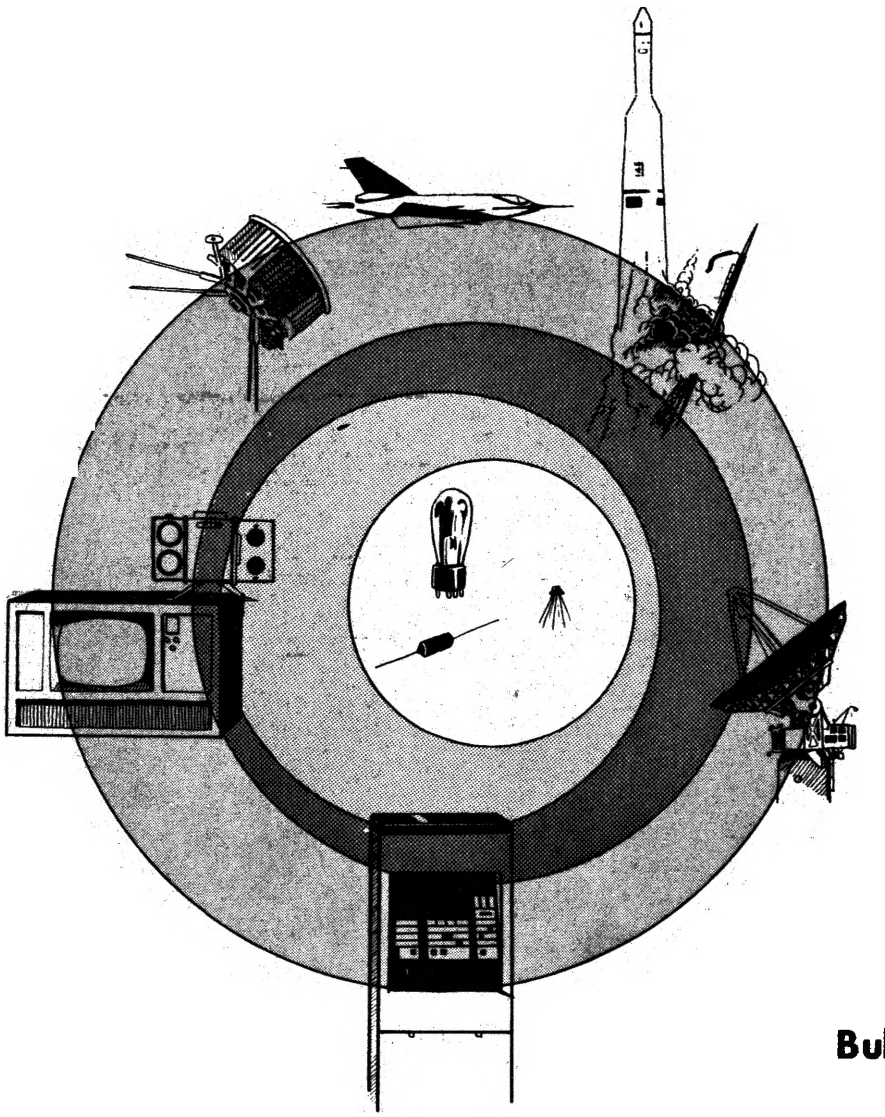
Employment Outlook and Changing Occupational Struture in Electronics Manufacturing



Bulletin No. 1363

UNITED STATES DEPARTMENT OF LABOR
W. Willard Wirtz, Secretary
BUREAU OF LABOR STATISTICS
Ewan Clague, Commissioner

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Page 1, column 1, line 7
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Page 7, column 2, last paragraph
Transpose to page 6, column 1, immediately before section beginning "Employment Size of Electronics Establishments"

Page 47, footnote 30, last line
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October 1963

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PREFACE

Few industries have shown such dynamic growth and change in our generation as electronics manufacturing. Originally consisting of only the manufacture of radios and, later, television sets, the electronics industry has become indispensable to the country's military and space programs and the production of many industrial and commercial products, as well as in the home. Continued rapid change in the nature of the industry is expected under the impact of an electronic technology which is broadening in scope and growing in complexity.

With the realization that electronics manufacturing has become one of the Nation's basic and vitally important industries has come an increased interest in information about the size, composition, and growth of the electronics manufacturing work force. Accurate manpower information for the industry, however, is not readily available. Employment estimates are rough approximations since employment data collected on a national basis are so classified that employment in electronics cannot be clearly separated from employment in other activities. Future manpower requirements are difficult to project because of the rapidity of the industry's growth and change.

This study was made not only to help fill the gaps in manpower information for the industry but also to show the approach used for doing this. It provides estimates of employment in electronics manufacturing for the period 1958-61 and projections of manpower requirements by 1970, classified by major product category and with some detail as to occupation and sex. The study also describes the methodology and sources used for developing these estimates and projections. It is hoped that this information may be helpful for such purposes as: (1) Planning educational and training programs adequate to meet anticipated manpower and skill needs of the industry; (2) providing vocational counseling and placement for young men and women seeking career opportunities; (3) developing employment estimates and projections for detailed segments of the industry, specific localities of the country, or years other than those covered here; and (4) generally improving employment and occupational statistics and techniques for projection in the electronics manufacturing field.

Although some material was obtained through talks and interviews with industry, labor, and Federal Government officials engaged in electronics work, most of the information for the study came from secondary sources, such as periodicals, books, special reports and studies, and newspaper articles. Data available from the Electronic Industries Association, a major trade association in this field, were especially helpful, as were those from Federal legislative committees and Federal agencies. In a few instances data used in the study were subsequently slightly revised by the issuing organization, but too late for incorporation here. This was the case with some of the statistics of the Electronic Industries Association.

This bulletin was prepared by Russell B. Flanders under the supervision of Joseph F. Fulton, who also participated in the writing. The study was directed by Bernard Yabroff in the Bureau's Division of Manpower and Occupational Outlook, under the general direction of Harold Goldstein, Assistant Commissioner for Manpower and Employment Statistics.

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Employment Outlook and Changing Occupational Structure in Electronics Manufacturing

SUMMARY OF FINDINGS

The electronics manufacturing industry in the United States has grown with extreme rapidity in recent years, and is expected to show substantial further growth during the rest of the 1960's. Employment in the industry was estimated at 778,000 workers in 1960--more than three times what it was in 1950--and is expected to reach nearly 1.1 million by 1970. Shipments of electronic products were estimated at $10.8 billion in 1961 and are projected to nearly $20 billion by 1970 (constant 1960 dollars).

These estimates and projections, developed by the Bureau of Labor Statistics to help provide manpower information for electronics manufacturing (defined to include research and development (R&D) as well as production), do not cover electronics activity in the Federal Government, universities, and nonprofit research centers, in which at least 55,000 workers are estimated to have been engaged in late 1960 (chiefly in research, development, and the negotiation and administration of contracts). The projections should be viewed only as indications of general magnitudes and directions of change. Some of the historical series upon which they are based do not extend back many years, and even if they did would not necessarily be too helpful since the past is an uncertain guide to the future in the rapidly changing electronics field. The projections, moreover, are heavily influenced by the major assumptions used in deriving them.

The growth rate projected for electronics manufacturing employment during the 1960's is expected to vary among the major categories into which electronic products are generally classified. In 1961, employment was distributed among these categories in the following estimated proportions: 36 percent in the manufacture of military and space electronic equipment, another 36 percent in the manufacture of electronic components, 16 percent in industrial and commercial electronic equipment, and 11 percent in consumer electronic products. By 1970, these proportions are expected to be about 42 percent in military and space electronic equipment, 30 percent in electronic components, 17 percent in industrial and commercial electronic equipment, and 11 percent in consumer electronic products.

The military and space electronic equipment category is expected to expand rapidly, because of such major influences as the growing electronic sophistication and complexity of spacecraft, missiles, aircraft, and other defense items; the national effort to complete a manned lunar expedition before 1970; and the increasing size and importance of the military space program. The relative share of electronics employment devoted to components manufacturing is expected to fall during the remainder of the 1960's. One reason is that shipments per worker in components manufacture is expected to rise faster than the industry average. Another is that the growing use of transistors and other solid-state components is expected to increase the reliability, length of life, and versatility of components and therefore decrease the rate of component replacement and the number of components needed to do a given job.

Employment in the manufacture of industrial and commercial electronic products is expected to increase during the remainder of the 1960's at a slightly faster rate than employment in electronics manufacturing as a whole, as the demand for these products, especially for computers and data processing equipment, continues to rise. In the consumer electronics field, employment in 1970 is projected at roughly the same proportion of total electronics employment as in 1961. Television sets, radios, and phonographs are expected to continue as the principal consumer electronic

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items during the decade of the 1960's, although many new consumer electronic products will become available commercially.

Production processes vary widely among the major electronic product categories, and these differences are reflected in differences in occupational distributions. The manufacture of military and space products, and to a lesser extent of industrial and commercial products, involves a great deal of research and development work and low-volume production of custom-made end products and requires relatively large proportions of professional and other highly trained workers. In comparison, the manufacture of consumer products and components tends to be an assembly-line, mass-production operation involving relatively large proportions of semiskilled manual workers. Illustrative occupational distributions collected for this study indicate that in mid-1962 nonproduction workers--engineers and other technical workers, administrative and executive personnel, and clerical and stenographic employees--were in the majority (60 percent of the work force) in military and space electronics manufacturing but in the minority (30 percent of the work force) in consumer electronics manufacturing. In military and space electronics, 33 percent of the work force were engineers and other technical workers and 27 percent were semiskilled and unskilled workers, while in the consumer products field, 11 percent were engineers and other technical workers and 63 percent were semiskilled and unskilled workers.

Nonproduction workers have been increasing rapidly as a proportion of total electronics employment. They represented roughly one-fifth of such employment in 1950 and an estimated two-fifths in 1961, and are expected to account for nearly half by 1970. The growing importance of R&D work, and of low-volume production of items made to order on a contract basis, increases the need for engineers and other technical personnel and decreases the need for semiskilled and unskilled production workers. For example, the number of engineers and scientists in electronics manufacturing increased nearly tenfold between 1951 and 1960--from an estimated 13,000 to an estimated 128,000--compared with a threefold increase in total electronics employment over approximately the same period. Another factor influencing expansion in the relative size of the nonproduction work force is the continual introduction of technological changes, which tends to decrease the number of production workers needed to produce a given output. Finally, the growth of recordkeeping and communication requirements in modern business has caused an increase in numbers of clerical and other office workers in electronics manufacturing, despite the introduction and expanded use of improved office equipment, especially for data processing.

Women represent a large but declining proportion of the total work force in electronics manufacturing. Because they are employed mainly as production workers in mass-volume operations, such as the manufacture of consumer products and semiconductors, tubes, and other components, their proportion of the total electronics manufacturing work force has been decreasing and is expected to continue to decrease, from an estimated 50 percent in 1950 to 41 percent in 1961 and a projected 39 percent by 1970. In terms of numbers, however, their employment is expected to grow, from an estimated 320,000 in 1961 to about 423,000 by 1970.

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CHAPTER 1. SCOPE AND NATURE OF ELECTRONICS MANUFACTURING

The electronics industry is engaged in "that branch of science and technology which deals with the study and application of techniques to direct and control the conduction of electricity in a gas, vacuum, a liquid, or a solid-state material. Electron tubes and semiconductors are combined with resistors, capacitors, transformers and similar components in equipments which detect, measure, record, compute and communicate information."[1] The distinguishing feature of electronic products as opposed to purely electrical ones is that, although electricity flows through the circuitry of both, electronic products also include tubes and semiconductors which can discharge, direct, control, or otherwise influence the flow of that electricity.

The Electronic Industries Association, a major trade association in the electronics manufacturing field, estimates that about 2,000 types of electronic products are manufactured in this country.[2] They are extremely varied in end use, function, value, size, and form. They range from "microscopic components less than a thousandth of an inch in diameter to giant computing and control systems."[3]

PRODUCTION CLASSIFICATION BY MAJOR CATEGORY

One frequently used classification divides electronic products into four major categories: (1) Military and space products, (2) industrial and commercial products, (3) consumer products, and (4) components. The first three categories represent end products, while the fourth consists of the parts and accessories which go into end products.

Military and space electronic products are vital parts of missiles, spacecraft, aircraft, tanks, ships, and other items used in national defense and space programs. Representative examples of these products include guidance and checkout systems; telemetering, ground tracking, and support equipment; radar, sonar, infrared, and other detection systems and devices; gyroscopes and other navigational equipment; fire control devices; and high-speed communication equipment. Representative industrial and commercial electronic products include computers; testing and measuring instruments; industrial control and processing equipment; electronic instruments for nuclear work, such as reactor sensing controls and radiation detection devices; television and radio broadcasting equipment; microwave devices; medical and therapeutic equipment, such as X-ray systems and diathermy units; and navigational instruments for civil and private aircraft, ships, etc.

Consumer products include some of the most familiar kinds of electronic equipment and also some of the newest. Examples are television and radio receiving sets; phonographs, high fidelity and stereophonic sound equipment; tape recorders; hearing aids; electronic ovens; and home intercommunication systems. Components are usually classified in three broad groups: tubes, semiconductors, and "other components." Tubes include receiving, power, television picture, and various special-purpose tubes. Principal semiconductor devices are transistors, diodes, and rectifiers. "Other components" include such items as capacitors, resistors, transformers, relays, connectors, and switches. For some purposes, components are classified in another way, as either (1) original equipment or (2) replacement parts.

Because the classification of electronic end equipment as military-space, industrial-commercial, or consumer products is in terms of intended use, the same type of item may be classified in more than one way if it can be manufactured for more than one kind of end use. A radio receiver, for instance, would be classified in the military and space category if produced for

[1] Electronic Industries Association, Electronic Industries 1962 Yearbook, Washington, D.C., September 1962, p. 1.
[2] Ibid.
[3] Ibid.

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use in a military aircraft, in the industrial and commercial sector if intended for use in a civil aircraft, and in the consumer products group if sold for use in a private home. Although computers are usually discussed in this report in terms of the industrial-commercial group, many computers are manufactured for installation in or ground support of military or space craft. Navigational devices may be made for military and space craft, for commercial ships and planes, or even for consumer use in pleasure boating. Many other examples could be cited of electronic items which can be manufactured for more than one kind of end use.

Product specifications and performance requirements vary with intended end use. In general, military and space electronic equipment and their components have the most rigorous requirements for reliability, ruggedness, quality control, accuracy, and other characteristics. Consumer products and their components generally have the least rigorous standards, while performance tolerances for industrial and commercial equipment and their components usually fall between these two limits.

PRODUCT CLASSIFICATION BY SIC CODE

In its compilation of statistics on shipments, employment, earnings, and other economic variables, the Federal Government uses the Standard Industrial Classification (SIC) system, a code which covers all economic activity.[4] The data collected by the Federal Government represent probably the main body of quantitative information about the electronics industry.

The code does not, however, readily identify all electronics manufacturing, which is scattered through at least two dozen of the more than 400 SIC 4-digit industries used to cover manufacturing activity.[5] According to the 1958 U.S. Census of Manufactures--the most recent complete count of manufacturing activity--as many as 20 SIC 4-digit industries (listed in appendix A) each reported at least $25 million worth of electronics shipments in that year, and a few additional 4-digit industries each reported less than $25 million in electronics shipments. Developing accurate estimates of electronics shipments and employment on the basis of the SIC code is a complicated procedure; one of the purposes of this report is to show an approach for doing this.

NATURE OF ELECTRONICS MANUFACTURING

Manufacturing processes in the electronics industry are necessarily extremely varied, in view of the wide range of electronic products and the great differences in their functions and purposes. The most extreme differences are found in a comparison between the fields of military-space and consumer electronics. Industrial-commercial electronics production generally falls between these extremes, and components manufacturing tends to vary according to the type of end equipment for which the components are made.

Performance requirements for military and space electronic items are extremely rigorous. Human life may depend upon the reliability, accuracy, and ruggedness of these items; in the case of unmanned spacecraft, a flight may be aborted or rendered otherwise unsuccessful because of the malfunction of an electronic system or part. Requirements for military and space items are not only severe but also constantly changing to meet the needs of an expanding space program and changing national defense patterns. The rate of obsolescence is high. Ever smaller devices and ever lower power requirements are sought, to overcome limitations o. booster power, fuel, and other energy sources. Consumer products, on the other hand, are generally much more standardized and performance requirements standards are not nearly so rigorous.

[4] The SIC code is contained in the Standard Industrial Classification Manual, 1957 edition, and the 1958 Supplement to that edition, both prepared by the Executive Office of the President, Bureau of the Budget. The SIC code was developed, according to p. 1 of the Manual, "for purposes of facilitating the collection, tabulation, presentation, and analysis of data relating to establishments; and for promoting uniformity and comparability in the presentation of statistical data collected by various agencies of the United States Government, State agencies, trade associations, and private research organizations."

[5] The more than 400 manufacturing industries consist of SIC industries 1911 to 3999. It should be noted that this study excludes electronics activity outside these manufacturing industries, such as that in the Armed Forces, the Federal Government (SIC 91), nonprofit research centers and universities (SIC 8291), engineering service establishments (SIC 8911), and commercial research laboratories (SIC 7391).

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Research and development work is a much larger part of the manufacture of military-space electronics than in consumer electronics.[6] Military and space items are commonly hand made in relatively small numbers on a contract basis, while consumer items are generally mass produced, using automated and mechanized processes, for mass distribution. The proportion of engineers, scientists, technicians, and skilled craftsmen in the work force is relatively high in military-space electronics production and relatively low in the consumer products field. Correspondingly, the proportion of semiskilled and unskilled assembly-line production workers is comparatively low in military-space electronics and high in consumer electronics. The proportion of women workers, who tend to be concentrated in the semiskilled and unskilled production jobs, is generally lower in military-space electronics than in consumer electronics.

All electronics establishments, regardless of product category, employ administrative, executive, clerical, and stenographic workers, and many employ engineers, scientists, and technicians for various functions, mainly R&D work. The relative numerical importance of R&D workers varies considerably with the type of product made. Production workers in the typical electronics plant include assemblers who use small hand tools, soldering irons, light welding devices, diagrams, and models to put together parts, circuits, and subassemblies; testers and inspectors who check, visually or with instruments, the products being manufactured through every stage of their production; and processing, fabricating, and machining workers, such as spray and dip painters, oven tenders, coil winders, electroplaters, anodizers, silk screen operators, and machine tool operators. Skilled maintenance craftsmen are responsible for the care of plant and equipment.

LOCATION OF EMPLOYMENT IN ELECTRONICS MANUFACTURING

Electronics establishments which are heavily engaged in R&D work and employ large numbers of engineers, technicians, and highly skilled craftsmen--such as many plants in military-space and industrial-commercial electronics--frequently locate in metropolitan areas. Cities are more likely to attract the trained personnel needed in R&D work, especially if the cities possess university facilities for the continued education of professional and technical workers. On the other hand, electronics establishments which are primarily engaged in large-volume production operations--such as plants manufacturing relatively standardized components and consumer products--frequently locate in small towns or rural areas, where semiskilled and unskilled workers are generally available in large numbers. Shipping costs are not an especially major consideration since products tend to be small and light in weight relative to their value.

Some information on location of electronics employment is available by State from unpublished data collected by the Bureau of Employment Security (BES), U.S. Department of Labor (tables 1 to 4). These unpublished State data cover electronics manufacturing employment in only the seven SIC 4-digit industries engaged primarily in such manufacturing. In both 1961 and 1958, these seven industries accounted for about three-fourths of the estimated employment in the manufacture of electronics products.[7]

More than 3 of every 10 workers in electronics manufacturing were located in the Middle Atlantic States in January 1961 (table 1). More than 2 of every 10 were located in the Pacific States, and nearly the same proportion were employed in the East North Central States. New England had the fourth largest group of electronics workers, with 12 percent of the industry total. These four major regions together accounted for more than four-fifths of the entire electronics work force in 1961; the three contiguous regions--Middle Atlantic, East North Central, and New England--accounted for more than three-fifths.

California had the largest concentration of electronics workers in both 1961 and

[6] Manufacturing, as used throughout this report, includes research and development work as well as production.

[7] Total electronics employment was 777,700 in 1961 and 609,800 in 1958, according to the estimates developed for this report. (See table 13.) The unpublished BES employment data are only approximately comparable with the estimates in table 13, since the latter figures relate to electronics employment only, while the BES figures cover all employment--nonelectronic as well as electronic--in industries primarily electronic.

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1958 (table 1). Other States with heavy employment concentrations, listed in decreasing order as of 1961, were New York, Illinois, New Jersey, Pennsylvania, Massachusetts, and Indiana. These were the only States with as much as 5 percent of total electronics employment in either 1961 or 1958. Of these leading States, California had a large increase in its share of total electronics employment between 1958 and 1961, while the others, except Pennsylvania, had decreases.

The regional distribution of electronics workers varies considerably by major industry segment. This fact is illustrated by the following tabulation based on data from tables 1-4, which arrays, by major industry segment, the four regions with the highest concentrations of electronics employment. The array for each industry segment is in descending order, according to the percent (shown in parentheses) of employment in the industry segment in January 1961 accounted for by each region.

All industry segments		Military and industrial electronics		Consumer electronics		Electronic components	
Middle Atlantic	(31)	Pacific	(31)	East North Central	(49)	Middle Atlantic	(36)
Pacific	(21)	Middle Atlantic	(27)	Middle Atlantic	(31)	New England	(21)
East North Central	(20)	East North Central	(12)	Pacific	(11)	East North Central	(18)
New England	(12)	New England	(18)	New England	(3)	Pacific	(13)

[1] One other region, the South Atlantic, ranked ahead of New England, with 10 percent of employment in the industry segment.

