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TECHNICAL MANPOWER IN NEW YORK STATE. VOLUME II.
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THE JOB CONTENT OF THE TECHNICAL OCCUPATIONS AND THE TECHNICAL SKILLS AND SUBJECT MATTER KNOWLEDGES REQUIRED ARE BASED PRIMARILY ON INFORMATION SUPPLIED BY EMPLOYERS FROM 17,414 ESTABLISHMENTS IN NEW YORK STATE. DATA ARE ALSO GIVEN ON GRADE STRUCTURE, EDUCATION AND EXPERIENCE REQUIREMENTS, TESTS AND LICENSES REQUIRED FOR THE JOB, SOURCES OF QUALIFIED WORKERS, AND PROMOTIONAL LINES. THE OCCUPATIONS ARE -- (1) DRAFTSMEN, (2) STRUCTURAL DESIGN TECHNICIANS, (3) ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS, (4) MATHEMATICS TECHNICIANS, (5) PHYSICAL SCIENCE TECHNICIANS, (6) BIOLOGICAL, MEDICAL, AND DENTAL TECHNICIANS, (7) INDUSTRIAL ENGINEERING TECHNICIANS, (8) CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS, (9) SALES AND SERVICE TECHNICIANS, (10) TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS, (11) SAFETY AND SANITATION INSPECTORS, (12) PRODUCT TESTING AND INSPECTION SPECIALISTS, (13) DATA PROCESSING SYSTEMS ANALYSIS AND PROGRAMING SPECIALISTS, (14) AIRWAY TOWER SPECIALISTS AND FLIGHT DISPATCHERS, AND (15) BROADCASTING, MOTION PICTURE, AND RECORDING STUDIO SPECIALISTS. "TECHNICAL MANPOWER IN NEW YORK STATE," VOLUME I, SUPPLEMENT A AND B (VT 000 576 - 000 578) ARE RELATED DOCUMENTS. (PS)

VOLUME II

TECHNICAL MANPOWER IN NEW YORK STATE

VOLUME II

STATE OF NEW YORK
NELSON A. ROCKEFELLER, *Governor*

DEPARTMENT OF LABOR
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In cooperation
with

THE STATE EDUCATION DEPARTMENT
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NEW YORK STATE DEPARTMENT OF LABOR

DIVISION OF RESEARCH AND STATISTICS

C. A. PEARCE, *Director*

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VOLUME 2

DECEMBER 1964

PREFACE

Volume 2 of the report contains a chapter on each of the main groupings of technical occupations, in which the content and requirements of the individual occupations included in the group are taken up. For example, chapter I, on draftsmen, presents data on the job functions, technical skills and subject matter knowledge needed on the job, grade structure, employers' education and experience requirements, tests and licenses required for the job, sources of qualified workers, and promotional lines. Much of the same information is given for each of the following types of draftsman: architectural; structural; electrical; mechanical; highway and street; map, topographical, and geological; and plant layout.

A substantial portion of volume 2 is taken up in describing the job content of the technical occupations and in setting forth the technical skill and subject matter knowledge needs of the jobs.

The descriptions of job content are based primarily on the job descriptions supplied by employers. They attempt to reflect all the significant responsibilities and functions performed in jobs classified under the title. Because they are a composite, the job responsibilities and functions set forth may well go beyond the content of a particular job as it exists in a particular establishment. Where possible, the responsibilities and functions common to all or the majority of establishments were distinguished from those encountered in a smaller proportion of cases.

The delineation of technical skills required to perform the jobs similarly is based on information supplied by employers, plus common knowledge concerning the kinds of skill that are needed to perform specific functions.

Most of the classifications and measurements found in volume 2 were introduced and explained in volume 1 in connection with the broad group comparisons and analyses set forth there. For an explanation of these classifications and measurements, the reader should refer to the chapters in volume 1 indicated below:

<u>Subject matter knowledge</u>: chapter V, pages 52-53.

<u>Grade-level classifications</u>: chapter II, page 24. (In volume 2, except for table III-6, workers in establishments that did not report a grading system were included in the "single grade only" category rather than shown separately.)

<u>Education and experience requirements</u>: chapter V, pages 44-45. (All the figures in volume 2 on median years of experience required by employers as a condition of hiring are based on job counts rather than worker counts. For this purpose, each grade within each technical occupation in an establishment was counted as a separate job. However, percentage distributions of years of experience were computed from worker counts, not job counts.)

<u>Tests and licenses</u>: chapter V, pages 51-52.

<u>Sources of qualified workers</u>: chapter IV, page 40.

Attention is called to the Preface of volume 1, which acknowledges the important contributions of the following consultants in preparing the contents of the present volume: Angelo Amatulli, Sidney Avner, Stanley M. Brodsky, Robin Spock, and Frank Stewart.

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Chapter I

DRAFTSMEN

Draftsmen formed the third largest group of technical occupations in New York State in 1962. The group (20,972 workers, who are 14 percent of all persons in technical occupations) ranks, in size, behind only the electro and mechanical engineering technician group (42,031) and the biological, medical, and related science technician group (25,445).

Draftsmen are in a sense the link between the engineer, architect, or designer, and the production or construction technician or craftsman. They take ideas, rough sketches, notes, and specifications and make detailed sketches, drawings, and working plans, which are then translated into actual products, machines, and structures.

As defined for the purpose of this survey, draftsmen include checkers but exclude jobs involving inking and tracing only. They also exclude jobs involving a substantial amount of design work in addition to drafting; these are classified in the design technician groups (see chapters II and III).

The survey distinguishes a number of different kinds of draftsmen, listed in table I-A. The electro, mechanical, and electro-mechanical groups together constitute 60 percent of the total number of jobs, the architectural and structural groups 30 percent, and the highway, map, plant-layout, and general draftsmen 10 percent.

The largest concentration of draftsmen is found in engineering and architectural service firms. Other concentrations are in the manufacture of electrical and nonelectrical machinery and equipment, in the manufacture of fabricated metal products, in transportation, communication, and public utilities, in

Table I-A. NUMBER AND PERCENT DISTRIBUTION OF DRAFTSMEN BY OCCUPATION

Occupation	Number	Percent
All occupations	20,972	100.0
Architectural and structural	6,294	29.9
Construction	5,973	28.4
Architectural	3,508	16.7
Structural	1,955	9.3
Combination: architectural and structural	510	2.4
Aircraft structures	105	0.5
Ship structures	216	1.0
Electrical-electronic	2,301	11.0
Construction	684	3.3
Other	1,617	7.7
Mechanical	6,526	31.1
Construction	1,020	4.9
Other	5,506	26.2
Electro-mechanical	3,767	18.0
Construction	211	1.0
Other	3,556	17.0
Highway, street, and related construction	270	1.3
Map, topographical, and geological	592	2.8
Plant layout	422	2.0
General draftsmen	661	3.2
Draftsmen n.e.c.	139	0.7

business and management consulting services and other miscellaneous business services, and in government. (See table I-B, taken from table I-1, at the end of the chapter.)

The majority of draftsmen (61 percent) are supervised by engineers or architects. About 29 percent are supervised by draftsmen or design technicians or engineering technicians of higher grade, while the remaining 10 percent work under persons who are in other occupations.

These proportions vary somewhat among the various types of draftsman occupation. For example, about 90 percent of ship structure draftsmen work under engineers or architects, while in the case of map draftsmen only 39 percent do so. (Table I-2, at the end of the chapter, gives detail on this point.)

Table I-B. NUMBER AND PERCENT DISTRIBUTION OF DRAFTSMEN BY INDUSTRY GROUP

Industry group	Number	Percent
All industries	20,972	100.0
Manufacturing	9,357	44.7
Machinery, except electrical	2,346	11.2
Electrical machinery and equipment	2,230	10.6
Fabricated metal products	1,159	5.5
All other manufacturing	3,622	17.4
Contract construction	1,163	5.5
Transportation, communication, and public utilities	1,055	5.0
Engineering and architectural services	5,863	28.0
Business services n.e.c.	1,618	7.7
Government	1,072	5.1
All other	844	4.0

FUNCTIONS

This section describes in detail the functions of the different types of draftsmen, the products of their work, and the technical skills they need, while the next section takes up subject-matter knowledge requirements.

Not all the functions listed below are performed by every draftsman, and not all draftsmen in practice need all the technical skills listed.

General Draftsmen

Products of work

Drawings, scaled or full size, for all types of -

Manufactured products such as machines and machine parts, tools, furniture, appliances, structural elements, etc.

Maps, charts, graphs, nomographs, etc.

Specialized applications such as patentable devices for inventors, pictorials and diagrams for instruction manuals, line diagrams for technical catalogs, etc.

Functions performed

Work from sketches, notes, specifications, and instructions prepared by engineers, contractors, inventors, vendors, manufacturers, customers, other draftsmen, designers, as well as from statistical reports, test data, catalogs, textbooks, handbooks, and technical literature.

Make complete or modified drawings or tracings using established drafting standards, such as those of the American Standards Association. Types of drawings include: working, detail, assembly and sub-assembly, plan, layout, chart, graph, block diagram, exploded-view, isometric, perspective, schematic, map, freehand sketch, patent, pattern, intersections, and developments.

Usually include lettered information on drawings, such as general notes regarding tolerances, dimensions, bill of materials (listing part numbers, quantities, nomenclature, materials), finishes, special notes and instructions, assembly sequence, metallurgical specifications, stock sizes, and references to related plans or drawings.

Technical skills

Ability to use drafting instruments: drawing board and drafting table, T-square, drafting machine, parallel straight edge, triangles, protractor, architect and engineer scales, french curves, ducks and splines, compass, bow compass, beam compass, drop compass, divider, proportional divider, standard and semi-automatic pencils, variety of ruling and lettering pens, lettering sets and guides, drafting accessories (tape, erasing shield, lead pointer, sandpaper pad, erasers, drawing ink, cleaning powder, ink cleaning fluid, dusting brush, pen wiper), drafting templates for shapes and standard symbols (ellipses, gear teeth, bolt heads, screw threads, electrical circuit components, plumbing, heating, and ventilating equipment, flow process industries equipment), drawing papers and cloths (pencil and ink tracing paper, buff detail paper, pencil and ink drawing and tracing cloths), sketch pads, printed graph papers (linear, semi-logarithmic, logarithmic, polar, trilinear), slide rule, planimeter.

Ability to produce a variety of high quality, neat and accurate drawings with reasonable speed in accordance with standard drafting practice.

General aptitudes and abilities such as visualization of spatial relationships, manual and finger dexterity, attention to details.

Specific skills such as lettering, freehand sketching, chart drawing, plotting graphs, producing uniformity of linework of various weights, utilizing geometric constructions for special shapes and curves.

Understanding and use of dimensioning practice and standards.

Reading and interpreting sketches, office and field notes, specifications, catalogs, handbooks, textbooks, manuals, statistical data, schematics, orthographic projection multiview drawings, pictorials, sections and drafting conventions, standard symbols, engineering terminology and nomenclature, shop terms and processes.

Architectural Draftsmen

Products of work

Architectural drawings of wide variety of structures, integrating many areas of engineering such as mechanical (plumbing, heating, ventilating, machinery, vertical or horizontal transportation, etc.), electrical (power, light, communication), and civil (site planning, structural design, services).

Functions performed

Make preliminary plans, sketches, and models of proposed structures and renovations, such as private dwellings, multi-story apartments, office buildings, manufacturing plants, railroad terminals, airport terminal buildings, hotels, motels, recreational facilities (stadiums, marinas, playgrounds, parks, etc.), hospitals, schools, churches, memorials, and many other diversified types initiated by clients. Presentation drawings and renderings in perspective are sometimes included, to provide effective and realistic representation of proposed designs and alterations.

Work from sketches, notes, specifications, and instructions prepared by architects, engineers, contractors, vendors, manufacturers, clients, other draftsmen, designers, as well as from catalogs, textbooks, handbooks, architectural and technical literature.

Make complete or modified drawings and tracings, using established architectural and engineering drafting techniques and standards. Types of drawings include plot plans, basement and foundation plans, floor plans, elevations (full or sectional), details (footing, window, door, entry, stairway, etc.), shop drawings for manufacturers, plans for structural framing of wood, steel or concrete, and separate plans for mechanical and electrical work.

Usually include on drawings, lettered information, such as sizes of doors, windows, beams, girders, columns, lintels, etc.; special notes such as references to details, other drawings, and schedules; and type, use, and placement of materials for roofing, flashing, sills, flooring, ceilings, caulking, etc.

Sometimes estimate quantities of material required for project and compute costs, especially for preliminary proposals.

Help to prepare specifications in conjunction with architects, chief draftsmen, contractors, associated engineers, and clients.

Technical skills

Basically the same as "General Draftsmen." Particularly needed is an understanding of and ability to use architectural and structural dimensioning practice, symbols, standards, and codes (local and national), as set forth by the American Standards Association, American Institute of Steel Construction, American Institute of Architects Files, and Sweet's catalogs.

Structural Draftsmen

Products of work

Structural drawings, to scale or full size, for such structures as buildings, bridges, elevated highways, dams, and tunnels, made of steel, concrete, timber, etc.

Functions performed

Work from general plans, maps, profiles, architectural plans, engineering designs, framing plans, sketches, and specifications, prepared by engineers, surveyors, contractors, customers, public works and other governmental agencies, as well as from statistical information, test data, catalogs, textbocks, handbooks, and technical literature.

Make complete drawings, such as line or framing plan of steel skeletons; shop detail and assembly of structural elements and members, such as beams, spandrels, lintels, purlins, rafters, struts, braces, columns, trusses, girders, etc.; reinforced concrete framing plans, structural elements, and bar steel placement, footings, foundations, and forms; falsework plans and details for construction of structures.

Make stress diagrams and drawings of structures giving main dimensions, loads, stresses developed in the various elements, and all information necessary to detail the various parts and members.

Work usually includes -- depending on type of drawing, bills of materials, type of fasteners (welds, rivets, bolts) -- directional marks to show relative location of elements, shipping and erection marks, weights, sizes, mill lengths of rolled steel sections to be ordered, and general notes to fabricators, erectors, and contractors.

Technical skills - the same as "Architectural Draftsmen."

Map Draftsmen

Products of work

Four types of map, as follows:

Cadastral: Shows political and civil boundaries for purposes of taxation, property transfer, land subdivisions, giving property lines and street or road lines. Includes all types of control maps or plats for cities, towns, villages, etc.

Topographic: Shows natural and man-made features of land areas, such as streams, rivers, lakes, types of vegetation (using symbols), relative elevations of terrain, country roads, highways, tunnels, bridges, aqueducts, reservoirs, houses, city or village streets, etc.

Engineering: Shows reconnaissance surveys, construction projects (highways, traffic exchanges, tunnels, pipe lines, bridges, water supply and sewage systems, underground and aerial electric power distribution, etc.), and maintenance for utilities, giving positions of hydrants, building connections, electric substation and distribution transformers, etc. Includes profile, topographical maps, and plats.

Geographic: Shows comparatively large areas in small scale with symbols, coloring, hatchures or shading, lines, etc., to indicate various locations of natural and man-made features. Examples are maps used for an atlas or geography text, globes, and road guides.

Functions performed

Work from surveying field notes and office computations, field and office sketches, specifications, local municipality land use codes, other maps (photogrammetry, land plats, geological, reconnaissance, topographical, etc.), engineers' and architects' instructions and designs, contractors requests and specifications, etc., as well as textbooks, handbooks, codebooks, and technical literature.

Make complete or modified map drawings and tracings, using special and conventional map symbols to indicate all man-made and natural objects found on land areas. Map drawings would include topographical, highway, and profile; city water supply and distribution; pipe lines (gas, petroleum, chemical); subsoil profiles; coordinate grids; relief of mountains and water features; navigational charts; private property (house lots, farms, subdivisions, etc.).

Maps may also include, depending on the type, civil boundaries, bearings and lengths of lines (plot lines, traverse lines, tangents to curves, etc.), true and magnetic north line, road and communication symbols, aeronautical symbols (military and commercial), azimuths, bench marks, triangulation stations, scales, and other symbols and lines. Lettered on maps is additional information such as volume of earthworks (cut, fill, and placement), curve data, contour interval, elevations, latitude and departures (coordinate lines, monuments, etc.), names (roads, railroads, streams, rivers, lakes, and landmarks), and any and all pertinent information necessary for clear interpretation by geologists, engineers, contractors, governmental agencies, etc.

May make computations such as areas, deflections, earthwork volumes, etc., when necessary to complete additional information not supplied by field notes or other information.

Technical skills

Basically the same as "General Draftsmen." Include, particularly, understanding and use of dimensioning practice, map drafting symbols, nomenclature and standard practice of map making; civil, architectural, geological, and engineering terminology used in preparing maps.

Highway, Street, and Related Construction Draftsmen

Products of work

Basically the same as "Map Draftsmen." Also includes elevated highways and access ramps, expressways, thruways, etc.; and final construction maps detailing all major items.

Functions performed

Basically the same as "Map Draftsmen." In addition, construction maps of highways and roads must have all necessary information for construction contractors, field crews, surveyors, such as position of line stakes, embankments, bridge abutments, culverts, drainage catch basins, grades, distances, cut and fill, borrow pits, and vertical and horizontal curves.

Technical skills - basically the same as "Map Draftsmen."

Plant Layout Draftsmen

Products of work

Plans, arrangements, relocations, and installation drawings, schematics, and diagrams for -

Manufacturing plants (production facilities, machinery, materials handling equipment, storage spaces, office layouts, structural modifications, utility systems).

Retail establishments (department stores - sales areas, displays, lighting, mechanical fixtures, traffic patterns; shopping centers, etc.).

Offices, schools, hospitals, transportation terminals, etc.

Functions performed

Work from architectural plans, plats, structural drawings, layouts, sketches, renderings, schematics, as well as from field notes and measurements, notes from engineers, designers, and clients, technical data, codes, standards, technical books, handbooks, catalogs, etc.

Make sketches, layouts, drawings, and plans of machinery arrangements, flow patterns, materials handling systems (conveyors, cranes, racks), office and sales area layouts, personnel locations, structural renovations (partitions, doors, stairwells, elevators, ceilings), painting and color coding (piping, machinery, aisles, safety zones), templates for planning (scaled shapes of machines and equipment, including two-dimensional and three-dimensional models), heating, ventilating, and air-conditioning equipment, etc.

Also may make direct measurements of plant dimensions, areas, and volumes for space planning; estimate cost of various plans; list materials and equipment for installation; check operation sheets for equipment sequence; write shop orders for installation, rearrangement, or alteration plans; make charts and displays occasionally requiring artistic ability; and may do some designing.

Technical skills - basically the same as "General Draftsmen" and "Architectural Draftsmen."

Aircraft Structures Draftsmen

Products of work

Engineering drawings, wiring diagrams, schematics, installation drawings of air or missile structures, component assemblies, weapons systems, parts, etc.

Functions performed

Work from rough sketches, notes, design memoranda, drawings, layouts, schematics, wiring diagrams, oral information, test data, etc.

Make accurate detail, assembly, sub-assembly, installation drawings and layouts, etc., applied to aircraft and missile structures and equipment. Functions are usually subdivided into specialty areas, such as airframe, heating and ventilating, piping, electrical, etc.

May make coordinate layouts to check for clearances, fits, tolerances, and interference of parts, assemblies, components, etc.

May prepare parts lists, bills of material, critical information, and instructions as directed.

May do simple calculations (shear, bearing, tension, flow, etc.).

May design simple parts (seals, locking devices, clips, brackets, mounts), and select standard components and parts in accordance with design requirements and approved parts lists.

Technical skills - basically the same as "General Draftsmen" and "Mechanical Draftsmen."

Ship Structures Draftsmen

Products of work

Engineering drawings, architectural plans, wiring diagrams, installation or damage repair drawings for ships (passenger, cargo, tankers, naval vessels), boats (pleasure craft, ferries, launches, lifeboats, tugs, fire-fighting), etc.

Functions performed

Work from drawings, layouts, sketches, notes, direct measurements, test data, etc., and make engineering drawings as in case of "General Draftsmen." Functions usually subdivided into specialty areas, such as hull and structure; machinery (propulsion, pumps, compressors, evaporators, winches, and hoisting gear, etc.); electrical (power, radio and radar, signal, control, annunciator); heating and ventilating, and piping (high and low pressure and temperature; steam, air, salt and fresh water, gas; pipe supports and hangers; expansion joints; welded or threaded; etc.).

Technical skills - same as "General Draftsmen" and "Mechanical Draftsmen."

Electrical-electronic Draftsmen, Construction

Products of work

Engineering drawings for electrical installations, such as wiring and schematics for light and power circuits of buildings, outdoor installations, stores, schools, etc. Includes wire sizes, conduits, and other information needed by contractors to perform work.

Functions performed

Work from layout drawings, architectural plans, structural plans, engineering design data, and specifications. Make complete or modified drawings of schematics, wiring, line circuit layouts, using standards and codes such as those of the American Standards Association, the National Electric Manufacturers Association, and the National Electric Code.

May do simple calculations and designs for wire sizes, conduits, and quantities.

Technical skills - the same as "General Draftsmen."

Electrical-electronic Draftsmen, Other than Construction

Products of work

Engineering drawings of various types of -

Manufactured products, such as AC or DC electric generators, motors, switchgear, converters, transformers, and rectifiers; electrical and electronic components, including relays, switches, antennas, vacuum tubes, transistors, printed circuits, and signal devices; electrical and electronic instruments for testing, measuring, and control; assembly drawings and layouts of amplifiers, oscillators, etc. The work may include panel layout and design.

Circuitry for these products in schematic and wiring diagrams; specialized applications, such as communication systems, data processing equipment, pictorials and diagrams for instruction manuals, line diagrams for technical catalogs, plans for lighting arrangement and installation, etc.

Performance characteristics graphs, charts, and nomographs.

Functions performed

Basically the same as "General Draftsmen," except that types of drawings include wiring diagrams and printed circuit diagrams and notations include electrical data.

Technical skills

Basically the same as "General Draftsmen," except that they also include familiarity with the types, sizes, functions, applications of available electrical and electronic components and devices, and a knowledge of the standard symbols and abbreviations of the Institute of Electrical and Electronic Engineers and the American Standards Association.

