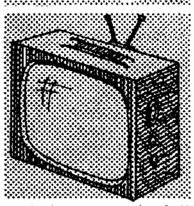
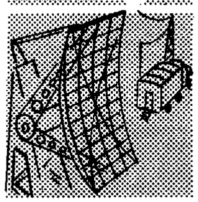
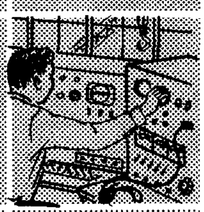
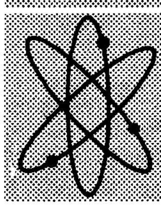
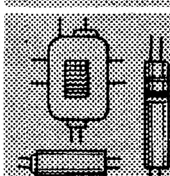
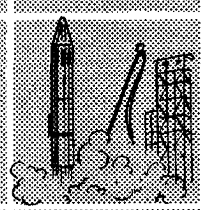
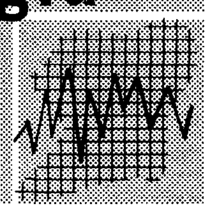
electronics

a manufacturing opportunity in Georgia

BY ROY B. COOPER • PREPARED FOR THE GEORGIA DEPARTMENT OF COMMERCE
ENGINEERING EXPERIMENT STATION, GEORGIA INSTITUTE OF TECHNOLOGY

Project E-127-19
B-140-10

E L E C T R O N I C S

A Manufacturing Opportunity in Georgia

Prepared for
The Georgia Department of Commerce
Abit Massey, Director
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Atlanta, Georgia

by

Roy B. Cooper

Industrial Development Branch
Engineering Experiment Station
Georgia Institute of Technology
October 1959

Foreword

It has been something of a puzzle to many Georgians active in industrial development that major electronics firms have not yet moved strongly into Georgia. For as this report indicates, the State offers major attractions. The technical training and research facilities available, in particular, should have strong appeal.

This study is designed to help answer questions which major manufacturers and local firms may have regarding opportunities which exist in the broad field of electronics. Subsequent reports will provide more detailed information on specific products or product complexes which can be profitably manufactured in Georgia.

Comments and questions regarding the study are invited.

Kenneth C. Wagner, Head
Industrial Development Branch

Table of Contents

Tables, Maps, and Charts

INTRODUCTION

Continued rapid growth of the electronics industry seems assured. Because of the relatively large number of workers per plant and the fact that electronics is a high value-added industry, Georgia's participation in this industry growth is highly desirable. Such participation is possible in two different ways; location in Georgia of a branch plant by a national manufacturer or entrance into the electronics field by a local concern.

The information required by each of these groups is not the same in every respect. For that reason, this report is divided into two sections, the first giving data which would be of interest to an already established manufacturer of electronic parts or equipment. The second supplies information about the industry in general which should be helpful to a local businessman interested in the industry as a new field or as a means of diversification.

Because of the competitive situation in many fields of electronics and the large amounts of capital which would be required to develop and market a standard product against severe competition, initial efforts should be concentrated on securing for Georgia branch plants of established manufacturers. Such branch plants would also offer opportunities for developing "satellite" plants to supply major concerns.

For the most part, direct entrance into the electronics field to manufacture a standard product is not advised. This does not mean that new firms cannot be started. The greatest probability for success is for a firm making a new product or for one which can find a new application for an old product. The manufacture of a superior version of an established product, while a less likely prospect, also always offers a challenge and an opportunity. Together, these several opportunities provide excellent potentials for extending Georgia's "new frontier."

The electronics field is wide open for men with ideas. Most of the smaller firms, and many which have now grown to be large companies, were started in this manner. The possibilities for new business ventures as a result of branch plant location in Georgia will, of course, depend on the requirements of the particular plant.

The electronics field also offers diversification opportunities to existing business. This might be done by the establishment of an electronics division, by the outright acquisition of an established firm, or by merger with an existing firm.

The same need for caution applies for a company wishing to establish an electronics division as for a new business venture in this field. However, an already established firm may be in much better position because of its availability of capital, facilities which can readily be adapted to electronic assembly, because it has a marketing setup adaptable to electronic items, or for other reasons.

Direct acquisition of or merger with an existing electronics producer would, of course, require a detailed study of the advantages expected to accrue, legal requirements, and other factors. This is particularly true now, since many companies have used this method of expanding into electronics and suitable prospects are not as plentiful as they once were. In addition, several large national manufacturers are at present looking for electronics firms for acquisition or merger.

WHAT GEORGIA OFFERS THE ELECTRONICS INDUSTRY

WHAT GEORGIA OFFERS THE ELECTRONICS INDUSTRY

The discussion in this section of some of the factors relating to plant location in Georgia cannot hope to answer all of the many detailed questions which are involved in plant location. Specific questions as to the availability of sites, water, labor, power, fuels, and so on, can only be answered in terms of a particular plant's needs. However, it is the intention of this section to give some of the general data which will be of interest to a prospective producer of electronic equipment in Georgia.

Labor

Since this industry is primarily labor oriented, one of the most important factors to be considered is the availability of labor. For the development and production of electronic equipment, "labor" consists for the most part of four categories of workers: production workers, technicians, management and administrative personnel, engineers and scientists. Also needed but of lesser importance are maintenance and custodial workers and clerical personnel. Georgia can supply in adequate quantities personnel in any of these categories.

Mechanization of farming has released large numbers of workers so that labor surpluses exist in 122 of the state's 159 counties.[1/] In addition to workers available in the immediate area of a plant, data[2/] indicate that a potential labor supply may exist up to a radius of 60 miles or more from the plant. Experience has proven the adaptability and trainability of these workers for production jobs. In particular, the large number of women workers trained for textile mill work (textiles is Georgia's largest industry) is of great interest for electronic producers. The high degree of manual and finger dexterity, eye-hand coordination, and concentration found in this type of worker has generally proven to be readily transferable to electronic assembly operations. The efficiency and productivity of Georgia workers is high.

1/ Fulmer, John L., Population Estimates in Georgia Counties for 1956-1957, with Analysis of Reasons for Changes from 1950, Special Report No. 33, Engineering Experiment Station, Georgia Institute of Technology, December 1957.

2/ Fulmer, John L., Analysis of Intercounty Commuting of Workers in Georgia, Engineering Experiment Station, Georgia Institute of Technology, in cooperation with the Employment Security Agency, Georgia Department of Labor, August 1958.

The facilities of the Southern Technical Institute, a unit of the Georgia Institute of Technology's Engineering Extension Division, assures a continuing supply of trained technicians. (See Educational Facilities.) Southern Tech is in the process of being located in new quarters in Marietta, a suburb of Atlanta.

The Georgia Institute of Technology in Atlanta provides an excellent source for a continuing supply of engineers, physicists, and mathematicians. Table 1 tabulates the graduates, by degree, for 1955 thru 1958. In addition to current engineering graduates, a large potential source of engineers and scientists exists among Georgia Tech graduates who would like to return to Georgia. A survey made by the Industrial Development Branch in 1957 of 237 electrical engineering graduates, for the period 1946-1957, indicated that almost 70 per cent would be interested in relocating in Atlanta or the surrounding area if suitable jobs became available.

Management and supervisory personnel are available as graduates from a number of schools in the state. (See Educational Facilities.)

Georgia was one of the first states to enact a "right to work" law. This act specifically outlaws the "closed shop" and prohibits contracts requiring that any individual be required to belong to a labor organization as a condition of employment or continuance of employment.

Labor-management relations are generally good, and work stoppages because of strikes have been relatively few. Georgia is among the top five states with fewest strikes.

Educational Facilities

Closely related to the supply of workers are facilities for training them. Outstanding facilities exist in Georgia for the training of every category of personnel required by the electronics industry.

Two primary methods exist for the training of production workers. Georgia has a vocational training program designed to meet the needs of a specific plant. This program is conducted by local school authorities, upon a company's request, in cooperation with the Georgia Department of Vocational Education. Under this program, company officials and the Vocational Education Department agree in advance on the requirements and details of training. Facilities, including building and utilities, and qualified instructors are supplied at no cost to the company. If qualified instructors are not available from other sources, employees of the company may be

Table 1

Graduates by Degree, Georgia Tech, 1955 - 1958

	1955	1956	1957	1958
Bachelor of Science in Applied Mathematics	5	4	11	7
Bachelor of Architecture	33	16	18	20
Bachelor of Aeronautical Engineering	31	26	46	56
Bachelor of Ceramic Engineering	3	7	19	14
Bachelor of Chemical Engineering	54	46	55	59
Bachelor of Science in Chemistry	6	4	4	13
Bachelor of Civil Engineering	59	73	42	68
Bachelor of Electrical Engineering	85	116	102	104
Bachelor of Science	48	43	44	56
Bachelor of Industrial Engineering	101	123	178	211
Bachelor of Science in Industrial Management	169	186	216	263
Bachelor of Mechanical Engineering	100	100	142	142
Bachelor of Science in Physics	11	12	24	25
Bachelor of Textile Engineering	9	3	9	4
Bachelor of Science in Textiles	48	34	37	34
Master of Science	97	107	97	110
Doctor of Philosophy	5	7	9	4

paid by the state to serve as instructors if desired. The company is required to furnish all machinery, on a loan basis, and any materials necessary. Courses may last from three to six hours per day and from four weeks to six months, depending on the time required to attain proficiency in the particular skills. Upon request of the company, the Georgia State Employment Service will advertise for and screen applicants for training. Trainees are informed of the number of job openings and the company's employment schedule, but the company is under no obligation to employ any excess. Trainees receive no pay.

The State Department of Education adopted a plan in mid-1958 for the establishment of area vocational-technical schools in the major population and industrial centers of the state. These schools would offer job training based on the needs of industry and the availability of jobs of a particular type. Already in existence are the North Georgia Trade School at Clarkesville and the South Georgia Trade School at Americus operated by the Georgia Department of Vocational Education. In addition, several city and county vocational schools are operated throughout the state on a local basis.

As mentioned previously, the Southern Technical Institute provides facilities for training of technicians. Technological courses over a two year period (six academic quarters) lead to an Associate in Science degree in any of eight different fields. Work in all of these fields has been fully accredited by the Engineers' Council for Professional Development, the national agency which accredits technical institute and engineering curricula throughout the United States. Plans are now underway to expand and modernize the facilities of Southern Tech thru the construction of a new $2 million campus at Marietta, 16 miles north of Atlanta. Courses of study available and the number of graduates in each in June 1958 were as follows:

Table 2

Graduates by Degree, Southern Tech, 1958

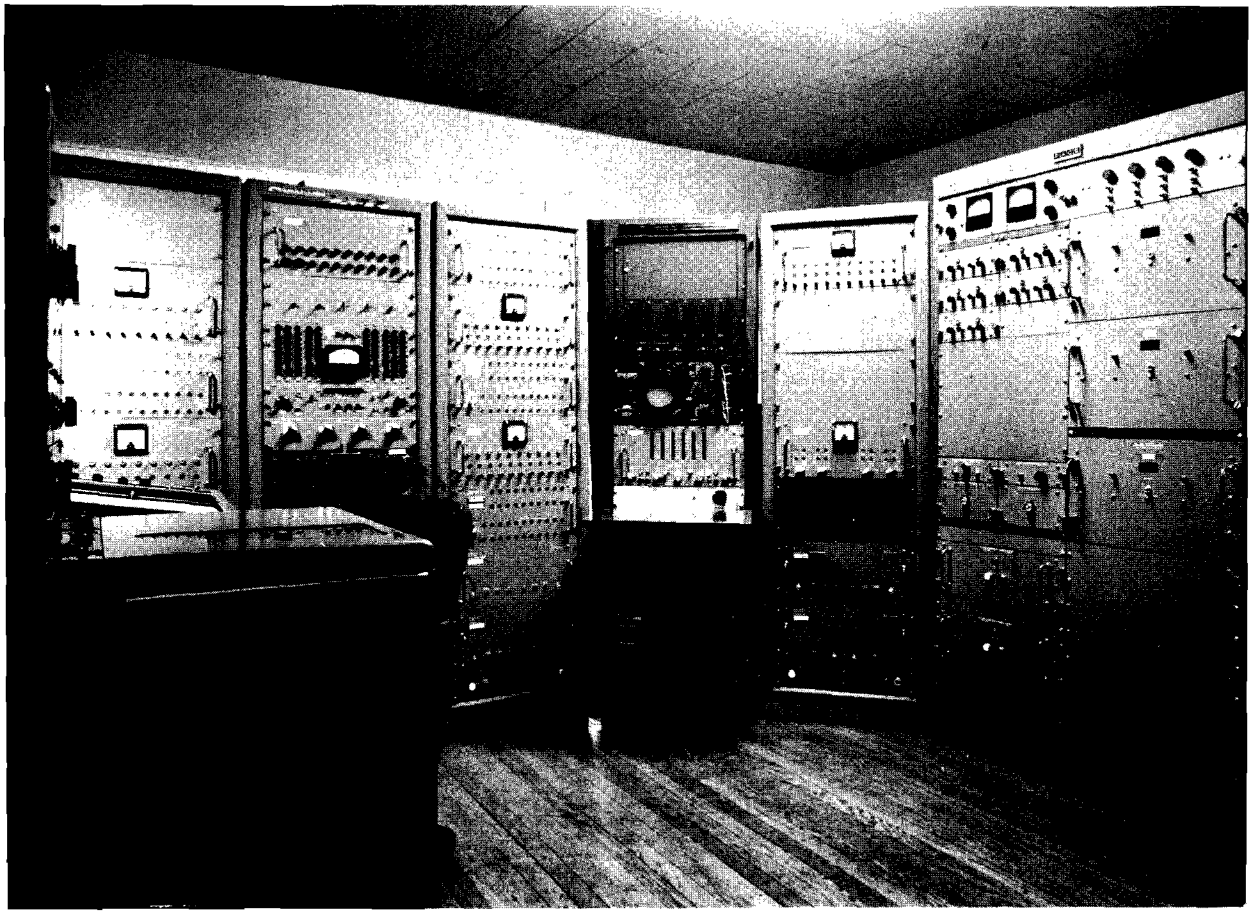
Course	June 1958 Graduates
Building Construction Technology	31
Civil Technology	18
Electrical Technology	12
Electronics and Communications Technology	62
Gas Fuel Technology	12
Heating and Air Conditioning Technology	32
Industrial Technology	24
Mechanical Technology	36

Current enrollment (1958-1959) is approximately 1,600. This training is also available on a part-time schedule thru the Engineering Evening School on the Georgia Tech campus. Approximately five years are required through part-time work to qualify for the Associate in Science degree.