The Pacific region, for example, ranked first in number of military and industrial electronics workers but only third and fourth in the two other industry segments shown. The East North Central States, on the other hand, ranked only third in two industry segments but accounted for roughly half (49 percent) of all employment in the consumer products field; this was the highest proportion accounted for by any region in any industry segment. The New England States ranked lowest in two industry segments but second in components manufacturing employment.

Between 1958 and 1961, each of the four major regions had increases in the number of electronics workers, but the increases were unequal in rate (table 1). As a result, regional employment as a proportion of national employment declined in the Middle Atlantic and East North Central States, remained the same in New England, and rose markedly in the Pacific region--from 15 percent to 21 percent. California accounted for virtually all electronics employment in the Pacific region in both 1961 and 1958.

EMPLOYMENT SIZE OF ELECTRONICS ESTABLISHMENTS

Table 5 presents data from the 1958 Census of Manufactures on the employment size of electronics establishments.[8] As in tables 1-4, the data do not relate to all electronics manufacturing employment, but only to that in the seven SIC 4-digit industries primarily engaged in such manufacturing.[9]

The major conclusion to be drawn from the data is that the majority of the electronics plants employ small numbers of workers and account for little overall industry employment, while a relatively few large plants account for sizable proportions of industry employment. Nearly two-thirds (65 percent) of the 2,527 plants had fewer than 50 employees each in 1958, and employed only 5 percent of the total work force. On the other end of the scale, establishments with 250 or more employees represented only 13 percent of the 2,527 establishments but accounted for 79 percent of

[8] In addition to the 2,527 establishments covered in table 5, many other plants making electronic products are classified in SIC industries not primarily engaged in electronics manufacturing--that is, in industries in which electronics shipments represent less than half of the value of total shipments. (See appendix A for a list of most of these industries.) The Electronic Industries Association estimates that more than 5,500 establishments were making some electronic products in the United States in late 1961 (Electronic Industries 1962 Yearbook, p. 1).

[9] The Census Bureau's figure of 401,400 in table 5 differs from the Labor Department's figure of 458,400 in table 1, even though both represent the sum of employment in the same seven SIC industries, because (1) collection methods and criteria differ between the two series, and (2) the figures in table 5 are averages for 1958 while those in table 1 are as of January 1958.

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total employment; establishments with 2,500 or more employees equaled only 1 percent of all establishments but accounted for at least 22 percent of total employment.[10]

On an individual industry basis, half or more of the establishments in 6 of the 7 industries had fewer than 50 employees each, but the proportion of industry employment accounted for by these smaller plants was in no case greater than 13 percent, and in one case as low as 1.5 percent. On the other hand, the proportion of establishments with 250 or more employees was in no case higher than 38 percent and in one case as low as 7 percent, but these larger establishments accounted for shares of industry employment ranging from 60 to 97 percent. While figures for the largest employment-size classes are not given for every industry in table 5, those given generally show employment concentrations in a few very large plants. In the consumer field of radio and TV receiving sets, for example, 20 establishments (9 percent of the total) had 57 percent of total industry employment; in the military and industrial field of radio and TV communication equipment, 31 establishments (6 percent of the total) accounted for 66 percent of industry employment; and in the manufacture of transmitting electron tubes, 6 establishments (12 percent of the total) had 55 percent of industry employment.

Rates of employment change between 1958 and 1961 in the four major regions were unequal also in terms of major industry segments, as indicated in the following tabulation based on data from tables 1 to 4, covering the four regions with the largest concentrations of electronics employment. The tabulation shows, for each major region and industry segment, the change which occurred between 1958 and 1961 in the proportion which workers in the region represented of total national employment in the industry segment. Changes are shown in terms of the number of percent points gained or lost in these proportions.

Major region	All industry segments	Military and industrial electronics	Consumer electronics	Electronic components
Middle Atlantic	-3.3	+0.5	[1] -7.6	-2.3
Pacific	+6.0	-.8	+3.0	+6.8
East North Central	-3.8	+2.4	+7.4	-5.1
New England	0	-2.9	+.6	+1.0

[1] This relatively sharp drop was due to a marked employment decline in New Jersey.

[10] Exact employment in plants with 2,500 or more employees is not ascertainable from table 5 because of data withheld for SIC industries 3671 and 3673, to avoid disclosing figures for individual companies. Maximum and minimum employment for this category of establishments, however, may be determined in these two SIC industries. With the help of these maximums and minimums, it may be concluded that, for the 7 industries of table 5 combined, employment in plants with 2,500 or more employees equaled between 22 and 26 percent of total employment.

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Table 1. Employment in electronics manufacturing,[1] by region and State, January 1958 and January 1961

Region[2] and State[3]	January 1958		January 1961	
	Number	Percent	Number	Percent
All employees	458,405	100.0	616,860	100.0
Middle Atlantic	158,328	34.5	192,193	31.2
New York	61,527	13.4	75,625	12.3
New Jersey	56,013	12.2	58,797	9.5
Pennsylvania	40,788	8.9	57,771	9.4
Pacific	69,849	15.2	130,552	21.2
California	68,914	15.0	129,090	20.9
Other	935	.2	1,462	.2
East North Central	107,544	23.5	121,703	19.7
Illinois	58,008	12.7	60,757	9.8
Indiana	28,888	6.3	31,233	5.1
Wisconsin	3,432	.7	13,772	2.2
Ohio	12,000	2.6	11,052	1.8
Michigan	5,216	1.1	4,889	.8
New England	55,312	12.1	74,591	12.1
Massachusetts	43,883	9.6	50,986	8.3
Connecticut	6,110	1.3	10,148	1.6
New Hampshire	4,133	.9	6,782	1.1
Other	1,186	.3	6,675	1.1
South Atlantic	28,402	6.2	40,636	6.6
North Carolina	13,744	3.0	16,151	2.6
Maryland	8,355	1.8	9,843	1.6
Florida	3,972	.9	9,789	1.6
Other	2,331	.5	4,853	.8
West North Central	12,226	2.7	22,553	3.7
Iowa	7,507	1.6	11,125	1.8
Minnesota	2,156	.5	6,098	1.0
Other	2,563	.6	5,330	.9
West South Central	7,793	1.7	16,880	2.7
Texas	6,764	1.5	15,821	2.6
Other	1,029	.2	1,059	.2
East South Central	11,035	2.4	11,937	1.9
Kentucky	4,936	1.1	4,403	.7
Other	6,099	1.3	7,534	1.2
Mountain	7,916	1.7	5,815	.9
Arizona	7,219	1.6	4,720	.8
Other	697	.2	1,095	.2

[1] Data in this table cover the seven 4-digit industries, 1957 SIC code, each with at least $25 million in electronics shipments in 1958, and with electronics shipments representing half or more of the value of total shipments. These industries are SIC 3651 (Radio and television receiving sets, except communication types), 3652 (Phonograph records), 3662 (Radio and television transmitting, signaling, and detection equipment and apparatus), 3671 (Radio and television receiving type electron tubes, except cathode ray), 3672 (Cathode ray picture tubes), 3673 (Transmitting, industrial, and special purpose electron tubes), and 3679 (Electronic components and accessories, not elsewhere classified).

[2] States in each region are as follows: Middle Atlantic--New Jersey, New York, Pennsylvania; Pacific--Alaska, California, Hawaii, Oregon, Washington; East North Central--Illinois, Indiana, Michigan, Ohio, Wisconsin; New England--Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; South Atlantic--Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia; West North Central--Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota; West South Central--Arkansas, Louisiana, Oklahoma, Texas; East South Central--Alabama, Kentucky, Mississippi, Tennessee; and Mountain--Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming.

[3] States individually listed are those which had, in either January 1958 or January 1961, at least 1.0 percent of total employment in the seven 4-digit industries covered by the table.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Unpublished data collected by the U.S. Department of Labor, Bureau of Employment Security.

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Table 2. Employment in military-space and industrial-commercial electronics manufacturing,[1] by region and State, January 1958 and January 1961

Region and State[2]	January 1958		January 1961	
	Number	Percent	Number	Percent
All employees	153,590	100.0	293,197	100.0
Pacific	48,211	31.4	89,856	30.6
California	47,493	30.9	88,858	30.3
Other	718	.5	998	.3
Middle Atlantic	41,284	26.9	80,349	27.4
New York	24,430	15.9	36,472	12.4
New Jersey	12,226	8.0	28,286	9.6
Pennsylvania	4,628	3.0	15,591	5.3
East North Central	14,193	9.2	34,153	11.6
Illinois	10,455	6.8	13,588	4.6
Wisconsin	802	.5	10,730	3.7
Ohio	1,979	1.3	4,763	1.6
Indiana	158	.1	4,205	1.4
Other	799	.5	867	.3
South Atlantic	20,561	13.4	30,713	10.5
North Carolina	11,450	7.5	13,552	4.6
Maryland	7,924	5.2	9,166	3.1
Florida	1,033	.7	6,617	2.3
Other	154	.1	1,378	.5
New England	17,508	11.4	24,998	8.5
Massachusetts	14,096	9.2	16,428	5.6
Connecticut	2,148	1.4	3,395	1.2
Other	1,264	.8	5,175	1.8
West North Central	2,566	1.7	15,181	5.2
Iowa	467	.3	9,376	3.2
Minnesota	1,128	.7	4,541	1.5
Other	971	.6	1,264	.4
West South Central	4,105	2.7	14,367	4.9
Texas	4,064	2.6	14,130	4.8
Other	41	([3])	237	.1
East South Central	167	.1	3,166	1.1
Tennessee	85	.1	3,093	1.1
Other	82	.1	73	([3])
Mountain	4,995	3.3	414	.1
Arizona	4,877	3.2	70	([3])
Other	118	.1	344	.1

[1] Data in this table cover the 4-digit military-space and industrial-commercial electronics industry, 1957 SIC code, with at least $25 million in electronics shipments in 1958, and with electronics shipments representing half or more of the value of total shipments. This industry is SIC 3662: Radio and television transmitting, signaling, and detection equipment and apparatus. This industry is identified in the 1957 SIC code, as amended by the 1958 supplement, as follows: "Establishments primarily engaged in manufacturing (1) radio and television broadcasting equipment; (2) electric communication equipment and parts, except telephone and telegraph; (3) electronic field detection apparatus, light and heat emission operating apparatus, object detection apparatus and navigational electronic equipment, infrared object detection equipment, and aircraft and missile control systems; and (4) other electric and electronic communication and signaling products, not elsewhere classified."

[2] States individually listed are those which had, in either January 1958 or January 1961, at least 1.0 percent of total employment in SIC 3662.

[3] Less than .05 percent.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Unpublished data collected by the U.S. Department of Labor, Bureau of Employment Security.

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Table 3. Employment in consumer electronics manufacturing,[1] by region and State, January 1958 and January 1961

Region and State[2]	January 1958		January 1961	
	Number	Percent	Number	Percent
All employees	127,185	100.0	97,186	100.0
East North Central	52,950	41.6	47,662	49.0
Illinois	27,963	22.0	26,814	27.6
Indiana	16,490	13.0	16,410	16.9
Michigan	3,002	2.4	2,293	2.4
Ohio	5,278	4.1	1,913	2.0
Other	217	.2	232	.2
Middle Atlantic	48,693	38.3	29,854	30.7
New York	17,132	13.5	15,585	16.0
Pennsylvania	9,345	7.4	7,925	8.2
New Jersey	22,216	17.5	6,344	6.5
Pacific	10,089	7.9	10,561	10.9
New England	2,963	2.3	2,843	2.9
East South Central	2,327	1.8	2,317	2.4
Tennessee	1,987	1.6	1,693	1.7
Other	340	.3	624	.6
West North Central	7,211	5.7	2,167	2.2
West South Central	2,292	1.8	809	.8
Other regions (South Atlantic and Mountain)	660	.5	973	1.0

[1] Data in this table cover the two 4-digit consumer electronics industries, 1957 SIC code, each with at least $25 million in electronics shipments in 1958, and with electronics shipments representing half or more of the value of total shipments. These industries are SIC 3651 (Radio and television receiving sets, except communication types) and 3652 (Phonograph records).

[2] States individually listed are those which had, in either January 1958 or January 1961, at least 1.0 percent of total employment in the two 4-digit industries covered by the table, except that individual listing of some States was withheld to avoid disclosure of confidential data.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Unpublished data collected by the U.S. Department of Labor, Bureau of Employment Security.

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Table 4. Employment in electronic components manufacturing,[1] by region and State, January 1958 and January 1961

Region and State[2]	January 1958		January 1961	
	Number	Percent	Number	Percent
All employees	177,630	100.0	226,477	100.0
Middle Atlantic	68,351	38.5	81,990	36.2
Pennsylvania	26,815	15.1	34,255	15.1
New Jersey	21,571	12.1	24,167	10.7
New York	19,965	11.2	23,568	10.4
New England	34,841	19.6	46,750	20.6
Massachusetts	28,483	16.0	33,338	14.7
Connecticut	2,434	1.4	5,322	2.3
New Hampshire	3,045	1.7	4,386	1.9
Other	879	.5	3,704	1.6
East North Central	40,401	22.7	39,888	17.6
Illinois	19,590	11.0	20,355	9.0
Indiana	12,240	6.9	10,618	4.7
Ohio	4,743	2.7	4,376	1.9
Wisconsin	2,413	1.4	2,810	1.2
Other	1,415	.8	1,729	.8
Pacific	11,549	6.5	30,135	13.3
South Atlantic	7,191	4.1	8,953	4.0
Florida	2,939	1.7	2,921	1.3
North Carolina	2,250	1.3	2,393	1.1
Other	2,002	1.1	3,639	1.6
East South Central	8,541	4.8	6,454	2.8
Mountain	2,911	1.6	5,398	2.4
Arizona	2,332	1.3	4,647	2.1
Other	579	.3	751	.3
West North Central	2,449	1.4	5,205	2.3
West South Central	1,396	.8	1,704	.8

[1] Data in this table cover the four 4-digit components industries, 1957 SIC code, each with at least $25 million in electronics shipments in 1958, and with electronics shipments representing half or more of the value of total shipments. These industries are SIC 3671 (Radio and television receiving type electron tubes, except cathode ray), 3672 (Cathode ray picture tubes), 3673 (Transmitting, industrial, and special purpose electron tubes), and 3679 (Electronic components and accessories, not elsewhere classified).

[2] States individually listed are those which had, in either January 1958 or January 1961, at least 1.0 percent of total employment in the four 4-digit industries covered by the table, except that individual listing of some States was withheld to avoid disclosure of confidential data.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Unpublished data collected by the U.S. Department of Labor, Bureau of Employment Security.

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Table 5. Employment size of establishments in electronics manufacturing, by SIC industry, 1958[1]

SIC number	SIC industry	All establishments	Establishments with an average of--				
			1-49 employees	50-249 employees	250-999 employees	1,000-2,499 employees	2,500 employees or more
	Totals:						
	Establishments:						
	Number	2,527	1,635	560	234	75	23
	Percent of total	100.0	64.7	22.2	9.3	3.0	0.9
	Employees:						
	Number	401,351	21,110	62,579	(2)	(2)	(2)
	Percent of total	100.0	5.3	15.6	(2)	(2)	(2)
3651	Radio and TV receiving sets:						
	Establishments:						
	Number	234	117	59	38	17	3
	Percent of total	100.0	50.0	25.2	16.2	7.3	1.3
	Employees:						
	Number	66,505	1,529	7,199	19,662	25,709	12,406
	Percent of total	100.0	2.3	10.8	29.6	38.7	18.7
3652	Phonograph records:						
	Establishments:						
	Number	94	67	20	5	2	0
	Percent of total	100.0	71.3	21.3	5.3	2.1	0
	Employees:						
	Number	7,421	991	1,937	4,493	(3)	0
	Percent of total	100.0	13.4	26.1	60.5		0
3662	Radio and TV communication equipment:						
	Establishments:						
	Number	512	327	100	54	18	13
	Percent of total	100.0	63.9	19.5	10.6	3.5	2.5
	Employees:						
	Number	129,515	3,904	12,307	27,252	30,652	55,400
	Percent of total	100.0	3.0	9.5	21.0	23.7	42.8
3671	Electron tubes, receiving type:						
	Establishments:						
	Number	85	54	[4] 6	9	14	2
	Percent of total	100.0	63.5	7.1	10.6	16.5	2.4
	Employees:						
	Number	36,968	567	421	35,980	(3)	(3)
	Percent of total	100.0	1.5	1.1	97.3		

See footnotes at end of table.

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Table 5. Employment size of establishments in electronics manufacturing, by SIC industry, 1958[1]--Continued

SIC number	SIC industry	All establishments	Establishments with an average of--				
			1-49 employees	50-249 employees	250-999 employees	1,000-2,499 employees	2,500 employees or more
3672	Cathode ray picture tubes:						
	Establishments:						
	Number	75	56	11	5	3	0
	Percent of total	100.0	74.7	14.7	6.7	4.0	0
	Employees:						
	Number	8,554	706	897	6,951	([3])	0
	Percent of total	100.0	8.3	10.5	81.3		0
3673	Electron tubes, transmitting:						
	Establishments:						
	Number	48	16	14	12	4	2
	Percent of total	100.0	33.3	29.2	25.0	8.3	4.2
	Employees:						
	Number	20,146	466	1,600	6,931	11,149	([3])
	Percent of total	100.0	2.3	7.9	34.4	55.3	
3679	Electronic components, n.e.c.						
	Establishments:						
	Number	1,479	998	350	111	17	3
	Percent of total	100.0	67.5	23.7	7.5	1.1	.2
	Employees:						
	Number	132,242	12,947	38,218	48,381	23,872	8,824
	Percent of total	100.0	9.8	28.9	36.6	18.0	6.7

[1] Data in this table cover the seven 4-digit industries, 1957 SIC code, each with at least $25 million in electronics shipments in 1958, and with electronics shipments representing half or more of the value of total shipments.

[2] Not available.

[3] Data which cannot be shown separately have been combined with figures in the next lower size class or classes. Combined figures are underlined.

[4] All establishments in this group reported an average of 50-99 employees.

Note: Because of rounding, sums of individual items may not equal totals.

Source: U.S. Bureau of the Census, U.S. Census of Manufactures: 1958, MC 58(2)-36D, table 4.

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CHAPTER 2. HISTORICAL GROWTH OF ELECTRONICS MANUFACTURING

Although the electronics industry as we know it today is relatively new, work was being done in electronics before the start of this century. In 1894, Oliver Lodge developed a system of wireless communication in England. During the next few years, considerable progress was made in wireless telegraphy by Guglielmo Marconi, Ernest Rutherford, F. K. Vreeland, R. A. Fessenden, and Lee De Forest, among others. The invention of the three-element vacuum tube by De Forest in 1906 made possible both the development of the radio broadcasting industry and the practical application of television. Between 1910 and 1920 rapid progress was made in the theory, application, and construction of vacuum tubes and their circuits, and E. H. Armstrong began his work in frequency modulation (FM).

During World War I, ground-to-aircraft radio communication was introduced. After that war, radio broadcasting stations began operations in all parts of the country. By 1939, electronics production had grown in value to $340 million, the number of radios produced equaled 10.8 million,[11] and employment in what was then known as the radios, radio tubes, and phonographs industry had risen to 56,000.[12]

Crude television pictures in color were demonstrated as early as 1930. Black and white television broadcasts began in 1936. During World War II, research in television transmitting and receiving continued because of potential military applications, and resulting improvements led to widespread consumer acceptance of television.

Military equipment, including new products such as radar, sonar, and the proximity fuse, dominated electronics production during World War II. Research during that war brought about many technological advances in electronics application. Electronic testing and measuring devices were developed, and improvements were made in radio navigation and air flight control equipment. The digital computer was developed, to meet the need for high-speed data processing in advanced scientific work and for automatic fire and flight controls.

The cessation of hostilities caused a sharp decline in employment in electronics manufacturing, from its wartime peak of 380,000 workers in 1944,[13] but the postwar advent of large-scale television production resulted in another upward trend in employment. Between 1947 and 1950, the production of television sets rose from 178,600 units, with a shipment value of $50 million, to 7.5 million units, with a shipment value of $1.35 billion, and electronics employment rose nearly one-fifth.[14]

Between 1950 and 1961 electronics manufacturing employment more than tripled, equaling an estimated 778,000 workers in the latter year.[15] The extreme rapidity of this expansion is evident when compared with a growth of only 7 percent over the same period for all U.S. manufacturing employment.[16]

Between 1950 and 1961, electronics shipments expanded more than fourfold, from

[11] Production and shipments data in this report, unless otherwise indicated, are estimates of the Electronic Industries Association (EIA) or are based on EIA estimates. Some of the EIA data used were subsequently slightly revised by that organization, but too late for incorporation here.

[12] U.S. Census of Manufactures: 1939, Vol. II, Pt. 2, table 2, U.S. Bureau of the Census, p. 388.

[13] Employment Outlook in Electronics Manufacturing (BLS Bulletin 1072, 1952), p. 10.

[14] From 206,000 workers in 1947, according to the U.S. Bureau of the Census, Census of Manufactures: 1947, Vol. II, table 1, p. 739, to 244,000 workers in 1950, according to "Expansion in Electronics Employment," Monthly Labor Review, February 1952, p. 151. Both employment figures cover all workers in the radios and related products and the electron tubes industries, as defined in the 1945 edition of the Standard Industrial Classification Manual (U.S. Executive Office of the President). It is believed that these two industries included nearly all workers engaged in electronics manufacturing in 1947 and 1950.

