forward causes the parts to act as a brake; and

That increased resistance to movement causes the parts to be gripped more firmly.

The fluid clutch patents number 30.

The patent to Boyd and West, 680,688, August 20, 1901, illustrates a new departure in the structure of gear teeth, in which a steel plate is located in the center of each tooth, by which means the tooth increases in hardness toward the center. Thus the more two such coacting gears wear toward an accurate mesh the bearing surface of the teeth becomes harder.

An illustration of change-speed gearing is the patent to Schellenbach, 667,406, February 5, 1901. In this device a rotatable casing supports two gear wheels, around which and meshing therewith are also carried 9 pinions, any one of which may be clutched to the driven shaft, and also any one of said pinions may be operatively connected to the driving shaft. By this mechanism 81 different speeds may be obtained in the driven shaft.

The patent to Shattuck, 682,391, September 10, 1901, belongs to another type of transmission gearing, in which a pinion on the driven shaft is made to engage with any one of a set of toothed gears of gradually smaller diameters, or "stepped" gears. In order, how-

ever, to obviate the abrupt change from one speed to another the cone of gears is divided longitudinally into two halves. By means of switches and an operating lever the two halves may be made to slide longitudinally and laterally to such an extent that the driven pinion will run smoothly from one half of any gear to the corresponding half of the next smaller or larger gear as desired, after which the parts return again to their nominal positions, sliding the pinion laterally upon its shaft. Thus the pinion may be caused to run smoothly from the highest to the lowest gear, or vice versa, producing a variety of speeds in succession without occasioning any sudden jar in the driven part.

The patent to Barnard, 696,301, March 25, 1902, illustrates a very ingenious method of transmitting power by means of differential gears. Hitherto one member of a differential train has been held by brake mechanism to serve as a fulcrum. In this device, however, the fulcrum member is retarded by causing it to perform useful work. For example, power being applied to the first member of the train, and the second member being directly connected with the front axle of a street car or motor vehicle, the third member may be connected with a dynamo and made to generate a current of electricity to operate a motor on the rear axle of the vehicle. It will thus be seen that the power imparted to the first member is divided into two always equal parts, each of which performs independent work, and by varying the load imposed upon one part, as by various kinds of resistance, the work performed by the other part is also made to vary.

Cranes and Derricks.—In this class 777 patents have been issued. Good examples of cranes are found in the following patents: 290,260, December 18, 1883, Morgan, sr.; 475,883, May 31, 1892, Morgan and Morgan; 478,803, July 12, 1892, and 496,427, May 2, 1893, Morgan.

Elevators.—In this class 2,217 patents have been issued. The patent to Bassett, 332,776, December 22, 1885, illustrates a type of elevator controller in which the controller cable is operated by means of a lever or wheel inside of the car. There is a class of devices in which the controller rope is so connected as to move with the car. This is illustrated in the patent to Reynolds, 317,202, May 5, 1885. Rowntree, 693,908, February 25, 1902, shows a running controller rope the speed of which is less than that of the car. Patents to Fraser, 610,481, September 6, 1898, and 616,096, December 20, 1898, show means whereby an endless cable determines the relative directions and speeds of the car and counterweight according to the rates of speed of two independent power pulleys over which independent bights of the cable operate.

There are many safety devices and they are very diverse in their nature. Typical ones are referred to below. The patent to Sawyer, 231,743, August 30, 1880, shows electrical means for locking the controller rope when any door of the elevator shaft is open. The reissue patent, 11,520, to Harkness, shows means for locking a controller handle in the car when the door of the elevator shaft is open.

Likewise in Otis and Sundt, 687,775, December 3, 1901, the controller is locked when any well door is open or unlocked, and it is impossible to open any door until the car is adjacent thereto.

The patent to Guild, 213,565, March 25, 1879, shows means for stopping an elevator when the car meets with an obstruction. The patent to Walker, 407,626, July 23, 1889, shows means for preventing the crushing by the car of a foot which might be projected slightly beyond the floor of the car or one of the floors of the building. Patent 497,431, McGill, May 16, 1893, provides means whereby the position of the elevator and the direction of its movements may be observed at any floor.

Patent to Harold Rowntree, 693,907, February 25, 1902, is for an improvement in safety devices, having means for automatically varying the speed at which the safety grips are actuated.

A difficult problem in devices to prevent the fall of a car is to secure promptness and certainty of action of the devices without unnecessary shock by sudden stoppage. One means for accomplishing this result, and the one employed on the elevator in the Washington Monument, was patented by Pratt, 676,152, January 11, 1901.

Much improvement has been made in the line of automatic means for operating well doors by means connected with the elevator car. In patent to Bitner, 676,833, June 18, 1901, a friction rail on the well door is operated by a friction wheel to open and close the door as the car approaches and leaves the landing, and means are employed whereby the speed of the door is reduced to prevent shock as the limit of its movement is reached.

The modern tall building has emphasized the necessity of absolutely perfect control of the winding drums. The lowering no less than the hoisting must needs be by positive engine power. This feature is developed in patents to Eades and Mathews, 602,312, April 12, 1898; Voss, 681,489, August 27, 1901; and Beck, 697,393, April 8, 1902. Patent 258,668, Paine, May 30, 1882, provides means whereby mail matter may be deposited or received at any floor of a building. Means were also provided to indicate the arrival of the mail box at the floor. Patent 517,619, Morgan, April 3, 1894, provides the ordinary passenger elevator car with a mail receptacle which automatically takes mail matter from boxes at the various floors, as well as deposits mail matter in such boxes.

Ladders.—Ladders have probably been used since the earliest neolithic savage placed a branch of a tree in such a position that he could clamber into his cave over it, and types of a great many of them have not materially

changed. In one or two respects, however, there have been in recent years some considerable improvements, as in ladders for store service; for example, in patent to Wildprett, 577,866, January 26, 1897. The upper guiding track in this ladder is made by a simple bend of sheet metal, and the lower end is provided with a track of one rail, the other rail running free. Two rollers in alignment of the track prevent the ladder from swerving, and a hinged connection permits it to be turned back out of the way when not in use. Taylor, 649,965, May 26, 1900, shows a ladder of the store-service type, provided with means for raising and lowering merchandise; also see Balfour, 662,108, November 20, 1900.

Truck ladders are illustrated by patents to Fall, 640,645, January 2, 1900, and Young, 568,999, October 6, 1896.

Pulleys.—In this subclass 1,027 patents have been issued. Patent 469,338, Walker, February 23, 1892, covers a radical departure in drums for driving the cables of cable railways. The invention consists in making the cable grooves in peripheral rings adapted to turn independently of the drum, whereby the cable is automatically tensioned with the varying loads as cars are put on or taken off the line. Patents 260,462, Dodge and Philion, July 4, 1882, and 351,064, McNeal, October 19, 1886, are two of the first practicable split wooden pulleys.

Patent 603,067, Reeves, April 26, 1898, is an improvement on speed-varying mechanisms in which two expansible pulleys are employed which may be so changed while the apparatus is in operation that the speed of a machine belted thereto may be varied while the speed of the line shaft remains constant, or whereby the countershaft speed can be altered without stopping the shaft or the machine driven, and whereby a uniform tension may be maintained on the driving belt.

Patent 641,281, Edison and Johnson, January 16, 1900, is an improvement on expansible pulleys whereby provision is made for tightening the belt on the expansible pulleys by adjusting one of the shafts toward and from the other.

Store Service.—In this class 1,122 patents have been issued. The art of store service is a very young one, the first patent for the carrying of goods and cash in stores having been granted to Brown on July 13, 1875, 165,473. As illustrating advancing steps, mention may be made of the patent to Martin, 255,525, March 28, 1882, in which the carriage is detachable from the cable and the cable is moved continuously by an engine; the patents to Martin, 276,441, April 24, 1883, and 284,456, September 4, 1883, in which provisions are made for automatically detaching the carrier from the continuously moving cable and switching it off from the main track, and the patent to Martin, 368,219, August 16, 1887, which illustrates this type as it is applied practically at the present day, and which provides, among other things, for conveying cash to all parts of a building. Another type is illustrated in the patents to Barr, 357,449, February 8, 1887, and Goodfellow, 493,621, March 14, 1893, in which the car is propelled by a wedging action of a motor cord.

For rapid distribution of mail matter in large cities pneumatic dispatch tube apparatus is coming into use. The Batcheller patents, 623,973, 623,970, and 623,968, granted May 2, 1899, show, respectively, a terminal station, an intermediate station, and a switching device for a branch tube of such a system.

ELECTRICITY.

Generation.—In this class 3,688 patents have been issued. In 1871 the state of the art of electric generation was as follows: Sonnenburg & Rechten had patented a machine for killing whales by electricity, patent 8,843, March 30, 1852, the earliest United States patent in this art. The so-called Alliance machine was in use to some extent for seaboard illumination, and is represented in the patent to Shepard, 15,596, August 19, 1856. These machines were provided with permanent field magnets. Wilde had patented a machine that was intermediate between those having permanent field magnets and those which had electro-magnets excited by the current of the machine itself. This is shown in patent 59,738, November 13, 1866.

Gramme and d'Ivernois had patented a machine having a continuous armature winding which, so far as the United States patents go, may be regarded as the progenitor of the modern dynamo-electric machine. This patent is 120,057, October 17, 1871. April 13, 1875, a patent, 161,874, was granted to Farmer embodying the principle announced in 1866 by Siemens, Wheatstone, and Varley of exciting the field magnets by the currents generated by the machine. Weston patented July 18, 1876, 180,082, a multipolar self-exciting machine. The first patented machine having the modern form with consequent poles was granted to Holcombe, December 5, 1876, 184,966. Brush, April 24, 1877, 189,997, patented a form of machine having an open coil ring armature. Weston patented, October 29, 1878, 209,532, a machine which had all the essential features of the most modern machines, viz, consequent poles and cylindrical ventilated armature with continuous winding. Brush, July 22, 1879, 217,677, introduced the so-called teazer, which is a high resistance winding upon the field magnets, connected in shunt to the work for the purpose of maintaining the magnetism of the field magnets when the machine is running, whether the external circuit is closed or open. Prior to this all machines had their field magnet winding in series with the work, and had no excitation except when the working circuit was closed. Edison patented, December 23, 1879, 222,881, a special structure of cylindrical armature. Thomson & Houston, January 13, 1880, patented their three-coil armature, 223,557. Brush pat-

ented a regulator consisting of a shunt around the field magnets, including a variable resistance, February 17, 1880, 224,511. Seeley patented June 22, 1880, 229,191, an armature in the form of a disk, wherein the active wire was radial. Sawyer, July 20, 1880, 230,345, patented a regulator which varies the number of active sections of field-magnet winding. Von Hefner-Alteneck patented, November 9, 1880, 234,353, a multipolar alternating current machine having a portion of its current commutated for exciting the field magnets. Edison, June 14, 1881, 242,898, patented an armature having its conducting parts formed of heavy copper bars. Van Depoele, May 16, 1882, 257,990, patented what is known as a motor generator or rotary transformer, in which there are two armature windings, one taking current from a line and driving the machine as a motor, while the other winding acts as a generator. Irwin, August 8, 1882, 262,421, patented a machine in which regulation is effected by changing the inductive relation of field magnet and armature. Patent to Wenstrom, 292,079, January 15, 1884, shows the first of the iron-clad machines. An armature winding for drum armatures, in which the coils may be prepared in advance and placed on the core as desired, was patented to Eickemeyer, February 14, 1888, 377,996. The employment of carbon collector brushes is represented in the patent to Van Depoele, February 25, 1890, 422,265. A form of machine in which the armature wire is stationary and is affected by the closing and opening of the magnetic circuit is shown in the patent to Sawyer, February 8, 1881, 237,632, and in a more improved form in that to Stanly, jr., and Kelly, June 13, 1893, 499,446. Machines on a vertical shaft are shown in the patent to Sellers, June 5, 1894, 520,940.

During the last few years there has been no startling innovation in this class, the attention of inventors having been directed to the improvement of minor details of known devices. The commutators have been improved, the collecting brushes have been better adapted to their purposes, variations made in the construction of the coils, and the manner of applying them have received much attention. A dynamo of modern type includes in its construction a large number of patented improvements, and its superiority does not rest on one any more than on another, and in many cases the improvement consists in some comparatively trivial change.

The first attempts at a commercial employment of transformers for purposes of distribution were based on the patent to Gaulard & Gibbs, October 26, 1886, 351,589. A transformer system for constant current is brought out in the patent to Thomson, April 2, 1889, 400,515. The relation of counter electro-motive force to direct electro-motive force, which renders transformers connected to line in parallel self-regulating, is found in the patent to Kennedy, July 16, 1889, 407,294, which was reissued September 24, 1889, 11,031. The monocyclic system is represented by Steinmetz, January 29, 1895, 533,248.

An electric meter for distributing electricity in proportion to the value of an inserted coin is shown by the patent to Phillips & Tilden, 626,298, June 6, 1899. This meter is arranged to be operated by coins of different denominations.

Electric Heaters.—An improvement in electrical heating is a woven fabric that is adapted to be uniformly heated throughout by an electric current. This is shown in patent 540,398, to Meek, June 4, 1895. This fabric is of great value in case of sickness, which reduces the temperature of the body and renders desirable the application of heat, and is also useful as a covering whenever a gentle heat is required.

Gold, 638,236, December 5, 1899, strings a coil of bare resistance wire upon an insulated supporting rod and puts it under such strain as to cause the convolutions to impinge at one point only against said supporting rod.

Electric Lighting.—In this class 5,833 patents have been issued. Some of the more important inventions in this art are the now common type of ring clutch used in arc lamps, patented by Brush, 203,411, May 7, 1878; a main and shunt magnetic differential feed for arc lights, patented by Brush, 212,183, February 11, 1879; a main and shunt mechanical differential feed, patented by Weston, 285,451, September 25, 1883; the double-carbon arc lamp, with mechanism to separate the pairs successively, patented by Brush, 219,208, September 2, 1879; the high-resistance filament in an exhausted glass globe, the present incandescent lamp, patented by Edison, 223,898, January 27, 1880; the use of bamboo as a material for making incandescent filaments, patented by Edison, 251,540, December 27, 1881; the process of standardizing filaments by electrically heating them in the presence of hydrocarbon vapor, patented by Maxim, 405,170, June 11, 1889; a system of distribution employing three wires in multiple series, patented by Edison, 274,290, March 20, 1883; the process of producing currents of enormous frequency and excessively high potential, and utilizing them for the production of light, patented by Tesla, 454,622, June 23, 1891; the system for supplying electro-motive force to a feed-wire system between the consumption circuit and source of supply of the main electro-motive force, patented by Mailloux, 475,877, May 31, 1892; the process of producing Geissler tube effects without the aid of induction coils by interrupting the current in a high vacuum, patented by Moore, 548,127, October 15, 1895; the socket detachable from an incandescent lamp, the parts being so arranged that the insertion of the lamp completes the circuit, patented by Edison, 251,554, December 27, 1881; a mechanical cut-out which will automatically take the current off the trolley wire in case it happens to break, and thus save danger of contact with live wires, patented by Morgan, 417,497, December 17, 1889; and a

method of interrupting an electric arc by generating a nonconducting vapor within the path of the arc, patented by Wurts, 470,773, March 15, 1892.

Flexible metallic tubes for house wiring are shown in patent to Greenfield, 630,501, August 9, 1899. An outlet box for making working connections is shown in patent to Greenfield, 642,521, January 30, 1900.

Since 1895 four new types of electric light have been brought forward and perfected in commercial form. The first of these is the Jablochkoff candle, used and abandoned some twenty years ago. This form of lamp depends on the fact that numerous nonconductive oxids, such as kaolin, chalk, zirconia, etc., become electrolytic conductors when highly heated, the resistance decreasing with increase of temperature, so that the best light-producing condition is coincident with the best condition of conductivity. Mixtures of oxids capable of becoming conductive at lower heat have been substituted for the kaolin, a separate electric heater and automatic cut-out therefor have been devised, and a ballast resistance to balance the decrease of resistance in the glower have been supplied. This light, which is far more brilliant than the carbon filament and better than either the arc or filament light as to color, is now on the market in competition with the inclosed arc. This development of the art is illustrated by the new subclass of lights, incandescent, second-class conductors, which contains some fifty-three patents, including the patents to Nernst, 623,811, 685,725, and 685,732; Potter, 685,486; and Van Vleck, 644,784.

The second is the mercury vapor lamp, which comprises a tube of considerable length caused to glow by conduction of low tension currents through rarefied pure mercury vapor contained therein. The entire mercury column gives off an intense and soft glowing light. The candlepower is great compared with the amount of current used. The patents for this invention, of which Hewitt, 682,690, is illustrative, constitute a new subclass of lights, incandescent, vapor conductors.

The third is the perfected McFarlan Moore vacuum lamp having no inleading wires, the energy being transferred from condenser surfaces on the ends of the tube to the extremely rarefied gas inside the same by electrostatic action. These lamps have been constructed in lengths of over 100 feet and have been made so as to be operated by commercial frequencies commonly employed for lighting purposes. See patents to McFarlan Moore, 702,315, 702,319, 702,320, and 702,321.

The fourth is the Bremer arc lamp, wherein the carbons approach each other at an acute angle. The principal feature of the light is the addition to the composition of the arc pencil of a large percentage of the salts of the alkaline metals. Such additions were known to greatly increase the efficiency of the light, but involved in practice great unsteadiness. Bremer discovered that the flickering caused by the addition of a desired amount of alkaline salts, instead of being made worse, is actually cured by still further increase in the proportion of such substance. See patents 658,423, 679,877, 679,878, 684,407, and 697,439.

Electric lighting of railway trains by power derived from the motion of the train has been perfected to a point where it is entirely practical in particulars illustrated by Preston, 602,182; Guillott, 672,877; Moskowitz, 684,083; Bohm, 688,382; and Creveling, 688,394, and reissue 11,961.

Miscellaneous.—The patents to Brown, 645,910 and 672,309, cover an apparatus and method for testing out and plotting the relative resistances of large areas of earth surface for the purpose of determining the location of underground veins of mineral, streams of water, and buried treasure. This scientific substitute for the witch-hazel fork and the divining rod has been extensively and successfully used both for discovering mineral ores and for determining the boundaries of veins already discovered.

Motive Power.—In this class 2,031 patents have been issued. Prior to 1871 there was nothing done in relation to the use of alternating currents for purposes of motive power. The growth of this art may be illustrated in the consecutive order of patents, as follows: Thomson, May 17, 1887, 363,186; Tesla, May 1, 1888, 381,968; Thomson & Wightman, March 19, 1889, 399,801; Zipernowsky & Deri, August 5, 1890, 433,758; Von Dolivo-Dobrowolsky, July 7, 1891, 455,683; Siemens, September 5, 1893, 504,630; Scott, June 5, 1894, 521,051; Hunting, February 20, 1894, 514,933.

Wireless transmission of electricity has been applied to the management of torpedo boats as presented in patents to Tesla, 613,809, November 8, 1898, and Fiske, 660,155, October 23, 1900.

A scheme for transmitting electric currents of different character (as continuous and alternating) over the same wire, is set forth in patent to Bedell, 647,741, April 17, 1900.

When two or more motors are employed they may be connected in series, in parallel, or in any relation of series and parallel. A simple scheme for this transition is shown in Knight, 587,442, August 3, 1897.

In the manufacture of insulators for high-tension currents, it has been found desirable to make them in sections, which are secured together by means of a fusible glaze. Patent to Boch, 600,475, March 8, 1898, shows one mode of making these insulators.

In starting electric motors from rest, it is desirable to apply an excess of power at first and diminish the power gradually as the motor acquires speed. One means for accomplishing this is shown in patent to Burke, 611,558, September 27, 1898.

The following patents are cited as illustrations of the growth of the art of operating elevators by electric power: A hydraulic elevator electrically controlled was patented by Smith, September 3, 1889, 410,212. Elevators in which the electric motor is carried on the

car, with connected gearing engaging rack bars in shaft, was patented by Sheridan & Gorn, 259,593, June 13, 1882, and Blades & McKee, 462,527, November 3, 1891. Elevators having motor stationary and automatically controlled by switch mechanisms on car or landings, are shown in patents to Wheeler, 324,621, August 18, 1885, and Eickemeyer, 454,462, June 23, 1891. Safety devices to break motor circuit when elevator door is opened are shown in the patent to Ongley, 389,853, September 18, 1888.

The application of electricity to agricultural apparatus is set forth in Schimpf, 582,237, May 11, 1897, and Foerster, 610,350, September 6, 1898.

It has been found advisable to charge different rates for electric service at different periods of the day. To facilitate this, electric meters have been organized to give different readings in accordance with the rates of charge. Among these are Kapp, 595,985, January 25, 1898, and Cox, 585,257, June 29, 1897.

It is important to know the maximum of electric consumption during any given period. This is shown by Hoyt, 600,265, March 8, 1898.

A galvanometer having two indexes and scales for volts and amperes, respectively, has been patented by Weston, 600,981, March 22, 1898.

Under this general class 292 patents have been issued pertaining to the transmission of electric power.

Electric Railways.—In this class 2,947 patents have been issued. There was nothing in this art prior to 1871. Some of the most prominent features in the growth of the art are represented by the following patents: Overhead direct and return conductors with double trailing trolley, in the patent to Finney, January 2, 1883, 270,186; overhead conductor trailing trolley, ground return, in that to Finney, September 18, 1883, 285,353; overhead conductors, upward pressed trolleys and double trolley, in that to Van Depoele, December 4, 1888, 394,038; overhead conductor with upward spring-pressed trolley broadly in that to Van Depoele, January 19, 1892, 467,448; underground conductor with slotted conduit is shown in patent to Knight, September 23, 1884, 305,731; an underground conductor with contacts projecting above the surface of the ground is shown in that to Painter, June 23, 1885, 320,679; underground conductor, the circuit being closed by the action of a magnet carried by the car, in that to Wynne, January 7, 1890, 419,094; a railway system in which an alternating current is transformed to a direct current for driving the motor is shown in patent to Westinghouse, May 28, 1889, 404,139; a motor elastically mounted so as to be independent of the vibration of the car is represented by Field, April 10, 1888, 380,880; electric railways operated by polyphase currents are represented by Badt, January 10, 1893, 489,597.

For electric railways operated partly by overhead and partly by underground supply, King & Babendrier have several patents relating to the automatic removal from the conduit of the underground collector. One of these is 623,248, April 18, 1899.

To secure a satisfactory bond between the rails of electric railways, Daniels applies the heads to these bonds by hot pressure to secure a practically integral joint (see patent 582,849, May 18, 1899), and McTighe employs cold pressure of sufficient force to form a cold weld (see patent 650,861, June 5, 1900).

Attention has been directed to the prevention of collisions. Patent to Cooley, 573,645, December 22, 1896, shows means for depriving a following train or car of its propelling current, so that it can not approach within a determined distance of the preceding car or train. Bentley, 658,336, September 25, 1900, illustrates means whereby the sections of a road are under the control of a signalman, who can cut out any section and stop a car at any point. Phillips, 631,491, August 22, 1899, provides for depriving a car of current on approaching an open drawbridge.

Westinghouse, 645,613, March 20, 1900, locates a gas-generating plant at some convenient point, from which he supplies gas for running engines at the different divisions of his road. These engines drive dynamos for supplying each its own division. Signaling and controlling devices are provided for the management of the local engines, which are started before a car enters the division. Somewhat in analogy to this is Heilmann, 622,466, April 4, 1899, in which there are local generators for the different sections driven by an electric current from a central source of power.

To provide additional power at high grades, Henry, 560,265, May 19, 1896, has two generators of, say, 400 and 600 volts, respectively. By a proper system of circuiting, these generators will deliver either 400, 600, or 1,000 volts, as occasion may require. Another mode of effecting the same purpose is to provide a propelling motor of somewhat more than sufficient capacity than is required for average work, using the excess of power when the requirements are the least for charging storage cells, from which additional power is drawn when required. An example of this plan is shown in Munson, 653,200, July 3, 1900.

Devices for the prevention of electrolysis of water and gas pipes by the vagrant currents from railway circuits are found in Kapp, 570,599, November 3, 1896; Jackson, 622,481, April 4, 1899; and Blake, 661,165, November 6, 1900.

In the operation of electric railways, trains may be made up of a number of cars, any number of which may be provided with apparatus for controlling the several motor equipments. See Sprague, 660,065, October 16, 1900; Rice, 608,301, August 2, 1898; and Entz, 619,287, February 14, 1899.

Electric Signaling.—In this class 1,622 patents have been issued. We have in this class the railroad-car telegraph, in which is employed a circuit on the car

extending from the metallic roof of the car to the rails, with transmitting and receiving devices therein, and an electric telegraph line in inductive proximity to the car, patented by Smith, 247,127, September 13, 1881; an improvement on the last, in which a closed electric circuit is employed on the car, patented by Phelps, 307,984, November 11, 1884; and as a still further improvement, the idea of using induction impulses from the train to the line wire so as not to interfere with the ordinary Morse signal sent between stations, patented by Edison, 350,235, October 5, 1886.

Of late years the line of invention has principally tended toward improving prior structures. There has, however, been marked advance in various lines illustrated in a number of patents, such, for example, as Thompson, 623,637, April 25, 1899, for signaling orders from one station to another, as from the pilot of a ship to the engineer, and having the signal repeated back to the sender; the patent to Hovey, 552,181, December 31, 1895, for sounding an alarm at grade crossings or other desired places; and that to Thebaud, 619,632, February 14, 1899, for recording the power generated by the flow of liquids. There has also been considerable activity in providing electric railway systems with apparatus whereby when a car passes on a section it cuts out or deadens the adjacent section and at the same time displays a signal, so that the danger of collision is reduced to a minimum. Of this the patents to Tilghman, 573,496, December 22, 1896; Burger, 602,208, April 12, 1898; and Bancroft, 621,205, March 14, 1899, are examples.

Telegraphy.—In this class 4,337 patents have been issued. There may be mentioned among the important inventions of the last thirty years in this art the following: A duplex system with a condenser in the artificial line, by which it was made practicable to send two messages over the same line in opposite directions, patented by Stearns, reissue 5,344, April 1, 1873; the quadruplex telegraph, in which two independently operated keys, one serving to control the polarity and the other the tension of the line current, have made it practicable to send two separate messages over the same line in the same direction, patented by Nicholson, 332,550, December 15, 1885; the sunflower multiplex, in which there is a series of contacts connected in independent groups, mechanism at each station for successively completing the line circuit through said contacts, telegraphic instruments in the circuit of each group of contacts, and means for automatically correcting the speed of the circuit breakers at the several stations, by which it is proposed to send any number of messages in the same direction over the same line at the same time, patented by Delaney, 286,278, October 9, 1883.

In multiplex telegraphy an indefinite number of messages have been sent over the same line in both directions at the same time by the use of alternating currents, the frequency for each transmitter and its receiver being different from that used in any other. It has been found that by the use of local inductively or conductively connected branches of the main line, each tuned by properly proportioned inductance and capacity to the single frequency which it is intended to receive, each local will select its particular frequency to the exclusion of all others. This system is described in the patents to Pupin, 640,515 and 640,516.

A printing system employs a selector for distributing the currents to several setting magnets and a type wheel or type bar set to its appropriate position by a series of adjusting devices controlled by the magnets, whose limits of actions collectively are commensurate with the entire range of type wheel movement, patented by Howe, 150,953, May 19, 1874; the same idea with the adjusters made independent of the press mechanism was patented by Fiske, 529,484, November 20, 1894; the same printing system, broadly speaking, combined into a complete system with an automatic transmitter, was patented by Buckingham, 487,982, December 13, 1892.

Synchronous multiplex printing telegraphy has been improved in several directions. The printing mechanism has been improved so that by the operation of a typewriter at the sending station exact copies are reproduced in similar machines at any desired number of receiving stations, and the multiplexing principles have been so refined that any desired number of these machines may be operated in both directions over a single wire at the same time.

Professor Rowland perfected a system the fundamental principle of which involves dividing the waves of an alternating current into groups of eleven impulses and modifying the groups by suppressing one or more waves according to a system of combinations, thereby transmitting forty-five characters which by means of an automatic selector print the characters on a sheet of paper at the receiving station. The illustrative patents are Rowland, 622,636, 689,415, 689,753, 689,754, 691,667, 699,574, and 699,575. Gilmore patent, 695,203, effects a similar purpose by impulses of the same strength but different duration, thereby making his apparatus particularly susceptible of multiplex use in a sunflower synchronizer system. Burry, 680,693, shows a well worked out printing receiver for reproducing a printed page instead of the tape record of the well-known stock ticker.

Other notable inventions within the epoch are the autographic telegraph for transmitting chirographical characters by means of electric currents in two lines varied in force by the movement of the sending tracer in two directions, patented by Cowper, 217,588, July 15, 1879; the method of autographic telegraphy, which consists in transmitting the movements of the transmitting pen in pulsations varying in number with the linear extent of the movement, patented by Gray, 386,815,

July 31, 1888; a fire telegraph embodying the broad idea of preventing one box when pulled from interfering with another box already pulled, patented by Gamewell, reissue 8,891, September 9, 1879; the use of a metallic circuit either as such or as grounded circuits by means of ground taps, patented by Carter, 140,011, June 17, 1873; and a fire-alarm telegraph repeater in which the reception and repetition of one signal causes the other circuits to be locked out to prevent interference, patented by Gamewell, 165,923, July 27, 1875.