Mechanical Draftsmen, Construction

Products of work

Engineering drawings, fabrication drawings, installation and erection drawings for: construction projects (buildings, industrial plants, airports, etc.), including heating, ventilating, air conditioning, refrigeration, piping, and plumbing (sanitation, water, drainage, steam); fueling systems; pneumatic and hydraulic systems.

Functions performed -- basically the same as "General Draftsmen."

Technical skills - basically the same as "General Draftsmen."

Mechanical Draftsmen, Other than Construction

Products of work

Engineering drawings of various types of -

Manufactured products, such as machines, machine parts, fasteners, housings and bases; tools; appliances; furniture; engines; turbines; etc.

Charts, graphs, nomographs, etc.

Specialized applications, such as patentable devices for inventors; pictorials and diagrams for instruction manuals, technical catalogs, and textbooks; pneumatic and hydraulic systems for automatic processes; etc.

Functions performed - basically the same as "General Draftsmen."

Technical skills

Basically the same as "General Draftsmen." Needed, also, is familiarity with available standard sizes and types of bolts, screws, rivets, nuts, washers, keys, pins, shafts, bearings, bushings, rods, plates, bars, springs, gears, couplings, belts, and pulleys and their applications.

Electro-mechanical Draftsmen, Construction

Products of work

Engineering drawings, schematics, wiring diagrams and layouts, and installation drawings for: construction projects (buildings, etc.); mechanical and electrical services and equipment, including electrical power and lighting systems and controls; heating, ventilating, air conditioning; refrigeration; vertical and horizontal transportation, such as elevators, escalators, endless belts, etc.

Functions performed - basically the same as "General," "Electrical-electronic," and "Mechanical" draftsmen.

Technical skills - basically the same as "General," "Electrical-electronic," and "Mechanical" draftsmen.

Electro-mechanical Draftsmen, Other than Construction

Products of work

Engineering drawings, schematics, wiring diagrams, installation drawings for: electro-mechanical control devices, mechanisms, and components as applied in various industries (machinery, instruments, aircraft, automotive, communications, electric power, etc.).

Functions performed

Work from layouts, drawings, schematics, sketches, specifications supplied by others such as engineers, contractors, vendors, manufacturers, customers, or other draftsmen.

Make complete or modified drawings or tracings using established standards and codes, such as those of American Standards Association, National Electrical Manufacturers Association, Military Specifications, and National Electric Code. Types of drawings include working, detail, plan, layout, block diagram, exploded view, isometric, schematic, and wiring. Includes on drawings special symbols and identification numbers; electrical requirements data; mechanical data; bill of materials; etc.

May do simple design, selection, or calculations for components, mechanisms, or machine parts.

Technical skills - basically the same as "General," "Electrical-electronic," and "Mechanical" draftsmen.

SUBJECT MATTER KNOWLEDGE

General Requirements for All Draftsmen

For draftsmen at the lowest level, the basic requirement is a knowledge of technical drawing. At the other end of the scale, an upper-grade draftsman is in some cases hard to distinguish from a design technician, since their functions overlap. A draftsman assuming these higher-level responsibilities may need subject matter such as descriptive geometry, stress analysis, and hydraulics.

Inasmuch as angular functions and relationships and angular and linear measurements and interrelationships are applied in all types of design and layout work, trigonometry is the minimum mathematics the draftsman needs.

General physics also ranks high in terms of employer statements as to what draftsmen need. The type of physics course needed is one that emphasizes the applications of basic physical principles to machines, electrical equipment, scientific instruments, structures, etc.

The draftsman must possess the skill and knowledge required to produce drawings, sketches, layouts, schematics, etc., involved in design, construction, and repair operations.

The specialized subject-matter needs are described in terms of whether a substantial number of employers say a subject is needed or whether it is only occasionally required. This information is presented below for each of the major fields in which the draftsman functions. The data are summarized in table I-C.

Special Requirements

Architectural draftsmen. Cited as needed in a substantial number of cases: basic electrical theory including circuitry and wiring, and orientation in construction technology and architectural technology.

Besides the rendering of finished drawings, the functions of this draftsman may require that he assist in the preparation of specifications, including the selection of materials and determination of the quantities required. Projects involving heat-conduction and insulation require some knowledge of heat and those involving lighting effects require a knowledge of light and basic electricity. Included in mechanics should be the study of strength of materials -- valuable for the selection of materials and sizes. Because the architectural draftsman may be involved in the preparation of plans to be used in building construction, a knowledge of construction techniques and standards is useful.

Architectural draftsmen function in different grade levels and areas of specialization. Consequently, these subjects are not universally required of all architectural draftsmen.

Table I-C. SUBJECT MATTER KNOWLEDGE NEEDED BY DRAFTSMEN IN MAJOR OCCUPATION GROUPS

Subject	Architectural	Structural	Electrical-electronic	Mechanical and electro-mechanical	Map, topographical, geological
Mathematics:					
Trigonometry	XXX	XXX	XXX	XXX	XXX
Advanced algebra	-	-	-	X	-
Analytic geometry	X	-	-	-	-
Calculus	X	-	-	X	-
Science:					
Chemistry, general	X	X	X	X	-
Metallurgy	X	-	-	XX	-
Physics, general	XXX	XXX	XXX	XXX	XXX
Hydraulics	-	-	-	X	X
Thermodynamics	-	-	-	X	-
Geology	-	-	-	-	XX
Technology:					
Technical drawing	XXX	XXX	XXX	XXX	XXX
Electrical technology, orientation	-	-	XX	XX	-
Basic electricity	XX	-	-	X	-
Mechanics and strength of materials	XX	XX	-	XX	-
Heating, ventilating, air conditioning, refrigeration, sanitation	X	-	-	X	-
Architectural technology, orientation	XX	-	-	-	-
Civil technology, orientation	X	X	X	-	-
Construction technology, orientation	XX	XX	XX	XX	-
Surveying	-	X	-	-	XX
Manufacturing processes	-	-	-	X	-
Shop theory and practice	-	-	XX	X	-
Building codes	X	X	X	-	-
Descriptive geometry	X	-	X	X	-
Acoustics	X	-	-	X	-

Key: XXX= generally needed; XX= needed in a substantial number of cases; X= occasionally needed.

Cited occasionally: analytic geometry, calculus, general chemistry, metallurgy, heating-ventilating-air-conditioning-refrigeration-sanitation, orientation in civil technology, acoustics, building codes, and descriptive geometry. These subjects are cited by employers only infrequently because they apply to a limited number of draftsmen jobs. Analytic geometry, descriptive geometry, and calculus are likely to be needed only by the draftsman functioning at the upper grade level. The same is true of the requirements for a knowledge of civil technology. The occasional specification of the subject of acoustics occurs in cases where the draftsman is engaged in a specialized architectural area -- for example, working on the soundproofing of rooms or on the acoustical characteristics of a church or auditorium. A knowledge of general chemistry helps to understand such problems as oxidation, corrosion, and electrolytic action, which are encountered in the selection of materials.

Structural draftsmen. Cited as needed in a substantial number of cases: mechanics (strength of materials), orientation in construction technology. These subjects are useful for the draftsman functioning at a level requiring more technical know-how than that required for the preparation of drawings from specifications. A knowledge of strength of materials, as well as an understanding of the principles of construction and structural technology, are useful to the draftsman engaged in making stress diagrams and drawings of structures giving stresses.

Cited occasionally: orientation in civil technology; surveying; general chemistry; building codes. A small percentage of employers cited these subjects as being needed. Some knowledge of civil engineering and surveying are useful where the draftsman is required to work from specifications prepared by surveyors, or from maps, profiles, and handbooks. Basic chemistry is useful where the draftsman assists in selecting materials.

Some draftsmen serve in the dual capacity of architectural-structural draftsmen. The subject matter requirements reported for them are essentially the same as those of the structural draftsman. They do only the simplest type of architectural drafting and do not require the broader technical background of the architectural draftsman.

Map, topographical, and geological. Required in a substantial proportion of cases: geology, surveying. A knowledge of geology is most useful to the draftsman involved in geological surveys and topography; of particular value is a knowledge of geological terminology and symbolism. Surveying enables the draftsman to work effectively with surveyor's field notes, office computations, other maps and to intelligently use bearings, azimuths, bench marks, latitude and departure, etc., in the preparation of maps. A knowledge of hydraulics is required occasionally.

Highway, street, and related construction. The subject matter requirements for this draftsman are the least demanding of any draftsman group. The general basic requirements fulfill most of their needs. Among the subjects occasionally mentioned as needed are surveying, advanced algebra, solid geometry, hydraulics, and orientation in construction technology.

Electrical-electronic. Cited as needed in a substantial number of cases: shop theory and practice, orientation in construction technology, and orientation in electrical technology. A knowledge of shop theory and practice is useful to the draftsman preparing plans to be used by mechanics and installers. It enables him to use good judgment in locating equipment and auxiliary accessories such as control panels; in prescribing proper aisle space; ventilation; etc. The electrical technology is used by personnel working in upper level grades, especially the supervisory level, where there is close liaison between the drafting department and engineering.

Cited occasionally: descriptive geometry, building codes, orientation in civil technology, general chemistry. Descriptive geometry is useful to the draftsman doing conduit layout involving bends and the intersection of planes and surfaces. Civil technology is used primarily by personnel working in upper grades.

A knowledge of general chemistry is useful in projects involving electro-chemistry. For example, in the preparation of the layout and circuit schematics for electroplating, the draftsman may be required to use chemical symbols, equations, etc. A knowledge of electrolytic action and associated phenomena is also useful when the draftsman assists in specification writing involving choice of materials, etc.

Mechanical and elec .o-mechanical. The subject matter requirements for these two draftsman groups are so similar that they can be presented together.

Required in a substantial number of cases: metallurgy, mechanics (including strength of materials), and orientation in construction technology and electrical technology. Metallurgy is significant for both the mechanical and electro-mechanical draftsmen. Draftsmen working on drawings of machines, machine parts, tools, etc., may be required to use metallurgical specifications for understanding and checking the specifications set by the engineer. A knowledge of applied mechanics is especially helpful to the higher-grade draftsman who works closely with the engineer. Orientation in construction technology enables the draftsman to use better judgment where there is a choice of procedures, sequence of operations, etc.

Cited occasionally: advanced algebra, calculus, general chemistry, hydraulics, thermodynamics, heating-ventilating-air-conditioning-refrigeration, basic electricity, shop theory and practice, manufacturing processes, descriptive geometry, and acoustics.

The advanced mathematics courses are of use principally to the higher-grade draftsman whose functions approach those of the design technician. Knowledge of heat is required with about the same frequency in the two draftsman groups and is especially useful to those involved with drafting problems in the field of heat transfer. Sound and light are occasionally required by the electro-mechanical draftsman.

In the field of hydraulics, an understanding of fluid flow, pressure distribution, etc., is helpful to the draftsman working on hydraulic systems or automatically controlled mechanical equipment. A knowledge of thermodynamics aids the person working on drawings involving types of chemical processing equipment, prime movers, heat engines, etc.

A knowledge of machine tools and operation is required occasionally by the mechanical draftsman, especially if he is concerned with drawings of tools and mechanical processes. Knowledge of manufacturing processes and plumbing and piping are of value to those draftsmen working in a specialized area such as production-operation sequence or piping layouts in chemical plants.

GRADE STRUCTURE

One of the points ascertained in the survey was whether or not a particular technical job involved major supervisory responsibilities over other technicians, and if not whether it was a single-grade job or one of several grades. Table I-D shows the distribution of workers among various grade levels, for each type of draftsman.

The table shows that, excluding the supervisory grades, a majority of draftsmen are employed by companies with single-grade structures. There are some exceptions, especially the electro-construction, electro-mechanical, and highway-construction draftsman groups, where multi-grade structures predominate.

The proportion of draftsmen in single-grade jobs is greatest in the smallest establishments (83 percent in those employing fewer than 50 workers of all sorts). It is lower in the largest establishments (21 percent in those with 1,000 or more workers).

Table I-D. PERCENT DISTRIBUTION OF DRAFTSMEN ACCORDING TO GRADE, BY OCCUPATION

Occupation	Total number	Percent distribution					
		All grades	Supervisory grades	Nonsupervisory grades			
				Single grade only	Multi-grade		
					Lowest grades	Middle grades	Highest grades
All occupations	20,972	100.0	2.6	51.7	15.2	10.7	19.8
Architectural and structural	6,294	100.0	2.1	64.8	10.1	6.8	16.2
Construction	5,973	100.0	2.2	63.7	10.4	6.9	16.8
Architectural	3,508	100.0	2.0	60.5	11.6	6.7	19.2
Structural	1,955	100.0	2.7	73.3	6.9	6.1	11.0
Combination: architectural and structural	510	100.0	1.6	48.0	15.7	12.2	22.5
Aircraft structures	105	100.0	1.9	77.1	8.6	4.8	7.6
Ship structures	216	100.0	0.5	92.1	0.9	3.7	2.8
Electrical-electronic	2,301	100.0	1.3	45.2	21.7	12.6	19.2
Construction	684	100.0	-	29.9	18.1	27.9	24.1
Other	1,617	100.0	1.8	51.7	23.3	6.1	17.1
Mechanical	6,526	100.0	2.7	55.3	15.2	8.8	18.0
Construction	1,020	100.0	0.8	72.4	7.5	8.2	11.1
Other	5,506	100.0	3.1	52.2	16.6	8.9	19.2
Electro-mechanical	3,767	100.0	2.8	29.8	17.9	18.8	30.7
Construction	211	100.0	1.9	38.9	28.4	8.1	22.7
Other	3,556	100.0	2.9	29.3	17.3	19.5	31.0
Highway, street, and related construction	270	100.0	0.7	36.3	35.6	8.9	18.5
Map, topographical, and geological	592	100.0	2.4	64.5	16.0	6.1	11.0
Plant layout	422	100.0	5.2	60.2	10.9	14.0	9.7
General draftsmen	661	100.0	6.8	30.7	20.4	16.8	25.3
Draftsmen n.e.c.	139	100.0	5.0	44.7	4.3	7.2	38.8

The responsibility and difficulty of draftsmen jobs at any grade level -- lowest, middle, or highest -- may vary from one firm to another. Analysis of the jobs shows the following to be the main elements that distinguish the grade levels of draftsman jobs: directness and closeness of supervision and checking of results of work; extent to which instructions are standardized or spelled out in writing; extent of discretion, initiative, and judgment expected and exercised; complexity and intricacy of structure, equipment, or product worked on; extent of routine drawing or tracing required, on the one hand, and extent of design work carried out, on the other; knowledge of materials, equipment, products, electro and mechanical technologies required in carrying out assignments.

The content of single-grade jobs will also vary a great deal from company to company. Judging by employers' educational requirements (taken up in the next section), their content is more nearly comparable to middle-grade and upper-grade than to lower-grade levels in multi-grade structures.

EDUCATION AND EXPERIENCE REQUIRED

Employers are satisfied with a high-school education to a greater extent in the case of draftsmen than is true for technicians and technical specialists generally. At the time of the survey, 60 percent of draftsmen worked for employers who required high school only, compared with 53 percent for all technical occupations in the survey combined.

Many employers, however, prefer some post-high-school education and most of them require some work experience related to the job.

Education Requirements

Graduation from a technical institute or community college is most often mentioned among the various types of post-high-school educational requirements, as table I-E shows. About 16 percent of draftsmen work for employers who have this

Table I-E. NUMBER AND PERCENT DISTRIBUTION OF DRAFTSMEN BY EDUCATION EMPLOYERS REQUIRE

Education required	Number	Percent
All levels	20,972	100.0
Post-high-school	8,387	40.0
Engineering college or architectural school	1,481	7.1
Graduation	645	3.1
Less than graduation	836	4.0
College, general	236	1.1
Graduation	15	0.1
Less than graduation	221	1.0
Technical institute or community college	3,697	17.7
Graduation	3,286	15.7
Less than graduation	411	2.0
Type not specified	2,231	10.6
Apprenticeship or armed forces school	742	3.5
High school	12,585	60.0
Technical or vocational	2,345	11.2
Other and not specified	10,240	48.8

requirement. Another 2 percent are required to have attended, but not required to have graduated from, such an institution.

The highest education requirements are found in the architectural draftsman group. It is the practice of some architectural firms to start young architectural-school graduates or undergraduates on drafting work and then in time move them along to work at the professional level. The experience they gain helps fulfill the State requirements for registration as an architect. About 28 percent of architectural draftsman jobs require graduation from or attendance at an engineering college or architectural school. (See table I-3 at the end of the chapter.)

Most draftsmen, however, work for employers whose requirements do not extend beyond high-school education. Drafting courses are commonly found in comprehensive high schools, as well as in technical and vocational-trade high schools, and are also found in some academic high schools.

Next to architectural draftsmen, construction draftsmen in the electric-electronic field and electro-mechanical draftsmen have the highest educational requirements. This is seen in the following list, which shows the percent of draftsmen of various types for whom education beyond high school was a requirement:

Architectural	56.4%	Electro-mechanical	
Structural	34.0	Construction	46.0
Combination: architectural and structural	43.5	Other	47.4
Aircraft structures	32.4	Highway, street, and related construction	18.1
Ship structures	22.7	Map, topographical, and geological	32.8
Electrical-electronic		Plant layout	28.7
Construction	44.3	General draftsmen	41.0
Other	32.0	Draftsmen n.e.c.	5.8
Mechanical			
Construction	22.4		
Other	35.7		

Education beyond high school is required for a somewhat larger proportion of draftsmen in the highest and middle grades than in the lowest ones:

Supervisory grades	42.7%
Nonsupervisory grades:	
Single grade only	40.2
Multi-grade:	
Lowest grades	29.8
Middle grades	43.6
Highest grades	45.0

Preferred vs. Required Education

Many of the employers whose minimum educational requirement was graduation from high school said that they preferred some type of education beyond high school. The following figures (taken from table I-4, at the end of the chapter) show that the percent of draftsmen -

whose employers require:	high-school education	is 60.0
	additional education	is 40.0
whose employers prefer:	high-school education	is 34.7
	additional education	is 65.3

Graduation from a technical institute (or community college) is the most common preference of employers who require a high-school education but prefer something more. (See table I-5 at the end of the chapter.)

Experience Requirements

Employers of a majority of draftsmen require that appointees to draftsman jobs have some experience in the same or a related line of work. It is required for almost all higher-grade and supervisory jobs, but for only 53 percent of the jobs in the lower grades:

Supervisory grades	99%
Nonsupervisory grades:	
Single grade only	57
Multi-grade:	
Lowest grades	53
Middle grades	96
Highest grades	95

Related work experience of the kind required of appointees to lowest-grade or single-grade jobs includes such directly-related work as inking, tracing, charting, and work that brings familiarity with the subject matter with which draftsmen deal, especially work in the crafts (tool-maker, electrician, mechanic, etc.).

The number of years of experience the employer requires is related to the education he requires. Taking together the draftsmen of all types whose employers require only a high-school education, the median number of years of experience required is 2.7, compared with a median of 1.2 for employers who require education beyond high school. In general, then, it may be said that post-high-school education is equivalent, in terms of requirements, to approximately 1.5 years of experience.

The extent to which these figures vary by type of draftsman may be seen in table I-F.

Table I-F. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR DRAFTSMEN IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

Occupation	All levels	Post-high-school	High school
All occupations	2.2	1.2	2.7
Architectural	2.5	0.5	3.5
Structural	1.4	0.0	2.6
Combination: architectural and structural	3.1	1.8	3.9
Aircraft structures	0.5	(a)	(a)
Ship structures	0.0	(a)	2.5
Electrical-electronic: construction	1.7	0.5	1.7
Electrical-electronic: other	2.1	2.0	2.2
Mechanical: construction	0.0	0.0	2.5
Mechanical: other	2.2	1.5	2.5
Electro-mechanical: construction	2.9	2.3	3.2
Electro-mechanical: other	2.3	1.9	2.6
Highway, street, and related construction	2.5	(a)	2.5
Map, topographical, and geological	2.5	1.1	2.7
Plant layout	2.0	0.0	2.7
General draftsmen	2.8	4.8(b)	2.3
Draftsmen n.e.c.	2.2	(a)	2.1

a. Not computed because of small numbers involved.
b. Includes a relatively high proportion of supervisors.

The median number of years of experience required, and its relation to the level of education required, also vary somewhat among the various grades of nonsupervisory draftsman jobs:

Nonsupervisory grade	All levels	Post-high-school	High school
Single grade only	1.7	0.0	2.4
Multi-grade:			
Lowest grades	0.8	0.0	1.2
Middle grades	2.9	2.4	3.3
Highest grades	4.1	3.3	4.7

About 9,000 of the approximately 21,000 draftsmen worked for employers who stated that they would like to use higher standards in hiring. The preference expressed as to about 70 percent of the 9,000 was for more education with the same or less experience required, as may be seen in the table at the top of the next page.

Kind of preference	All draftsmen	High school required (a)
Total	20,972	12,585
No preference expressed	11,983	5,832
All preferences	8,989	6,753
Required education, more experience	1,485	752
More than required education, less experience	3,218	2,639
More than required education, same experience	3,122	2,546
More than required education, more experience	1,164	816

a. Number of draftsmen for whose jobs no post-high-school education is required.

The typical case is the employer requiring high-school education and some experience who would trade off some or all of the experience for more education. (See table I-6 at the end of the chapter.)

Judging by experience requirements, employers think well of high-school technical curriculums in the drafting field. Employers' reports show that they require substantially less work experience of graduates of technical than of other high-school programs; and in respect to experience requirements high-school technical-program graduates in drafting compare favorably with technical institute graduates.

TESTS AND LICENSES

Fairly common means of determining the qualifications of draftsmen are civil service examinations in government agencies, and in private businesses the submission of work samples, plus intelligence and aptitude tests in some cases.

A few consulting architectural firms require one or more of their draftsmen to be registered architects.

SOURCES OF WORKERS

Method of Obtaining Workers

To obtain qualified draftsmen, employers used recruitment from outside the establishment more often than they used upgrading during a representative period preceding the survey:

All methods	100.0%
Recruited from outside the firm	69.0
Upgraded, total	31.0
With organized training	2.5
Without organized training	28.5

Recruitment is the predominant method in the case of nearly every subgroup. The proportion obtained by outside recruitment ranges from 89 percent in the case of ship structure draftsmen to around 50 percent in the electro-mechanical group. (See table I-7 at the end of the chapter.)