[15] Employment estimate for 1950 appears in footnote 14, estimate for 1961 appears in table 13.

[16] U.S. manufacturing employment averaged 15,241,000 workers in 1950 and 16,267,000 workers in 1961. Data for 1950 from Employment and Earnings Statistics for the United States, 1909-60 (BLS Bulletin 1312, 1961), p. 29; data for 1961 from Employment and Earnings, June 1962, p. 92.

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$2.6 billion to $10.69 billion (table 6).[17] This rapid growth in shipments can be attributed mainly to the widening variety of electronic products which have resulted largely from a steadily growing effort in R&D work by both Government and private industry. The computer and the transistor (discussed later in this chapter) are major examples of the many innovations due to R&D work.

Expenditures for electronics R&D have been rising in recent years, but statistics on these expenditures are fragmentary. Funds for R&D in the electrical equipment and communication industries rose about 60 percent between 1956 and 1960, from $1.5 billion to $2.4 billion.[18] A large portion of electronics R&D is financed by the Federal Government. This portion was "approximately 85 percent of the whole" in 1959, according to one estimate.[19]

TRENDS IN MAJOR PRODUCT CATEGORIES, 1950-61

Military and Space Products. Virtually the only purchaser of military and space electronic products is the Federal Government. The Department of Defense is the largest Federal customer, and was virtually the only one before the National Aeronautics and Space Administration (NASA) was established in 1958. Since then, the Department of Defense has been purchasing more than 90 percent of the military and space shipments shown in table 6.

Shipments of military and space products rose from a value of $500 million in 1950 to $5.49 billion in 1961--an elevenfold increase. These shipments jumped from about one-fifth of total electronics shipments in 1950 to about one-half during the years of the Korean conflict and have remained at the latter level since then.

One major reason for the growth of expenditures for military electronics is the shift in defense expenditures from aircraft to missiles; electronic equipment accounts for a smaller proportion of the cost of aircraft than of missiles. Between the fiscal years 1954 and 1961, expenditures for the procurement of missiles rose from $417 million to $2.97 billion while expenditures for aircraft procurement declined from $9.08 billion to $5.9 billion (table 7).

Another major reason for growth in military electronics expenditures is the rapid expansion of military research, development, test, and evaluation (RDT&E)--from $2.19 billion in fiscal 1954 to $6.13 billion in fiscal 1961 (table 7). Expenditures for electronics have been taking an increasing share of these RDT&E funds, as the Department of Defense develops more complex weaponry and increases the portion of its development effort for spacecraft.

Expenditures by the National Aeronautics and Space Administration have risen sharply since the agency was established. From fiscal 1958 to fiscal 1961 they rose more than eightfold--from $89 million to $744 million. They are estimated at $1.29 billion for fiscal 1962 and $2.25 billion for fiscal 1963.[20] An estimated one-fourth of these expenditures are disbursed to manufacturing establishments for electronic product research, development, and procurement.

Industrial and Commercial Products. Industrial and commercial electronics shipments rose rapidly between 1950 and 1961, from $350 million to $2.2 billion (table 6). The growth rate for this product category exceeded that for the electronics industry as a whole; industrial and commercial shipments rose from 14 percent of total electronics shipments in 1950 to 21 percent in 1961. Expansion of this product category has been especially rapid since 1956. Table 8 shows detailed data for the years since 1956 for various types of industrial and commercial equipment.

Expanding applications for computing, data processing, and industrial control equipment represent the principal reason for this rapid recent expansion. Between

[17] Shipment values are not available by major product category for years prior to 1950. Shipment values in table 6, and everywhere else in this report unless otherwise stated, are in current dollars. Shipments shown in table 6 are reproduced in appendix A, table A-1, in constant 1960 dollars as well as current dollars.

[18] National Science Foundation, Review of Data on Research and Development, No. 30, NSF 61-51, September 1961, p. 5.

[19] Coordination of Information on Current Federal Research and Development Projects in the Field of Electronics, prepared for the Senate Committee on Government Operations and its Subcommittee on Reorganization and International Organizations, 87th Cong., 1st sess., 1961, p. 130.

[20] The Budget of the United States Government, Fiscal Year Ending June 30, 1963 (1962), p. 110 for fiscal 1958 figure and p. 246 for figures for other years. NASA expenditures in constant 1960 dollars are shown in appendix A, table A-2.

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1956 and 1961, shipments of computers and industrial controls rose from $240 million to $980 million, and from 25 percent to 45 percent of total industrial-commercial electronics shipments (table 8).

The first general-purpose electronic computer designed for business data processing and scientific use (Univac I) was produced around 1948. By 1960, computers in use in this country were estimated to number between 3,600 and 4,400[21]; by the close of 1961, more than 8,800 computers had been installed.[22]

Computers have found application in research laboratories, business offices, and industrial production. The first computer designed for on-line industrial use was applied to a petroleum refinery operation in 1958. Computers have since been installed to control many additional types of production operations, such as those in chemical plants, electric power stations, and steel rolling mills.

Computer research also contributed to the development of specialized electronic devices used to control metalworking operations. Machines equipped with these devices operate automatically, taking their instructions from perforated tape, magnetic tape, or other media. Numerical control has been applied to drilling, boring, milling, turning, shaping, punching, flame cutting, welding, grinding, and tube bending operations. More than 1,500 numerically controlled machine tools were sold by mid-1961.[23]

Testing and measuring equipment is another type of industrial electronic product which has found expanded applications in recent years. Shipments of such equipment rose from $170 million in 1956 to $290 million in 1961 (table 8). Examples of newer kinds of testing and measuring equipment include transistorized scale systems; electronic calipers; X-ray gages, such as those used in steel plants to control the thickness of sheet steel; tube and electronic circuitry testing equipment; cathode-ray oscilloscopes; and audio oscillators.

Shipments of landmobile, microwave, and broadcasting equipment increased between 1956 and 1961, from $120 million to $215 million (table 8). Contributing to this increase has been the growing demand for two-way radio equipment designed for use in automobiles, boats, and other mobile installations, for microwave relay equipment, and for commercial radio and television broadcasting equipment. Microwave relay is a relatively new system of communication involving the transmission of ultrahigh frequencies (UHF) along a series of short-range radio repeater stations. Many types of multiestablishment enterprises, including manufacturing firms, public utilities, insurance companies, and banks, use microwave equipment to feed data into computers from diverse locations. Commercial radio and television stations on the air increased by 28 percent between 1956 and 1961, from 3,922 to 5,034, and the number of educational television stations on the air rose from 20 to 54.[24] Stereo-FM radio broadcasting began in 1961, and, by December of that year, more than 30 stations were on the air.[25]

Between 1956 and 1961 the shipment value of "Other industrial and commercial products" rose by 70 percent, from $420 million to $715 million (table 8). This growth reflects increases in the number of civil aircraft,[26] the growing use of electronic navigational aids on passenger ships and merchant vessels, expansion of the atomic energy field,[27] and an expanding market for medical and therapeutic electronic equipment.[28][29]

[21] Frank Leary, "New Developments in Computers," Electronics, McGraw-Hill, New York, Aug. 26, 1960, p. 30.

[22] "Computers Census as of December 1961," Business Automation, O. A. Business Publications, Inc., Elmhurst, Ill., January 1962, p. 39.

[23] American Machinist/Metalworking Manufacturing, McGraw-Hill, New York, Nov. 27, 1961, p. 89.

[24] 27th Annual Report, Fiscal Year Ended June 30, 1961 (Federal Communications Commission), pp. 59-60.

[25] Electronic News, Fairchild Publications, Inc., New York, Nov. 27, 1961, p. 28.

[26] Among the electronic items used for civil aircraft are communication equipment and navigational aids such as air and ground traffic control equipment, altimeters, autopilots, radio direction finders, and flight control equipment.

[27] Examples of electronic devices for nuclear work include dosimeters, geiger counters, reactor sensing controls, radiation detection devices, and particle accelerators.

[28] Including such items as X-ray equipment, cardiographs, diathermy equipment, ultraviolet microscopes, and ultrasonic drilling equipment used by dentists.

[29] Additional example of "other industrial and commercial products" include commercial sound equipment (coin-operated phonographs, public address systems, intercommunications systems, and theater sound equipment); cryptographic devices, and other communication equipment; automotive equipment, such as headlight dimmers and speed controls; geophysical exploration equipment; meteorological equipment, such as radiosondes and wind-speed indicators; radio astronomy equipment; lie detectors; photoelectric equipment; and electronic drafting equipment.

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Consumer Products. The value of consumer electronics shipments increased from $1.5 billion in 1950 to $2.05 billion in 1961 (table 6). This represented a considerably lower rate of growth than the average for the electronics industry as a whole. Consumer products fell from the position of largest electronics product category in 1950, with 58 percent of total electronics shipments, to third largest category in 1961--following both military and industrial electronics--with 19 percent of total electronics shipments.

Major consumer items are monochrome (black and white) television sets, which accounted for about 40 percent of consumer electronics shipments in 1961; phonographs and radios, each accounting for roughly 15 percent of 1961 consumer electronics shipments; and phonograph records, accounting for approximately 12 percent of 1961 consumer electronics shipments. Trends between 1950 and 1961 in television and radio production are indicated in table 9, and in phonograph and phonograph-record sales in table 10.

Some of the newer consumer products include color television receivers, tape recorders, high fidelity and stereophonic sound equipment, electronic organs, home intercommunication systems, automatic garage-door openers, electronic ovens, miniaturized hearing aids, and Citizen's-Band radio equipment for consumer use. Color television accounted for only a small segment of the total television market during the 1950's. Several major producers have recently begun manufacturing color sets, and consumer acceptance of the product is expected to grow with a wider variety of models to choose from, improvements in quality of sets, and increased color programing. Sales of color television sets more than doubled between 1961 and 1962, totaling over 400,000 in the latter year.

Electronic Components. Electronic components consist of receiving tubes, TV picture tubes, power tubes, and special-purpose tubes such as those used in ultra-high frequency equipment; semiconductors, principally transistors, diodes, and rectifiers; and other components, such as capacitors, resistors, transformers, relays, connectors, switches, printed circuit boards, speakers, tuners, and antennas.

Components are used in original military, industrial, or consumer electronic equipment or as replacements to maintain and repair such equipment. The majority of components--about 70 percent of shipments value in 1960 and 1961--are used in original equipment and the rest as replacement parts (table 11).

Shipments of electronic components increased from $1.16 billion in 1950 to $3.27 billion in 1961 (tables 11 and 12). Shipments of transistors, diodes, and rectifiers expanded especially rapidly during the 1950's. Between 1954--the earliest year for which shipments data for these products are available--and 1961, transistor shipments increased from $5.1 million to $299.5 million, and diode and rectifier shipments from $20.0 million to $200.0 million (table 12). Much of this increase has been at the expense of receiving tubes, since semiconductors perform many of the functions performed by tubes. Shipments of receiving tubes have risen relatively little since 1954. In 1960 and 1961, transistor shipments alone were nearly as large as those of receiving tubes.

The transistor, invented in 1948, is a "solid state" device[30] which can perform many of the functions of an electron tube, such as rectification, amplification, oscillation, switching, and pulse generation. The advantages of transistors over certain types of electron tubes--small size, low power requirements, low heat dissipation, long life, and ruggedness--led to their use during the 1950's where these qualities were especially important. Transistors found widespread application not only in military-space and industrial-commercial equipment but also in many consumer products, such as hearing aids, portable radios, and television receivers.

[30] The operation of transistors and other semiconductors depends on the structure and characteristics of solids, whereas electron tubes enclose a vacuum or gas.

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Table 6. Value of electronics shipments, by major product category, 1950-62

Year	All electronics shipments	Military and space products[1]	Industrial and commercial products	Consumer products[2]	Replacement parts
	Value (millions)				
1950.....	$2,600	$500	$350	$1,500	$250
1951.....	3,250	1,050	450	1,400	350
1952.....	4,250	2,050	500	1,300	400
1953.....	5,150	2,650	600	1,400	500
1954.....	5,400	2,700	650	1,400	650
1955.....	5,800	2,800	750	1,500	750
1956.....	6,850	3,450	950	1,600	850
1957.....	8,000	4,100	1,300	1,700	900
1958.....	8,260	4,420	1,380	1,600	860
1959.....	9,240	4,740	1,600	2,000	900
1960.....	9,950	5,100	1,850	2,100	900
1961.....	10,690	5,490	2,200	2,050	950
1962[3].....	11,820	6,220	2,500	2,100	1,000
	Percent of total electronics shipments				
1950.....	100.0	19.2	13.5	57.7	9.6
1951.....	100.0	32.3	13.8	43.1	10.8
1952.....	100.0	48.2	11.8	30.6	9.4
1953.....	100.0	51.5	11.7	27.2	9.7
1954.....	100.0	50.0	12.0	25.9	12.0
1955.....	100.0	48.3	12.9	25.9	12.9
1956.....	100.0	50.4	13.9	23.4	12.4
1957.....	100.0	51.3	16.3	21.3	11.3
1958.....	100.0	53.5	16.7	19.4	10.4
1959.....	100.0	51.3	17.3	21.6	9.7
1960.....	100.0	51.3	18.6	21.1	9.0
1961.....	100.0	51.4	20.6	19.2	8.9
1962[3].....	100.0	52.6	21.2	17.8	8.5

[1] Consists of expenditures for (1) military electronics research, development, and procurement (exclusive of maintenance work and services), except that most research and development expenditures are excluded for the years before 1961, and (2) space electronics research, development, and procurement.

[2] Includes phonograph records. Excludes color television sets.

[3] Estimated.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Based on estimates of the Electronic Industries Association, except that shipments of military and space products include an addition estimated by the Bureau of Labor Statistics for space electronics expenditures by the National Aeronautics and Space Administration, beginning with 1958 when the civilian space agency was established.

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Table 7. Department of Defense expenditures for military functions,[1] fiscal years, 1954-63

[In millions]

Function	Fiscal year ending June 30									
	1954	1955	1956	1957	1958	1959	1960	1961	1962[2]	1963[2]
Total[3]	$40,336	$35,532	$35,791	$38,439	$39,062	$41,233	$41,215	$43,227	$46,710	$47,950
Military personnel	$11,643	$11,403	$11,582	$11,409	$11,611	$11,801	$11,738	$12,085	$13,250	$13,415
Operations and maintenance	9,162	7,931	8,400	9,487	9,761	10,378	10,223	10,611	11,595	11,511
Procurement	15,957	12,838	12,227	13,488	14,083	14,409	13,334	13,095	14,836	15,356
Aircraft	9,080	8,804	7,835	8,647	8,793	7,730	6,272	5,898	6,449	5,568
Missiles	417	604	1,005	1,855	2,434	3,337	3,027	2,972	3,523	3,899
Ships	905	944	858	842	1,105	1,491	1,744	1,801	2,049	2,308
Ordnance, vehicles, and related equipment	3,334	1,191	1,260	674	365	399	443	675	1,135	1,717
Electronics and communications	700	441	660	704	663	720	1,093	1,042	1,196	1,208
Other equipment	1,521	854	608	767	723	730	755	706	484	656
Research, development, test, and evaluation	2,187	2,261	2,101	2,406	2,504	2,866	4,710	6,131	6,039	6,650
Military construction	1,744	1,715	2,079	1,968	1,753	1,948	1,626	1,605	1,250	1,189
Revolving and management funds	-210	-610	-685	-320	-651	-169	-416	-300	-260	-171
Adjustment to budget basis	-148	-6	86	-	-	-	-	-	-	-

[1] Excludes military assistance, atomic energy work, civil defense, and defense-related services.
[2] Estimated.
[3] Totals are shown in constant 1960 dollars in appendix A, table A-2.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Office of the Assistant Secretary of Defense (Comptroller), Fiscal Analysis Division (FAD) 397-FY 1963 (1), Jan. 18, 1962.

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Table 8. Value of industrial and commercial electronics shipments, 1956-61

[In millions]

Type of equipment	1956	1957	1958	1959	1960	1961
All shipments	$950	$1,300	$1,380	$1,600	$1,850	$2,200
Computing, data processing, and industrial control equipment[1]	$240	$415	$450	$525	$710	$980
Testing and measuring equipment	170	210	220	245	265	290
Landmobile, microwave, and broadcasting equipment	120	150	155	175	190	215
Other industrial and commercial products	420	525	555	655	685	715

[1] Includes estimated value of leased, as well as sold, electronic equipment.

Source: Data for 1960 and 1961 from Electronic Industries Association. Data for 1956 to 1959 from the Association's Electronic Industry 1960 Fact Book, Washington, D.C., p. 23.

Table 9. Quantity and value of television and radio production, by type of unit, 1950-61

[Quantity and total value, in thousands]

Year	Television production[1]					
	Quantity				Value	
	Total production	Table-portable	Console	Phonograph-combination	Total production	Average per set
1950...	7,463.8	2,941.6	3,820.1	702.2	$1,350,000	$181
1951...	5,384.8	2,275.9	2,774.9	334.0	956,986	178
1952...	6,096.3	2,837.5	3,038.9	219.9	1,049,000	172
1953...	7,215.8	3,224.7	3,755.3	235.8	1,230,298	171
1954...	7,346.7	4,249.3	3,011.5	85.8	1,028,540	140
1955...	7,756.5	4,439.7	3,199.8	117.0	1,071,020	138
1956...	7,387.0	4,753.8	2,556.8	75.4	938,596	127
1957...	6,399.3	3,845.8	2,433.4	120.1	832,747	130
1958...	4,920.4	2,716.9	2,068.6	134.9	667,899	136
1959...	6,349.4	3,612.6	2,567.0	169.8	896,405	141
1960...	5,708.3	3,274.3	2,211.2	222.8	825,501	145
1961...	6,177.8	3,812.2	2,135.4	230.3	835,423	135

Year	Radio production						
	Quantity					Value	
	Total production	Home	Clock	Portable	Auto	Total production	Average per set
1950...	(2)	7,053	(2)	1,675	4,740	(2)	(2)
1951...	11,928	5,275	777	1,333	4,543	$298,439	$25
1952...	10,431	3,539	1,929	1,720	3,243	238,348	23
1953...	12,852	3,885	2,041	1,742	5,183	286,471	22
1954...	10,028	2,696	1,875	1,333	4,124	220,616	22
1955...	14,133	2,998	2,244	2,027	6,864	283,225	20
1956...	13,518	3,037	2,311	3,113	5,057	288,474	21
1957...	14,505	3,228	2,516	3,265	5,496	351,601	24
1958...	11,747	2,621	2,038	3,373	3,715	314,585	27
1959...	15,622	3,145	2,794	4,128	5,555	330,874	21
1960...	17,127	3,440	2,720	4,535	6,432	340,484	20
1961...	17,374	3,042	3,017	5,747	5,568	313,531	18

[1] Excludes color television sets.
[2] Not available.
Note: Because of rounding, sums of individual items may not equal totals.
Source: Based on estimates of the Electronic Industries Association.

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Table 10. Quantity and value of phonograph sales, by type of unit, and value of sales of phonograph records, 1950-61

Year	Phonographs					Phonograph records
	Quantity: Total sales	Quantity (thousands)			Value of total sales[2] (millions)	Value of total sales[2] (millions)
		Single phonograph	Radio-phonograph combination[1]	Record player attachments		
1950...	(3)	(3)	(3)	(3)	$116.2	$82.0
1951...	(3)	(3)	(3)	(3)	(3)	85.0
1952...	1,350.0	322.0	538.0	490.0	(3)	90.0
1953...	1,605.0	724.0	491.0	390.0	(3)	91.0
1954...	2,683.0	1,886.0	358.0	439.0	(3)	87.0
1955...	3,006.0	2,234.0	393.0	379.0	111.1	112.0
1956...	4,101.0	3,338.0	451.0	312.0	154.5	155.5
1957...	4,872.0	3,718.0	941.0	213.0	186.7	180.0
1958...	4,096.0	3,212.0	760.0	124.0	198.3	198.0
1959...	4,390.0	3,475.0	829.0	86.0	372.7	230.5
1960...	4,627.0	3,681.0	842.0	104.0	394.5	228.4
1961...	(3)	2,979.0	1,010.0	(3)	(3)	244.3

[1] Radio-phonograph combinations are included here rather than with radios. Television-phonograph combinations, on the other hand, are counted with television production.
[2] Sales value at factory level.
[3] Not available.

Source: Based on estimates of the Electronic Industries Association.

Table 11. Value of electronic component shipments, by use as original equipment or replacement parts, 1950-61

[Value in millions]

Year	All components shipped	Components shipped for use in original equipment		Components shipped for use as replacement parts	
		Amount	Percent of all components shipped	Amount	Percent of all components shipped
1950...	$1,158	$908	78.4	$250	21.6
1951...	1,261	911	72.2	350	27.8
1952...	1,730	1,330	76.9	400	23.1
1953...	(1)	(1)	(1)	500	(1)
1954...	2,008	1,358	67.6	650	32.4
1955...	2,200	1,450	65.9	750	34.1
1956...	2,280	1,430	62.7	850	37.3
1957...	2,435	1,535	63.0	900	37.0
1958...	2,325	1,465	63.0	860	37.0
1959...	2,833	1,933	68.2	900	31.8
1960...	3,054	2,154	70.5	900	29.5
1961...	3,266	2,316	70.9	950	29.1

[1] Not available.
Source: Based on estimates of the Electronic Industries Association.