Georgia Tech offers programs leading to a bachelors degree in virtually every field of science and engineering and in management. (See Table 1.) Graduate programs leading to the master of science and doctor of philosophy degrees are offered in many of these. For companies which might locate in the vicinity of Atlanta, an important consideration is the ability to offer engineering and scientific personnel the opportunity for graduate work at Tech. An opportunity of this type can be a very powerful recruiting weapon.

Georgia Tech offers advantages to industry other than those mentioned above. The facilities of the new Price Gilbert Library, which has one of the finest technical collections in the country, may be made available to industry. The Engineering Experiment Station has a full-time staff of approximately 250 scientists and technicians and a part-time staff of 150 to 200. The staff and facilities of the Experiment Station are available to industry on a contract basis for research in almost every scientific field. Facilities include both analog and digital computer centers, electron microscope, machine shop, and many fully equipped laboratories for work in all aspects of electronics, ceramics, chemistry, etc. The present volume of research in the electronics field exceeds $900,000 per year.

There are a number of colleges and universities in the state which offer programs in management and business administration. The largest of these are Georgia Tech, Georgia State College of Business Administration, and Emory University, all in Atlanta, and the University of Georgia in Athens, 70 miles distant.



Analog Computer Laboratory at Research Area 4, Georgia Institute of Technology.

Markets

Electronics manufacturers in Georgia would be ideally situated for serving the ever growing southeastern market area.

Estimates for the six state area place the total population at over 21 million, about 12.5 per cent of the U. S. total. (See Table 3.)

Table 3

Population Estimates, 1957[1/]

State	Population (thousands)	Per Cent of U. S.
Alabama	3,151	1.9
Florida	4,098	2.4
Georgia	3,779	2.2
North Carolina	4,498	2.6
South Carolina	2,370	1.4
Tennessee	3,463	2.0
Total	21,359	12.5
United States	170,333	100.0

Table 4 gives disposable personal income figures for the same region for 1955, the latest year for which tabulations of federal individual income taxes are available. It can be seen that the total disposable income as a per cent of the total U. S. is 9.15; this figure compares with Sales Management's estimate for the 1957 effective buying income for the region of 9.18 per cent.[2/]

Table 4

Disposable Personal Income, 1955[3/]

State	Per Cent of U. S.		Amount Per Capita		Per Capita Disposable Income as a % of National Average
Alabama	1.25		1,098		67
Florida	2.02		1,496		91
Georgia	1.66		1,233		75
North Carolina	1.87		1,174		71
South Carolina	.89		1,046		63
Tennessee	1.46		1,168		71
Total	9.15	Average	1,203	Average	73
United States	100		1,651		100

1/ Survey of Current Business, U. S. Department of Commerce, Office of Business Economics, August, 1958, p. 13.

2/ Sales Management, Survey of Buying Power, May 10, 1958, p. 208.

3/ Survey of Current Business, op. cit., p. 12.

Although per capita income for the region is still less than the national average, it has been increasing at a faster rate. (See Table 5.) In addition, average annual expenditure per household for electronic consumer items compares favorably with other regions.

Table 5

Per Capita Personal Income[1/]

State	Per Cent of U. S. 1929	1940	1950	1957	Per Cent Increase 1929-1957	1950-1957	1956-1957
Alabama	46	47	58	65	309	53	6
Florida	74	86	86	91	252	43	5
Georgia	50	57	68	71	309	41	1
North Carolina	48	55	68	65	294	31	-1
South Carolina	38	52	59	58	337	34	2
Tennessee	54	57	67	68	267	39	3
United States	100	100	100	100	188	36	3

The Life Study of Consumer Expenditures shows that the southern region, which includes the six state area under consideration, spends five per cent per household for recreation and recreation equipment of the total spent for all goods and services. The national average is also five per cent. Of the portion spent for recreation and recreation equipment, households in metropolitan markets in the southern region expend 22 per cent for radios, phonographs, and television sets; households in non-metropolitan areas spend 32 per cent for these items. (See Table 6.)

Table 6

Household Expenditures for Radios, Phonographs, and Television Sets[2/]

	Metropolitan Regions Per Cent	Dollars	Non-metropolitan Regions Per Cent	Dollars
Northeast region	16	39	22	48
Central region	17	43	22	38
Southern region	22	41	32	48
Western region	15	42	16	36

All households--20 per cent, 42 dollars

1/ Survey of Current Business, op. cit., p. 10.

Note: Income expansion for 1956-1957 was relatively low for some states due to a drop in farm income, primarily resulting from unfavorable weather conditions and quota allotments for cotton and tobacco.

2/ Life Study of Consumer Expenditures, Vol. 1, 1957, Time, Inc., pp. 132 and 134.

The potential market in this area for electronic consumer products is very large. Electrical Merchandising[1/] estimates the percentage saturation, January 1, 1958, for wired homes nationally for television sets at 86.0 per cent and for radios at 96.8 per cent. As can be seen from Table 7, the index of saturation for the six state area is about 74 per cent of total homes for television sets and 95.6 per cent for radios, both figures under the national average. Of particular significance is the differential for television set saturation. As television saturation has occurred, the market has naturally shifted from primarily a first set market to a replacement one. As a per cent of total sales, the replacement market for 1957 has been estimated at 59.4.[2/] For this six state area, however, the potential market, in addition to replacements for old sets, includes a greater portion of homes for the initial set market.

Map 1 shows television stations in the area. The coverage indicated is such that most of the population is in range of a station and are potential consumers of television sets.

Table 7

Television and Radio Set Penetration[3/]

State	Total Homes	% Television Penetration	Television Homes	% Radio Penetration	Radio Homes
Alabama	829,500	71.03	589,250	95.49	792,100
Florida	1,226,700	77.15	946,380	95.53	1,171,900
Georgia	998,100	74.47	743,320	95.17	949,900
North Carolina	1,097,600	73.93	811,440	95.73	1,050,800
South Carolina	586,900	72.08	423,090	96.23	564,800
Tennessee	941,100	73.26	689,480	95.83	901,900
Total	5,679,900	Av. 73.99	4,202,960	Av. 95.62	5,431,400

Sales of television sets and radios for the six state area with the percentage of the total market for these items in the area are presented in Table 8.

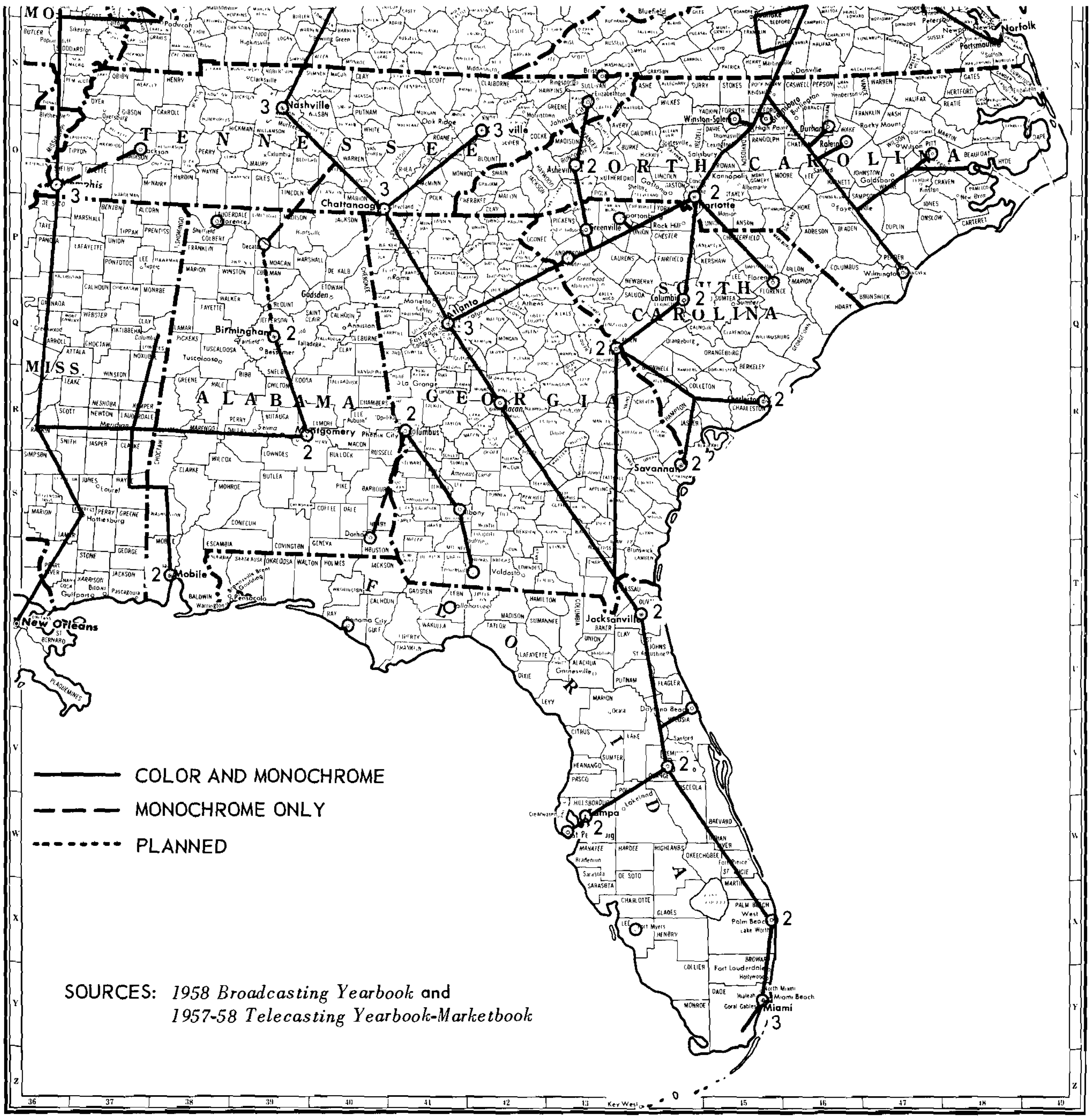
1/ Electrical Merchandising, McGraw-Hill, January, 1958, p. 93.

2/ Ibid, p. 96.

3/ 1958 Broadcasting Yearbook, p. A-17.

Map 1

Bell System Television Network Routes



NOTE: Number of stations, other than one, are shown for each location.

Table 8

Television and Radio Sales[1/]

Television

State	1956 Unit Sales	1956 % of Market	Total 11 Years 1946-1956	Average % of Market 1946-1956
Alabama	107,710	1.54	598,822	1.20
Florida	238,140	3.40	1,050,000	2.10
Georgia	147,751	2.11	872,910	1.74
North Carolina	150,102	2.14	899,171	1.80
South Carolina	64,736	0.92	389,024	0.78
Tennessee	129,471	1.85	741,305	1.48
Total	837,910	11.96	4,551,232	9.10

Radio

State	1956 Unit Sales	1956 % of Market	Total 6 Years 1951-1956	Average % of Market 1951-1956
Alabama	97,822	1.16	594,700	1.36
Florida	168,152	2.00	951,669	2.19
Georgia	135,478	1.61	856,810	1.97
North Carolina	126,820	1.51	845,492	1.94
South Carolina	50,601	0.60	364,297	0.84
Tennessee	114,118	1.36	679,167	1.56
Total	692,991	8.24	4,292,135	9.86

Map 2 shows the present location of television and radio receiver production centers. Except for the one plant in Tennessee, there is at present no production by a major producer in the Southeast. An opportunity for branch plant location to serve this market is apparent.

In addition to the market for consumer goods, the growing missile and aircraft industry in the Southeast (See Map 4) along with the rapidly expanding electronics industry provides a market for components, systems, test equipment, etc. The continuing industrialization of the South also provides markets for industrial controls, automatic machinery, computers, and data processing equipment. Measurement of these markets is beyond the scope of this study.

1/ Electrical Merchandising, op. cit., p. 106.

Map 2

Major Production Centers for Radio and Television Receivers

Transportation

Since most electronic products are distributed nationally, transportation facilities are an important plant location consideration. A good transportation network increases the market area that can be effectively served.