The new subclass of telegraphy, wireless, containing 65 patents, represents the beginning and growth of the art of wireless transmission by broken off radiant energy as distinguished from more or less imperfect earth or water conduction and as distinguished from the inductive transformer action of a local field of force, or the condenser action of charged plates. The perfection which this art has already reached in actual practice is foreshadowed rather than indicated by the first Marconi patent, 586,193, and the Lodge patent, 609,154, disclosing the principle of selectivity by tuning. Tesla, in his patents 645,576 and 649,621, has proposed a method of wireless transmission by actual conduction through the rarefied upper strata of the atmosphere.

Telephony.—In this class 3,969 patents have been issued. In this art, which dates from 1876, is found the broad art of causing electrical undulations similar in form to the vibrations of air accompanying sound, patented by Bell, 174,465, March 7, 1876; the metallic diaphragm in a magnetic telephone, patented by Bell, 186,787, January 30, 1877; the broad method of microphonically transmitting speech, patented by Berliner, 463,569, November 17, 1891; the broad idea of using a low-resistance conductor in a microphone, patented by Edison, 474,231, May 3, 1892; the use of finely divided carbon in a loose state in a microphone, patented by Hunnings, 246,512, August 30, 1881; the use of a weight and spring to hold the electrode against the diaphragm, and the use of two electrodes in combination with the diaphragm, the well-known form of Blake transmitter, 250,127, 250,128, and 250,129, November 29, 1881; in telephone systems, the use of a separate talking wire passing to each subscriber and to the central operator, called the Law system, patented by Shaw, 220,874, October 21, 1879; the use of test circuits in multiple switch boards, whereby the operator at any one board can determine whether the line is connected at another board, patented by Haskins & Wilson, 266,287, October 24, 1882; Kellogg, 308,315, November 18, 1884; and Scribner, 321,390, June 30, 1885; a divided central multiple board system, in which the telephone lines are divided into two classes and the multiple switch boards are divided into two sections, with an appropriate distribution of the spring jacks and annunciators, patented by Kellogg, 424,310, March 25, 1890; the combination of a terminal switch board and a connecting switch board, the call-receiving annunciators being at the terminal board and there being a separate set of operators at each board to divide the work, patented by Hall, 495,087, April 11, 1893; a telephone switch by which the telephone instruments and signaling instruments are placed in two branches from the main line, patented by Watson, 202,495, April 16, 1878; a telephone switch in which the telephone receiver automatically actuates the switch, patented by Roosevelt, 215,837, May 27, 1879; and a telephone switch in which the movement of the telephone receiver signals the central-office operator, patented by Scribner, 251,955, January 3, 1882.

A great number of automatic systems have been devised, and at least three have been actually constructed, whereby the operation of a large exchange is absolutely automatic. See Callender, 511,874; Strowger, 589,798 and 591,201; Seligmann-Lui, 639,186, and Faller, 686,892.

Telephone registers for measured service systems have been produced in large numbers, as illustrated by the following patents: Field, 558,168; Hayes, 589,431; Dean, 609,331; Scribner, 617,839; McBerty, 641,400; and Scribner, 655,164.

An improvement in long distance transmission by wires of great practical and scientific interest is the loaded line disclosed in the Pupin patents 652,230 and 652,231. This invention discloses the use in a long distance line of inductance coils inserted in series, a plurality to the half wave length, the purpose being to decrease the attenuation and distortion caused by the distributed capacity on the line by suitably proportioning and disposing such inductance sources. This invention has been applied to a line between New York and Chicago, making possible satisfactory telephonic communication between New York and Denver.

Multiplex telegraphy based upon the principle of selectively receiving a single one of a plurality of frequencies in a given branch circuit has been made applicable to multiplex telephony by the simple expedient of making all the frequencies to be selectively received higher than the highest overtones of articulate speech. See Hutin and Leblanc, 522,564, 596,017, and 628,246.

HYDRAULICS.

Baths and Closets.—In this class 3,897 patents have been issued. Patent to Smith, October 24, 1876, 183,716, exhibits the first siphon water-closet in which the action of the discharge siphon is assisted by a jet of water ascending the upleg. Patent to Boyle, January 1, 1884, 291,139, shows the first system wherein the action of the discharge siphon from the closet is assisted by the exhaustion of air from its crown, caused by the flow of water from the cistern in flushing.

A movement has been developed in this class toward the improvement of slow-closing valve mechanism for controlling a flush direct from the main, and in some degree toward improvements in the air-tight cistern that may be placed lower and into which water first

flows from the main, compressing the air therein to provide a flushing pressure, and then flows under such pressure to the bowl, the flow to and from the cistern being controlled by a single valve. An example of the latter is Kelly, 632,417, September 5, 1899. The more energetic movement thus far is toward the direct flush. This movement was inaugurated by the valve mechanisms shown in patents to Kenney, 566,770 and 566,771, September 1, 1896. Kenney in his first patents contemplated the use of a cistern. The valve mechanisms have, however, gone into use for direct flushing.

A movement is traceable in all of the hydraulic arts in the direction of actuating and governing the movements of mechanical auxiliary parts, such as valves, by fluid pressures instead of mechanical connections. The patent to Marsh, 643,906, February 20, 1900, illustrates this.

Filters.—In this art 2,074 patents have been issued. Chamberland, February 16, 1886, 336,385 and 336,386, disclose the use of the Pasteur filtering material. This is a germ-proof filtering element, devised for the purpose of applying to the purification of water the principles discovered by Pasteur's researches respecting microbes. Patent to Stockheim, February 21, 1888, 378,379, shows means for the filtration of an aerated liquid, such as beer, under back pressure, for the purpose of retaining the gas in the liquid while removing sediment, with air traps for the escape of waste air or gas in transit.

There is a particular movement in the direction of systemal organization, especially in the purification of sewage. The essence of the septic treatment of sewage is the passage of the sewage through beds, in which the growth of the bacterial organisms which cause decay of organic matter is encouraged to the maximum, whereby the process of decay is accelerated and completed, the effluent being pure and inoffensive. The problem now is the proper management of such beds and of ordinary filter beds, upon a large scale, with suitable intervals of activity and rest when required. See, for example, Ridgway, 625,605, May 23, 1899.

Fire Extinguishers.—A general effort is manifest in improvements in pressure-controlled main valves for admitting water to stationary dry pipe systems upon the occurrence of a fire, with preference for mechanisms actuated by fluid pressure. See Derby, 647,810, April 17, 1900. A more particular movement, which began within the last few years, is in valves constructed to prevent the evil effects of "columning," i. e., the accidental closing of the valve after a column of water has accumulated in the delivery pipes. See Gray & Cox, 626,654, June 6, 1899.

Another movement is in the direction of applying a fire-extinguishing gas, such as sulphur dioxide, to a fire occurring within a more or less closely confined space. See Clayton, 633,807, September 26, 1899, and 661,496 and 661,497, November 13, 1900; and Febiger, 649,924, May 22, 1900.

Fluid-pressure Regulators.—Three patents cover the more important lines of invention of late years. Considerable attention has been given to that class of regulator in which the main valve is actuated by a piston or its equivalent, the fluid pressure to operate the piston being controlled by an auxiliary valve. Metzger, 648,592, May 1, 1900, shows one of the most recent forms of this type of valve. The only provision for the escape of the fluid from behind the actuating piston is to make the piston fit loosely enough in its cylinder so that the fluid may leak by. Waring, 664,515, December 25, 1900, shows a valve of this description in which special provision is made for exhausting the fluid from behind the actuating piston, without depending upon leakage by the piston. Baylis, 646,064, March 27, 1900, is of interest because it involves a radical departure from the usual regulating valve. It makes use of a construction working on the principle of the injector, by which the valve is not permitted to close immediately on an inflow of fluid from the inlet to the outlet side of the device. On the contrary, the valve is at first opened still wider under such conditions, in order that the pressure on the outlet side may have time to "build up," as expressed by the inventor.

Hydraulic Motors.—In this class 3,030 patents have been issued. Patent to Baldwin, April 9, 1878, 202,215, is the first patent on a circulating system. In this system the piston which operates the cage is driven in one direction by liquid introduced into the cylinder from the source of pressure, and is moved in the opposite direction by the weight of the cage, the liquid in advance of it being circulated or returned to the opposite side of the cylinder, the valve opening communication between the two ends of the cylinder at that time. Patent to Moore, December 30, 1884, 309,865, shows the first auxiliary or pilot valve applied to a hydraulic motor. Patent to Reynolds, March 31, 1885, 314,720, shows the first application of the pilot valve to a hydraulic elevator. In these devices the pilot valve is operated by the person in charge, and pressure is thus applied to the main valve. Patent to Reynolds, October 20, 1885, 328,614, shows, among other features, the first automatic safety valve in a hydraulic elevator, the operation of which is to stop the motor automatically as the cage reaches either end of its travel.

Westinghouse, 595,027, December 7, 1897, connects a rotary pump with the two ends of the power cylinder and simply pumps the water from one end of the cylinder to the other to impart movement to the piston, the pump being of the type in which paddles work in a cylinder, the eccentricity of which with reference to the shaft of the pump can be changed to vary the direction of the water being pumped, the elevator in this case being controlled by shifting the cylinder in question either by hand or by electrical devices.

Herdman, 623,152, April 18, 1899, relates to elevators in which the weighted plunger in a hydraulic cylinder is depended upon to raise the car, the plunger being elevated when the car is to descend, and he controls the movements of the main valve automatically to admit or to exhaust the motive fluid in direct proportion to the load in the elevator car.

In the class of presses may be mentioned the patents to Parfitt, 579,441, March 23, 1897; Winans, 582,839, May 18, 1897; Graves, 565,111, August 4, 1896; and Sellers & Lewis, 642,009, January 23, 1900. The first two relate to riveting machines, and employ compressed air or steam together with a constant body of a liquid, like oil or water, and each providing for an initial pressure upon the rivet, and a second or finishing pressure. In both patents the initial pressure is attained by compressing the diaphragm or a relatively large piston upon or into the body of liquid, and the heavy or finishing pressure by directing the stream of steam or compressed air upon a second piston having a relatively small piston rod which is forced into the same body of liquid to effect the desired pressure. In Graves's is a hydraulic brick machine of the type in which there are two opposing hydraulic cylinders and plungers, the latter being provided with drawback pistons under constant pressure. In this patent the liquid is put under pressure by a single low-pressure pump in constant communication with the drawback cylinders and with the main cylinders through a system of valves. The system is also provided with a high-pressure device. The preliminary movements of the plungers and the initial pressing of the clay are effected by the low-pressure pump, and upon the pressure rising to a certain point, the high-pressure device automatically completes the pressure of the material. The patent to Sellers & Lewis presents a forging press, the movements of which are automatic and produced by water under pressure of continuously running pumps, and controlled by automatic valves between the same and the press.

In the class of reciprocating motors may be mentioned the patents to Cowles, 608,838, August 9, 1898, and 631,698, August 22, 1899, together with Stumpf, 643,831, February 20, 1900. The two patents to Cowles disclose systems for operating simultaneously or separately bulkhead doors, hatches, etc., on board ship. Each bulkhead door is carried by a cylinder mounted upon a stationary piston head and rod, all the motors being connected by piping to a steam accumulator or like source of pressure, the system as a whole being controlled by a single valve and each door or like device having also its individual valve. The later patent has provision for an ordinary and an emergency pressure. The patent to Stumpf presents a motor driven by water under pressure and adapted to be connected to a pump located in the bottom of a mine, the motive fluid coming from a force pump at the surface.

In the class of rotary motors may be mentioned the patents to Hall, 626,996, June 13, 1899, and Dyer, 639,541, December 19, 1899, which relate to mechanism for use in automobiles and embody the usual explosive or other engine running continuously, a pump connected thereto, and a motor connected to the driving axle, the pump continuously forcing the column of liquid through the motor, but provision being made for controlling the output of the pump in such a manner as to control the vehicle.

Patent to Pelton, October 26, 1880, 233,692, shows the first so-called "hurdy-gurdy" water wheel, a very simple machine, consisting of a wheel with cup-shaped buckets, into which a jet of water is directed. In Doble, 633,184, September 19, 1899, is illustrated an improved type of bucket for Pelton wheels.

In the class of turbines may be mentioned the two patents to Rice, 620,964 and 621,141, March 14, 1899. One of the objects of modern turbine installation is to combine a plurality of wheels so as best to obtain the power and speed necessary for driving dynamos.

Pumps.—In this class 5,046 patents have been issued. Patent to Worthington, September 25, 1894, 526,429, shows the gradual closing of the pump valves at the end of the stroke of the plunger. This feature enables a pump to be driven by a direct-acting steam engine with an increased velocity, and also avoids wear and tear upon the valves by slamming. A very general movement is in the direction of economy of power, space, and weight of material in high-duty pumps, great quantities of water being pumped by relatively small machines running at high velocity. As examples of high-duty direct-acting steam pumps, see Worthington, 607,902, July 26, 1898, and 657,976, September 18, 1900. As examples of types adapted for deep-well pumping, see O'Neil, 602,869, April 26, 1898; Horsley, 663,029, December 4, 1900; and Rigby, 687,067, November 19, 1901.

In this class also the tendency to actuate and govern moving parts by fluid pressure is discernible. Examples are the patents to Worthington above cited.

See also patents to Frizell, October 19, 1880, 233,499, and J. G. Pohle, December 6, 1892, 487,639. The first is probably unimportant except as it discloses a principle contained in the second, which marks the beginning of an extended application of compressed air for raising water by the introduction of air into the rising column of water to lessen its weight. Activity has continued in the development of machines for elevating liquid by compressed air, acting, in one type, by pressure upon the surface of a body of liquid (see Merrill, 609,943, August 30, 1898, and Conrader, 657,917, September 18, 1900, and 664,723, December 25, 1900), in another type by aerating and thus reducing the specific gravity of the rising column. See Young & Shaw, 592,037, October 19, 1897.

As an example of the present development of centrifugal pumps, see Marburg, jr., 647,856, April 17, 1900.

The development of rotary pumps with intermeshing runners is illustrated in Enyart, 647,951, April 24, 1900.

Water Distribution.—This class is to a considerable extent composed of inventions of devices that are employed as elements in hydraulic or analogous machines and systems. The effort for structural perfection is conspicuous. A particular direction in which such perfection is sought is in valves, as, for example, in the following cases: McLeod, 617,118, January 3, 1899; O'Meara, 594,895, December 7, 1897; Bunting, 556,133, March 10, 1896; Geurink, 646,979, April 10, 1900; Heston, 560,993, May 26, 1896; Glauber, 615,546, December 6, 1898; and Hoxie, 604,617, May 24, 1898.

Patent to Pollock, December 20, 1892, 488,220, shows a ball nozzle. This is an exceedingly simple device, in which the ball, rotated by the issuing water, remains in the mouth of a flaring nozzle and distributes the stream. There have been 429 patents issued in the subclass of nozzles.

Another particular direction which the effort for perfection has taken is in devices for detachably coupling pipes in various situations. There have been 1,924 patents granted for such devices. Many are excellent, but apparently the preeminently satisfactory couplings have not yet been found, unless it be in train-pipe service. Patent to Westinghouse, April 15, 1879, 214,334, shows a pipe coupling between cars which is automatically uncoupled upon the separation of the cars while in motion, by accident or otherwise. Patent to Sewall, May 24, 1887, 363,553, has the same function.

TRANSPORTATION.

Bicycles.—In this class, including polycycles and unicycles, 5,668 patents have been issued. The patent to Hood, 537,462, April 16, 1895, shows a handle bar which can be adjusted to any height. The patent to Metz, 546,071, September 10, 1895, covers a form of pedal. The patent to Copeland, 529,110, November 13, 1894, covers a crank-shaft fastening designed to dispense with the keys which had heretofore been used for connecting the cranks with the crank shaft. The patent to Shire, 216,231, June 3, 1879, shows the first hammock saddle, a form which was exclusively used for many years. The patent to Sawyer, 222,537, December 9, 1879, shows what is probably the earliest use of a changeable speed gearing in a velocipede. The patent to Pressey, 233,640, October 26, 1880, shows the original Star machine. The patent to Latta, 360,101, March 29, 1887, shows the first drop-frame machine for the use of women. The patent to Smith, 403,153, May 14, 1889, shows the first convertible machine, which by the removal of the upper bar of the frame can be adapted to the use of women. The patent to Lawson, 345,851, July 20, 1886, contains claims to the modern form of rear-driven safety machine.

Several features mark the advance in bicycle structures within the last five years of the nineteenth century. These are all material improvements, and among them may be mentioned the tubular clamping device for saddle posts and handle bars, the adjustable handle bar, the rotating side shaft of the so-called chainless wheel, and the back-pedaling brake. An example of the tubular clamp is shown in patent to White, 602,149, April 12, 1898. By means of the distortion of a certain screw a wedging action is given to the parts and they are very firmly bound together. Another good example is found in Gulick, 579,265, March 3, 1897. The patent to Phipps, 639,765, December 26, 1899, has handle bars independently adjustable, a very common type in bicycles nowadays. Also see Kelly, 622,490, April 4, 1899, and Gaylor, 624,643, May 9, 1899. These are all of a type, differing only in details.

The patent to Richards, 560,647, May 26, 1896, discloses a bicycle provided with a rotating side shaft supported in a casing which forms a part of the frame of the bicycle. This is an improvement upon the early invention. Other patents to Richards are 562,662, June 2, 1896, and 568,581, September 29, 1896, relating to the same subject-matter in general, the latter being intended to alter the speed of the pedal at various periods in its rotation. Jocelyn, 620,929, March 14, 1899, provides a support for the gearing of a bicycle and its independent adjustment, and two speeds may be obtained by means of a double set of gearing and shifting one or the other in the position desired.

The type of back-pedaling brake in which the braking surface is contained in or made a part of the hub has been much improved during the last half decade. Patents to Morrow, 646,302, 646,303, and 646,304, March 27, 1900, are good examples. In each of them two rotary surfaces with inclined parts are made to separate either axially or radially, as the case may be, when back pressure is applied on the pedal. This separation is made to effect pressure upon appropriate braking surfaces.

Advancement in bicycle construction has consisted largely in simplifying the manufacture of the more complicated parts and in reducing the weight, as shown in patents for crank hangers, 581,907, Forg, May 4, 1897, and 619,550, Fauber, February 14, 1899. The former is made of a seamless drawn-metal tube, bosses for attachment to the other parts of the frame being made by forcing dies through the tube from the inside. The latter consists of a crank hanger and rear fork made in two sections of sheet metal, given their form by means of drawing and swaging dies, and permanently joined by brazing.

Motor cycles or bicycles are attracting considerable attention, and about 50 patents have been granted on this style of vehicle, of which the following are characteristic: Libbey, June 1, 1897, 583,809; Pennington, June 6, 1899, 626,295; Halley, March 26, 1901, 670,590; and Keating, June 4, 1901, 675,393.

Brakes, Electric.—In this subclass 222 patents have been granted. Electric brakes for electric street rail-

ways in which the electric motor is by a movement of the controller instantly transformed into a generator, which may of itself act as a brake, or the generated current may be utilized to apply a brake, are shown in patents to Potter, 546,247, September 10, 1895, and to Case, 548,952, October 29, 1895.

In that type of electric railway brake in which the motor is made to act as a generator and the current therefrom actuates a braking device, a storage battery has been supplied which is automatically thrown into the braking circuit when the motor has slowed up so that the generated current is comparatively small. See patents 571,409, Sperry, November 17, 1896, and 574,120, Sperry, December 29, 1896. Rail brakes applied to trucks which also carry wheel brakes exert a lifting tendency on the truck, and lessen the tractive effect of the wheel on the rail, so that the wheel brakes must be applied more lightly. By the use of an electromagnetic brake shoe, a pull from the truck to the rail is possible. See patent 616,956, Newell, January 3, 1899; reissue 11,786.

An interlocking of motor-reversing and brake-controlling switches is shown in patent 560,751, Potter, May 26, 1896, so that improper movements of the switches can not be made.

An electric brake for automobiles, in which the driven wheels and also the steering wheels are each provided with brakes, is embraced in patent 645,903, Sperry, March 20, 1900.

Brakes, Railway.—In this class 3,998 patents have been granted. In an automatic air-brake system the essential features are an air pump, a main reservoir, and engineer's valve, all on the locomotive; an auxiliary reservoir; a triple valve and a brake cylinder upon each car; a train pipe extending from the engineer's valve throughout the length of the train and adapted, through the means of the triple valve, to be thrown into communication with the auxiliary reservoir or brake cylinder, the triple valve being controlled by the engineer's valve through the variation of pressure of the air in the train pipe. See patent to Westinghouse, 168,359, October 5, 1875, for an illustration of this. Patent to Westinghouse, 360,070, March 29, 1887, exhibits the triple-valve feature.

Where two or more locomotives are connected together to haul a train, the control of the air-brake system is with the engineer of the head locomotive, and the brake-controlling apparatus of the second locomotive is cut out. Patents 632,093, Brown, August 29, 1899, and 641,576, Buckalew, January 16, 1900, show devices for effecting a greater cooperation of the air-brake mechanisms of locomotives when "double heading."

The ordinary cast-iron brake shoe wears out rapidly, and when partially worn out it is liable to break. To lessen the wear the use of relatively soft and hard metal surfaces has been resorted to. In one type of shoe a metal insert is secured in the face of the shoe by casting, as shown in patents 568,226, Applegate, September 22, 1896, and 624,262, Streeter, May 2, 1899. The liability to breakage has been lessened by casting the shoe with a wrought-iron back, as in patents 595,588, Streeter, December 14, 1897, and 642,318, Gallagher, January 30, 1900. A shoe face formed of metal of different degrees of hardness is produced by casting the shoe with ductile metal netting therein, as shown in patents 587,493, Sargent, August 3, 1897, and 642,295, Cardwell, January 30, 1900. To trim or grind the wheel tread surfaces, abrading brake shoes are temporarily used on the trucks. See patents 580,920, Babcock, April 20, 1897, and 605,056, Hoffman, May 31, 1898.

Cars, Buffers, Couplings, etc.—In patent 628,575, Canda, July 11, 1899, is shown the most advanced type of wooden car frame, which with the same factor of safety must yield the palm to the steel car for low rate of ratio of the dead to the live road. As an example of a steel box car, see patent 647,927, Schoen & Hansen, April 17, 1900.

Steel hopper-bottom cars are shown in patents 571,882, Pennock, November 24, 1896, and 584,709, Schoen, June 15, 1897, and a later development will be seen in patent 658,783, King, October 2, 1900. The bulk of the steel car building up to the present time has been of cars of the hopper-bottom and gondola types.

A car for street-railway service, convertible into an open car or a closed car, is shown in patent 623,764, Brill, April 25, 1899.

With the very high pressures used in air-storage motor cars, the problem of charging the car or locomotive reservoir from the stationary plant presents some difficulties. Such charging devices are shown in patents 577,024, Hardie, February 16, 1897, and 580,827, Hardie, April 3, 1897.

Dumping cars wherein the unloading of each car is accomplished by a train pipe and compressed-air motor controlled from the locomotive are shown in patents to Thayer, 404,447, June 4, 1889, and to Duff, 409,394, August 20, 1889.

Fluid-pressure car buffers, in which a constant supply of fluid under pressure is provided by a pump or train pipe, whereby the pressure against the buffers may be maintained as required, are shown in patents to Balderston, 287,084, October 23, 1883, and to Leonard, 543,030, July 23, 1895. Vestibule trains, in which the cars are connected to one another by inclosed passages, which at their meeting ends are provided with yieldingly supported door-like frames engaging one another by frictional contact, usually, whereby end rocking of cars is prevented in starting and stopping the train, and while running the lateral oscillation of the cars is reduced to a minimum, are shown in patents to Sessions, 373,098, November 15, 1887, and to Pullman, 403,137, May 14, 1889. Car frames in which the trussed structure is built up of rolled-steel plates, angles, and channels,

whereby a car body of great resistance to telescoping or crushing is obtained in case of collision or derailment, are shown in patents to Bissell, 457,486, August 11, 1891, and to Jewett, 512,960, January 16, 1894.

A train made up of steel cars, of 50 tons capacity each, sets up such enormous draft and buffing strains that old forms of drawbars with coil springs for resisting elements are not entirely satisfactory. Friction drawbars are coming into use, in which the action of the springs is supplemented by friction-producing parts. See patent 649,187, Westinghouse, May 8, 1900.

In the class of car couplings 6,611 patents have been granted. An automatic car coupler of the vertical-plane type, in which there are means for automatically throwing and holding the knuckle in open position after the locking device has been withdrawn, obviates the necessity of the entrance of the railway employee between the cars. See patent to Browning, 254,106, February 28, 1882.

Street-car trucks consisting of a rigid frame independent of the car body and adapted to support the car motor are shown in patent to Brill, 430,418, June 17, 1890. Another development in the street-car truck is of the bogie type, which is also adapted to support the motor. See patent to McGuire and Hubbard, 531,208, December 18, 1894. Metallic car trucks made of common rolled-steel sections or of pressed sheet-steel plates are shown in patents to Voss, 431,089, July 1, 1890, and to Fox, 505,159, September 19, 1893.

For suburban electric railway service the long car body with a swiveled truck under each end is the favorite. Motor trucks with spring-supported equalizer bars on each side, as shown in patent 610,118, Brill & Curwen, August 30, 1898, have come into considerable use.

Elliptic springs are deemed preferable to coil springs where abruptness of action is to be avoided. Coil springs, however, are cheaper than elliptic springs of the same capacity. Friction attachments to a coil spring to dampen its effect so as to approximate the action of an elliptic spring has proven successful. See patent 629,109, McCord, July 19, 1899.

Cable Transportation.—In the line of trolley transportation of excavated materials—earth, coal, or ore—by overhead cable or way, improvements have been made, patents 228,980, June 22, 1880, 268,181, November 28, 1882, and 282,163, July 31, 1883, to Carson; 281,446, July 17, 1883, 300,689 and 300,690, June 17, 1884, 302,706, July 29, 1884, and 382,946, May 15, 1888, to Brown; 434,550, August 19, 1890, 447,892, March 10, 1891, 458,183, August 25, 1891, 474,047, May 3, 1892, and 496,203, April 25, 1893, to Miller; 516,084, March 6, 1894, to Delaney; and 545,807, September 3, 1895, to Miller, being examples of this.

Coaling Steamers.—Patents 516,053, March 6, 1894, to Hulett; 527,117, 527,118, and 527,119, October 9, 1894, to Long; and 536,209, March 26, 1895, and 545,293, August 27, 1895, to Hulett, show means for discharging coal into vessels.

Handling Hay.—Patents 254,691, March 7, 1882, 423,274, March 11, 1890, 497,207, May 9, 1893, 518,895, April 24, 1894, and 535,725, March 12, 1895, to Porter; 337,173, March 2, 1886, 472,175, April 5, 1892, 515,296, February 20, 1894, 526,839, October 2, 1894, and 530,232, December 4, 1894, to Louden, show means for unloading hay.

Motor Vehicles.—In this subclass 513 patents have been issued. A line of invention in which much interest has been taken by the general public of late is the class of motor vehicles or automobile wagons. This is not strictly a new art, but rather the revival and carrying forward of old ideas, and the adaptation of modern devices, such as electric motors and gasoline engines, to vehicles for the purpose of self-propulsion. The steam engine, while adapted for traction engines or vehicles intended to draw other vehicles with heavy loads like thrashers, sawmills, and freight wagons, is not suitable for light passenger vehicles. The Benz motor was patented in the form adapted for use on a vehicle of this kind July 31, 1888, 386,798. The patent of Daimler, January 17, 1888, 376,638, shows a motor for this purpose. Duryea, in 540,648, June 11, 1895, exhibits a device for this purpose.

Grouping the late improvements in motor vehicles (under carriages and wagons) in reference to the motive power employed, the leading types are as follows:

Electric: Morris & Salom, March 30, 1897, 579,890; Maxim, November 30, 1897, 594,805; Woods, June 29, 1897, 585,371; Knudsen, November 1, 1898, 613,420; Hunter, July 18, 1899, 629,079; Riker, November 13, 1900, 661,553; and Sperry, February 13, 1900, 643,258.

Gas engines: Winton, September 6, 1898, 610,466; Muller, May 11, 1897, 582,539; Baker, May 25, 1897, 583,018; Duryea, June 22, 1897, 585,159; Olds, November 23, 1897, 594,338; Lewis, May 17, 1898, 604,332; Maxim, Pope & Alden, March 21, 1899, 621,532; and Grant, December 5, 1899, 638,331.

Steam propelled: Overman & Bullard, April 24, 1900, 648,286; Whitney, July 3, 1900, 652,941; Stanley, September 11, 1900, 657,711; and Gibson, August 28, 1900, 656,962.

A distinct type of heavy dray wagons for handling bulky goods is found in the patents of Bullard, January 23, 1900, 641,834; Thorneycroft, November 20, 1900, 662,206; and Herschmann, December 4, 1900, 663,028.

Hunter patented May 30, 1899, 625,953, a device in which all the propelling apparatus was mounted upon a truck which could be substituted for the fore truck of any vehicle; and Zimmerman took patent 628,514, July 11, 1899, for a device of analogous character, which could be clamped to the rear axle of a carriage to serve as a pusher.

In electric automobiles several patents have been granted for the direct combination of the propelling

motors with the wheels, as in Newman and Ledwinka, 638,643, December 5, 1899, and Whittlesey, 643,854, February 20, 1900.

On account of the short range of electric automobiles, it has been proposed to employ upon the vehicle an explosion engine and a generator of electricity which may be used to charge a storage battery. The generator may be reversible and used as a motor to drive the vehicle. Monson, 654,478, July 24, 1900, and 653,199, July 3, 1900, show this feature.

