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APPENDIX B

CENSUS DATA ON NUMBER OF ENGINEERS AND CHEMISTS, 1890-1950

WE HERE present the basic data on the number of engineers and chemists and the number of workers in the labor force that we use in Chapters I and III. Census definitions of occupations and industries have changed so greatly even within the last two decades that it proved impossible to utilize census data directly in our analyses. Rather we were forced to develop series with more consistent coverage. The details of our calculations are described in the notes to the following tables.

TABLE B-1
Growth of Labor Force and Engineering and Chemical Professions

Coverage	Labor Force	Engineers including Surveyors	Chemists including Metallurgists	Engineers and Chemists including Surveyors	Engineers excluding Surveyors	Engineers and Chemists excluding Surveyors
1. 1890 Gainful workers 10 years and over	23,318,183	28,239	4,503	32,742		
2. 1900 Gainful workers 10 years and over	29,073,233	43,239	8,847	52,086		
3. 1910 Gainful workers 10 years and over	37,370,794	88,755	16,273	105,028		
4. 1920 Gainful workers 10 years and over	42,433,535	136,121	32,941	169,062		
5. 1930 Gainful workers 10 years and over	48,829,920	226,249	47,068	273,317		
6. 1930 Labor force, 14 years and over	47,404,000	228,932	48,009	276,941	217,845	265,494
7. 1940 Labor force, 14 years and over	53,299,000	277,872	60,005	337,877	261,428	321,433
8. 1940 Civilian labor force	53,299,000	302,995	60,005	363,000	286,551	346,556
9. 1950 Civilian labor force	59,071,655	556,176	80,224	636,400	529,947	610,171
10. 1950 Civilian labor force	59,071,655	560,183	75,747	636,400	534,424	610,171
11. 1930 Total employment, gainful workers 10 years and over	45,642,273	218,215	45,703	263,918	208,178	253,881
12. 1940 Total employment, labor force, 14 years and over	45,166,083	258,632	57,025	315,657	245,288	302,313
13. 1940 Civilian employment, labor force, 14 years and over	44,888,083	285,489	57,025	342,514	272,145	329,170
14. 1940 Civilian employment, labor force, 14 years and over	44,888,083	288,669	53,845	342,514	275,325	329,170
15. 1950 Civilian employment, labor force, 14 years and over	56,225,340	546,177	78,833	625,010	520,856	599,689
16. 1950 Civilian employment, labor force, 14 years and over	56,225,340	550,577	74,433	625,010	525,256	599,689

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NOTES TO TABLE B-1

Labor Force

Line	Source
1-5	Alba M. Edwards, <i>Comparative Occupation Statistics for the United States, 1870 to 1940</i> , Bureau of the Census, 1943, p. 104.
6-8	<i>Ibid.</i> , p. 12. The figures for 1890-1940 (lines 1-8) include the following numbers in the armed forces in the United States.
	1890 27,919
	1900 43,195
	1910 77,153
	1920 225,503
	1930 132,830
	1940 222,485
	1890-1930 from <i>ibid.</i> , p. 119; 1940, <i>ibid.</i> , p. 56.
9-10	<i>Census of Population, 1950</i> , Vol. II, Part 1, Table 124. Since the number of persons in the armed forces in 1950 was very large, but the number of engineers and chemists in the armed forces is not available, we exclude the armed forces from the 1950 figures.
11	<i>Census of Population, 1930</i> , Vol. V, <i>General Report on Occupations</i> , Chapter 7, Table 1; and <i>Census of Unemployment, 1930</i> , Vol. I, Tables 21 and 22, and Vol. II, Table 3.
12	<i>Census of Population, 1940</i> , Vol. III, Part 1, Table 58.
13-16	<i>Census of Population, 1950</i> , Vol. II, Part 1, Table 125. The figure for employment in 1940 as published in the 1950 census excludes the armed forces and public emergency workers. This estimate of civilian employment in 1940 is slightly smaller than the 1930 figure for total employment. Actually, total employment in 1940 was about 400,000 larger than in 1930 (see <i>Census of Population, 1940, Population, Estimates of the Labor Force, Employment, and Unemployment in the United States, 1940 and 1930</i> , prepared by John D. Durand and Edwin D. Goldfield). This discrepancy is due mainly to the fact that the 1930 employment figure is based on the gainful worker concept which includes persons 10-14 years of age. Partly it is due to the exclusion of about 300,000 armed forces from the 1940 census.