Atlanta is the distribution center of the Southeast, and the transportation network which radiates from Atlanta--unsurpassed anywhere in the South--would give a Georgia producer ease of access to markets and raw materials or components. In addition, engineers, research personnel and executives would have suitable connections to all points for the important aspects of customer service, contact with other scientific personnel, and access to other company plants and distribution points.

Table 9

Typical Airline Time Between Atlanta and Selected Points

*Washington, D. C.	2 hours - 2 minutes
*New York, N. Y.	2 hours - 40 minutes
*Chicago, Ill.	2 hours - 30 minutes
*St. Louis, Mo.	2 hours - 46 minutes
**Denver, Colo.	7 hours - 40 minutes
**Seattle, Wash.	9 hours - 45 minutes
***San Francisco, Calif.	10 hours - 21 minutes
***Los Angeles, Calif.	9 hours - 35 minutes
*Dallas, Texas	2 hours - 42 minutes
*Miami, Florida	2 hours - 12 minutes
**Cape Canaveral, Fla.	2 hours - 53 minutes
*Huntsville, Ala.	1 hour - 0 minutes

*Non-stop
**One stop
***Two stops

Note: Times include layover where stops are made.

Major airlines operating in Georgia are Capital, Delta-C.& S., Eastern, National, Trans-World, Southern, and Northwest Orient.

Direct motor freight service to and from major U. S. cities is furnished by numerous interstate carriers. Important centers such as New York and Chicago receive third-day service from most Georgia communities. Georgia is served by about 100 scheduled carriers and about 400 irregular carriers, contract haulers and commodity carriers.

Georgia has 32 rail carriers, including 15 Class 1 railroads. The more important interstate lines are the Atlantic Coast Line, Atlanta and West Point, Central of Georgia, Georgia, Louisville and Nashville; Nashville, Chattanooga and St. Louis; Seaboard Air Line and the Southern. Fast and dependable freight and passenger service is available throughout the state.

Georgia has two excellent ports at Brunswick and Savannah suitably located for export trade to Europe, Africa, and South America.

Climate

Georgia's climate is characterized by mild winters and not too severe summers enabling substantial savings in plant construction and maintenance costs. It also insures that while heating costs will be relatively low in winter, the resultant saving will not be dissipated by high air conditioning costs in the summer. Table 10 shows temperature and rainfall data for Georgia, with comparative data for Chicago and New York.

Work stoppages due to weather are extremely rare, and the mild, year-round climate contributes to pleasant working and living conditions, an important factor in recruiting personnel from other areas.

Table 10

Georgia Temperature and Rainfall Data by Section

State Division	Average Temperature (°F)			Annual Rainfall (Inches)
	January	July	Annual	
Northwest	44.4	79.6	61.6	52.26
Northcentral	44.6	78.2	61.0	51.13
Northeast	45.0	78.4	61.2	53.24
Westcentral	48.6	79.9	64.0	49.62
Central	49.1	81.1	64.8	46.36
Eastcentral	50.4	81.6	65.7	42.76
Southwest	53.1	81.6	67.4	50.28
Southcentral	53.3	81.6	67.3	46.15
Southeast	53.9	81.5	67.5	47.87
State	49.9	80.6	65.0	48.30
Chicago	25.1	73.6	49.7	33.1
New York	31.8	74.6	52.8	42.9

INDUSTRY PRIMER

INDUSTRY PRIMER

There is no general agreement on what comprises the electronics industry. At one end of its range, electronics merges into electrical machinery; at the other end, into atomic energy. There is, however, agreement that electronics is one of the fastest growing industries and today ranks fifth to automotive, steel, aircraft, and chemicals.

History and Organization of the Industry

Prior to World War II, the electronics industry consisted primarily of the production of radios and related broadcasting equipment. Sales for 1939 totaled less than half a billion dollars. The use of radar and other electronic equipment by the military during the war pushed the industry forward, and the advent of television in 1946-47 added impetus which carried sales to over two and one-half billion dollars in 1950. Since 1950 demand for television sets has leveled off, but the electronics industry has continued to expand at an even faster rate; sales almost tripled between 1950 and 1957. Sales for 1957 were almost $8 billion, including approximately $1 billion for replacement parts.

Table 11

Factory Sales of Electronic Equipment--1957 1/

Military	$4.20 billion
Industrial	1.31
Consumer	1.53
Replacement Parts	.90
	$7.94

The continued growth of electronics results from two important factors:

(1) emphasis by the industry on research and development, and

(2) increasing use of electronic equipment by the military, especially in guided missiles.

The constant search for new and better products by the electronics manufacturers has been the driving force behind the rapid expansion of the industry. In 1956 the president of RCA stated that 80 per cent of his company's

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1/ Electronics, business edition, McGraw-Hill, August 22, 1958, p. 13.

products were either unknown or not commercially developed 10 years earlier. In 1957 alone, expenditures on research and development by industry and government in electronics totaled almost a billion dollars.

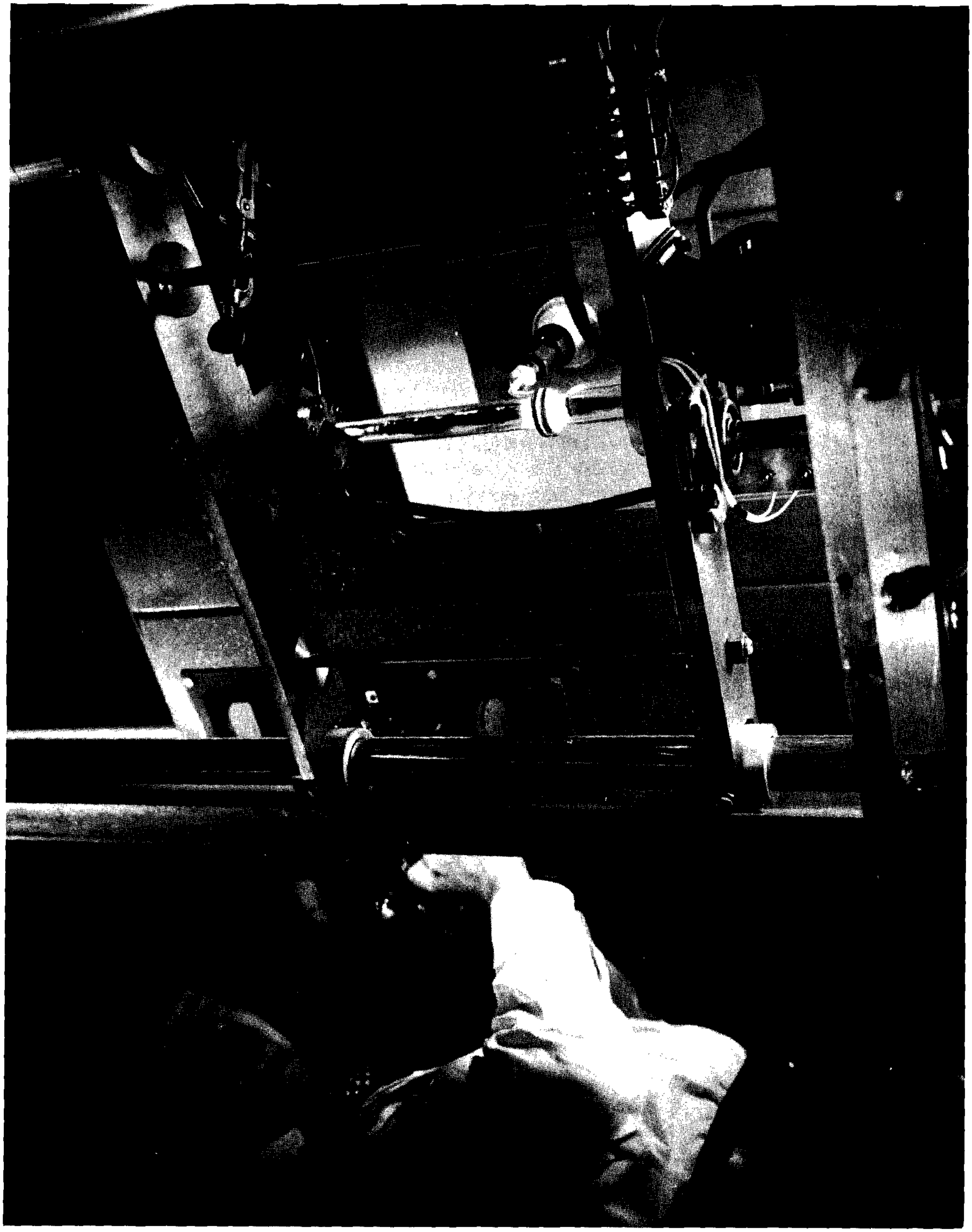
Over 50 per cent of electronic sales are to military agencies, and the portion of the defense budget expended for electronic equipment is expected to increase as added emphasis is given to missiles, detection, communications, etc. As long as the United States is faced with the threat of war due to communist activities, military expenditures, and consequently electronic purchases, are expected to continue at a very high rate.

Manufacturing operations vary widely in electronics. At one end of the scale are the component manufacturers, with huge investments in specialized machines, who turn out vast quantities of standardized products. At the other end is the production by hand assembly of a few highly specialized, complex items for use by the military.

For the most part, electronics is an assembly operation bringing together the tubes, resistors, capacitors, etc., and wiring them together. Most plants specialize in the manufacture of one type of end product, and where more than one product is produced, each different product is usually produced on a separate assembly line. Some companies are completely integrated, producing everything from components to finished products. However, there are very few of these and most buy standard components from outside sources for assembly.

Continued research and development are prerequisites for success in the electronics field, and most firms, whether manufacturing components or assembling finished products, maintain staffs of engineers, mathematicians, physicists, and other scientists for product development and application. Research facilities, particularly in larger companies, are often at completely different sites from the manufacturing operations.

Estimates on the number of firms in electronics production vary from 3,000 to 5,000, and the picture is constantly changing due to the formation of new companies, mergers, and the setting up of electronics divisions by companies in other lines. Electronics firms are located in virtually every state, but six states account for approximately 70 per cent of production. (See Map 3.) In addition to those states indicated, substantial growth has been made in the past two or three years in Arizona, New Mexico, and especially in Florida. Despite the large number of firms in the industry, approximately 20 companies account for about 70 per cent of total sales and about



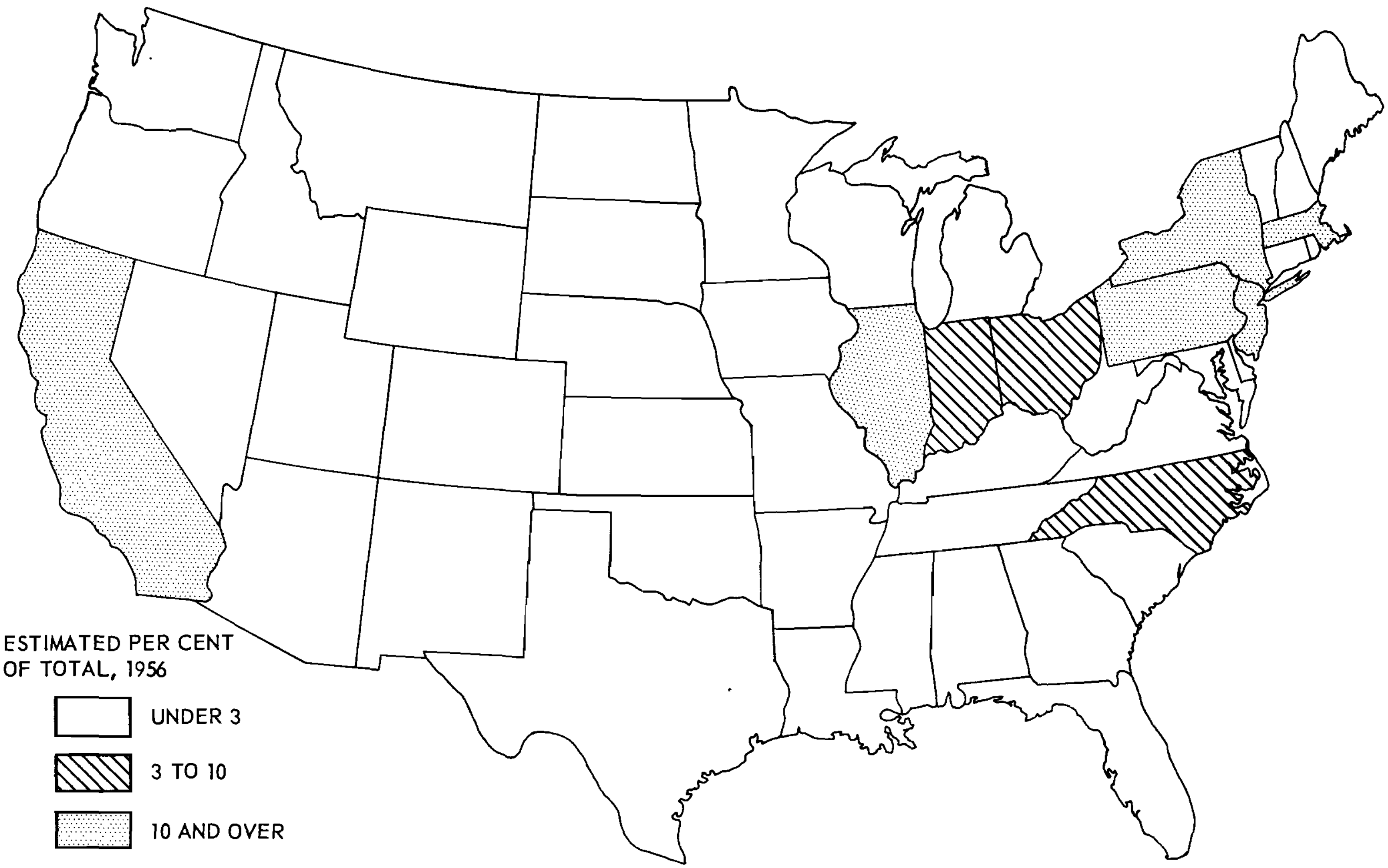
Floating Zone Crystal Grower

Designed by Mallory engineers, this equipment grows purer single crystals without a quartz crucible. With reduced boron and oxygen in the crystal, the finished silicon rectifiers possess superior electrical characteristics.