Where upgrading is used, training by the employer plays a comparatively small role. (Table I-7 gives figures for each subgroup.)

In obtaining supervisory workers, recruitment is used 25 percent of the time, and in obtaining workers for the highest grades of a multi-grade system it is used 39 percent of the time, as the following distributions show. These proportions are higher than in most other technical occupations.

Grade	All methods	Recruited from outside the firm	Upgraded with organized training	Upgraded without organized training
Supervisory grades	100.0	25.4	2.2	72.4
Nonsupervisory grades:				
Single grade only	100.0	85.7	0.5	13.8
Multi-grade:				
Lowest grades	100.0	78.9	3.4	17.7
Middle grades	100.0	40.1	8.5	51.4
Highest grades	100.0	39.4	3.5	57.1

Table I-G. PERCENT OF DRAFTSMEN WHO ARE GRADUATES OF COLLEGES OR TECHNICAL INSTITUTES, BY OCCUPATION

Occupation	Total number	College graduates	Technical institute graduates
All occupations	20,972	9.2%	33.9%
Architectural and structural	6,294	24.3	34.0
Construction	5,973	25.5	34.1
Architectural	3,508	37.3	30.2
Structural	1,955	8.7	36.8
Combination: architectural and structural	510	9.4	50.2
Aircraft structures	105	1.0	60.0
Ship structures	216	2.3	20.8
Electrical-electronic	2,301	1.5	24.5
Construction	684	1.6	16.4
Other	1,617	1.5	27.9
Mechanical	6,526	2.7	39.8
Construction	1,020	2.9	55.2
Other	5,506	2.7	37.0
Electro-mechanical	3,767	2.8	28.1
Construction	211	9.0	28.0
Other	3,556	2.5	28.1
Highway, street, and related construction	270	4.4	38.1
Map, topographical, and geological	592	4.1	23.6
Plant layout	422	7.3	28.7
General draftsmen	661	1.8	51.7
Draftsmen n.e.c.	139	2.9	34.5

College and Technical Institute Graduates

Approximately one-third of the total of 20,972 draftsmen were graduates of one-year, two-year, or three-year technical institutes or community colleges, as table I-G shows. The reason why as many as 9 percent were four-year-college graduates or graduates of architectural schools was indicated earlier: a number of architectural firms in New York City require their draftsmen to have graduated from architectural school. As a result, 37 percent in the architectural-draftsman subgroup are college graduates.

PROMOTIONAL LINES

Employers were asked to report promotional lines involving draftsmen -- jobs from which they are promoted and also jobs to which draftsmen are promoted.

The most common promotional line reported by employers involves different grades of draftsmen, in establishments with multi-grade systems. Outside of these cases, lower-grade jobs from which promotion to draftsman is reported include other technical jobs and craft jobs (for example,machinist, tool-and-die maker, sheet-metal shop mechanic, template maker, pipe fitter, millwright, maintenance foreman, and surveyor helper), a few production jobs (for example wireman and assembler), and a few clerical jobs (for example drawing control clerk, copier, tracer, inker, and blueprint-machine operator).

Designer technician, engineer, and architect were most often mentioned as jobs to which draftsmen are promoted (other than a higher grade of draftsman). Other jobs mentioned include estimator, specifications writer, sales technician, layout man, and supervising jobs of various sorts.

D r a f t s m e n

Table I-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

A. Architectural and Structural Draftsmen and Electrical-electronic Draftsmen

Industry group	All occupations	Architectural and structural							Electrical-electronic		
		Total	Construction				Aircraft structures	Ship structures	Total	Construction	Other
			Total construction	Architectural	Structural	Combination (a)					
All industries	20,972	6,294	5,973	3,508	1,955	510	105	216	2,301	684	1,617
Manufacturing	9,357	808	660	155	452	53	103	45	999	12	987
Durable goods	8,529	751	603	145	419	39	103	45	979	12	967
Ordnance and accessories	165	-	-	-	-	-	-	-	6	-	6
Lumber and wood products, except furniture	16	6	6	-	6	-	-	-	-	-	-
Furniture and fixtures	358	12	12	10	2	-	-	-	-	-	-
Stone, clay, and glass products	277	127	127	89	38	-	-	-	9	-	9
Primary metal industries	238	7	7	1	6	-	-	-	10	-	10
Fabricated metal products	1,159	448	406	45	336	25	-	42	-	-	-
Machinery, except electrical	2,346	12	12	-	12	-	-	-	125	-	125
Electrical machinery and equipment	2,230	14	14	-	-	14	-	-	647	11	636
Transportation equipment	800	124	18	-	18	-	103	3	132	1	131
Instruments; photographic and optical goods	940	1	1	-	1	-	-	-	50	-	50
Nondurable goods	828	57	57	10	33	14	-	-	20	-	20
Food and kindred products	111	5	5	3	-	2	-	-	1	-	1
Textile mill products	17	-	-	-	-	-	-	-	-	-	-
Apparel and other finished fabric products	5	3	3	-	-	3	-	-	-	-	-
Paper and allied products	115	-	-	-	-	-	-	-	-	-	-
Printing, publishing, and allied industries	144	-	-	-	-	-	-	-	-	-	-
Chemicals and allied products	277	43	43	1	33	9	-	-	17	-	17
Petroleum refining and related industries	69	6	6	6	-	-	-	-	2	-	2
Rubber and miscellaneous plastic products	28	-	-	-	-	-	-	-	-	-	-
Leather and leather products	23	-	-	-	-	-	-	-	-	-	-
Miscellaneous manufacturing industries	39	-	-	-	-	-	-	-	-	-	-
Nonmanufacturing	11,615	5,486	5,313	3,353	1,503	457	2	171	1,302	672	630
Mining	18	-	-	-	-	-	-	-	2	-	2
Contract construction	1,163	436	436	85	314	37	-	-	103	103	-
General building contractors	234	136	136	78	31	27	-	-	6	6	-
Heavy construction	177	162	162	7	145	10	-	-	1	1	-
Special trade contractors	752	138	138	-	138	-	-	-	96	96	-
Transportation, communication, and public utilities	1,055	141	136	4	13	119	2	3	589	304	285
Railroad transportation	75	63	63	-	-	63	-	-	4	4	-
Local and interurban passenger transportation	2	-	-	-	-	-	-	-	-	-	-
Air transportation	19	19	14	4	-	10	2	3	-	-	-
Communication	425	6	6	-	-	6	-	-	285	-	285
Electric, gas, and sanitary services	534	53	53	-	13	40	-	-	300	300	-
Wholesale and retail trade	635	141	141	87	36	18	-	-	13	3	10
Wholesale trade	451	49	49	10	34	5	-	-	13	3	10
Retail trade	184	92	92	77	2	13	-	-	-	-	-
Building materials, hardware, and farm equipment	2	2	2	-	2	-	-	-	-	-	-
General merchandise stores	47	13	13	-	-	13	-	-	-	-	-

Continued

Table I-1, part A (concluded)

Industry group	All occupations	Architectural and structural							Electrical-electronic		
		Total	Construction				Aircraft structures	Ship structures	Total	Construction	Other
			Total construction	Architectural	Structural	Combination (a)					
Retail trade (continued)											
Food stores	4	1	1	1	-	-	-	-	-	-	-
Apparel and accessories	1	-	-	-	-	-	-	-	-	-	-
Furniture, home furnishings, and equipment	84	74	74	74	-	-	-	-	-	-	-
Eating and drinking places	3	-	-	-	-	-	-	-	-	-	-
Miscellaneous retail stores	43	2	2	2	-	-	-	-	-	-	-
Finance, insurance, and real estate	64	34	34	26	-	8	-	-	1	1	-
Banking	13	6	6	6	-	-	-	-	-	-	-
Insurance carriers	13	6	6	-	-	6	-	-	-	-	-
Insurance agents, brokers, and services	2	-	-	-	-	-	-	-	-	-	-
Real estate	26	22	22	20	-	2	-	-	1	1	-
Holding and other investment companies	10	-	-	-	-	-	-	-	-	-	-
Services and miscellaneous	7,608	4,283	4,115	3,113	827	175	-	168	501	238	263
Personal services	2	-	-	-	-	-	-	-	-	-	-
Miscellaneous business services	1,618	282	282	166	71	45	-	-	173	80	93
Advertising, news, credit, duplicating, building, and related services	1	-	-	-	-	-	-	-	1	-	1
Business services n.e.c.	1,617	282	282	166	71	45	-	-	172	80	92
Research, development, testing laboratories	298	14	14	-	14	-	-	-	21	-	21
Business and management consulting services	762	111	111	88	14	9	-	-	115	80	35
Other business services n.e.c.	557	157	157	78	43	36	-	-	36	-	36
Miscellaneous repair services	20	-	-	-	-	-	-	-	-	-	-
Motion pictures	4	-	-	-	-	-	-	-	2	-	2
Amusement and recreation, except motion pictures	1	1	1	1	-	-	-	-	-	-	-
Private medical services	5	2	2	-	-	2	-	-	-	-	-
Voluntary hospitals	3	2	2	-	-	2	-	-	-	-	-
Medical and dental laboratories	2	-	-	-	-	-	-	-	-	-	-
Private colleges and schools	67	8	8	2	-	6	-	-	11	-	11
Nonprofit membership organizations	2	-	-	-	-	-	-	-	-	-	-
Miscellaneous services	5,889	3,990	3,822	2,944	756	122	-	168	315	158	157
Engineering and architectural services	5,863	3,990	3,822	2,944	756	122	-	168	310	158	152
Nonprofit educational and scientific research	26	-	-	-	-	-	-	-	5	-	5
Government	1,072	451	451	38	313	100	-	-	93	23	70
County	87	2	2	2	-	-	-	-	-	-	-
New York State	340	184	184	31	81	72	-	-	19	18	1
Colleges	3	1	1	1	-	-	-	-	-	-	-
Other	337	183	183	30	81	72	-	-	19	18	1
New York City	362	232	232	-	232	-	-	-	72	5	67
Hospitals	3	-	-	-	-	-	-	-	2	1	1
Colleges	1	-	-	-	-	-	-	-	-	-	-
Other	358	232	232	-	232	-	-	-	70	4	66
Cities other than New York City	51	3	3	3	-	-	-	-	-	-	-
Towns and villages	46	-	-	-	-	-	-	-	-	-	-
Federal	186	30	30	2	-	28	-	-	2	-	2
Hospitals	2	1	1	-	-	1	-	-	-	-	-
Arsenals and navy yards	106	2	2	2	-	-	-	-	-	-	-
Other	78	27	27	-	-	27	-	-	2	-	2

Table I-1 (continued)

B. Draftsmen Other Than Architectural and Structural and Electrical-electronic

Industry group	Mechanical: Total	Mechanical: Con-struc-tion	Mechanical: Other	Electro-mechanical: Total	Electro-mechanical: Con-struc-tion	Electro-mechanical: Other	High-way (b)	Map (c)	Plant layout	General drafts-men	Drafts-men n.e.c.
All industries	6,526	1,020	5,506	3,767	211	3,556	270	592	422	661	139
Manufacturing	4,565	17	4,548	2,505	9	2,496	-	95	254	24	107
Durable goods	4,031	17	4,014	2,484	9	2,475	-	-	176	9	99
Ordnance and accessories	30	-	30	129	-	129	-	-	-	-	-
Lumber and wood products, except furniture	2	-	2	-	-	-	-	-	8	-	-
Furniture and fixtures	244	-	244	-	-	-	-	-	2	1	99
Stone, clay, and glass products	90	-	90	16	-	16	-	-	34	1	-
Primary metal industries	94	2	92	101	-	101	-	-	25	1	-
Fabricated metal products	654	-	654	54	-	54	-	-	3	-	-
Machinery, except electrical	1,592	2	1,590	610	9	601	-	-	7	-	-
Electrical machinery and equipment	553	11	542	985	-	985	-	-	25	6	-
Transportation equipment	400	2	398	112	-	112	-	-	32	-	-
Instruments; photographic and optical goods	372	-	372	477	-	477	-	-	40	-	-
Nondurable goods	534	-	534	21	-	21	-	95	78	15	8
Food and kindred products	73	-	73	12	-	12	-	-	17	3	-
Textile mill products	17	-	17	-	-	-	-	-	-	-	-
Apparel and other finished fabric products	2	-	2	-	-	-	-	-	-	-	-
Paper and allied products	101	-	101	-	-	-	-	-	9	3	2
Printing, publishing, and allied industries	74	-	74	2	-	2	-	60	-	8	-
Chemicals and allied products	176	-	176	4	-	4	-	-	37	-	-
Petroleum refining and related industries	8	-	8	3	-	3	-	35	14	1	-
Rubber and miscellaneous plastic products	22	-	22	-	-	-	-	-	-	-	6
Leather and leather products	23	-	23	-	-	-	-	-	-	-	-
Miscellaneous manufacturing industries	38	-	38	-	-	-	-	-	1	-	-
Nonmanufacturing	1,961	1,003	958	1,262	202	1,060	270	497	168	637	32
Mining	6	-	6	-	-	-	-	10	-	-	-
Contract construction	545	505	40	24	24	-	9	-	-	46	-
General building contractors	46	6	40	-	-	-	-	-	-	46	-
Heavy construction	5	5	-	-	-	-	9	-	-	-	-
Special trade contractors	494	494	-	24	24	-	-	-	-	-	-
Transportation, communication, and public utilities	23	19	4	226	104	122	8	42	-	26	-
Railroad transportation	4	-	4	-	-	-	4	-	-	-	-
Local and interurban passenger transportation	-	-	-	-	-	-	-	-	-	2	-
Air transportation	-	-	-	-	-	-	-	-	-	-	-
Communication	-	-	-	114	-	114	-	-	-	20	-
Electric, gas, and sanitary services	19	19	-	112	104	8	4	42	-	4	-
Wholesale and retail trade	327	16	311	50	-	50	-	-	74	30	-
Wholesale trade	286	16	270	50	-	50	-	-	23	30	-
Retail trade	41	-	41	-	-	-	-	-	51	-	-
Building materials, hardware, and farm equipment	-	-	-	-	-	-	-	-	-	-	-
General merchandise stores	-	-	-	-	-	-	-	-	34	-	-
Food stores	-	-	-	-	-	-	-	-	3	-	-
Apparel and accessories	-	-	-	-	-	-	-	-	1	-	-

Continued

Table I-1, part B (concluded)

Industry group	Mechanical: Total	Mechanical: Construction	Mechanical: Other	Electro-mechanical: Total	Electro-mechanical: Construction	Electro-mechanical: Other	Highway (b)	Map (c)	Plant layout	General draftsmen	Draftsmen n.e.c.
Retail trade (continued)											
Furniture, home furnishings, and equipment	-	-	-	-	-	-	-	-	10	-	-
Eating and drinking places	-	-	-	-	-	-	-	-	3	-	-
Miscellaneous retail stores	41	-	41	-	-	-	-	-	-	-	-
Finance, insurance, and real estate	3	3	-	-	-	-	-	5	15	2	4
Banking	-	-	-	-	-	-	-	-	3	-	4
Insurance carriers	-	-	-	-	-	-	-	-	7	-	-
Insurance agents, brokers, and services	-	-	-	-	-	-	-	-	-	2	-
Real estate	3	3	-	-	-	-	-	-	-	-	-
Holding and other investment companies	-	-	-	-	-	-	-	5	5	-	-
Services and miscellaneous	956	433	523	896	74	822	120	338	74	419	21
Personal services	-	-	-	-	-	-	-	-	2	-	-
Miscellaneous business services	267	39	228	591	9	582	25	59	36	177	8
Advertising, news, credit, duplicating, building, and related services	-	-	-	-	-	-	-	-	-	-	-
Business services n.e.c.	267	39	228	591	9	582	25	59	36	177	8
Research, development, testing laboratories	4	-	4	240	9	231	-	-	-	19	-
Business and management consulting services	201	39	162	132	-	132	25	24	33	113	8
Other business services n.e.c.	62	-	62	219	-	219	-	35	3	45	-
Miscellaneous repair services	-	-	-	-	-	-	-	-	20	-	-
Motion pictures	2	-	2	-	-	-	-	-	-	-	-
Amusement and recreation, except motion pictures	-	-	-	-	-	-	-	-	-	-	-
Private medical services	-	-	-	2	-	2	-	-	1	-	-
Voluntary hospitals	-	-	-	-	-	-	-	-	1	-	-
Medical and dental laboratories	-	-	-	2	-	2	-	-	-	-	-
Private colleges and schools	44	-	44	1	-	1	-	1	2	-	-
Nonprofit membership organizations	2	-	2	-	-	-	-	-	-	-	-
Miscellaneous services	641	394	247	302	65	237	95	278	13	242	13
Engineering and architectural services	640	394	246	282	65	217	95	278	13	242	13
Nonprofit educational and scientific research	1	-	1	20	-	20	-	-	-	-	-
Government	101	27	74	66	-	66	133	102	5	114	7
County	1	1	-	-	-	-	35	39	-	8	2
New York State	23	23	-	-	-	-	95	12	-	2	5
Colleges	-	-	-	-	-	-	-	-	-	2	-
Other	23	23	-	-	-	-	95	12	-	-	5
New York City	51	1	50	-	-	-	-	3	1	3	-
Hospitals	1	1	-	-	-	-	-	-	-	-	-
Colleges	-	-	-	-	-	-	-	-	1	-	-
Other	50	-	50	-	-	-	-	3	-	3	-
Cities other than New York City	1	1	-	-	-	-	-	28	-	19	-
Towns and villages	-	-	-	-	-	-	-	20	-	26	-
Federal	25	1	24	66	-	66	3	-	4	56	-
Hospitals	1	1	-	-	-	-	-	-	-	-	-
Arsenals and navy yards	22	-	22	64	-	64	-	-	-	18	-
Other	2	-	2	2	-	2	3	-	4	38	-

a. Do both architectural and structural drafting.
b. Highway, street, and related construction drafting.
c. Map, topographical, and geological drafting.

Draftsmen

Table I-2. OCCUPATION OF DRAFTSMEN'S SUPERVISORS
(Percent distribution of draftsmen according to supervisor's occupation)

Occupation	Total number	Occupation of supervisor			
		Total	Engineer or architect	Draftsman or other technician	Other
All occupations	20,972	100.0	61.1	28.7	10.2
Architectural and structural	6,294	100.0	66.8	23.9	9.3
Construction	5,973	100.0	66.6	23.7	9.7
Architectural	3,508	100.0	66.9	24.1	9.0
Structural	1,955	100.0	62.8	25.4	11.8
Combination: architectural and structural	510	100.0	78.6	14.3	7.1
Aircraft structures	105	100.0	32.4	67.6	-
Ship structures	216	100.0	89.8	8.8	1.4
Electrical-electronic	2,301	100.0	54.3	40.8	4.9
Construction	684	100.0	65.5	32.5	2.0
Other	1,617	100.0	49.6	44.3	6.1
Mechanical	6,526	100.0	60.6	30.4	9.0
Construction	1,020	100.0	79.9	19.4	0.7
Other	5,506	100.0	57.1	32.4	10.5
Electro-mechanical	3,767	100.0	63.0	24.3	12.7
Construction	211	100.0	68.3	14.2	17.5
Other	3,556	100.0	62.7	24.9	12.4
Highway, street, and related construction	270	100.0	51.1	44.1	4.8
Map, topographical, and geological	592	100.0	39.0	33.3	27.7
Plant layout	422	100.0	61.3	19.0	19.7
General draftsmen	661	100.0	57.0	36.3	6.7
Draftsmen n.e.c.	139	100.0	31.7	19.4	48.9

D r a f t s m e n

Table 1-3. EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

(Percent distribution of draftsmen according to level of education required)

A. Architectural and Structural Draftsmen and Electrical-electronic Draftsmen

Education required	All occupations	Architectural and structural					Electrical-electronic	
		Construction			Aircraft structures	Ship structures	Construction	Other
		Architectural	Structural	Combination (a)				
All levels: Number	20,972	3,508	1,955	510	105	216	684	1,617
Percent distribution								
All levels: Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	40.0	56.4	34.0	43.5	32.4	22.7	44.3	32.0
Engineering college or architectural school	7.1	28.1	4.5	2.7	1.9	1.4	35.0	0.7
Graduation	3.1	17.1	0.3	1.6	-	-	-	-
Less than graduation	4.0	11.0	4.2	1.1	1.9	1.4	35.0	0.7
College, general	1.1	1.0	0.8	2.7	-	-	-	1.2
Graduation	0.1	0.1	-	-	-	-	-	-
Less than graduation	1.0	0.9	0.8	2.7	-	-	-	1.2
Technical institute or community college	17.7	19.0	16.4	22.2	28.6	0.5	3.2	13.5
Graduation	15.7	18.7	16.2	20.6	28.6	0.5	3.2	8.7
Less than graduation	2.0	0.3	0.2	1.6	-	-	-	4.8
Type not specified	10.6	8.3	12.3	14.9	1.9	20.8	5.7	13.9
Apprenticeship or armed forces school	3.5	-	-	1.0	-	-	0.4	2.7
High school	60.0	43.6	66.0	56.5	67.6	77.3	55.7	68.0
Technical or vocational	11.2	8.0	6.9	9.0	-	47.2	14.0	10.8
Other and not specified	48.8	35.6	59.1	47.5	67.6	30.1	41.7	57.2

Table 1-3 (concluded)

B. Draftsmen Other Than Architectural and Structural and Electrical-electronic

Education required	Mechanical: Construction	Mechanical: Other	Electro-mechanical: Construction	Electro-mechanical: Other	Highway (b)	Map (c)	Plant layout	General draftsmen	Draftsmen n.e.c.
All levels: Number	1,020	5,506	211	3,556	270	592	422	661	139
Percent distribution									
All levels: Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	22.4	35.7	46.0	47.4	18.1	32.8	28.7	41.0	5.8
Engineering college or architectural school	1.7	1.5	-	0.5	-	-	3.3	1.1	-
Graduation	-	0.4	-	0.1	-	-	1.2	0.2	-
Less than graduation	1.7	1.1	-	0.4	-	-	2.1	0.9	-
College, general	-	2.1	-	0.8	-	0.4	0.2	0.9	-
Graduation	-	(d)	-	0.1	-	0.2	-	0.7	-
Less than graduation	-	2.1	-	0.7	-	0.2	0.2	0.2	-
Technical institute or community college	9.7	21.2	31.8	16.5	18.1	10.6	17.4	32.5	5.8
Graduation	8.4	17.5	31.8	14.3	18.1	8.7	17.2	31.8	5.8
Less than graduation	1.3	3.7	-	2.2	-	1.9	0.2	0.7	-
Type not specified	10.1	9.3	14.2	13.0	-	21.5	7.3	6.5	-
Apprenticeship or armed forces school	0.9	1.6	-	16.6	-	0.3	0.5	-	-
High school	77.6	64.3	54.0	52.6	81.9	67.2	71.3	59.0	94.2
Technical or vocational	26.1	12.7	18.0	8.8	9.3	4.9	22.5	4.5	8.6
Other and not specified	51.5	51.6	36.0	43.8	72.6	62.3	48.8	54.5	85.6

a. Do both architectural and structural drafting.
b. Highway, street, and related construction drafting.
c. Map, topographical, and geological drafting.
d. Less than 0.05 of a percent.