Separate motors for the driving wheels, for ease in turning, are found in Morris and Salome, 578,651, March 9, 1897. From this the use of the motors for steering followed quite naturally, and this is found in Krieger, 607,997, July 26, 1898, reissued 11,780, October 31, 1899.

Accidents resulting from the fall of the operator from his seat are averted by provisions for stopping the vehicle instantly in such an event. This is represented by Kitsee, 676,263, June 11, 1901, and Stevens, 680,444, August 13, 1901. There were 22 interfering applications filed for this idea.

Pneumatic Tires.—In this subclass 1,000 patents have been granted. The invention of pneumatic tires was revived in the year 1889 and brought into use in connection with bicycles, and since that time in connection with sulkies and other light vehicles. March 12, 1889, 9 patents were granted to Thomas for pneumatic tires, said patents being numbered 399,354 to 399,362, inclusive. Patents to Dunlop, September 9, 1890, 435,995, and June 2, 1891, 453,550, embody forms of pneumatic tires, and said tires have been extensively manufactured and used. The following are regarded as some of the more important patents in this line: Patent of Gray, May 26, 1891, 452,876, for a self-healing tire, as an air-cushioned tire with a lining of plastic rubber, which provides for the closing up of holes made in the air cells of the tire. Patent of Jeffery, June 16, 1891, 454,115, covers an outer shoe or cover provided with hooked edges to engage the rim of the wheel. Patent of Bartlett, March 24, 1891, 448,793, covers what is known to the trade as the clincher tire. The shoe is held to the rim by the inwardly inclined flanges thereof. Patent of Schrader, January 5, 1892, 466,577, covers a shoe held to the rim by an adjustable clamping bend. Patent to Garford, January 19, 1892, 467,164, covers a tire with multiple air cells, so that in case one of said cells becomes punctured the others may be further inflated so as to supply the loss of air caused by the deflation of the punctured cell. Patent of Palmer, June 7, 1892, 476,680, covers a self-healing tire in which the tread portion of the rubber is placed under compression, so that any puncture therein will tend to close up rather than to gape open. Patent of Brown & Stillman, December 20, 1892, 488,494, covers a tire shoe or cover having nonstretching edges, which are held in the concaved rim by the inflation of the inner air tube. Patent of Palmer, January 10, 1893, 489,714, covers a tire made from a fabric in which there are separate parallel threads, each embedded in rubber. Patent of Huss, April 25, 1893, 495,975, covers a tire having its tread portion reenforced by a spiral winding of thread or threads. Patent of Tillinghast, 497,971, May 23, 1893, covers a single-tube tire in which the ends are united and vulcanized together, so as to form a homogeneous endless tube. Patent of Morgan & Wright, April 25, 1893, 496,321, covers a mandrel for forming an endless tubular sheath. Patent of Moomy, January 30, 1894, 513,617, covers a method of securing the shoe to the rim by a winding of cord.

Patent was granted to Sterling Elliott, March 21, 1893, 494,113, for a trotting sulky provided with low pneumatic wheels. The performance with this vehicle lowered the record for trotting horses by some five seconds.

Patent to Grant, 554,675, is typical of the cushion type of tire. Although but a slight advance over the prior art, yet it seemed to combine simplicity and attractive design and went into immediate use in great numbers and led to many infringement suits. Patents to Kempshall, 639,399 and 639,400, are examples of adaptation of pneumatic tires to heavy motor vehicles.

Traction Engines.—Patent of Frick, May 23, 1882, 258,401, shows the use of a spring link between the power and the drive or traction wheel to prevent too sudden a start and permit a yielding motion. Fairchild, in patent of August 3, 1880, 230,762, shows a change of speed gear. Helphinstine, in patent of June 7, 1887, 364,411, shows a steering device by which the power of the engine can be used to steer it. Patent of Heggem, April 2, 1889, 400,846, shows a convenient application of a brake. Two hundred and forty-four patents have been issued in this subclass.

FLUID-EXPANSION DEVICES.

Under this heading are included air and gas engines and pumps; ordnance, arms and explosives, refrigeration; steam engines, stoves and furnaces, in which the expansive force of heated fluids are used to convey heat or to overcome resistance.

AIR AND GAS ENGINES AND PUMPS.

Engines.—In this class 2,268 patents have been issued. Lenoir's engine, patented March 19, 1861, 31,722, showed the possibilities of using fuel directly in the engine. In 1874 Brayton received a patent dated June 2, 151,468, for a petroleum-gas engine which was quite efficient in the use of fuel, but its gas-burning grate required frequent renewal and gave trouble; and it was not until August 14, 1877, when Otto received a patent, 194,047, for an engine which operated upon a new and efficient cycle, that the gas engine became an active competitor of the steam engine, especially where small power is required. Since then nearly all gas-engine

patents relate to improvement in the details of the original type of Otto engine. In 1879 Daimler received a patent, December 9, 222,467, for the first compound gas engine. Wiegand, April 22, 1884, obtained patent 297,329, for a compression gas engine giving a power stroke at each revolution and greatly increasing the available expansion of the burning fuel; Atkinson's, February 16, 1886, 336,505, and Von Martini's, 358,796, March 1, 1887, were for engines using a modified Otto cycle, the mechanism being such as to result in a large increase in the available expansion and efficiency of the burning fuel. Regan, June 16, 1885, 320,285, introduced the spring-steel electric igniter, operated by a finger on the piston. Patent to Nash, July 17, 1888, 386,211, was for an engine in which the piston controlled the inlet and exhaust ports, thus reducing the number of valves necessary. Selden, in 1895, received a patent November 5, 549,160, which may be considered the pioneer invention in the application of the compression gas engine to road or horseless-carriage use.

Of the later patents among the most important, so far as theoretical efficiency is concerned, are the patents to Diesel, 608,845, August 9, 1898, and 654,140, July 24, 1900, for improvements upon his original invention patented July 16, 1895, 542,846. Among patents covering constructions which have gone into most extensive and general use, or which either by themselves or in connection with prior patents have become the basis of large manufacture and sale of stationary engines, automobiles, or launches, and generally under the names of the patentees, are those to De Dion & Bouton, 593,877, November 16, 1897, for a sparking igniter; Westinghouse & Ruud, 583,584, 583,585, 583,586, June 1, 1897, for charge-feeding, speed-regulating, and igniting mechanisms; Tuttle, 604,241, May 17, 1898, and 649,778, May 15, 1900; Weiss, 592,033 and 592,034, October 19, 1897; Priestman, 552,718, January 7, 1896; Sintz, 539,710, May 21, 1895; Charter, 573,762, December 22, 1896; Truscott, 617,372, January 10, 1899; Winton, 626,121, May 30, 1899, 636,606, November 7, 1899, 610,465, September 6, 1898, 635,218, October 17, 1899; Olds and Hough, 655,172, July 31, 1900.

In the subclass of explosive air and gas engines 1,513 patents have been issued, of which 710 were taken out in the five years 1896–1900.

Pumps.—In this art 2,311 patents have been issued. This includes pumps for gas as well as for air. The former are mainly used in refrigerating machines, and the chief improvements since 1870 adapting them for that purpose have been those of Boyle, 175,020, March 21, 1876, and Ballantine, 191,638, June 5, 1877, in which the cooling effect still remaining in the spent gas returning from the refrigerating coils is utilized to remove the heat of compression. In air pumps proper, Allen, in 1884, obtained patent 299,314, May 27, for what is known as the straight-line compressor, and in 1889 Popp, 405,971, June 25, patented a distribution system for compressed air.

The chief progress in later years has been in the matter of controlling the compressor so as to "unload" the same at a predetermined maximum pressure. Among patents covering these general features are those to Rix, 640,949, January 9, 1900, and De Laval & Aborn, 664,563, December 25, 1900. Mention may also be made of the patent to Parsons, 613,775, November 8, 1898, for a screw fan to be driven by the well-known steam turbine of the same inventor.

ORDNANCE, ARMS, EXPLOSIVES.

Breech-loading Mechanism.—In this art 278 patents have been issued. An important improvement in breechblocks is operated by a single movement of lever to open or close the breech, the expended shell being expelled by the same mechanism. Driggs and Schroeder, 378,828, February 28, 1888; Nordenfelt, 384,537, June 12, 1888; Seabury, 425,584, April 15, 1890; Dashiell, 468,331, February 9, 1892; Fletcher, 541,042, June 11, 1895. The art has advanced noticeably by avoiding the former necessity of cutting away 50 per cent of the thread of the breech closure. In patents to Haeseler, 637,110, November 14, 1899, and Meigs & Hammar, 648,767, May 1, 1900, the entire thread is retained, thus reducing the weight and length of the breechblock without weakening the breech closure. It is now proposed to make heavy ordnance purely automatic, whereas heretofore such guns have rarely been larger than 6-pounder. See Maxim, 593,227 and 593,228, November 9, 1897, and Dawson & Silverman, 644,969, March 6, 1900.

The old favorite Hotchkiss type of gun has been made semiautomatic by a simple attachment (see Benét & Mercié, 649,393, May 8, 1900), and the same has been done for the Krupp system of sliding wedge block (see Pohlit, 661,550, November 13, 1900).

Formerly the firing mechanism was automatically cocked by opening the breech, and hence it was necessary to reopen the breech to recock in case of failure to fire, which operation would be disastrous in case of hang fire. It is now proposed to use a firing lever, a pull of which first arms the main spring, then releases the firing pin or hammer, and on release automatically reengages for another pull without disturbing the breech mechanism. See Ternstrom, 617,614, January 10, 1899.

Compressed-air Ordnance.—In this art 70 patents have been issued. Among the earliest patents in this line of invention are the patents to Bartlett, 294,349 to 294,352, of March 4, 1884.

The patents in this class issued since 1895 show that the pneumatic gun has been superseded owing to the development of high explosives for charging shells which are insensitive to the shock of gun discharge.

Gas Checks.—Valuable improvements have been made in gas checks for ordnance, whereby the full force of the powder is directed against the base of the projectile, and such devices are obtained by placing an annular

canvas sack containing asbestus and tallow between the front face of the breechblock and a mushroom-shaped piece against which the gases of explosion impinge: De Bange, 301,220, July 1, 1884; Gerdom, 539,733, May 21, 1895, and Schneider, 427,370, May 6, 1890.

Ring sabots for projectiles to prevent erosion of the gun by the hot gases are illustrated by patents to Nobel, 563,609, July 7, 1896, and Maxim, 662,798, November 27, 1900.

Gun Mounts and Attachments.—In addition to the improvements in heavy ordnance, wherein the improvement lay in the specific construction of the gun itself, its means of loading and firing the projectile, and in the particular manner of operating its breechblock, an advance has been made in the manner of handling the gun itself, whether to train it on its support, or to elevate or depress it, as occasion might require, or to take up its recoil on firing. Some of these instrumentalities apply merely to the recoil of the gun, which is taken up by springs, or by pneumatic or hydraulic cylinders; and while these devices have proved effective as far as that function alone is concerned, an additional feature has been provided, by which the guns on their recoil are caused to travel in an arc of a circle and to disappear behind embrasures or to be lowered into a pit. This movement is accomplished by various systems of combined springs and pneumatic or hydraulic cylinders, and by the application of these forces this power is utilized not only to take up the recoil of the gun, but to assist its movement into battery when it has been reloaded and is again ready for firing. These appliances are considered of great value in gunnery where heavy ordnance is used, and these various mechanisms have rendered it possible and practicable for one man to operate very heavy weights with ease and facility: Powlett, 339,466, April 6, 1886; Hoyle, 381,979, May 1, 1888; Anderson, 424,448, April 1, 1890; and Gordon, 497,977, May 23, 1893.

Tower, 640,051, December 26, 1899, shows a remarkable attempt to automatically maintain a gun in an absolute position, regardless of the rolling of the gun platform in a seaway. Roscusvard & Telander, 684,105, October 8, 1901, shows a device for imitating the rolling and pitching of a naval gun platform for the practice of seamen gunners in port or ashore. Dashiell, 573,210, December 15, 1896, shows an approved form of naval mount. Benét, 615,522, December 6, 1898, shows a readily segregable field mount for naval landing parties. Bevans, 605,376, June 7, 1898, shows a field mount with a rotary fluid recoil check as less cumbersome than the ordinary reciprocating one. Buffington & Crozier, 555,426, February 25, 1896; Howell, 556,926, March 24, 1896; Dawson, 605,459, June 7, 1898; Crozier, 613,252, November 1, 1898; Borger, 632,634, September 5, 1899; and Krone, 641,872, January 23, 1900, show the trend of development in mounts for disappearing guns. Meigs & Stout, 632,134, August 29, 1899, show the recoil fluid applied directly to operate the breech mechanism, and Krone, 664,089, December 18, 1900, shows the latest form of fluid recoil check and reciprocator.

Considerable attention has been given to ammunition hoists. See Dawson & Buckham, 633,816, September 26, 1899; Dawson & Horne, 653,071, July 3, 1900, and 658,244, September 18, 1900. Geared rammers appear to be superseding hydraulic ones. See Fenton, 627,404, June 20, 1899; Schoeller, 631,999, August 29, 1899, and 663,242, December 4, 1900; Dawson & Horne, 654,443, July 24, 1900, and 660,418, October 23, 1900.

Bevans, 642,670, February 6, 1900, shows a large graduation adjustment for telescopic sights dispensing with verniers; Korrodi, 661,269, November 6, 1900, shows a convenient device by which the angle of terrain is allowed for without the use of verniers, and Scott, 658,287, September 18, 1900, shows the latest improvement in automatic range-finding sights working on a vertical base line.

Firearms.—In this class 4,715 patents have been issued. There has been a generally decided advance in many important particulars during the last thirty years, involving greater power, greater rapidity of fire, a flatter trajectory, increased effective firing distance, greater penetration of bullet, decreased weight of gun, a smaller caliber, and a lighter projectile, the two latter features leaving the soldier much less encumbered on the march and enabling him to carry a greater number of cartridges. The devices for operating the firing of small arms have also taken a new departure in other essential particulars, in which breech mechanism is manipulated by the recoil of the gun against the shoulder to fire it, to expel the expended cartridge shell, to withdraw a fresh cartridge from the magazine in the gun, and to place it in position in the barrel of the gun for another discharge. This operation is automatically repeated until the last cartridge in the magazine is exhausted. The prominent patents representing this feature are: Fasoldt, 181,566, August 29, 1876; Maxim, 317,162, May 5, 1885; and Burgess, 520,752, May 29, 1894. Other novel means of firing small arms have been developed of late years, some of which consist in the use of the explosion of gas to operate the breech mechanism. Others are operated by an electric battery in the stock, the cartridge being exploded in closing the circuit by a pull on the trigger. Compressed air and also liquefied carbonic-acid gas have been utilized as a motive power to operate the breech mechanism of small arms. These different means are shown, respectively, in the patents of Pitcher, 433,420, July 29, 1890, and Browning, 544,661, August 20, 1895; Brown, 291,288, January 1, 1884; Frost, 319,898, June 9, 1885; Giffard, 136,315, February 25, 1873, and 452,882, May 26, 1891. Also other novelties have been patented in firearms which involve means for discharging in alternative succession the two barrels of a double-barreled fowling piece by a single trigger: Heuser, 191,341, May 29, 1877; Wesson, 243,183, June 21, 1881; Pupke, 409,704,

August 27, 1889; and Granger, reissue, 11,458, December 11, 1894.

The Krag-Jörgensen, 492,212, February 21, 1893, adopted by our Army, and Lee, 547,583, October 8, 1895, adopted by our Navy, are both magazine guns, although of different types and of different caliber.

While no broad distinctions may be drawn between the later patents, the following illustrate the lines on which inventions and improvements in this art have advanced:

Borchardt, 571,260, November 10, 1896; Ehbets, 570,388, October 27, 1896; Browning, 580,923, April 20, 1897; Ehbets, 580,935, April 20, 1897; Mannlicher, 581,295 and 581,296, April 27, 1897; Mauser, 584,479, June 15, 1897; Burgess, 589,120, August 31, 1897; Roth, 616,260, December 20, 1898; Roth & Krnka, 634,913, October 17, 1899; Von Zeke & Redl, 661,900, November 13, 1900; and Burgess, 663,955 and 663,956, December 18, 1900.

A great majority of these patents apply to small arms, to be manipulated by one hand, indicating an effort to devise an efficient substitute for the "revolver." Inventions in single-trigger mechanisms have been directed to overcoming the liability of firing the second barrel by the involuntary pull following the first discharge. Illustrations of the results of these efforts are shown in patents to Holland & Woodward, 608,046, July 26, 1898; Thorn, 602,610, April 19, 1898; and Lard, 630,061, August 1, 1899.

Convenient devices have been patented for use in connection with firearms, which consist in a clip or packet adapted to hold a few cartridges, and which may be inserted in the magazine of a gun, so that when the magazine is exhausted a fresh supply may be ready for use. These packs or clips are entire, and a number may be conveniently carried in the pockets. Bell, 223,100, December 30, 1879, and Krnka, 449,287, March 31, 1891, and incidentally shown in the Lee navy gun.

Explosives.—Six hundred and eighty-seven patents have been issued in this class, which has received two important additions, 363,887, Du Pont, May 31, 1887; 381,507, Olds, April 17, 1888. The first has been produced mostly for Government use, and especially for guns of large caliber. Smokeless powders have been patented as follows: Maxim, 430,212, June 17, 1890; 456,508, Nobel, July 21, 1891; and 489,684, Munroe, January 10, 1893, and have been adapted for firearms of both small and large caliber. Most of the smokeless powders contain nitrocellulose and nitroglycerin, or both, rendered plastic, coherent, homogeneous, and convertible into hard, horny rods, as disclosed in 538,618, Maxim, April 30, 1895, or into grains of free-running powder.

Most of the recent patents have been granted for improvements in the minutiæ of older processes. Du Pont, 648,147, has an ingenious method of removing the acid from gun cotton; Street, 598,618, has devised solutions of picric acid in oils; Stevens has a number of patents for incorporating neutralizing bodies in pyroxylin, of which 617,450 may be taken as an instance; Jones, 625,682, has improvements in the regulation of the rate of combustion of collodized pyroxylin; and Moffatt, 627,436, has improved the methods of making nitrostarch.

Devices for accelerating the projectile by successively igniting separate propelling charges have been entirely superseded by employing a single powder charge, so formed as to burn at a gradually accelerating rate. Smokeless powder lends itself readily to this purpose, and McGahie, 622,777, April 11, 1899, shows a powder rod longitudinally perforated in such a way that the burning surfaces gradually increase in extent, and all parts of the rod are simultaneously consumed. Gathmann, 650,567, October 30, 1900, shows the perforations vented at regular intervals.

Projectiles.—In this class as now organized 880 patents have been issued. Projectiles and shells for high explosives, adapted to be fired from ordinary powder guns, have shown a marked advance, various forms and appliances having been employed to overcome the danger of premature explosion due to the shock of concussion created by the change of a mass of powder from a solid or granulated condition to that of a gas for propelling the projectile from the gun. Other projectiles have been invented within a few years to cause them to penetrate, without fracture, armor plates of the most improved hardness and capacity of resistance, and from recent experiments it has been shown that armor plates constructed on the most advanced theories and what has been considered as representing the most impenetrable types have been successfully pierced by such projectiles. By these means shells carrying high explosives are rendered capable of penetrating armor plates and exploding after such penetration has taken place: Graydon, 382,224, May 1, 1888, and 382,228, May 1, 1888; Zalinski, 384,661, June 19, 1888, and 384,663, June 19, 1888; Emmens, 415,707, November 26, 1889; Justin, 424,482, April 1, 1890; Walker, 458,026, August 18, 1891; Berdan, 478,216, July 5, 1892; Winslow, 494,696, April 4, 1893; and Johnson, 541,280, June 18, 1895.

An attempt to prevent tumbling of the projectile by attaching a drag thereto is shown in Brown, 656,934, August 28, 1900. De Maré, 660,581, October 30, 1900, shows an armor-piercing shell in which the rear portion forms, as it were, a small gun to further assist the point, which is a smaller shell, to pierce the armor. An attempt to render dynamite nonsensitive to the shock of gun discharge by freezing it, and thus making it suitable for a bursting charge for shells, is shown in Bakewell, 572,401, December 1, 1896. The same result has been obtained without desensitizing the dynamite by dividing the shell into transverse chambers of a limited height. See Isham, 622,479, April 4, 1899.

A notable advance has been made in safety devices

for shell fuses. The detonator is contained in a relatively large chamber and separated from the bursting charge by a movable metal barrier. An accidental explosion of the detonator is thus rendered harmless, the barrier being removed only during the flight of the shell. See Gathmann, 583,042, May 25, 1897. Gathmann, 644,321, February 27, 1900, maintains the detonator external to the war nose of a torpedo and moves it into the war nose only during the travel of the torpedo.

REFRIGERATION.

In the entire class of refrigeration there have been 4,337 patents issued.

In that branch of the art of refrigeration which most exemplifies modern mechanical and scientific progress, viz., the artificial production of cold by means of volatile liquids, whether for the making of ice or for other purposes, there has been considerable progress since 1870 along the lines struck out by Carre's invention of the absorption ice machine. In 1871 Seely, in patent 119,795, October 10, substituted chloride of calcium for water as the absorbent, and also employed two stills, acting alternately as such and as absorbers. In 1872 Reece, in patent 131,783, October 1, employed the expanding gas returning from the refrigerator to drive the pumps. In 1881 Rankin, in patent 239,591, March 29; in 1886 Hendrick, in patent 336,235, February 16; in 1889 Perkins, in patent 399,207, March 5; and in 1892 Palson, in patent 482,694, September 13, made important improvements. In compression machines, of which Twining's invention, patented November 8, 1854, 10,221, is the prototype, even greater progress has been made, and this class of refrigerating machine bids fair to completely displace the absorption type. In 1872 Boyle, in patent 128,448, June 25, loosened the ice from the molds by reversing the current of hot gas. In 1877 Holden, in patent 190,036, April 24, added the automatic valve for controlling the supply of liquefied ammonia to the refrigerating coils, afterwards improved upon by Winkler in patent 452,536, May 19, 1891. Other advances have been made by Linde, in patent 228,364, June 1, 1880, and Pictet, in patent 415,881, November 26, 1889.

Later improvements have been directed largely to automatic regulators and controlling devices. Examples of these are: Knox, 596,601; Marshall, 630,617; Sharpneck, 559,753; Singer, 577,328; Starr, 624,560; and Dortch, 610,438. For improvement of the condenser, Campbell, 635,955, is an example.

Devices for cooling water by evaporation upon exposure to a current of air for cooling the condensers of steam engines and ice machines have been the subject of considerable improvement. Loughridge, 570,318; Stocker, 594,440; and Seymour, 621,718, are examples.

In refrigerator cars, in addition to the ordinary run of improvements in the details of the ice tank and the air circulation, the most notable patents are those for improvements in the application of the ice machine thereto, of which Nichols, 610,276, is an example.

The most notable patents in this class granted in the last five years are probably those relating to liquid air. Ostergren, 621,536, and Tripler, 652,058, are examples of the liquefier. Hampson, 620,312, shows a device for separating the oxygen and nitrogen in air by the liquefaction and subsequent distillation of air. A large number of patents have been granted on containers preserving liquid air in storage and shipment. An example of this is Ostergren, 644,259.

STEAM ENGINES.

Steam Engines.—In this class there have been 10,141 patents issued, and in the class of steam-engine valves 2,976 patents, or a total of 13,117 patents.

Duplex pumping engines are those in which one engine controls the valve of the other. An example is found in the patent to Blake, January 30, 1877, 186,659, and Worthington, 609,953, August 30, 1898. Compensating devices for steam pumping engines are those in which power is accumulated; the first half of the stroke of the steam piston to assist in moving the piston, and the other half of the stroke during the expansion of the steam. An example is found in the patents to Davies, March 9, 1880, 225,351, and Worthington, 627,511, July 11, 1899, used in pumping oil through pipe lines. Steam or air hand hammers, in which the piston is the hammer and strikes a tool projecting through the head into the cylinder, may be found in the patents to Brazelle, September 4, 1883, 284,173, and Carlinet, February 26, 1895, 534,812. Some of these tools are particularly adapted for riveting, the tool being placed in a cylinder supported on one end of a yoke and automatically advanced and retracted from rivet. See patent to Fielding, May 2, 1899, 624,435.

Rock-drilling engines in which the movement of the valves is operated by the piston at any portion of its stroke are illustrated in the patent to Halsey, March 11, 1884, 295,003. Shaft governors in which the eccentric for operating the engine valve is moved around or across the main or auxiliary shaft are exemplified in the patent to Begtrup, August 7, 1888, 387,205. Valve gear of the Corliss type, in which the steam valve is detached from the gear by the governor, is shown in the patent to Dixon, April 10, 1888, 381,001. Multiple-cylinder engines in which several cylinders, either single or double acting, are arranged to cooperate with a common shaft are seen in patents to Brotherhood, 145,719, December 23, 1873, and to Westinghouse, 240,482, April 19, 1881.

Another important invention is in steam sanding devices for locomotives, by which sand is automatically fed to the rails at the same time the air brake is applied. Such a device is shown in the patent to Sherburne, November 14, 1893, 508,849. Starting valves are used for starting compound locomotives or ascend-

ing steep grades, in which both high and low pressure cylinders are supplied with live steam, and when the steam, exhausted from either high or low pressure cylinders into the receiver, has reached a predetermined pressure, the engine works on the compound principle. See patents 481,148, to Player, August 18, 1892, and 511,186, to Ball, December 19, 1893.

Single-acting compound engines in which two or more cylinders are arranged tandem, the steam acting only in one direction and the exhaust steam of one acting upon the piston in the cylinder next of the series, are used in pairs, so that while one is acting downward the other is acting upward. The diminished floor space required for a given horsepower is advantageous: 339,242, to Willans, April 6, 1886, and 358,844, to Creuzbaur, March 8, 1887. Valves actuated by steam controlled by the main piston or auxiliary valve operated by main piston are shown in the patent to Goyne, August 10, 1886, 347,173. See also 557,135, Mellin, March 31, 1896, and 619,641, Vauclain et al., February 14, 1899. Throttle valves automatically closed upon the bursting of a pipe, breaking of machinery, or operated by electricity automatically, or by hand at a distance, were patented to Grossman, June 28, 1893, 500,492, and to Nash & Eddy, March 29, 1892, 471,999.

Compound marine engines in which the weight of the reciprocating parts, the crank angles, the length of the cranks, and distance between the centers of the cranks on the shaft are so related as to reduce the disturbing vibrations of the unbalanced forces are shown in 594,288, Schlick, November 23, 1897, and 614,674, Taylor, November 22, 1898. Locomotives are provided with devices to prevent compression in the cylinders when "drifting" or running without steam. See patents 581,789, Symington, May 4, 1897, and 624,667, Mellin, May 9, 1899. For steam and vacuum pumps operated by using explosive mixtures, see 625,882, Gross, May 30, 1899, and 632,663, Tatham, September 5, 1899.

In rotary engines the compound type and those of the impact type known as steam turbines are shown in the patents to Eickershoff, 501,223, July 11, 1893, and De Laval, 522,066, June 26, 1894.

The steam turbine has been developed in the last few years into a very efficient engine and is now largely employed wherever high speed is desired, as in running electric generators and the propellers of steamships. They have so far been applied mainly to torpedo boats and small steamers, but so excellent have been the results that it is thought to be only a few years before they will supplant all other types of marine steam engines. This development is largely due to C. A. Parsons, of England. See patents 553,658, January 28, 1896; 608,969, August 9, 1898; 656,208, August 21, 1900; and 655,414, August 7, 1900.

In this country the chief inventor in this line has been C. G. Curtis, of New York. See patents 566,969, September 1, 1896, and 530,210, September 21, 1897.

Lubricators.—In the class of lubricators invention has for the most part taken the direction of specialized forms for various purposes. The simpler forms, in which the oil is fed by gravity, have been improved in details relating, for example, to the filtration of the lubricant, as in the patent to Pound, 607,456, July 19, 1898; supplemental devices for lubricating, as in McCoy, 614,307, November 15, 1898. Patent to Jones, 584,688, June 15, 1897, shows a device for automatically controlling the feed of lubricant by varying the periodicity of its action.

In Caum, 564,969, August 4, 1896, and Vandresar, 662,838, November 27, 1900, are shown systems of oil distribution in which the oil is forced to the points of use by air pressure. Gielow, 657,408, September 4, 1900, shows a device for feeding graphite as a lubricant.

Another type of lubricator is a positively actuated device in which a piston is driven from the engine to slowly force the oil from its container. A recent example of this type is shown in Byington, 648,386, May 1, 1900.

An example of a lubricator in which the feed of oil is determined by the revolution of parts is shown in patent to Nugent, 626,291, June 6, 1899. Seyffarth, 603,997, May 10, 1898, shows a device for lubricating the cylinders of elevators. Tenham, 644,306, February 27, 1900, shows a lubricator especially designed for use with windmills, and Bowen, 583,668, June 1, 1897; Wilson, 598,044, January 25, 1898; Winkley, 642,860, February 6, 1900, show modern types of oil cups.

One of the most important types of lubricators is that in which oil is displaced by condensation of steam. Leading patents thereon are: Tippett, 556,074, March 10, 1896; Porter & Hennessey, 587,272, July 27, 1897; Kaczander & Ruddy, 619,962, February 21, 1899; McAlexander, 628,019, July 4, 1899; MacBain, 664,170, December 18, 1900; and Buckley, 631,275, August 22, 1899.