Photo: P. R. Mallory & Company, Inc., Indianapolis, Indiana

Map 3

Distribution of Electronic Manufacturing Employment, 1956



SOURCE: *Occupational Outlook Handbook*, 1957 edition, U. S. Department of Labor, Bureau of Labor Statistics, p. 468

100 companies for 95 per cent.

The primary locational factor for many years was the influence of the highly populated centers of the Northeast and Midwest, both from the standpoint of the market for radios and from the standpoint of labor supply. As the electronics industry grew during and subsequent to World War II, other firms were attracted to the field, including many manufacturers of electrical equipment in the same areas. This contributed further to the concentration of manufacturers in the Northeast and Midwest.

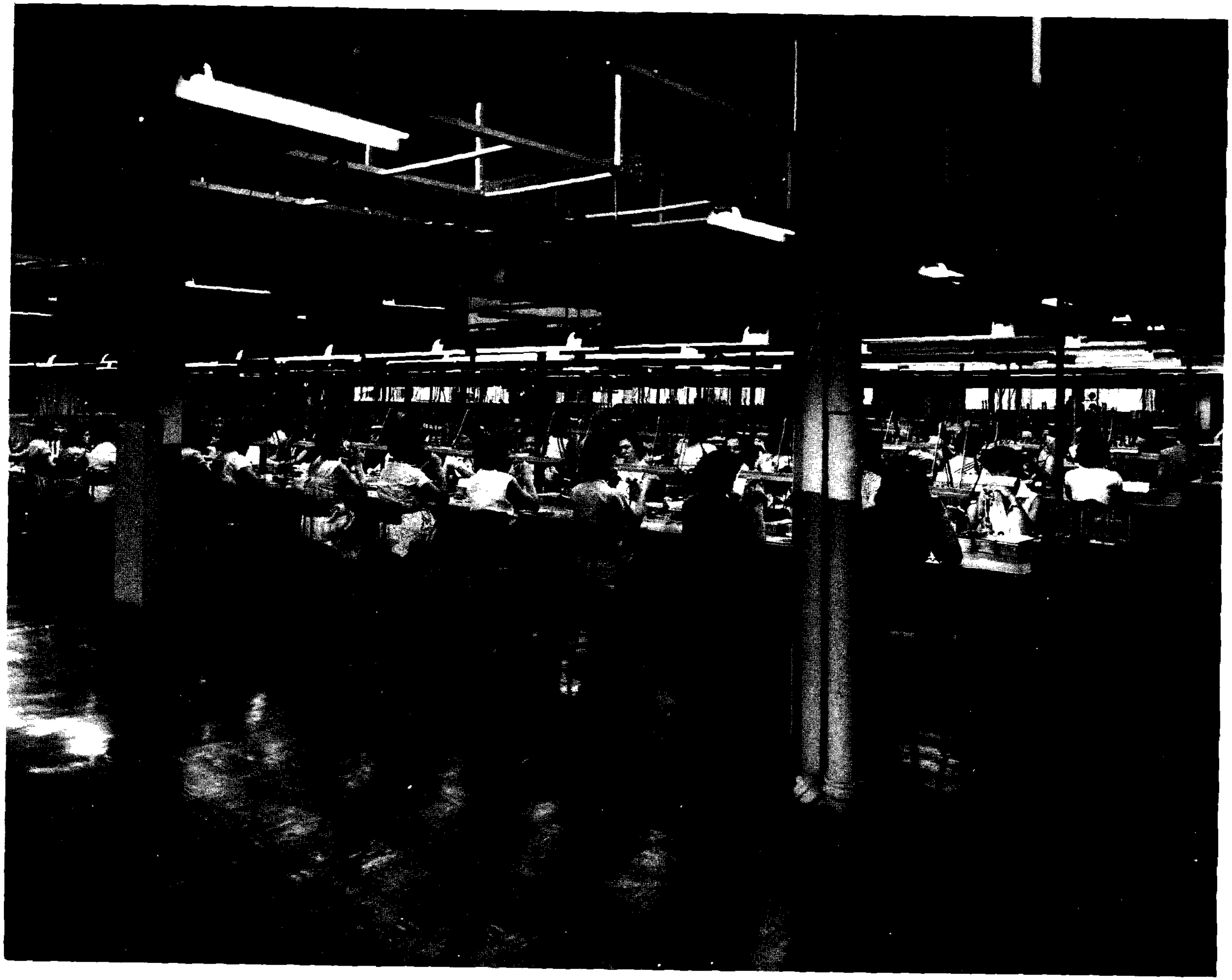
The development of the industry on the West Coast, particularly Southern California, is partially due to the concentration of aircraft manufacturers there, with their requirements for highly complex navigational, communications, fire and bomb control systems. It is also due partially to the availability of workers as a result of the aircraft industry, but even more directly it may be attributed to the climate of the area. Since World War II, during electronics industry's period of greatest expansion, the securing of engineers and scientists has been a primary concern of this industry, rooted as it is in research and development. With the supply of engineers and technicians insufficient to meet the demand, many companies found that they could recruit personnel on the basis of the climate and living conditions of the area. This has been a very strong contributing factor to the expansion of the industry in California, and in the last two or three years in Arizona, New Mexico and Florida. Also contributing to the expansion in these states has been the location of military test or research centers such as the Missile Test Center at Cape Canaveral, Florida.

Transportation costs seem to have little effect as a locational factor, since electronic equipment is usually a high valued item and transportation costs are a relatively small portion of the total cost. Neither is the location of raw materials an important factor, since most components are small and light and can be easily transported.

Two significant employment characteristics of the industry are the large percentages of technical personnel and women production workers. About a third of all non production workers are engaged in research and development. The proportion of nonproduction workers varies, of course, in different segments of the industry, depending on the product manufactured and the amount of research and development required. For example, in those plants engaged in the production of military equipment, over 30 per cent of the workers are

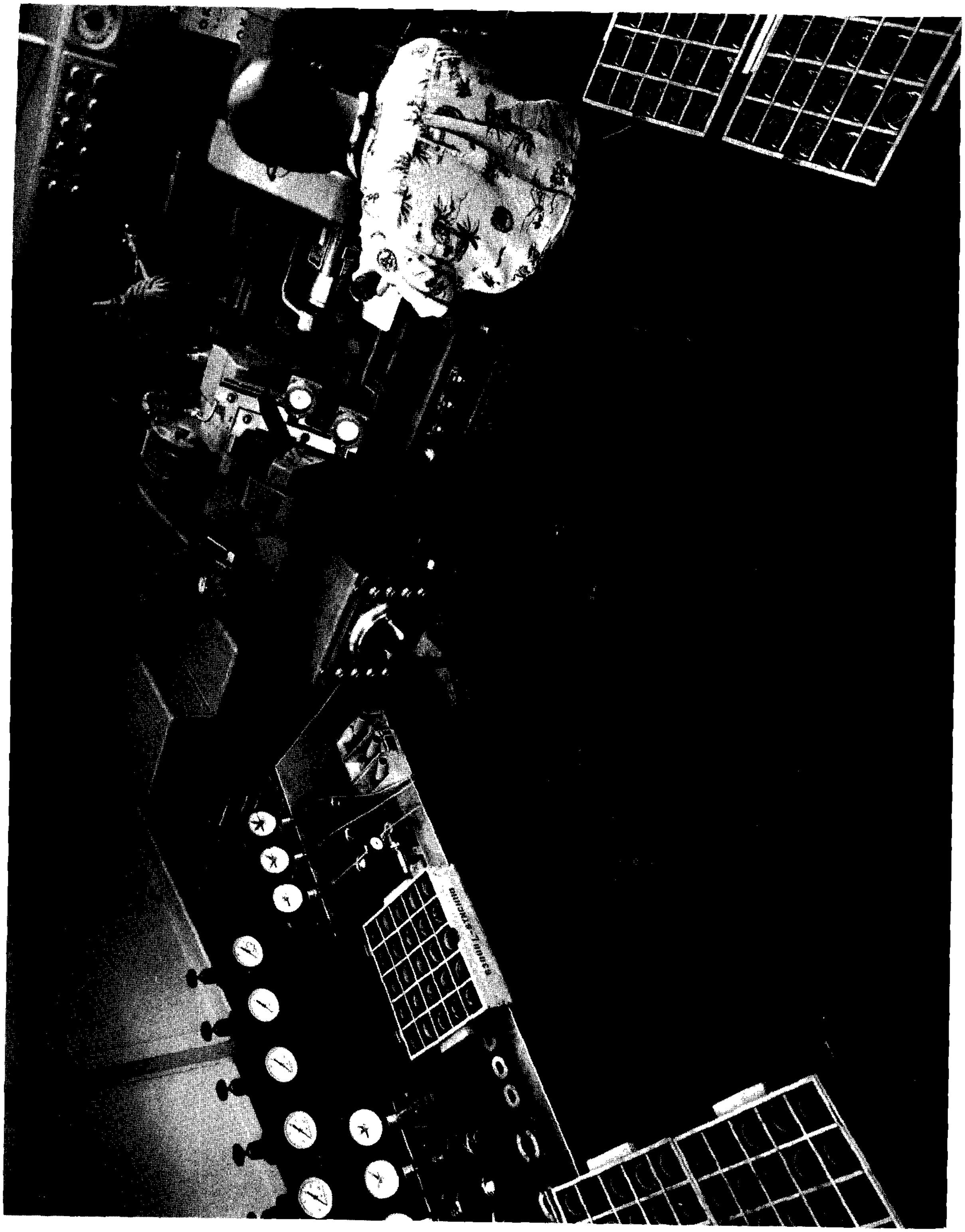
Women Assembly Workers

Photo: The Magnovox Company, Fort Wayne, Indiana



Women Assembly Workers

Photo: The Magnovox Company, Fort Wayne, Indiana



Electronic Production

Photo: The Magnovox Company, Fort Wayne, Indiana

nonproduction workers, but in radio and component parts plants they constitute only about 20 per cent. For the industry as a whole, nonproduction workers account for about 27 per cent of all jobs. (See Table 12.) About half of the industry's workers are women, most of whom are employed in semiskilled production jobs and office work. The relative number of women workers varies from less than 45 per cent for the production of military and industrial equipment to as high as 60 per cent in tube and components plants.

Table 12

Categories of Employment for Electronics Industry[1/]

	Per Cent of Total
Nonproduction workers	26.9
Managerial and supervisory	4.4
Research and development	10.0
Professional	4.1
Technical	3.0
Craftsmen	.8
Other	2.1
Other professional	2.3
Office	9.2
Accounting	2.0
Other, including sales	7.2
All other nonproduction workers	1.0
Production workers	73.1
Assembly	30.5
Machining	7.1
Other fabricating	5.6
Processing (coating, plating, and cleaning)	2.4
Inspection, testing, and related	13.7
Materials handling	4.1
Plant clerical	1.3
Maintenance	3.7
Custodial	2.1
All other production workers	2.6

1/ Occupational Outlook Handbook, 1957 edition, U. S. Department of Labor, Bureau of Labor Statistics, p. 471.

Products and Applications

The number of different electronic products and applications are too numerous to allow a discussion of each in a report of this scope. Those discussed here represent the primary categories from component parts to complete systems.

Components

Electronics equipment manufacture consists primarily of the assembly of standardized components. In most electronic circuits, up to 90 per cent of the individual components consist of resistors, capacitors, and tubes--or transistors, the tube's counterpart.

Competition is intense in the components field, and entrance is probably possible only in areas of low volume and for specialized items. Component production is dominated by a few firms using highly specialized machines, representing tremendous capital investments, to turn out vast quantities of standardized, interchangeable parts. Because of the influence of military requirements, great progress has been made in recent years in increasing the life and reliability of components and in their miniaturization.

Table 13

Value of Manufacturers' Sales of Components by Selected Years[1/]
(millions of dollars)

Year	Tubes	Resistors	Capacitors	All Other	Total
1939	$ 39	$ 9	$ 22.6	$ 43.4	$ 114
1943	230	33	92	148	503
1944	391	48.2	119	246	804.2
1945	250	42	104	215	611
1947	122	19	49	281	471
1950	443	na	na	na	1,140
1951	473	na	na	na	1,261
1952	604	100	200	826	1,730
1954	708	130	200	970	2,008
1955	800	150	215	1,035	2,200
1956	830	175	220	1,055	2,280
1957	970	180	225	1,060	2,435

1/ Electronics Industry Fact Book, 1958, Electronics Industry Association, p. 23.