Engineers and Chemists including Surveyors

Line	Source
1-5	Edwards, <i>op. cit.</i> , p. 111.
6-7	<i>Ibid.</i> , p. 49. Lines 1-7 include engineers and chemists in the armed forces in the United States.
8	Employed engineers in 1940 from <i>Census of Population, 1950</i> (Vol. II, Part 1, Table 124), 275,325
	plus unemployed engineers from 1940 census ^a 16,140
	Total engineers (including metallurgists) <u>291,465</u>
	Total engineers (excluding metallurgists) ^b <u>286,551</u>

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NOTES TO TABLE B-1 (continued)

Line Source
 been added to the number of employed engineers in 1940, as shown in the 1950 census, the total for 1940 would be 291,465, instead of 261,428. This discrepancy of some 30,000 appears to be due to changes in classification.
 The 1940 data on engineers in lines 13 and 14 are from the 1950 census and are comparable to the 1950 figures in lines 15 and 16. (The 1950 census does not give any data on the total number of engineers in 1940, including unemployed.)

Excluding Surveyors

Line	Source												
6-16	For 1940 and 1950 the total numbers of surveyors and of employed surveyors are given in <i>Census of Population, 1950</i> (Vol. II, Part 1, Table 124), and in <i>Census of Population, 1940</i> (Vol. III, Part 1, Table 58). For 1930 the number of surveyors was estimated by reference to the ratio of surveyors to engineers in 1940 and 1950. The actual figures are:												
	<table border="0"> <thead> <tr> <th></th> <th style="text-align: center;"><i>All Surveyors</i></th> <th style="text-align: center;"><i>Employed Surveyors</i></th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1950</td> <td style="text-align: center;">26,229</td> <td style="text-align: center;">25,321</td> </tr> <tr> <td style="text-align: center;">1940</td> <td style="text-align: center;">16,444</td> <td style="text-align: center;">13,344</td> </tr> <tr> <td style="text-align: center;">1930</td> <td style="text-align: center;">11,447</td> <td style="text-align: center;">10,037</td> </tr> </tbody> </table>		<i>All Surveyors</i>	<i>Employed Surveyors</i>	1950	26,229	25,321	1940	16,444	13,344	1930	11,447	10,037
	<i>All Surveyors</i>	<i>Employed Surveyors</i>											
1950	26,229	25,321											
1940	16,444	13,344											
1930	11,447	10,037											

TABLE B-2

Engineers and Chemists as a Percentage of the Labor Force

	<i>Engineers including Surveyors</i>	<i>Chemists including Metallurgists</i>	<i>Engineers and Chemists including Surveyors</i>	<i>Engineers excluding Surveyors</i>	<i>Engineers and Chemists excluding Surveyors</i>
1. 1890	0.121	0.019	0.140		
2. 1900	0.149	0.030	0.179		
3. 1910	0.237	0.044	0.281		
4. 1920	0.321	0.078	0.398		
5. 1930	0.463	0.096	0.560		
6. 1930	0.483	0.101	0.584	0.459	0.560
7. 1940	0.521	0.113	0.634	0.490	0.603
8. 1940	0.568	0.113	0.681	0.538	0.650
9. 1950	0.942	0.136	1.077	0.897	1.033
10. 1950	0.949	0.128	1.077	0.905	1.033
11. 1930	0.478	0.100	0.578	0.456	0.556
12. 1940	0.573	0.126	0.699	0.543	0.669
13. 1940	0.636	0.127	0.763	0.606	0.733
14. 1940	0.643	0.120	0.763	0.613	0.733
15. 1950	0.971	0.140	1.112	0.926	1.067
16. 1950	0.979	0.132	1.112	0.934	1.067

Source: Table B-1.