Table 1-4. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of draftsmen according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	20,972	20,972	100.0	100.0
Post-high-school	8,387	13,688	40.0	65.3
Engineering college or architectural school	1,481	2,925	7.1	13.9
Graduation	645	1,831	3.1	8.7
Less than graduation	836	1,094	4.0	5.2
College, general	236	870	1.1	4.1
Graduation	15	260	0.1	1.2
Less than graduation	221	610	1.0	2.9
Technical institute or community college	3,697	7,360	17.7	35.2
Graduation	3,286	6,821	15.7	32.6
Less than graduation	411	539	2.0	2.6
Type not specified	2,231	1,851	10.6	8.8
Apprenticeship or armed forces school	742	682	3.5	3.3
High school	12,585	7,284	60.0	34.7
Technical or vocational	2,345	1,522	11.2	7.3
Other and not specified	10,240	5,762	48.8	27.4

Table I-5. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Percent distribution of draftsmen according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require: Post-high-school: Post-high-school, total	Post-high-school: Engineering college: Graduation	Post-high-school: Engineering college: Less than graduation	Post-high-school: College, general: Graduation	Post-high-school: College, general: Less than graduation	Post-high-school: Technical institute: Graduation	Post-high-school: Technical institute: Less than graduation	Post-high-school: Type not specified	High school: High school, total	High school: Technical or vocational	High school: Other and not specified
All levels	100.0	64.8	35.2	33.3	5.7	2.2	1.2	2.0	19.8	1.0	1.4(b)	1.9	1.3	0.6
Post-high-school	100.0	80.0	20.0	18.6	9.3	1.4	1.5	1.1	5.2	(a)	0.1	1.4	(a)	1.4
Engineering college or architectural school	100.0	86.0	14.0	13.9	13.2	-	-	-	0.7	-	-	0.1	-	0.1
Graduation	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	75.2	24.8	24.6	23.4	-	-	-	1.2	-	-	0.2	-	0.2
College, general	100.0	86.9	13.1	13.1	8.4	-	4.7	-	-	-	-	-	-	-
Graduation	100.0	73.3	26.7	26.7	26.7	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	87.3	12.7	12.7	7.7	-	5.0	-	-	-	-	-	-	-
Technical institute or community college	100.0	80.6	19.4	18.0	11.1	1.8	2.2	0.6	2.2	-	0.1	1.4	-	1.4
Graduation	100.0	80.7	19.3	17.7	12.4	2.0	2.5	0.6	-	-	0.2	1.6	-	1.6
Less than graduation	100.0	79.6	20.4	20.4	0.5	-	-	-	19.9	-	-	-	-	-
Type not specified	100.0	70.9	29.1	26.4	7.1	1.4	1.3	3.3	13.2	0.1	-	2.7	(a)	2.7
Apprenticeship or armed forces school	100.0	90.3	9.7	9.4	-	2.6	-	-	6.8	-	-	0.3	-	0.3
High school	100.0	54.7	45.3	43.1	3.2	2.8	1.0	2.6	29.6	1.7	2.2(b)	2.2	2.2	(a)
Technical or vocational	100.0	53.0	47.0	46.9	3.5	1.0	0.3	2.7	38.8	0.3	0.3	0.1	-	0.1
Other and not specified	100.0	55.1	44.9	42.2	3.1	3.2	1.2	2.5	27.6	2.0	2.6(b)	2.7	2.7	-

a. Less than 0.05 of a percent.
b. Includes 0.1 "apprenticeship or armed forces school."

Draftsmen

Table I-6. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number of draftsmen according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
All levels	20,972	11,983	8,989	1,485	3,218	3,122	1,164
Post-high-school	8,387	6,151	2,236	733	579	576	348
Engineering college or architectural school	1,481	1,186	295	88	80	115	12
Graduation	645	604	41	39	-	2	-
Less than graduation	836	582	254	49	80	113	12
College, general	236	189	47	14	25	8	-
Graduation	15	10	5	1	-	4	-
Less than graduation	221	179	42	13	25	4	-
Technical institute or community college	3,697	2,589	1,108	507	253	237	111
Graduation	3,286	2,305	981	464	253	203	61
Less than graduation	411	284	127	43	-	34	50
Type not specified	2,231	1,517	714	122	221	189	182
Apprenticeship or armed forces school	742	670	72	2	-	27	43
High school	12,585	5,832	6,753	752	2,639	2,546	816
Technical or vocational	2,345	1,028	1,317	212	349	453	303
Other and not specified	10,240	4,804	5,436	540	2,290	2,093	513

D r a f t s m e n

Table I-7. EMPLOYERS' METHOD OF OBTAINING DRAFTSMEN, BY OCCUPATION

(Percent distribution of draftsmen according to method of obtaining them)

Occupation	Total number	Percent distribution: All methods	Recruited from outside the firm	Upgraded with organized training	Upgraded without organized training
All occupations	20,972	100.0	69.0	2.5	28.5
Architectural and structural	6,294	100.0	80.5	0.3	19.2
Construction	5,973	100.0	80.1	0.3	19.6
Architectural	3,508	100.0	84.1	0.3	15.6
Structural	1,955	100.0	77.4	0.4	22.2
Combination: architectural and structural	510	100.0	62.5	0.2	37.3
Aircraft structures	105	100.0	86.7	-	13.3
Ship structures	216	100.0	89.8	-	10.2
Electrical-electronic	2,301	100.0	59.9	1.4	38.7
Construction	684	100.0	47.8	0.1	52.1
Other	1,617	100.0	64.9	2.0	33.1
Mechanical	6,526	100.0	70.1	2.1	27.8
Construction	1,020	100.0	81.3	0.4	18.3
Other	5,506	100.0	68.1	2.4	29.5
Electro-mechanical	3,767	100.0	50.9	7.5	41.6
Construction	211	100.0	53.6	-	46.4
Other	3,556	100.0	50.8	7.9	41.3
Highway, street, and related construction	270	100.0	62.6	-	37.4
Map, topographical, and geological	592	100.0	75.6	0.2	24.2
Plant layout	422	100.0	68.5	4.5	27.0
General draftsmen	661	100.0	82.7	3.2	14.1
Draftsmen n.e.c.	139	100.0	64.8	5.0	30.2

Cnapter II

STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS

The small group of technical occupations in structural design employs approximately 2,500 persons, or 2 percent of all persons in technical occupations in New York State. The number of technicians and specialists in each subgroup of this classification is shown in table II-A.

The work of the persons in this structural-design classification is closely related to architectural and structural draftsman occupations (which were taken up in chapter I). It differs from that of those electro and mechanical engineering technicians who work with engineers in designing electrical, electronic, mechanical, and electro-mechanical equipment, products, and instruments (see chapter III).

The largest concentration of structural design technicians and related specialists is found in engineering and architectural services and in business and management consulting services. Substantial numbers, also are employed by building contractors and, in manufacturing, by producers of aircraft and of ships. Some work for government agencies. The technical workers reported in food, chemicals, and other manufacturing are employed in connection with plant design and ventilation and other equipment design. (Table II-B, based on table II-1, at the end of the chapter.)

Nearly 90 percent of the structural design technicians and specialists work under the direction of architects or engineers, or technicians of higher grade. The remainder work under production foremen or management officials. (Table II-C.)

Table II-A. NUMBER AND PERCENT DISTRIBUTION OF STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS BY OCCUPATION

Occupation	Number	Percent
All occupations	2,516	100.0
Construction	2,004	79.6
Architectural	349	13.9
Structural	337	13.4
Combination: architectural and structural	71	2.8
Electrical	186	7.4
Mechanical	467	18.6
Combination: electrical and mechanical	162	6.4
Highway, street, and related construction n.e.c.	76	3.0
General construction	356	14.1
Aircraft structure	427	17.0
Design	261	10.4
Lofting	166	6.6
Ship structure	85	3.4
Design	28	1.1
Lofting	57	2.3

FUNCTIONS

The following sections describe the functions performed by the various types of structural design technician and specialist, and indicate the technical skills they need for the work they do.

Architectural Designers

Technicians who are architectural designers assist in the design of a large variety of structures, such as private dwellings, apartment houses, office buildings, theatres, recreational facilities, schools, churches, department stores, manufacturing and other industrial plants, municipal buildings, and civic centers.

Table II-B. NUMBER AND PERCENT DISTRIBUTION OF STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS BY INDUSTRY GROUP

Industry group	Number	Percent
All industries	2,516	100.0
Manufacturing	495	19.7
Transportation equipment (aircraft and ship)	429	17.1
Food and kindred products	16	0.6
Chemicals and allied products	36	1.4
Other manufacturing	14	0.6
Nonmanufacturing	2,021	80.3
Contract construction	329	.1
Transportation and public utilities	83	3.3
Wholesale trade	37	1.5
Business services n.e.c.	495	19.7
Research, development, testing laboratories	55	2.2
Business and management consulting services	339	13.5
Other business services	101	4.0
Engineering and architectural services	945	37.5
Government	126	5.0
Other nonmanufacturing	6	0.2

Usually working under the direction of an architect, they make preliminary studies, plans, sketches, renderings, models, cardboard prototypes, color schemes, and plans for materials to be used for the interior or exterior of various types of structure, incorporating the client's functional and aesthetic requirements.

They work from preliminary specifications, survey maps, plans and drawings of buildings to be renovated, other architectural plans and drawings for interior designs (space, color schemes, furniture placements, equipment of all types, lobbies, functional relationship of all facilities, and efficient space utilization); engineering reports and specifications; materials catalogs, handbooks, architectural and technical literature, and building codes. They may work with and coordinate the work of designers of structural components and equipment components (steel, concrete, masonry, timber, heating, ventilating, air conditioning, plumbing, power and light, interiors, etc.). They prepare specifications, sketches, notes, instructions, dimension requirements, etc., needed by draftsmen to make drawings.

Table II-C. PERCENT DISTRIBUTION OF STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS, BY OCCUPATION OF SUPERVISOR

Occupation	Occupation of supervisor			
	Total	Architect or engineer	Technician (a)	Other
All occupations	100.0	46.7	42.4	10.9
Construction	100.0	44.0	46.0	10.0
Architectural	100.0	50.7	28.1	21.2
Structural	100.0	38.6	58.4	3.0
Combination: architectural and structural	100.0	28.2	59.1	12.7
Electrical	100.0	33.9	58.0	8.1
Mechanical	100.0	39.6	52.9	7.5
Combination: electrical and mechanical	100.0	58.6	35.8	5.6
Highway, street, and related construction n.e.c.	100.0	94.8	3.9	1.3
General construction	100.0	39.0	47.8	13.2
Aircraft structure	100.0	62.7	34.0	3.3
Design	100.0	100.0	-	-
Lofting	100.0	4.2	87.4	8.4
Ship structure	100.0	29.4	-	70.6
Design	100.0	89.3	-	10.7
Lofting	100.0	-	-	100.0

a. Structural design technician or related specialist, or other technician.

They may make preliminary cost estimates for clients, prepare bid specification documents, estimate time requirements, prepare work schedules, and assume responsibility for fulfilling specifications and building code requirements.

They may be responsible for overseeing an entire project, from start to finish, meeting with clients, engineers, contractors, and subcontractors to check and discuss progress, change orders, etc.

<u>Technical skills</u> needed include:

Ability to use the drawing and drafting instruments of the architectural draftsman; the degree depends on the nature of the design and the extent to which the designer is required to formulate, initiate, illustrate, and indicate ideas, plans, proposals, etc. Artistic and aesthetic expression on paper requires, as well, use of artists' and illustrators' equipment and materials.

Ability to read and interpret office and field notes, specifications, handbooks and manuals, pictorials, engineering terminology and graphic symbols, shop terms and processes, and field construction methods and logistics.

Structural Designers

These technicians assist in the design of structural components of buildings. The complexity of the problems they deal with varies from simple low-rise, statically loaded structures to those for which complex stress analysis must be made prior to design.

They work from architectural plans, existing building plans, engineering designs, engineering drawings, framing plans, sketches, maps, profiles, soil borings test data, specifications, and code requirements prepared by architects, engineers, surveyors, clients, manufacturers, public works agencies and other governmental agencies, draftsmen, other designers, vendors, contractors, as well as fron statistical data, test data, catalogs, textbooks, charts, handbooks, and technical literature.

They make partial or complete designs of structural steel elements, such as roof trusses, internal trusses, columns, girders, beams, braces, and struts; also reinforced concrete slabs, columns, footings, foundations, soil-bearing pads, piling, bar steel requirement and placements, etc.

They make analyses of soil-bearing and boring-test data, static and dynamic loads and stresses, size requirements, space requirements, materials to be used, economical use and placement of structural elements, and factors affecting the ultimate design.

They may prepare specifications, sketches, drawings, notes, and other information required for the completion of the structure by other designers, draftsmen, fabricators, contractors, vendors, manufacturers, etc.

They may be required to supervise, coordinate, and check the work of draftsmen.

They may be required to make field inspections and tests to check the progress of the work and to confer with fabricators, contractors, suppliers, and field engineers and make reports.

Technical skills needed include:

Ability to read and interpret engineering and architectural drawings and customer's requirements and specifications and to make necessary sketches, drawings, and notes for draftsmen, other designers, fabricators, manufacturers, etc.

Ability to use drawing and drafting equipment.

Electrical Designers

These technicians design and assist in the design of electrical wiring for light and power, communications, etc., for buildings. They work from architectural and engineering drawings and specifications of proposed structures and buildings.

They make layouts and schematics; prepare wiring specifications for light and power; locate wiring layouts, ducts, conduits, etc., on architectural and engineering prints.

They establish wiring requirements for service entrances, transformer vaults, main and local distribution panels, feeder and branch circuitry of light and power, clock systems, alarm systems, paging systems, emergency lighting systems, heating and ventilating electrical controls, public address systems, telephony wiring systems, ducts, risers, conduits, etc.

They make necessary calculations to determine the size of panel boards, electrical components, switches, switch gear, protective devices, motors, etc.

They may confer and work with clients, vendors, suppliers, manufacturers, architects, engineers, and contractors; make field inspections and follow-ups; submit reports and make necessary changes where required; plan, schedule, and coordinate work of other designers and draftsmen.

Technical skills needed include:

Ability to read and use architectural and structural prints and drawings, electrical schematics, technical handbooks, and codes.

Ability to use drafting equipment and make drawings and sketches according to accepted standards and practices.

Ability to use electrical engineering technology and theory to make necessary calculations for wiring circuitry and electrical components.

Mechanical Designers

Typically, these technicians assist in the layout of and selection of major components for systems involving heat exchange, sanitation, chemical production, etc.

They work from architectural plans, existing building plans, engineering drawings, framing plans, sketches, flow diagrams, specifications, etc., prepared or supplied by architects, engineers, clients, manufacturers, other designers, draftsmen, vendors, contractors, as well as fron statistical data, test data, catalogs, textbooks, handbooks, and technical literature.

They prepare sketches of piping systems, duct work, flow diagrams, sanitation systems, vacuum systems, etc., for fuel, waste, gas, air, water, chemicals, etc., for the use of other designers or draftsmen, and make necessary detail and layout drawings or supervise the preparation of drawings by others.

They make computations and assist in the selection and location of properly rated sizes of manufactured equipment, such as piping, pumps, prime movers, heat exchangers, boilers, compressors, fuel storage tanks, valves, controls, telemetering devices, cooling towers, sanitation facilities, etc., suited to the requirements and specifications of the project. They make calculations of strength of materials, weights, simple forces and stresses, etc., using charts, tables, nomographs, and catalogs.

They may be required to confer with equipment manufacturers to arrange for modifications and adaptations to ensure feasible use within the limits and tolerances of the design requirements.

They may supervise, coordinate, and check the work of other designers and draftsmen involved in the same project and give technical guidance as needed. They may make field surveys of existing equipment that is to be modified or incorporated into the design of the new facility. They may be required to make periodic field inspections of work in progress and confer with fabricators, contractors, field engineers, and clients and make necessary reports or changes in design as required by on-the-job conditions.

Technical skills needed include:

Ability to use standard drafting equipment; to read architectural and framing plans for a variety of structures; to read and interpret flow diagrams, schematics, and line diagrams for mechanical systems; to make simple or comprehensive sketches suitable for draftsmen; to use standard mechanical engineering tables, charts, handbooks, manuals, as well as manufacturers' catalogs and technical literature.

Designers: Highway, Street, and Related Construction

These designers lay out and/or design streets, roads, highways, and related construction, involving grades, curbs, curves, storm-water catch basins and drains, culverts, sanitary sewers, pumping stations, water mains, fire hydrants, bridges, tunnels, etc.

They work from surveying field notes and office computations, field and office sketches, newly prepared and existing land maps (plats, topographical, cadestral, reconnaissance, engineering, profile, etc.), specifications, civil engineers' instructions and designs, as well as textbooks, handbooks, technical literature, standards of the American Association of State Highway Officials, and of the American Society of Testing and Materials, standards for highway construction materials, and local land-use codes and ordnances.

They make earthwork computations for cut-and-fill and borrow pits, using profile and contour maps; make computations for vertical and horizontal curves and establish line and grades; make computations involving the number, size, type, and placement of materials used for road surfaces, utilities, etc.

They make preliminary and final sketches of the placement of various utilities, retaining walls, cribbage, etc.

They coordinate layouts with existing or proposed installations of other utilities such as sanitary sewers, underground and aerial electric and telephone cables, road and street lighting poles, etc.

They may make takeoffs from maps and drawings to estimate quantities, types, and costs of materials used in all parts of the project.

They may be required to make field trips to confer with inspectors or field engineers, check work progress, ascertain changes in designs necessitated by on-the-job conditions and problems encountered by contractor, and check contractor performance in accordance with specifications and accepted standards of highway, road, and street construction.

They may be required to use surveying instruments to check conformance of lines and grades with design requirements.

They may be required to make preliminary and final drawings incorporating all necessary information for field construction.

Technical skills needed include:

Ability to use drafting instruments and engineering drawings related to area of design; ability to read and interpret surveying field notes, land maps of all types, and local land use codes and ordnances; ability to use surveying instruments; ability to use tables, charts, handbooks, manufacturers' catalogs, and technical data.

Designers: Aircraft and Ship

Aircraft designer technicians assist in the design of structural airframe components requiring complex stress analysis, such as engine mounts, conic-section bulkheads, tapered beams, and compression members. They also work on the original design of structural and nonstructural subassemblies, requiring simple stress analysis and involving axial load distributions such as bolted and riveted joints and splices, small fittings, and simple beams and trusses.

They work directly from sketches, engineering drawings of parallel designs, standards dictated by the Federal government, trade standards and manufacturer's standards, vendor and contractor specifications, test data, parts data, reference texts, technical handbooks, and trade literature.

They assist in quality-control engineering and in the redesign of both structural and nonstructural members. They write detail specifications, operation sheets, and routing sheets for redesigned units, while working in close liaison with the drafting, lofting, and stress departments.

They are called upon to draw up specifications and make sketches and notes required by subcontractors, vendors, draftsmen, etc., to facilitate completion of the design.

They work with inspection personnel and the drafting department to specify necessary corrective action in the event of assembly-line error and make the necessary sketches and drawings.

Technical skills needed include:

Ability to read blueprints; ability to use drafting instruments, reference, and engineering manuals; ability to operate test equipment such as hardness testers, X-ray and magnaflux equipment; ability to use precision instruments such as vernier height and depth gauges, taper gauges, strain gauges, and torque wrenches.

Ship designer technicians in New York State are very few in number. For the most part they serve as general assistants to engineers and architects.

Loftsmen: Aircraft and Ship

Aircraft loftsmen lay out the lines of airplane structural components prior to the making of final blueprints. Their functions may include one or more of the following:

From engineering data and sketches, they lay out and develop lines and configurations of proposed models in full-sized or scaled proportions to establish and ascertain basic shapes, critical dimensions, tolerances, etc.

Transfer engineering changes and revised prints to loft plates to assure incorporation of all changes and dimensions. Contact engineering personnel to point out drafting errors and dimensional corrections required.

Prepare templates.

May prepare tables of full-scale offsets.

At higher levels, may suggest changes in design and contour to eliminate fabrication difficulties.

Ship loftsmen lay out the lines of a ship to full size in various plan views on the loft floor. They make adjustments until corresponding points in all views agree. They construct templates of metal structure parts, molds, and wood mock-ups to be used as patterns, guides, and checks for the layout and fabrication of various structural parts.

Technical skills needed by loftsmen include:

Ability to work from blueprints, tables of offsets, loft-floor plans, etc.; ability to use draftsman's tools and woodworking tools such as saws, planers, and jointers.

SUBJECT MATTER KNOWLEDGE

The general subject-matter needs of structural design technicians and related specialists are trigonometry, general physics, and technical drawing. Trigonometry is a minimum requirement for the design of structures where angular, linear, and curvilinear configurations are widely applied. General physics is fundamental to the design of structural members subjected to either static or dynamic force and moment systems, such as beams, columns, slabs, trusses, and structural bases, frames, housings, and supports for mechanical or electrical machinery.

The designer needs the skill and knowledge of the draftsman, for he may be required to make design drawings, sketches, layouts, schematics, etc. of structures or components within a specialty area or a combination of several areas.

Beyond the basic requirements mentioned above, the subject-matter needs of structural design technicians and related specialists are determined to a large degree by grade level and field of specialization (architectural, structural, electrical, mechanical, etc.)