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Table 12. Value of electronic component shipments, by type of component, 1950-61

Type of component	1950	1951	1952	1953	1954	1955
	Value (millions)					
All components shipped..	$1,158.0	$1,261.0	$1,730.0	(1)	$2,008.0	$2,200.0
Tubes and semiconductors.....	461.0	473.0	604.0	(1)	708.0	800.0
Receiving tubes.....	250.0	261.0	259.1	$303.7	276.0	358.1
TV picture tubes.....	210.7	122.2	170.7	234.9	206.1	209.0
Transistors.....	(1)	(1)	(1)	(1)	5.1	12.3
Diodes and rectifiers.....	(1)	(1)	(1)	(1)	[2] 20.0	[2] 30.0
All others.....	(1)	(1)	(1)	(1)	(1)	(1)
Capacitors.....	(1)	(1)	200.0	(1)	200.0	215.0
Resistors.....	(1)	(1)	100.0	(1)	130.0	150.0
Transformers.....	(1)	(1)	150.0	(1)	103.0	96.0
All other components[3].....	(1)	(1)	676.0	(1)	867.0	939.0
	Percent of total components shipped					
All components shipped..	100.0	100.0	100.0	100.0	100.0	100.0
Tubes and semiconductors.....	39.8	37.5	34.9	(1)	35.3	36.4
Receiving tubes.....	21.6	20.7	15.0	(1)	13.7	16.3
TV picture tubes.....	18.3	9.7	10.0	(1)	10.3	9.5
Transistors.....	(1)	(1)	(1)	(1)	.3	.6
Diodes and rectifiers.....	(1)	(1)	(1)	(1)	[2] 1.0	[2] 1.4
All others.....	(1)	(1)	(1)	(1)	(1)	(1)
Capacitors.....	(1)	(1)	11.6	(1)	10.0	9.8
Resistors.....	(1)	(1)	5.8	(1)	6.5	6.8
Transformers.....	(1)	(1)	8.7	(1)	5.1	4.4
All other components[3].....	(1)	(1)	39.1	(1)	43.2	42.7
	1956	1957	1958	1959	1960	1961
	Value (millions)					
All components shipped..	$2,280.0	$2,435.0	$2,325.0	$2,833.0	$3,054.0	$3,266.0
Tubes and semiconductors.....	853.0	925.0	914.0	1,152.0	1,289.0	1,303.0
Receiving tubes.....	374.2	384.4	341.9	368.9	331.7	311.1
TV picture tubes.....	196.2	183.2	163.5	183.8	180.8	185.6
Transistors.....	37.4	69.7	112.7	222.0	301.4	299.5
Diodes and rectifiers.....	76.0	102.3	112.8	166.3	224.0	200.0
All others.....	169.2	185.4	183.1	211.0	251.1	306.8
Capacitors.....	224.0	225.0	218.0	267.0	295.0	338.0
Resistors.....	175.0	171.0	158.0	194.0	227.0	274.0
Transformers.....	90.0	110.0	102.0	129.0	136.0	153.0
All other components[3].....	938.0	1,004.0	933.0	1,091.0	1,107.0	1,198.0
	Percent of total components shipped					
All components shipped..	100.0	100.0	100.0	100.0	100.0	100.0
Tubes and semiconductors.....	37.4	38.0	39.3	40.7	42.2	39.9
Receiving tubes.....	16.4	15.8	14.7	13.0	10.9	9.5
TV picture tubes.....	8.6	7.5	7.0	6.5	5.9	5.7
Transistors.....	1.6	2.9	4.8	7.8	9.9	9.2
Diodes and rectifiers.....	3.3	4.2	4.9	5.9	7.3	6.1
All others.....	7.4	7.6	7.9	7.5	8.2	9.5
Capacitors.....	9.8	9.3	9.4	9.4	9.7	10.4
Resistors.....	7.7	7.0	6.8	6.8	7.4	8.4
Transformers.....	3.9	4.5	4.4	4.6	4.5	4.7
All other components[3].....	41.1	41.2	40.1	38.5	36.3	36.7

[1] Not available.
[2] Includes only germanium and silicon diodes and rectifiers.
[3] Includes such components as speakers, tuners, antennas, relays, chassis, printed circuit boards, and filters.
Note: Because of rounding, sums of individual items may not equal totals.
Source: Based on estimates of the Electronic Industries Association.

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CHAPTER 3. ESTIMATES AND PROJECTIONS OF ELECTRONICS MANUFACTURING EMPLOYMENT

EMPLOYMENT AND SHIPMENTS ESTIMATES AND PROJECTIONS

This chapter presents estimates of electronics manufacturing employment for 1958 to 1961, and projections of such employment for 1970. The methodology used to derive these estimates and projections is summarized briefly at the end of this chapter and described in detail in appendix A.

The estimates and projections are shown in table 13 and charts 1 and 2 for employment, and table 14 for shipments. Estimated employment in electronics manufacturing rose from 610,000 workers in 1958 to 778,000 in 1961, and is expected to reach nearly 1.1 million workers by 1970. The annual growth rate projected for the remainder of the 1960's (3.8 percent) is considerably lower than that which occurred between 1958 and 1961 (8.4 percent), chiefly because the industry's growth rate is expected to slacken after 1965 owing to an anticipated leveling off in military and space electronic expenditures.

Value of electronics shipments, in constant 1960 dollars, rose from $8.2 billion in 1958 to $10.8 billion in 1961, and is expected to reach nearly $20 billion by 1970. As in the case of employment, the annual growth rate projected for the rest of the 1960's (6.8 percent) is lower than that which occurred between 1958 and 1961 (11.3 percent),[31] and the larger part of the projected increase is expected to take place by 1965. The more rapid expansion projected for shipments than for employment reflects an adjustment for projected increases in shipments per worker of roughly 2.9 percent per annum compounded.[32]

As stated earlier in the report,[33] the estimates and projections of this study refer to electronics employment and shipments in manufacturing industries, and exclude electronics activity in the Armed Forces, the Federal Government, universities, and nonprofit research centers. Estimates of the number of electronics workers in the Armed Forces are not available, but at least 55,000 workers are estimated to have been employed in late 1960 in electronics work in the Federal Government, universities, and nonprofit research centers. The electronics work done in these organizations consists chiefly of research, development, and the negotiation and administration of contracts.[34]

The remainder of this section of the chapter describes employment and shipment trends and outlook in each of the major electronic product categories.

Military and Space Products. The work force engaged in manufacturing military and space electronic products is expected to grow by 176,000 workers between 1961 and 1970, from 283,000 to 459,000. This

[31] See table 14, footnote 3.

[32] This adjustment was varied for each of the four major product categories to reflect projected differences among them in technological change, automation, etc. The adjustment rates were so calculated, however, that their weighted average approximated a per annum increase of 2.9 percent compounded, equal to the estimated rate of annual increase over the 1947-60 period in manufacturing output per man-hour. (Rate of annual increase from Bureau of Labor Statistics estimates in U.S. Department of Labor News Release 4698, "Output per Man-Hour in the Private Economy in 1960," Aug. 18, 1961, p. 2.) The 1947-60 annual increase in manufacturing output per man-hour was used as the best available approximation of the annual increase in shipments per employee in electronics manufacturing, despite differences between the concepts of output per man-hour and shipments per employee.

[33] See footnote 5. That footnote lists the exclusions from the report in terms of SIC industries.

[34] Sources for this employment estimate are few. A survey conducted by the Electronic Industries Association in late 1960 indicated that 22,000 engineers and scientists were employed in electronics R&D in these organizations--13,000 in the Federal Government and 9,000 in universities and nonprofit research centers. A survey sponsored by the National Science Foundation indicated that about 40 percent of the work force in research installations are engineers and scientists. (See Nonprofit Organizations--Expenditures and Manpower--1957, National Science Foundation (NSF 61-37), May 1961, p. 31.) Applying this 40 percent assumption to the estimate of 22,000 engineers and scientists derived from the EIA survey, a resultant total of 55,000 workers is obtained. This estimate is probably low since, in addition to its R&D activities, the Federal Government employs large numbers of administrative and clerical workers to negotiate and supervise electronics contracts.

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growth represents more than half (57 percent) of the employment expansion projected for the entire electronics industry. The 1961-70 rate of employment growth for military and space products is expected to be more rapid than that for any other major electronic product category, although most of the projected increase will occur before 1965. By 1970, the work force in military and space products is projected at 42 percent of total electronics employment, compared with 36 percent in 1961. (See table 13 and charts 1 and 2).

The constant-dollar value of military and space electronics shipments is expected to nearly double between 1961 and 1970 (from $5.5 billion to $10.7 billion--table 14). As with employment, the anticipated growth rate in shipments for this product category is higher than that for any other major product category but most of the expansion is expected to occur before 1965.

Shipments of military and space electronic products depend almost entirely upon expenditures for electronics research, development, and procurement by the Department of Defense and NASA. The Department of Defense accounts for most of these expenditures--96 percent in fiscal 1961 and an expected 86 percent for fiscal 1970.[35] NASA's electronics spending, beginning from a much smaller base, is expected to increase relatively much faster than that of the Department of Defense. Between the fiscal years 1963 and 1970, NASA's electronics expenditures are expected to grow nearly threefold as against an anticipated 50 percent increase in DOD expenditures.[36]

Major factors expected to boost military and space electronics spending during the 1960's include (1) the growing electronic sophistication and complexity of not only spacecraft but also missiles, aircraft, and other defense items; (2) the national effort to complete a manned lunar expedition before 1970; and (3) the increasing size and importance of the military space program. It is expected that electronics expenditures of the Department of Defense will slow down in their rate of growth during the last half of the 1960's, as some of the Nation's large military electronic programs move beyond their research, development, and major production stages, and also that NASA's expenditures will level off during the mid-1960's.

Industrial and Commercial Products. Employment in the manufacture of industrial and commercial electronic products is expected to rise by 60,000 workers between 1961 and 1970, from 126,000 to 186,000. This annual growth rate of 4.5 percent compounded will be slightly higher than that for the electronics industry as a whole over the same period, although much lower than that for the industrial-commercial field between 1958 and 1961. By 1970, employment in the industrial-commercial sector is projected at 17 percent of total electronics employment, compared with 16 percent in 1961. (See table 13 and charts 1 and 2.)

This expansion in employment is based on an anticipated growth in shipments of industrial and commercial electronic products, from $2.2 billion in 1961 to $4.1 billion in 1970 (table 14). A variety of factors are expected to contribute to this anticipated growth.

Rising levels of population and real income per capita projected for the 1960's are expected to stimulate larger expenditures for business plant and equipment, including industrial and commercial electronic equipment. Electronic devices are expected to assume increasing importance, not only in manufacturing but also in such diverse industrial activities as mining, the service industries, and wholesale and retail trade. Automation systems, heavily dependent on electronic devices, will be installed in growing numbers in American industry. Electronic control of product quality, color, quantity, and other characteristics will become more common in industries such as chemicals, petroleum refining, beverages, and dairy products. In metalworking, growing numbers of production machines will be operated automatically through the use of electronic controls. The atomic energy industry, which will need increasing amounts of electronic products such as reactor sensing controls, Geiger counters, and dosimeters, exemplifies growth industries expected to stimulate industrial electronics demand during the 1960's.

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[35] See appendix A, table A-2. The projections for military and space expenditures shown in table A-2 and elsewhere in this report reflect the assumptions used, conversations with industry and government officials, published information bearing on the subject, projections of historical trends, etc. The projections might be different, of course, if based on other assumptions or other interpretations of the sources available.

[36] See appendix A, table A-2.

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Continuance of the population shift to the suburbs should result in larger numbers of point-to-point microwave installations to facilitate communications between central city headquarters--such as downtown banks, department stores, and warehouses--and their suburban branches. Increasing use of intercommunication systems between offices and production departments is expected. Past trends indicate that the use of mobile radio systems will be in growing demand by police and fire departments, highway maintenance services, taxicab companies, ambulance services, forestry conservation crews, and other users. The demand for aircraft electronics apparatus, such as radar and communication systems, is also expected to rise. The number of active civil aircraft in the country by 1970 is projected at about 105,000, one-third higher than the number in 1961,[37] and the amount of electronic equipment per aircraft will continue to grow.

Perhaps the major growth item in the industrial electronics spectrum is the computer. Computing and data processing equipment are expected to experience a steadily rising demand during the rest of this decade from factories, insurance companies, banks, research laboratories, and other sources. Very recent developments include self-service computer centers, computers to program other computer operations, and computers for use in classrooms, libraries, and medical diagnostic centers.

Consumer Products. Employment in the manufacture of consumer electronic products is expected to grow by 30,000 workers between 1961 and 1970, from 89,000 to 119,000. The projected annual growth rate of 3.3 percent compounded is only slightly lower than that for the electronics industry as a whole, and employment in the consumer electronics field will account for roughly the same proportion of employment in total electronics manufacturing--11 percent--in 1970 as in 1961. (See table 13 and charts 1 and 2.)

Shipments of consumer electronic products are expected to rise from $2.1 billion in 1961 to $3.5 billion in 1970 (table 14). This expectation is based on projections of (1) increases in population and real income per capita, (2) increases in the number of women workers,[38] which are expected to create more demand for laborsaving household equipment, much of it electronic, and (3) increases in the number of new family formations, with expanding demand for new homes and for electronic household equipment. The rate of new family formations is expected to rise especially rapidly after the mid-1960's,[39] as children born during the postwar period of the mid-1940's reach marriageable age. Largely because of this, the growth rate in shipments and employment for consumer electronics is expected to be higher during the second half of the 1960's than during the first half.

Television sets, radios, and phonographs are expected to continue as the principal consumer electronic items during the remainder of the 1960's. Increases are anticipated in the number of homes with television sets and with more than one set, and in the number of television sets that need replacement. The demand for color television should also increase as the cost of such sets is reduced, a wider variety of models becomes available, color transmission and reception are improved, and more programs are telecast in color.

Rising R&D expenditures by industry and government are expected to result in many new and improved consumer products. Recently developed items include FM-stereo radio broadcasting and reception equipment; compact radars, radio-telephones, and radio direction finders for pleasure boats; electronic toys, such as ready-to-assemble radios and intercommunication systems; transistorized, battery-operated television sets; and transistorized, portable tape recorders. Many other consumer electronic products are in various stages of development. Some may be marketed commercially before 1970 while others may not become commercially feasible until after that date.

Components. Employment in the manufacture of electronic components is expected to grow by 40,000 workers between 1961 and 1970, from 280,000 to 320,000. The

[37] Data for 1961 from FAA Statistical Handbook of Civil Aviation, 1961 edition (Federal Aviation Agency), p. 35.

[38] Interim Revised Projections of U.S. Labor Force, 1965-75 (U.S. Department of Labor, BLS Special Labor Force Report 24, 1962), p. 4.

[39] "Illustrative Projections of the Number of Households and Families: 1960 to 1980," Current Population Reports, Series P-20, No. 90, Series B estimates (U.S. Bureau of the Census), p. 1.

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annual growth rate of 1.5 percent compounded is the lowest growth rate projected for any major product category, and is much lower than that for components between 1958 and 1961. The category's share of total electronics employment is expected to drop from 36 percent in 1961 to 30 percent in 1970. (See table 13 and charts 1 and 2.)

Several reasons explain why employment in the components category is expected to grow less rapidly during the 1960's than employment in the electronic end-product categories, even though the demand for components reflects the demand for end products. One reason is that shipments per worker in components manufacturing is expected to rise faster than the industry average. A second is that the rate of component replacement appears to be decreasing with the growing use of transistors and other solid state components and the declining relative importance of electron tubes,[40] and this decrease is expected to continue.[41] A third reason is found in the increasing versatility and efficiency of components, which is expected to lower the proportion which components value represents of total end-equipment value. This is illustrated by the fact that the projected annual growth rate of 5.3 percent compounded between 1961 and 1970 in value of components shipments (table 14) is less than those projected for the major end-product categories.

The decade ahead will undoubtedly see marked changes in the nature of the components field. One major trend has been in the direction of microminiaturization or microelectronics, that is, of extremely small units measurable in millionths of an inch, with exceedingly low power requirements. Although spurred chiefly by needs of the national defense and space programs, microminiaturization probably will find increasing applications in industrial-commercial electronics and even in consumer products during the years ahead.

Most microminiaturized circuits involve no discrete components, such as transistors and diodes. By eliminating such parts and the connections between them, reliability is increased while space and power requirements are decreased. Examples of microcircuits are "semiconductor integrated" and "thin film" circuits. Semiconductor integrated microcircuits are fabricated on or within a semiconductor slab by techniques such as oxide masking, alloying, diffusing, metal depositing, and surface shaping. In thin film microcircuits, thin metallic films are evaporated on a glass substrate or other insulating base to function as resistors, capacitors, and other circuit elements.

Despite the recentness of developments in microminiaturization, engineers and scientists are already looking toward the nanominiaturization of electronic components--"nano" in this case referring to measurements in billionths of an inch.

METHODOLOGY FOR DERIVING EMPLOYMENT ESTIMATES AND PROJECTIONS

To derive the employment figures for 1958 to 1961, the estimated value of total shipments and shipments per employee, in constant 1960 dollars, were first developed. By dividing the shipments estimates by the shipments-per-employee estimates, employment estimates were obtained. The estimates were made by major product category as well as for the industry as a whole.

The shipments estimates were based on data of the Electronic Industries Association (EIA).[42] The shipments-per-employee estimates were based on data from the 1958 U.S. Census of Manufactures, and for 1959 to 1961 were adjusted to reflect estimated annual increases in shipments per employee.

The estimated percent which electronics shipments were of total shipments was calculated for each SIC 4-digit industry which shipped at least $25 million in

[40] Projected employment in tubemaking will be lower in 1970 than in 1961 and about the same as in 1958. Between 1958 and 1961, employment in the manufacture of components other than tubes rose about four times more rapidly than employment in the manufacture of tubes.

[41] Shipments value of replacement parts equaled 37 percent of shipments value for all components in 1958, 29 percent in 1961, and is projected at 27 percent for 1970 (table 14).

[42] These data were selected for use in this study because of their comprehensive and detailed nature. They were prepared by the EIA's Marketing Services Department, on the basis of recurrent reports from cooperating respondents and periodic surveys of electronics manufacturers, supplemented by material from the Bureau of the Census and the Business and Defense Services Administration, both of the U.S. Department of Commerce.

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electronic products in 1958. This percent was applied to total employment in the industry to derive estimated employment; this step involved the assumption that employment in the manufacture of electronic products may be distinguished with reasonable accuracy from nonelectronic employment by prorating total employment according to proportions of electronics and nonelectronics shipments. Value of electronics shipments per electronics employee could then be derived for 1958, by relating estimated electronics employment to electronics shipments. To develop comparable shipments-per-employee estimates for 1959, 1960, and 1961, the 1958 shipments-per-employee estimates were adjusted to take account of changes in shipments per worker.

The same basic method was used to derive employment projections for 1970, that is, shipments projections were divided by shipments-per-employee projections. The dollar projections were stated in terms of the same 1960 price level as were the 1958-61 dollar estimates.

The shipments-per-employee projections were based on those for 1958 to 1961 and were adjusted to take into account projected changes to 1970 in shipments per worker. The shipments projections were derived through projections and correlations of various historical series, described in detail in appendix A.

The projections should be viewed only as indications of general magnitudes and directions of change. Some of the historical series upon which they are based do not extend back many years, and even if they did, might be an uncertain guide to the future in this rapidly changing field. The projections probably would be different if the major assumptions used in deriving them had been different.

These major assumptions concerning the remainder of the 1960's are the following: (1) The institutions and fundamental economic structure of the United States will not change significantly; (2) high levels of economic activity and employment will be maintained though temporary recessions may occur; (3) scientific and technological advances will continue at a rapid rate, including the development of new and improved weapons and space systems; (4) neither war nor substantial disarmament will occur, and the Nation will continue to strive for a defense capability sufficient to deter potential aggressors; and (5) the achievement of a manned lunar expedition before 1970 will continue as a national goal and as the major element in our civilian space program.

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Table 13. Employment in electronics manufacturing, by product category, estimates for 1958-61 and projections for 1970

Product category	Employment (thousands)					Percent change per annum compounded		Percent of total employment		
	1958	1959	1960	1961	1970	1958-61	1961-70	1958	1961	1970
All categories.....	609.8	689.4	734.1	777.7	1,084.5	8.4	3.8	100.0	100.0	100.0
Military and space products.	245.6	256.2	270.7	283.0	458.7	4.8	5.5	40.3	36.4	42.3
Industrial and commercial products.....	86.3	96.8	109.4	126.0	186.5	13.4	4.5	14.2	16.2	17.2
Consumer products.....	72.7	89.9	93.3	88.7	119.2	6.8	3.3	11.9	11.4	11.0
Components.....	205.2	246.5	260.7	280.0	319.9	10.9	1.5	33.7	36.0	29.5
1. Tubes.....	79.6	89.2	87.6	88.8	80.0	3.7	-1.2	13.1	11.4	7.4
2. Other than tubes.....	125.6	157.3	173.1	191.2	239.9	15.0	2.5	20.6	24.6	22.1
1. Original equipment...	129.5	168.1	183.8	198.6	232.5	15.3	1.8	21.2	25.5	21.4
2. Replacement parts....	75.7	78.4	76.9	81.4	87.4	2.4	.8	12.4	10.5	8.1

Note: Because of rounding, sums of individual items may not equal totals.

Source: Estimates and projections developed by U.S. Department of Labor, Bureau of Labor Statistics.