Tantalum Capacitor

Photo: P. R. Mallory & Company, Inc., Indianapolis, Indiana

Tubes. It was the development of the electron tube which made possible the electronics era. Tubes are of three general classes; receiving tubes, the familiar kind used in radios; cathode ray tubes, such as the television picture tube; and special purpose tubes such as those used in radar and microwave systems.

a. Receiving tubes. Receiving tube production is the most highly concentrated of all the electronics industry, with the four largest producers accounting for about 80 per cent of total production. The eight largest account for about 97 per cent of the total.

Table 14

Manufacturers' Sales of Receiving Tubes, By End Use[1/]
(millions)

Year	Initial	Renewal	Export	Government*	Total	Value
1939	65.3	25.4	7.8	-	98.5	$ 28.0
1940	72.3	29.0	7.2	-	108.5	27.6
1941	92.0	33.8	10.0	-	135.8	47.5
1942	64.6	36.5	6.6	-	107.7	43.0
1943	54.5	19.6	3.1	32.8	110.0	51.0
1944	60.2	20.9	4.6	43.4	129.1	62.1
1945	57.2	40.5	5.0	36.8	139.5	68.5
1946	129.6	65.2	10.0	.4	205.2	101.0
1947	132.0	43.5	23.2	.8	199.5	107.0
1948	146.2	47.1	10.7	.8	204.8	112.0
1949	147.3	39.7	10.1	1.7	198.8	119.0
1950	301.5	69.3	10.8	1.4	383.0	250.0
1951	247.9	94.6	24.4	8.8	375.7	261.0
1952	241.4	83.8	13.9	29.3	368.4	259.1
1953	293.6	112.8	20.6	10.1	437.1	303.7
1954	246.7	115.4	15.9	7.1	385.1	276.0
1955	288.8	150.7	24.4	15.8	479.7	385.1
1956	262.9	166.6	25.4	9.3	464.2	374.2
1957	240.7	184.5	23.4	7.9	456.5	384.4

*Includes only direct sales after 1954.

1/ Electronics Industry Fact Book, 1958, Electronic Industries Association, p. 22.

Production of tubes is not expected to again reach the peak volume achieved in 1955 until 1967 because of the increasing use of transistors, coupled with decline in radio and television set production.

b. Cathode ray tubes. Cathode ray tubes are the familiar television picture tubes and are also used in some test instruments, such as oscilloscopes, and as radar scopes for display of information. Sales are tied very closely to television set sales, but as saturation of the television market has continued and the average set age increased, replacement sales have become increasingly important. In 1950 replacement sales accounted for about six per cent of all CRT sales, but by 1956 they had grown to almost 45 per cent. The figures shown in Table 15 do not give the full picture on replacement sales, because today perhaps half of all replacement sales are rebuilt tubes. Reliable rebuilding is equivalent to producing a new tube, since only the glass envelope is used. Most rebuilders give a new tube warranty.

This portion of the tube market is not quite as concentrated as for receiving tubes, but the top eight companies account for about 80 per cent of production.

Table 15

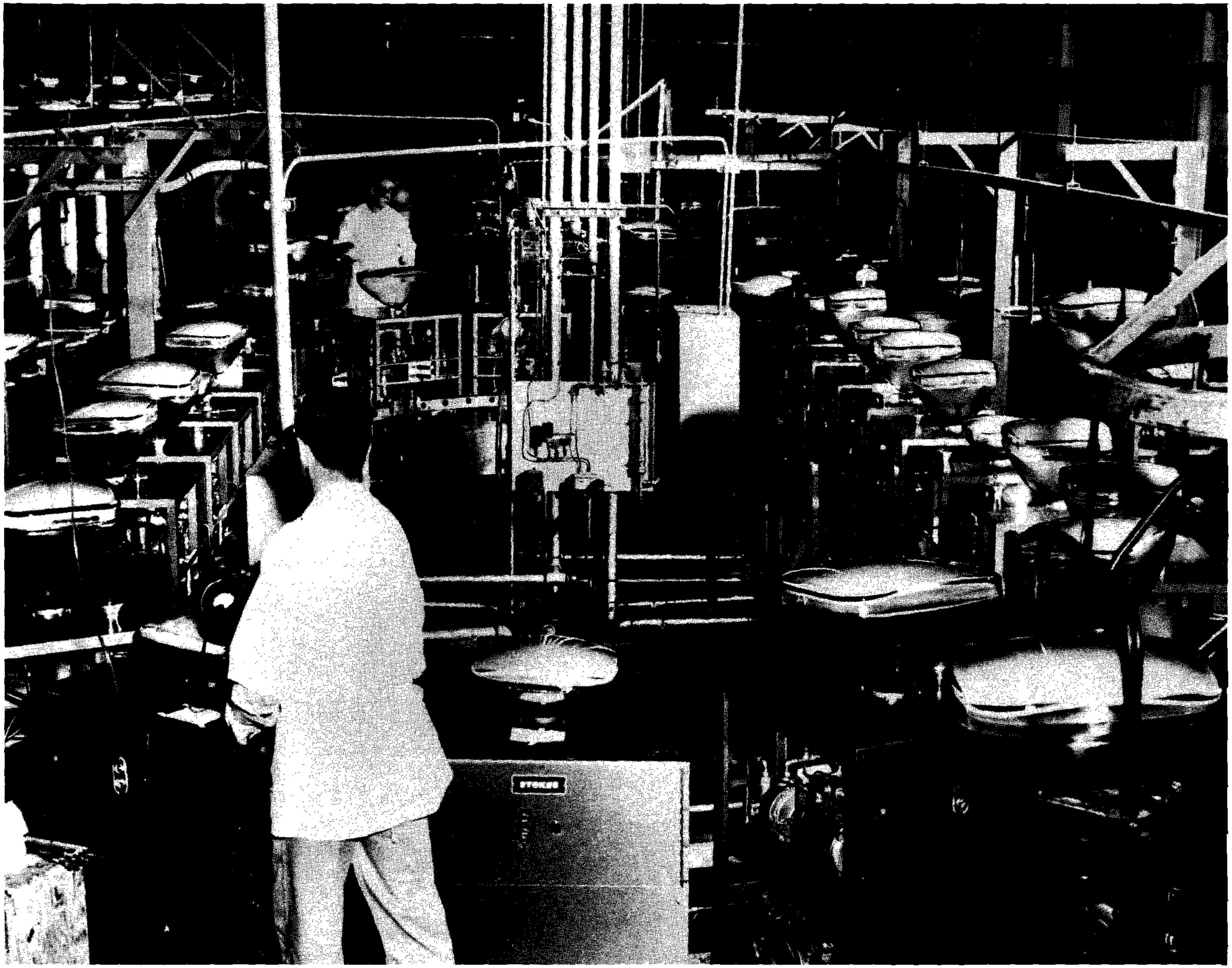
Manufacturers' Sales of Picture Tubes By End Use*1/
(millions)

Year	Initial	Renewal	Export	Total	Value
1948	-	-	-	1.3	$ 33.5
1949	3.3	.2	-	3.5	98.1
1950	7.5	.5	-	8.0	210.7
1951	4.4	.7	-	5.1	122.2
1952	6.1	1.4	-	7.5	170.7
1953	7.6	1.8	.5	9.9	234.9
1954	7.5	1.8	.6	9.9	206.1
1955	7.8	2.4	.8	11.0	209.0
1956	7.5	2.7	.7	10.9	196.2
1957	6.2	2.8	.8	9.8	183.2

*Made from new glass.

Note: Direct sales to government and export sales prior to 1953 are too small to be included.

1/ Electronics Industry Fact Book, 1958, Electronic Industries Association, pp. 20-21.


STOKES

Television Picture Tube Production

Photo: Sylvania Electric Products, Inc.
(Now General Telephone and Electronics Corp.)
Batavia, New York

c. Special purpose tubes. This class of tubes includes such types as magnetrons, klystrons, and traveling wave tubes. It was the development of such tubes which made possible radar and microwave communications. These tubes are for the most part highly specialized, low volume items, but the unit cost is very high. About 82 per cent of production is accounted for by the eight largest manufacturers, with the first four holding approximately 56 per cent of the total market. Value of power and microwave tubes was approximately one-fourth of the total electron tube output for 1957.

Semiconductors. Semiconductors are a class of electronic components which can perform many of the functions of a tube and in some ways are better and more efficient. Semiconductors depend for their functioning on the flow of current in a solid, unlike tube in which electrons flow through a vacuum, gas, or vapor. Semiconductors have a conductivity lower than that of metals but higher than that of insulators. Some of the more important semiconductor devices are discussed below.

a. Transistors. Transistors, one of the class of semiconductors, were introduced in 1948 by Bell Laboratories. Quantity production did not begin until 1953, with about 600,000 units produced that year. The phenomenal growth curve for transistors points up the rewards which can be reaped as a result of research and development. The transistor performs many of the functions of a vacuum tube such as detection or amplification. It is not, however, a direct replacement in a conventional circuit; special circuits must be designed using transistors.

The limitations inherent in vacuum tubes--short life, high power requirements, bulk, and fragility--have been overcome to a great extent through the use of transistors. Without them the task of missile development would have been magnified because of the increased bulk and weight which the use of tubes would have added.

The primary materials used in the production of transistors are very high purity germanium and silicon. Today about 95 per cent of all transistors are germanium and the other 5 per cent silicon. However, increasing use of silicon is expected in the next five years. Silicon's resistance to heat is superior to germanium, giving it an advantage in much of the military and industrial market. Although experimentation with other materials is continuing, silicon and germanium are expected to dominate the market at least for the next decade.

Prospects for entrance into this field are shown by the following quotation from Fortune:

> Any company that has not yet started in semiconductors may find that it is pretty late to get into the business. Certainly, the ante to join the game has gone way up. In 1954, General Transistor of Jamaica, New York, started making transistors on an investment of $100,000. Today the manufacture of semiconductors has become so complicated that $5 million probably would be the minimum cost of getting into production, with no assurance that even such a sum would buy a respectable standing in the field. And the outlook is that by 1960 the semiconductor market will be so competitive, and manufacturing techniques so specialized, that the only way to enter semiconductor manufacturing will be via the merger route. 1/

Table 16 presents sales data by factories for the years 1954 through 1957.

Table 16

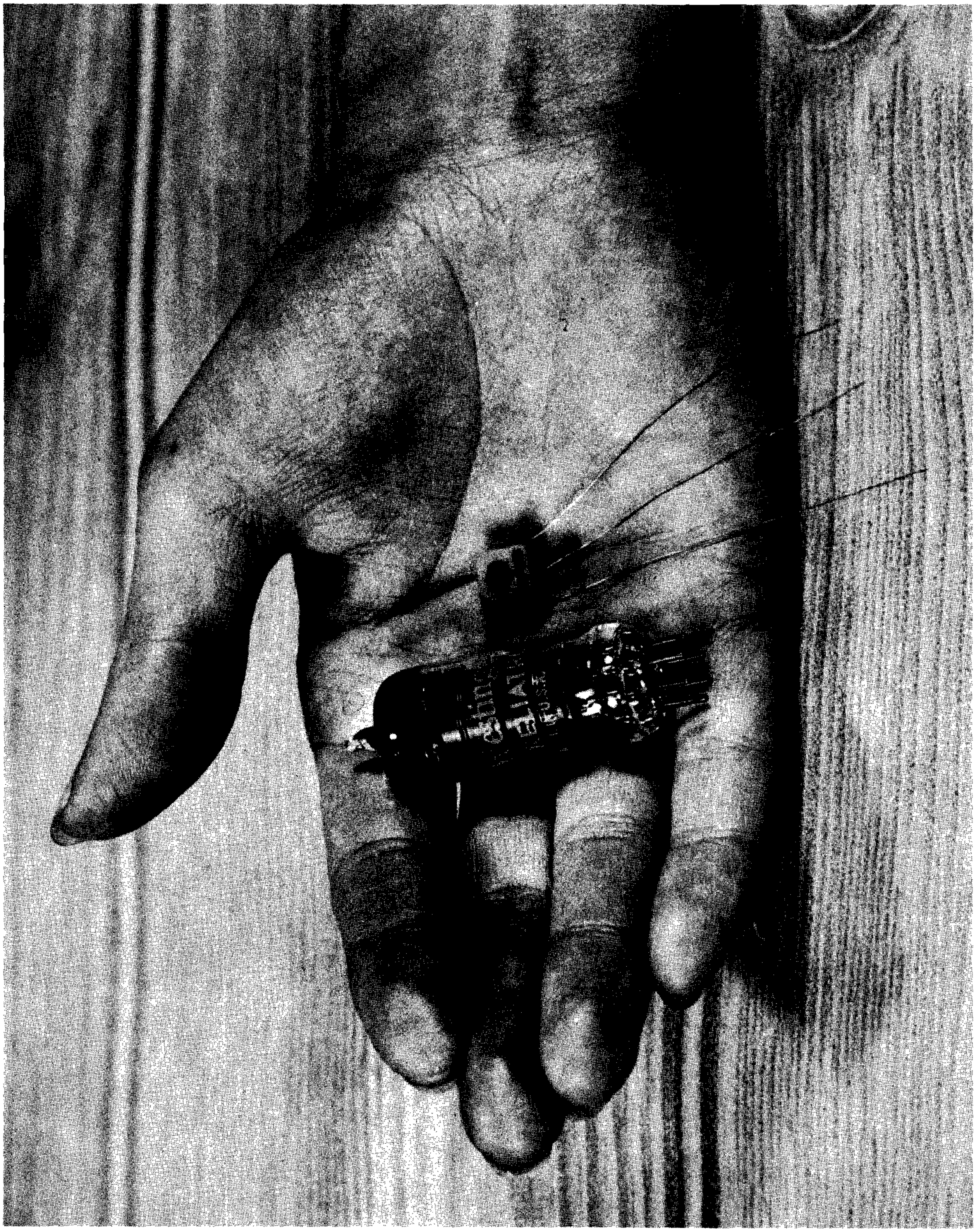
Factory Transistor Sales 2/
(thousands)

	1954	1955	1956	1957
Original Equipment				
Units	1,293	3,505	11,770	24,964
Dollars	$4,493	$9,448	$32,524	$63,369
Distributors				
Units	12	111	723	1,304
Dollars	$ 130	$ 234	$ 1,095	$ 2,302
Direct Government				
Units	7	16	185	85
Dollars	$ 89	$ 92	$ 3,329	$ 679
Export				
Units	6	15	162	2,385
Dollars	$ 48	$ 86	$ 404	$ 3,389
Total				
Units	1,318	3,647	12,840	28,738
Dollars	$4,760	$9,860	$37,352	$69,739

Estimates of sales for 1958 are for a value in excess of $100 million. Forecasts of production run as high as 400 million units per year by 1965.