Table II-D shows in summary form the subjects that employers reported as generally needed, or needed in a substantial number of cases, or needed occasionally by architectural, structural, and other construction design technicians. The following paragraphs give more information on these points.

The needs of the <u>architectural designer</u> vary depending on his function and major area of work, but a knowledge of architectural and structural technologies is generally needed. In a substantial number of cases, this designer needs a general knowledge of chemistry to understand problems of oxidation and corrosion of building materials used in interiors and exteriors where atmospheric conditions such as salt air or air pollution affect life and maintenance. Problems involving heating, ventilating, and air conditioning, electric power and light, and insula-

Table II-D. SUBJECT MATTER KNOWLEDGE NEEDED BY STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS IN SELECTED CONSTRUCTION OCCUPATIONS

Subject	Architectural	Structural	Electrical	Mechanical	Highway, street, and related construction
Mathematics:					
Trigonometry	XXX	XXX	XXX	XXX	XXX
Advanced algebra	-	XX	-	XX	-
Solid geometry	X	X	-	X	XX
Analytic geometry	-	XX	XX	XX	-
Calculus	X	XX	XX	-	XX
Science:					
Chemistry, general	XX	XX	XX	X	XX
Metallurgy	-	-	-	X	-
Physics, general	XXX	XXX	XXX	XXX	XXX
Hydraulics	X	XX	XX	XX	XX
Thermodynamics	X	-	XX	XX	-
Technology:					
Technical drawing	XXX	XXX	XXX	XXX	XXX
Electrical technology, orientation	-	X	-	-	-
Basic electricity	XX	X	XXX	XX	XX
Electrical codes	XX	X	XX	XX	XX
Mechanical technology, orientation	X	X	X	XXX	XX
Mechanics and strength of materials	XX	XX	-	-	XX
Heating, ventilating, air conditioning, refrigeration, sanitation	XX	-		XXX	-
Architectural technology, orientation	XXX	X	-	-	-
Civil technology, orientation	-	X	-	-	XXX
Construction technology, orientation	XXX	XXX	XX	XX	XX
Concrete and steel	-	X	-	-	XX
Building codes, except electrical	XX	XX	X	XX	X
Acoustics	XX	-	XX	-	-
Descriptive geometry	-	-	-	X	-

Key: XXX= generally needed; XX= needed in a substantial number of cases; X= occasionally needed.

tion and acoustics call for a knowledge of heat, light, sound, electrical theory, and governmental codes. Knowledge of mechanics and strength of materials is useful in the selection of materials and in determining sizes required for given loadings.

Solid geometry and calculus may be needed by the top-grade or supervisory designer in reviewing and studying technical literature relating to the development of geometric shapes and curves used in many modern architectural designs. Moreover, hydraulics, thermodynamics, and orientation in mechanical technology are subjects required by the top-grade designer, since his functions may call for coordinating the work of specialists in specific areas of design of structures.

The structural designer is a specialist in steel or concrete designs for a whole structure or for component sections and generally requires an orientation in construction technology. The extent to which advanced algebra, analytic geometry, or calculus is used depends on the grade or level of designer. A designer may be required to perform design calculations on complex structural frames, arches, curvilinear and geodesic shapes, etc., which require the higher mathematics. Mechanics and strength of materials are used for the selection of types and sizes of materials, load and stress distribution, design of beams, and other components of load-carrying frames. A knowledge of hydraulics finds application in the design of pressure vessels, dams, water storage tanks, and their supporting structures.

The structural designer occasionally requires a knowledge of basic electricity and of electrical codes, and an orientation in mechanical, architectural, and civil engineering technology.

The electrical design technician generally needs a knowledge of basic electricity. In a substantial number of cases, especially at the higher grades, he needs to know electrical codes; the mathematics necessary to make computations to select and size materials for conductors, insulators, cable spacings, switches, transformers, electrical machinery, etc.; and circuitry for control, protection, telemetering, annunciating, telephony, lighting, and other systems. The need for analytic geometry and calculus is generally restricted to the top-level designer.

General chemistry, hydraulics, and thermodynamics may serve the needs of the electrical designer for a variety of designs. Examples are electrically-operated devices, such as pH indicators and control-valving in water treatment plants; heating, ventilating, and air conditioning control circuits; placement and control of illuminating devices and emergency lighting systems; and auxiliary power systems.

The electrical designer in the construction field must work from architectural, structural, and engineering drawings and specifications. A knowledge of construction technology, especially needed by the higher or supervisory grade designer, is applicable in preliminary and final layouts of conduits, ducts, trays, and risers, placement of heavy electrical equipment in relation to structural support requirements, service entrances, transformer vaults, lighting fixtures, and switches.

Knowledge of mechanical technology and heating, ventilating, and air conditioning are basic requirements for the top-grade mechanical design technician. The planning, layout, and final design require calculations for sizes of boilers and convectors, ventilating fans and blowers, refrigeration equipment, cooling towers, and carrier systems, such as pipes, vents, ducts, etc. This designer's functions may include the writing of specifications for such systems. Advanced algebra, analytic geometry, and mechanics are applicable in the solution of mechanical design problems that require analysis of manufacturer's data and technical literature such as load-characteristic curves for mechanical equipment, thermal curves, heating and cooling surfaces, gas and fluid flow, machinery vibration characteristics, etc. Principles of hydraulics are applied to problems in fluid flow systems, such as sanitation, cooling, heating, control, washing, valving, and water supply. Thermodynamics and mechanical technology are required of the higher-grade designer in the design and planning of power plant (diesel, steam, and gas turbine), engines, heat exchangers, and air conditioning, ventilating, and heating systems.

In a substantial number of cases, the mechanical designer of equipment for structures must have an orientation in construction technology so that he is able to discuss with architects, engineers, and clients the varied problems involved in the installation of machinery, heating equipment, ducts, plumbing, etc., and their relation to the structural and architectural features of the building.

Solid geometry may be used by the mechanical designer in volumetric design of various shapes of pressure vessels, tanks, etc. Descriptive geometry is applicable to the solution of design layouts, such as duct work, piping, and steam line expansion loops. Chemistry and metallurgy are needed if the designer's work includes the selection of materials for mechanical, heat transfer, piping, and control systems exposed to temperature variations, chemicals, direct stresses, fatigue stresses, corrosive effects, and vibratory motion. Such a designer is required to interpret test data, engineering data, and physical and chemical characteristics of metals, and to apply this information to the solution of design problems.

Some mechanical designers may be required to lay out electrical circuits and wiring found in thermostatic controls, pneumatic and hydraulic valving, electromechanical pressure indicators, etc.

Established codes (plumbing codes, building codes, industrial standards) are of prime importance for the mechanical designer, since his designs must conform to them.

GRADE STRUCTURE

In the structural design group's nonsupervisory grades, for every two employees in single-grade structures there are three in multi-grade structures. The percent distribution of employees among grades is as follows, over-all:

All grades	100.0
Supervisory grades	5.6
Nonsupervisory grades:	
Single grade only	36.6
Multi-grade:	
Lower grades	16.2
Higher grades (a)	41.6

a. Middle grades plus highest grades.

Structural design jobs are closely related to structural drafting jobs. In practice they are, in some cases, part of the same grade structure or promotional line, the draftsman jobs being at the lower end and the design jobs at the upper end of the scale. Top drafting jobs may overlap in the scale with low-grade technical design jobs.

For an indication concerning how job responsibilities may vary by grade, see discussion of draftsman jobs on page 20 in chapter I.

EDUCATION AND EXPERIENCE REQUIRED

The majority (56 percent) of structural design technicians work for employers who require some post-high-school education as a prerequisite for employment. Regardless of the type of educational requirement, employers usually insist upon some related work experience. For structural design technicians of all levels combined, a median of 5.7 years of such experience is required.

Education Requirements

Attendance at, but not graduation from, an engineering college or architectural school is the most frequent type of post-high-school educational requirement. About 19 percent of structural design technicians work for employers who have such a requirement. Significant proportions are also required to have graduated from a technical institute or community college, or from an engineering or architectural school. However, 44 percent of these technicians and specialists work in jobs for which employers require only high-school education. (Table II-E, based on table II-2 at the end of the chapter.)

Table II-E. NUMBER AND PERCENT DISTRIBUTION OF STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS, BY EDUCATION EMPLOYERS REQUIRE

Education required	Number	Percent
All levels	2,516	100.0
Post-high-school	1,419	56.4
Engineering college or architectural school	681	27.0
Graduation	208	8.3
Less than graduation	473	18.7
College, general	80	3.2
Graduation	-	-
Less than graduation	80	3.2
Technical institute or community college	329	13.1
Graduation	300	11.9
Less than graduation	29	1.2
Type not specified	237	9.4
Apprenticeship or armed forces school	92	3.7
High school	1,097	43.6
Technical or vocational	317	12.6
Other and not specified	780	31.0

The educational requirement varies considerably from occupation to occupation within this group. A requirement of post-high-school education is especially frequent in the case of aircraft structure design technicians (100 percent) and of general construction technicians (89 percent). The figures that follow show the percent for whom post-high-school education is required for eight selected occupations. For all occupations combined it is 56 percent. (The specific types of education beyond high school that are required are shown in table II-3 at the end of the chapter.)

Construction:	
Architectural	70.8%
Structural	49.6
Electrical	36.0
Mechanical	38.3
Highway, street, and related construction n.e.c.	63.2
General construction	88.5
Aircraft structure:	
Design	100.0
Lofting	44.6

Preferred vs. Required Education

Most employers who require that the applicant for the technician or specialist job have a high-school education prefer that he have more advanced education. The following figures (taken from table II-4 at the end of the chapter) show what percent of technical employees in this group work for employers who require a given level of education in contrast to the proportion where this is the preferred level:

Level of education	Required	Preferred
All levels	100.0	100.0
Post-high-school	56.4	90.8
High school	43.6	9.2

As to 865 jobs the employers stated that they required high school but preferred applicants who had had further study. In respect to one-fourth of these jobs the preference is for technical-school graduates; as to somewhat more than one-fourth it is for graduation from or study at an engineering or architectural school. Almost all the rest give college graduation or study as their preference, as the following distribution shows (based on table II-5 at the end of the chapter):

All levels	100.0
Engineering college or architectural school	
Graduation	15.5
Less than graduation	13.2
College, type not specified	
Graduation	21.6
Less than graduation	24.6
Technical institute, graduation	23.7
Other	1.4

Experience Requirements

Employers of the large majority (86 percent) of structural design technicians require that appointees to these jobs have some related work experience. Almost all of the jobs for which no experience is required are in single-grade structures or at the entrance level in multi-grade systems. (Table II-F.) Moreover, the no-experience requirement usually applies only to jobs for which some post-high-school education is a prerequisite.

Table II-F. PERCENT DISTRIBUTION OF STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS ACCORDING TO YEARS OF EXPERIENCE REQUIRED BY GRADE

Grade	Total	No experience	Under 3 years	3 and under 5	5 and under 7	7 and under 10	10 and over
All grades	100.0	13.8	6.5	11.4	26.1	24.8	17.4
Supervisory grades	100.0	-	2.8	2.1	11.3	24.1	59.7
Nonsupervisory grades:							
Single grade only	100.0	34.7	7.8	5.4	32.6	11.7	7.8
Multi-grade:							
Lower grades	100.0	4.7	20.9	31.5	17.4	15.0	10.5
Higher grades (a)	100.0	0.8	0.3	9.9	25.9	40.3	22.8

a. Middle grades plus highest grades.

The experience required for structural design technicians is considerable. The median years required range from 4.2 in the single-grade set-up to 10.1 for supervisory grades. For all grades combined, the requirement is 5.7 years.

Experience requirements are related not only to grade but also to educational requirements. Over-all, post-high-school education is equivalent in terms of requirements to approximately 2 years of experience for technicians in multi-grade structures. For example, at the lowest grade, a median of 3.0 years is needed for jobs that require some post-high-school education, while 5.3 years is needed when only high school is required.

Table II-G. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY GRADE

Grade	All levels	Post-high-school	High school
All grades	5.7	4.4	7.2
Supervisory grades	10.1	9.1	10.9
Nonsupervisory grades:			
Single grade only	4.2	0.0	6.3
Multi-grade:			
Lower grades	4.7	3.0	5.3
Higher grades (a)	7.0	6.0	8.5

a. Middle grades plus highest grades. Medians were estimated.

A comparison of the education and experience requirements and preferences of employers of structural design technicians indicates that the most common preference is for more education and the same amount of experience -- or less experience, if necessary. The most usual case is of the employer who requires high-school education and some experience, but who would give preference to an applicant who had post-high-school education, even though he had less experience. (Table II-H, based on table II-6 at the end of the chapter.)

Table II-H. NUMBER OF STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS ACCORDING TO EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE, BY EDUCATION EMPLOYERS REQUIRE

Kind of preference	All levels	Post-high-school	High school
Total	2,516	1,419	1,097
No preference expressed	873	641	232
All preferences	1,643	778	865
Required education, more experience	153	153	-
More than required education, less experience	741	349	392
More than required education, same experience	463	190	273
More than required education, more experience	286	86	200

SOURCES OF WORKERS

Methods of Obtaining Workers

Recruitment from outside the establishment and upgrading were of about equal importance as methods of obtaining qualified structural design technicians during a representative period preceding the survey. However, there was considerable variation from one occupation to the next. Organized training by the employer had an insignificant role in the upgrading process.

Table II-I. PERCENT DISTRIBUTION OF STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS ACCORDING TO METHOD OF OBTAINING THEM BY SELECTED OCCUPATION

Occupation	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All occupations	100.0	51.7	0.7	47.6
Selected occupations				
Construction	100.0	51.5	0.5	48.0
Architectural	100.0	69.3	-	30.7
Structural	100.0	36.2	-	63.8
Electrical	100.0	41.4	1.6	57.0
Mechanical	100.0	48.2	1.5	50.3
Highway, street, and related construction n.e.c.	100.0	53.9	-	46.1
General construction	100.0	49.2	-	50.8
Aircraft structure	100.0	47.3	-	52.7
Design	100.0	39.8	-	60.2
Lofting	100.0	59.0	-	41.0
Ship structure: Lofting	100.0	87.7	12.3	-

College and Technical Institute Graduates

One-third of all structural design technicians are graduates of a technical institute or community college. About 26 percent -- more than in most other technical-occupation groups -- are 4-year-college graduates or graduates of engineering or architectural schools.

The architectural construction field is highest in the proportion of college graduates, as is seen in table II-J, showing the percent of all structural

Table II-J. PERCENT OF STRUCTURAL DESIGN TECHNICIANS AND RELATED SPECIALISTS WHO ARE GRADUATES OF COLLEGES OR TECHNICAL INSTITUTES, BY SELECTED OCCUPATION

Occupation	College graduates	Technical institute graduates
All occupations	26.3	33.0
Selected occupations		
Construction	26.5	40.6
Architectural	64.5	21.5
Structural	22.0	41.2
Electrical	33.9	49.5
Mechanical	25.7	43.0
Combination: electrical and mechanical	19.1	25.9
Highway, street, and related construction n.e.c.	1.3	14.5
General construction	3.4	58.4
Aircraft structure	30.2	0.9
Design	48.7	0
Lofting	1.2	2.4
Ship structure: Lofting	0	0

design technicians and related specialists who had a college degree or a technical institute degree.

PROMOTIONAL LINES

Employers were asked to report on the jobs from which, and also those to which, structural design technicians are promoted. The most common promotional line is upgrading from draftsman; the next most important involves different grades of structural design technicians within multi-grade structures. Designer was most often mentioned as the job to which these technicians are promoted.

Structural Design Technicians and Related Specialists

Table II-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

Industry group	All occupations	Construction: Total	Construction: Architectural	Construction: Structural	Construction: Combination architectural and structural	Construction: Electrical	Construction: Mechanical	Construction: Combination electrical and mechanical	Construction: Highway, street, and related construction n.e.c.	Construction: General construction	Aircraft structure	Ship structure
All industries	2,516	2,004	349	337	71	186	467	162	76	356	427(a)	85(d)
Manufacturing	495	68	2	7	8	14	21	-	-	16	427(a)	-
Durable goods	442	15	-	1	1	8	5	-	-	-	427(a)	-
Stone, clay, and glass products	1	1	-	1	-	-	-	-	-	-	-	-
Machinery, except electrical	9	-	-	-	-	-	-	-	-	-	9(b)	-
Electrical machinery and equipment	3	-	-	-	-	-	-	-	-	-	3(b)	-
Transportation equipment	429	14	-	-	1	8	5	-	-	-	415(c)	-
Nondurable goods	53	53	2	6	7	6	16	-	-	16	-	-
Food and kindred products	16	16	2	2	6	-	6	-	-	-	-	-
Chemicals and allied products	36	36	-	4	-	6	10	-	-	16	-	-
Petroleum refining and related industries	1	1	-	-	1	-	-	-	-	-	-	-
Nonmanufacturing	2,021	1,936	347	330	63	172	446	162	76	340	-	85(d)
Contract construction	329	329	26	48	-	24	74	-	6	151	-	-
General building contractors	299	299	26	48	-	24	50	-	-	151	-	-
Heavy construction	6	6	-	-	-	-	-	-	6	-	-	-
Special trade contractors	24	24	-	-	-	-	24	-	-	-	-	-
Transportation and public utilities	83	80	-	77	-	-	-	-	-	3	-	3(e)
Railroad transportation	2	2	-	1	-	-	-	-	-	1	-	-
Water transportation	3	-	-	-	-	-	-	-	-	-	-	3(e)
Electric, gas, and sanitary services	78	78	-	76	-	-	-	-	-	2	-	-
Wholesale trade	37	37	-	-	-	-	-	-	-	37	-	-
Insurance carriers	1	1	1	-	-	-	-	-	-	-	-	-
Services and miscellaneous	1,445	1,420	302	205	63	148	372	162	63	105	-	25(e)
Business services n.e.c.	495	495	112	51	43	61	74	55	38	61	-	-
Research, development, testing laboratories	55	55	-	-	-	-	-	55	-	-	-	-
Business and management consulting services	339	339	88	35	43	61	74	-	38	-	-	-
Other business services n.e.c.	101	101	24	16	-	-	-	-	-	61	-	-
Private colleges and schools	5	5	-	-	-	-	-	-	-	5	-	-
Engineering and architectural services	945	920	190	154	20	87	298	107	25	39	-	25(e)
Government	126	69	18	-	-	-	-	-	7	44	-	57(b)
County	6	6	-	-	-	-	-	-	6	-	-	-
New York State	62	62	18	-	-	-	-	-	-	44	-	-
Towns and villages	1	1	-	-	-	-	-	-	1	-	-	-
Federal: Arsenals and navy yards	57	-	-	-	-	-	-	-	-	-	-	57(b)

a. Design 261, lofting 166. b. All lofting. c. Design 261, lofting 154. d. Design 28, lofting 57. . All design.

Structural Design Technicians and Related Specialists

Table II-2. EDUCATION EMPLOYERS REQUIRE, BY GRADE

(Percent distribution of technicians and specialists according to level of education required)

Education required	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Nonsupervisory grades: Multi-grade: Lower grades	Nonsupervisory grades: Multi-grade: Higher grades (a)
All levels: Number	2,516	141	920	408	1,047
Percent distribution					
All levels: Percent	100.0	100.0	100.0	100.0	100.0
Post-high-school	56.4	44.0	52.4	45.1	66.0
Engineering college or architectural school	27.0	13.5	25.2	14.0	35.7
Graduation	8.3	5.0	17.3	2.0	3.3
Less than graduation	18.7	8.5	7.9	12.0	32.4
College, general, less than graduation	3.2	-	3.9	3.4	2.9
Technical institute or community college	13.1	19.9	12.7	17.7	10.7
Graduation	11.9	19.9	12.3	11.6	10.7
Less than graduation	1.2	-	0.4	6.1	-
Type not specified	9.4	10.6	10.2	4.4	10.5
Apprenticeship or armed forces school	3.7	-	0.4	5.6	6.2
High school	43.6	56.0	47.6	54.9	34.0
Technical or vocational	12.6	29.8	11.1	12.3	11.7
Other and not specified	31.0	26.2	36.5	42.6	22.3

a. Middle grades plus highest grades.

Structural Design Technicians and Related Specialists

Table II-3. EDUCATION EMPLOYERS REQUIRE, BY SELECTED OCCUPATIONS(a)

(Percent distribution of technicians and specialists according to level of education required)

Education required	Construction: Archi-tectural	Construction: Struc-tural	Construction: Electri-cal	Construction: Mechani-cal
All levels: Number	349	337	186	467
Percent distribution				
All levels: Percent	100.0	100.0	100.0	100.0
Post-high-school	70.8	49.6	36.0	38.3
Engineering college or architectural school	54.7	11.9	10.8	17.5
Graduation	38.4	0.6	5.4	5.1
Less than graduation	16.3	11.3	5.4	12.4
College, general, less than graduation	0.9	6.8	8.6	5.4
Technical institute or community college	7.2	10.1	13.9	12.2
Graduation	7.2	8.9	8.5	9.0
Less than graduation	-	1.2	5.4	3.2
Type not specified	8.0	20.8	2.7	2.8
Apprenticeship or armed forces school	-	-	-	0.4
High school	29.2	50.4	64.0	61.7
Technical or vocational	0.3	13.4	36.6	20.1
Other and not specified	28.9	37.0	27.4	41.6

a. Occupations for which detailed breakdowns were not significant were omitted.