Lunken, 640,576, January 2, 1900, and Power, 652,290, June 26, 1900, each show supplemental means for supplying oil in case the displacement lubricator fails to work.

It may be noted as a general tendency that the lubricators which depend upon gravity and difference in pressure are being greatly displaced by those having positive feeding means, mainly lubricators in which the oil is forced to the parts by pumps. Important examples of this type are found in Butler, 564,503, July 21, 1896; Dewitt, 602,128, April 12, 1898; Manzel, 635,694, October 24, 1899; McCanna, 648,669, May 1, 1900; and Richardson, 661,323, November 6, 1900.

STOVES AND FURNACES.

In this class 20,031 patents have been issued. The arts of heating and cooking, as represented in the patents which are classified under the title of "stoves and furnaces," are of ancient origin, and were, as might be

supposed, very fully developed prior to the year 1871. Improvements of various kinds have been made since that year, but most of these involve only the minor matters of structure, which are naturally evolved after any art has been fairly well matured.

Artificial Fuel.—Improvements have been made in this class of inventions in many cases by devising specific compositions and processes to suit local conditions and to utilize waste material, particularly culm and slack of coal mines, and in machines for briquetting fuel as represented by patents to Batter, 580,568, April 13, 1897; Edwards, 664,017, December 18, 1900; Taggart, 655,282, August 7, 1900; and Forester, 630,676, August 8, 1899. A notable departure in the way of fuel is disclosed in patent to Deissler, 663,239, in which the heat of oxidation of aluminum, magnesium, and other metals of high heat of combustion is utilized to produce intense heat for heating small objects or parts. The powdered metal is intimately mixed with a pulverized, easily decomposed oxide which, when raised to a sufficient temperature by external heat, gives up its oxygen to, or is reduced by, the powdered metal, the union of which with the oxygen produces intense heat. Patent to Hall & Espey, 559,704, May 5, 1896, represents improvements in fire lighters for fire engines in which a vial of sulphuric acid is broken in a box (attached immediately under the fuel in the furnace) containing a mixture of potassium chlorate, sulphur, and sugar or other carbon-supplying compound.

Combustion.—Schlicht, 556,280, March 10, 1896, causes a supporter of combustion to flow in direct contact with a current of the products of combustion, by which the supporter of combustion becomes highly heated while passing to the zone of combustion. Another important patent, Lewis, 658,069, September 18, 1900, relates to the method of feeding fuel elements to a zone of combustion, consisting in introducing powdered carbonaceous fuel and oxygen by the joint action of impinging blasts of air projected into said zone simultaneously in the same direction at different velocities.

Bole & Patterson, 653,206, July 10, 1900, feed pulverized fuel into a combustion chamber, suspending said fuel in said chamber upon an underlying blast of an oxygen-bearing fluid, and burning the fuel while thus suspended. In Curtis, 663,119, December 4, 1900, to prevent the smoke nuisance, oil is atomized at its normal temperature in whirling or crossing currents and simultaneously mixed with the smoke drawn from the furnace, and the mixture forced into a furnace and ignited. In the art of burning cement, Hurry & Seaman, 645,031, March 6, 1900, feeds air under high pressure and pulverized carbonaceous fuel into an inclined rotary furnace in a long and relatively compact stream, with additional means for supplying air to the furnace, whereby a core of pulverized fuel in combustion, surrounded by air to support combustion, is produced in the furnace without impinging upon the walls of the furnace.

A hay and straw burning stove is disclosed in patent 156,730, to Hamilton, November 10, 1874. It is the first stove to include means for holding the straw under compression during combustion.

Patent 350,021, to Smith, September 28, 1886, covers an apparatus for burning standing weeds and grass. A fire chamber is drawn over the ground so as to burn a swath as it advances, and a wide flange bearing upon the ground not only prevents the fire from spreading, but extinguishes the fire which would be left in its path. Another invention for a similar purpose, shown in patent 419,559, to Rice, January 14, 1890, is used in destroying the Russian thistle, which had defied all previous efforts to exterminate it.

Car Heaters.—Prior to 1871 the car stove was practically the only means of heating cars. The train-heating system of the present day, an example of which is shown in patent 512,239, to Towne, January 2, 1894, has displaced that dangerous heating apparatus. This is the first water-heating system for trains in which is utilized the heat of steam taken from the locomotive, and which has an emergency heater in each car for heating the water when steam heat from the locomotive is not available.

Regulators.—In the art of temperature regulation, one of the most important inventions is the patent to Paul, 647,024, April 10, 1900, which comprises, in combination, a circulatory heater, a thermostat in operative connection with some intermediate part of the heater, and a passage controlled by the thermostat, and means for cutting the thermostat out of action, said thermostat being adjustable along the surface of the heater. By adjusting the thermostat along the heater the effective heating surface thereof may be varied. Osborne, 645,929, March 20, 1900, has thermostatically controlled means for introducing air into a radiator when the temperature rises above a predetermined limit and withdrawing same when the temperature falls below a limit.

Steam Heating.—A steam-heating system for towns provided with a central steam-generating plant is shown in patent 193,086, to Holly, July 17, 1877. Its principal features are underground mains, which are constructed to permit of expansion and contraction, service pipes, steam meters, and means for carrying away the water of condensation.

Sterilizing Water.—Scientific investigation of bacteria has recently rendered apparent the desirability of purifying drinking water. A sterilizing and filtering system for liquids is shown in patent 471,261, to West, March 22, 1892. This system provides for the heating and filtration of water out of contact with the germ-laden air, thus destroying the bacteria of the water and delivering it in a pure and wholesome condition.

Vapor Stoves.—The new-process vapor stove disclosed in patent 420,797, to Hollingsworth, February 4, 1890,

does not require preliminary heating of its burner. It contains an elevated carbureting chamber, in which air is laden with the vapor of gasoline and from which the mixture is conducted by gravity to the burners of the stove, where it is ignited by a flame.

INDUSTRIAL MECHANICS.

Under this heading are included nearly all the arts in which raw material is converted by the direct or final application of mechanical agencies into finished commercial products. Means not purely mechanical are sometimes employed in the primary preparation, but the final operation or effect is nearly always produced by means which are purely mechanical.

ARTESIAN AND OIL WELLS.

There has been great improvement in well-drilling plants, and the following show, perhaps, the most prominent types: 443,070, Chapman, December 16, 1890; 464,182, Bullock, December 1, 1891; and 622,459, Freeman, April 4, 1899.

The purpose of the invention of Gardner, 478,791, July 12, 1892, is to adapt the electric motor to deep-well boring. Hence it is inclosed in a water-tight casing, which is suspended from a derrick by a cable, with the necessary conductors attached, for reaching the depth desired. It is also provided with signaling devices whereby the operator can tell by the sound whether or not the work is proceeding in a satisfactory manner, however great a depth may have been reached.

The object of the patent to Horton, 537,114, April 9, 1895, is to enlarge the hole in the rock below the casing, so that it may be sunk to a lower depth when for any reason this becomes necessary, and to that end it consists of an expansible cutting device, which can be passed through the casing, and by suitable manipulation caused to enlarge the bore of the well below it.

In some of the Southern states large deposits of free sulphur are found, and generally these deposits are overlaid by beds of quicksand, which preclude the mining of the sulphur in the usual way, i. e., by sinking a shaft to the deposit or mine, and Frasch's invention, patent 461,430, October 20, 1891, relates to the mining of sulphur under such conditions; and to that end he sinks a casing to the sulphur deposit, and then introduces a solvent, which may be water heated to a degree sufficient to dissolve the sulphur, or any of the well-known solvents, such as bisulphide of carbon, tar, or petroleum. If water is the agent employed, it must be under sufficient pressure to raise the melted sulphur into tanks provided for the purpose. Otherwise a pump may be used for raising the liquefied sulphur to the surface.

The invention of Masseth & Black, patent 535,709, March 12, 1895, belongs to the class of devices intended for the purpose of recovering lost drilling tools from oil or gas wells.

BRUSHING, CLEANING, AND POLISHING.

Brushing Machines.—In nearly every variety of brush machine that is embraced in this class there have existed for nearly half a century practical and useful devices. A modern machine for blacking boots and shoes contains a suitable framework, a rest for the foot, reservoirs containing the blacking, brushes that automatically apply the blacking and then recede, and polishing brushes. This machine is usually actuated by an electric motor that, in many cases, is put in motion by the action of coin-controlled starting mechanism. Examples of such machines are shown in the patents to Gilman, 460,335, September 29, 1891; Norton, 496,437, May 2, 1893; and Bicknell, 526,361, September 18, 1894.

Patent 557,878, for a machine for cleaning and disinfecting carpets, draperies, upholstery, etc., has a series of cylinders for compressed air, cleaning solutions, and disinfecting solutions connected with a discharge pipe or nozzle so that either can be used as desired.

Brush-making Machines.—The patent to Kennedy, Diss, and Cannan, 469,479, February 23, 1892, exhibits what is probably the highest degree of attainment yet reached in these machines. In this brush blocks of varying sizes by the same machine and the same pattern are bored for the reception of the bristle and the tufts inserted therein as fast as the tuft holes are bored, the machine being automatic in its operation.

Grinding and Polishing.—In this class 3,473 patents have been issued. Advances have been made in the finishing of metallic articles by grinding instead of by turning or filing, and in the grinding of every variety of lathe to a predetermined point with mathematical accuracy by means of a template, the machine being provided with means by which an accurate record of the shape of the tool can be made, so that the tool can be reground to that precise shape whenever desired. The former type of machine is shown in the patents to Handloser, 423,243, March 11, 1890, and Landis, 483,288, September 27, 1892, and the latter in the patent to Bancroft, 460,497, September 29, 1891.

Patent 661,348, for a machine for grinding mower and reaper knives, grinds the V-shaped blades from heel to point.

Patent 585,836 trues car wheels by grinding without removing them from place, the car being raised intact by means of jacks, the grinder carriage being mounted upon the tracks under the car.

The patent which represents the most important advance in the art of abrading was granted October 18, 1870. It is known as the "sand blast," a machine for cutting, boring, dressing, engraving, or grinding hard substances, such as glass, metal, and stone, the operation being carried out by means of sand projected against the substance operated upon by a jet or current of air, steam, or water, an elastic stencil of the desired pattern being placed over the article when engraving

is to be done. This invention is illustrated in patents to Tilghman, 108,408, October 18, 1870; Atkins, 250,185, November 29, 1881; King, 365,261, June 21, 1887; Goodfellow, 437,922, October 7, 1890; and Nehr, 469,642, February 23, 1892.

Laundry.—Every class of washing machine was well developed prior to 1870. Of improvements in washing machines, Burton and Benjamin, 408,690, August 13, 1889, show a power machine in which the rotating cylinder containing the clothes is provided with an arrangement of pipes by which either steam, water, or bluing can be introduced into the cylinder through its hollow journals as desired, so that the clothes can be washed, rinsed, and blued without removal from the machine. Garrison, 452,129, May 12, 1891, shows a machine in which the cylinder is provided with reciprocating perforated pistons, between which clothes are alternately squeezed and released, a supply of fresh water being constantly introduced through one of the hollow journals of the cylinder, while the water that has been used is constantly discharged through the other journal. Baker, 550,672, December 3, 1895, has a casing in which is journaled a perforated cylinder, in which the clothes are placed, one end of the cylinder being provided with propeller blades which force a continuous current of water from the casing through the clothes, these blades being assisted by spiral blades upon the periphery of the cylinder.

Patent 638,180 shows a washing machine having an oscillating squeezer extending across the center thereof. When the tub is oscillated the clothes on opposite sides of the squeezer are pressed thereby, valves on opposite sides of the squeezer being alternately opened and closed during the oscillations to remove the dirty water.

An improvement in this art is shown in patent 634,346, for a machine for starching fabrics. The starching roll runs several hundred times faster than the drum upon which the goods rest and this generates frictional heat at the point where the roll acts upon the goods, the starch being cold when it is discharged upon the fabric.

Valuable improvements in ironing machines are shown in the patents to Monk, 204,594, June 4, 1878, and Watson, 293,290, February 12, 1884.

Street-sweeping Machines.—In these the most marked improvement consists in the use of pneumatic means for removing the dirt from the street, and thus avoiding the dust that is caused by the use of revolving brooms or brushes, such removal being effected by means of a hood that covers the area of street beneath the body of the machine and incloses an air exhaust, the sweepings being drawn through the exhaust mechanism and deposited in a receptacle for the purpose, or, in some instances, deposited in a furnace carried by the machine, and there burned—Ethridge, 434,178, August 12, 1890; Wood, 452,153, May 12, 1891; and Furnas, 484,191, October 11, 1892.

In patent 633,296 one of the wheels is provided with buckets and serves as an elevator for conveying the sweepings to a cart.

GARMENTS.

Armpit Shields.—The armpit shield is illustrated in patents to Kleinert, 287,298, October 23, 1883; Canfield, 317,626, May 12, 1885. The first of these patents shows the shield made in two parts stitched together; the second, however, marks an advance in the art, whereby the article is produced by a single operation in its integral form.

Cutting Machines.—In the manufacture of ready-made clothing an important line of inventions is shown in patents to Warth, 165,636, July 13, 1875; Warth, 186,643, January 23, 1877; Eschbach, 335,996, February 9, 1886; Salisbury, 431,998, July 8, 1890; Salisbury, 502,052, July 25, 1893. The earliest of these marks the original form of machine called the overboard cutter, which comprises an apparatus guided by the hand over a table upon which has been laid 20 or 30 plies of fabric. The earliest forms employed familiar kinds of power-transmitting means. The later forms, however, are operated by electrical means.

Hat Finishing.—Another noteworthy invention is that relating to the perfecting and finishing of hats. Eickemeyer was an early inventor in this field. See patents to Avery, 11,405, reissued March 20, 1894; Howe, 540,445, June 4, 1895; Eickemeyer, 540,219, May 28, 1895.

Toilet.—In this class the inventions shown in patents to Lonsdale, 351,331, October 19, 1886; Bookser, 501,646, July 18, 1893; Snyder, 520,904, June 5, 1894; Rush, 552,487, December 31, 1895, show the improvement over the ordinary slate pencil for curling the hair. From the ordinary mandrel and clamp attached thereto, as shown in Lonsdale, the invention has advanced until the mandrel itself and clamp attached are automatically rotated in the hand. Certain of the later forms of this improvement are provided with means for electrically and automatically heating the mandrel.

Whalebone substitutes for corset stays may be seen in patents to Warner et al., 234,757, November 23, 1880; Warren, 286,749, October 16, 1883; Stone et al., 351,344, October 19, 1886; Bowling, 362,568, May 10, 1887; Wheeler, 379,882, March 20, 1888.

GAS.

Gas.—The manufacture of gas was revolutionized by the process patented to Lowe, 167,847, September 21, 1875, which disclosed a method by which a carburetted water gas is produced. The Franklin Institute, in 1886, gave for this a grand medal of honor, as being the invention exhibited that year which contributed most to the welfare of mankind. That invention has been the forerunner of a large number of others, and a large proportion of the heating and illuminating gas manufactured in this country embodies the basic idea of the Lowe process.

The patent to C. Dellwick, 636,899, November 14, 1899, has occasioned much comment and seems to be regarded by gas manufacturers as covering quite an ad-

vance in the art. Its point is in using such a quantity of air and under such pressure as to produce more carbonic acid than carbon monoxide during the blasting period, whereby the blasting is shortened and the gas-making period is lengthened.

Acetylene gas, produced by the reaction between calcium carbide and water, was patented to Dickerson and Suckert, 535,944, March 19, 1895. In this subclass, including generators, 882 patents have been issued.

The present trend of the class appears to be toward those generators which feed carbide to water as distinguished from those feeding water to carbide. Examples of different types of generators are shown in the following patents: Dickerson, 533,781, January 28, 1896; Clarke, 556,736, March 24, 1896; Porter, 562,911, June 30, 1896; Bucher, 569,273, October 13, 1896; Buffington, 575,281, January 12, 1897; Fuller, 575,474, January 19, 1897; Deuther, 567,955, February 9, 1897; Rhind, 583,582, June 1, 1897; Bournonville, 617,632, January 10, 1899. The patent to Claude and Hess, 664,383, December 25, 1900, claims the storage of acetylene by dissolving it in acetone.

GLASS, POTTERY, AND PLASTICS.

Glass and Enameled Ware.—The manufacture and sale of granite or enameled sheet-iron ware received a great impetus by the method disclosed in patent to Niedringhaus, 199,735, January 29, 1878, while the cost of glass articles was remarkably cheapened by the method of simultaneously blowing and pressing the metal in a mold to produce the finished article, first patented to Atterbury, 139,993, June 17, 1873. Glass of varying depths of colors in the same mixture is produced by cooling and reheating the portion in which the color is desired: Locke, 282,002, July 24, 1883. The problem of supporting large expanses of glass for roofings, skylights, and windows was solved by perfecting the methods of embedding wire in glass. The product is old, but the manner of making it was too crude to allow it to become a commercial commodity. This difficulty was overcome by Shuman in patent 483,020, September 20, 1892.

Until recent years practically all glass blowing has been done by highly skilled labor. Machines which require no such skill in the operative are steadily displacing the human glass blower and are able to produce articles of a size, with a rapidity, and of a finish of which a man is absolutely incapable.

A German inventor, Sievert, has obtained a series of patents, illustrated by 641,048, January 8, 1900, and 646,133, March 27, 1900, especially adapted for blowing glass articles of large size, as bath tubs, but also applicable to the manufacture of window glass and bottles. The blowing is by compressed air or steam, or in some cases the glass is supported at its edges and allowed to sag into a shaping mold by its own weight.

New and more successful attempts have been made to manufacture window glass by drawing glass vertically into the form of a cylinder or a flat sheet from a tank of molten "metal," a "bait" of iron being used to start the sheet. This unique process is shown by the patent to George & Shortle, 618,861, February 7, 1899.

Rapid strides have been made in the improvement of partially, or wholly, automatic machines for the manufacture of bottles in the two successive steps of pressing a blank in one mold and then blowing it to shape in a finishing mold. This is shown by the patents to Blue, 567,071, September 1, 1896, and to Power, 619,694, February 14, 1899. Altenbaugh (patents 584,138, June 8, 1897, and 618,975, February 7, 1899) has devised an automatic machine for gathering definite amounts of glass from a tank or furnace and delivering the glass to a mold for making tumblers, etc.

Brick and Pottery.—The idea of erecting a brickkiln having one continuous burning chamber, divided into sections, in which the firing was periodically advanced, was a notable step in brickkilns and was patented to Hoffman, 158,085, December 22, 1874. Susan Frackelton disclosed a portable kiln for firing pottery and porcelain in patent 349,935, September 28, 1886. A machine adapted to form and express a cement conduit was patented to Howson, 291,849, January 8, 1884.

Improvements in continuous kilns more efficiently to use the heat of the cooling material are shown in patent to Gobbe, 622,219, April 4, 1899, in which the heated air current is divided, part going to the drying and heating chambers and part only passing through the last-fired kiln to be intensely heated for the purpose of combustion in the furnaces of the chamber being fired. Patent to Fiske, 633,955, September 26, 1899, shows an important improvement in the way of inserting and removing bodily a kiln of brick into the burning chamber by means of a traveling crane. Patents to Grath, 660,188, October 23, 1900, and Koch, 663,606, December 11, 1900, show representative improvements in brick machines.

Lime and Cement.—Patent to Church, 487,606, December 6, 1892, discloses a means for applying plaster to extensive surfaces.

An important improvement in treating or preparing lime for mortar and plastering compositions is disclosed in patent to Pierce, 599,792, March 1, 1898. The lime is first slacked to a putty, then roasted in the presence of carbon dioxide and ground to a powder. This gives a product containing a proportion of subcarbonate of lime which, when mixed with sand or other filler, hardens in a shorter period than where pure hydroxide of lime is used, as is ordinarily done, and further, the lime is ready for mixing and use as it comes from the plant.

An important step in the saving of carbon dioxide from limekilns is the subject of patent to Westman, 651,684, June 12, 1900. The gas is derived practically

pure by calcining the limestone by means of a current of highly heated carbon dioxide and water vapor, the excess of carbon dioxide being drawn off at one point of the circuit and stored in a gas holder, from which it may be condensed by pressure into cylinders. Patent to Hay, 582,587, May 11, 1897, shows an improvement in the utilization of the heat of cooling clinker of a cement kiln for supplying hot air for combustion and in generating fuel gas from oil. Patent to Fahrney, 590,057, September 14, 1897, shows a method differing widely from former practice in calcining cement and like products. The material is formed into a tube and then acts as a flue through which the flame and hot gases are caused to pass. Patent to Merceron-Vicat, 655,501, August 7, 1900, is for an improvement in a process for producing cement free from sulphur consisting in fusing the material and subjecting it to a blast of air, by which the sulphur is said to be removed. An improvement in a process of preparing slag for cement by which the sulphur is removed is described in patent to Wuth, 643,856, February 20, 1900.

Rubber and Plastics.—Patents to Palmer, 493,220, March 7, 1893; to Huss, 539,224, May 14, 1895; and to Morgan, 544,627, August 13, 1895, disclose means for shaping rubber fabric into pneumatic tires. Patents to Mitchell, 249,970, November 22, 1881, and 250,943, December 13, 1881, disclose ways and means for reclaiming waste rubber.

Among the patents which have been granted for rubber substitutes or artificial rubber may be mentioned 615,863 and 615,864, granted to Leonard, December 13, 1898. These patents are based on the discovery that the oil extracted from corn may be vulcanized by mixing with it sulphur or sulphur compounds. The new corn rubber is claimed to possess all the essential qualities of Para rubber, including resiliency. It is said to be the cheapest oil substitute for rubber that has been put on the market.

Old rubber is reclaimed by devulcanizing it, after which it is used again in the manner of crude rubber. The devulcanization is effected by removing the sulphur in various ways, such as by heating or by the action of solvents. Among the patents the following may be mentioned: 601,091, Clark, May 22, 1898; 627,689, Heinzerling, June 27, 1899; 630,435, Zingler, August 8, 1899; 635,141, Marks, October 17, 1899; 642,764, Theilgaard, February 6, 1900; and 664,529, Brimmer, December 25, 1900.

Patents to Lantzke, 563,775, July 14, 1896, and to Chapin, 639,523, December 19, 1899, show composition coverings which are built up of thin sheets of material in such a way as to secure the greatest possible number of small air cells. Improvements in that type of covering in which hair or fiber is used are represented by patents to Michell, 620,476, February 28, 1899, and McConnell, 649,469, May 15, 1900; and in roofing fabrics and compositions by patents to Terpening, 652,150, June 19, 1900, and Yetter, 633,255, September 19, 1899.

Great progress has been made in machines for the manufacture of inlaid linoleum or floor cloth. Among the patents for these may be mentioned those to Mather, 555,650, March 3, 1896; Thomson, 619,634, February 14, 1899; and Walton, 629,280, July 18, 1899.

Silk, Artificial.—Patent to De Chardonnet, 394,559, December 18, 1888, is the foundation United States patent for the process of manufacturing artificial silk. This silk is made from a viscous solution of pyroxylin, which is allowed to escape from small orifices in fine streams. Owing to the evaporation of the solvent, these streams become hard flexible fibers with the luster and some of the other characteristics of cocoon silk. Improvements in this art may be seen in the following patents: 617,009, Fremery et al., January 3, 1899; 625,033, Hoyne, May 16, 1899; and 646,799, Bronnert, April 3, 1900.

Stone, Artificial.—Patents to Josia, Nos. 265,501 to 265,515, inclusive, October 3, 1882, disclose methods of making imitation marble by treating dehydrated gypsum with various coloring solutions. One thousand two hundred and four patents have been issued in this class.

Garchey, 587,809, August 10, 1897, makes imitation stone from waste glass fused and devitrified in a suitable furnace. It is being used for paving blocks. Because of the devitrification it is not slippery and fragile like ordinary glass.

Concrete mixers are illustrated by McKelvey, 664,000, December 18, 1900; Gilbreth, 620,028, February 21, 1899; Fisher, 624,200, May 2, 1899, and 631,782, August 28, 1899.

One of the most improved kind, as cited, is a drum mixer, the drum being rotated by the action of the wheels themselves, or otherwise, and the concrete mixed as it is being transported to the place of use.

Patent to Foster, 616,834, December 27, 1898, covers a complete paving plant on wheels. Laster, 552,913, January 14, 1896, has a new method and apparatus for repairing defective and worn asphalt pavements.

LEATHER AND LEATHER WORKING—SHOES.

Leather.—The manufacture of leather from skins by tanning them by vegetable extracts containing tannin requires months if a good quality of leather is to be obtained. Since 1880 the art of manufacturing leather has taken an entirely new departure. Chemists have sought and found various processes by which the natural gelatin of the hides by the effect of mineral substances is rendered insoluble and nonputrescible. The use of chromium compounds greatly shortens and cheapens the manufacture of leather. The patent to

Schultz, 291,785, January 8, 1884, and those to Heinzerling, 238,389, March 1, 1881, and 231,797, August 31, 1880, were granted to pioneer inventors in this art.

Subsequent important patents are those to C. S. Dolley, 630,494, August 8, 1899, and to G. Popp and H. Becker, 607,549, July 9, 1898. Dolley's patent covers the manufacture of leather by the aid of formaldehyde.

The patent to Popp and Becker is for a special culture of bacteria for the bating of skins; this patent was followed by that of J. T. Wood, 638,828, December 12, 1899, for a similar process.

The patents to Bayley, 632,984 and 636,942, show improvements in a late type of skiving machine whereby the delicate operation of skiving very thin leather for bookbinding and other work can be successfully accomplished. The patents to Barton, 596,440, Hall, 619,477, and Busfield, 629,062, show some of the more important improvements in leather-splitting machines.

Boots and Shoes.—The inventions in this class are necessarily specific. There have been marked improvements in cushion heels for shoes, as indicated by the following patents: Pevey, 583,814, Arnold, 598,838, O'Sullivan, 625,897, Zickerman, 634,435, Berry, 634,680, Haigh, 636,796, Wolf, 653,161, and Comingor, 663,865; and some valuable improvements in ventilated shoes, as evidenced by the following patents: King, 556,825, Kennedy, reissue patent 11,694, Arnsfield et al., 641,572, Dunbar, 644,412, Kennedy, 635,101, Sharood, 660,522, and Troxel, 660,603.

Boot Treeing.—Advances have been made whereby the operation has been simplified and cheapened and the capacity of the machine increased. See patents to Fowler, December 2, 1890, 442,034, and Copeland, April 5, 1892, 472,108.

The patents to Clark, 564,407, 589,696, and 589,697, and Noyes, 589,744, show decided improvements in boot-trees.

Button-setting and Eyeletting Machines.—Since 1871 machines of various types for setting eyelets and buttons have come into practical operation. Machines of one type take buttons from one hopper and fasteners from another, feed them separately, unite them, and fasten the buttons to the shoe, the whole operation being automatic and extremely rapid. In machines of another type the fasteners are made from a continuous piece of wire passed through the eye of the button and secured. These machines are not confined to placing buttons on shoes, but are also used for attaching them to clothing. As examples of the types of button-sewing machines, see patents to Kellogg, 195,715, October 2, 1877; Smith, 286,741, October 16, 1883; and Brosnan, 327,917, October 6, 1885.

Among the important improvements in eyeletting machines are those relating to machines for setting a plurality, or gang, of eyelets. This type of machine is illustrated in patents to Glass, 628,309 and 636,035; and to Whittemore et al., 628,289 and 628,290, and Glass, 636,035. Other important improvements in eyeletting machines are represented in patents to Buffum, 626,050; Wearden, 629,000; Knight, 627,340; and Knight, 627,341.

Some important improvements for setting lacing hooks are shown in patents to Heinemann et al., 626,700; Glass, 631,038; Pierce, 657,673; and McGrath, 663,387.

Channeling Machines.—Machines for cutting channels in the insole to receive the stitches uniting the upper and the insole have also acquired much prominence. One type of this machine is shown in patent to French and Meyer, November 27, 1894, 529,900. See also patent to Wellington, June 23, 1891, 454,631, as an instance of innovation in this art, extensively used and largely improved upon.

The patents to French and Meyer, 599,602; Reid, 603,968; Littlefield, 623,325; and Eaton, 637,926, show some of the later and important improvements.

Heel-nailing Machines.—The pioneer patent for attaching the finished heel with but one blow of the hammer is shown in patent to Henderson, 252,215, January 10, 1882. This art has been extensively improved, a good example being shown in patent to Raymond, October 8, 1889, 412,414. The patents to Raymond, 581,039, 619,707, 650,420, and 651,447, and to Winter, 591,366 and 611,370, show the character of the late improvements.

Heel-trimming Machines.—Instances of these are patents to Busell, October 9, 1888, 390,750, and Noble, July 23, 1895, 543,349. These machines are capable of efficient work, and as labor-saving machines are somewhat remarkable. The type of heel-trimming machines shown in the patent to Langill, July 30, 1895, 543,491, is also an innovation in this art.

The patents to Mayo, 609,519, and reissue 11,770, the patents to McDowell, 615,092, and Belmer, 641,822, show the trend of late improvements upon sole and heel-edge trimming machines.

Valuable and characteristic improvements in heel-breasting machines are shown in patents to Heys, 636,990, Brewer, 645,994, and to Buzzell, 693,833.