1/ "The Battle of the Components," Fortune, May 1957, p. 138.

2/ Electronics Industry Fact Book, 1958, Electronic Industries Association, p. 18.



Vacuum Tube and Transistor

Photo: Westinghouse Electric Corporation, Elmira, New York

Estimates of the dollar value for 1965 vary between about $250 million and $500 million. The wide range is a result of differences of opinion as to unit price reductions resulting from standardization of types and increased mechanization of production. At the present time rapid obsolescense of transistor types and production processes means delay in mechanization and has resulted in high prices. Average unit price in 1958 was about $2.30, with expectations for a gradual reduction in prices to about $1 as standardization and mechanization take place. Some types expected to run as low as 50 cents.

At the present time only about 20 per cent of electronic equipment is transistorized. Estimates on the potential range between 70 and 90 per cent.

b. Diodes and rectifiers. A semiconductor diode is another device which can perform some of the functions of a tube; it allows a current flow in only one direction but is not capable of any amplification, as is a transistor. It can be used for detection or rectification.

A rectifier is a device for changing alternating current to direct current.

Sales of these items, semiconductor diodes and rectifiers, for 1957 were approximately 71 million units with a value of $103 million. Comparable figures for 1956 were 42 million units with a value of $40 million.

Consumer Products

The most widely used consumer electronic products are television and radio sets. Their value ranks second in the industry behind military electronics, with increasing sales of phonographs, high fidelity equipment, and tape recorders. Lesser markets include hearing aids and home intercom systems. Still largely in the experimental stage, but having enormous potential for future markets, are such items as electronic ranges, refrigerators, air conditioners, and lighting.

RCA now has under development an all-electronic noiseless refrigerator, having no moving parts, and an all-electronic air conditioner. Raytheon has developed a "radarange" which cooks by microwaves and is able to turn out a complete dinner in a matter of minutes. There are several models on the market, but they have not met with wide consumer acceptance, largely because of high price.

These products are primarily nationally distributed brand name products. Competition is intense, and in the past seven or eight years more than 50 firms have dropped out of the television business. At the present time probably 80 per cent or more of television production is accounted for by 10 companies, and the same portion of the radio market is held by perhaps 20 firms. Successful entrance into this portion of the electronics field is highly unlikely.

At the end of 1957 there were almost 4,000 radio broadcasting stations, both AM and FM, and over 500 television stations in the U. S. Broadcasting revenue as well as installation and maintenance of home radio and television sets amounts to several billion dollars per year, but this aspect of the industry will not be discussed in this report.

Radio. For many years radio receivers and broadcasting equipment constituted almost the entire electronics industry. From the early '20's sales of radios grew steadily until, pushed by pent up demand after World War II, they reached a peak in 1947--the year television was introduced. About 97 per cent of all homes have at least one radio; many have more than one. In addition there are over 35 million radios in cars. Production of auto radios now exceeds home production, so changes in demand for cars are an important factor in radio set production.

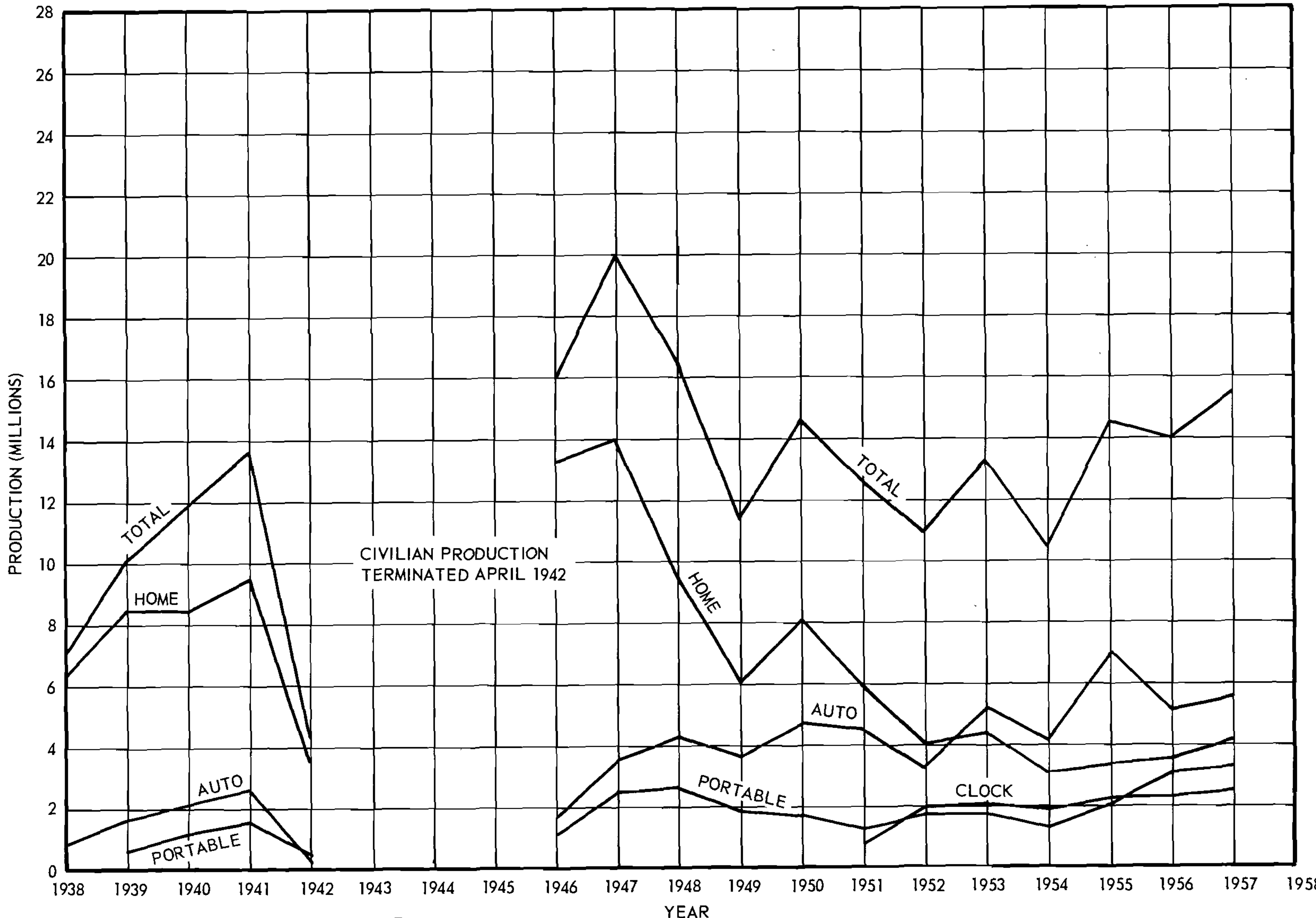
Television. Television is by far the major segment of the electronics consumer market. The television era in electronics began in 1946, although there was very little production that year. By the end of 1957 over 59 million sets had been produced. Today over 86 per cent of the nation's homes have one or more sets. The market has now changed from a predominantly first set market to a replacement market with replacement sales increasing from 36 per cent of total television sales in 1952 to 60 per cent in 1957.

The introduction of portable sets in 1955 by General Electric gave impetus to the second set market, and by the beginning of 1958 between eight and nine per cent of total homes with television had two or more sets. The second set market is not expected to have a significant effect on production, however.

Color television is an important factor in weighing the future market, but its impact is not expected to approach that of black and white. For one thing, the initial cost is greater, and at the present time, installation and service are heavy charges. Though technological changes will bring price

Chart 1

Radio Production



SOURCE: *Electronics Industry Factbook, 1958,* Electronic Industries Association, p. 9.

reduction, it is expected that color will always cost substantially more than black and white. Indications are that many people will not be willing to pay the differential to gain color. However, price reductions and increased color programming will gradually bring about a shift from black and white to color sets.

The period of rapid growth of the television market is past, but moderate growth can be expected. Increasing population, with increased family formations, the influence of color, and an increasing number of second set homes will all be contributing factors. Some estimates place the 1965 market as high as 10 million sets.

Phonographs. Under the influence of the current high fidelity boom, phonograph sales in 1957 reached an all time high of approximately five million sets. Between 1956 and 1957 sales of hi-fi phonographs increased almost 400 per cent to a retail value of over $300 million. Estimates are that the high fidelity market alone will increase to almost a billion dollars by 1963.

Intercoms. At the present time very few homes have intercom systems, and these are primarily in the more expensive houses. About three per cent of the houses built in 1956--approximately 36,000--had intercoms. Their total value was $3 to $4 million, and the expected market penetration for 1957 was estimated at 10 per cent of home construction. This electronics market holds promise for the future, especially in terms of a combination intercom/radio unit and fire and burglar alarms.

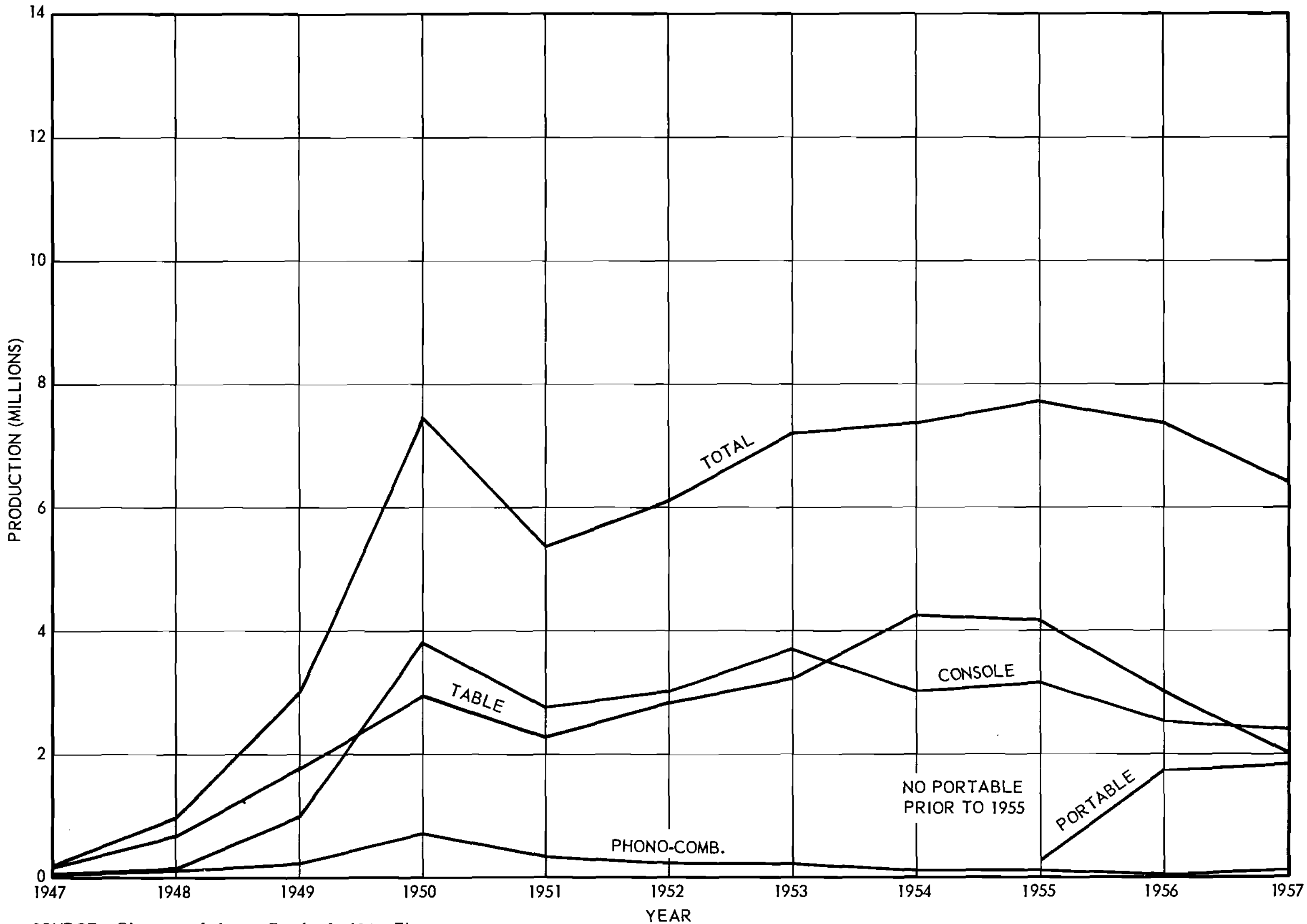
Entrance into this portion of the electronics consumer market by a new firm may be possible. The influence of brand names would not be as great and competition would be less. Through a tie-in with contractors, an assured market might be found, and the systems could be tailored to the particular home. Components could be purchased individually and a limited amount of capital would be required.