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Chart 1. Employment in Electronics Manufacturing

Estimates 1958-61, and Projections 1970

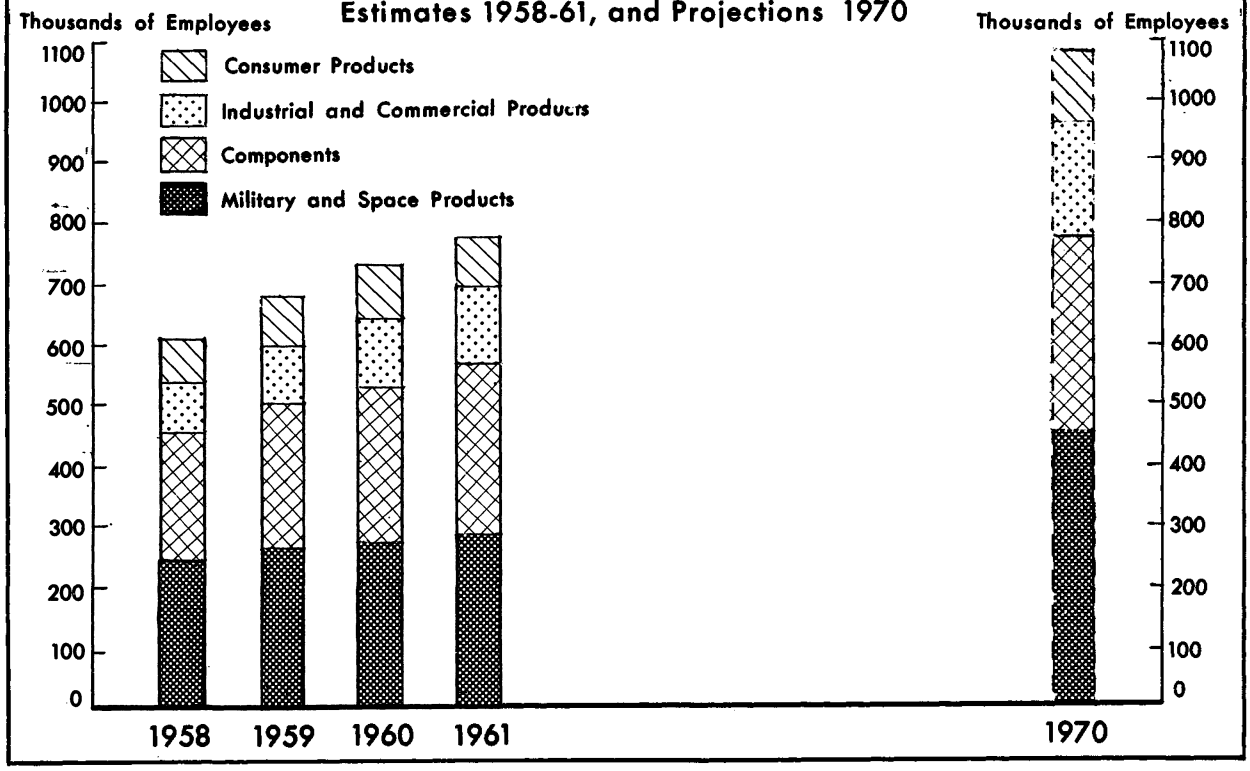

Chart 2. Employment Increases in Electronics Manufacturing

Esrimates 1958-61, and Projections 1961-70

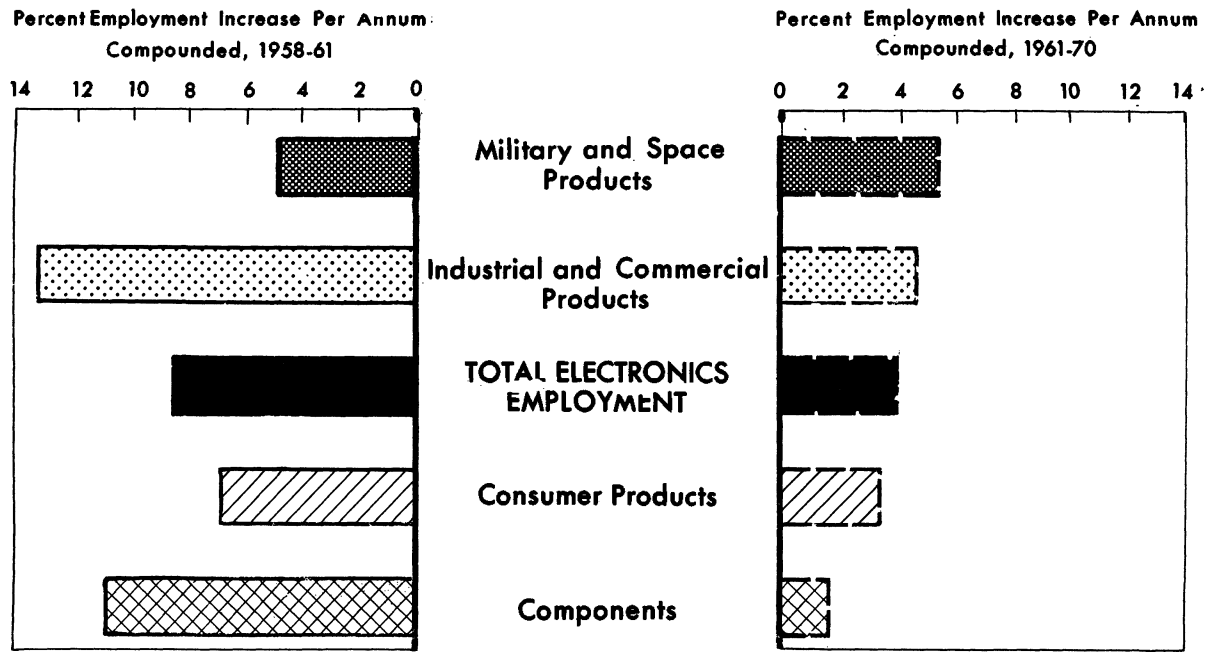

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Table 14. Value of electronics shipments in constant 1960 dollars, by product category, estimates for 1958-61 and projections for 1970

Product category	Shipments (in billions of 1960 dollars)					Percent change per annum compounded		Percent of all shipments		
	1958	1959	1960	1961	1970	1958-61	1961-70	1958	1961	1970
All electronics shipments[2]	$8.18	$9.16	$9.95	$10.75	$19.80	[3] 11.3	[3] 6.8	100.0	100.0	100.0
Military and space products	4.43	4.72	5.10	5.49	10.70	7.4	7.7	54.2	51.1	54.0
Industrial and commercial products	1.38	1.59	1.85	2.20	4.10	16.8	7.2	16.9	20.5	20.7
Consumer products	1.55	1.97	2.10	2.06	3.50	9.9	6.0	18.9	19.2	17.7
Components	2.21	2.77	3.05	3.44	5.49	15.9	5.3	--	--	--
Original equipment[2]	1.39	1.89	2.15	2.44	3.99	20.6	5.6	([2])	([2])	([2])
Replacement parts	.82	.88	.90	1.00	1.50	6.8	4.6	10.0	9.3	7.6

[1] Shipment estimates for 1958-61 are in constant 1960 dollars and to that extent differ from the current-dollar estimates in tables 6, 8, 11, and 12.

[2] The value of components used in original equipment is not included in total shipment value in order to avoid duplication, since original-equipment components are already counted in the value of the end equipment of which they are a part. See also footnote 3.

[3] These per annum rates of change were computed from total shipments estimates which include components used as original equipment, and not from the unduplicated total shipments estimates shown in the table. This was done to permit a more valid comparison with the per annum growth rates shown for employment in table 13.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Estimates and projections developed by U.S. Department of Labor, Bureau of Labor Statistics.

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CHAPTER 4. OCCUPATIONAL TRENDS AND OUTLOOK IN ELECTRONICS MANUFACTURING

NONPRODUCTION AND PRODUCTION WORKERS

Two outstanding features of the occupational structure in electronics manufacturing are (1) a trend toward increases in the relative size of the nonproduction work force, and (2) the existence of marked differences in occupational distributions among the industry's major product categories.

Nonproduction workers--engineers and other technical workers, administrative and executive personnel, and clerical and stenographic employees--are expected to account for nearly half (48 percent) of total electronics manufacturing employment by 1970 (table 15). They represented an estimated 40 percent of such employment in 1961, 38 percent in 1958, and only 19 percent in 1950.[43] [44] Growth during the 1960's in the relative size of the nonproduction work force is projected for each of the electronic product categories, and is expected to be especially rapid in the categories of military-space and industrial-commercial products and of electron tubes.[45]

The ratio of nonproduction to production workers varies widely between military-space and industrial-commercial electronics on the one hand (52 to 48 in 1961) and the consumer products and components fields on the other (each with a ratio of 27 to 73 in 1961--table 15). Manufacturing processes in military and space electronics, and to a lesser extent in industrial and commercial electronics, involve a great deal of R&D work and low-volume production of custom-made end products. In the consumer products and components fields, conversely, manufacturing processes tend to be of an assembly line, mass production nature.

The trend toward growth in the relative size of the nonproduction work force is due to several factors. One is the growing importance of R&D work and low-volume production of items made to order on a contract basis, thus increasing the need for engineers and other technical personnel and decreasing the need for semiskilled and unskilled production workers. This factor is especially significant in military and space electronics, and to a smaller degree in the industrial and commercial field, but the R&D content is high and increasing also in other products, such as semiconductors and special-purpose tubes. Another factor is the continual introduction of technological changes, such as mechanization in assembly line work, which tends to decrease the number of production workers needed to produce

[43] The 1950 percentage is based on different data from those in table 15 and is not precisely comparable, but it helps to provide a rough order of magnitude for the change since 1950. The 1950 estimate is based on information in "Expansion in Electronics Employment," Monthly Labor Review, February 1952, p. 151, and "The Effect of the Defense Program on Employment Outlook in Electronics Manufacturing," Occupational Outlook Handbook, Supplement No. 15, May 1951.

[44] For U.S. manufacturing as a whole, in comparison, nonproduction workers represented a smaller and less rapidly expanding part of the work force: 26 percent in 1961, 25 percent in 1958, and 18 percent in 1950. (Data for 1961 from Employment and Earnings, June 1962; data for 1958 and 1950 from Employment and Earnings Statistics for the United States, 1909-60 (BLS Bulletin 1312, 1961).

[45] The methodology used to derive the estimates and projections in table 15 is described in detail in appendix A. The estimates were developed from statistics of nonproduction and production workers published monthly by the Bureau of Labor Statistics in its Employment and Earnings series. Since these figures are published by SIC group, they had to be converted to the product categories of table 15; this was done by means of procedures described in appendix A. Because of the form in which the BLS data are available, estimates for the military-space and industrial-commercial product categories could be developed only as a combined group.

The projections for 1970 involved the assumption that changes in ratios of nonproduction to production workers would continue, but not so rapidly as between 1958 and 1961. This assumption was based on analysis of the many variables expected to affect the industry and its employment composition during the remaining years of the 1960's. The projections were calculated by using approximately half the per annum rates of change in nonproduction-production worker proportions between 1958 and 1961, with slight variations from product category to product category as deemed reasonable in the light of special influences expected to affect employment in that category. The resultant proportions for 1970 were applied to the employment forecasts already made for that year (see table 13) to derive projected numbers of nonproduction and production workers. Alternative projections of nonproduction-production worker ratios were also made, and appear in appendix A.

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a given output. This trend toward automatic operation is especially significant where mass production techniques are the rule, as in the consumer products and components fields. Finally, the growth of record-keeping and communication requirements in modern business has caused an increase in numbers of clerical and other office workers, despite the introduction and expanded use of improved office equipment, especially for data processing.

The number of engineers and scientists in electronics manufacturing was estimated at 128,000 in 1960,[46] nearly 10 times as many as the estimated 13,000 in mid-1951.[47] The increase in these workers was considerably greater than the threefold growth in total electronics manufacturing employment over approximately the same period.[48] By 1960, engineers and scientists were estimated to represent roughly 17 percent of total electronics employment.[49]

Many production operations in electronics manufacturing have been mechanized in whole or in part in recent years, and many other operations are expected to be mechanized in the years ahead. The following discussion describes some of these innovations, separately for end-equipment and components manufacturing.

Mechanization in End-Equipment Manufacturing. No single development so modified the production of electronic end equipment during the 1950's as the introduction of the printed-circuit board, which eliminated the mass of wiring found in electronic products manufactured conventionally. The printed-circuit board consists of a laminate of paper and phenolic plastic, bonded to copper foil. A wiring pattern or circuit is printed on the copper foil. Components for the circuit are threaded through holes in the board so as to make contact with the copper. Soldering of these contacts can be done in one operation. "Because the board is regular in shape and puts all the conductors into one plane. . . [manufacturers in the 1950's were] provided for the first time with the means of handling. . . production in automatic machinery."[50]

The printed-circuit board was introduced in plants manufacturing large quantities of standardized items, such as radios and television receivers. By the mid-1950's, most manufacturers of consumer equipment were using circuit boards in their products. By the late 1950's, circuit boards were standard equipment in computers and many other industrial and military end products. Since the introduction of these boards, numerous production improvements have been introduced in such processes as the insertion of components into the boards and the testing of completed circuits and equipment.

Many other innovations which increased productivity were introduced in end-equipment manufacturing during the 1950's and the early 1960's. Improvements were made in dip-soldering and plating techniques. New soldering, welding, and fastening devices were developed to speed assembly, even where miniaturized circuitry was used. Miniaturization of components and circuits reduced storage requirements and increased materials-handling efficiency. New types of movable conveyor systems were introduced. New machines were developed to transfer partly assembled units from one assembly line to another. Various devices were made to feed components more conveniently to assemblers. Improved types of automatic test equipment were engineered. Machine tools used in 1958 were, on the average, 40 percent more productive than those of 10 years before.[51]

Greater efficiency was achieved by improvements in plant layout and facilities. Producers built or remodeled plants so

[46] Electronic Industries Association, Electronic Industries 1962 Yearbook, p. 67. This estimate is based on a 1960 yearend survey by the EIA Marketing Services Department in cooperation with the Department of Defense.

[47] Mid-1951 estimate from "Expansion in Electronics Employment," Monthly Labor Review, February 1952, p. 154. As with the total employment figures in this report, both the 1960 and 1951 figures exclude engineers and scientists working for the Federal Government, universities, and nonprofit research centers (estimated at 22,000 by the EIA's 1960 survey).

[48] From an estimated 244,000 workers in 1950 ("Expansion in Electronics Employment," Monthly Labor Review, February 1952, p. 151) to 734,000 in 1960 (table 13).

[49] Calculated by relating the EIA survey figure of 128,000 engineers and scientists to the total employment estimate of 734,000 workers (table 13). This estimate has the weakness of being derived from two different sources, which may not be comparable in every respect. Scattered data in the files of the Bureau of Labor Statistics indicate that the percentage may be too high, and that 14-15 percent may be a more accurate estimate.

[50] "Automation," address by Dr. Elmer W. Engstrom, Radio Corporation of America, at the Centennial Symposium on Modern Engineering, University of Pennsylvania, Philadelphia, Nov. 11, 1955.

[51] George Sideris, "Production Machinery for the Electronics Industry," Electronics, New York, McGraw-Hill, Oct. 24, 1958, p. 73.

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that production lines could be realigned swiftly. Lighting systems were improved. Gas, electricity, water, and other utilities were placed for greater accessibility to production stations. The use of compressed air was introduced "to operate and feed small parts to bench and hand tools, to drive assembly machinery, for drying, painting, cleaning, and chemical tank agitation."[52]

Mechanization in Components Manufacturing. The introduction of the transistor in the early 1950's represented an important development in the components field. Techniques to make transistors differ considerably from those used to make other components. Transistor manufacture is a chemical-metallurgical process; the silicon and germanium crystals used are specially "grown" and assembled in meticulously clean and fully air conditioned rooms. Although the first transistors were assembled entirely by hand with a relatively high rejection rate, improvements in techniques rapidly decreased unit labor requirements and increased product reliability and performance. Production lines were increasingly mechanized, with automatic equipment for such operations as assembling, sorting, and testing.

Advances in production techniques have occurred since the early 1950's also in the manufacture of components other than transistors. Tube manufacturing has become highly mechanized in all operations except mount assembly, and improvements in productivity continue. Test equipment is becoming more and more automatic, as exemplified by a machine which can test 1,800 electron tubes an hour. A computer-controlled assembly line has been introduced in an already highly automated plant making resistors, which has doubled the plant's production rate to 2,400 units an hour. Still another development is a multistation winding machine which winds inductors automatically. Automated procedures are being introduced also in the relatively new field of microelectronics.

OCCUPATIONAL DISTRIBUTIONS AND TRENDS

To supplement and verify the material on occupational trends presented above, field visits were made in mid-1962 to several electronics establishments. Although the plants visited employed nearly 5 percent of all electronics manufacturing workers and covered every major electronic product category, they do not provide a representative sample of the industry and the information received from them is illustrative only.

This information supports the conclusion that occupational patterns vary according to the type of electronic products made. Illustrative occupational distributions shown in table 16 indicate that, in mid-1962, nonproduction workers were in the majority (60 percent of the work force) in military and space electronics manufacturing[53] but definitely in the minority (30 percent of the work force) in consumer products manufacturing.[54] The greater emphasis in military and space electronics on R&D work and low-volume custom production is evident from these distributions. In military and space electronics, 33 percent of the work force were engineers, technicians, and draftsmen compared with 11 percent in the consumer products field,[55] 13 percent were skilled workers compared with 7 percent in the consumer products field, and 27 percent were semiskilled and unskilled workers compared with 63 percent in consumer products electronics.

Assemblers were the largest manual occupational group, representing 42 percent of all workers in the consumer products category and 16 percent in military and space electronics (table 16). All assemblers in the consumer products plants were classified as semiskilled or unskilled but some in the military-space products plants were

[52] Ibid., p. 77.

[53] The most comparable proportion shown in table 15 to this figure is that of 52 percent for the 1961 nonproduction-worker proportion in military-space and industrial-commercial products combined. This would imply that nonproduction workers represent a smaller part of the work force in industrial-commercial than in military-space electronics.

[54] The comparable proportion shown in table 15, for consumer products manufacturing in 1961, is 27 percent.

[55] Engineers and scientists alone represented 21 percent of the work force in military and space electronics and 6 percent in the consumer products category (table 16). Additional data in the files of the Bureau of Labor Statistics, covering about one-seventh of total estimated electronics employment, show that in January 1961 engineers and scientists represented approximately 18 percent of electronics employment in the military-space and industrial-commercial categories combined, 10 percent in components manufacturing, and 7 percent in the consumer products field. (Cf. estimates earlier in the present chapter showing that for electronics manufacturing as a whole engineers and scientists represent an estimated 14 to 17 percent of all employment.)

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classified as skilled. Other relatively large manual occupational groups were inspectors and testers; analyzers and troubleshooters; fabricating workers; processing workers; and machinists and repairmen.

A few of the plant officials interviewed in mid-1962 made comments and predictions regarding occupational trends. Discussing the future electronics work force, one executive of a plant making military-space and industrial-commercial electronic equipment stressed the role of microelectronics: "The composition of the work force of the future will depend heavily on the future of microelectronics. Although being developed mainly for its military and space applications, microelectronics will undoubtedly find application also in other electronic sectors. This growing field is creating an acute demand for technical people with background in solid-state work. It may affect production workers as well, since it should require fewer soldering, wiring, and similar operations and more microscopic, 'white room' work. This trend toward more and more miniaturization may increase the numerical importance of women in assembly work."

An executive in another establishment manufacturing military-space and industrial-commercial electronic equipment emphasized the especially rapid growth in numbers of engineers and other nonproduction workers: "Between 1958 and 1962, the number of engineers in this plant rose 68 percent, the number of technicians 56 percent, draftsmen 78 percent, and clerical workers 58 percent. During this period the total number of salaried workers increased 45 percent while the number of hourly wage workers fell 10 percent. As a result, salaried workers rose from 41 percent of total employment in 1958 to 53 percent in 1962. This trend is due mainly to the growth in contracts for missile and space electronics; these generally have a high R&D content and involve low volumes with extremely high reliability requirements. Engineers and related workers will find increasing job opportunities at this plant in the years immediately ahead. One possible exception is industrial engineers; the smaller production runs common to missile and space work may adversely affect job opportunities for them."

An official in consumer products manufacturing evaluated the impact of technological change on production workers in his plant: "The drive toward lowering costs continues as a strong trend in this plant, in order to meet domestic and foreign competition. Innovations which make production processes more automatic occur frequently. Production workers displaced by technological change are not laid off but transferred to other jobs. In the short run, of course, innovations curtail the total number of production jobs, but the ultimate purpose is to increase reliability and lower costs and thus sell a greater number of improved, less expensive sets. To the extent this purpose is realized, technological change need not decrease employment on the production line. Production workers are usually the first to be taken on when sales demand increases."

The employment outlook differs considerably among occupational groups in a plant manufacturing semiconductors, according to an official of that plant: "The most promising future job opportunities here and elsewhere in semiconductor electronics exist for highly skilled equipment mechanics, electromechanical technicians, and electronics technicians.

"Engineering shortages may force continued reliance on some nondegree engineers, although the recruiting drive at this plant is for degree engineers. Nearly one-fourth of the engineers now employed here are nondegree engineers, almost all of them being former production or laboratory technicians who have been upgraded.

"Clerical workers may be adversely affected if the plant introduces computers for some of its office work, as is being actively considered. On the other hand, new jobs should be created for keypunch operators and other computer-associated workers.

"Job opportunities for semiskilled and unskilled production workers have been curtailed in this plant in the past two or three years by the introduction of automatic processing and testing equipment. This trend toward more automation may be expected to continue because it is part of our answer to improved product quality and reliability and to the lowered costs needed to meet competition both at home and from abroad. Future job opportunities for semiskilled and unskilled production workers will grow only if product demand expands sufficiently to more than offset anticipated increases in output per worker."