Insole Reenforcing.—The patents to Hadaway, 603,763 and 614,860, and the patents to Johnson, 641,683 and 656,843, show machines for reenforcing insoles, and mark an important and distinct advance in the art.

Lasting.—The art of lasting shoes by machinery as a practical thing has grown up since 1871. The first machine to come into extensive use was the step-by-step laster and tacker patented to Matzeliger, March 20, 1883, 274,207. This machine performs the operation of lasting shoes in the same way as the hand method. Many improvements were made, the perfected form being represented by the patent to Gooding and Ladd, March 25, 1890, 423,922; to Ladd, 584,471, 584,472, and 597,321; and to Ladd & McFeeley, 584,744. It has taken a leading place in the operation of lasting shoes.

Another very important advance in the art is evi-

denced by the pulling-over machine, shown in patent to McFeeley, 663,777. This machine pulls over the upper in proper position for the shoe to be lasted by the hand-method machine above referred to.

Another type of lasting machines in which the outer edge of the upper is drawn over the bottom of the last at one operation by fingers or blades has been greatly improved since 1871. This is shown in patent to Patten, May 26, 1891, 452,879.

The more important improvements in another type of lasting machine, wherein the upper is drawn over the last by wipers or wiper plates at each end of the last, are represented by patents to Preston, 584,192, 584,600, and 592,826; to Brock, 601,939, 601,940, 601,934, 601,935, 601,936, 601,937, and 601,938; to Gardner, 622,846; to Eaton, 635,129; to Woodward, 644,120; and to Stirckler, 629,476.

Lasting and sewing machines wherein the upper is drawn over the last by sewing mechanism have been much improved. The line of improvements on such machines is indicated by patents to Hamm, 570,252; Jackson, 583,181; Collyer, 591,327, and patents to Keith, 585,675 and 592,971.

Improvements in still another type of lasting machine are shown in patents to Kotzlovsky, 574,337, and Sellers et al., 647,037.

Lasts.—Great activity has been displayed looking to the improvement and perfection of hinged lasts. The foundation patent on this type was granted to Smith, January 1, 1889, 395,668. The following patents are distinctive of the trend of improvements in this type of last: Miller, 597,779; Saunders, 597,784; Tyler, jr., 601,622; Trufant, 633,741; Arnold, 640,076 and 607,978; Prindle, 648,525; Heath, 652,616; Tyler, jr., 655,314; and Decker, 661,397.

Machines for turning seams in uppers, especially the scallops in button shoes, have grown up since 1880. A typical form is shown in patent to Booth, April 18, 1893, 495,776.

Markers and Cutters.—That part of the art of shoemaking comprising the various means for cutting out gores and marking the uppers, which was formerly nearly all handwork, is now largely done by machinery. The machine shown in patent to Stiggins, January 15, 1895, 532,491, replaces several of the machines formerly in use.

Miscellaneous.—The patents to Kenison, 629,132, and Evans et al., 629,316, show ingenious and complicated machines for blacking the edges of soles.

Patents to Rand, 594,181, and to Gale, 645,642, show perfected machines for covering boot straps, and mark a distinct advance in this branch of the art.

Shoe-nailing Machines.—Machines for driving the nails in heels and soles of boots and shoes were not perfected until a comparatively recent period. These machines are of various types, some of which make the nails from a continuous length of wire and drive them; some screw in the wire and then cut it off flush with the surface of the sole; while other machines take the nails in bulk from the hopper and separate, feed, and drive them, the whole operation being automatic. Examples of these various devices are shown in the patent to Goddu, July 10, 1888, 385,802, and the patent to the same inventor, January 4, 1893, 490,624.

The following patents give a fair index to the improvements being made in shoe nailing and stapling machines: Goddu, 565,074; Coupal, 575,296; Goddu, 583,044 and 584,775; Ambler, 586,154; Dorman, 629,553; Casgrain, 611,405; Freeman, 618,082; Ashton, 602,390 and 602,184; and Goddu, 583,046.

The patents to Small, 577,213; to Elliott & Glidden, 577,241; and to Mayo, 607,940, 607,941, and 607,942, show marked improvements in nail assorting and feeding devices for nailing machines.

The more important improvements in pegging machines are shown in patents to Davey & Ladd, 581,066, and in Leonard et al., 666,278.

Sole-leveling Machines.—The leveling of shoe soles was prior to 1871 largely done by hand. It is now done by automatic machinery. Probably the best example of an improved automatic machine requiring but a single operator is shown in patent to Winkley and Phillips, May 28, 1895, 540,222. Judd, 591,766, and Winkley, 627,034, and 644,654, show later important improvements in leveling machines.

Stitch Separating and Indenting.—Indenting the welt of the finished shoe was formerly done by hand. Since 1890, however, a practical machine for automatically locating, separating, and indenting the stitches has been made. The pioneer in this art was Hadaway, patent 521,978, June 26, 1894.

The character of the improvements in these machines is shown by patents to Hadaway, reissue 11,538 and 11,587, and 579,231, 609,100, 635,015, 652,908, 653,236, 664,405; to Mower, 567,251, 584,597; to Bertrand, 620,730, 655,820; to Eppler, 611,571; to Coupal, 560,976; and to Goddu, 662,416.

Sole-rounding Machines.—Machines for trimming and rough rounding soles in large quantities are of comparatively recent origin. Instances are patents to Loewer, July 23, 1889, 407,735, and Ross, January 10, 1893, 489,876. The patent to Julian, October 23, 1894, 528,128, illustrates another type of sole-rounding machine.

Patents to Gooding and Beauregard, 593,537, and 653,159, show a late type of machine for cutting soles from sheet material more especially intended for soles of rubber boots or shoes. Crosby, 607,736, and Julian, 663,656, show other improved types of rounding machines.

METALLURGY.

Leaching Methods.—In patent 295,815, March 25, 1884, Russell discloses a method for treating ores containing gold and silver by lixiviating them with an

aqueous solution of a double hyposulphite of sodium and copper. The precious metals are dissolved out and are precipitated from the resultant clear solution by means of sodium or calcium sulphide. The cyanide process was disclosed in patent to MacArthur, 418,137, December 24, 1889. The ores of gold and silver are treated with a weak cyanide solution, thus dissolving out the precious metals, which may then be precipitated by zinc or by the electric current. See also Christy, 643,096, February 6, 1900.

In patent 387,688, August 14, 1888, Low discloses a treatment of sulphide ores by roasting and leaching them, with an aqueous solution of the sulphurous acid gas driven off. In patent 444,997, January 20, 1891, to West, is disclosed a process of converting roasted zinc ores into soluble sulphites by means of the joint action of steam and the sulphurous acid gas from the roaster, the temperature of the gases being maintained below 180° F. The sulphide is leached out by water at a temperature also below 180° F.

The well-known process invented by Bessemer for refining iron is now largely used in treating copper. See patent to Manhes, 456,516, June 21, 1891. By this method the sulphur and other impurities are removed from the molten copper matte by blowing through it blasts of air. A process now commonly used in steel manufacture is that of patent 404,414, January 4, 1889, to Jones, in which is described a means of getting a uniform product of metal by mixing together in a suitable receptacle batches of metal from different furnaces, so that the mixture when drawn off will be the average of the differing charges. A steel which has the property of hardening in the air and of producing very smooth castings was invented by Hadfield, and is described in his patent 303,150, August 5, 1884. This steel is produced by alloying manganese with ordinary steel. Fine smooth castings are now also obtained by mixing with the molten iron or steel a little metallic aluminum. This is the Mitis process, patented by Wittenström in patent 333,373, December 29, 1885. The use of iron containing large percentages of phosphorus has been rendered practicable by processes introduced by Kunkel, 182,371, September 19, 1876, and Thomas, 218,334, August 5, 1879, which consists in lining furnaces with or by otherwise introducing into the molten metal lime generally obtained from magnesian limestone, in order that the phosphorus in the iron may combine with the lime and be removed in the slag. Nickel steel, produced by alloying nickel with steel, a product possessing the qualities of great hardness and tenacity, is now largely used for armor plate and projectiles. See patents 415,655 and 415,657, November 19, 1889, to Schneider.

Smelting Processes.—In patent 116,604, July 4, 1871, Lewis disclosed a process of smelting argentiferous lead ores and collecting the fumes resulting therefrom in bags. The fumes are subsequently treated. In patent 308,031, dated November 11, 1884, Crooke discloses a method of dissolving gold, silver, arsenic, and antimony out of coarsely ground copper matte by repeatedly immersing the ore in a bath of molten lead, which is maintained at a temperature below the fusing point of the matte. The first immersion serves to extract nearly all the gold and about 7 per cent of the silver. In patent 386,629, July 24, 1888, Dixon discloses a means for smelting pyrites by introducing the crushed raw ore, mixed with fuel, into the body of the melted charge by means of an air blast. In patent 453,529, June 2, 1891, Austin discloses a means for smelting pyrites, when it is mixed with lime and siliceous ore, by heating the lower part of the charge to a point where combustion of the sulphur can take place, and then introducing a blast of air heated to 1,000° F. By this process the use of carbonaceous material is dispensed with. In patent 478,110, July 5, 1892, James treats zinc sulphide ores by calcining a part of the charge until it becomes oxidized, mixing this oxide with about half its weight of crude ore, and treating it in a reverberatory furnace until the mass becomes converted into zinc and sulphurous acid gas, the zinc passing off in fumes and being condensed. In patent 532,809, January 22, 1895, Nichols and James disclose a similar process for the reduction of refined copper, in which calcined copper matte is mixed with raw matte in such proportion that the sulphur and oxygen pass off as sulphurous acid gas. In patent 488,471, December 20, 1892, to Convers, is disclosed a method for treating certain zinc ores by heating, whereby the franklinite which may be contained therein becomes magnetic. This is then separated by magnetic action from the willemite. The franklinite is then converted into zinc oxide in a Wetherill hearth, and the willemite reduced to spelter in a Belgian furnace. In patent 489,882, January 10, 1893, Thomson discloses a treatment of nickel ores or matte by smelting them with a sulphide of an alkaline base, whereby nickel sulphide is formed, allowing this sulphide to settle by gravity from the copper, iron, and alkaline salts, separating the resultant nickel sulphide and repeating the operation. In patent 489,881, of the same date, to Thomson, is disclosed a method for smelting nickel ores and mattes with hydroxide, or carbonate of an alkaline base, allowing the crude nickel to settle and separate by gravity, resmelting the same with an alkaline metal sulphide, and allowing the nickel sulphide to separate by gravity. In patent 488,797, December 27, 1892, to Pearce, is shown a roaster having an annular hearth with a horizontal slot in the inner wall, through which slot pass rotating arms, which serve to actuate the stirrers used to agitate the ore. The slot is kept closed by a ring carried around by the arms.

A process of reducing refractory oxides is disclosed by patent 578,868, March 16, 1897, Goldschmidt, which consists in mixing the oxide with finely divided alumi

num and igniting by means of a magnesium ribbon. The intense heat developed by the oxidation of the aluminum fuses and reduces the oxide.

The patent to Gayley, 652,178, June 19, 1900, is worthy of note as illustrating an apparatus for drying the large quantity of air to be supplied to a blast furnace or steel converter.

Petroleum.—The production of petroleum in this country began practically in 1859. The oil found in Ohio and Indiana contains, however, refractory sulphur compounds, which give them an extremely bad odor and which are not removable by the ordinary processes of refining. A series of discoveries, made mostly since 1887, have made this oil capable of yielding a good burning oil. See the following patents: Kennedy, 370,950, October 4, 1887; Frasch, 378,246, February 21, 1888; Pitt 379,492, March 13, 1888; Frasch, 448,480, March 17, 1891; Frasch, 487,216, November 29, 1892; Frasch, 543,619, July 30, 1895. In this class 741 patents have been issued.

METAL WORKING.

Annealing and Tempering.—There have been 860 patents issued in this class. Steel wire is now tempered and annealed by electricity. See patent 211,938, February 4, 1874, to Shaw. It is found that the wire can be heated by the passage of the current more evenly than by combustion, the product being of uniform temper throughout. This process is much used in producing clock and watch springs. The Harvey process, patents 376,194, January 10, 1888, and 460,262, September 29, 1891, for making armor plate by embedding the face of the plate in carbon, protecting the back and sides with sand, heating to about the melting point of cast iron, and subsequently hardening the face, is now in general use.

Making Bolts, Nails, Nuts, Rivets, and Screws.—Good illustrations of modern machines for the production of wood screws, bolts, rivets, and nuts may be seen in patents to Rogers, July 10, 1888, 386,091; to Passoni, May 21, 1895, 539,590; and to Dunham, June 12, 1894, 521,233. The only marked advance in screw machinery has been in the production of a rolled or swaged thread for wood screws, shown in patents to Rogers, September 20, 1887, 370,354, and August 6, 1889, 408,529. In the making of metal screws a marked advance has been made in rendering machinery rapid in operation and capable of working on a multiplicity of blanks or stock rods, as shown in the patent to Hakewessel and Henn, December 10, 1895, 551,119, but the automatic production of a complete screw is older than this period.

In the art of tack making, patent to Russell, May 25, 1897, 583,420, discloses a machine for automatically making tacks from a coil of wire without waste of material and with great rapidity. Machines for automatically forging horseshoe nails are found in patents to Abbott, July 27, 1897, and to Williams, May 16, 1899, 625,229. An ingenious automatic machine for rapidly threading nuts fed and discharged in a continuous stream is exhibited in patent to Riggs, December 4, 1900, 662,965.

Making Chains, Staples, and Horseshoes.—Improvements in this line have been largely in details. Machines for automatically manufacturing chains, both by rolling from solid bar and by twisting and assembling wire links, existed prior to 1871, the only improvements, with one exception, being on lines then existing and exhibited in patents to Klatte, July 24, 1894, 523,432, and Breul, January 19, 1892, 467,331. The exception relates to machines for stamping links from sheet metal and assembling such links, and is shown in patent to Egge, April 16, 1878, 202,528.

Automatic machines for cutting, bending, and shaping links for drive chains from a continuous strip of metal and assembling them into a completed chain are shown in patents to S. D. Locke, April 13, 1897, 580,579, and to Viellard & Oswald, April 13, 1897, 580,564.

Metal Boring and Drilling.—In this art effort has been directed mainly in two directions, viz, to the development of high-speed, friction-driven drills of the sensitive type for small work (Stover & Hoefer, July 16, 1895, 542,695), and to multi-spindle drills capable of being adjusted by telescopic or flexible shafting, as shown in the patent to Zinzen, August 13, 1895, 544,495. Many special tools, particularly those designed for bicycle work, have been devised, as exhibited by Hillman, August 11, 1891, 457,718, but improvements have generally been in the line of greater speed and capacity and in rendering the action automatic, for which attention is called to the patent to Richards, April 29, 1890, 426,571.

Metal Founding.—Patent 629,480, July 25, 1899, Uehling, and patents 583,424, May 25, 1897, and 657,069, 657,070, 657,071, and 657,072, each August 28, 1900, to Acklin and Pattison, relate to continuously operating pig-iron casting machines of an endless-chain type which receives the metal from a blast furnace, cools it, and delivers the pigs to cars. A rotary-table type of machine for the same purpose is covered by patents 629,903, August 1, 1899, Hartman, and 620,020, February 11, 1899, Davies. It is understood that these machines have revolutionized the pig-casting art in this country and that they have been introduced into England, Germany, and Austria.

Barr, in patent 207,794, September 10, 1878, improves on the old method of chilling the rim of a cast wheel by a sectional chill, which, when heated by the molten iron, expands inwardly, maintaining a continuous pressure on the rim of the wheel as the wheel contracts on cooling. This has been further improved by Whitney, patent 10,804, February 1, 1887, reissue, who uses an outer ring, an inner ring composed of a series of sections, and webs connecting the inner section and the outer ring. Giers, patent 283,735, August 21, 1883,

takes the ingot from the mold and puts it in a soaking pit to allow the heat within the ingot to radiate outward and reheat the exterior. The ingot is then immediately rolled without reheating.

Patents 648,292, April 24, 1900, Pridmore, and 682,325, May 11, 1897, and 654,292, July 24, 1900, Tabor and Mumford, mark important practical improvements in molding machines which have gone into extensive use.

Metal-tube Manufacture.—In this the improvements since 1871 have been principally in the manufacture of seamless metal tubes. Three processes are worthy of mention: (1) Passing a heated solid rod endwise between the working faces of two rapidly rotating tapered rolls set with their axes at an angle to each other, Mannesmann, April 25, 1887, 361,954; (2) forcing a tube into a rapidly rotating die, whereby the friction softens the tube and the pressure and rotation of the die spin it into a tube of reduced diameter, Bevington, January 13, 1891, 444,721; (3) placing a hot ingot in a die and forcing a mandrel through the ingot, thereby causing it to assume the shape of the interior of the die and greatly condensing the metal, Robertson, November 26, 1889, 416,014, and Ehrhardt, April 11, 1893, 495,245.

Patents to Stiefel, February 7, 1899, 618,917, and Becker, June 12, 1900, 651,790, show how to modify, for the purpose of avoiding twisting the metal, the rolls invented by Mannesmann.

The manufacture of butt-weld iron and steel tubing has been facilitated by the method set forth in patent to Patterson, April 20, 1897, 581,251. W. A. McCool, in a patent dated April 12, 1898, 602,416, disclosed an improvement in the manufacture of drawn tubing by clearing the oxid from the interior and exterior of the blank by means of a blast of chilled shot directed against it instead of by the chemical treatment previously adopted.

A practical machine for making tubing from a cold blank by an electrical welding process is described in patent to Parpart, September 25, 1900, 658,741.

The patent to J. T. Crowden, 633,430, September 19, 1899, illustrates a departure in the manner of assembling pipe sections, the joints between the several sections being formed by hydraulic pressure while supported within a jig or mold.

Metal Turning, Planing, and Milling.—The improvements in this art consist essentially in making the machines more automatic in character, thus increasing their speed and capacity. In lathes entire automatic action is secured by the use of a differential screw nut for all purposes, thereby dispensing with rack feed altogether. An example of this is found in the patent to McClellan, February 12, 1895, 533,997. Milling machines are so constructed that the same machine may be used in all kinds of milling work. Such devices are those of Lipe, February 5, 1884, 292,928; Cosgrove, August 7, 1883, 282,704; and Jones, July 25, 1893, 502,257. In cutting gears the blank may be revolved while the teeth are being cut, and at the same time the cutters moved bodily in the direction that the blank is revolved. This is shown in the patent to Swasey, December 29, 1885, 333,488.

Later improvements have been of the so-called tooth-generating type, wherein the cutter in operation bears to the blank being cut the relationship of an intermeshing gear. Patents of this type are Fellows, March 30, 1897, 579,708; Warren, August 24, 1897, 588,738; and Beale, December 27, 1898, 616,648.

Improved turret screw machines and lathes designed to increase the output and broaden the range of usefulness of such machines are disclosed in patent to Davenport, May 17, 1898, 604,306, and patent to Conradson, December 26, 1899, 639,888. Patents to Brockie, June 20, 1899, 627,385, and to Hartness, October 31, 1899, 635,887 and 635,888, describe automatic turret lathes controlled by fluid pressure whereby an infinite variety of tool speeds may be obtained and unlimited sensitiveness and delicacy of control.

Planing machines have been improved by causing the cutting tool to move in cycloidal and other curved paths. For examples see Wainwright and Morrison, January 22, 1895, 533,025. In turning car wheels an improvement consists in bringing the wheel to be dressed into close proximity to the edge of a rapidly revolving smooth metal disk, whereby the surface of the wheel is melted away without there being any actual contact between the wheel surface and disk, and is shown in the patent to Miltimore, August 24, 1886, 347,951.

Metal Rolling.—Marked results in methods of rolling heavy steel railroad rails have proceeded from the inventions of Kennedy, patented April 18, 1899, 623,479, and Morrison, patented July 17, 1900, 654,071.

A machine designed to roll sheet metal for tin plate automatically is covered by patent to Norton, March 8, 1898, 600,165. Patent to Donner, December 6, 1898, 615,535, is said to set forth a practical improvement in the manufacture of black plate.

Metal Welding.—Here the chief improvement has been in welding by electricity. This branch has developed entirely since 1881, and there are now four systems in use: (1) Welding by means of a voltaic arc sprung between the work and a carbon-pencil electrode, which may be moved so as to concentrate heat at a desired point, De Benardos and Olszewski, May 17, 1887, 363,320. (2) The Thomson method consists in inducing in an electric current of large amperage and low voltage a resistance, as by abutting together the bars to be welded, whereby the heat is concentrated at the point of abutment or weld, Thomson, August 10, 1886, 347,141, and Thomson and Harthan, July 18, 1893, 501,546. (3) The Coffin system is a combination of the arc and Thomson methods in one apparatus, Coffin, April 16, 1889, 401,639; January 7, 1890, 419,032; and January 9, 1894, 512,604. (4) In the water-pail sys-

tem, introduced since 1892, an acidulated bath forms one electrode and the work the other. By introducing the work into a bath, a gaseous resistance envelope is formed about the submerged part, which is rapidly raised to a white heat. See Hunter, May 22, 1894, 520,360, and Burton, April 9, 1895, 537 405. In this class 857 patents have been issued.

Brown & McFeaters, in a patent granted April 17, 1900, 647,478, show how to unite the ends of lead pipe by coating with mercury and then applying pressure and slight heat.

Miscellaneous.—Patents 220,768, October 21, 1879, Morewood; 329,240, October 27, 1885, Taylor et al., and 426,962, April 29, 1890, Rogers and Player, describe important machines for automatically coating iron plates with tin, largely dispensing with hand labor.

Patent 539,058, May 14, 1895, Jerome, describes an apparently successful application of aluminum to horseshoes. Fine particles of hardened metal, such as steel, are pressed into the light aluminum body, thus securing the desired lightness with the hardness of the wearing surface essential in a serviceable shoe.

Patent 491,289, February 7, 1893, Manville, shows the mechanism used in forming the hump on the De Long garment hook.

A method of producing thin foil of certain non-malleable as well as of the malleable metals is covered by patent to Alefeld, March 13, 1900, 645,197.

A machine for making secondary battery plates by spinning up ribs on both sides of a lead plate is disclosed in patent to Madden, December 1, 1896, 572,363.

So-called expanded metal, widely used for building purposes, is rapidly manufactured by a machine patented to Pitkin, February 14, 1899, 619,340.

Patent to Einfeldt, March 27, 1900, 646,269, covers a machine that automatically makes metal vehicle wheels by progressively bending a strip of metal to form the rim and successively fastening the spoke simultaneously to the rim and hub.

Patent 382,321, May 8, 1888, Norton and Hodgson, describes a successful method of producing sheets of lead or solder by pouring molten metal in a continuous unbroken stream between two rollers revolving together with a space between them equal to the thickness of the sheet metal to be produced, and at a sufficiently great surface speed to offer no obstruction to the flowing stream of molten metal.

Sheet-metal Ware Making.—In this art, especially in soldering mechanism, important steps forward have been taken. In patent 243,287, June 21, 1881, Miller applies an endless chain as the means for pushing a series of cans along a waved track, whereby cans are rapidly fluxed and soldered. In 250,096, November 29, 1881, Norton applies to a similar mechanism asbestus wipers to remove the surplus solder from the cans as the side seams are automatically soldered. In 267,014, November 7, 1882, Norton, is well illustrated the advance in machines which automatically apply to can bodies heads fitted outside the same, sizing the body so that it may readily receive the head. 384,825, June 19, 1888, Coleman, covers a machine which solders the head on one end of the already prepared can body, rotating the can so as to get an even application of the solder and wiping off the excess. When an attendant reverses the position of the can the other end is treated in the same manner. 450,624, April 21, 1891, Kendall, shows improvement in a machine in which the bodies are clamped by retaining jaws which register the heads and bodies, and retain them in such relation while the heads are forced upon the bodies. In 465,018, December 15, 1891, and 480,256, August 9, 1892, Foote, devices are shown which automatically apply and solder the can heads and bodies while in continuous motion. In patent 495,426, April 11, 1893, Murch and Gray disclose an apparatus whereby they form the complete can body or other tubular structures at a single operation, edging the blank, folding to shape, interlocking, and compacting the side seam as the metal is carried forward by an endless chain. Patent to Kendall and Schaake, 489,484, January 10, 1893, affords a fair illustration of one of the more recent and most compact machines for seaming can bodies.

In later years the hermetic sealing of sheet-metal cans by vacuum or atmospheric pressure is an important improvement. The patent to Norton, 620,247, February 28, 1899, shows a machine of this type adapted to simultaneously seal a tray full of cans. The machine comprises a receiver, through which the cans may be inserted or removed, a follower plate for forcing the covers home upon the cans, a valve for opening and closing the exhaust and air-inlet communications, and means for automatically operating such parts.

The above exhibit some of the steps and progressive types in the advance from hand and foot operated can machines to those power machines which automatically convert a simple blank or plate of sheet metal into the finished can, an advance in the art which has taken place within the period of thirty years.

Wire Working.—In the art of wire working great progress has been made in several types of machines. Power mechanism for barbing fence wire has been originated, advanced to practical perfection, and in recent years the art has lain dormant. Reissued patent 7,566, March 20, 1877, Glidden and Vaughan, is the foundation patent of this type. Later machines are but improvements in specific details on this invention. Patent 380,664, April 3, 1888, to Scarles, shows the advanced type of wire-netting machines which, though not originated, have been largely improved by minute steps since 1871. Few types of wire-working devices have made greater or more important advances than machines for building standing wire fences. From the old line and tie fence making by hand tools, through the initial successful wire and picket fence machine of

Fultz, 298,368, May 13, 1884, to the machine of Kitselman, 356,322, January 18, 1887, there is evident advance. In this class 1,861 patents have been issued. Patent 406,450, July 9, 1889, La Casse and Wille, is an important contribution to the bottling art, being for a machine which expeditiously wires the corks in bottles. Patent to Perry, 619,692, February 14, 1899, illustrates an important step in fabric making, the strand and stay wires being electrically welded during the continuous feed of the machine. The patent to Anderson, 654,583, July 31, 1900, shows the advance made in electric coil winding mechanism, wherein the wire is wound into helices, bobbins, etc., and sheets of paper or other insulating material introduced at intervals.

MINERALS.

Ore Reduction and Separation.—In this subclass 3,889 patents have been issued. The application of centrifugal force has given centrifugal mills, as in 325,804, Huntington, September 8, 1885; and such high-speed concentrators as that shown in patent 503,687, Seymour, August 22, 1893. By centrifugal force in these devices particles having such slight differences in specific gravity as to be inseparable in settlers or currents of water are readily classified.

The separation of materials of finely differing magnetic susceptibilities has been perfected, as in patent 555,792, Wetherill, March 3, 1896, and in the wet concentration of ores there are improved forms and constructions of the shaking riffled tables, as in patent 590,675, Wilfley, September 28, 1897.

Stoneworking.—The most notable development in this class has been in coal drilling, especially in the application to small machines for single operators of the electric motor, of which the following seem the best examples: 459,596, Sperry, September 15, 1891, and 479,961, Van Depoele, deceased, August 2, 1892. In this class 2,373 patents have been issued.

Oil and Gas Combustion.—The important inventions in devices for burning oil and gas followed closely upon the discovery of petroleum in 1859. The patents granted prior to that time were, for the most part, devices for burning fixed oils and fats, and many were mere refinements of the old Roman *lampas*. A patent was, however, granted to Reichmann, September 21, 1858, 21,576, for a lamp for burning "kerosene, benzole, paraffine, and other coal oils," which were at that time beginning to be made in commercial quantities by the destructive distillation of coal.

There are now 7,491 patents for devices for burning hydrocarbon oils directly for illuminating, including the necessary accessories, such as chimneys, globes, shades, wicks, etc., and 954 for burning oil directly for heating purposes, making a total of 8,445 patents involving the burning of oil directly.

The best devices for burning oil directly are improvements on the burner invented in 1784 by Ami Argand, of Paris. The first application of Argand's burner that went into general use was in the well-known "student's lamp," patented in this country by Kleeman, March 10, 1863, 37,867. A typical illustration of the Argand burner is shown in the patent to Henkle, 348,969, September 14, 1886.

There are 625 patents for burning mineral oils indirectly for illuminating purposes, by first converting the oil into a vapor by the application of heat from the lamp itself, and 1,113 patents for indirectly burning the oil in the same manner for heating purposes. (Patents for carburetting devices, which number about 1,200, and which burn an inflammable gas produced by forcing the air or gas through liquid hydrocarbon, thereby causing the air or gas to become ladened with the vapor of the oil, are not included.) Among the most important devices for burning the vapor of oil for producing light are those covered by the patents to Fennessy, 424,964, April 8, 1890, and to Kitson, 598,491, February 1, 1898. The patent to Howard, 634,642, October 10, 1899, illustrates a device for producing heat in the same manner for heating the steam boiler of an automobile. The quantity of fuel supplied by Howard's device is automatically regulated by the steam pressure in the boiler.

The greatest advance in the art of gas lighting was made by Von Welsbach, in 1886, when he invented the well-known Welsbach incandescent mantle. He obtained a patent for a burner to heat his mantle, August 20, 1889, 409,530; October 7, 1890, 438,125. The Welsbach burner has been rendered more highly efficient by supplying the necessary air under pressure, and in a heated condition, a patent for which was granted to Litle, jr., November 21, 1899, 637,269. A device for prolonging the life of the delicate mantle by carrying the burner on a spring was patented by Cortis, May 4, 1897, 581,879.

The patents to Fuller, 580,126, April 6, 1897, and to Dolan, 602,835, April 26, 1898, are illustrative of burners designed to burn acetylene gas.