TABLE B-3

Total Employment and Employment of Chemists and Technical Engineers in Selected Industries, 1930, 1940, and 1950
(number of persons)

INDUSTRY	TOTAL EMPLOYMENT				TECHNICAL ENGINEERS AND SURVEYORS					
	All Gainful Workers 1930	Estimated Total Employ- ment 1930	Total Employ- ment (com- parable to 1930)	Total Employ- ment (com- parable to 1950)	Including Surveyors		Excluding Surveyors			
					Gainful Workers 1930	Esti- mated Em- ployed 1930	Em- ployed (com- parable to 1930)	Em- ployed (com- parable to 1950)		
I. Mining, total	1,156,377	966,885	907,520	907,520	928,260	9,137	8,391	10,940	10,080	13,860
1) Coal mining	691,288		523,680	523,680	510,180	2,485		2,020	1,700	2,610
2) Petroleum and nat- ural gas	198,446		181,860	181,860	233,160	2,047		4,100	3,660	7,290
3) Metal mining	114,235		116,340	116,340	92,970	2,062		3,560	3,480	2,730
4) Other, including quarries	152,408		85,640	85,640	91,950	2,543		1,260	1,240	1,230
II. Construction	3,029,791	2,489,700	2,094,220	2,094,220	3,398,040	31,712	28,892	45,360	41,040	77,130
III. Manufacturing ^a (Durable goods ^a)	5,472,037	4,972,946	5,626,440	5,626,440	8,182,290	73,543	70,496	114,700	114,560	253,580
	3,741,824	3,364,202	3,617,300	3,617,300	5,534,970	44,611	42,366	73,540	73,400	173,060
I. Iron and steel industries	1,931,857	n.a.	1,876,380	1,267,280	1,660,560	21,423	n.a.	34,200	18,940	33,840
a) Blast furnaces, steel works	620,894		545,300	545,300	661,380	7,126		9,500	9,500	13,860
b) Other primary iron and steel					285,180					4,050
c) Miscellaneous iron and steel products	1,310,963		1,331,080	721,980	714,000	14,297		24,700	9,440	15,930

TABLE B-3 (continued)

INDUSTRY	TOTAL EMPLOYMENT					EMPLOYMENT OF CHEMISTS AND TECHNICAL ENGINEERS				
	All Gainful Workers 1930	Estimated Total Employment 1930	Total Employment (comparable to 1930)	Total Employment 1940 (comparable to 1950)	Total Employment 1950	Including Surveyors			Excluding Surveyors	
						Gainful Workers 1930	Estimated Employment 1930	Em- ployed 1940	Em- ployed 1940	Em- ployed 1950
7. Food, drink, tobacco	1,056,816	974,725	1,207,940	1,207,940	1,472,550	4,233	4,069	6,400	6,400	13,020
8. Chemicals and allied products	321,492	305,851	440,820	440,820	654,480	16,810	16,403	21,200	21,180	43,860
a) Synthetic fibres	33,982		52,480	52,480	53,370	723		1,160	1,160	2,220
b) Paints, varnishes, etc.	37,074		43,280	43,280	57,090	1,427		2,640	2,640	3,450
c) Drugs and medicines					57,030					3,570
d) Misc. chemicals	250,436		345,060	345,060	486,990	14,660		17,400	17,380	34,620
9. Petroleum and coal products	185,564	176,537	202,180	202,180	284,280	5,924	5,780	10,700	10,560	18,690
a) Petroleum refining	173,798		178,980	178,980	257,190	5,628		9,960	9,820	17,790
b) Misc. petroleum and coal products	11,766		23,200	23,200	27,090	296		740	740	900
10. Rubber products	166,391	151,631	158,200	158,200	236,010	1,965	1,878	3,020	3,020	4,950
Transportation, communications, and other public utilities	4,013,684	3,788,587	3,295,920	3,414,540	4,869,460	42,548	41,447	41,500	43,820	68,520
IV. Transportation	2,737,997	2,553,118	2,176,460	2,176,460	2,927,010	14,858	14,358	8,600	8,380	11,910
1) Air transportation	18,189		22,320	22,320	94,500	467		480	440	1,260
2) Railroads and express service	1,645,306		1,137,000	1,137,000	1,381,740	10,706		5,820	5,680	6,180