Structural Design Technicians and Related Specialists

Table II-4. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of technicians and specialists according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	2,516	2,516	100.0	100.0
Post-high-school	1,419	2,284	56.4	90.8
Engineering college or architectural school	681	1,092	27.0	43.4
Graduation	208	822	8.3	32.7
Less than graduation	473	270	18.7	10.7
College, general	80	464	3.2	18.4
Graduation	-	206	-	8.2
Less than graduation	80	258	3.2	10.2
Technical institute or community college	329	515	13.1	20.5
Graduation	300	511	11.9	20.3
Less than graduation	29	4	1.2	0.2
Type not specified	237	123	9.4	4.9
Apprenticeship or armed forces school	92	90	3.7	3.6
High school	1,097	232	43.6	9.2
Technical or vocational	317	62	12.6	2.5
Other and not specified	780	170	31.0	6.7

Structural Design Technicians and Related Specialists

Table II-5. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Number and percent distribution of technicians and specialists according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require (a)						
				Post-high-school						
				Post-high-school, total	Engineering college or architectural school		College, general		Technical institute graduation	Type not specified
					Graduation	Less than graduation	Graduation	Less than graduation		
Number										
All levels	2,516	1,042	1,474	1,474	614	142	206	213	287	12
Post-high-school	1,419	810	609	609	480	28	19	-	82	-
Engineering college or architectural school	681	336	345	345	345	-	-	-	-	-
Graduation	208	208	-	-	-	-	-	-	-	-
Less than graduation	473	128	345	345	345	-	-	-	-	-
College, general, less than graduation	80	45	35	35	25	-	10	-	-	-
Technical institute or community college	329	228	101	101	88	4	9	-	-	-
Graduation	300	224	76	76	63	4	9	-	-	-
Less than graduation	29	4	25	25	25	-	-	-	-	-
Type not specified	237	111	126	126	22	24	-	-	80	-
Apprenticeship or armed forces school	92	90	2	2	-	-	-	-	2	-
High school	1,097	232	865	865	134	114	187	213	205	12
Technical or vocational	317	62	255	255	5	-	15	213	22	-
Other and not specified	780	170	610	610	129	114	172	-	183	12
Percent distribution										
All levels	100.0	41.4	58.6	58.6	24.4	5.6	8.2	8.5	11.4	0.5
Post-high-school	100.0	57.1	42.9	42.9	33.8	2.0	1.3	-	5.8	-
Engineering college or architectural school	100.0	49.3	50.7	50.7	50.7	-	-	-	-	-
Graduation	100.0	100.0	-	-	-	-	-	-	-	-
Less than graduation	100.0	27.1	72.9	72.9	72.9	-	-	-	-	-
College, general, less than graduation	100.0	56.2	43.8	43.8	31.3	-	12.5	-	-	-
Technical institute or community college	100.0	69.3	30.7	30.7	25.8	1.2	2.7	-	-	-
Graduation	100.0	74.7	25.3	25.3	21.0	1.3	3.0	-	-	-
Less than graduation	100.0	13.8	86.2	86.2	86.2	-	-	-	-	-
Type not specified	100.0	46.8	53.2	53.2	9.3	10.1	-	-	33.8	-
Apprenticeship or armed forces school	100.0	97.8	2.2	2.2	-	-	-	-	2.2	-
High school	100.0	21.1	78.9	78.9	12.2	10.4	17.0	19.5	18.7	1.1
Technical or vocational	100.0	19.6	80.4	80.4	1.6	-	4.7	67.2	6.9	-
Other and not specified	100.0	21.8	78.2	78.2	16.5	14.6	22.1	-	23.5	1.5

a. All employers who expressed a preference mentioned some post-high-school level of education; none mentioned high school.

Structural Design Technicians and Related Specialists

Table II-6. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number and percent distribution of technicians and specialists according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	More than required education: Same experience	More than required education: More experience
			Number				
All levels	2,516	873	1,643	153	741	463	286
Post-high-school	1,419	641	778	153	349	190	86
Engineering college or architectural school	681	305	376	31	260	35	50
Graduation	208	181	27	27	-	-	-
Less than graduation	473	124	349	4	260	35	50
College, general, less than graduation	80	25	55	-	6	25	24
Technical institute or community college	329	110	219	122	73	14	10
Graduation	300	106	194	122	48	14	10
Less than graduation	29	4	25	-	25	-	-
Type not specified	237	111	126	-	10	116	-
Apprenticeship or armed forces school	92	90	2	-	-	-	2
High school	1,097	232	865	-	392	273	200
Technical or vocational	317	62	255	-	18	79	158
Other and not specified	780	170	610	-	374	194	42
			Percent distribution				
All levels	100.0	34.7	65.3	6.1	29.4	18.4	11.4
Post-high-school	100.0	45.2	54.8	10.8	24.5	13.4	6.1
Engineering college or architectural school	100.0	44.8	55.2	4.6	38.2	5.1	7.3
Graduation	100.0	87.0	13.0	13.0	-	-	-
Less than graduation	100.0	26.2	73.8	0.8	55.0	7.4	10.6
College, general, less than graduation	100.0	31.3	68.7	-	7.5	31.3	29.9
Technical institute or community college	100.0	33.4	66.6	37.1	22.2	4.3	3.0
Graduation	100.0	35.3	64.7	40.7	16.0	4.7	3.3
Less than graduation	100.0	13.8	86.2	-	86.2	-	-
Type not specified	100.0	46.8	53.2	-	4.2	49.0	-
Apprenticeship or armed forces school	100.0	97.8	2.2	-	-	-	2.2
High school	100.0	21.1	78.9	-	35.8	24.9	18.2
Technical or vocational	100.0	19.6	80.4	-	5.7	24.9	49.8
Other and not specified	100.0	21.8	78.2	-	47.9	24.9	5.4

Chapter III

ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS

Electro (electrical, electronic) and mechanical technicians, the largest of the technical occupation groups, contained 42,031 persons in New York State in 1962, or 28 percent of all persons in technical occupations.

Electro and mechanical technicians come closest to meeting the popular conception of the engineering technician. They assist and support the engineer by performing or sharing one or more of his functions. In doing this they often combine the application of engineering and science knowledge with the application of the technical skills of the craftsman.

Not all engineering technicians are in the electro and mechanical fields. Some, for example, work in structural design and in industrial, civil, and other engineering fields covered in other chapters of this volume. (The definition of the engineering technician is discussed in volume 1, at the end of chapter II.)

Almost half of the electro and mechanical engineering technicians are supervised by engineers and scientists. A third work under other technicians of higher grade (electro or mechanical or other), and the rest under plant and department managers, etc.

Function	Total	Engineer or scientist	Technician	Other
All functions	100.0	47.4	33.6	19.0
Design	100.0	74.7	14.7	10.6
Development	100.0	64.0	26.8	9.2
Troubleshooting and related	100.0	29.1	43.7	27.2

Engineers and scientists supervise considerably more than half of the first two groups, but less than a third of the troubleshooting group.

Field and Function

Electro and mechanical engineering technicians have been classified in three ways for purposes of this report: by field, by function, and by product or equipment.

Field of engineering	Function performed	Products or equipment worked on
•Electronic	Design	(See list in next section)
•Electrical	Development	
•Electronic-electrical	Design and development	
•Mechanical	Design and/or development and installation and/or troubleshooting	
•Electronic-mechanical and electrical-electronic-mechanical	Troubleshooting and related	
	Installation	
	Troubleshooting and installation	

The following combinations of fields have been used in the analyses presented in this chapter:

Field	Number of technicians
All fields	42,031
Electronic	10,791
Electrical, total	8,794
Electrical	3,618
Electronic-electrical	5,176
Mechanical	8,461
Electro-mechanical, total	13,985
Electronic-mechanical	12,709
Electrical-mechanical and electrical-electronic-mechanical	1,276

Similarly, the functions were reduced to three main classifications, by combination:

Function	Number of technicians
All functions	42,031
Design	7,689
Development	11,936
Development	6,803
Design and development	1,392
Design and/or development and installation and/or troubleshooting	3,741
Troubleshooting and related	22,406
Troubleshooting	18,880
Installation	458
Troubleshooting and installation	3,068

See table III-1 at the end of the chapter for figures on detailed fields and functions.

The separate <u>fields</u> of the electro and mechanical engineering technicians may be described in the following way:

<u>Electronic</u>. Electronics engineering deals primarily with the controlled flow of electrically charged particles in space. An example is the flow of free electrons in the evacuated envelope of the cathode ray tube (television picture tube) which are controlled by the application of electric and magnetic fields. Further illustration is the controlled flow of charge in devices such as the transistor or vacuum tube by the application of differences in potential. Electronics engineering is basic to the fields of communication (radio, television, microwaves), computers, and many general industrial areas such as photoelectric systems, induction heating, controllers for motors, welders, etc.

<u>Electrical</u>. Electrical engineering is concerned basically with the control of electrical energy in its applications to produce heating, lighting, mechanical, and magnetic effects. The field includes both the generation and distribution of alternating and direct current electrical energy. It is usually restricted to the applications of electrical energy requiring the use of wire conductors rather than free space. The electrical technician typically works with resistors, capacitors, inductors, transformers, relays, switches, generators, batteries, and motors. The principal applications of electrical engineering are associated with the conversion of electrical energy to mechanical energy (as in motors), in changing the temperature of the environment (as in heaters), or in routing information over wires (as in telephone switch gear and telegraphy).

<u>Mechanical</u>. Mechanical engineering is concerned fundamentally with the design, production, and use of mechanically, thermally, hydraulically, and pneumatically operated equipment. It involves the conversion, distribution, and control of energy in devices utilizing the mechanical transmission of power by gears, cams, levers, etc., as in, for example, milling machines and prime movers; thermal conversion and transmission of energy as in internal combustion engines and steam generating plants; hydraulic conversion and transmission as in aircraft landing gear and hydraulically controlled machine tools; pneumatic conversion and transmission as in a pneumatic hammer and pneumatic amplifiers.

<u>Electro-mechanical</u>. The electro-mechanical engineering field is concerned with instruments and systems in which electrical, electronic, and mechanical elements are combined. Typical of the field are instruments that sense some physical variable or phenomenon such as force, displacement, pressure, temperature, fluid flow, etc.; measure the amount of the variation; automatically record the measurement; compare the variation to predetermined limits; and in response make an adjustment in an element in the system controlling the operation or process.

Measurement usually consists of conversion of the variable to be measured into a hydraulic or pneumatic impulse or an electrical signal. The resultant signal may be amplified, divided, multiplied, etc. In some cases, the signal may be combined with signals measuring other variables in an operation or process and interconnected, as with an analog or digital computer built into the system, to bring about completely automatic operation and control.

A simple example is the use of a thermostat to control room temperature. It utilizes the differential expansion of metals in a bimetallic strip to open and close an electrical circuit, which in turn controls the burner valve of the furnace that provides heat.

Another example is the turbine-type flowmeter. A small turbine is placed in the path of a flowing liquid. Attached to the turbine shaft is a small permanent magnet. The movement of liquid through the pipe turns the turbine at a speed which is directly proportional to the flow and rotates the magnetic member so that it changes the flux linking a pick-up coil on the outside of the pipe. This then induces in the coil an emf (electromotive force) the frequency of which is directly related to the rate at which the turbine is turning. Since each impulse means that a certain volume of liquid has been measured, the total number of voltage impulses is a measure of the total flow.

The separate function classifications are defined in the following way:

1. Design. Creation of form, appearance, and structural components and their relationships for machinery, apparatus, equipment, products, etc. Involves application of engineering and mathematical knowledge to solve problems, both of over-all design and components design. Involves making rough sketches, working drawings, and schematic diagrams; giving verbal and written instructions.

2. Development. Applies to development of prototypes, models, new products. Involves one or more of the following functions: mocking up; breadboarding; determining parts requirements; ordering parts; building; developing test procedures; constructing and maintaining test equipment; testing; calibrating; troubleshooting; analyzing malfunctions; rebuilding; modifying; analyzing production feasibility; maintaining, analyzing, and presenting test and performance data; etc.

3. Troubleshooting and related. Applies to equipment at point of manufacture or point of use. Includes preventive and corrective maintenance; inspecting and testing; troubleshooting and diagnosing; taking action to replace or repair malfunctioning systems, components, or units. Includes inspection and checking out complex instruments.

4. Installation. Assuring proper operation of equipment and instruments where they are used. Involves laying out, arranging, hooking up, setting up, adjusting, calibrating.

5. Combination of design and development. If development functions were performed only occasionally and quite incidentally, the design classification was used.

6. Combination of design and/or development and installation and/or troubleshooting.

7. Combination of troubleshooting and installation.

Further explanations of function classification

(a) Persons engaged in planning, advising, coordinating, and/or supervising, as well as performing the specific functions were classified under the relevant group (provided they were not working in a professional engineering capacity).

(b) Routine and semi-routine tasks performed in connection with development, installation, and maintenance ordinarily are assembly, mechanic, or craft rather than technician occupations. Examples are assembly or disassembly of equipment and building or rebuilding that do not involve analysis of functions or malfunctions and which follow a blueprint or specific instructions. Similarly, repair of components or parts that is generally repetitious once mastered, and which ordinarily is done as benchwork, ordinarily took a mechanics classification. Generally speaking, installation and repair operations for which recognized trade, craft, or manual labor experience and knowledge are a paramount requirement were excluded.

(c) Testers and inspectors (for defects) of materials used or of finished products or equipment were excluded from the survey if they involved the kind of task that could be taught within a period of roughly 3 months to a person of average intelligence having no related training or substantial technical or scientific education. They were classified under "Product Testing and Inspection Specialists" if the task required roughly from 3 to 15 months of specialized training for such a person. If more than roughly 15 months was required for such a person, or if a substantial technical or scientific education was required, they were classified in group 3, above, "Troubleshooting and related" (unless, as previously stated, a trade or craft skill was the paramount requirement for the job, in which case they were excluded from the survey).

(d) Technicians engaged in developing test equipment were classified under "development" whether the equipment was used for prototype testing or for production testing. If this development of test equipment was the principal part of their work, the product classification was that of the test equipment. If it was simply one of many development activities, the classification was the product or equipment for which the test equipment was being developed.

(e) Another technician classified in group 3 was the technician engaged in inspecting, testing, and checking out the products manufactured or used by a company--if the work was sufficiently complex to warrant an engineering technician classification. If it was not, the occupation usually was in the Product Testing and Inspection Specialist group (chapter XII).

(f) Troubleshooting of prototype or experimental equipment or products is classified under "development." Troubleshooting other products or equipment is under "troubleshooting and related."

Five field-function groups account for nearly 30,000 or 70 percent of all electro and mechanical engineering technicians.

All fields; all functions	42,031
Electro-mechanical troubleshooting(a)	9,767
Electronic troubleshooting(a)	5,429
Electrical troubleshooting(a)	5,291
Electronic development	4,873
Mechanical design	4,450
All other	12,221

a. Includes related functions

The five groups are defined in terms of both field and function, after making the combinations of fields and the combinations of functions indicated at the beginning of the chapter. (See table III-1 at the end of the chapter for other categories.)

Products and Equipment Worked On

Electro and mechanical engineering technicians work on or with a wide variety of products and equipment. These have been classified in approximately 40 groups, described in the next pages.

1. Instruments and Electronic and Science Laboratory Equipment

a. Electronic equipment and instruments

(1) Communication equipment

(a) Radio, television, audio. - Monaural and stereo audio amplifiers; intercommunication systems; single and double sideband AM or FM radio receivers and transmitters; transmission line termination equipment; closed circuit or broadcast television receivers or transmitters; special purpose sheet metal parts and components; systems such as pulse position modulators, time sharing equipment, etc.; public address systems; linkages and simple mechanisms used in electronic equipment; ground control approach equipment and aircraft radio navigational systems; marine and air telephone systems; telemetering equipment; magnetic recording equipment.

(b) Radar, sonar, microwave. - Radar; guidance systems; microwave relay communication; radar and microwave instrumentation; microwave signal generators and amplifiers; wave guides; transmission lines; antennas; delay lines; lasers; masers; scatter communications; microwave receivers and transmitters; mechanical components.

(c) Other and combinations. - Frequency sensitive switches, frequency trackers, miscellaneous small sub-assemblies and amplifiers. Combinations of radio, television, audio, radar, sonar, and microwave equipment.

(2) Digital computers. - Electronic and magnetic logical elements such as gates, inverters, blocking oscillators, triggers, multivibrators, etc.; circuits such as counters, registers, adders, etc. Memory equipment such as read-write circuits, delay lines, drivers, core sensing circuits, ferrites, cathode ray tubes, etc.; thin film memories and assemblies; input-output equipment such as buffers, lamplighters, photo-electric circuits, etc.; core memories; specialized computers such as may be found in navigation work, numerical control of machine tools, industrial automation systems, or elsewhere in which the program is essentially wired into the equipment.

(3) Testing, measuring, and control instruments. - Vacuum tube voltmeters; oscilloscopes; ratiometers; oscillators; waveform generators; analyzers; filters; marker generators; slotted lines; counters; noise instruments; stroboscopes; phasemeters; power supplies and inverters; field strength meters; modulation meters; frequency calibration equipment; signal generators; voltage calibrators; pulse generators and analyzers; events per unit time (EPUT) meters.

(4) Electronic components. - Vacuum tubes; gas tubes; transistors; diodes and rectifiers; silicon controlled rectifiers; zener and avalanche effect diodes; silicon controlled switches; tunnel diodes; thin film devices; unijunction

transistors; integrated circuits; klystrons; travelling wave tubes; magnetrons; crystals; cathode ray tubes; absorbers; couplers; isolators; wave guides; windows; photomultipliers; phototransistors and photodiodes.

(5) General and other. - Combinations of communication equipment, computers, test equipment, and components.

b. Electro-mechanical instruments

(1) Industrial servo-control instruments, fire control, guidance, and other analog applications. - Star tracking and inertial guidance systems for space vehicles, aircraft, and ships; auto pilots; aircraft and naval fire control systems; missile detection and remote control systems; radar antenna control systems; process control systems as found in chemical plants, refineries, and other liquid, slurry, and gas manufacturing operations; analog computers.

(2) Testing, measuring, and control instruments, other than servo. - Transducers and recorders actuated by vacua, gases, liquids, solids, electricity, and radiation used in the measurement of temperature, pressure, displacement, force, velocity, flow rate, thickness, liquid level, position, density, mass, and torque whose output is either an electrically operated instrument or relies principally for its operation on electronic circuits. For example, chart recorders, strain gauges, leak detectors, thermo-electric pyrometers, synchros, accelerometers, synchroscopes, xerographic equipment, etc.

(3) General and other. - Combinations of servo systems and test instruments in the category of electro-mechanical instruments.

c. Mechanical instruments

(1) Testing, measuring, and control instruments.

(a) General.

(b) Hydraulic, pneumatic, and other. - Hardness testers; strain and torsion gauges; dynamometers; micrometer gauges; vernier calipers; tachometers; steam traps; mechanical counters; tire gauges; hydraulic valves; liquid depth indicators and controls; draft and ballast tank indicators; liquid level gauges; industrial cylinders; automatic tube systems; pneumatic butterfly valves; pneumatic and hydraulic control of temperature and pressure; electro-pneumatic relays; pressure or vacuum draft valves.

(2) Optical and photographic instruments. - Periscopes; telescopes; microscopes; bomb sights; optical systems for ultraviolet and infra-redradiation; range finders; choppers; photometers; encoders; optically polished crystals and flats; high vacuum coatings; photointerpretation mapping; tracking and reconnaissance plotting instrumentation; optical comparators; reproducing and photographic equipment; mirrors; filters; fire-control instruments; colorimeters; polarizers; interferometers; theodolites; projectors.

(3) General and other. - Surgical and dental hand tools including hammer, scalpel, prober, orthopedic chisel, scissors, etc.; boroscope; centrifuge; bone cutter; stethoscope; dental drill, ultrasonic dental units; abrasive wheels and discs; etc. Clocks; watches; timers; elapsed time indicators; repeat cycle timers; time delay relays; interval timers; etc.

d. Science laboratory equipment not elsewhere classified

(1) Chemical laboratory equipment. - Analytic balance; torsion balance; vacuum pump; drying ovens; furnaces; burners; hot plates; water and oil baths; manometers; thermometers; pyrometers; pH meters; Westphal balances; hydrometers; pycnometers; pressure measuring devices; hygrometers; electrolysis and electroplating apparatus; melting point apparatus; spectrophotometer; gas chromatograph; viscosimeter; refractometer; colorimeter; calorimeter; Orsat gas analyzer; stills; flash and fire point apparatus; color grinders; dye bath; fadometer; laundrometer; adhesion and cohesion test devices; electrometric filtration apparatus; densitometer; spectrometer; photometer; see also optical and electrical equipment and instruments.

(2) Physics laboratory equipment, nuclear. - Geiger counters; scalers; electroscopes; film badges; sand blasters; vacublasters; lift machinery; gas cutting equipment; slave units and other remote control apparatus; cloud chambers; bubble chambers; cyclotrons; synchrotrons; linear accelerators; nuclear piles; Van De Graaff generators; fluoroscopes;projectors.

(3) Physics laboratory equipment, other. - X-ray machines; X-ray diffraction; electron microscope; microtome; polarimeter; manual and automatic collimators; stroboscopic light sources; special purpose scientific digital computers; high vacuum apparatus; Atwood's machine.

(4) Biological or medical laboratory equipment. - Electroencephalograph; electrocardiograph; autoanalyzers; inhalators; medical pumps and filtering apparatus as used in artificial kidneys, etc.; sphygmomanometer; medical radiation and shielding equipment; stethoscopes; small instruments such as hypodermic needles, etc.

(5) General.

2. Machinery, Electrical, and Mechanical Equipment

a. Electrical equipment

(1) Telephone, teletype, and related equipment. - Telephone, teletype and telegraph equipment, including manual and automatic switching systems; facsimile equipment; repeaters; boosters; switchboards; testboards; wiring racks; instrument and equipment cases; telephone ringers; terminating and other associated equipment and circuits; wirephoto and data transmitters and related equipment; telemetering equipment.

(2) Electric power plant equipment. - Electrical generators and motors; transformers; switchgear; varmeters; power factor meters; switchboards; circuit breakers; arc suppression equipment; phase rotation indicators; relays.

(3) Electrical control and signaling equipment. - Railway track circuitry; railway signaling; heating, ventilating and air conditioning controls; aerospace electrical controls; traffic controls; fire and burglar alarm and detection systems; elevator controls; pressure transducers; potentiometers.

(4) Electrical equipment parts, and components n.e.c. - Resistors; capacitors; switches; relays; inductors (including chokes and coils); wiring devices; fixtures; electro-mechanical displays; motors; generators; packaging machinery;

voltmeters; ammeters; wattmeters; ohmmeters; multitesters; electrical bridges; revolution counters; insulation testers.

(5) Combination: control, signaling, and other equipment n.e.c.

b. Nonelectrical machinery and other metal equipment

(1) Tool and die equipment. - Tools; punches and dies; molds; gauges; jigs; fixtures; special machine attachments; patterns for foundry use; heat treating furnaces; jig boring machines.