The patent to Duke, 548,909, October 29, 1895, is one of the first of the modern catalytic devices for igniting gas by the occlusion of the gas by the catalytic material.

One hundred and twenty-nine patents have been granted for devices for automatically closing a gas cock in case the gas is blown out or becomes accidentally extinguished. The first patent for such a device was granted to Smith, February 11, 1868, 74,440.

Five hundred and forty-four patents have been granted for devices for burning oil under boilers and furnaces by atomizing the oil by means of a blast of steam or air striking the oil and carrying it into the fire box.

A total of 13,458 patents have been granted for oil and gas burners and their accessories.

PACKING AND STORING.

Accouterments.—The patent to Donavin & Parsons, 646,622, April 3, 1900, shows a hammock which may also be folded into knapsack form for carrying clothing, provisions, etc. The patent to Tabler, 608,927, August 9, 1898, covers the poncho holder adopted by the United States Government for use during the Spanish-American War. The patent to Knapp, 626,238, June 6, 1899, shows a canteen which has combined therewith a filter. Another canteen of the same character is covered by the patent to Parker, 647,580, April 17, 1900. The patent to Preston, 555,882, March 3, 1896, covers the field-ration mess kit used by the United States troops during the Spanish-American War. This mess kit can be readily used by the soldier, and the mess pans can be detached and clamped together separately when it is necessary to carry cooked rations.

Bottling.—While the inventions relating to bottles and jars are usually slight changes in construction, yet they are important from a commercial standpoint. There have been nearly 3,000 patents granted on bottles and jars alone, and the applications for improvements are being filed at the rate of over 50 a month.

A quick-acting, reliable, and cheap bottle stopper which may be used over and over again has been desired ever since bottle liquids have been introduced on a large scale. Patent 158,406, January 5, 1875, to De Quillfeldt, is among the first to disclose the features of the automatic stopper. In recent years the consumption of cork has been so enormous that the price of good cork stoppers is almost prohibitive in those industries where competition is severe. To overcome this obstacle, very thin disks of cork placed in thin metal caps, which are crimped over a shoulder upon the neck of the bottle, have been widely introduced, and now promise to supersede in time the ordinary cork in bottles. A prominent patent in this line is 468,258, February 2, 1892, to Painter.

While above 500 patents have been granted on devices to prevent the refilling of bottles, and applications therefor are being filed at the rate of about 20 per month, as yet they have not been commercially successful.

Substantial advance has been made in apparatus for racking or transferring beer to packages or casks and bottles to equalize the pressure between the supply tank and the package. In one class the valve controlling the outlet from the supply is controlled by the movement of the bottle to be filled, so that pressure is first equalized and then the liquid permitted to flow by gravity, so that foaming is prevented in the package. In another class the improvements aim to simplify the operating devices for lowering the filling head and filling tube to form an air-tight connection with the package prior to the admission of the gas under pressure and the admission of the liquid from the supply tank. As noting advancement in this art, the following patents are cited: Colby, 654,714, July 31, 1900; Schneider, 651,274, June 5, 1900; Champ, 670,395, March 19, 1901; and White, 691,997, January 28, 1902. Patents to Tufts & Hopkins, 639,632, December 19, 1899; Champ, 687,726, December 3, 1901, and Boyle, 628,137, July 4, 1899, represent marked improvements in carbonators for introducing the liquid spray and controlling the liquid feed.

In dispensing beverages, advance has been made in devices for delivering aerated liquids where a reducing or intermediate vessel is employed to reduce the pressure before delivery to the drinking vessel or glass. The following patents are cited: Nageldinger, 660,164, October 23, 1900, and Hucks, jr., 695,314, March 11, 1902.

Filling.—A machine for filling receptacles with sugar, salt, and similar materials, and closing such receptacles was patented to Henry E. Smyser, 564,722, July 28, 1896, and 609,472, August 23, 1898. The receptacles are made and carried for some distance in a drying chute before the hydroscopic material is introduced. Types of the improved machines in this class are patents to Okell, 655,574, August 7, 1900, and Rose, 645,016, March 6, 1900.

Important advances have also been made in automatic machines for filling cans with meats or fish, which broadly consist in pressing the fish into cylindrical form of a size to enter the cans, cutting the fish into proper lengths, and forcing the mass into cans fed by carriers. Examples of these are Fulton, 664,142, December 18, 1900; Manula, 670,182, March 19, 1901; and Brown, 671,392, April 2, 1901.

Label Affixers.—Invention in this class has been directed in the main to securing devices which will automatically feed the article to be labeled, and also paste the label and place it in position. In Cornell, 599,792, March 30, 1897, is shown a machine for pasting labels on bottles, in which the label is sprayed with an adhesive and then spread upon the bottle. Tebbetts, 637,708, October 10, 1899, shows a machine in which labels are removed from a magazine by means of a conveyor which has a suction face, and secured around bottles. In patents to Kohl, 573,667, December 22, 1896; Weber, 604,182, May 17, 1898; McLean, 641,311, January 16, 1900; and Strassburger, 647,043, April 10, 1900, are shown other representative types of machines for labeling bottles.

Pettee, 560,324, May 19, 1896; Neth, 585,282, June 29, 1897; Outcalt, 635,108, October 17, 1899; and Knapp, 613,686, November 8, 1898, show machines in which bottles or cans are automatically fed to and discharged from a machine after labels are applied thereto. Burt, 631,239, November 1, 1898, shows a machine in which the label is pasted around a can, and its ends then folded

over onto the ends of the can; and a machine for putting revenue stamps on cigarette boxes is shown in Cowles & Reynolds, 604,855, May 31, 1898, in which the stamps are taken one by one and printed, gummed, and pressed upon packages. A number of these machines are also devoted to affixing stamps, such as ordinary postage stamps, to envelopes, and the like, examples being seen in patents to Grady, 640,650, January 2, 1900, and Herrick, 655,865, August 14, 1900, in which the stamps are cut successively from a strip, moistened, and secured to the missive.

Mail Boxes.—The patent to Crowder, 618,846, is for a post-office depository for suburban or rural districts, and Bates, 627,635, June 27, 1899, is for a rural mail delivery box having a signal actuated by the deposit of the mail.

Paper Files and Binders.—The principal inventions in this class relate to means for temporarily holding together the leaves of so-called "perpetual or loose leaf ledgers." In patents to Winfield, 619,525, February 14, 1899; McClure, 644,210, February 27, 1900; Jones, 646,221, March 27, 1900; and Bystrom, 649,867, May 15, 1900, are shown binders which are extensible to receive varying numbers of leaves, the structure being such that the leaves may be readily removed when required.

A useful form of newspaper file is seen in patent to Green, 645,086, March 13, 1900, and a bill file is shown in patent to Bein, 631,772, August 24, 1899. Patents to Macy, 619,323, February 14, 1899, and Kelly, 664,558, December 25, 1900, relate to improvements in file cases for cards, such as are employed in card-index systems. In Macy, longitudinal rods are provided along the sides to engage the notches in the cards when revolving in one direction and release the cards when revolving in the opposite direction. In Kelly, the object is largely the same, but the rods are pivoted in the middle portion of the box and engage corresponding slots in the cards, and by revolving them so that they lie near together the cards are released.

Paper Receptacles.—Improvements in envelope openers and in return and multiple pocket envelopes, folded blank boxes of cylindrical, tubular, pyramidal, and sector form, are illustrated by patents to Criswell, 581,019, April 20, 1897; Gillette, 599,960, March 1, 1898; Murphy, 652,370, June 26, 1900; and Merridew, 661,064, November 6, 1900. In folded blank boxes, see patents to Knobeloch, 634,645, October 10, 1899; Knobeloch, 636,047, October 31, 1899; Hibson, 640,766, January 9, 1900; Schmidt, 646,920, April 3, 1900; Wagnitz, 648,448, May 1, 1900; and Jack et al., 658,849, October 2, 1900.

Wooden Receptacles.—The most activity and advance noted is in folding knockdown crates and boxes. The following are good illustrations: Drew, 644,796, March 6, 1900; Kesting, 655,244, August 7, 1900; Braun, 659,165, October 2, 1900; Palmer, 662,018, November 20, 1900; Remer, 638,473, December 5, 1899; and Montgillion, 642,245, January 30, 1900.

PAPER.

Paper Making.—Since the invention of the processes resulting in the production of soda pulp, disclosed by the patent to Watt and Burgess, 11,343, July 18, 1854, reissue 1,449, April 7, 1863; ground wood, disclosed in the patent to Voelter, 21,161, August 10, 1858, reissue 4,418, June 6, 1871; and sulphite pulp, disclosed in patent to Tilghman, 70,485, November 5, 1867, there have been no new processes or new stocks added to the art. The last-named process was first practiced commercially in this country in 1882, and was found unprofitable until the use of the cement-lined digester, patented by Russell, 445,235, January 27, 1891, reissue 11,282, November 15, 1892, rendered it a complete commercial success. In the disintegrating machines the beating engines have been improved by the substitution of a vertical for a horizontal circulation, Umpherston, 297,037, April 15, 1884, reissue 10,658, November 3, 1885, and Hoyt, 303,374, August 12, 1884, but the finishing engine, as well as the pulp strainers and paper-making machines, while improved in mechanical details, have not changed their forms. In molding pulp articles, such as pails, satisfactory machines are found in Bodge, 287,614, October 30, 1883, and 293,220, February 12, 1884, and a satisfactory method of waterproofing and indurating the same in the patent to Carmichael, 267,492, November 14, 1882, reissue 10,282, February 6, 1883.

In machines the main advance has been in the perfecting of the Fourdrinier and the cylinder machines. The strength of the product, the width of the web, and speed of the machine have all been much increased, resulting in a greatly increased and better product.

As illustration of the Fourdrinier type are the patents to Barrett & Horne, 634,228, October 3, 1899; Moore & White, 620,548, February 28, 1899; and Kutter, 654,651, July 31, 1900.

Patents to Keeney, 581,732, May 4, 1897, and Beveridge & Frye, 659,283, October 9, 1900, illustrate the cylinder type. In this class 3,601 patents have been issued. The patent to Parker & Fairbanks, 612,931, October 25, 1898, is worthy of note as showing an apparatus in which a continuous web of paper is passed through a chamber wherein it is dried in a partial vacuum.

Paper Manufactures.—In this class patents have been granted for inventions which mark advances in the arts in bag machines, box machines, label affixers, and wrapping machines.

A patent was granted in 1881, Leinbach et al., 242,661, June 7, 1881, for a machine for making square satchel-bottom paper bags, from which the modern high-speed paper-bag machine has been developed. As an example of such modern machine, see the patent to Stillwell, 407,794, July 30, 1889. In this subclass 465 patents have been issued.

A patent was granted in 1891, Beach, 11,167, reissued May 26, 1891, which may be regarded as a pioneer

patent in machinery for automatically applying stays to the corners of boxes.

Notable types of box machines are that developed by Loyens and Paulson, as shown in patents 556,996, March 24, 1896, 556,997, March 24, 1896, and 557,516, March 31, 1896, and that illustrated in machines for making shucks for match boxes by "refolding," as patents to H. R. Corkhill, jr., 554,987, February 18, 1896, and H. S. Munson, 583,072, May 25, 1897. A machine for making cell cases to be used as egg crates, etc., in which one set of partitions is bent, thrust through slots in a second set at right angles to the first, and then straightened to interlock, was patented to W. E. Williams, December 29, 1896, 573,947. In 1879, Jaeger, 219,949, September 23, 1879, the first patent was granted for a machine for making cell cases. In this subclass 462 patents have been issued.

Various forms of label-affixing devices were patented prior to 1871, and while a substantial advance has been made since that time, such advance is the result of numerous minor improvements. As showing a modern machine, see patent to Cornell, 514,705, February 13, 1894.

The earliest patent for a fruit-wrapping machine was granted in 1886, Rice, 336,823, February 23. A later patent, Williams, 533,516, February 5, 1895, shows a material advance in the art.

Special machines have been developed for making paper tubes of widely differing characteristics and adapted to a great variety of purposes. As the cigarette machine, 565,853, Bonsack, August 11, 1896, and the water-pipe apparatus, 659,437, Dixon, October 9, 1900. Other types of machines are seen in the fireworks tube machine, 647,234, Miller, April 10, 1900, and the apparatus for making electrical insulation conduits, 609,094, Gallinowsky, August 16, 1898. In all of these patents the tubes have a convolute wind, and hence can be made in short lengths only. Machines for forming continuous tubing by a spiral wind are shown in patents 616,044, Wilson and Grimm, December 13, 1898, and 586,054, Noble, July 6, 1897.

In envelope machines the most noteworthy advance has been in machinery for fixing wires or threads in envelopes to serve as convenient means for opening the envelopes. See 566,075, Grube, August 18, 1896, and 635,356, Sheldon, October 24, 1899.

PRINTING.

Printing.—The importance of the art of printing resulted in an early development, and the printing presses of the present day are built upon lines which differ in no radical respect from those of an earlier date. There has been much activity, however, among inventors in improving the various component parts of printing presses.

The modern rotary web perfecting press, by means of which webs are printed, associated, folded, and delivered at high speed in the production of newspapers, may be said to be the combined result of numerous patented improvements upon various mechanisms which go to make up the organized machine. As illustrative of different types of rotary printing machines, see the patents to Crowell, 325,197, August 25, 1885, and Firm, 415,321, November 19, 1889. The speed of the modern rotary perfecting press is limited only by the capacity of the delivering and folding mechanisms, and perhaps the most important improvements in this style of press in late years relate to these parts. Examples of machines for rapidly associating, delivering, and folding the product of the rotary press are found in the following recent patents: Scott, 558,424, April 14, 1896; Potter, 574,493, January 5, 1897; Scott, 655,355, August 17, 1900; North, 664,574, December 25, 1900; Spalckhaver, 671,061, April 2, 1901; Read, 687,268, November 26, 1901.

A new type of machine has been invented, known as the traveling-cylinder machine, which is adapted to print upon continuous webs by means of a cylinder and flat form, and at the same time maintain a high rate of speed. The earliest patent of this type was granted to Kidder, 291,521, January 8, 1884. The patents to Miehle, 574,207, December 29, 1896, and North, 648,984, May 8, 1900, disclose important improvements in bed and cylinder machines.

A patent worthy of mention was granted to Harris & McNutt, 577,405, February 16, 1897, for a rotary printing press which is especially adapted for printing on cards, envelopes, and the like.

There has been much activity in the art of multi-color printing. A single inventor, Mr. Edward Hett, took out, during the years 1899 and 1900, 76 patents for machines and methods especially intended for multi-color work. The salient feature of Hett's invention is an electrolytically deposited printing surface of zinc which can be developed and used like an ordinary lithographic stone. The coating of zinc is deposited upon a permanent base and after having been used can be removed by mechanical or chemical agencies without disturbing the base. The following patents to Hett are referred to: 637,560, 637,561, 637,568, 637,596, November 21, 1899; and 662,854, November 27, 1900.

Other important inventions in this art are found in the patents to Spalckhaver, 627,447, June 20, 1899, and 664,592, December 25, 1900, which show multiple printing couples for printing on a plurality of webs.

Inventors have long been seeking effective means for preventing the off-set of freshly printed ink in printing presses. The following patents disclose recent improvements: Wood, 589,519, September 7, 1897; Bechman, 613,055, October 25, 1898; North, 618,125, January 24, 1899; Crowell, 618,058, January 24, 1899; Pattberg, 639,763, December 26, 1899; Firm, 686,926, November 19, 1901; Roesen, 687,575, November 26, 1901; Miehle, 693,044, February 11, 1902.

Patent to Miehle, 636,826, November 14, 1899, is worthy of note as showing an apparatus wherein the separate sheets as they issue from a printing press are

received on separate trays which are automatically transferred in cycle during the drying operation.

Mail-marking machines existed prior to 1871, but no provision was made for holding the printing mechanism out of operative position in case a letter was not in position to be stamped. Several patents have been granted since the above date for obviating this objection; see the patents to Hey, 408,411, August 6, 1889, and Laass et al., 388,366, August 21, 1888. As illustrative of modern mail-marking machines, see the patents to Ethridge, 521,605, June 19, 1894, and Barry, 511,745, January 2, 1894.

Several address-printing machines illustrating new types have been patented since 1871. A patent was granted April 18, 1876, 176,248, to Slosson, for a machine which prints addresses by means of a stencil. An improved machine of the same type is shown in the patent to Belknap, 551,751, December 24, 1895, and a different style of machine in the patent to Hadley, 449,320, March 31, 1891.

One of the important subclasses under the class of printing is that of setting and distributing. Machines for setting or composing type were quite early developed, but during recent years many improvements have been made upon the details, which render the machines more perfect and accurate in their operation. See, for example, the patent to Dow, 637,858, November 28, 1899. Distributing machines have also been perfected in many important features, as shown, for example, in the patents to Reynolds, 192,281, June 19, 1877; Cox, 578,216, March 2, 1897; Burg, 652,423, June 26, 1900.

Several patents have been granted for type setting and justifying machines in which the operation of the machine is controlled by a perforated pattern strip. These machines, owing to their complicated mechanism, do not admit of brief description. See Lanston, 364,525, June 7, 1887, and Goodson, 530,481, December 4, 1894. The greatest effort in this art, however, in recent years has been to produce machines for justifying. These machines involve mechanism for measuring the composed line, ascertaining its variation from normal length and selecting from a space magazine proper spaces to justify the line or casting, or otherwise making said spaces. Machines for casting spaces to justify the line are disclosed in the late patents to McGrath, 608,997, August 9, 1898, and Berri, 612,010, October 11, 1898.

A machine which selects proper justifying spaces from a magazine is shown in the patent to Ennisson & Honiss, 583,224, March 25, 1897; and a machine for cutting off a proper width of space from a bar of space timber is disclosed in the patent to Johnson, 607,047, July 12, 1898.

The following patents disclose means for justifying lines of type which involve the use of wedges forced into the line at the word spaces, and means for thereafter substituting for such wedges permanent justifying spaces selected from a magazine: Converse, 601,706, April 5, 1898; McClintock, 608,002, July 26, 1898; Dickinson, 633,309, September 19, 1899; and McGrath, 645,512, March 13, 1900.

Another class of machines which has been largely perfected and brought into use during recent years involves the casting of individual types as they are selected by a keyboard mechanism or by a perforated controller strip. Perhaps the best known machine of this class is that invented by Mr. Tolbert Lanston, disclosed in his patent 633,088, September 12, 1899, and in a modified form in the patent to Bancroft, 625,998, May 30, 1899. Another well-known type of machine of this kind is shown in the patent to Goodson, 609,098, August 16, 1898. The patent to Fowler & Fowler, 667,212, February 5, 1901, discloses an organized machine for casting, composing, and justifying, which involves means for casting compressible spaces and justifying the line by compression.

The patents to Gilbert-Stringer, 675,827 and 675,829, June 4, 1901, disclose a somewhat novel departure from the ordinary method of setting up justified lines of type. These patents involve means for composing and justifying a line of matrices somewhat after the manner of the well-known Mergenthaler linotype machine. The wedges used for justifying the matrices are availed of to set a mold for casting justifying spaces. The matrices forming the justified line of matrices are then brought individually to a type-casting mechanism and type cast therefrom. The mold having been set by the justifying wedges will produce proper justifying spaces.

The principal activity in the class of matrix making has been in perfecting variable spacing mechanism and justifying mechanism. Notable examples are found in the patents to Risley & Lake, 620,183, February 28, 1899, and 626,098, May 30, 1899.

Bookbinding.—In the art of bookbinding, machines are now in use which automatically collect the signatures and arrange them in the proper order for binding. The books themselves are prepared for binding by machinery which saws or rasps away the folded edges of the signatures, and the covers are made by machines which operate upon a continuous roll or strip of cloth or leather, cutting it up into proper lengths, pasting the stiff boards thereto, and folding the edges down to complete the work. The following patents illustrate the three classes of improvements just described: 180,103, July 25, 1876, to Averell; 476,208, May 31, 1892, to Lovell and Bredenberg; and 330,303, November 10, 1885, to Durkee and Campbell. See also Smyth, 565,146, August 4, 1896, and Dexter, 588,635, August 24, 1897.

Machines kindred to bookbinding machines have been invented for automatically stapling newspapers as they

proceed from the printing press. The patent to Crowell, 510,528, December 12, 1893, is the first of its kind and thoroughly illustrates the art.

Machines for making and for applying cloth book covers, are illustrated by patents to Jacobs, 580,111, April 6, 1897, and McClellan, 603,406, May 3, 1898.

Improvements in machines for folding and stapling newspapers are indicated by the patents to Dexter, 602,816, April 19, 1898, 618,648, January 31, 1899, 632,448, September 5, 1899, 653,196, July 3, 1900; and Crowell, 612,830, October 25, 1898.

Linotype Machines.—An important invention was made by Mergenthaler for producing cast lines of type, for which he obtained patent 436,532, dated September 16, 1890. In the present Mergenthaler construction there is a magazine containing a series of tubes for the letter or character molds, each of which molds is provided with a single character. There are a number of duplicates of each character and the molds containing the same character are all arranged in one tube. The machine is provided with a series of finger keys which, when pressed like the keys of a typewriter, cause the letter molds to assemble in a line in their proper order for print. A line mold and a melting pot are then brought into proper relation to the assembled line of letter molds and a cast is taken, called the linotype, which represents the entire line, a column wide, of the matter to be printed. The letter molds are then automatically returned to their proper magazine tubes.

The Mergenthaler machine is largely in use in the principal newspaper offices, with the result that a single operator does at least the work of 4 average compositors.

Improvements upon the well-known commercial machine in the last few years have been mainly along lines which adapt it for special work, such as bookwork, tabulating work, display advertisements, and the like. Late inventions which have for their object the improvement of the organized machine are, for example, the patents to Rogers, 678,036, July 9, 1901, and Mergenthaler, 678,268, July 9, 1901. Rogers obtained patent 437,139, September 23, 1890, for a machine for casting lines of type, the principal feature of which is that the letter molds are strung on wires secured in a hinged frame. When the frame is in one position, the letter molds are released by the keys, slide down the wires by gravity, and are assembled in line at the casting point. After the cast is taken, the lower ends of the guide wires are elevated, which cause the letter molds to slide back on the wires to their original storage position, when the operation is repeated for the next line. A later patent thereon is Rogers, 679,481, July 30, 1901.

Another type of linotype machines, called the monoline, has been devised by Scudder, and is shown in patent 506,198, October 3, 1893.

Improvements in rotary linotype machines are disclosed in the patents to Storm, 660,263, October 23, 1900, and Rogers, 613,724, November 8, 1898.

A linotype machine showing means for successively impressing the characters in a metal slug by keyboard mechanism, the slug to be thereafter used as a matrix from which the linotype is cast, is shown in the patent to Johnson, 584,363, June 15, 1897.

Machines which assemble and justify lines of matrices and then impress soft metal slugs which are to be used as matrices from which to cast the linotype, are found in the patents to Dodge, 618,044, January 17, 1899, and St. John, 657,041, August 28, 1900.

A new departure in the art of linotyping is disclosed in the patent to Brott, 694,307, February 25, 1902. This machine casts individual types, assembles them into lines, justifies the lines, and then converts the justified lines into integral bars or linotypes. Another departure from the ordinary construction of linotype machines is disclosed in the patent to Beals, 696,360, March 25, 1902. This patent discloses an organized machine having a plurality of keyboards, a plurality of composing mechanisms, and a single casting mechanism. (See also Printing.)

There have been 326 patents issued in the class of linotyping.

Typewriting Machines.—The forerunner of the modern typewriter of the usual form is the so-called Remington machine. No patent was ever granted on the broad elements of a typewriter, although several hundred patents have been granted of more or less scope on the detailed features thereof. Owing to the intricate and technical nature of the improvements covered by the patents on typewriters, it is impossible, within the scope of this report, to give more than the data of the characteristic patents on this subject. See the following list: Sholes, 207,559, August 27, 1878; Yost, 313,973, March 17, 1885; Yost, 408,061, July 30, 1889; Jenne, 478,964, July 12, 1892; Jenne, 548,553, October 22, 1895; Brooks, 202,923, April 30, 1878; Clough & Jenne, 199,263, January 15, 1878; Spiro, 435,775, September 2, 1890; Brown, 465,451, December 22, 1891; Davidson, 487,047, November 22, 1892; Densmore, 507,726, October 31, 1893; Unz, 400,146, March 26, 1889; Blickensderfer, 472,692, April 12, 1892; Hammond, 290,419, December 18, 1883; Williams, 442,697, December 16, 1890; Webb, 471,710, March 29, 1892; Hall, 238,387, March 1, 1881.

In late years inventors have been unusually diligent in perfecting what is generally known as "front-strike" machines, or machines in which the printed impression upon the paper is visible to the operator without raising the carriage. Examples are found in the patents to Daugherty, 553,153, January 14, 1896; Wagner, 559,345, April 28, 1896, and 633,672, September 26, 1899; and Felbel, 657,927, September 18, 1900.

Recent notable improvements in the class of "understrike" machines are disclosed in the patents to Diss, 607,226, July 12, 1898, and Brown, 616,888, January 3, 1899.

Among the most notable advancements in the art of typewriting during recent years has been the development and perfecting of "book typewriters." The following patents disclose various features of this kind of machine: Fisher, 569,625, 569,627, October 20, 1896; Elliott, 573,081, December 15, 1896, and 615,017, December 29, 1898.

At the present time inventors are actively at work improving what are known in the art as "power typewriters." In this class of machines the operator has merely to touch the key with sufficient force to release latch mechanism, whereupon power from some external source completes the impression. Examples of this class of machines are: Selden, 557,239, March 31, 1896; Blickensderfer, 656,085, August 14, 1900; and Allen, 684,163, October 8, 1901.

Many improvements have been made in recent years in electrical typewriters, examples of which are: Davis, 560,572 and 560,573, May 19, 1896; and Cahill, 566,442, August 25, 1896, and 604,001, May 10, 1898. In this class of machines the impression mechanism is operated by magnets, the circuit being closed by the operator touching the key. The Cahill patents also disclose a permutation system of type-selecting means, which involves fewer keys than the ordinary keyboards of typewriters, the combination of two or more keys being required to operate a single type bar.

In the class of typewriters 1,856 patents have been issued.

In connection with typewriters there have been invented inking ribbons, single and manifold. The first typewriter ribbon was patented in 1886 by Anderson, 349,026, September 14, and the first inking ribbon for manifolding was patented in 1888 by Wortman, 376,764, January 24.

SEWING MACHINES.

Sewing Machines.—The vast majority of patents, within the period under consideration, are of the nature of specific improvements upon generic inventions in use prior to said period, and for machines for special work. In this class 7,285 patents have been issued.

High-speed, power-driven machines, making from 2,500 to 4,000 stitches per minute, have been brought into extensive use. Improvements to this end have been directed to the various parts of the stitch-forming mechanism—the needle-actuating mechanism, the loop-taker, the feeding mechanism, and the take-up and tension devices. Patents to Willcox et al., 603,988 and 603,989, May 10, 1898; to Diehl & Grieb, 663,673 and 663,696; and to Diehl, 663,807 and 663,808, December 11, 1900, are instances of such improvement.

The art of sewing buttons to fabrics has been greatly facilitated by such special machines as that shown in patent to Morley, 236,350, January 4, 1881, a machine which, supplying itself with buttons from the hopper, automatically lays the button upon the fabric and stitches the same in the place upon which it is to be secured.

In buttonhole work perhaps the most important are those shown in patents to Reece, 240,546, April 26, 1881; Reece, 349,359, September 21, 1886; Reece, 544,827, August 20, 1895. These machines mark an important departure, which consists in working the eyed buttonhole by moving the stitch-forming mechanism about the buttonhole instead of moving the fabric in which the buttonhole is to be wrought about the stitch-forming mechanism. There are many other patents, however, showing machines for doing in substance the same class of work. Six hundred and sixty patents have been issued in this subclass.

Patent to Curtis, 639,216, December 19, 1899, shows a machine for sewing the mouth of a filled bag of the modern Timewell type, such as illustrated in patent to Timewell, 562,438, June 23, 1896, wherein the sack-holder has a forward traveling movement past the stitching mechanism. Patent to Miller, 618,798, January 31, 1899, shows a broom-sewing machine which comprises means for automatically starting the stitching mechanism by the positioning of the broom-holding vise and also controlling the stitching mechanism by means of the same vise. Patent to Gammons, 555,479, February 25, 1896, shows a specialized two-needle machine for sewing a sweatband into the hat body. Patent to Kursheedt et al., 591,079, October 5, 1897, shows a mechanism for automatically feeding and stitching spangles to a foundation fabric and means for controlling the line of direction of the stitch. Patents to White, 619,375, February 14, 1899, and Von Bültzingslöwen, 638,004, November 28, 1899, each show mechanism for automatically inserting shirring strings into one end of a tubular incandescent-mantle blank.

Patent to Hatch, 629,074, July 18, 1899, shows a new type of device for threading lace or ribbon into the cross-barred edgings of garments, comprising a tape-carrying needle or bodkin having a pivoted head and means on said pivoted head which direct the point upward and downward in alternation as the needle is advanced.

Certain machines such as shown in patents to Palmer, jr., 308,982, December 9, 1884; Koch, 456,727, July 28, 1891; Palmer, 541,625, June 25, 1895, show a type of machine devised for stitching quilts by means of gangs of needles under the control of pattern cams. There have been 214 patents issued in this subclass.