3) Streetcars and buses	195,408	202,320	202,320	325,200	1,549	900	900	1,320
4) Trucking and taxicabs	483,148	511,520	511,520	765,260	40	100	100	540
5) Warehousing and storage	59,394	62,060	62,060	97,350	429	240	240	840
6) Water transportation	299,804	180,240	180,240	203,250	1,325	400	320	480
7) Pipelines	25,001	17,420	17,420	20,220	217	460	440	990
8) Incidental transportation services	11,747	43,580	43,580	41,490	125	260	260	300
V. Communications	871,502	851,284	703,140	1,163,950	13,303	12,180	12,160	25,020
1) Postal service	283,936	309,240	309,240	460,510	0	80	80	150
2) Telephone	} 578,602	} 370,300	} 370,300	594,750	} 12,760	} 9,820	} 9,800	15,600
3) Telegraph				46,260				510
4) Radio and television	8,964	23,600	23,600	62,430	543	2,280	2,280	8,760
VI. Utilities and sanitary services	404,185	416,320	534,940	778,500	14,297	13,940	20,660	31,590
1) Electric light and power	289,255	329,880	329,880	448,890	12,633	18,640	18,280	22,860
2) Gas supply	114,930	86,440	86,440	114,720	1,664	2,020	1,980	2,760
3) Water supply	n.a.	excl.	excl.	73,700	n.a.	excl.	excl.	3,420
4) Sanitary services	n.a.	excl.	excl.	105,820	n.a.	excl.	excl.	1,170
5) Not specified utilities	n.a.	excl.	excl.	35,370	n.a.	excl.	excl.	1,380
VII. Professional and related services	2,965,742	2,908,072	3,320,000	1,749,880	57,934	57,373	25,860	38,190
Including education	} included	} included	} included	1,570,120	} included	} included	} included	7,740
Excluding education				in 16				in 16
1) Government	in 16	in 16	in 16	2,076,630	n.a.	n.a.	n.a.	4,980
2) Private	in 16	in 16	in 16	1,547,000	n.a.	n.a.	n.a.	2,760
IX. Public administration	1,049,576	1,019,903	1,448,680	26,935	26,555	35,280	35,280	35,280
Including armed forces								

TABLE B-3 (continued)

INDUSTRY	TOTAL EMPLOYMENT				EMPLOYMENT OF CHEMISTS AND TECHNICAL ENGINEERS			
	All Gainful Workers 1930	Estimated Total Employment 1930	Total Employment (comparable to 1930)	Total Employment 1940 (comparable to 1950)	Including Surveyors		Excluding Surveyors	
					Gainful Workers 1930	Estimated Employment 1930 to 1950	Em- played 1940 (com- parable to 1930)	Em- played 1940 (com- parable to 1950)
Excluding armed forces			1,147,180	2,030,160			28,100	54,480
1) Federal government	n.a.		excl.	1,006,260	n.a.	excl.	11,380	36,660
2) State government	n.a.		excl.	299,280	266,760	excl.	16,720	5,400
3) Local government	n.a.		excl.	847,900	757,140	excl.		12,420
Subtotal, above industries	17,687,257	16,146,093	16,692,780	16,509,900	24,103,480	241,719	233,154	273,800
All other industries ^b	31,142,663	29,496,180	28,688,580	28,569,960	31,700,040	31,598	30,764	39,000
Total, all industries								
Including armed forces	48,829,920	45,642,273	45,381,360			273,317	263,918	312,800
Excluding armed forces				45,079,860	55,803,520			296,000
								592,500

n.a. = not available.

^a Includes industries listed under this heading; excludes manufacturing industries included in "All other industries," enumerated in footnote ^b.