(2) Manufacturing and mining machinery and equipment n.e.c. - Corrugated paper machinery; wire drawing machinery; packaging equipment; canning machinery; roasting equipment and machines for coffee, cocoa, and peanuts; die casting equipment; rolling mills; printing machinery; high precision tool room lathes and milling machines; materials handling equipment such as hoists, monorails, conveyors, ramps, cranes, etc.; ball mills; roller mills; hammer mills, jaw, cone, and gyratory crushers; sieves; concentrators; classifiers; flotation machinery; magnetic separators; belt, chain, drag, bucket, or vibrating conveyors; rock drills; drill sharpeners; separators; hoists.

(3) Chemical processing machinery and equipment. - Evaporators; spray dryers; mixers; agitators; condensers; drum dryers; heat exchangers; vacuum rotary dryers; vacuum crystallizers; disintegrators; pulverizers; crushers; grinders; classifiers; blenders; distilling apparatus; tanks; proportion metering; filters; autoclaves; bucket elevators; etc.

(4) Construction machinery and equipment. - Cement and concrete mixers and spreaders; tractor shovels; electric hoists; cranes; dump wagons; pile drivers; rollers; travelers; building block machines; pneumatic drills; compressors; tampers; grapples; pavers; flushers; sprinklers; pulverizers; sweepers; graders; bulldozers; scrapers; vibrators; spreaders; finishers; slopers; ditchers; excavators; loaders.

(5) Agricultural machinery and equipment. - Sprayers; potato diggers; rice diggers; dump carts; stone rakes; string bean pickers; subsoilers; disc harrows; harrows; tractors; reapers; threshers; combines; baggers; graders; moving machines; cucumber pickers; fertilizer distributors; aerators; harvesters; cultivators; seed treating machines; row crop thinners; onion harvesters; hulling and polishing machinery; grinders; separators; plows; rotary cutters and power hoes; rakes; rollers.

(6) Warehouse and other material moving machinery and equipment. - Belt conveyor systems and other bulk material handling systems. Belt, chain, bucket, screw, drag, vibrating, or pneumatic conveyors; platform, shelf, bin, wagon, rack, or dolly dump trucks; mechanical, hydraulic, and electric lift trucks; bucket or screw elevators; etc.

(7) Heating, air conditioning, and related machinery and equipment. - Ventilating, heating, or air conditioning equipment; refrigeration machinery and equipment; heat exchangers; economizers; evaporators; fans and blowers; air washers and cleaners; dehumidifiers and humidifiers; condensers; compressors.

(8) General and other. - Hardware and related equipment, such as locks, shelf, sliding door, and cabinet hardware; wheels; casters; bolts; nails; washers; screws; nuts; rivets; ball bearings; air compressors; slicing machines; laundry and dry cleaning machines; printing and typing machines; turbines.

3. Transportation Equipment, Aircraft, and Ordnance

a. Aircraft and missile parts and equipment n.e.c.

(1) Aircraft electronic-electrical systems n.e.c. - Stable platforms; air data computers; aircraft simulators; stabilizing systems; fuel control systems; in flight refueling systems; ignition systems.

(2) Jet engine. - Ram jet engines; pulse jet engines; turbo jet engines; fan jet engines.

(3) Rocket engine. - Solid fuel rocket engines;liquid fuel rocket motors; related guidance equipment; plasma propulsion engines.

(4) Other aircraft engine. - Piston engines.

(5) Aircraft mechanical equipment and systems. - Landing gear systems and parts; shock struts; power control units; valves; wing panels; fuselage subassemblies; hydraulic equipment; aileron rudder or flap controls.

(6) Missile equipment. - Air conditioners; suit ventilators; cryogenic seals; cryogenic pumps and motors; thermoelectric coolers; fuel and fuel booster pumps; re-entry parachute systems; liquid propellant utilization; loading, control, monitoring, and depletion of fuel; solid propellant thrust control; burn rate control; ground support equipment systems such as radar consoles; mobile electronic test equipment; missile cradles and dollies; environmental test equipment; guidance and tracking systems; pressure vessels; nose cones; tail cones; guide vanes; exhaust hoods; hydraulic, pneumatic, and mechanical actuators and controls; separation devices; ejection and recovery systems; see also electronic and electrical equipment.

(7) General.

b. Transportation vehicles and equipment n.e.c.

(1) Ships and ship equipment. - Ship propulsion equipment; combustion apparatus; burners; boilers; heaters; marine diesels; engines; marine turbines; reactors; propellors; shafts; gearing; ship piping; heating, ventilating, and air conditioning equipment; winches; windlasses; jib cranes; pumps and pumping equipment; compressors; generators; motors.

(2) Motor vehicles and equipment. - Gasoline and diesel engines; gas turbines; electric motors; bodies and body parts; axles; transmissions; pumping systems; suspension systems; radiators; heat exchange systems and apparatus; etc.

(3) Railroad vehicles and equipment. - Electric motors; steam engines; diesel engines; gasoline engines; kerosene engines; freight and passenger cars; hydraulic and mechanical track jacks; tie spacers; rail pullers and expanders; tie removers and replacers; rail dollies; car and journal jacks; etc.

c. Ordnance

Armored vehicles; guided bombs; rocket test sleds; explosive cartridge actuated devices; machine guns; machine gun mounts; turret type cupolas; striker heads; recoilless mortar shells; underwater depth bombs; torpedos; missile weapons systems; missile warheads; missile test equipment; missile launchers; mechanical, electro-mechanical, and electronic ordnance fire controls; gunsights; cartridges; bomb sights; explosives; firearms; range finders; etc.

4. Other Products and Equipment

a. Nonmetal cartons and containers: Paper, fiber, and plastic containers.

b. Other: Fabrics; brushes; polyethylene fiber packages and sealers; corrugated panels; pipes and tubing; toys; furniture.

The number of technicians found working in each of the product groups described above is shown cross-classified by field in table III-2 and cross-classified by function in table III-3, at the end of this chapter.

Although most electronic engineering technicians work on electronic equipment and instruments, some work on products or equipment that are essentially or predominantly mechanical or electrical. Similarly, many mechanical technicians are found working on or in connection with products or equipment that would be classified as electronic or electrical. The extent to which this is true is suggested by the four illustrations in the following table:

Product or equipment worked on	All fields	Electronic technicians	Electrical technicians	Mechanical technicians	Electro-mechanical technicians
Electronic equipment and instruments	15,845	8,822	1,604	783	4,636
Electrical equipment	10,981	392	5,451	951	4,187
Nonelectrical machinery and other metal equipment	4,242	80	46	3,758	358
Aircraft and missile parts and equipment n.e.c.	2,784	234	897	411	1,242

The importance of the different functions varies from one product and equipment group to another. The design function is relatively most important in mechanical instruments, nonelectrical machinery and equipment, transportation

Table III-A. PERCENT DISTRIBUTION OF ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS ACCORDING TO FUNCTION, BY PRODUCT OR EQUIPMENT WORKED ON

Product or equipment worked on	Total number	Percent distribution			
		All functions	Design	Development	Trouble-shooting and related
All products or equipment worked on	42,031	100.0	18.3	28.4	53.3
Instruments and electronic and science laboratory equipment	23,090	100.0	11.8	35.0	53.2
Electronic equipment and instruments	15,845	100.0	10.0	31.1	58.9
Electronic-mechanical instruments	4,629	100.0	13.0	40.4	46.6
Mechanical instruments	1,470	100.0	25.3	40.5	34.2
Science laboratory equipment n.e.c.	1,146	100.0	14.3	60.0	25.7
Machinery, electrical and mechanical equipment	15,223	100.0	27.4	19.3	53.3
Electrical equipment	10,981	100.0	12.8	20.6	66.6
Nonelectrical machinery and other metal equipment	4,242	100.0	65.1	15.8	19.1
Transportation equipment, aircraft, and ordnance	3,372	100.0	15.3	26.0	58.7
Aircraft and missile parts and equipment n.e.c.	2,784	100.0	9.8	25.4	64.8
Transportation vehicles and equipment n.e.c.	508	100.0	36.8	33.1	30.1
Ordnance	80	100.0	71.2	3.8	25.0
Other products and equipment	346	100.0	78.1	12.1	9.8
Nonmetal cartons and containers	114	100.0	81.6	7.0	11.4
Other	232	100.0	76.2	14.7	9.1

vehicles other than aircraft, ordnance, and nonmetal cartons and containers. Development functions figure most prominently in connection with instruments of all kinds; troubleshooting in connection with electronic and electrical instruments and equipment, and with aircraft and missile parts and equipment, as is seen in table III-A.

Industry

Industry also is a significant basis for classifying electro and mechanical engineering technicians. How it differs from the product-and-equipment basis, described just above, may be illustrated by the example of four different establishments doing design and development work on microwave products and equipment. One is a manufacturer of such equipment, one is a Federal government agency, one is a private engineering service, one is a university. The product and equipment classification is the same, namely "radar, sonar, and microwave." But the four are in four different industry classifications, namely "electrical machinery and equipment manufacturing," "Federal government," "engineering services," and "private colleges." On the other hand, a single establishment in the electronic and electrical field, say a large manufacturer or an engineering firm, may be doing design and development work on a wide variety of products and equipment.

The largest concentration of electro and mechanical engineering technicians, as might be expected, is in durable goods manufacturing, especially in the making of machinery, transportation equipment, and instruments. Other concentrations occur in public utilities, especially in telephone service; in research, development, and testing laboratories, and engineering services; and in government. The following data show how many are in these industries (more detail in tables III-4 and III-5).

All industries	42,031	100.0%
Manufacturing	23,632	56.2
Electrical machinery, and equipment	7,720	18.3
Machinery, except electrical	4,432	10.5
Transportation equipment	3,426	8.2
Instruments	4,287	10.2
All other manufacturing	3,767	9.0
Transportation, communication, and public utilities	8,911	21.2
Communication	5,209	12.4
Air transportation	1,917	4.6
All other transportation and public utilities	1,785	4.2
Wholesale trade	2,947	7.0
Research laboratories and engineering services	2,163	5.1
Government	2,506	6.0
All other	1,872	4.5

It may come as a surprise that nearly 3,000 technicians are reported under wholesale trade. Almost all these technicians are employed as troubleshooters and servicemen on complex electronic and electro-mechanical equipment in the sales and service branches of large manufacturing concerns. Under the standard industrial classification system used in this report such branches are classified in wholesale trade.

ELECTRONIC ENGINEERING TECHNICIANS

This section and the ones that follow will describe in detail the functions of engineering technicians and will present survey findings covering the experience and education that employers require for the jobs; also the types of subject knowledge that the various technicians need if they are to do their work efficiently.

The electronic-engineering field of work includes, among other products, commmunication systems and equipment covering the audio, radio, television, and microwave frequency spectrum, including masers and lasers; sonar and the electronic portions of radar systems; industrial and military servo systems including computers for fire control and missile guidance; general purpose electronic instruments such as oscilloscopes; special purpose electronic test equipment; logical electronic or electromagnetic circuits and subsystems as found in digital computers;

industrial electronic equipment other than for control purposes, such as in dielectric or induction heating and ultrasonic degreasing; electronic components.

Electronic Design

The responsibility for the over-all design of electronic circuits and equipment is commonly assigned to engineers. The role of the design technician in many instances is restricted to those modifications necessary to get new equipment into production or to redesign old equipment or circuits for newer jobs. Much of the work of the electronic design technician is involved in the physical layout of the components.

Their functions include one or more of the following:

Guided by sketches and schematics, these technicians assist engineers in the design and modification of electronic equipment of varying complexity.

Make layouts, detailed drawings, or sketches of panels or chassis showing or noting positions of component parts, wiring, etc.

Direct the activities of draftsmen and other technicians to carry through the design.

Specify functional, qualification, reliability, and environmental tests to assure that the mechanism complies with design and performance specifications.

Analyze the test data made on the electronic components or equipment by other technicians to determine whether operation falls within acceptable limits.

Perform less complex calculations (e.g., voltage divider network calculations, power calculations, and phase-shift calculations), to expedite design of equipment.

Prepare unit specifications and test procedures relating to the function and operation of the units, properties of the various circuits involved, test techniques, test equipment required, etc.

Follow a detailed design procedure laid out by an engineer to supply numerical values for components in a circuit. This is particularly true where considerable experience in the basic circuit operation is available, as for example in simple audio amplifiers.

Supervise construction of own work especially where quantity is limited or design is simple.

Prepare preliminary drafts of specifications and parts lists, showing names, number, quantities, and brief descriptions, etc.

Receive information from other departments concerning manufacture, test, and inspection problems and utilize this information to coordinate and achieve design and schedule objectives.

Do some estimating (particularly in smaller companies).

Prepare and edit instruction books, especially in those cases where the quantity of equipment is limited or the organization is not large.

The technical skills that may be required by electronic design jobs include:

Ability to write technical reports and procedures.

Ability to understand manuals and standards, and to read schematics, wiring diagrams, parts, layouts, and mechanical drawings.

Ability to use the instruments which are commonly found in electronic laboratories: AC and DC voltmeters and ammeters; wattmeters; ohmmeters; multitesters; Wheatstone and impedance bridges; tube or transistor testers; vacuum tube voltmeters; oscillators; signal generators; oscilloscopes; power supplies; slotted lines; counters; filters; precision potentiometers; pulse generators; etc.

Ability to comprehend the principles of operation and possibly use the following, which are examples of less commonly used equipment; ratiometers; Q meters; microwave oscillators; field strength meters; waveform generators; function generators; pulse analyzers; electronic switches; frequency analyzers; distortion analyzers; variable frequency bandpass filters; shorting stubs and other wave guide loads; interpolation oscillators; precision frequency measuring equipment; voltage and current standardizing equipment.

Ability to use slide rules, desk calculators, special nomographs, and charts.

Electronic Development

The functions of electronic development engineering technicians include one or more of the following:

Working from engineers' sketches or schematics, they construct breadboard layouts of electronic circuits; calibrate and adjust these circuits for proper operation and make minor design changes where required.

Working from preliminary blueprints, they form chassis and assemble cabinets or other hardware for prototype electronic equipment. Recommend minor design changes to facilitate production.

Set up environmental, qualification, or reliability test equipment and may run the tests using this equipment.

Periodically inspect and calibrate their own test equipment, such as vacuum tube voltmeters, and make certain that they remain within tolerance.

Use company standards of National Bureau of Standards transmissions.

Make calculations using basic circuit theory, standard nomographs or charts, etc., for the values of the setting of a component.

Write reports and draw graphs of the results of tests for the use of design, supervisory, or engineering personnel.

Design and construct simple test equipment and fixtures used in the production testing of equipment or the incoming inspection of components.

Develop more complex test equipment under direction of engineers.

Under the direction of an engineer or supervisor, investigate methods of assembly such as wire wrapping or encapsulation for performance and reliability, especially with respect to their electrical characteristics.

Write simple test procedures for use by production line test people.

In smaller companies, may investigate, troubleshoot, and recommend changes when production problems are encountered, such as in printed circuit preparation and etching, dip or hand soldering, special component manufacture, subassembly construction and test, and final assembly construction and test of electronic equipment.

Reconstruct or repair manufacturer's equipment returned for servicing which is not currently in production by the company -- especially where a department is not specifically set up to do this job.

Spot check the quality of work of wirers and production testers to ensure conformance to company specifications.

Maintain records and files for a group of technicians. May also maintain a stock room, especially where the number of technicians is not large.

<u>Technical skills</u> that may be required include:

Ability to write simple technical reports and understand technical manuals.

Ability to read and understand schematics, wiring diagrams, parts layouts, system drawings, and mechanical drawings.

Ability to use the electrical and electronic instruments that are typically found in laboratories such as: voltmeters (AC or DC); ammeters (AC or DC); wattmeters; watthourmeters; ohmmeters; multitesters and vacuum tube voltohmmeters; vacuum tube voltmeters; basic testers for tubes, transistors, diodes, and capacitors; Wheatstone and other DC bridges; AC impedance, capacitance, or inductance bridges; oscillators; signal generators; square wave generators and electronic switches; DC regulated power supplies; counters; filters; potentiometers; pulse generators; and slotted lines and stubs.

Ability to use such small hand or power tools as soldering iron, hammer, screwdriver, pliers, and drill.

Ability to comprehend the function of and operate less common equipment such as Q meters; distortion analyzers; wave analyzers; noise generators and measuring equipment; electric field strength measuring equipment; waveform and function generators; marker generators; microwave oscillators; loads; modulators and demodulators; precision frequency measuring equipment; phase meters; electrical standardization equipment; qualification test equipment such as ovens, low temperature chambers, vibration tables, rate tables, humidity chambers, sand and salt spray test chambers.

Electronic Troubleshooting and Related Functions

The functions of electronic troubleshooting and related technicians may include some or all of the following:

Diagnose and locate the causes of trouble of a nonroutine nature in malfunctioning equipment, such as open and short circuits, cross connections, etc. May work from final drawings or schematics.

Adjust, repair, or have repaired the equipment in which malfunction has been located. If a number of units are involved, may refer to maintenance or production departments after pinpointing trouble.

Perform functional or environmental tests (heat, cold, vibration, etc.) on production units, especially in those cases where the volume is not large or the equipment is complex and requires analytical ability.

Collect the mechanical or electrical equipment required to perform tests on a production unit and may be required to connect up electrical test equipment.

Design and construct simple test fixtures or equipment as may be required to test components (such as inductors, capacitors, and resistors) for inherent properties.

Control the work of a group of testers to ensure that the product conforms to company specifications.

Are responsible for the calibration and certification of the production units. Determine that the time limits on the calibration of test equipment have not expired. Keep any necessary written records on the calibration of units.

Requisition replacement for defective equipment and recommend the acquisition of new equipment.

Suggest new methods of assembly or design to improve productivity.

Determine whether equipment that cannot be repaired should be scrapped or salvaged.

Install electronic equipment at the point of use. This task principally consists of mounting and calibrating the equipment, ensuring that all necessary instruction books are available, and possibly teaching the operation of the equipment to production workers and their supervisors. The installation may require some tests for compatibility with other electronic equipment to avoid such problems as radio noise interference, cable crosstalk, and reflections.

Troubleshoot and repair equipment in the field.

Perform preventive maintenance by scheduling such tasks as testing and replacing components, cleaning contacts, and lubricating switches at regular intervals in the test equipment.

Do electrical calculations (e.g., Ohm's law) as necessary to determine parameters of circuit where these are not explicitly spelled out.

Technical skills required include:

Ability to read schematics, wiring diagrams, mechanical drawings, system drawings, and wiring lists with facility.

Ability to read technical manuals and instruction books.

Ability to use the following instruments, which are examples of equipment commonly found: AC or DC ammeters; AC or DC voltmeters; wattmeters; vacuum tube voltmeters; vacuum tube voltohmmeters; buzzers; multitesters; ohmmeters; DC bridges such as Wheatstone bridge; oscillators or signal generators in various frequency ranges; oscilloscopes of varying complexity; AC bridges for measurement of inductance, capacitance, or impedance; tube or transistor testers; counters; microwave signal generators, modulators and demodulators; loads; slotted lines; DC power supplies; special test equipment.

Technicians may be required to use less common equipment such as the following: waveform and function generators; pulse generators and analyzers; electronic switches; synchroscopes; events per unit tune meters; delay lines; admittance bridges; distortion analyzers; wave analyzers; phase meters; Q meters; special purpose bridges; field strength meters; differential voltmeters; and environmental test equipment such as ovens and low temperature chambers.

ELECTRONICS SUBJECT KNOWLEDGE

In the reports of employers concerning the subject matter that electronics technicians need to know to perform their jobs, some subjects are mentioned less regularly than others. Technicians whose function is development need to know more of these subjects than do design technicians or troubleshooters. While design and development usually call for calculus, troubleshooting rarely does. (Table III-B.)

As indicated above, there is a common fund of knowledge required for the electronics technician, whether his function is that of design, development, or troubleshooting. The basic electronics he needs includes AC and DC circuitry, electrical measurements, and transistor and vacuum tube theory and application. He needs general physics (including the major areas of mechanics, sound, light, etc.) because the principles are widely applied in electronics. Trigonometry is needed for calculations, particularly when working with AC circuits.

The electronic engineering technician engaged in design or development also generally needs a knowledge of advanced algebra in connection with circuit analysis; for example, it would be helpful to the design technician in determining

Table III-B. SUBJECT MATTER KNOWLEDGE NEEDED BY ELECTRONIC ENGINEERING TECHNICIANS

Subject	Design	Development	Troubleshooting and related functions
Mathematics			
Trigonometry	XXX	XXX	XXX
Advanced algebra	XXX	XXX	XX
Solid geometry	-	X	-
Analytic geometry	-	X	X
Calculus	XX	XX	X
Differential equations	-	X	-
Science			
Chemistry, general	X	XX	XX
Metallurgy	-	X	X
Physics			
General	XXX	XXX	XXX
Advanced	-	XX	-
Technology			
Technical drawing	XXX	XXX	X
Basic electricity	XX	XX	XX
Basic electronics	XXX	XXX	XXX
Advanced electronics (a)	XX	XX	XX
Mechanics and strength of materials	X	X	-
Instrumentation	X	XXX	XXX
Machine shop theory and practice	-	X	X
Computers	X	X	X

a. Includes a specialization such as communication, digital, and industrial electronic circuits, microwave theory, or instrumentation.

Key: XXX = generally needed; XX = needed in a substantial number of cases; X = occasionally needed.

the potential in multimesh networks. It is not significant for troubleshooters who have no design or development functions.

Technicians whose function is design or development need technical drawing in order to be able to interpret detailed drawings and schematics, and on occasion to produce them. The troubleshooter is usually called on only to read and interpret layouts and schematics.

Technicians engaged in development and troubleshooting also generally need a knowledge of instrumentation.

The electronics field may be considered in terms of four broad areas; namely, communications below the microwave region, microwaves, digital circuitry and applications, and general industrial electronics. As the electronics technician becomes more experienced and advances to higher grades it frequently becomes necessary for him to use and understand the theory involved in one of the major areas, as for example microwaves.

It is often difficult to draw a sharp line of distinction between the major areas of electronics in terms of what the technician should be expected to know; for example, microwaves is in reality an extension of communication theory. Moreover, the same device may be used in different applications in different areas; for example, the astable multivibrator is used as a clock in digital computers and as an oscillator in television receivers. Similarly, the principles of modulation are the same regardless of the signal frequencies involved.