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WOMEN WORKERS

Because of the numerical importance of women workers in electronics manufacturing, information concerning them was collected during the field visits made in mid-1962 and much of it is included in table 17. Although the data are fragmentary, they point up the relatively large proportions of women among production workers and the relatively small proportions in nonproduction occupations except clerical and stenographic. Women outnumber men in some types of production jobs, especially in mass production operations such as those in consumer-product and semiconductor manufacturing.

In 1961, women workers represented an estimated 41 percent of total employment in electronics manufacturing (table 18).[56] For U.S. manufacturing as a whole, in comparison, women workers represented about 26 percent of all workers in that year.[57] They represented a lower proportion (30 percent) in the military-space and industrial-commercial category in 1961 and higher proportions in the consumer products (49 percent) and components (56 percent) categories. These differences are associated chiefly with differences in proportions of production workers. Women are employed mainly as production workers and therefore are more numerous where production workers are more numerous.

Because the proportion of production workers to total employment in electronics manufacturing is expected to decline between 1961 and 1970 (table 15), the proportion of women workers to total employment is also expected to decline between those years (table 18).[58] Projected declines are relatively small in the military-industrial and consumer products categories, but rather sharp (from 50 percent in 1961 to 41 percent in 1970) in the manufacture of electron tubes. Tube manufacturing, moreover, is the only industry segment in which the absolute number of women workers is expected to fall between 1961 and 1970; the industry's anticipated expansion through the 1960's should result in increases in the absolute number of women workers in all other product categories.

In only one product category shown in table 18--components other than tubes--is the proportion of women workers expected to increase during the 1960's even though, in this category as in the others, the proportion of production workers is expected to continue to decline. One reason for this difference in projections is that women are employed not only as production workers but also in clerical and other office jobs, and the projected trend in the proportion of office jobs is upward. A second reason lies in the marked trend toward microminiaturization of semiconductors and other components, which may give women an advantage over men in some types of assembly and other production-line work and as a result may increase the proportion of women production workers. This trend may be important also in the military and industrial field because of the increasing use in that field of microminiaturized components and circuits. This may help to explain why in that product category the projected drop in proportionate employment is expected to be less for women workers than for production workers.

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[56] The estimates for 1958-61 in table 18 were developed from statistics on women workers published quarterly by the Bureau of Labor Statistics in its Employment and Earnings series. Since these figures are published by SIC group, they had to be converted to the product categories of table 18. The methodology for doing this, and for developing the projections to 1970, is similar to that used to derive the data in table 15 and is described in appendix A. Because of the form in which the BLS data are available, estimates for the military-space and industrial-commercial product categories could be developed only as a combined group.

[57] Employment and Earnings, August 1962, pp. iv and viii.

[58] The projected decrease is from 41 percent to 39 percent. In 1950, women workers were estimated at 50 percent of total electronics employment. The 1950 figure is not precisely comparable with those in table 18, but it provides a rough indication of the extent of change. (1950 estimate developed by U.S. Department of Labor, Bureau of Labor Statistics, on the basis of material from "Expansion in Electronics Employment," Monthly Labor Review, February 1952, and "The Effect of the Defense Program on Employment Outlook in Electronics Manufacturing," Occupational Outlook Handbook, Supplement No. 15 (Bureau of Labor Statistics), May 1951.

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Table 15. Nonproduction and production workers in electronics manufacturing, by product category, estimates for 1958-61 and projections for 1970

Product category and type of worker[1]	Number of workers (thousands)					Percent of employment in product category				
	1958	1959	1960	1961	1970	1958	1959	1960	1961	1970
Total electronics employment....	609.8	689.4	734.1	777.7	1,084.5	100.0	100.0	100.0	100.0	100.0
Nonproduction workers.....	229.0	256.1	285.3	314.3	516.0	37.6	37.1	38.9	40.4	47.6
Production workers.....	380.8	433.3	448.8	463.4	568.3	62.4	62.9	61.1	59.6	52.4
Military-space and industrial-commercial products[2].....	331.9	353.0	380.1	409.0	645.2	100.0	100.0	100.0	100.0	100.0
Nonproduction workers.....	158.3	173.0	190.4	214.3	386.5	47.7	49.0	50.1	52.4	59.9
Production workers.....	173.6	180.0	189.7	194.7	258.7	52.3	51.0	49.9	47.6	40.1
Consumer products.....	72.7	89.9	93.3	88.7	119.2	100.0	100.0	100.0	100.0	100.0
Nonproduction workers.....	19.0	22.7	24.5	23.8	33.3	26.1	25.2	26.3	26.8	27.9
Production workers.....	53.7	67.2	68.8	64.9	85.9	73.9	74.8	73.7	73.2	72.1
Components.....	205.2	246.5	260.7	280.0	319.9	100.0	100.0	100.0	100.0	100.0
Nonproduction workers.....	51.7	60.4	70.4	76.2	96.2	25.2	24.5	27.0	27.2	30.1
Production workers.....	153.5	186.1	190.3	203.8	223.7	74.8	75.5	73.0	72.8	69.9
Tubes.....	79.6	89.2	87.6	88.8	80.0	100.0	100.0	100.0	100.0	100.0
Nonproduction workers.....	20.5	23.7	25.1	26.6	30.0	25.8	26.6	28.7	30.0	37.5
Production workers.....	59.1	65.5	62.5	62.2	50.0	74.2	73.4	71.3	70.0	62.5
Other than tubes.....	125.6	157.3	173.1	191.2	239.9	100.0	100.0	100.0	100.0	100.0
Nonproduction workers.....	31.1	36.7	45.2	49.5	66.2	24.8	23.3	26.1	25.9	27.6
Production workers.....	94.5	120.6	127.9	141.7	173.7	75.2	76.7	73.9	74.1	72.4

[1] "Production and related workers" (referred to in this report simply as production workers), as defined by the Bureau of Labor Statistics include "working foremen and all nonsupervisory workers (including leadmen and trainees) engaged in fabricating, processing, assembling, inspection, receiving, storage, handling, packing, warehousing, shipping, maintenance, repair, janitorial and watchman services, product development, auxiliary production for plant's own use (e.g. power plant), and recordkeeping and other services closely associated with the above production operations."

[2] Because of the form in which the source data were available, estimates could not be developed for the military-space category separately from the industrial-commercial category.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Estimates and projections developed by U.S. Department of Labor, Bureau of Labor Statistics.

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Table 16. Illustrative occupational distributions in electronics manufacturing, military-space and consumer products, mid-1962

Occupation	Military and space products	Consumer products
	Percent	
Total employment	100.0	100.0
Nonproduction workers	60.0	30.0
Engineers and other technical workers	33.4	11.0
Engineers[1]	21.0	6.0
Technicians	7.7	3.0
Draftsmen	4.7	2.0
Administrative and executive[2]	13.2	12.0
Clerical and stenographic	13.4	7.0
Production workers	40.0	70.0
Skilled	12.6	6.8
Assemblers	5.2	--
Analyzers and troubleshooters	1.1	5.1
Processing workers[3]	.2	--
Machinists and repairmen	3.7	.3
Sheet-metal workers	.8	--
Tool and die makers	.3	.4
Welders	.6	.1
Carpenters	.2	.2
Electricians	.2	.2
Plumbers and pipefitters	.2	.1
Other skilled workers[4]	.1	.4
Semiskilled and unskilled	27.4	63.2
Assemblers	11.0	42.0
Inspectors and testers	3.1	14.4
Fabricating workers[5]	3.7	1.2
Processing workers[6]	3.1	1.2
Shipping and receiving workers	1.3	1.2
Material handlers, truckdrivers, and laborers	.3	2.2
Custodial and janitorial workers	1.5	.4
Other semiskilled and unskilled workers[7]	3.4	.6

[1] Includes such occupations as electrical engineer, electronics engineer, design engineer, industrial engineer, mechanical engineer, value engineer, test and quality control engineer, and chemical engineer. The occupational distribution for military and space products also includes a small number of scientists, such as physicists, chemists, mathematicians, and metallurgists.

[2] Includes such employees as managers and supervisors, foremen, salesmen, and personnel in purchasing, industrial relations, accounting, marketing, and advertising.

[3] Includes such occupations as skilled electroplater and etcher.

[4] Includes such occupations as stationary engineer, millwright, blacksmith, and skilled machine tool operator.

[5] Includes such occupations as punch press, drill press, power brake, shear, and saw operator, grinder, and buffer.

[6] Includes such occupations as spray and dip painter, oven tender, silk screen operator, plating machine loader, etching machine operator, degreaser, and cabinet retoucher.

[7] Includes such occupations as stationary boiler fireman, machine setup man, relief operator, and cabinet repairman.

Source: U.S. Department of Labor, Bureau of Labor Statistics; based on information obtained through field visits to electronics establishments.

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Table 17. Women workers as percent of all workers in electronics manufacturing occupations, by major product category, mid-1962

Occupation	Women as percent of all workers in occupation[1]		
	Military-space and industrial-commercial products	Consumer products	Semiconductors
All occupations	[2] 20-30	[2] 48	([3])
Nonproduction workers	15-16	18	([3])
Engineers	([4])	0	([3])
Technicians	8	0	([3])
Draftsmen	2	16	([3])
Administrative and executive	2	2	([3])
Clerical and stenographic	60	65	([3])
Production workers	25-45	45-60	70-72
Assemblers	50-90	80	90-100
Inspectors and testers	20-40	70	90- 99
Processing and fabrication	25-30	([3])	65- 90
Craftsmen	[4] - 2	0	0
Shipping and receiving	0- 6	([3])	([3])
Materials handlers, including truck drivers	0	([3])	([3])
Custodial and janitorial	7-14	0	5

[1] Two figures given in a column indicate the range of the percents supplied by respondents; 1 figure indicates either that only 1 respondent supplied a percent figure or that more than 1 respondent furnished the same percent. Figures have been rounded slightly in some cases.

[2] These figures, though based only on illustrative data from a few field visits, are consistent with estimates based on data published quarterly by the Bureau of Labor Statistics in its Employment and Earnings series, which indicate that in 1961 women represented 30 percent of all employees in the military-space and industrial-commercial products category and 49 percent in the consumer products category. (See table 18.)

[3] Not available.

[4] Less than 0.5 percent.

Source: U.S. Department of Labor, Bureau of Labor Statistics; based on information obtained through field visits to electronics establishments.

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Table 18. Men and women workers in electronics manufacturing, by product category, estimates for 1958-61 and projections for 1970

Product category and sex of worker	Number of workers (thousands)					Percent of employment in product category				
	1958	1959	1960	1961	1970	1958	1959	1960	1961	1970
Total electronics employment	609.8	689.4	734.1	777.7	1,084.5	100.0	100.0	100.0	100.0	100.0
Men	357.9	399.9	428.4	458.0	661.6	58.7	58.0	58.4	58.9	61.0
Women	251.9	289.5	305.7	319.7	422.7	41.3	42.0	41.6	41.1	39.0
Military-space and industrial-commercial products[1]	331.9	353.0	380.1	409.0	645.2	100.0	100.0	100.0	100.0	100.0
Men	231.0	249.2	268.7	288.3	463.3	69.6	70.6	70.7	70.5	71.8
Women	100.9	103.8	111.4	120.7	181.9	30.4	29.4	29.3	29.5	28.2
Consumer products	72.7	89.9	93.3	88.7	119.2	100.0	100.0	100.0	100.0	100.0
Men	36.9	44.7	46.6	45.7	62.6	50.8	49.7	50.0	51.5	52.5
Women	35.8	45.2	46.7	43.0	56.6	49.2	50.3	50.0	48.5	47.5
Components	205.2	246.5	260.7	280.0	319.9	100.0	100.0	100.0	100.0	100.0
Men	90.0	106.0	113.1	124.0	135.7	43.9	43.0	43.4	44.3	42.4
Women	115.2	140.5	147.6	156.0	184.2	56.1	57.0	56.6	55.7	57.6
Tubes	79.6	89.2	87.6	88.8	80.0	100.0	100.0	100.0	100.0	100.0
Men	33.9	39.3	40.7	44.1	47.0	42.6	44.1	46.4	49.7	58.7
Women	45.7	49.9	46.9	44.7	33.0	57.4	55.9	53.6	50.3	41.3
Other than tubes	125.6	157.3	173.1	191.2	239.9	100.0	100.0	100.0	100.0	100.0
Men	56.1	66.7	72.4	79.9	88.7	44.7	42.4	41.8	41.8	37.0
Women	69.5	90.6	100.7	111.3	151.2	55.3	57.6	58.2	58.2	63.0

[1] Because of the form in which the source data were available, estimates could not be developed for the military-space category separately from the industrial-commercial category.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Estimates and projections developed by U.S. Department of Labor, Bureau of Labor Statistics.

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APPENDIX A. METHODOLOGY

This appendix describes the procedures used to develop estimates and projections of electronics employment and the distribution of these estimates and projections between nonproduction and production workers and between men and women workers. The employment projections should be viewed only as indications of general magnitudes. Some of the historical series upon which they are based do not extend back many years and would not necessarily be too helpful if they did, since the past is an uncertain guide to the future in the rapidly changing electronics field. The projections, of course, are heavily influenced by the major assumptions used in deriving them. These assumptions are given in chapter 3 in the section on methodology.

Described first in this appendix is the methodology used to derive employment estimates for the years 1958 to 1961 and projections for 1970. Described next are the procedures used to distribute these estimates and projections between nonproduction and production workers and between men and women workers.

DERIVATION OF EMPLOYMENT ESTIMATES AND PROJECTIONS, BY MAJOR ELECTRONIC PRODUCT CATEGORY

Although several statistical series on employment by industry are available,[59] they do not provide data on electronics employment accurate enough for this study. The data in these series are classified by SIC code. As noted in chapter 1, 2 dozen or more of the more than 400 SIC 4-digit manufacturing industries contain some electronics activity, although only 7 are engaged primarily in such activity.[60] Even in these seven, some workers should be excluded from any count of electronics employment because they are engaged in the manufacture of products which are not electronic.[61] In industries only secondarily engaged in electronics manufacturing, the majority of workers generally should be excluded. Electronics manufacturing employment is frequently equated with the sum of total employment in the seven SIC 4-digit industries primarily engaged in electronics production, but this sum is only a minimal measure because many additional electronics workers are employed in SIC industries not primarily engaged in electronics activity. Between 1958 and 1961, for example, employment in the seven industries averaged approximately three-fourths of the total electronics employment estimated in this study.[62]

Since the industry employment statistics currently available do not furnish sufficiently accurate employment estimates for purposes of this study, an alternative method was adopted which utilized electronic shipments statistics and converted them into employment totals by dividing into them shipments-per-employee statistics. This methodology will be described in two steps: (A) Derivation of electronics shipments estimates and projections; and (B) derivation of electronics shipments-per-employee estimates and projections.

Derivation of Electronics Shipments Estimates and Projections. The shipments series used in this study is that published by the Electronic Industries Association, a major trade association in the electronics

[59] The U.S. Department of Labor regularly issues an employment series prepared by the Bureau of Labor Statistics (Employment and Earnings series) and another prepared by the Bureau of Employment Security (Employment and Wages series). Comparable series are published regularly by the Bureau of the Census, U.S. Department of Commerce, singly in its censuses and surveys of manufactures and jointly with the Social Security Administration, U.S. Department of Health, Education, and Welfare, in the County Business Patterns series.

[60] The seven are SIC industries 3651, 3652, 3662, 3671, 3672, 3673, and 3679.

[61] In 1958, for example, the value of nonelectronic shipments ranged among the seven industries from 3 to 17 percent of the value of total industry shipments (U.S. Census of Manufactures: 1958, MC 58(2)-36 D, table 5A (U.S. Bureau of the Census)).

[62] Employment data for the seven industries are from the Employment and Earnings series of the Bureau of Labor Statistics, and employment estimates developed for this study are shown in table 13. In the Employment and Earnings series, data for SIC 3651 and 3652 are combined as are data for SIC 3671, 3672, and 3673; data for SIC 3662 and 3679 are shown separately.

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manufacturing industry.[63] The series is shown, for the years 1950 to 1962, in table A-1, in current dollar figures and by major electronic product category. These figures were converted by the Bureau of Labor Statistics, through procedures described in the next section into "real" (that is constant dollar) values (also shown in table A-1). The conversion was made because employment estimates and projections can be better derived from shipment values from which the influence of price changes is eliminated.

Conversion of Shipments from Current to Constant Dollar Estimates. Price deflation would be a simple and relatively accurate matter if available price indexes were exactly specific to the major electronic product categories. This is not the case however, and the indexes selected are only roughly appropriate. This limits the accuracy of the constant dollar estimates shown in table A-1, and although the estimates are adequate for the purpose of approximating physical shipment trends, from which to extrapolate projections to 1970, they are not definitive measures of price changes and cannot provide definitive measures of total output or output per worker.

Current dollar shipment values for each of the major product categories were deflated separately, and the resultant constant dollar figures were added together to obtain constant dollar estimates for total electronics shipments.

Military and space shipments were converted from current to constant dollars through the use of two price indexes, one for military electronics shipments and the other for civilian space electronics shipments. The price deflator considered most appropriate for military electronics shipments was that constructed for industrial and commercial electronic products (described later), the underlying assumption being that price movements for the two product categories are similar. The index selected as the most appropriate for civilian space electronics shipments was that for Federal Government purchases of goods and services for national defense.[64]

Price deflators selected for industrial and commercial electronics shipments consisted of BLS wholesale price indexes for electrical machinery and equipment; integrating and measuring instruments; switchgear, switchboard, etc. equipment; and radio receivers and phonographs. These indexes were converted from their 1947-49 base to a 1960 base. Each index was weighted by an estimate of the relative importance, based on value of shipments, of the industrial and commercial products for which it was considered appropriate and the average of the weighted indexes became the price deflator for industrial-commercial electronics as a whole.

These price deflators could be developed only for the years 1954 to 1960. For 1950 to 1953, shipments data were grouped differently from those for later years, and the wholesale price indexes cited above could not be used. For 1961 and 1962, the wholesale price indexes were not available at the time of this study. Price deflators for these years were obtained by extrapolating the 1954-60 deflator series back to 1950 and forward to 1962. Based on available evidence on price trends, the 1960 index value was also used for 1961 and was increased by 2 percent for 1962--less than the estimated annual increase between 1950 and 1961.[65]

The BLS wholesale price index for radios, television sets, and phonographs was selected as the most appropriate deflator for consumer electronics shipments. This index was converted from its 1947-49 base to a 1960 base. No wholesale price indexes were available beyond 1960, and values for 1961 and 1962 were derived by extrapolating the index's 1950-60 trend, which was downward,

[63] This series was selected because of its comprehensive and detailed nature. It is prepared by the EIA's Marketing Services Department, and is based on recurrent reporting from cooperating respondents and periodic surveys of electronics manufacturers, supplemented by material from the Bureau of the Census and the Business and Defense Services Administration, both of the U.S. Department of Commerce. Some of the data have since been slightly revised by the EIA, but too late for incorporation here.

[64] Index values were derived from Economic Report of the President, January 1961, tables C-1 and C-2, and Economic Report of the President, January 1962, tables B-1 and B-2.

[65] Except for the 1960 indexes, which were available only as unpublished data at the time of this study, the BLS Wholesale Price Indexes used as price deflators came from Bureau of Labor Statistics publications. For Electrical Machinery and Equipment, indexes for 1954-56 were from BLS Bulletin 1214, Wholesale Prices and Price Indexes, 1954-56; for 1957 from BLS Bulletin 1235, Wholesale Prices and Price Indexes, 1957; and for 1958 and 1959 from BLS Bulletin 1295, Wholesale Prices and Price Indexes, 1959. BLS Bulletin 1295 was also the source for the 1954-59 values for the three other wholesale price indexes used.

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at a constant per annum rate. Index numbers were not available for 1953 and 1954, and they were interpolated on the basis of values for preceding and subsequent years.[46]

Since no appropriate index series was available for electronic components, a price index was constructed. The ratio of component shipments to end-product shipments in the base year 1960 was applied to the constant dollar value of end-product shipments in 1954, obtained through procedures described earlier, to derive a constant dollar value of component shipments for the same year. This procedure assumed the same ratio of component to end-product shipments in 1954 as in 1960. Because of the rapidly changing product mix in component shipments, 1954--the year in which semiconductors were marketed in sizable volumes for the first time--was considered the earliest year for which this assumption could be validly made, and no index values for components were attempted for years before 1954.

A price index for 1954 was calculated by dividing the derived constant dollar value of components shipments in 1954 into the current dollar value of such shipments. This 1954 index and the 1960 base-year index of 100 provided two points between which to connect a price trend line. This trend line showed a decline of 14.9 percent between the 2 years. Index values for 1955 to 1959 were constructed by interpolating a constant rate of decline along this trend line; each value represented a price decrease of 2.34 percent from that for the preceding year. The index value constructed for 1961 assumed a decrease from 1960 of about twice this average annual rate of decline, because of a sharp drop in semiconductor prices during 1961. No price index could be constructed for 1962 because current dollar shipments data were not available at the time of the study.

Constant dollar estimates for replacement and original-equipment component shipments were obtained by using the same price deflators as those for component shipments as a whole.

[46]Except for the 1960 index value, which is a preliminary figure from Monthly Labor Review, November 1961, index values are from BLS bulletins. Those for 1950-52 and 1955-58 are from BLS Bulletin 1257, Wholesale Prices and Price Indexes, 1958 and that for 1959 from BLS Bulletin 1295, op. cit.