Industrial and Commercial Products

The use of electronics for industrial and commercial applications holds the greatest promise for the future of any of the major segments of the electronics industry. This portion of the electronics market is tied in with increasing capital expenditures by industry to meet the immediate problem of rising costs of production and with the long range need to produce more goods with fewer workers, since the percentage of non-workers is increasing at a

Chart 2

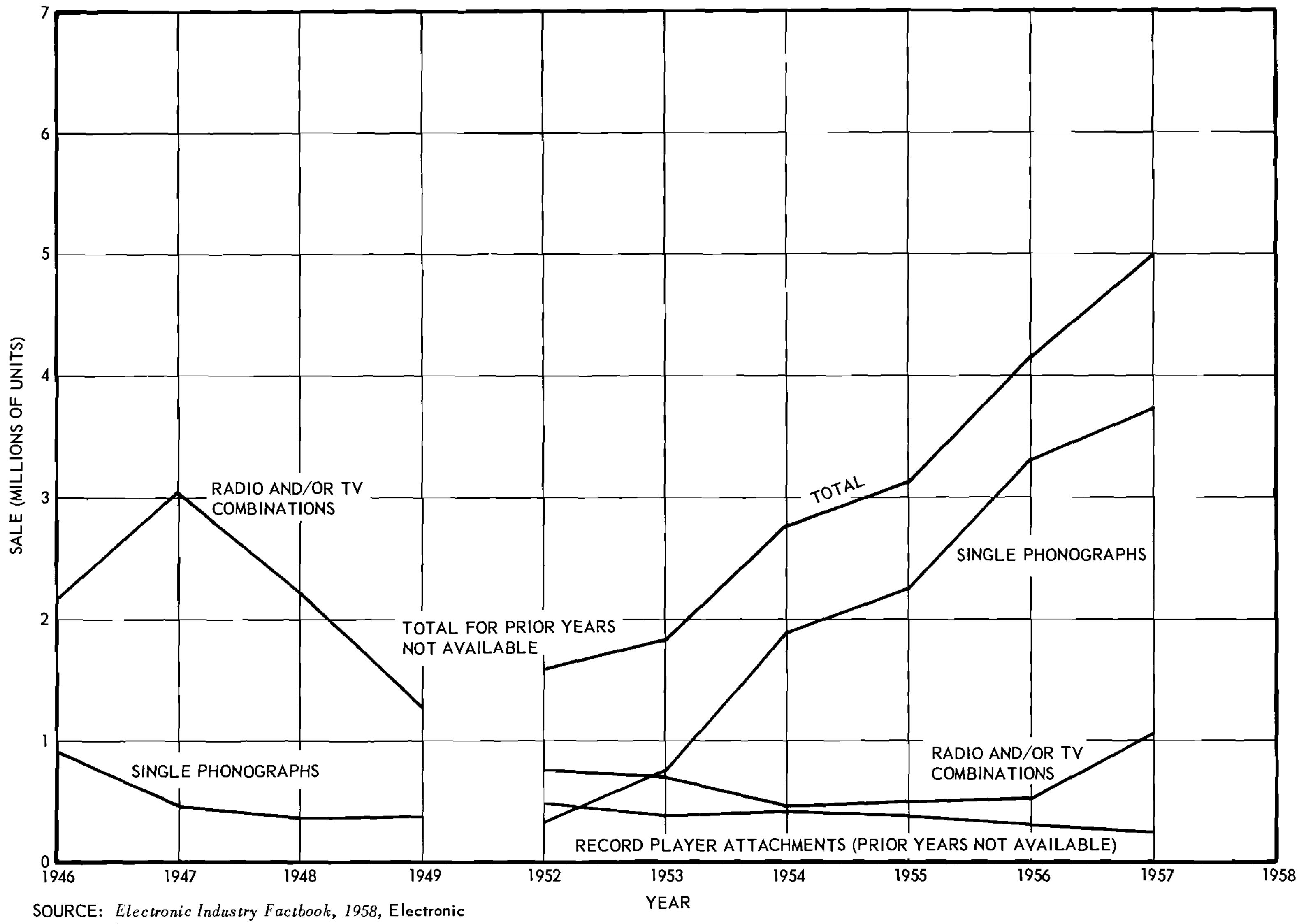
Television Set Production



SOURCE: *Electronic Industry Factbook, 1958*, Electronic Industries Association, pp. 4–5.

Chart 3

Phonograph Sales



SOURCE: *Electronic Industry Factbook, 1958*, Electronic Industries Association, pp. 12–13.

faster rate than the percentage of workers. Because electronic devices can perform with greater exactitude and speed than any purely mechanical device or human operator, and because by automatic or semiautomatic operation one worker can often operate more than one machine, we can expect an increasing use of electronic products to meet these two needs. It is expected that the rate of growth in industrial and commercial electronics in the next decade will exceed that of consumer products in the last 10 years. Sales in 1955, for example, were about $700 million and by 1957 had risen to $1.3 billion.

This portion of the industry covers a wide range of products and applications, some of which, like computers, may grow to such stature as to become classified as a separate portion of the industry. It touches virtually every phase of our economy; production, distribution, transportation, communications, banking, and medicine, for example. The field is open here for new ideas, new products, and new applications on an ever widening base. Companies in this field vary from small companies making a single specialized product to large integrated firms making large scale computers and automated assembly lines. Where products tend to be standardized, major companies predominate.

Computers. Perhaps no other phase of the electronics industry has captured the fancy of the public as has the introduction of electronic computers, the so called "giant brains" or "thinking machines." No machine, mechanical or electronic, has yet been devised which can think. No computer can solve a problem which has not been thought out by a human mind, and a computer can only carry out those instructions which its human operators have given it. Nevertheless, because of the amazing speed with which it can carry out these instructions, we are able to achieve quickly the solutions to problems which would normally be prohibitive in time and effort. It is thereby possible to attain savings and greater control for industry through the rapid solution of a wide variety of business and scientific problems.

Computers are of two different types, analog and digital. The analog computer is primarily concerned with the solution of differential equations through a system of electrical analogs. The digital computer is primarily a counting device which stores vast amounts of facts and figures and acts on them according to some prearranged program. It can perform additions, subtractions, multiplications and divisions at an incredible speed. As a result it has found particular favor in the handling of inventories, payrolls, accounting problems, statistical analyses, and the like.

Cost savings through the use of a computer are sometime questioned because of the high cost of purchase or rental and the high salaries of the men who program and operate them. Even if no savings accrue, however, the rapidity and accuracy with which they operate insure that data needed for executive decisions will be available much sooner than would ordinarily be the case--or made available when it otherwise would not exist. The computer's role as an aid to management decision making is still in its infancy.

The computer market, especially for general purpose computers, is dominated by a few giants--International Business Machines and Remington Rand in the digital field, and Electronic Associates in the analog field. Several large, well establsihed firms have withdrawn from the computer field entirely in the face of increasing competition, or have transferred their efforts to special purpose computers.

The computer market has opened up largely since 1950, and it wasn't until January 1954 that the first large-scale computer to process business-office data was delivered. This was the Univac I of Remington Rand. By 1957, sales of data processing equipment totaled about $300 million. Estimates for 1960 are $1 billion and for 1965 run as high as $2 billion, although more conservative sources place the 1965 market at between $1 and $1.5 billion.

Lack of a sufficient pool of adequately trained personnel could be a limiting factor in the computer field. Effective utilization of the equipment to insure maximum benefits is dependent on personnel who can translate the needs of the businessman into the language of the computer. Especially in the early stages, some firms found that after they had invested sizable sums in data processing equipment they didn't know what to do with it. As a result, equipment stood idle much of the time. Education of company personnel in the use of computers has now become an integral part of the sales program of the larger computer manufacturers, particularly IBM and Remington Rand.

Communications and Navigation. Communications is the second largest segment of the industrial and commercial electronics market, after computers, and covers a wide variety of products and methods of communication. In 1947 total sales were $52 million, and by 1957 sales had grown to over $250 million, divided unequally between totally different products such as two-way radio, microwave relay systems, closed-circuit television, commerical aviation and marine products. This sales figure does not include expenditures by the

American Telephone and Telegraph system which in 1956 spent a fourth of its capital budget--about $500 million--for electronic facilities.

While the total communications and navigation market is large, the markets for individual items are much smaller, due to the wide variety of products, and are adequately served. Competition in some areas is intense and dominated by large established companies. Most producers in this field also supply similar products to the military.

a. Radio. The best known portion of communications is in radio, which is used very extensively in police cars, taxicabs, some truck fleets, and trouble shooting cars for utilities such as light, gas, telephone and pipeline companies. In addition, two-way radios are finding increasing use on large construction jobs and in big warehouse systems. The total number of federally licensed transmitters is close to a million. Sales for 1957 totaled $55 million. This figure does not include radio equipment installed in civilian aircraft and ships which, along with radar and navigational aids, had sales in 1957 in excess of $80 million. Cost of outfitting the average ocean going vessel with radio, radar, navigational gear, etc. is between $60,000-$70,000.

An increasing number of pleasure craft of moderate size now have two-way radios. It might be possible for a Georgia manufacturer to tie in with a boat builder to supply two-way radios for this use.

In the year ending 30 June 1958, the Civil Aeronautics Authority spent over $100 million on improvement of air traffic facilities, including radio, radar and navigation aids, of which about three-fourths was for electronic products.

b. Closed-circuit television. This market is expanding rapidly but is still relatively small. Sales in 1957 were about $6 million and accounted for less than one-half of one per cent of total industrial and commercial sales. Estimates for 1958 are for an increase of about one-third, and predictions for 1963 run as high as $18 million.

This application finds a number of uses including educational television for use by schools. This has been proposed as a partial solution to the teacher shortage. By use of a closed-circuit system, one teacher can handle a much larger number of students.

In medicine television is becoming a vital tool of instruction. It enables medical students, researchers, technicians, and doctors to study operations while actually in progress. This method is much better than observation in an amphitheater, since a magnified view of the operational area can be given and techniques can be demonstrated better.

In industry television can be used to watch production processes which are too dangerous to be observed first hand or are too inaccessible for efficient supervision or control.

In banking television makes possible verification of signatures and other essential data, such as account balances, from widely separated locations.

c. Microwave relays. Microwave relay systems utilize short waves at very high frequencies for such purposes as telephone, television, and teletype transmission. Advantages are the elimination of wires and poles through the use of relay towers spaced 10 to 50 miles apart and the fact that multiple-channel operation can be used for a wide variety of signals. The American Telephone and Telegraph Company has the widest network of microwave relay stations for its long distance system, and Western Union also has a very large network. In addition, numerous pipelines, utilities and railroads are adding microwave systems. Sales in 1957 were $18 million.

Whole systems involving large amounts of engineering are required, so competition is possible only for fairly large companies such as General Electric, Raytheon, and RCA.

d. Facsimile. Facsimile transmission is simply a radio-transmission system for reproduction of almost any type of printed matter at a remote distance. The most common example is in the photographs appearing daily in our newspapers, but the system can also be utilized for sending reproductions of maps, charts, and similar materials. The principle manufacturer of this type of equipment is the Times Facsimile Corporation, a subsidiary of the New York Times. Current markets are $3 to $5 million, and estimates vary from $25 to $50 million in the next five years.

Controls. The automatic assembly line has long been a dream of production men, and electronics seems to be the road to fulfillment of this dream.

Electric controls offer these distinct advantages:

(1) Closer tolerances and closer control of properties than can be obtained with human operators or purely mechanical controls.

(2) Cost cutting through more automatic operation. (Competitive pressure and rising labor costs have increased interest in this field.)

(3) Significant time saving as a result of reduced set up time and faster operation.

(4) Increased flexibility from the ease with which instructions can be changed to facilitate shifting from one size or design to another. Additional savings result from the elimination of expensive templates and precision cams. The flexibility of electronic control allows its effective use on even short production runs.

The use of electronic controls has already made rapid strides in those manufacturing operations involving continuous regulation of such factors as temperature, humidity, liquid level, and mixture. Continuous-flow process industries such as chemicals and petroleum refining have been the largest users of this type of equipment to date.

The use of electronic controls for machining operations is growing rapidly. Through the use of coded instructions on punched cards and punched or magnetic tape, such operations as drilling, milling, and cutting can be done automatically, eliminating constant supervision by highly paid skilled machinists and allowing one man to operate several machines.[1/]

Through the use of computers and servomechanisms, machines can be made self correcting by employing "feedback" which involves a comparison of the performance of the machine with specified instructions and correction of errors.