^b Includes agriculture, forestry, fisheries; the following manufacturing industries: lumber and wood products, glass products, stone and clay products, textiles and clothing, paper and printing, leather and leather products. Includes further: wholesale and retail trade, finance, insurance and real estate, business and repair service, entertainment and recreation, and personal services.

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NOTES TO TABLE B-3 (continued)

Source: *Census of Population, 1930, Vol. V, General Report on Occupations*, Chap. 7, Table 2 (based on full count); *Census of Population, 1940, The Labor Force, Occupational Characteristics*, Table 19 (based on a 5 per cent sample); *Census of Population, 1950, Special Report P. E., 1 C, Occupation by Industry* (based on a 3½ per cent sample); *Census of Unemployment, 1930, Vol. I, Tables 21 and 22; Vol. II, Table 3*; Alba M. Edwards, *Comparative Occupation Statistics for the United States, 1870 to 1940*, Bureau of the Census, 1943.

Comparability and Adjustment of Data

a) *Gainful Workers and Employed Persons*

The 1930 census refers to "gainful workers, 10 years old and over"; the relevant tables of the 1940 and 1950 censuses to "employed persons (except on public emergency work), 14 years old and over." Partly because of these different concepts the total number of persons included in the occupation-by-industry cross-classification was 48.8 million in 1930 as compared to 45.4 million in 1940.

In the second column for 1930 the unemployed gainful workers have been excluded using the data given in the Census of Unemployment. Since this adjustment does not take account of the differences between the "labor force" and "gainful worker" concept, the resulting total for employed persons in 1930 (45.6 million) is still some 260,000 larger than the total employment figure for 1940. On a basis comparable to that of the 1940 census, total employment in 1930 would have been 45.0 million, that is, about 400,000 less than in 1940 (see *Census of Population, 1940, Population, Estimates of the Labor Force, Employment, and Unemployment in the United States, 1940 and 1930*, prepared by John D. Durand and Edwin D. Goldfield). These adjusted data, however, are available only for total labor force and employment, not for industries or occupations.

The 1930 Census of Unemployment gives data for broad industry groups, a few industrial subgroups, and for occupations. Unemployment data for occupation by industry and for most industrial subgroups are not available. For some other industry groups unemployment had to be estimated. The broad group "Chemicals and allied products" of the Unemployment Census was broken down into "Chemicals," "Petroleum and coal products," and "Gas works." Unemployment in these subgroups was assumed to be at the same rate as for the group as a whole. "Gas works" were shifted to "Utilities" and unemployment in "Electric light and power" (a group which is missing in the Unemployment Census) was estimated at the same rate as in "Gas works." For the remaining industry groups the Unemployment Census data were used.

The estimated numbers of unemployed chemists and engineers in the various industry groups were derived as follows: The rate of unemployment was calculated for each industry. These rates (which varied from 1.9 to 16.4 per cent) were applied to the total number of chemists and engineers attached to each industry group. Since unemployment in these professions was far below the average rate, the resulting figures added up to a total almost twice as large as the number of unemployed chemists and engineers given in the Unemployment Census. These figures for the various industry groups were then reduced using the ratio of the given total to the above-mentioned calculated total.

b) *Occupational Classification*

In 1930, "Surveyors" are included in "Civil Engineers" and could not be separated. In the attached tables they are included in the 1940 column comparable to 1930; excluded from the 1940 figures comparable to 1950.

In 1930 and 1940 "Chemists" include also "Assayers and Metallurgists" and

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possibly also some metallurgical engineers. In 1950, metallurgists are allocated to "Technical Engineers." This shift in classification is largely responsible for the apparent decline in the employment of chemists in the metal industries, and especially in "Primary metals" between 1940 and 1950.

At the 1940 census persons under 35 years were not classified as technical engineers unless they had had at least four years of college education. In 1930 this rule did not apply (see Edwards, *op. cit.*, p. 24), nor did it in 1950.