Embroidering.—Patents to Irish, 348,562, September 7, 1886; Smith, 377,408, February 7, 1888; Irish, 407,352, July 23, 1889; Willcox et al., 435,876, September 2, 1890; Groebli, 528,632, November 6, 1894, illustrate mechanisms for producing embroidered fabrics. These machines build, upon a foundation fabric, out of threads carried by the needles, any and all patterns. In the patent to Smith the control of the needles is secured under the direction of the operator by a pneu-

matic means operating over a perforated cardboard. In the Irish machines the operative force is electrical. While these machines are complex, the product marks the latest advances in the art of embroidering.

Patent to Parkes, 652,326, June 26, 1900, shows a machine for automatically stitching or embroidering doilies, centerpieces, etc., comprising mechanism for moving the work circularly and at the same time automatically changing the relative positions of the needle and the fabric on lines at right angles to the circular path of movement. There have been 317 patents issued in this subclass.

Shoe-stitching Machines.—Patents to French et al., 412,703, October 8, 1889; French et al., 473,870, April 26, 1892; Eppler, jr., 447,872, March 10, 1891; Eppler, 533,639, February 5, 1895; Collyer, 546,695, September 24, 1895, show the most perfected forms in which to sew uppers to the soles of boots and shoes. Collyer secures the upper to the last by means of sewing threads instead of tacks.

STATIONERY.

In this class is included a great variety of small articles of manufacture, the most important of which perhaps are pencil sharpeners and fountain pens.

In the former class Lord, 575,964, January 26, 1897; Wheeler, 620,862, March 7, 1899; Buchelew, 636,112, October 31, 1899; and Cook, 652,286, July 10, 1900, show machines in which a rotating cutter is employed and the pencil to be sharpened rotated in contact therewith.

In fountain pens the difficulties to be overcome have related to the means for controlling the flow of ink and the supply of air and means for filling the pen.

Couper, 602,829, April 26, 1898, and Rogers, 566,938, September 1, 1896, each shows means for filling a pen by means of a piston. Minich, 562,842, June 30, 1896, shows a flexible wall in the ink reservoir with means for pressing it to force the ink to the pen. Boman, 610,428, September 6, 1898, shows a removable feeder, facilitating cleaning of the pen.

Wirt, 651,735, June 12, 1900, and Waterman, 607,400, July 12, 1898, show examples of improved feeding means for controlling the flow of the ink to the pen; while McKee, 646,127, March 27, 1900, and Robinson, 631,823, August 29, 1899, show valves for this purpose.

TEXTILES.

Carding.—The art of carding and combing is so well developed that further marked novelty in invention seems improbable. The details of carding and combing machines are, however, subject to constant improvement, and the aggregate advance since 1896 is doubtless important. The patents 611,108 and 611,109, to Drury, and 682,806, to Midgely, are, however, for types involving a wide departure in carding machines for their particular purposes.

Cordage.—An important invention is the knot-tying implement for spoolers, which is mounted upon the hand of the operative; Colman, 672,636, April 23, 1901. It is used to tie in warps or in any other place where the threads are frequently broken and must be tied. It is an exceedingly useful and practical device which enables a spooler using it to make an addition of at least a dollar per week to his wages.

The making of a cheap binder twine for harvesting machinery has occupied the attention of inventors in this art for many years, but an economical production of a grass twine for this purpose was unsuccessful until the improvements by G. A. Lowry. By placing the straws parallel in a feed box or hopper, drawing out a few strands of the straw lengthwise by an automatic nipper or series of nippers, twisting the drawn-out straws together into a strand, and binding or wrapping the strand with a light twine or thread, he has obtained a very satisfactory product. See patents to Lowry, 654,991, July 31, 1900, and 689,949, December 24, 1901.

A further development of this art by producing a grass twine without the wrapping or covering thread, by interlapping and twisting together unretted, unhackled cortices of flax straw, and treating the twine so formed with oil or coal tar, either of which renders the twine approximately proof against decomposition or insect attack, has been patented by G. H. Ellis, 679,694 and 679,695, July 30, 1901.

Spinning.—In the art of spinning advances of the most important character have been made since 1871, and especially is this true in spindle structures. Prior to this date the average speed of a spindle was limited to about 5,000 revolutions a minute, while to-day it is limited only by the speed with which operatives can make good piecings of broken yarn, and as high as 20,000 revolutions a minute have been secured with reasonable steadiness. This result was accomplished about 1878, when the bolster supporting the spindle was made capable of yielding by a device shown in patent to Birkenhead, 205,718, July 9, 1878, and was further perfected about 1880, when the bolster was placed loosely in a bolster case of slightly larger diameter than the bolster. Patent to Rabbeth, 227,129, May 4, 1880, shows this.

In the new type of ring spinning machines the ring is usually supported in a casing and is dragged around by the traveler. In the operation the ring and traveler rotate as one, with the ring directly out of contact with the casing, since it revolves somewhat on the principle of the gyroscope, and is supported by the tension of the yarn. This improvement is the invention of Victor Belanger, of Marshfield, Mass., and was patented January 2, 1900, 640,525. In this class 3,123 patents have been issued.

Knitting and Netting.—In the art of knitting, inventions of the most important character have been made during the last twenty-five years. These inventions

have been in the direction of producing automatic power machines, capable of turning out a complete article, needing but little finishing, and at a cost commercially practicable. Circular machines were devised as early as the year 1859, patent to Colvin, 24,284, June 7, 1859, but they were very crude and did not go into general use. Nothing of importance was done in this class of devices until 1879, when Shaw invented a machine which not only embodied in a practicable form the desirable automatic operation above referred to, but contained provisions by which at proper points a splicing or reinforcing thread could be introduced and removed; for this he obtained patents 218,458, August 12, 1879, and 228,480, June 8, 1880. Since 1879 a long series of important steps have been taken in this class of devices, as shown by the following patents: To Aiken, 324,795, August 25, 1885; Kilbourn, 408,180, July 30, 1889; Cathcart, 410,071, August 27, 1889; Mayo, 461,357, October 13, 1891; King, 479,986, August 2, 1892; Franck, 502,292, August 1, 1893; Burleigh, 537,802, April 16, 1895.

Many fabrics of new kinds, or anciently made on hand-operated reciprocating machines not very different from the early "stocking loom," are now made on rotating automatic machines, effecting a greatly increased economy of labor and time. This is particularly true of the manufacture of seamless hosiery in a nearly complete state. See the patents to Huse, 589,174; Scott, 607,002; Hemphill, 629,503; Lasher and Beach, 632,872; Clark, 638,096; Houseman, 694,382; and Scott, Williams, and Swinglehurst, 697,555.

The prevailing fashions have caused great activity in the invention of machines for knitting open-work hosiery, of which machines the patents to Steber, 646,474; Houseman, 654,347; Brown, 642,579; Ellis, 697,078; and Blood, 674,667, show typical instances.

Improvement of the flat-bed or straight knitting machines of the Lamb and Cotton types continues. The patents to Wilcomb, 654,695, and Boessneck, 658,826, are typical instances of highly developed machines in this class.

The following patents are typical of advance in knitting ribbed and striped fabrics: Rice, 604,638; Williams and Swinglehurst, 604,646; Hurley, 607,798; Wildman, 613,346; McGenniss, 616,344; Houseman, 640,769; Scott, 676,372; Wilcomb, 685,075; and Hirner, 698,499. One thousand nine hundred and eighty-six patents have been issued.

Weaving.—The beneficent effects of this class of inventions since 1871 are attested by the wonderful and continuous reductions in cost to the consumer of all kinds of textile fabrics made possible by the perfections attained in loom construction and labor-saving devices. Prominent among these are the inventions in the loom for weaving plain fabrics; patents to Northrop, 454,810, June 23, 1891, 529,943, November 27, 1894; and Draper, 536,948, April 2, 1895. This loom, as usual, employs a single shuttle, but as the weft becomes exhausted another bobbin is automatically supplied to the shuttle without stopping the operation of the machine.

The patent to Chace, 633,976, September 26, 1899, shows a construction in which the failure of the weft is detected, and such detection utilized to bring about a closing of an electric circuit, whereby the replenishing devices are set in operation.

The patents to Northrop, 648,986, May 8, 1900; Moore & Clark, 674,632, May 21, 1901; Roper and Draper, 678,284, July 9, 1901; Roper, 678,321, July 9, 1901; and Northrop, 685,563, September 10, 1901, show improvements of the original Northrop loom.

The Chace looms, as well as the Northrop and other looms above referred to, effect the transfer of the bobbin without the loss of a pick, but it has been found necessary in such looms to reduce the speed to about 170 picks per minute in order to effect a transfer of a new bobbin to the shuttle, together with the ejection of the spent bobbin. Harriman in 1899, produced a series of looms designed to enable a weft-replenishing loom to be operated at a higher rate of speed and at the same time permit the correct operation of the replenishing devices. The looms of Harriman normally operate at a speed of 200 or more picks per minute, and when replenishment becomes necessary the speed is reduced so that the replenishing devices operate while the loom is running at the rate of perhaps 100 picks per minute; see the patents to Harriman: 626,834, June 13, 1899; 636,228, October 31, 1899; 637,113, November 14, 1899; and 639,975, December 26, 1899.

Wyman, 665,845, January 8, 1901; Baker and Kip, 671,202, April 2, 1901; and Smith, 692,934, February 11, 1902, show weft-replenishing looms having drop shuttle boxes, thus enabling this very desirable improvement to be applied to the production of fabrics woven in colors.

There has been great activity in the line of warp stop motions for looms, and in recent years a large number of patents on applications of electricity to such stop motions have been issued.

During the year 1895 the first loom for weaving an open-mesh cane fabric having diagonal strands was invented. Patents to Morris, 549,930, and to Crompton, 550,068, November 19, 1895, were obtained for this. Prior to this time two distinct machines were necessary to produce this fabric, and the operation was slow and expensive. Between 1893 and 1895 two machines were invented, upon either of which the well-known Turkish carpets can be woven. Patents to Youngjohns, 510,755, December 12, 1893, and to Reinhart von Seydlitz, 533,330, January 29, 1895, disclose this. The drawing of warp threads into the eyes of the heddles and through the reed of a loom requires great skill, and prior to 1880 was performed by hand at great expense. In 1882, however, a machine for doing this was invented, thereby dispensing with the old hand method and cheap-

ening the operation. Patents to Sherman and Ingersoll, 255,038, March 14, 1882, and Ingersoll, 461,613, October 20, 1891, were granted for this machine. The class is credited with 4,999 patents.

Cloth Finishing.—As fabrics are taken from the machines upon which they are woven, the body and surface thereof present a rough and harsh feel and render the fabric unfit for use. To overcome these objections, especially in that class of fabrics known as napped surface, the energies of inventors have been principally directed, resulting in the year 1886 in the production of the planetary napping machine, patent to Ott, 344,981, July 6, 1886, whereby the finished napped surface could be given quickly, and yet with delicate adjustment. The full development is found in the planetary machines of 1892 and 1895, patents to Grosselin, 485,929, November 8, 1892, and 536,516, March 26, 1895.

WOOD WORKING.

Coopering.—In this class 885 patents have been granted. For a barrel-stave machine, see patent to Philbrick, 362,901, May 10, 1887. For a barrel-making machine, see the patent to Wiegand, 437,408, September 30, 1890. For a barrel-head machine, see patent to Reed, 467,629, January 26, 1892. For a machine for making fruit baskets, see patents to Horton, 530,048, November 27, 1894; 680,149, August 6, 1901; and Mergenthaler, 690,322, December 31, 1901. Recent tub-crozing machines are patents to Haines, 654,822, July 31, 1900, and Vogel, 654,296, July 24, 1900.

Wood Sawing.—In this class 4,935 patents have been granted. A saw which planes as well as severs is shown in the patents to Douglass, 431,510, July 1, 1890, and 542,630, July 16, 1895. Steam-power mechanism for operating knees is shown in the patent to Wilkin, 317,256, May 5, 1885. Jar-absorbing mechanism for hand-operated knees is shown in the patent to Cunningham & Mueller, 407,334, July 23, 1889. Means for supporting the last thin portion of a log are shown in the patent to O'Connor & Donovan, 537,708, April 16, 1895. Means for offsetting are shown in patents to Gowen, 383,460, May 29, 1888, 401,945, April 23, 1889; Hinkley, 368,669, August 23, 1887. For patents showing direct steam position or shotgun feed, see Prescott, 8,160, reissued April 9, 1878. Means for quarter sawing in both directions of log travel are shown in the patent to Gray, 550,825, December 3, 1895; Dees, 555,037, February 18, 1896, shows twin carriages from one to the other of which the quarter section of the log is alternately tipped in its forward and backward travel past oppositely toothed saws cutting in the same plane; Davidson, 561,569, June 9, 1896, in which apex-united cone rollers feed the log to a gang of saws; Allen and Jones, 606,041, June 21, 1898, shows two carriages with alternate tipping of the log and a circular saw and special placing gauge; McDonough, 633,028, September 12, 1899, uses horizontal and opposite vertical feed rollers alternately shifted step by step toward each other—the log section being tipped from side to side—with a band saw.

For means to operate log turners and log loaders, see patents to Hill, 496,938, May 9, 1893, 466,682, January 5, 1892, 526,624, September 25, 1894; Kelly, 497,098, May 9, 1893. For a self-cooling circular-saw shaft, see patent to Jenks, 193,004, July 10, 1877. A shingle sawing machine involving a rotating compartment wheel and two saws is shown in patents to O'Connor, 358,474, March 1, 1887, 292,347, January 22, 1884; Perkins, 380,346, April 3, 1888. Means for severing veneer spirally, dividing it into and shaping staves are shown in patents to Hayne, 509,534, November 28, 1893. Means for balancing band-saw shaft are shown in the patent to Prescott, 369,881, September 13, 1887. A band-sawing machine having two reverse band saws is shown in the patent to Cook, 321,194, June 30, 1885. The application of a steam engine to operate the set works of a sawmill carriage governed by a positive stop and liquid cushion is shown in patent to Barker and Corry, 608,018, July 26, 1898.

Wood Turning.—In this class 784 patents have been granted. An irregular form lathe, with adjustments, is shown in patent to Kimball, 471,006, March 15, 1892. A polygonal form lathe is shown in patent to Merritt, 504,812, September 12, 1893. A multiple lathe is shown in patents to Albee, 429,297, June 3, 1890; Aram, 550,401, November 26, 1895. For a tubular lathe, see patent to Lenhart, 355,540, January 4, 1887. For a spiral-cutting lathe, see patent to Mackintosh, 396,283, January 15, 1889. Pringle and Brodie, 630,928, August 15, 1899, provide for successively shaping and severing collar buttons from the ends of a plurality of rods. Many spindle lathes, carried in a circular path around, but eccentric to, a cutter head with shaping knives, are disclosed in patents to Topping, 572,726, December 26, 1896, and Elder and Kelly, 569,488, October 13, 1896. Patent to Reed, 580,531, April 13, 1897, involves a machine for turning lasts by alternate chucking by spindles and grasping by the body part in order to fully turn the heel and toe.

Wood-working Machines.—In this class 6,973 patents have been granted. For a sash-stile, pocket-cutting machine, see patent to Phillips, 548,454, October 22, 1895. A machine for dovetailing box blanks in stacks is shown in the patent to Morgan, 517,705, April 3, 1894. A machine for pointing skewers is shown in patent to Berst, 483,205, September 27, 1892. An example of a planer and matcher is shown in patent to Woods, 364,743, June 14, 1887. An automatic clothes-pin-making machine is shown in patents to Senate, 323,453, August 4, 1885; Hall, 513,572, January 30, 1894. A machine for scooping out wooden trays is shown in patent to Smith, 276,198, April 24, 1883. A machine for spirally severing veneer is shown in patent to Ellis, 390,289, October 2, 1888. Machines for sever-

ing and packing toothpicks are shown in patents to Scamman, 521,734, June 19, 1894, and 521,736, June 19, 1894. A machine for making matches complete from wood is shown in the patent to Beecher, 389,435, September 11, 1888; one for making them from tapes is shown in the patent to Young, 538,888, May 7, 1895.

Lebe, 587,130, July 27, 1897, contemplates the conversion simultaneously of a large number of blocks into strips laid into built-up racks and severed into splint lengths preparatory to dipping; Eisenhart, 643,047, February 6, 1900, unrolls a log into a veneer, divides the veneer into splints, inserts the splints into a dipping carrier chain, and discharges complete matches into boxes made from pasteboard sheets and closed by appropriate mechanism.

For a machine to box matches, see patent to Palmer, Denmead & Baughman, 538,535, April 30, 1895. For a machine for the multiple reproduction in duplicate of carving, see the patent to Smith & Post, 443,802, December 30, 1890. For a pattern-controlled shaping machine, see patents to Goehring, 394,763, December 18, 1888; Gray, 134,596, January 7, 1873. For a machine to cut bungs, see patents to Boeklen, 135,196, January 28, 1873; Bachelder, 164,251, June 8, 1875; and for a machine to cut corks, see patent to Dodge & Weaver, 374,891, December 13, 1887. For an umbrella-stick cutting, boring, and slotting machine, see patent to Brown & Walton, 466,321, January 5, 1892. For a floor-board boring machine, see patent to Sherman, 515,506, February 27, 1894. A multiple brush-block machine is seen in patent to Shaw & Ditchfield, 471,709, March 29, 1892. A chair-leg boring machine is shown in patent to Parker, 250,167, November 29, 1881. An endless chain mortising machine is shown in patent to Douglas, 379,566, March 20, 1888. For mortising augers, see patents to Oppenheimer, 10,655, reissue October 27, 1885, and Charlton, 461,666, October 20, 1891. For an automatic screw-driving device, see patent to Briggs, 529,701, November 27, 1894. For the same, and a washer-setting machine, see patent to Tobey, 480,530, August 9, 1892. For a box-nailing machine, see patents to Foster, 309,297, December 16, 1884; Edwards, 482,866, September 20, 1892; Jones & Blundell, 542,768, July 16, 1895; Brock, 230,230, July 20, 1880; Rosback, 608,917, August 9, 1898, and 625,958, May 30, 1899; and Stuckenberg, 659,772, October 16, 1900. For a machine to nail baskets, see patent to Doig, 549,348, November 5, 1895. For a box-blank wiring machine, see patent to Knudtson and Uhri, 518,038, April 10, 1894. Patent to Rosback, 609,630, August 23, 1898, by special feed device, carries box-blank material made up of sheets, cleats, and strengthening wires, past cutters, and saws which cut stepped grooves in its face.

For a machine to apply slats to canvas, see patent to Kingwill, 453,176, May 26, 1891. For a machine to glue boxes, see patent to Richardson, 350,943, October 19, 1886. For a machine to glue slate frames, see patent to Shepherd, 312,391, February 17, 1885. For a machine to glue veneer and cloth, see patent to Oncken, 512,211, January 2, 1894. For a machine to bush mortises, see patent to Wright, 470,276, March 8, 1892. For a machine to cover piano hammers, see patents to Koeniges, 493,274, March 14, 1893, and Dolge, 361,144, April 12, 1887. Patent to Durant and Prichard, 606,223, June 28, 1898, describes the reduction of bamboo stalks in cross section by forcing them through a heated tapering die. In Pomeroy and Larsson, 649,678, May 15, 1900, is described a machine for dividing rattan stalks into tapering V-shaped sections by a succession of cutting operations. Patent to Shimer, 11,617, reissued June 25, 1897, shows a cutter head having trapezoidal faces giving the cutter blade a diagonal or spiral action.

INSTRUMENTS OF PRECISION.

Many of the arts in this class are comparatively new and have been practically begun within the last thirty years.

Patent 626,609, June 6, 1899, Guillaume & Dumas, relates to an alloy of five parts of iron and three parts of nickel, whose coefficient of expansion is only one-tenth that of glass, and for this reason is well adapted for use in instruments of precision.

Calculators.—The recent advance in this art seems to have been in the way of details and grouping of elements. In the new machines the total of the figures in a column is printed at the bottom and again at the top of another column on the same sheet or of another sheet, the succeeding figures being added to the former total if desired. Devices have also recently been added which prevent the operation of the keys a predetermined distance from the bottom of the sheet of paper, thus avoiding the possibility of running off the sheet. Felt, 568,021, September 22, 1896, and Hiett, 638,118, November 28, 1899, are illustrative of these improvements.

Cyclometers.—This art is intimately connected with bicycles. The most popular cyclometers are small devices which indicate to a rider at any time the rate at which he is riding and the number of miles ridden. The patents to Hastings, 537,824, April 23, 1895; Hilliard, 508,941, November 21, 1893; Loew, 537,896, April 23, 1895; and Veeder, 548,482, October 22, 1895, fairly represent the different types of these instruments. A second type of speed measures includes that class of devices designed for use principally upon street cars and intended to indicate to the passengers the rate at which the car is traveling, and to sound an alarm, put on the brakes, or automatically reduce the power employed in case a certain limit of speed is exceeded. The increased demand for these devices has been created by municipal legislation defining the limits of speed which may be lawfully employed. Patents to Darley, 539,381, May 14, 1895; Blumenstein et al., 550,775, December 3, 1895; and Phillips, 473,341, April 19, 1892.

Horology.—In this class 3,196 patents have been

granted. The rapid growth of the watch industry followed the manufacture of watches of fair accuracy and low price, and this in turn resulted from the use of modern machinery in their making. Patent 204,000, May 21, 1878, Buck, is an early illustration of the present cheap commercial watch. The stem-winding watch in a crude form was patented in England about the middle of the last century. Patent 280,719, July 3, 1883, to Church, is a type of the present form.

The main trend of invention in this art is the improvement of electric clocks and time-operated valves and dampers. The electrically operated clocks are not only kept wound as long as the battery lasts, but are once a day automatically set to proper time by a connection through the telegraph lines with the Observatory at Washington. Patents to Gardner, 287,015, October 23, 1883; Gregory, 550,090, February 25, 1896; and Fischer, 595,911, December 21, 1897, fairly illustrate this art. The time-operated mechanisms are intended to turn on and off gas in cities at the proper time, automatically operate stock-feeding devices, turn on and off stove or furnace dampers and electric-light switches, etc. The patents to Schmidt et al., 611,822, October 4, 1898; Gunning, 631,522, August 22, 1899; and Kellogg, 591,169, October 5, 1897, fairly illustrate the recent advance in this art.

A device for keeping an account of the time employees are actually present is shown in patent 453,230, June 2, 1891, to Bundy. Workman's time recorders have been notably improved by the addition of a machine patented by Giroud, October 23, 1900, 660,250, in which each time the time-printing mechanism effects the printing operation upon a removable record card a part is cut from such card to form an abutting shoulder to properly align the card for the next succeeding time impression. These devices have been improved also by the machine of J. and A. Dey, patented March 28, 1899, 621,994, such machine involving improvements in automatically shifted time-printing wheels.

Registers, Cash and Fare.—In this art 1,326 patents have been granted. The first of these, in time of invention, are the fare registers, which are intended to compel conductors to report in some manner the number of passengers carried. The patent to Hornum, 165,829, July 20, 1875, shows the first disclosure and the gradual development of the registers which would indicate two or more varieties of fares, e. g., a ticket fare, a transfer, and a cash fare. The patent to Fowler, 185,740, December 26, 1876, illustrates a fare register primarily different from the Hornum register in the manner of resetting the register to zero at the end of each trip, and first discloses and shows various improvements on what is technically known as the trip's register.

Fare registers have been notably improved by the machine patented by Honis, September 8, 1896, 567,315, in which a record upon a record strip, inaccessible to the conductor, is made at the end of each trip of the total registration made, thus dispensing with the usual hand-marked record card. On this strip is also printed the number of the car or register, thus distinguishing each record from the others, and the direction of the trip is also printed upon the strip.

The machine of Rein, patented May 2, 1899, 624,091, is also an improved device in this class of inventions, in which a record of different kinds of fares, as tickets and cash fares, is printed upon the conductor's card, and the machine is so arranged that before a conductor can remove his card from the register at the end of a trip or a period of time, he must print the condition of the recording register upon his card, and before the machine can be operated by his successor, he must insert his card and print the condition of the register upon his card, which must be the same as upon the card removed by his predecessor.

The cash register is intended to compel honesty on the part of retail salesmen by requiring them to keep records of every sale made, and is, consequently, a check upon the amount of money returned by them. Distinct types of each cash register now put upon the market are fairly represented by the following patents: Lockwood, 500,919, July 4, 1893; Cook, 448,937, March 24, 1891; and another type is shown in the patent to Carney, 497,860, May 23, 1893.

Among the more important of the later patents may be mentioned 570,141, to McCormick, the first patent on the Hallwood cash register; 616,866, to Bockhoff, on the cash register with a separate drawer for each clerk; 618,932, to Dement and Bassett; 653,626, to McAneny; and 658,828, to Brandt, on different types of change-making machines.

Scales.—In this art 1,209 patents have been granted. A great effort has been made to produce a spring weighing scale which will accurately and automatically show not only the weight, but the total price of the goods weighed, the price per unit weight being known. The practical difficulty to be overcome is inaccuracy of the machine caused by friction between its movable parts. Patent 542,969, July 16, 1895, to Swift, illustrates a typical scale of this class. The type of price scales illustrated by the patent to Swihart, 575,077, January 12, 1897, in which the fulcrum of the weigh-beam is shifted in accordance with the rate per unit of weight, has been perfected. Fuller, 603,505, May 3, 1898, is worthy of note as illustrating a line of improvement along which invention has been active.

Another class of weighing machines in which inventors have been active are those which are constructed to weigh automatically and accurately and register the weight of large masses of material, such as grain, coal, cottonseed, and the like. This style of machine is illustrated in the patent to Richards, 535,729, March 12, 1895, and 572,067, November 24, 1896, and it is marked by a construction in which more than enough material is supplied to the weighing receptacle to bring the weighbeam to a poising position, the excess being

discharged from the receptacle automatically until a poise is effected. The type of weighing machine in which the grain is first measured or weighed in gross, so as to get a load approximating that necessary to balance the scales before the precise weighing operation proper is begun, has been so improved as to be brought in favor. This type is illustrated by the patent to Richards, 570,303, October 27, 1896, and Watson, 633,675, September 26, 1899.

The patent to Ozias, 648,289, April 24, 1900, shows means for automatically compensating for variations in temperature in the indications of a spring balance; and the patents to McGarvey, 633,471, September 19, 1899, and to Vernon & Ross, 638,893, December 12, 1899, are worthy of note as illustrating means for communicating the indications of weighing scales to a distant point.

Testing Machines.—The patents to Dudley, 628,928, July 18, 1899, and 651,136, June 5, 1900, are worthy of mention as showing means for studying the stress to which the rails of railways are subjected while traversed by moving trains. The patents to Atwood, 607,819, July 26, 1898, and 624,151, May 2, 1899, illustrate apparatus for determining the mean effective pressure of the steam in steam engines. The patent to Lawther, 634,007, October 3, 1899, illustrates a new type of lubricant-testing machines.

Voting Machines.—In this subclass 219 patents have been granted. Voting machines designed to overcome some of the difficulties heretofore experienced in conducting elections, first, by obviating the necessity of printing ballots; second, by preventing the possibility of fraudulent balloting; and, finally, by furnishing the results of an election as soon as the polls are closed, are shown in patents to Myers, 415,548, November 19, 1889, constituting one fairly developed type; patent to Davis, 526,668, September 25, 1894, represents another similar type; while the patent to Davis, 534,239, February 12, 1895, represents a different type.

The machines that illustrate notable advance in recent years have been those designed to permit the return of a key improperly operated and the subsequent actuation of the correct one. The counters of the new machine are not operated as the key is operated, but the key only sets the counter to be operated, and as the voter leaves the voting booth the booth door completes the operation. Improvements on the interlock—i. e., the mechanism preventing the operation of more than the prescribed number of voting keys—also characterize the marked advance in this art. Gillespie, 628,792, July 11, 1899, and Dean, 636,730, November 7, 1899, are good types of these machines.

MUSIC, FINE ART, AND OPTICAL INSTRUMENTS.

Music.—In the class of music a new instrument, the autoharp, has been developed, having bars arranged transversely across the strings, and provided with dampers which, when depressed, silence all the strings except those producing the desired chords. An ingenious musical instrument of the class having keyboards like the piano or organ has been recently invented. All keyboard instruments in ordinary use produce tones that are only approximately correct in pitch, because these must be limited in number to twelve to the octave, while the tones of the violin are absolute or untempered. The improved instrument produces untempered tones without requiring extraordinary variations from the usual arrangement of the keys. Self-playing musical instruments have been known for more than forty years, but it is within the past twenty-five years that devices have been invented for controlling tones by pneumatic or electrical appliances to produce expression. Examples of the three kinds of musical instruments named may be found in the following patents, respectively: 257,808, May 9, 1882, to Zimmermann; 443,305, December 23, 1890, to Tanaka; 222,030, November 25, 1879, to Gally.

In 1896 an instrument was invented which plays any one of a number of tunes at the will of an operator, the machine automatically removing one tune sheet or disk from its playing position and placing it in its own compartment of a receptacle, selecting another tune sheet from the receptacle, placing it in operating position and playing a tune; the operator only moving a pointer to indicate the piece of music he desires to hear. See patent to Brachhausen, 596,393, December 28, 1897.