The step up from control of single machines or single production processes to completely automatic production or assembly lines is inevitable and has already begun in some areas of production. The combination of electronic controls with electronic measuring and testing equipment, discussed below under instruments, is required. The development of such systems will require a tremendous application of electronic know-how, coupled with advances in materials handling and production techniques. Increased reliability and reduction of complexity in electronic controls and instrumentation will be an important factor contributing to their increased use. Knowledge and techniques developed in the field of military electronics, with its great emphasis on reliability, have already begun to pay dividends in commercial

1/ There has been much written on the impact of automation on labor and resistance to automation by labor groups. This subject will not be covered here although it is evident that the increased use of automatic controls will involve close cooperation and understanding between labor and management.

applications. Miniaturization and ruggedization, through the use of semiconductors, have played an important part.

Total sales for 1957 were $170 million with estimates for 1958 of $195 million, despite a sharp over-all reduction in capital expenditures. Minneapolis-Honeywell is the big producer in this field, particularly for electromechanical devices. But there seems to be ample room for small producers, especially for production in specialized areas and for specific industries. In this field, as in other electronic fields, a competent staff of application and product development engineers is essential. An opportunity might exist here for diversification through the combination of a firm's specific industry know-how with electronic applications know-how. For example, a textile firm might find it profitable to add an electronics division for the production of controls for the textile industry.

Instruments. Closely related to the area of controls is the use of electronic instruments which measure the various factors to be controlled: humidity, temperature, viscosity, speed, voltage, and the myriad other items which must be regulated in production processes. In addition, the use of electronic testing and inspection instruments for quality control has become widespread in industry. They are also used by virtually every industrial and scientific laboratory. For example, a device has been developed, the spectrophotometer, which can detect minute variations in color for use by comestic, chemical, textile, paper or paint manufacturers. This apparatus can distinguish more than a million color variations. A machine for electronically inspecting fabric for flaws is used by the textile industry. Test equipment which will detect imperfections in steel bars, tubing, castings, etc. has become almost standard in metal products manufacture. Electron microscopes, mass spectrometers, oscilloscopes and other test equipment have become indispensable for laboratory work.

These are but a few examples of the many applications of electronic equipment for testing purposes. Sales of industrial test instruments in 1957 were $195 million, with an expected market in 1958 of $220 million. These figures include test instruments for research activities but do not include X-ray equipment, part of which is used for medical purposes and part for industrial testing. Sales of X-ray equipment for 1957 were $111 million.

Many small, closely held companies compete in this field, with Hewlett-Packard probably the leader. Opportunities for small businesses exist in the instrument field through new product development.

Atomic Energy Instrumentation. Sales in 1958 of instruments made especially for atomic purposes will be approximately $40 million, with another $8 million of conventional instruments used in the atomic energy program.

Instrumentation of nuclear power plants requires two and a half to three per cent of total capital costs; conventional power plants require only about one per cent. For research and test reactors, instrumentation may run 10 per cent or more. For 1958 reactor instrumentation sales will be approximately $15 million. Sales should increase rapidly over the next few years and will then either level off in the mid-60's or zoom up, depending on the ability of the nuclear engineers to make this source of power competitive with present methods.

Nuclear power plants for aircraft, missiles, and space ships are still in the research and development stage, but these will require many new types of radiation-tolerant instruments and automatic controls in the future when they come into general use.

Another large potential market is in the use of reactors to furnish heat and steam for industrial firms. Estimates on the cost of such reactors is about $2 million, with instrumentation costs of six or seven per cent. This price would make them competitive with large boilers.

The use of radioactive isotopes for use by industry, medicine and research groups is one of the major factors generating sales for radiation instruments. There are almost 4,000 licensed isotope users today, with many others using isotopes under general licensing. About 100 firms process and distribute isotopes for these users. Virtually all of these users need electronic instruments, if nothing more than a simple radiation counter.

Over half of nuclear sales are made to government agencies, chiefly the Atomic Energy Commission, but industry sales are rising. Free use of AEC patents has allowed a large number of companies to enter the market with limited capital, with the result that there are many firms competing for a limited, though growing market. Profits are still small (about two per cent in the past), and many firms are taking a loss on their nuclear instruments, subsidizing these lines with other more profitable ones.

Electronic Heating Equipment. The use of electronic equipment for dielectric and induction heating is widespread in industry. Sales for 1957 were $34 million, but possibilities for entrance into this field are limited since it is adequately served at present. Applications engineering plays an important part in this field.

Induction heating has been used for many years in the heat treating of metals and for welding and soldering operations. This method is much faster and can be localized much better than other methods of heating.

Dielectric equipment is particularly useful in the heating of nonconductive materials such as rubber, wood, and plastic products. One of the growing applications of dielectric heating is in the joining and sealing of plastic products. It has also found increasing application in medical therapy.

Military Products

As stated earlier, one of the two important factors affecting the contined rapid growth of the electronics industry has been the increasing use of electronic equipment by military agencies, especially in guided missiles.

The growth of electronics can be roughly divided into four eras: the radio era, the radar era, the television era, and now the missile era. The next era is expected to be rooted in the increasing use of electronics for industrial and commercial purposes, as discussed in the previous section. Of the four major periods of growth in the electronics industry, two can be attributed to military activity. The radar era began with World War II and lasted through the war. The missile era, although it began in the early '50's, did not begin to show its full force until about 1955, and the end is not yet in sight.

In 1958 electronic sales to military customers are expected to be approximately 55 per cent of total electronic sales. The relative amount of the total defense budget expended for electronics is expected to increase due to the added emphasis on missiles, not only because of their use as offensive weapons but also because of the necessity for detection of and defense against enemy missiles.

The increasing speed and complexity of modern weapons has forced us into the use of electronic equipment for defense and counterattack. This increased speed and complexity of modern weapons is itself based on the use of electronics, the result being a more or less "closed loop" which generates increased electronic expenditures. (See Table 17.)

Faced with the threat of Communism, we can expect our defense budget to remain at a high level, if not increase, for a long period of time. Consequently, this portion of the electronics market can be expected to continue as a very important portion of the industry.

Table 17

Military Electronics Expenditures,
Fiscal Years 1951 - 1957[1]
(millions of dollars)

Budget Category	FY 1951	FY 1952	FY 1953	FY 1954	FY 1955	FY 1956	FY 1957
Aircraft	$314	$ 632	$ 968	$1,085	$1,046	$ 999	$1,083
Ships & Harbor Craft	34	56	106	97	90	79	81
Combat Vehicles	39	210	396	141	52	4	7
Support Vehicles	2	28	13	9	16	6	3
Missiles	11	91	159	159	306	628	1,108
Electronics & Communications	193	597	1,001	827	636	771	880
Research & Development	136	209	253	248	244	267	303
Miscellaneous	18	106	146	100	64	48	41
Total	$747	$1,929	$3,042	$2,666	$2,454	$2,802	$3,506

For calendar year 1958, military electronics sales are expected to total $4.6 billion. Of this amount, aircraft electronics will make up about 44 per cent, about 24 per cent of total industry sales, for a total of over $2 billion. Despite the increasing emphasis on missiles, aircraft electronics still takes the largest share of our electronics defense dollar. Missiles are the fastest growing segment, however. In 1958 missiles will take about 24 per cent of military electronic spending.[2]

The complexity of military electronic systems has emphasized the need for greater component reliability. With the addition of more and more components

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1/ Electronics Industry Fact Book, 1958, Electronic Industries Association, pp. 14-15.

Note: Federal government fiscal year begins 1 July and runs through 30 June; for example, fiscal year 1957 begins 1 July 1956 and runs through 30 June 1957.

2/ These percentages differ somewhat from those figures presented in Table 17 due to a difference in the method of estimating. These percentages are from Electronics, business edition, August 22, 1958, p. 14. This source feels that previous estimates for aircraft had been understated and those for missiles overstated. These figures reflect the electronics cost of missiles as 35 per cent of the total; other estimates run as high as 50 per cent.

in a complex system, reliability has gone down. In tactical situations where system failure can result in mission abortion, with loss of expensive equipment at best and at worst, loss of many lives, failure cannot be tolerated. As a result, part of the military research and development program, as well as that of industry, has been directed toward the development of components with longer life, greater resistance to shock, vibration, heat or radiation. In addition, for many military requirements, savings in space and weight are important. For a given aircraft, any addition of weight means a reduction in range, and for guided missiles additional weight increases the amount of thrust required, with the resulting need for larger engines and increased fuel requirements. The use of semiconductors, such as transistors, has been a partial solution because of their longer life and their small size and weight.

Because of the stringent requirements for system reliability, contracts for the production of military equipment are let on the basis of the ability of the contractor to perform, based on past reputation, as well as from a cost standpoint. In this respect direct entrance into this field would be impossible. In addition, the scope and complexity of many systems require considerable investments in research and development facilities, requiring a staff of competent engineers and scientists and large amounts of working capital. Many contracts require that the contractor have the ability and facilities to complete the entire contract, even though subcontracts may subsequently be let.

In summary, it may be said that the best possibility for entrance into the field of military electronics lies in establishing a reputation for reliability and trying to secure subcontracts for some portion of a larger contract, perhaps for individual components or subassemblies.

Communications. Two-way communication is a vital part of modern warfare. The ability of a commander to receive reports from his tactical units, to appraise the situation, and relay commands back to all echelons can be the difference between victory and defeat.

Military communications makes use of all the types of equipment discussed previously under "Communications and Navigation." From the "walkie-talkie" in the hands of infantry squads to the complex communications center directing air defense, radio, telephone, and teletype all find a place in the network. Virtually all planes and ships, and many vehicles, have two-way radios. Closed-circuit television has been used to observe river crossings and beach landings by assault troops.

Detection, Fire, and Bombing Control. The speed and complexity of modern weapons is such that the ability of their human operators, perception and reaction time, for example, is insufficient for effective control. The use of electronic equipment has enabled us to utilize these weapons by making many aspects of detection, fire, and bombing control more or less automatic and relieving the operator of many of the functions which he can no longer perform satisfactorily.

a. Computers. Military uses for computers are even more varied than for industry. Not only are they used for such purposes as inventory control, payroll preparation, and such other standard business adaptations, but they are also used extensively in studying problems in logistics, forces allocation, and planning of battle strategy.

Computers are an integral part of virtually every fire control and bombing system for warships, planes, and antiaircraft batteries. For these uses the computer is often part of a system involving radar as well. Because of the speed of aircraft and missiles and the many parameters which must be evaluated such as speed, direction, and wind velocity, a fair degree of accuracy can be obtained only through the utilization of computers. The "SAGE" ("Semi-Automatic Ground Environment") system for control of interceptors and antiaircraft missile batteries in the event of enemy attack combines radar (for detection), with computers (for storage and evaluation of data on the number of aircraft, height, speed, direction, etc.), for the most effective allocation of available defense measures and control to the point of interception.

b. Radar. Radar had its inception during World War II and provided the impetus for the second great period of growth of the electronics industry. Basically radar is a device for transmitting and receiving electromagnetic radiation and uses what is essentially an echo effect for detecting aircraft, missiles, ships, and other objects.

Vast expenditures have been made for building radar networks for the detection of attacking enemy bombers. The "Pinetree and Dew Lines" across Canada are examples of these networks. In addition to these lines, radar picket ships, Texas towers, and aircraft are used to supplement coverage. Radar is used for control of interceptors and antiaircraft fire. For example, each Nike battery must have at least two radars, one for tracking the attacker and the other for tracking the countering missile. In addition to the immense initial expenditures involved in these systems, continued maintenance and modification require additional capital outlay of sizable proportions.

Missile Guidance. Because missile electronics is the fastest growing portion of the military electronics market, this application is discussed separately.

There are almost as many guidance systems as there are missiles, but for the most part they are one of the following types or some combination of these:

Active - An active system is one in which the illuminator (radiation source) as well as the receiver is carried by the missile.

Passive - A passive system is one in which only a receiver is carried by the missile with the target furnishing the source of radiation, electromagnetic, infrared, or acoustic.

Semiactive - In this system the radiation source is usually a radar on the ground illumating the target with the missile carrying a receiver for homing.

Beam Rider - This system involves the use of two radars, one which tracks the target and one which supplies a narrow beam up which the missile rides. When the missile starts to stray from the beam an error signal activates the missile control surfaces for realignment.

Command Guidance - This system also involves the use of two radars, one for tracking the target and one for tracking the missile, but signals for changes in course are radioed to the missile.

Inertial - Inertial guidance systems are used primarily for long-range missiles. This system is completely self-contained and requires no outside information. It utilizes accelerometers and a gyro-stabilized platform to determine the speed and direction of the missile at any instant from which its location can be determined and compared with a programmed flight path stored in a computer and corrections made. Most of the ballistic missiles use inertial guidance during the initial phase of their flight.

The electronics part of missile cost varies with the type of missile. For ballistic missiles the figure is 25 per cent, for long-range, nonballistic missiles it is 35 per cent, and for other types 50 per cent.

Situated in the center of a rapidly expanding missile industry (see Map 4) Georgia is favorably located for the production of complete missile systems or component parts. In addition, research and development work in the missile field would find Georgia a favorable location not only because of the proximity of the Army Ballistic Missile Center at Huntsville, Alabama, and the Air Force Missile Test Center at Cape Canaveral, Florida, but also because the transportation network centered on Atlanta would give easy access to home offices, production facilities, and government agencies.

Map 4

Aircraft and Missile Production, Modification, Development, or Test Centers