Projections of Constant Dollar Shipments. These projections, shown in table A-1, are for 1970. They were developed separately for each major electronic product category and added together to obtain projections for the entire industry. They assume continuance of the same shipments-to-inventory relationships that existed during the years covered by the historical series used for the projections. The following sections describe the methodology used.

Derivation of Projection for Military and Space Electronics Shipments. Although the future trend of military space electronics shipments is subject to many uncertainties, projections of this market, which accounts for half or more of all electronics sales, are especially vital for developing projections of manpower requirements in electronics manufacturing. The Federal Government is virtually the only customer for military and space products; its outlays depend on many factors, such as the international situation, the state of military technology, and national goals concerning the exploration and use of space. Basic assumptions concerning the course of these factors during the 1960's are cited earlier in this appendix.

By 1970, military and space electronics shipments are expected to rise to $10.7 billion in constant 1960 dollars (table A-2, column 8). This projection was derived first on a fiscal year basis (table A-2, column 7) and then translated to a calendar year basis, for comparability with projections for other major electronic product categories. The projection was derived by adding together projections of electronics expenditures by both the Department of Defense (DOD) and the civilian space agency (NASA). In terms of table A-2, the data in column 7 represent the sum of the figures in column 4 (DOD electronics expenditures) and column 6 (NASA electronics expenditures). DOD and NASA electronics expenditures are treated in this study as coterminous with military and space electronic shipments, since these two Federal agencies account for virtually all expenditures for military and space electronics. Only relatively small amounts for space electronics are accounted for by other Federal agencies, such as the Atomic Energy Commission, the Federal Aviation Agency, and the National Bureau of Standards, and by private enterprise engaged in space communications systems.

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The following procedures were used to derive the 1970 projections in columns 4 and 6, table A-2, and to convert the fiscal year figures in column 7 of that table to the calendar year figures in column 8.

Projection of DOD electronics expenditures (column 4, table A-2). Two correlations were made for this projection of $9.0 billion for 1970. First, a least squares straight line was fitted to DOD electronics expenditures for the years 1955 to 1963 (column 4) and extrapolated to 1970 (method 1). Second, a straight line was fitted to the percent which DOD electronics expenditures for the years 1955 to 1963 (column 4) were of DOD expenditures for military functions in the same years (column 2). This trend line was extrapolated to 1970, and the percent that resulted was applied to the 1970 projection in column 2, derived, as described later, to develop a 1970 projection for DOD electronics expenditures (method 2). Coefficients of correlation were +.99 for method 1 and +.96 for method 2.[67] The projection selected for this study lay between the two projections described.

On the basis of informed opinion of industry and government personnel as well as literature in the field, it was assumed that DOD expenditures for military functions would rise to roughly $53 billion by 1970, in constant 1960 dollars (column 2). To check on the reasonableness of this assumption, the historical relationship between these expenditures and Gross National Product (GNP) were analyzed. A least squares trend line was fitted to the percents which DOD expenditures for military functions were of GNP, for the years 1955 to 1963 (column 3), and extrapolated to 1970. The resultant proportion of 7.0 percent--which assumes a continued decline in the ratio of DOD expenditures for military functions to GNP--when applied to the GNP projection of $755.1 billion for 1970 (column 1), results in an estimate of DOD military expenditures for 1970 of $53 billion.

The assumption of $53 billion for DOD military expenditures for 1970 is higher than the estimate of $49 billion for 1970 which would result from extrapolating a straight-line trend fitted to DOD military expenditures for the years 1955 to 1963. The 1955-63 data do not lend themselves well to a straight line formula, in view of a break in the trend, with relatively stable expenditure levels between 1955 and 1960 and rather rapid growth between 1960 and 1963.

Projection of NASA electronics expenditures (column 6, table A-2). Estimates and projections of NASA electronics expenditures (column 6) were derived by calculating them at roughly one-fourth of estimates and projections for NASA total expenditures (column 5). This proportion was used because it is estimated that about half of NASA's total expenditures are disbursed to electronics manufacturing establishments for space research, development, and procurement,[68] and "approximately fifty cents of every dollar spent for space systems goes into electronics."[69] The estimates of NASA total expenditures for fiscal years 1958 to 1963 are based on Federal budgetary information, and the projection for 1970 of $6.0 billion, in constant 1960 dollars, is based on informed opinions of government and industry personnel.[70]

Conversion from fiscal to calendar year basis (columns 7 and 8, table A-2). For the years 1955 to 1963, this conversion was based largely on estimates of the Electronic Industries Association (EIA) of military electronic shipments, which are available on a calendar year basis as well as the fiscal year basis shown in table A-2, column 4. The EIA calendar year estimates were deflated to constant 1960 dollars with the same price index used to deflate the

[67] These simple correlations were checked with multiple correlations, which resulted in similar coefficients of correlation. The multiple correlations were (1) DOD electronics expenditures for 1955 to 1963 (column 4) with DOD military expenditures for the same years (column 2) and time; and (2) the percents which DOD electronics expenditures were of DOD military expenditures, for 1955 to 1963, with DOD military expenditures for the same years (column 2) and time.

[68] This estimate is based on the opinions of government and industry personnel. As earlier noted, electronics employment in this study relates to manufacturing industries and not to the Armed Forces, the Federal Government, universities, and nonprofit research centers.

[69] "Electronics in Space," by James E. Webb, Administrator of the National Aeronautics and Space Administration, Electronic Age, New York, autumn 1961, p. 11.

[70] For examples of relevant statements to this effect, see Independent Offices Appropriations for 1963, Hearings before a Subcommittee of the Committee on Appropriations, U.S. House of Representatives, 87th Cong., 2d. sess., pt. III, p. 443; and "The $50-Billion Space Push," Missiles and Rockets, Washington, D.C., Nov. 27, 1961, pp. 46-49.

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EIA fiscal year estimates, and added, for the years since 1958, to constant-dollar NASA electronics expenditures. The resultant sums represent the calendar year estimates of military and space electronic shipments shown in table A-2, column 8. The fact that NASA electronics expenditures were on a fiscal year basis did not introduce a large error because of their comparatively small size. The 1970 projection on a calendar year basis was derived by applying to the 1960 calendar year estimate of military and space electronic shipments ($5.10 billion--table A-2, column 8) the projected increase of 110 percent in such shipments between fiscal years 1960 and 1970 (column 7).

Derivation of Projection for Industrial and Commercial Electronics Shipments. The 1970 projection for industrial and commercial electronics shipments of $4.1 billion, in constant 1960 dollars, assumes a lower rate of growth for these shipments during the rest of the 1960's than during the 1950-62 period (table A-1). To develop the projection, industrial-commercial shipments in constant 1960 dollars, already available in table A-1, were correlated with other series whose movement might logically be related to or associated with their movement. The results were then modified in the light of informed judgments about the future course of these relationships.

The series with which industrial-commercial shipments were correlated are among those listed in table A-3 for the years 1950 to 1960, the latter year being the latest for which data were available at the time of this study. The series which seemed logically related to or associated with industrial-commercial electronics shipments and therefore correlated with them were the following: GNP; gross private domestic investment; producers' durable equipment; expenditures for new plant and equipment; the Federal Reserve Board (FRB) index of industrial production; and kilowatt-hours of electricity produced by or sold to industrial and commercial establishments.

Graphic correlations in the form of scatter diagrams were prepared, in which data for the years 1950 to 1960 for each of the series were plotted against industrial-commercial shipments for the same years. Three of the series showed a close relationship with industrial-commercial shipments: Kilowatt-hours of electricity, GNP, and the FRB industrial production index. Coefficients of correlation were +.95, +.94, and +.89, respectively. Trend lines were fitted to the plotted points by visual inspection in each of these three scatter diagrams.

The trend lines were extrapolated to 1970, and from them industrial-commercial shipments for 1970 were projected, after adjustments to reflect expected changes in historical relationships between electronics shipments and each of the three series. Projections were extrapolated to 1970 by means of scatter diagrams for the years 1950 to 1960 between GNP and the FRB index and between GNP and kilowatt-hours of electricity. A trend line was visually fitted to the plotted points in each diagram and extended to 1970, on the basis of the GNP projection for 1970 (already available--see table A-2). As a check on the results of these procedures, other scatter diagrams were made, for example, between the FRB index and new plant and equipment expenditures.

Derivation of Projection for Consumer Electronics Shipments. The 1970 projection for consumer electronics shipments, $3.5 billion in constant 1960 dollars (table A-1), was made in the same way as that for industrial-commercial products, that is, by correlating consumer shipments with other series whose movement might logically be related to or associated with their movement and modifying the results in the light of informed judgments concerning the future course of these relationships.

The series with which consumer shipments were correlated are among those listed in table A-3. They consist of GNP; personal consumption expenditures; expenditures for furniture and household equipment; expenditures for radio and TV receivers, etc.; and number of primary families--husband and wife present. Graphic correlations in the form of scatter diagrams were prepared, in which data for the years 1950 to 1960 for each of the series were plotted against consumer product shipments for the same years. Except in the case of furniture and household equipment expenditures, all the scatter diagrams

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showed a close relationship[71] and trend lines were fitted visually to the plotted points.

Projections for 1970 were next developed for each of the series, with the help of which consumer electronic shipments were projected for the same year. A projection for 1970 was already available for GNP in constant 1960 dollars (table A-2). A scatter diagram was made for the years 1950 to 1960 between GNP and one of its components--personal consumption expenditures. The trend line fitted visually to the plotted points in the diagram was extended, on the basis of the GNP projection, to 1970. A projection estimate for personal consumption expenditures was then determined from this extrapolated line. The same basic method was used to derive projections for radio and TV receivers, etc., except that this series was correlated with furniture and household equipment expenditures rather than with GNP. Projections for 1970 for primary family formations were available from a Census Bureau source.[72]

Derivation of Projection for Electronic Components Shipments. The projection developed for 1970 for electronic components shipments, in constant 1960 dollars, is $5.49 billion, of which $1.50 billion is for replacement parts and the rest for original-equipment components (table A-1). The first step in developing these projections was to compute the proportion which components were to end products in 1960. This proportion (33.7 percent--calculated from statistics in table A-1) is expected to decrease during the 1960's, and although any estimate of the extent of the decrease must be treated as only a broad approximation, the ratio projected for 1970 for this study represented a slight decline, to 30 percent.[73] This proportion, multiplied by end-product shipments anticipated for 1970, provided a projection for components shipments for that year.

Projections of 1970 shipments of replacement parts were developed through the use of scatter diagrams correlating shipments of (1) end products with replacement parts, and (2) components with replacement parts. Historical shipments data for these correlations are available in constant dollar values in table A-1.[74] Trend lines were fitted freehand to these data and extrapolated to 1970 on the basis of projections for that year for end-product and components shipments, derived through procedures already described in this and immediately preceding sections. The projections selected for replacement parts represented the midpoint between the extrapolated trend lines, which were similar to one another. The projection for 1970 shipments of original-equipment components was derived as the projected difference between shipments of total components and of replacement parts.

Derivation of Electronics Shipments-Per-Employee Estimates and Projections. Shipments-per-employee estimates and projections were developed for the study on the basis of product shipment analyses which appear in the 1958 Census of Manufactures.[75] The 1958 Census is the most recent complete count of manufacturing in the United States; legislation authorizes a census of manufactures every 5 years. Annual surveys are conducted in the intercensal years, but they are made on a sample basis and do not include the detailed analysis of product shipments contained in the Census volumes and needed for the methodology used here.

The derivation of shipments-per-employee figures was made on the basis of the 20 SIC 4-digit industries which reported for 1958 at least $25 million in electronics shipments each. These 20 industries, are believed to account for nearly all electronics

[71] Coefficients of correlation for the relationship between consumer electronic shipments and the other series were as follows: With personal consumption expenditures--+.89; with expenditures for radio and TV receivers and with number of primary families--+.85 in each case; and with GNP--+.83.

[72] U.S. Bureau of the Census, Current Population Reports, Population Characteristics, Series P-20, No. 90, released Dec. 29, 1958, table 5, Series B projections.

[73] One major reason behind the projection of a decreasing ratio of components to end products is that the replacement rate of components appears to be trending downward with the growing use of solid state components and the decreasing relative importance of electron tubes. Another is the increasing versatility and efficiency of components, which has tended to lower the proportion which their value represents of total end-equipment value.

[74] Coefficients of correlation were +.95 for the relationship between end products and replacement parts and +.91 for the relationship between components and replacement parts.

[75] The Census statistics used appear in U.S. Bureau of the Census, U.S. Census of Manufactures: 1958, Vol. II, Industry Statistics, tables 5A, 5B, 6A, and 8. In the case of one industry--SIC 3571--the Census table comparable to table 6A in other industries was numbered table 6, and, in the absence of any table 8, table 4 was used for employment totals.

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shipments. In seven of these industries, electronics shipments in 1958 represented half or more of the value of the industry's total shipments; between 1958 and 1961, as noted earlier in this appendix, employment in these seven industries averaged about three-fourths of the total electronics employment estimated in this study.

SIC 4-digit industries with at least $25 million in electronics shipments each, and with electronics shipments representing half or more of the value of total shipments (1958 data)

Industry Number	Industry title
3651	Radio and television receiving sets, except communication types
3652	Phonograph records[1]
3662	Radio and television transmitting, signaling, and detection equipment and apparatus
3671	Radio and television receiving type electron tubes, except cathode ray
3672	Cathode ray picture tubes
3673	Transmitting, industrial, and special purpose electron tubes
3679	Electronic components and accessories, not elsewhere classified

[1] Phonograph records are not uniformly considered to be an electronic product. They are treated as electronic in this report chiefly because the shipments estimates of the report are based upon figures of the Electronic Industries Association which include phonograph records.

SIC 4-digit industries with at least $25 million in electronics shipments each, and with electronics shipments representing less than half of the value of total shipments (1958 data)

Industry Number	Industry title
1925[1]	Guided missiles, complete
3571	Computing and accounting machines, including cash registers
3611	Electric measuring instruments and test equipment
3622	Industrial controls
3661	Telephone and telegraph apparatus
3693	Radiographic X-ray, fluoroscopic X-ray, therapeutic X-ray, and other X-ray apparatus and tubes
3721	Aircraft
3722	Aircraft engines and engine parts
3729	Aircraft parts and auxiliary equipment, not elsewhere classified
3811	Engineering, laboratory, and scientific and research instruments and associated equipment
3821	Mechanical measuring and controlling instruments, except automatic temperature controls
3842	Orthopedic, prosthetic, and surgical appliances and supplies
3931	Musical instruments and parts

[1] This industry is a special Census grouping, and is part of SIC industry number 1929--Ammunition, not elsewhere classified.

The first procedure was to determine the proportion of total shipments which was electronic in each of the 20 SIC 4-digit industries. Shipments of each industry are divided in the Census statistics into three groups: (1) Products classified in that industry and therefore primary to it;[76] (2) products classified in other industries (secondary products); and (3) miscellaneous receipts for contract and commission work, sales of products bought and resold without further manufacture, etc.

The primary products category, quantitatively the largest, was the most readily allocable as between electronic and nonelectronic items since the greatest amount of Census detail--to a 7-digit level--is provided for it. The chief methodological problem was that the primary product shipments for which detail is given are those of all manufacturing establishments, which may include some establishments not classified in the 4-digit SIC industry being analyzed. It was therefore assumed, after determining the percent of all primary products which was electronic, that the same proportion applied to the primary products of the 4-digit SIC industry being analyzed. This assumption was generally fairly accurate since most of the industries being analyzed accounted for 80 percent or more of all the products shipped in the United States which were primary to them.[77] Furthermore, in the case of the seven 4-digit industries primarily engaged in electronics manufacturing and accounting for most electronics employment, this assumption was not required since all their primary products were known to be electronic and no allocation procedure was necessary.

Although the secondary products category generally could be allocated between electronic and nonelectronic, sometimes this could be done only in an approximate way. Estimating was often required for various reasons, such as the existence of gaps in Census data to avoid disclosing information for individual companies. The miscellaneous receipts category, which was quantitatively

[76] According to the Bureau of the Census, U.S. Census of Manufactures: 1958, Vol. II, "The group of products assigned to an industry is said to be 'primary' to that industry. . . .an establishment is classified in a particular industry if its production of the primary products of that industry exceeds in value its production of products of any other single industry."

[77] In more technical language, the "coverage ratio" of these industries was 80 percent or more. According to the Bureau of the Census, ibid., a coverage ratio is "the proportion of primary products shipped by the industry to total shipments of such products by all manufacturing industries."

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quite small relative to the other two categories, could not be allocated between electronic and nonelectronic activities because of insufficient Census detail.

After determining by the above procedures the proportion of total shipments which was electronic in each of the 20 SIC 4-digit industries,[78] the next step was to multiply this proportion by total employment in the industry. The resultant product represented our estimate of the number of workers in that industry engaged in electronics manufacturing. This equating of shipment ratios with employment ratios required the assumption that electronics and nonelectronics workers produce equal shipment values, and excluded the consideration that electronics workers may be engaged part time on nonelectronics shipments or vice versa.

Dividing these electronics employment estimates into the electronics shipment estimates used to derive them produced a "shipments per electronics employee" value for each of the 20 SIC industries.

Each industry value was weighted according to the ratio which electronics shipments in that industry bore to electronics shipments in the major electronic product category in which the industry would be classified. The weighted values were used to obtain shipments-per-employee estimates for 1958 for each of the four major product categories used in the study. These estimates were then deflated to constant 1960 dollars, with the same price indexes used to deflate total shipments for each major product category. The next step was to develop comparable estimates, in the same 1960 dollars, for the other years for which employment estimates and projections were made--1959, 1960, 1961, and 1970.

The significant correction needed to convert 1958 shipments-per-employee estimates into estimates for other years involved adjusting for changes in shipments per worker. This was done by multiplying the 1958 figures by estimated annual increases in shipments per worker in each major product category. These estimated shipment increases were different for each category, reflecting variations in such things as production processes, technological developments, and R&D activity. The increases for the product categories were so calculated, however, that their average, weighted according to the estimated value of shipments of these categories for the years 1959-61 and 1970, approximated a per annum increase of 2.9 percent compounded. This is equal to the estimated rate of annual increase over the 1947-60 period in manufacturing output per man-hour,[79] and assumes no changes in hours worked per employee.

The 1947-60 annual increase in manufacturing output per man-hour was used as the best available approximation of the annual increase in shipments per employee in electronics manufacturing, despite differences between the concepts of output per man-hour and shipments per employee. Although the resultant approximations of annual shipments-per-employee increases are considered adequate for their intended purpose of assisting in developing employment estimates and projections, they do not represent measures of changes in output per worker and should not be construed as such.

Table A-4 presents the shipments-per-employee estimates, developed by the above procedures, for each major product category for the years 1958, 1959, 1960, 1961, and 1970. The estimates derived for electronic components were used for the two breakdowns of components, original equipment and replacement parts. The table also shows total shipments for the same years, by product category; these shipment estimates are based on EIA data and appear also in tables 14 and A-1.[80] Dividing shipments per employee into total shipments, by product category and year, results in estimates of electronics employment by category and year. These employment estimates, the end product of this phase of the methodology, appear in table A-4.

[78] Electronics shipments equaled primary plus secondary electronic-product shipments; total shipments equaled primary plus secondary product shipments and also miscellaneous receipts.

[79] According to Bureau of Labor Statistics estimates in U.S. Department of Labor News Release 4698, "Output per Man-hour in the Private Economy in 1960," August 18, 1961, p. 2.

[80] Except that in table A-4, unlike tables 14 and A-1, it was necessary to the methodology to include some double counting in the value of total electronics shipments (see explanation in footnote 3, table A-4).

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DISTRIBUTION OF EMPLOYMENT ESTIMATES AND PROJECTIONS BETWEEN NONPRODUCTION AND PRODUCTION WORKERS AND BETWEEN MEN AND WOMEN WORKERS, BY MAJOR ELECTRONIC PRODUCT CATEGORY

This methodology was based on data for the years 1958 to 1961 published by the Bureau of Labor Statistics in its Employment and Earnings series, which provides employment statistics by industry not only for all employees but separately for production workers and for women workers. The data used covered the seven SIC 4-digit industries primarily engaged in electronics manufacturing. The BLS employment statistics do not furnish information individually for each of the seven industries; some are available only in combined form (table A-5). SIC industries 3651 (radio and television receiving sets) and 3652 (phonograph records) are combined as SIC 365. SIC 3662 (radio and television communication equipment) is shown individually, but SIC 3671, 3672, and 3673 (each one covering certain types of electron tubes) are available only in combined form. SIC 3679 (electronic components other than tubes) is shown individually. SIC 3671, 3672, 3673, and 3679, combined as SIC 367, represent the electronic components and accessories group.

To use the BLS employment statistics for all employees, production workers, and women workers, it was necessary to convert the figures from SIC industries to the major product categories used in this study. This was done by assuming that SIC 365 was the same as the consumer products category, SIC 3662 the same as the military-space and industrial-commercial product categories combined, and SIC 367 the same as the electronic components category. Because of the form in which the BLS data are available, estimates for the military-space and industrial-commercial product categories could not be derived separately but only as a combined group, while on the other hand, estimates for components could be broken down between tubes and components other than tubes. The validity of these conversions is supported by the fact that, for every year between 1958 and 1961, employment in each SIC group (365, 3662, and 367) equaled roughly three-fifths or more of the employment estimated in this study for the comparable product category.