A marked advance has been made in the last few years in piano keyboard players or "pianolas." The aim has been to give to the automatic instrument a possibility and range of expression previously obtained only by the human hand. Besides devices for obtaining crescendo, diminuendo, forte, and pianissimo effects, an important feature has been the emphasizing or accentuation of the theme by striking certain keys with greater force than others. This class of invention is illustrated by the patents to Crooks, 663,118, December 4, 1900, and Salyer, 653,263, July 10, 1900. Electrically operated pianos and pianos analogous in purpose have come into general use during this period. The patent to Davis, 606,279, June 28, 1898, is typical.

Of a totally different type is the instrument of Cahill, 580,035, April 6, 1897. In this, electrical vibrations are produced of frequencies corresponding to the notes of a musical scale; these vibrations are combined by keyboards to correspond to chords made up of notes of any desired quality and collected on a wire and are then transmitted thereby to a number of loud-speaking telephones, so a piece of music played at a central station, but inaudible at that point, is distributed over a city.

In wind instruments sundry improvements in details have been made, while a new departure has been made in transformers for changing the pitch of clarinets, etc. The inventor partly fills the bore by a rod or sleeve, without affecting the finger holes. See patents to Oliveri, 570,647, November 3, 1896, and 583,077, May 25, 1897.

Phonographs.—In this art 353 patents have been issued. The phonograph art, including an active line of inventions, may be said to have had its origin in 1877. On February 19, 1878, the patent to Edison, 200,521, was issued. Probably the greatest advance in the art has been the cutting of the record in a solid body (see patent 341,214, May 4, 1886, to Bell & Tainter) instead of indenting it by means of the vibratory style. By means of this improvement permanent and accurate records are made, and the phonograph is put to many practical uses to which it was not adapted before said improvement.

Engraving Machines.—In the fine arts a machine and method have been produced which reproduce a picture telegraphically at any distance. A picture in relief is first made by the swelled gelatin or other process; a tracing point is then moved in parallel lines across the undulating surface of the picture, and movements of the tracer are imparted by suitable electrical apparatus to a cutter or engraving tool. Amstutz, 448,404, March 17, 1891, has the first patent in this art.

The method of engraving described by Amstutz in patent 569,595, October 13, 1896, enables an operator to produce in a few minutes from a swelled gelatin photograph a plate ready for the printing press.

Miscellaneous.—In painting, the air brush is an instrument for spraying paint, and was first intended as an artist's appliance; more recently a similar device has been used in painting large buildings. See patent to Church, 487,606, December 6, 1892. The first air brush was patented to Curtis, 248,579, October 25, 1881.

In the manufacture of lead pencils paper has been substituted for wood to a considerable extent. The lead or crayon is covered with slitted or creased paper spirally rolled. Pencils are also now made with a number of short sharpened marking leads or crayons, arranged in series and adapted to be projected one after the other as fast as worn away. The patent to Blaisdell, 461,911, October 27, 1891, covers a pencil of the first description, and that to Goldsmith and Burt, 512,954, January 16, 1894, covers the second.

The attention of inventors of theatrical appliances has been especially directed to improving devices for producing illusions; thus, the old racing machine has been perfected by the inventions used in the chariot race in "Ben Hur" and described in the patents to Hagen, 653,997, July 17, 1900, and 656,969, August 28, 1900; and Tower, 666,714, January 29, 1901; and the illusion of fire has been perfected by the waving sheets of silk strongly lighted, invented by Carter, 662,708, November 27, 1900.

Other marked improvements in this art relate to the production of duplicate records. An example of such improvements is found in the celluloid record of Lambert, patented March 20, 1900, 645,920. The series of push-button, selective, multiple-record graphophones patented by Gomber, October 16, 1900, 659,737, 659,738, and 659,740, form another interesting group of improvements.

In the acoustical art among the most interesting recent inventions is the telegraphone patented by Poulsen, November 13, 1900, 661,619, which is a magneto-electric-sound reproducing machine in which a traveling steel record surface is magnetized in spots in accordance with the degree of intensity of sound waves transmitted by a diaphragm controlling a recording magnet. When said magnet is fed again over the magnetized surface, the magnetized spots effect the vibration of the diaphragm in accordance with the degree of magnetization of the spots and thus reproduce the recorded sound wave.

Optics.—Activity in optics has been very marked. An important scientific invention has been made by Beehler, called the solarometer, patent 533,340, January 25, 1895. This invention relates to instruments for taking observations of heavenly bodies and solving mechanically the parts of the astronomical triangle used in navigation and like work, the principal feature and object of which is to determine the position or the compass error of a ship at sea, independently of the visibility of the sea horizon. If the horizon is clouded and the sun or a known star is visible, a ship's position can still be determined by the solarometer.

An invention by Fiske determines the position and distance of distant objects, and is described in patent 418,510, December 31, 1889. The purpose of the Fiske invention is to provide a method by which the individual in charge of a gun may direct it upon a given target when the distance of said target is not known to him, and even when he is unable to see the target from the point where he is stationed by reason of fog, smoke, breastworks, or other causes. He accomplishes this object by stationing observers at points distant from the gun itself, which points are at the extremities of a known base line and command a view of the area within range of the gun. The observers discover the position and range of the object by triangulation, and set certain pointers. By means of electrical connections between these pointers and pointers at the gun station, based on the system of the Wheatstone bridge, the latter pointers, or the guns themselves serving as pointers, may be placed in position to indicate the line of fire.

The kinetoscope has been perfected, its pictures have been made stereoscopic, and views in natural color have been produced by the application of the three-color process. In field glasses and other telescopes the aim has been to reduce the body of the instrument and increase the field. Great success has been attained in this direction by the use of Porro prisms. In binoculars these prisms are employed as the objectives and are set a distance apart greater than the distance between the eyes, thus increasing the stereoscopic effect. Also, by employing several of these prisms, properly arranged,

the path of light in the telescope may be broken up, resulting in a more compact instrument. A similar idea has been applied to a monocular telescope.

In instruments for testing the eyes, the retinoscope enables the oculist to ascertain for himself all the defects of vision of the patient, avoiding errors necessarily present when the patient has to be relied upon for information.

An optical pyrometer has been produced which enables differences of 10 degrees or less to be detected between temperatures which range in the thousands. The method employed in this instrument is scientific to a marked degree.

Owing to the prevalence of very high buildings, prism lights have been largely introduced for the purpose of directing the sun's rays more efficiently into cellars and lower rooms. These lights are expensive to manufacture, each pane being molded separately and being necessarily small. Processes have been devised whereby such panes may be manufactured in large sheets and cut to the desired size, lessening both their cost and weight.

Magic lanterns and scenic apparatus for theaters have also received a full meed of attention at the hands of the inventor.

As exemplifying what has been done in optics, the following patents are referred to: Armat, 578,185, March 2, 1897; Abbe, 584,976, June 22, 1897; Jenkins, 606,993, July 5, 1898; Prentice, 627,011, June 13, 1899; Lee & Turner, 645,477, March 13, 1900; Ripley & Wadsworth, 661,023, October 30, 1900; and Fitch, 663,266, December 4, 1900.

Photography.—In this class 2,048 patents have been issued. The art of photography as at present practiced has been almost entirely developed since 1871. Among the most important inventions and improvements may be mentioned exposure meters, Watkins, 456,869, July 28, 1891; burnishers, Boles, 527,315, October 9, 1894; magazine and roll-holding cameras, Brainerd, 331,677, December 1, 1885; magazine camera, Spooner, 522,921, July 10, 1894; roll-holder, Houston, 248,179, October 11, 1881; kodak, Eastman, 388,850, September 4, 1888; the kinetograph, for taking a series of pictures of rapidly moving objects, Gray, 540,545, June 4, 1895; and finders, Young, 317,915, May 12, 1885.

The principal development in cameras in late years has been in folding cameras, so-called, which have been rendered much more compact and convenient for operation. Attention is directed to the following patents: Reichenbach, 613,310, November 1, 1898, and Locke, 643,720, February 20, 1900.

In automatic cameras, such, for instance, as shown in the patent to Raders, 645,215, March 13, 1900, means have been provided whereby, by the dropping of a suitable coin in the slot, the exposure of the photographic plate is effected and a complete finished photograph is delivered in the course of a few minutes.

In panoramic cameras, the principal development has been in the adaptation of the folding principle to a panoramic camera. Attention is invited to the patents to Houston, 670,154, March 19, 1901, and 694,929, March 4, 1902; and Brownell, 689,159, December 17, 1901.

The shutters used in photographic cameras have also been very much improved, particularly with respect to those shutters which make graded exposures and which operate without being previously set. Attention is directed to the patents to Vogt, 647,342, April 10, 1900, and 668,965, February 26, 1901; Wollensak, 642,861, February 6, 1900; Klein, 695,564, March 18, 1902; and Nerrlich, 564,216, July 21, 1896.

The development of the art of mechanical printing, notably half-tone printing, by which the art of illustrating has been revolutionized, and the development of the three-color process for the reproduction by photography and mechanical printing of the natural colors of objects, Kurtz, 498,396, May 30, 1893; Ives, 432,530, July 22, 1890; McDonough, 611,457, September 27, 1898, carries forward a process of color photography originally disclosed in 1868 by Ducos du Hauron. Attention is also directed to the recent patents to Frederic E. Ives, 648,748, May 9, 1900; 655,712, August 14, 1900; 666,423, January 27, 1901; and 668,989, February 26, 1901.

Other patents of note are in rapid-printing machines, for printing on continuous bands of paper, Urie, 478,663, July 12, 1892; roll holders, Eastman, 407,647, July 23, 1889; Crane, 549,232, November 5, 1895; shutters, Thornton, 482,854, September 20, 1892; Bausch et al., 444,083, January 6, 1891; Tisdell, 536,242, March 26, 1895; the nonhalation plate, Vogel, 442,741, December 16, 1890; isochromatic plate, Roche, 519,646, May 8, 1894; flexible celluloid films, Reichenbach, 417,202, December 10, 1889; and the improvements in the positive printing processes, Willis, 423,849, March 18, 1890.

NAVIGATION.

Ships.—In this class 3,296 patents have been granted. In shipbuilding the improvements since 1871 have rested mainly upon internal structures which have served to strengthen and stiffen the hull, but in which no startling departure in principle seems to be involved. A vessel which is known as the "whale back" is embodied in patents to McDougall, 259,889, June 20, 1882, and 500,411, June 27, 1893. This boat has a bottom nearly flat, vertical sides, arched top or deck, spoon-shaped or skegged bow and stern, straight deck lines, and hollow turrets supporting the upper deck, cabins, and steering gear, while the machinery and cargo are contained in the main hull.

Important improvements have been patented in water-tight doors for bulkheads for the compartments of vessels, by which, in case of collision, the compartments can be separated from each other, and the vessel

kept afloat. Some of the patents covering these features are Pattersen & Cumming, 432,070, July 15, 1890; Muller, 459,533, September 15, 1891; Katzenstein, 539,953, May 28, 1895; Melville, 542,169, July 2, 1895; Montgomery-Moore, 542,935, July 16, 1895.

Means for automatically closing the doors of bulkheads operated by the water entering one of the compartments are shown in patents: Dorr & Stuhler, 588,793, August 24, 1897, and Houghton, 629,790, August 1, 1899; also means for closing the doors in numerous bulkheads are shown in patent to Montgomery-Moore, 617,593, January 10, 1899; and devices by which the doors may be closed from the bridge or pilot house, appear in the patents to Cowles, 564,474, July 21, 1896, 589,958, September 14, 1897, and 605,399, June 7, 1898; and Bowles, 651,004, June 5, 1900.

Floating Docks.—Improvements are probably best shown in patents to Cousins, 601,431, March 29, 1898; Clark, 601,554, March 29, 1898; Dutton, 615,440, December 6, 1898; Jamieson, 655,441, August 7, 1900; and Lang, 656,582, August 21, 1900.

Clark & Jamieson of the above show sectional docks adapted for self-docking the various sections. The others illustrate various means for strengthening the structure and maintaining the proper balance of flotation.

Fog Horn.—A fog horn has been devised which by variations in its sound indicates the point of the compass at which the horn is situated relatively to any person hearing it. This device has been adopted by the United States Government. See patent 617,856, Foster, January 17, 1899.

Life-preservers.—Life-preservers and buoys of many varieties have been patented, consisting of cork jackets and inflatable bags, and some automatically lighted buoys find an important place in the merchant marine and naval services. Some of these involving hollow buoys have signal torches pivoted to the sides and adapted to swing into an upright position when the buoy is thrown into the water, the torches containing calcium phosphate to ignite them upon contact with the water; and other buoys carrying an electric battery and incandescent lamps, the contact points of the electric circuit being held apart by a soluble nonconductor, which dissolves when the buoy is cast upon the water, allowing the circuit to be completed and the lamps to glow. Instances of such devices are shown in patents to Hichborn, 388,971, September 4, 1888, and Guest and Bates, 512,957, January 16, 1894.

The offer of the Pollok prize for the best life-saving appliance has brought forth numerous applications for boat lowering and detaching devices, life-preservers, etc., the most notable improvements perhaps being in the self-inflatable life-preservers. These devices generally consist of a collapsible belt containing an air-tight receptacle adapted to contain, or have connected therewith, a receptacle containing compressed air adapted to be discharged into the inflatable belt, or to contain gas-forming chemicals which will operate on the admission of a small quantity of water to expand the collapsible belt. See patents: Gordon, 572,109, December 1, 1896; Matignon, 625,582, May 23, 1899; Ruck, 651,169, June 5, 1900; and Roden, 655,373, August 7, 1900.

Gordon shows the type of life-preserver inflated by means of compressed air, the others being inflated by gas-forming compounds.

Types of boat lowering and detaching devices are shown in Blanding, 557,475, March 31, 1896; Hillyer, 563,174, June 30, 1896; McKinnon, 579,119, March 16, 1897; Holtorp, 579,434, March 23, 1897; Agnew, 602,611, April 19, 1898; and Cappellini, 609,532, August 23, 1898.

Blanding and Holtorp's devices are adapted to release the boat on its being water borne. Hillyer carries his boat by a line passed through a tube in the boat so that on either end being released the rope will reeve through the tube and free the boat. Agnew and Cappellini hang their boats on swinging davits that will launch them at a safe distance from the side of the vessel. McKinnon's device is adapted to swing the davits by the operation of mechanism connected with the means for lowering the boat.

Oiling Waves.—Of the many devices which have been patented for this purpose the following represent, perhaps, the most prominent: Chesebrough, 254,112, February 28, 1882; Hayes, 300,073, June 10, 1884; Gordon, jr., 303,507, August 12, 1884; Gregory, 303,999, August 26, 1884; Gordon, jr., 339,054, March 30, 1886; Montague, 364,538, June 7, 1887; Ericsson, 380,479, April 3, 1888; Larsen, 387,427, August 7, 1888; Lyle, 393,995, December 4, 1888; Locher, 413,346, October 22, 1889; Moore, 457,554, August 11, 1891; and Hallett, 529,379, November 20, 1894.

Propellers.—From the almost universal adaptation of the screw propeller to all characters of steam vessels, it may be assumed that experience has settled upon that form as the best for all purposes, whether naval or merchant marine. There have been 1,990 patents issued in the class of propellers and 636 patents in the subclass of screw propellers. Many varieties of screw propellers have been patented for which particular advantages are claimed. As representing various types, reference is made to the following patents, among many others: Armit, 210,982, December 17, 1878; Vogelsang, 360,833, April 5, 1887; Steves & Hill, 370,567, September 27, 1887; Vogelsang, 381,193, April 17, 1888; Spanoghe, 435,330, August 26, 1890; De Albornoz, 474,939, May 17, 1892; Wattles, 484,382, October 11, 1892; Carstairs, 484,651, October 18, 1892; Case, 496,857, May 9, 1893; Sintz, 512,627, January 9, 1894; and Case, 527,045, October 9, 1894.

In late years perhaps the most active subclass has been that of screw propellers, adjustable blades. The growing use of nonreversible engines for propelling vessels, especially small yachts, launches, etc., has made it essential that there be supplied some means for

reversing the angle of the screw propeller blades. Patents showing types of these devices are as follows: Bray, 554,331, February 11, 1896; Hubbard, 573,977, December 29, 1896; Sinty, 581,625, April 27, 1897; Beck, 612,511, October 18, 1898; Truscott, 617,373, January 10, 1899; Gere, 642,601, February 6, 1900; and Blomstrom, 657,054, August 28, 1900.

Torpedoes and Torpedo Boats.—Various types of torpedoes and submarine torpedo boats have been patented, some of which have attracted world-wide attention, and some of which have been put into practical use both in this country and abroad. These various systems are operated on different principles, and involve different constructions and appliances, but the same general purpose obtains in nearly all, viz, to provide a boat or torpedo which is capable of being submerged and directed and propelled either by instrumentalities contained therein and controlled by connecting with the shore or with another vessel, or which contains the motive power as well as submerging appliances and means for operating the boat and its torpedo by persons within the boat. Electrical devices are extensively used, some of which involve batteries within the boat, and some batteries on shore, which, by means of wires extending therefrom to various electrical devices in the boat, have the function of raising and lowering the same, giving it the proper lateral direction, and, at the opportune moment, firing the torpedo.

Other marine torpedoes have been devised which are constructed to be fired from tubes on the vessel, the torpedoes themselves being provided with devices, such as raising and lowering vanes, rudders, screw propellers, and valves, which are so arranged at a predetermined pressure as to give the proper submersion and direction to the torpedo, according to the distance of the object to be attacked, and to explode the torpedo when impacted with such object. Instances of such boats and torpedoes are shown in the patents, among others, of Lay, 211,302, January 14, 1879; Howell, 311,326, January 27, 1885; Kaselowsky, 361,526, April 19, 1887; Howell, 458,677, September 1, 1891; Howell, 484,658, October 18, 1892; Holland, 522,177, June 26, 1894; Baker, 530,466, December 4, 1894; and Lloyd and Hutchinson, 548,374, October 22, 1895.

Automatic steering devices embodying the use of gyroscopic mechanisms adapted to operate on the principle that a gyroscope will seek to maintain a given plane of rotation are shown in patents, among others, of Obry, 562,235, June 16, 1896, and Kaselowsky, 591,768, October 12, 1897.

Maxim, 641,787, January 23, 1900, extends the propelling power of a chamber of compressed air by burning a slow-combustion cartridge therein.

SAFES AND LOCKS.

Safes.—In this class 613 patents have been issued. The leading inventions in safes have been in the way of preventing lockouts, and also in so fastening safes that they can only be opened by heavy machinery located at either end of a railroad route. Upon failure of the time lock to release the bolt work, the safe owner is enabled by a series of movements of the safe itself, or by jarring the safe by blows upon a certain point in the walls, to open the safe after several hours of work. These operations would require more time than a burglar could get during the absence of the owner, either by night or day. Safes have been made of parts telescoped or crowded together by hydraulic power, requiring heavy machinery, and this machinery, both for locking and unlocking, is located in machine shops not accessible to burglars. If, therefore, train wreckers or robbers get possession of safes in transit they can not open them. Patents of Colburn, August 27, 1895, 545,153 and 545,154, illustrate the forms.

One of the leading inventions has been in the construction of safes and vaults to prevent the use of liquid explosives, such as nitroglycerin, around the door opening. Patents to Hibbard, November 27, 1900, 662,428 and 662,435, illustrate types of such safes. These safes are cast in one piece of manganese steel.

Another leading invention is the construction of safes and vaults to prevent the use of the electric arc in melting or fusing a hole through the safe wall or door. The hardness of the metal is, of course, no hindrance to such an attack. Patents to Shankland, January 18, 1898, 597,694, and December 6, 1898, 615,503, and Holmes, February 21, 1899, 620,073, illustrate types of such safes. Dogging devices for controlling the bolt work of safes have also been patented. Said devices are held normally inoperative by a thermostatic controlling device which upon a rise of temperature of the door will release said dogging devices and permit the same to move into engagement with the bolts. See patents to Curtis, December 28, 1897, 596,294, and Damon, January 15, 1901, 666,185.

Locks.—The most important improvements in locks have been made with reference to the special use to which they are applied, few important changes having been made in locks for general purposes. One type of lock is that for safety deposit vaults and boxes, in which a primary key, in the keeping of a janitor, operates tumbler or guard mechanism to set the lock so that the box holder may use the secondary key to completely unlock the box. Types may be found in patents of Roche, August 30, 1892, 481,736, and Mix, December 17, 1895, 551,685. Primary and secondary key, master-key locks, are another improved class of locks, typified by patent of Sparks, October 2, 1888, 390,527. Such locks are in common use in hotels and apartment houses, the tumbler mechanism being so arranged that the principal key, held by a guest, can operate the lock of but one room, whereas the secondary or master key, held by the janitor or manager, is common to the tumbler mechanism of the locks of all the rooms. Other improvements in this general field of invention are found in locking systems which comprise a series of locks for locking doors, windows,

water faucets, and electric switches, said locks being so systematized that the main or front door of a building having been unlocked and the main key removed and placed in a lock or holder, and the locks of such doors, windows, faucets, or switches having been unlocked consecutively and the keys removed and placed in such holder, it is necessary to take out each subsidiary key in reverse order and use before the main door key can be released and the building locked up at the close of the day. Types of such locks are found in patents of Stiner, September 2, 1890, 435,569, and Schade, April 9, 1895, 537,311.

One form of lock adapted for hotels is shown by patent to H. G. Carleton, August 21, 1900, 656,341. A series of these locks, preferably electrically connected, is employed, one on each room door. Each lock is adapted to be independently operated, and the entire series may also be simultaneously operated from a central point and at the same time an alarm or signal is given in each room, thereby notifying the occupant thereof in case of fire. The same inventor discloses in patent 608,319, August 21, 1898, a form of electric combination lock in which the bolt thereof has no exterior means for moving it, and is secured by a keeper which is adapted to be electrically withdrawn. Within the lock case proper is a combination mechanism for completing the circuit for operating the keeper, and exterior means are employed for operating the combination. An alarm will be given when the combination means is tampered with. A type of lock adapted for mail boxes and the like is disclosed by patent to Fergusson, February 20, 1900, 643,955. The sliding bolt is positively operated in both directions by a rotary tumbler which is mounted to turn thereon. The tumbler is operated by a key which moves tangentially thereto. The key can not be withdrawn without positively moving the bolt to its locked position.

Bicycle locks have come into existence since 1871. Improvements in this kind of lock comprise means for dispensing with the use of the chain and padlock originally used, and consist of permutation or key-operated locks, fixed in or to a fixed part of the frame and adapted to lock a movable part from movement necessary to its proper use, or give an alarm when such parts are moved. Types of such locks may be found in patents of McKaig, December 26, 1893, 511,738; Crancer, August 20, 1895, 544,909; and Free et al., October 16, 1894, 527,418.

STATIC APPLIANCES.

Furniture.—The principal labor-saving device contained in this class relates to extension tables, whereby as the table is extended by separating the sections the leaves are automatically raised into position. This may be done by a series of lazy tongs, as in the patent to Brassington, 223,273, January 6, 1880, or by a series of parallel links, as in the patent to Cloony, 276,159, April 24, 1883. In sewing-machine tables, in which the machine head is dropped beneath the table top when not in use, devices have been used to counterbalance the weight of the head and machine in order that it may be more easily raised when desired for use, as is shown in the patent to Bolton and Van Dyke, 300,684, June 17, 1884. With the development of the modern typewriting machine there has been a corresponding development in the tables and desks designed for the support of the machine. The principle of these constructions has been the same as in the case of the sewing-machine tables, and various devices have been used to counterbalance the weight of the machine, an example of which is shown in the patent to Horrocks, 333,225, December 29, 1885.

The development of the well-known sectional bookcase received its impetus in the grant of a patent for a "knockdown" or "sectional" case to O. H. L. Wernicke and M. C. Burr, 557,736, April 7, 1896, the form on which all the varieties of sectional cases are based. A further and later development is shown in the patent to Frank Macey, 644,434, February 27, 1900, where the automatic retracting door is noted as a special feature.

Perhaps the most important development in store furniture has been in the line of all-glass show cases. The desirability of such a case for the display of goods and the natural obstacles to be overcome have afforded a good opportunity for the exercise of invention, and have given rise to several types of such devices, which are illustrated, in part, by the patents to Pollard, 561,339, June 2, 1896; Ganter, 584,584, June 15, 1897; Biele, 615,788, December 13, 1898; Crane, 624,460, May 9, 1899; and Paulle, 642,875, February 6, 1900.

Spittoons of the sanitary, flushing type have also developed rapidly, as seen in the patents to Hurlbut, 563,664, July 7, 1896, and Browne, 655,051, July 31, 1900, the first patent using a revolving bowl which is rotated and flushed by a single jet of water, while the latter patent shows the expedient of "spreading" a thin stratum of water over the inner surface of the bowl, completely and noiselessly cleansing it.

Beds.—The principal development is shown in the type of folding bed, the purpose of which is to economize space, illustrated by the patents to Albee, 358,101, February 22, 1887, Herrinton, 380,258, March 27, 1888, and for sofa bedsteads, convertible into a bed of ordinary dimensions, patent to Storr, 596,637, January 4, 1898. Wardrobe bedsteads, constructed entirely of angle iron or steel, have received attention. The patent to Stuart, 570,348, October 27, 1896, is a structure embodying this idea. Considerable attention has been given to invalid bedsteads, which are designed for the purpose of shifting the position of the patient, as shown in the patent to Gorham, 525,952, September 11, 1894.

Chairs.—In children's chairs, structures have been made to be converted into perambulators, as shown in the patents to Chichester, 259,368, June 13, 1882; Kenna, 254,023, February 21, 1882; and Odell, 317,000, May 5, 1885. In dentists' chairs the art has been de-

veloped until at the present time the operator's work in raising and lowering the chair has been so reduced that it is only necessary for him to manipulate the valves governing fluid under pressure, as shown, for example, in the patents to Waring, 300,538, June 17, 1884; Mann, 547,221, October 1, 1895; and Wilkerson, 663,-143, December 4, 1900, the chair being then raised or lowered by the action of the fluid.

The class of car seats has been particularly active. Inventive effort seems to have been devoted largely to the mechanism for reversing the seats. In this connection the patent to Hale, 595,624, December 14, 1897, is notable. This patent discloses a seat comprising two independent chairs rotarily mounted on a rotating beam. A mechanism coacts with the independent seats and the stationary pedestal, so that a rotation through a small angle of the beam on which the chairs are mounted, completely reverses the facing direction of the chairs.

Upholstering machines have been largely developed in the last three or four years. The patent to Jones, 635,046, October 17, 1899, is indicative of the work in this line. This machine performs the complete operation of forming and tacking the material, through the medium of a horizontal table and a combined button-staple-carrying and pressure roller, revolubly carried above it.

Miscellaneous.—In curtains, shades, and screens the principal improvement is the spring shade roller whereby the shade is automatically rolled upon its stick to adjust it, as shown in the patents to Hartshorn, 44,624, October 11, 1864, and 299,782, June 3, 1884. Window screens are now made extensible and adjustable to fit different sizes of windows in two different ways, one by providing the screen proper with an adjustable sidepiece, as shown in the patent to Conard and Collins, 548,963, October 29, 1895, and the other by making the screen of two adjustable sections, as shown in the patent to Dowling, 208,675, May 13, 1884. Curtains used in open street cars are provided with friction devices which will securely hold them in position, but which may be easily manipulated to raise the curtain, as illustrated in the patents to Hall, 483,490, September 27, 1892; Burrowes, 493,885, March 21, 1893; and Forsyth, 524,060, August 7, 1894.

The principal labor-saving devices in kitchen and table articles are in stopper extractors, designed to expedite the drawing of corks and to supersede the old type of hand corkscrews. The whole operation is performed by the movement of a single lever, which causes the corkscrew to be forced into the cork, draws the cork, and then strips the same from the corkscrew, leaving the latter in position for the next operation, as is shown in the following patents: Williams, 450,957, April 21, 1891; Gilchrist, 478,545, July 5, 1892; Walker, 515,412, February 27, 1894; and Williams, 619,648, February 14, 1899.

SURGERY.

In this class 4,176 patents have been issued. There have been vast improvements in devices for molding, cutting (223,139, Hubel, December 30, 1879), capping (326,578, Merz, September 22, 1885), and filling (507,870, Young, October 31, 1893) gelatin capsules, so commonly used to conceal unpalatable remedies. Much ingenuity has also been exercised in syringes (494,048, Wardell, March 21, 1893), especially in that class known as hypodermic, of which 475,909, Wilcox, May 31, 1892, used for subcutaneous injection of liquid remedies, is an example. In inhalers there have been many important advances in the manufacture of devices for applying medicated vapors to the air passages, of which patent 218,434, Haight, August 12, 1879, is an example, and also for the administration of volatile anæsthetics, shown in 374,831, Harrington, December 13, 1887. The latest of the instruments of this class enable either a single vapor or a mixture of vapors of various medicinal agents to be administered in any desired proportions and at normal or any desired pressure. See Dunlap, 620,895, March 14, 1899, and Holman, 661,313, November 6, 1900.

Devices for atomizing and spraying liquids, shown in patent 397,315, Shurtleff, February 5, 1889, have been much improved.

Artificial sponges for surgeons' use have found ready acceptance by reason of their cheapness, great absorptive capacity, and the ready and complete sterilization of which they are capable. See Johnson, 582,926, May 18, 1897.

Appliances for the alleviation and cure of certain cases of partial blindness and deafness by vacuum and air pressure have come into recent extensive use (Wigmore, 627,790, June 27, 1899; Garey, 653,573, July 10, 1900; and Watson, 660,233, October 23, 1900), as have also analgesic appliances for the relief of pain and the cure of seasickness by pressure upon various parts of the body. See Callaino, 633,424, September 19, 1899.