The 1930 and 1950 data for chemists and engineers attached to the various industries refer to males and females, the 1940 data to males only. But in this year the number of employed females in these professions was negligible. The final census count (not the sample statistics used for the attached tables) reports 2,384 employed female chemists and engineers, that is, 0.78 per cent of the total employment in these professions.

c) Industrial Classification

The 1930 data and the data for 1940 comparable to 1930 refer to all industries, including the armed forces, but excluding public emergency work. The 1950 data and the 1940 totals comparable to 1950 exclude the armed forces.

The 1940 and 1950 censuses use basically the same industrial classification. The 1950 Census lists a number of additional subgroups which for comparison with earlier years had to be combined into larger units, e.g. "Professional equipment" and "Photographic equipment" are one subgroup in 1940. A few subgroups had to be shifted, as for instance, "Broadcasting and television" from "Entertainment and recreation" to "Communications." The 1940 subgroup "National defense" was removed from "Public administration" which in 1950 is limited to civilians. For a few subgroups comparability could not be established: in 1950 there is a separate category "Watches, clocks, and timepieces," while "Jewelry and silverware" are included in "Miscellaneous manufacturing industries." In 1940, watches and clocks are combined with jewelry and silverware and could not be separated. In the nonferrous industries, the subgroups "primary products" and "miscellaneous products" are not identical in 1940 and 1950, but the group as a whole appears to be comparable for these years.

Generally, large relative changes in small subgroups should be interpreted with caution. Thus the large increase in professional employment in "Warehousing" or "Trucking" appears to be due partly to changes in classification or errors resulting from the small size of the sample. (Since in the 1950 occupation-by-industry-tables the number of persons in the sample was multiplied by 30, these tables include small industrial subgroups which show 30 females, but no males as employed chemists.)

The industrial classification system used in the 1930 census was markedly different from the later systems. First of all, the group "Professional service, including education, excluding amusement and recreation" includes a considerable number of engineers and chemists who were not allocated to specific industries although most likely they were not working as independent professionals but were employed by different industries. The 1930 census reports 57,934 chemists and engineers in "Professional service" as compared to 25,860 in 1940. That is, comparability with later years is impaired by the fact that some 30,000 to 35,000 were not distributed among the various industries. It appears that the construction industry is especially affected and that a much larger number of engineers was attached to this group in 1930 than shown by the census data.

For two of the most important industry groups—chemicals and iron and steel industries—the 1930 classification is so different from the later systems that Edwards and also Daniel Carson in his "Changes in the Industrial Composi-

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tion of Manpower since the Civil War" (in *Studies in Income and Wealth, Volume Eleven*, National Bureau of Economic Research, 1949) declare these 1930 and 1940 industries are not comparable. In the attached tables the attempt has been made to establish more or less comparable groups, mainly by shifting and combining of subgroups. Thus the 1940 category "Miscellaneous machinery" was combined with "Miscellaneous iron and steel products" for comparison with 1930. But certain inconsistencies could not be eliminated. The subgroup "Agricultural machinery" includes tractors in 1940 but not in 1930; the 1930 group "Blast furnaces and steel rolling mills" includes some workers in manufacturing establishments, etc.

The 1930 group "Utilities" consists of "Gas works" (shifted from Chemicals and allied products) and "Electric light and power" from the census group "Miscellaneous manufacturing industries." Other utilities, for which 1930 data are not available, were excluded from the 1940 column comparable to 1930 and shifted to "All other industries."

Except for the different treatment of "Other utilities" and "Jewelry and silverware" (see above—1950), the broad group "All other industries" includes in 1930 the same categories as in 1940 and 1950. It combines all those industries in which employment of engineers was negligible and has not been computed for this survey. The groups included are: agriculture, forestry and fishing; textiles and clothing; leather and leather products; lumber and wooden goods; paper and printing; stone, clay and glass products; wholesale and retail trade; finance, insurance and real estate; business and repair services; personal services; amusement and recreation; and industry not specified.

In conclusion it should be pointed out that the comparability of the 1930 figures with later data is affected more strongly by the difference between the "gainful worker" and "employed persons" concept and the incomplete industrial distribution of professional personnel than by inconsistencies in the composition of specific industries or subgroups.