The conversion of SIC industry groups to major product categories made it possible to apply the percents in table A-5, which are in terms of SIC groups, to the employment estimates of this study, which were developed by major product category. In this way, breakdowns of nonproduction and production and men and women employment were derived by major product category for the years 1958 to 1961 (ch. 4, tables 15 and 18).

The data in table A-5 also permitted the calculation of per annum rates of change between 1958 and 1961 in nonproduction and production and men and women worker ratios. Projections for 1970 were developed on the basis of these per annum rates of change. Three sets of projections were made (table A-6). Projection A assumed no change in the ratios as they existed in 1961, and was calculated using these 1961 ratios. Projection C, to take the other extreme of the three projections, assumed that the per annum rate of change in the proportions would continue unabated to 1970, and was calculated using that rate of change. Projection B, the middle projection, assumed change would continue to 1970 but not so rapidly as between 1958 and 1961; the projection was calculated by using approximately half the per annum rate of change in the proportions between 1958 and 1961, with slight variations from product category to product category as deemed reasonable in the light of any special influences expected to affect employment in that category.

The B projections are used in this study; they appear in tables 15 and 18. These projections were decided upon as the most probable of the three, after analysis of the many variables expected to affect the industry and its employment composition during the remaining years of the 1960's. It seems unlikely that the 1960's will see the rapid changes of 1958-61 either suddenly stop and the ratios remain as they were in 1961 (Projection A), or continue without diminution (Projection C). It seems even more unlikely that the 1958-61 trends will reverse themselves during the 1960's, or continue at an accelerated rate, so these possibilities were not projected.

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Table A-1. Value of electronics shipments, by major product category, estimates for 1950-62 in constant 1960 dollars and current dollars, and projections for 1970 in constant 1960 dollars

Year	All electronics shipments[1]	Military and space products[2]	Industrial and commercial products	Consumer products[3]	Components		
					Total	Used in original equipment	Replacement parts
	1960 dollars (billions)						
1950.....	(4)	$0.67	$0.47	$1.42	(4)	(4)	(4)
1951.....	(4)	1.35	.58	1.38	(4)	(4)	(4)
1952.....	(4)	2.53	.62	1.28	(4)	(4)	(4)
1953.....	(4)	3.15	.71	1.37	(4)	(4)	(4)
1954.....	$5.77	3.09	.74	1.37	$1.75	$1.18	$0.57
1955.....	6.11	3.13	.84	1.47	1.96	1.29	.67
1956.....	7.12	3.74	1.03	1.57	2.08	1.30	.78
1957.....	8.01	4.20	1.33	1.64	2.28	1.44	.84
1958.....	8.18	4.43	1.38	1.55	2.21	1.39	.82
1959.....	9.16	4.72	1.59	1.97	2.77	1.89	.88
1960.....	9.95	5.10	1.85	2.10	3.05	2.15	.90
1961.....	10.75	5.49	2.20	2.06	3.44	2.44	1.00
1962[5].....	(4)	6.10	2.45	2.13	(4)	(4)	(4)
1970.....	19.80	10.70	4.10	3.50	5.49	3.99	1.50
	Current dollars (billions)						
1950.....	$2.60	$0.50	$0.35	$1.50	$1.16	$0.91	$0.25
1951.....	3.25	1.05	.45	1.40	1.26	.91	.35
1952.....	4.25	2.05	.50	1.30	1.73	1.33	.40
1953.....	5.15	2.65	.60	1.40	(4)	(4)	.50
1954.....	5.40	2.70	.65	1.40	2.01	1.36	.65
1955.....	5.80	2.80	.75	1.50	2.20	1.45	.75
1956.....	6.85	3.45	.95	1.60	2.28	1.43	.85
1957.....	8.00	4.10	1.30	1.70	2.44	1.54	.90
1958.....	8.26	4.42	1.38	1.60	2.33	1.47	.86
1959.....	9.24	4.74	1.60	2.00	2.83	1.93	.90
1960.....	9.95	5.10	1.85	2.10	3.05	2.15	.90
1961.....	10.69	5.49	2.20	2.05	3.27	2.32	.95
1962[5].....	11.82	6.22	2.50	2.10	(4)	(4)	1.00

[1] Not included in this total is the value of components used in original equipment, because such components are already counted in the value of the end equipment of which they are a part.

[2] Consists of expenditures for (1) military electronics research, development, and procurement (exclusive of maintenance work and services), except that for the years before 1961 most R&D expenditures are excluded, and (2) space electronics research, development, and procurement.

[3] Includes phonograph records. Excludes color television sets, except in projection for 1970.

[4] Not available.

[5] Estimated.

Source: Current dollar figures are based on estimates of the Electronic Industries Association, except that shipments of military and space products include an addition estimated by the Bureau of Labor Statistics for space electronics expenditures by the civilian space agency (the National Aeronautics and Space Administration), beginning with 1958 when that agency was established.

The Bureau of Labor Statistics computed the constant dollar estimates for 1950-62 from the current dollar figures, and developed the constant dollar projections for 1970 (see text of this appendix for methodology).

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Table A-2. Selected data used to develop 1970 projection for military and space electronics shipments

(Billions of 1960 dollars)

Year[1]	Gross National Product[2]	Defense Department expenditures			NASA expenditures		DOD-NASA expenditures for electronics	
		Total[3]	Total as percent of GNP	For electronics[4]	Total[5]	For electronics[6]	Fiscal year basis[7]	Calendar year basis[8]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1954.....	--	--	--	--	--	--	--	$3.09
1955.....	$449.7	$42.9	9.5	$2.9	--	--	$2.90	3.13
1956.....	459.2	41.0	8.9	3.3	--	--	3.30	3.74
1957.....	467.8	42.0	9.0	4.0	--	--	4.00	4.20
1958.....	459.7	41.4	9.0	4.3	$0.09	$0.02	4.32	4.43
1959.....	490.6	42.3	8.6	4.5	.15	.04	4.54	4.72
1960.....	504.4	41.2	8.2	4.9	.40	.10	5.00	5.10
1961.....	514.6	42.5	8.4	5.1	.73	.19	5.29	5.49
1962.....	546.8	46.1	8.4	5.6	1.27	.32	5.92	6.10
1963.....	569.3	47.1	8.2	6.0	2.20	.55	6.55	6.70
1970.....	755.1	53.0	7.0	9.0	6.00	1.50	10.50	10.70

[1] Data in col. 1 and col. 8 are on calendar year basis. Data in all other columns are on fiscal year basis. (Fiscal year in the Defense Department and NASA runs from July 1 to June 30. Fiscal year 1955, for example, runs from July 1, 1954, to June 30, 1955.)

[2] GNP for 1960 and earlier years, in 1960 dollars, were obtained from Economic Report of the President, January 1961, table C-2, and Economic Report of the President, January 1962, table B-1. GNP for 1961 in 1961 dollars--$521.3 billion--was converted to a 1960 dollar estimate using a derived price deflator of 101.3. Both the GNP figure and the price deflator for 1961 are from Economic Indicators, March 1962, prepared for the Joint Economic Committee by the Council of Economic Advisers. Estimates of 1962 and 1963 GNP, in 1960 dollars, were derived by increasing the 1960 GNP figure by 4.12 percent per annum compounded--the 1960-70 per annum rate of increase indicated by the GNP projections to 1970. This GNP projection to 1970 is from a BLS staff publication, Guide to Manpower--Challenge of the 1960s, p. 5. The BLS projection is in 1958 dollars, and was converted to 1960 dollars by using price deflators for GNP for the years 1958-60 from the July 1961 issue of Survey of Current Business, table 65.

[3] DOD expenditures for military functions. Excludes military assistance, atomic energy, civil defense, and defense-related services. Obtained in current dollars from the Office of the Assistant Secretary of Defense (Comptroller), FAD Report 397-Fiscal Year 1963 (1), Jan. 18, 1962; figures for fiscal year 1962 and 1963 are estimates. Current dollar figures for fiscal year 1955 to fiscal year 1961 were converted to constant 1960 dollars by using the price index for Federal Government purchases of goods and services for national defense (from Economic Report of the President, January 1961, tables C-1 and C-2; and Economic Report of the President, January 1962, tables B-1 and B-2). Current dollar estimates for fiscal year 1962 and 1963 were converted to constant 1960 dollars by assuming no change in the price index between 1961 and 1962 and a 1 percent increase between 1962 and 1963. Projection for 1970 was developed by the Bureau of Labor Statistics; see text of this appendix for methodology.

[4] Consists of expenditures for military electronics research, development, and procurement (exclusive of maintenance work and services), except that for the years before 1961 most R&D expenditures are excluded. Current dollar estimates for fiscal year 1955-63 are from the Electronic Industries Association. They were converted to constant 1960 dollar estimates by using a price deflator constructed for industrial-commercial electronics products; the assumption was that price movements are similar for military and industrial-commercial electronics. (See text of this appendix for methodology for construction of industrial-commercial shipments price deflator.) Projection for 1970 was developed by the Bureau of Labor Statistics; see text of this appendix for methodology.

[5] Expenditures in current dollars, actual for fiscal years 1958-61 and estimated for fiscal years 1962 and 1963, were obtained from the Budget of the United States Government for the Fiscal Year Ending June 30, 1963, pp. 110 and 246. Conversion to constant 1960 dollars was effected through use of the price index for Federal Government purchases of goods and services for national defense (see footnote 3 above for the source of this index). Projection for 1970 was developed by the BLS; see text of this appendix for methodology.

[6] Consists of expenditures disbursed to electronics manufacturing establishments for space electronics research, development, and procurement. Figures were developed by the BLS and equal roughly one-fourth of the figures in column 5; see text of this appendix for methodology.

[7] Represents sum of cols. 4 and 6.

[8] Converted from fiscal year basis by the BLS; see text of this appendix for methodology.

Source: Developed by U.S. Department of Labor, Bureau of Labor Statistics. See table footnotes for sources and methodology.

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Table A-3. Selected data used to develop 1970 projections for industrial-commercial and consumer electronics shipments

[Dollar figures in billions of 1960 dollars]

Series	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
National income accounts:[1]											
Gross national product	$362.3	$392.0	$406.8	$425.5	$416.8	$449.7	$459.2	$467.8	$459.7	$490.6	$504.4
Personal consumption expenditures	238.7	240.8	247.0	258.9	262.3	282.0	291.3	299.1	302.0	319.3	328.9
For furniture and household equipment	15.1	14.2	14.3	15.4	15.1	17.3	18.0	17.6	17.5	19.0	18.8
For radio and TV receivers, records, and musical instruments	2.0	1.9	2.2	2.4	2.7	2.9	3.0	3.1	3.1	3.5	3.6
Gross private domestic investment	66.7	69.2	60.7	61.4	58.9	74.7	74.3	69.8	58.2	72.9	72.4
Producers' durable equipment	25.9	26.7	26.5	27.4	25.3	27.4	30.3	29.9	23.6	25.9	27.5
Other series:											
Expenditures for new plant and equipment[2]	28.2	32.1	33.0	34.8	32.6	34.0	39.1	38.8	31.2	32.7	35.7
Federal Reserve Board index of industrial production (1957=100)[3]	74.5	80.8	83.8	90.8	85.4	96.0	99.3	100.0	92.9	104.9	108.0
Number of primary families--husband and wife present (thousands)[4]	34,075	34,378	35,138	35,560	35,875	36,266	37,043	37,711	37,967	38,420	([5])
Kilowatt-hours of electricity produced by or sold to industrial and commercial establishments (monthly average, in billions)[6]	21.2	23.6	24.9	28.0	29.3	34.7	37.7	38.9	38.3	42.1	45.4

[1] National income accounts are from Economic Report of the President, January 1961, table C-2, and Economic Report of the President, January 1962, table B-1, except for personal consumption expenditures for (1) furniture and household equipment, and (2) radio and TV receivers, records, and musical instruments, which were separately derived. Current dollar personal consumption expenditures for furniture and household equipment are available in Economic Report of the President, January 1962, table B-9; they were converted to constant 1960 dollars using price deflators available, for 1950-56, in U.S. Department of Commerce, U.S. Income and Output (A Supplement to the Survey of Current Business), table VII-13, and, for 1957-60, from Survey of Current Business, July 1961, table 70. The price deflators were in 1954 dollars and were converted to 1960 dollars. Current dollar personal consumption expenditures for radio and TV receivers, records, and musical instruments were obtained, for 1950-57, from U.S. Income and Output, op. cit. table II-4, and, for 1957-60, from Survey of Current Business, July 1961, table 15. They were converted to constant 1960 dollars on the basis of unpublished data of the Bureau of Labor Statistics.

GNP is made up of 4 major components: Personal consumption expenditures, gross private domestic investment, net exports of goods and services, and government purchases of goods and services. Data for only the first 2 of these 4 major components are shown in the table, the other 2 components being considered not relevant to the projections for this study.

[2] Derived by deflating to constant 1960 dollars current dollar figures for new plant and equipment expenditures available in Economic Report of the President, January 1962, table B-34. The deflation was made with the price index used to deflate producers' durable equipment (a subcomponent of gross private domestic investment, in the national income accounts). This price index was computed for this study by dividing current dollar figures for producers' durable equipment by constant 1960 dollar figures, both sets of figures being available in Economic Report of the President, January 1961, tables C-1 and C-2.

[3] From Economic Report of the President, January 1962, table B-32.

[4] From U.S. Bureau of the Census, Current Population Reports, Population Characteristics, Series P-20, No. 94, released Aug. 24, 1959, table 4. Data are for March or April of each year.

[5] Not available.

[6] Calculated from U.S. Department of Commerce, Business Statistics, 1961 biennial edition, A Supplement to the Survey of Current Business, p. 126.

Source: Developed by U.S. Department of Labor, Bureau of Labor Statistics. See table footnotes for sources and methodology.

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Table A-4. Electronics shipments and shipments per employee (in constant 1960 dollars), and employment, by product category, estimates for 1958-61 and projections for 1970

Item and year	All electronics shipments	Military and space products	Industrial and commercial products	Consumer products	Components		
					Total	Original equipment	Replacement parts
Value of shipments per employee (1960 dollars):							
1958	$15,694	$18,037	$15,991	$21,320	$10,770	(1)	(1)
1959	16,028	18,423	16,426	21,913	11,237	(1)	(1)
1960	16,483	18,837	16,908	22,509	11,698	(1)	(1)
1961	16,961	19,399	17,460	23,224	12,286	(1)	(1)
1970	21,937	23,327	21,984	29,362	17,162	(1)	(1)
Value of shipments (billions of 1960 dollars):							
1958	[2] 9.57	4.43	1.38	1.55	2.21	$1.39	$0.82
1959	11.05	4.72	1.59	1.97	2.77	1.89	.88
1960	12.10	5.10	1.85	2.10	3.05	2.15	.90
1961	13.19	5.49	2.20	2.06	3.44	2.44	1.00
1970	23.79	10.70	4.10	3.50	5.49	3.99	1.50
Employment (thousands):							
1958	609.8	245.6	86.3	72.7	205.2	129.5	75.7
1959	689.4	256.2	96.8	89.9	246.5	168.1	78.4
1960	734.1	270.7	109.4	93.3	260.7	183.8	76.9
1961	777.7	283.0	126.0	88.7	280.0	198.6	81.4
1970	1,084.5	458.7	186.5	119.2	319.9	232.5	87.4

[1] Same as shipments-per-employee estimates for all components.

[2] Figures in this column exceed comparable figures in tables 14 and A-1 to the extent that they add in all components shipments, including those of original equipment components even though these are already included in end product shipments. This double counting was necessary to derive shipments-per-employee estimates for the industry as a whole.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Developed by U.S. Department of Labor, Bureau of Labor Statistics. See text of this appendix for methodology.

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Table A-5. Distribution of employment between nonproduction and production workers, and women workers, in selected electronics manufacturing industries, 1958-61

Industry, and type and sex of worker[1]	Number of workers (thousands)				Percent of industry employment			
	1958	1959	1960	1961[2]	1958	1959	1960	1961[2]
SIC 365, 3662, 367: total.....	477.9	554.9	583.0	594.8	100.0	100.0	100.0	100.0
Nonproduction workers.....	165.2	192.9	213.5	225.2	34.6	34.8	36.6	37.9
Production workers.....	312.7	362.0	369.5	369.6	65.4	65.2	63.4	62.1
Women workers.....	210.9	245.5	255.4	256.5	44.1	44.2	43.8	43.1
SIC 365: Radio and TV receiving sets.....	104.4	114.4	111.5	113.2	100.0	100.0	100.0	100.0
Nonproduction workers.....	27.3	28.8	29.3	30.3	26.1	25.2	26.3	26.8
Production workers.....	77.1	85.6	82.2	82.9	73.9	74.8	73.7	73.2
Women workers.....	51.4	57.6	55.7	54.9	49.2	50.3	50.0	48.5
SIC 3662: Radio and TV communication equipment.....	194.6	229.2	246.3	254.4	100.0	100.0	100.0	100.0
Nonproduction workers.....	92.9	112.4	123.4	133.2	47.7	49.0	50.1	52.4
Production workers.....	101.7	116.8	122.9	121.2	52.3	51.0	49.9	47.6
Women workers.....	59.1	67.4	72.2	75.0	30.4	29.4	29.3	29.5
SIC 367: Electronic components and accessories.....	178.9	211.3	225.2	227.2	100.0	100.0	100.0	100.0
Nonproduction workers.....	45.0	51.7	60.8	61.7	25.2	24.5	27.0	27.2
Production workers.....	133.9	159.6	164.4	165.5	74.8	75.5	73.0	72.8
Women workers.....	100.4	120.5	127.5	126.6	56.1	57.0	56.6	55.7
SIC 3671-3: Electron tubes.....	69.5	76.4	75.6	72.0	100.0	100.0	100.0	100.0
Nonproduction workers.....	17.9	20.3	21.7	21.6	25.8	26.6	28.7	30.0
Production workers.....	51.6	56.1	53.9	50.4	74.2	73.4	71.3	70.0
Women workers.....	39.9	42.7	40.5	36.2	57.4	55.9	53.6	50.3
SIC 3679: Components other than tubes[3].....	109.4	134.9	149.6	155.2	100.0	100.0	100.0	100.0
Nonproduction workers.....	27.1	31.4	39.1	40.2	24.8	23.3	26.1	25.9
Production workers.....	82.3	103.5	110.5	115.0	75.2	76.7	73.9	74.1
Women workers.....	60.5	77.7	87.0	90.4	55.3	57.6	58.2	58.2

[1] For definition of "production worker," as used by the Bureau of Labor Statistics in collecting the data in this table, see table 15, footnote 1. Women workers are included in both the nonproduction and production worker figures.

[2] Preliminary.

[3] Includes, according to Standard Industrial Classification Manual, 1957 edition, specialty resistors for electronic end products; solid state electronic devices and similar devices; inductors, electronic transformers, and capacitors; and other electronic components, not elsewhere classified.

Note: Because of rounding, sums of individual items may not equal totals.

Source: U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings Statistics for the United States, 1909-60 (Bulletin 1312, 1961), pp. 196-201 (for data for 1958-60), and Employment and Earnings, February 1962, tables B-2 and B-4 (for data for 1961).

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Table A-6. Nonproduction and production workers, and women workers, in electronics manufacturing, by product category, 3 projections for 1970

Product category, and type and sex of worker[1]	Projections for 1970					
	Number of workers (thousands)			Percent of employment in product category		
	A	B	C	A	B	C
Total electronics employment	1,084.5	1,084.5	1,084.5	100.0	100.0	100.0
Nonproduction workers.....	456.1	516.0	591.6	42.1	47.6	54.6
Production workers.....	628.2	568.3	492.7	57.9	52.4	45.4
Women workers.....	427.9	422.7	418.4	39.5	39.0	38.6
Military-space and industrial-commercial products..	645.2	645.2	645.2	100.0	100.0	100.0
Nonproduction workers.....	338.1	386.5	448.4	52.4	59.9	69.5
Production workers.....	307.1	258.7	196.8	47.6	40.1	30.5
Women workers.....	190.3	181.9	173.6	29.5	28.2	26.9
Consumer products.....	119.2	119.2	119.2	100.0	100.0	100.0
Nonproduction workers.....	31.9	33.3	34.6	26.8	27.9	29.0
Production workers.....	87.3	85.9	84.6	73.2	72.1	71.0
Women workers.....	57.8	56.6	55.3	48.5	47.5	46.4
Components.....	319.9	319.9	319.9	100.0	100.0	100.0
Nonproduction workers.....	86.1	96.2	108.6	26.9	30.1	33.9
Production workers.....	233.8	223.7	211.3	73.1	69.9	66.1
Women workers.....	179.8	184.2	189.5	56.2	57.6	59.2
Tubes.....	80.0	80.0	80.0	100.0	100.0	100.0
Nonproduction workers.....	24.0	30.0	37.8	30.0	37.5	47.2
Production workers.....	56.0	50.0	42.2	70.0	62.5	52.8
Women workers.....	40.2	33.0	26.6	50.3	41.3	33.2
Other than tubes[2].....	239.9	239.9	239.9	100.0	100.0	100.0
Nonproduction workers.....	62.1	66.2	70.8	25.9	27.6	29.5
Production workers.....	177.8	173.7	169.1	74.1	72.4	70.5
Women workers.....	139.6	151.2	162.9	58.2	63.0	67.9

[1] For definition of "production worker," as used in collecting the BLS data upon which these projections are based, see table 15, footnote 1. Women workers are included in both the nonproduction and production worker figures.

[2] For types of components included in this category, see table A-5, footnote 3.

Note: Because of rounding, sums of individual items may not equal totals.

Source: Developed by U.S. Department of Labor, Bureau of Labor Statistics. See text of this appendix for methodology.

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