Beyond the core of basic subject matter, knowledge needed depends on the technician function, as the next paragraphs show.

Electronic Design

In connection with design, the electronics technician needs to know basic electricity. Calculus is also frequently needed, especially for those required to do circuit analysis; for example, it would be employed to determine current and voltage relations in simple and polyphase rectifier circuits.

Specialized areas occasionally have unusual subject matter requirements. For example, the design technician concerned with logic circuits would find Boolean algebra useful, and integrated circuit and transistor design would require a knowledge of general chemistry. A knowledge of computer technology, instrumentation, and strength of materials is also occasionally cited as a requirement.

Electronics Development

In connection with development, a knowledge of basic electricity including wiring and circuitry is important.

The electronics development technician frequently functions in areas of applied chemistry and physics, involving items such as low temperature chambers, salt spray test equipment, vibration test devices, phosphor coatings, and electronic optical systems. Consequently general chemistry and advanced physics are often mentioned.

Calculus is often specified and for the same basic reasons as for the design technician. In addition, this subject is helpful to the development technician in understanding unusual wave forms developed. Occasionally solid geometry, analytic geometry, and differential equations are also required.

In an atypical area of electronics application, knowledge of metallurgy, strength of materials, or machine shop theory and practice may be called for. Computer technology is also occasionally needed.

Electronics Troubleshooting and Related Functions

For troubleshooters, a substantial number of employers specify the same needs in the areas of general chemistry and basic electricity (including wiring and circuitry) as they do for the development technician. Advanced electronics is also needed in a substantial number of cases. On the other hand, advanced physics and calculus are not significant for troubleshooters who have no design or development functions; analytic geometry and calculus are infrequently cited as a requirement for them.

The troubleshooter and installer may encounter some mechanical problems in the solution of which a knowledge of metallurgy and machine shop theory and practice is useful. Occasionally these subjects are specified by employers, as is a knowledge of technical drawing or computer technology.

The troubleshooter is often required to make decisions based on incomplete data in a situation that is difficult to define or diagnose, and in which time is of utmost importance. Some firms prefer a "functional" type of training for troubleshooters -- in which the basic tool for training is the actual system. Such training is oriented to developing an awareness of the source of trouble rather than a basic understanding of the operations and the technology behind them. Fundamentals are taught when needed only for understanding. In many cases, it is possible to prepare a manual with instructions that define the test for determining if a system or piece of instrumentation is functional and this tells how to locate faults and correct them. (See volume 1, chapter IX, page 82.)

ELECTRICAL ENGINEERING TECHNICIANS

In the electrical engineering field of work, among other products, are electrical components and circuits, including resistors, capacitors, inductors, transformers, switches, relays, filters, magnetic amplifiers, motors and generators; high voltage switchgear; wire, cables, and insulation; electrically operated heating, ventilating, and air-conditioning systems; starters and electric power generation control equipment excluding computers; relay operated control equipment for industrial processes; railroad signalling and control equipment; aircraft and marine electrical systems; telegraph and telephone switchgear.

Electrical Design

The functions of electrical design technicians include one or more of the following:

Working from engineering specifications, sketches, ideas, experimental models, customer specifications, written and verbal instructions, schematics and related drawings of existing parts, they prepare sketches, drawings, and layouts of prototypes, adaptations, alterations, and improvements of electrical products.

Make preliminary studies and investigations relative to design assignments to determine such factors as function, circuitry, size, shape, environment, stability, reliability, sensitivity, voltage, current, and power requirements.

Obtain data and information on performance, components, etc., from sources such as trade and technical publications, sales, service, shop, related equipment, and own observations.

Design layouts of original configurations such as printed circuit cards, electromechanical displays, etc. Design circuits and determine the necessary wiring for the installation of electrical machinery, test, and industrial equipment, and special products such as electrical fixtures, and packaging and vending machines.

Direct draftsmen in completion of engineering layout of circuitry and products.

Visit customers' plants to investigate special conditions.

Submit preliminary design for engineering review, discussion, and approval.

Supervise assembly and test of experimental models, changing design to correct any defects which appear.

List specifications indicating sequence and kind of testing for inspection of production units.

Collaborate with sales, service, shop, quality control, and others to consider and appraise recommendations relating to improvements and cost reduction.

Keep a file of sketches, drawings, calculations, and reference data.

Check proposed or completed designs for technical errors and compliance with company, industrial, local, and national codes or standards.

The technical skills needed by electrical design technicians may include:

Ability to write reports and specifications; ability to read electrical schematics, wiring diagrams, mechanical drawings, standard, and technical manuals.

Ability to use slide rule, nomograph, or desk calculator.

Ability to use the instruments commonly found in an electrical laboratory such as: continuity testers; ohmmeters; multimeters; DC or AC voltmeters; DC or AC ammeters; wattmeters; varmeters; power factor meters; watthourmeters; tachometers; power supplies; different types of DC bridges such as Wheatstone bridges, etc; impedance bridges; DC or AC potentiometers; insulation resistance and breakdown measuring equipment; stroboscopes; etc.

Ability to comprehend the principles of operation of (and possibly to use) less common electrical laboratory equipment of which examples are: counters; oscilloscopes; oscillators or signal generators; tube or transistor testers; ratiometers; function or waveform generators; wave or distortion analyzers.

Electrical Development

The electrical development technicians perform one or more of the following functions:

Assist designers and engineers who are determining specifications for development of electrical instruments, machines, and products by offering suggestions with respect to the construction of the equipment.

Under the general supervision of a designer or an engineer, plan and construct, or supervise construction of, breadboard, prototype, development, or initial production models of new equipment, instruments, machines, and products. Select common small components and material to be used in the equipment. Mount components (particularly where little machining is required) and wire up equipment.

Diagnose, locate, and correct malfunctions and internal electrical and mechanical deficiencies in the prototype components or equipment under test. Compare test data with design specifications.

Make recommendations to the engineer for changes in design.

Less frequently:

Set up qualification, environmental, production, or reliability test equipment and may run tests using this equipment.

Devise the simpler tests and construct equipment for the quality control of the manufactured product or incoming material.

Write reports of tests and development projects including preparation of charts, diagrams, graphs, and drawings.

Technical skills needed by electrical development technicians may include:

Ability to read wiring diagrams, schematics, mechanical drawings.

Ability to read and understand technical manuals, specifications, or reports.

Ability to use the instruments commonly found in an electrical laboratory. (See electrical design for a listing of these instruments.)

Ability to comprehend the principles of operation of (and possibly to use) less common electrical laboratory equipment. (See electrical design for examples of such equipment.)

Ability to use small hand tools such as pliers, screwdriver, hammer, and soldering iron.

Electrical Troubleshooting and Related Functions

The functions of technicians doing electrical troubleshooting and related work include one or more of the following:

Diagnose and locate trouble of a nonroutine kind in production of electrical equipment. Work from schematics or drawings. Replace or repair the defects or refer the equipment to maintenance or production department.

Collect the necessary mechanical or electrical equipment for testing and ensure the reliability and accuracy of the test equipment.

Make qualification and functional tests on systems and complex equipment.

Perform environmental tests such as vibration, shock, resistance to corrosion or fungus attack, and high and low temperature.

Less frequently:

Make elementary electrical calculations, such as of voltage across a circuit or resistance in the circuit.

Are responsible for the accuracy of the test equipment in their own charge and either calibrate this equipment themselves or ensure that others calibrate it.

Work with and assist the quality control engineer, especially in those cases where the percentage of rejects has been found to be unusually large.

Assemble and wire special-purpose electrical test equipment, or connect up standard equipment to perform special tests.

Maintain calibration records for the equipment in their charge.

Requisition replacements for defective equipment and may recommend the acquisition of new equipment.

Technical skills needed by electrical troubleshooters may include:

Ability to read wiring diagrams, schematics, mechanical drawings, etc.

Ability to read and understand technical manuals and specifications.

Ability to use the more common instruments found in an electrical laboratory of which examples are: continuity testers; ohmmeters; multitesters; DC or AC voltmeters; DC or AC ammeters; wattmeters; varmeters; power factor meters; watthourmeters; tachometers; stroboscopes; power supplies;DC resistance bridges such as the Wheatstone bridge; AC bridges to measure capacitance, inductance, or impedance; DC or AC potentiometers; insulation resistance testers; insulation breakdown testers; specialized test equipment under their immediate control; tube or transistor testers.

Ability to use less common electrical or electronic equipment found in electrical work such as: counters; oscillators and signal generators; specialized DC or AC bridges; ratiometers; function or waveform generators; wave or distortion analyzers; voltage or current standardization equipment.

Ability to use small hand tools such as pliers, screwdriver, hammer, and soldering iron.

ELECTRICAL SUBJECT KNOWLEDGE

Reports of employers concerning subject matter knowledge needed to perform electrical technician jobs named some subjects much oftener than others: (Data are summarized in Table III-C.)

Table III-C. SUBJECT MATTER KNOWLEDGE NEEDED BY ELECTRICAL ENGINEERING TECHNICIANS

Subject	Design	Development	Troubleshooting and related functions
Mathematics			
Trigonometry	XXX	XXX	XXX
Advanced algebra	XXX	XXX	X
Science			
Chemistry, general	XX	XX	XX
Physics, general	XXX	XXX	XXX
Technology			
Technical drawing	XXX	XXX	X
Basic electricity	XXX	XXX	XXX
Basic electronics	XX	XX	XX
Electrical machinery	XX	XX	XX
Mechanics	X	XX	XX
Instrumentation	XX	XXX	XXX
Manufacturing processes	X	-	-
Machine shop theory and practice	X	X	-

Key: XXX = generally needed; XX = needed in substantial number of cases; X = occasionally needed.

Electrical Design

Generally needed: A knowledge of mathematics through advanced algebra is needed for circuit analyses and calculation of phase relationship; general physics for background in understanding the principles of mechanics, electricity, and magnetism; basic electricity including circuitry to provide an understanding of the application of electrical parameters (voltage, current, resistance, and capacitance) for test purposes; technical drawing for preparing and reading layouts, schematics, wiring diagrams, parts lists, and wire lists.

Needed in a substantial proportion of cases: A knowledge of basic electronics is needed because many controllers now use electronic principles; AC and DC machines, because of their widespread application in industry; general chemistry for an understanding of new materials, insulation, electroplating, corrosion, etc. a knowledge of instrumentation is also often needed.

Infrequently needed (though some particular individuals may be required to have an extensive background in these subjects) are a knowledge of heat (for industrial electric furnaces); light (for electrical fixtures); sound (for noise effects); logic (for relay systems); mechanics (for links and springs in contact circuit breakers); machine shop theory and practice and manufacturing processes (for packaging machines, printed circuit cards, etc.)

Electrical Development

Generally needed: Advanced algebra and trigonometry, to determine voltages, currents, and phase angles; general physics to relate electricity and magnetism to other physical phenomena in the area of heat, light, sound, mechanical forces, etc.; basic electricity for an understanding of electrical-energy distribution and its control; technical drawing, for reading and interpreting schematics and wiring diagrams; instrumentation.

Frequently needed: AC and DC machines, because they are widely used in industry; basic electronics because tubes, transistors, and particularly silicon-controlled rectifiers are more and more becoming a part of what used to be purely electrical circuits. Mechanics is needed because vectors in statics and phasor diagrams in electricity are closely related; general chemistry for background and a better understanding of environmental tests, involving insulation and corrosion.

Occasionally need: machine shop theory and practice -- where construction of prototypes is required of the technician.

Electrical Troubleshooting and Related Functions

The basic subject knowledge needed is mathematics through trigonometry for the majority of the calculations made in the testing and repair of electrical equipment; general physics, particularly for understanding the performance of equipment under the influence of temperature, humidity, etc.; basic electricity, for understanding the function of individual components of electrical equipment; instrumentation, for familiarity with and use in measuring instruments, either as part of the electrical circuit or for testing components in the circuit.

Needed in a substantial proportion of cases is a knowledge of mechanics, since many electrical circuits fail because of mechanical stress, and for an understanding of the forces involved in the use of arms, levers, springs, couplings, etc., in electrical equipment such as relays, switches, circuit breakers; basic electronics, because of its increasing application in the electrical field (for controllers, rectifiers, repeaters, etc.); AC and DC machines because they serve as prime movers in many pieces of equipment; general chemistry, for understanding the effects of corrosion, humidity, etc. on electrical equipment.

Occasionally required is a knowledge of advanced algebra, to determine, for example, the potentials in relatively complicated circuits such as simple filter networks; technical drawing for reading and interpreting schematics and wiring diagrams.

MECHANICAL ENGINEERING TECHNICIANS

The mechanical engineering field of work includes, among other products, regulator parts and assemblies; mechanical components and hardware for radio, T.V., microwave, computer, electronics, electrical, and electro-mechanical equipment; mechanical machinery and equipment for aircraft, transportation, and ordnance industries; manufacturing machinery and equipment for wire drawing, rolling mills, printing, canning, roasting, packaging, die casting, paper, materials handling, mining, heating, ventilating, and air conditioning; mechanical, hydraulic, and pneumatic measuring, testing, and control instruments; tools, dies, jigs and fixtures.

Mechanical Design

The functions of mechanical design technicians include one or more of the following:

They work from engineering specifications, sketches, ideas, customer specifications, written and verbal instructions, schematics, and related drawings of existing parts to design new tools, products, instruments, adaptations, alterations, and improvements.

Make preliminary studies and investigations relative to design assignments to determine such design factors as size, simplicity, sequence of operations, speeds, interchangeability, costs, facility of repair and maintenance, materials, and heat treatment to be used.

Obtain data and information on performance, components, etc., from sources such as trade and technical publications, sales, service, shop, related equipment, and own observations.

Visit customers' plants to investigate special conditions.

Prepare preliminary sketches, drawings, and layouts.

Submit preliminary design for review, discussion, and approval.

Determine other design factors such as fits, clearances, tolerances, finish, loads, stresses, materials, and gear ratios. Determine what purchased units may be incorporated in the design.

Make necessary calculations for gears, cams, drives, mechanisms, tools, and other parts.

Prepare complete layouts, detailed working or assembly drawings. May supervise other personnel in the preparation of the drawings.

Less frequently:

Supervise assembly and test of experimental models, changing design to correct any defects which appear.

List specifications, indicating sequence and kind of testing for inspection of production units.

Collaborate with sales, service, shop, quality control, and other personnel to consider and appraise suggestions and recommendations relating to improvements and cost reduction.

Assist in solution of problems in manufacturing, customer complaints, field service, sales requests, etc., which have been referred to engineering.

The technical skills required by mechanical design jobs include:

Ability to use the standard drawing instruments (see chapter 1), and occasional use of mechanical precision measuring instruments such as micrometers, vernier calipers, etc.

Ability to read blueprints and schematics.

Ability to read and understand scientific or engineering data found in notes, sketches, reports, reference books, technical manuals, handbooks, standards, and periodicals, ability to write technical reports.

Mechanical Development

The functions of mechanical development technicians include one or more of the following:

They consult with designers and engineers for the purpose of determining specifications for the development of mechanical devices, equipment, and machines.

Work from sketches, engineering drawings, specifications, written and verbal instructions.

Construct complete prototype, developmental, or initial production models of mechanical products or test equipment which may involve a variety of mechanical devices such as gears, variable speed drives, link and chain mechanisms, etc.

Troubleshoot, diagnose, locate, and correct malfunctions or defects in experimental models.

Record data and write reports of tests and development projects including preparation of charts, graphs, and diagrams.

Less frequently:

Set up environmental test equipment and run qualification tests.

Develop and set up test equipment to evaluate functional adequacy of experimental models.

Recommend changes in design, materials, or processes for more efficient operation, production, or correction of defects.

Test and adjust first production models.

Develop tests and equipment to be used for quality control of manufactured product or incoming material that is utilized in the manufactured product.

Help coordinate effort of engineering, sales, procurement, and manufacturing departments to expedite new products from the development stage to factory production including follow up through purchasing, model testing, tooling, and pilot run stages of development.

Cooperate with engineering and other personnel in formulating test procedures, interpreting test standards or specifications, and evaluating test data during the development of new product designs or modification of existing designs.

Technical skills include:

Ability to read and interpret engineering and wiring drawings.

Ability to write technical reports concerning laboratory tests, production problems, evaluation of new designs, etc.

Ability to use the following instruments and tools: hand and power tools such as pliers, screw driver, wrench, electric drill, lathe, and grinder; precision measuring tools such as micrometer, vernier caliper, comparator, and gauge blocks; thermometers; pyrometers; hardness testers; and tachometers. Occasional use of environmental test equipment such as ovens, salt spray cabinets, vibration and shock testers; electric and gas welders; jeweler's lathe; voltmeter, ammeter, and ohmmeter; manometers and other pressure indicating equipment.

Mechanical Troubleshooting and Related Functions

The functions of workers in this area include one or more of the following:

Diagnose and locate defects in equipment and machines.

Repair or have repaired any defects that are located -- the decision as to who repairs the defect being determined by company guidelines.

Work from final drawings, wiring diagrams, specifications, and written instructions.

Do preventive maintenance by setting up lubrication and replacement schedules for those machine parts that require it.

Eliminate functional and constructional problems encountered on test equipment or products, utilizing experience in gearing, leverage, tolerance, electrical circuitry, etc.

Test, repair, maintain, and modify mechanical and environmental test equipment.

Less frequently:

Perform environmental tests such as heat, corrosion, resistance, vibration, and shock on production units.

Install or supervise the installation of company equipment in the field. This function is used primarily in connection with air conditioning, heating, and ventilating equipment.

Certify, calibrate, and align production test equipment and keep any necessary records on the calibration of test units.

Supervise or work with a group of testers to ensure conformance of the product to company specifications.

Recommend replacements for defective test equipment.

Inspect and check out complex equipment and instruments.

Troubleshoot and repair equipment in the field.

Prepare periodic reports of test results for the test supervisor or quality control department.

Recommend improvements of quality and testing methods.

Investigate causes and make recommendations for correction of larger sources of scrap.

Technical skills include:

Ability to read and interpret mechanical drawings, specifications, and instructions.

Ability to write technical reports of test results.

Ability to use the following instruments and tools: hand and power tools such as pliers, screw driver, wrench, and electric drill; precision mechanical inspection equipment such as micrometers, vernier calipers, height and depth gauges, gauge blocks, ring and plug gauges; hardness testers; manometers and other pressure indicating equipment. Occasional use of pyrometers; leak detectors; strain gauges; electrical instruments such as ammeters, voltmeters, ohmmeters, etc.; optical instruments such as interferometer, spectrometer, densitometer, and lens bench; environmental test equipment such as ovens, humidity testers, and vibration testers.

MECHANICAL SUBJECT KNOWLEDGE

Reports of employers concerning subject matter knowledge needed to perform mechanical technician jobs named some subjects much oftener than others. (Data are summarized in table III-D.)

Mechanical Design

Mechanical engineering jobs generally require knowledge of mathematics through trigonometry, general physics, and machine shop theory and practice.

Technical drawing is a basic need of the design technician and the development technician, but not of the troubleshooter, who is ordinarily required only to read layouts, schematics, flow charts, etc. Mechanics, strength of materials, and machine design are also basic needs of the design technician.

Required in a substantial proportion of cases is a knowledge of advanced algebra, for stress analysis and particularly for the design of beams and columns; general chemistry, for background leading to a better understanding of metallurgy; metallurgy, for the selection of the best metals and heat treatment for a particular application; tools and fixtures, because design is influenced by the tools and

Table III-D. SUBJECT MATTER KNOWLEDGE NEEDED BY MECHANICAL ENGINEERING TECHNICIANS

Subject	Design	Development	Troubleshooting and related functions
Mathematics			
Trigonometry	XXX	XXX	XXX
Advanced algebra	XX	XX	X
Calculus	X	X	-
Science			
Chemistry, general	XX	XX	XX
Metallurgy	XX	XX	X
Physics, general	XXX	XXX	XXX
Hydraulics	X	X	X
Pneumatics	X	X	X
Technology			
Technical drawing	XXX	XXX	X
Basic electricity	X	XX	XX
Basic electronics	X	XX	XX
Mechanics and strength of materials	XXX	XX	X
Manufacturing processes	XX	-	-
Machine shop theory and practice	XXX	XXX	XXX
Machine design	XXX	X	X

Key: XXX = generally needed; XX = needed in substantial number of cases; X = occasionally needed.

fixtures to be used in the manufacture; and manufacturing processes in order to make efficient use of available manufacturing equipment.

A knowledge of calculus is required occasionally for the design of certain cam profiles, differential controls, and for the determination of the moment of inertia of unusual cross-sections; basic electricity and electronics, for the understanding of motors, switches, relays, controllers, and recorders in some mechanical designs; hydraulics, when dealing with liquid flow such as in automatic transmissions, braking systems, and servos; and pneumatics for the use of air cylinders in the positioning of cutting tools.

Approximately 38 percent of the mechanical design technicians are tool and die designers. These persons are recruited mainly from among draftsmen and from the tool-and-die maker craft. Their subject-knowledge needs lean more heavily toward metallurgy, mechanics, strength of materials, tools, fixtures, dies, manufacturing processes, and machine shop theory and practice. Depending upon the industry, they may be required to have specialized knowledge, for example to know expansion and compression characteristics and other properties of plastics, rubber, ceramics, and metals.

Mechanical Development

In general, the development technician has less need for mathematics knowledge than the design technician has.

The basic requirement is a knowledge of mathematics through trigonometry, general physics, and technical drawing. Machine shop theory and practice and tools and fixtures are also essential for the fabrication of experimental and initial production models.

Frequently needed is a knowledge of general chemistry for background; metallurgy, for an understanding of the selection and heat treatment of metals parts; mechanics and strength of materials as a basis for making suggestions and minor modifications; advanced algebra for the presentation of test data such as log-log plots; and basic electricity and electronics, for understanding and testing the use of motors, switches, and relays in the mechanical design.

Among the subject knowledge which is occasionally required, depending upon the project, is an introductory course in calculus for an understanding of differential controls, ball and disc integrators, dashpots, etc.; hydraulics when dealing with liquids, to apply pressure, as in hydro-press forming; pneumatics, when compressed air is used for pressure measurement or tool positioning; and machine design as a basis for suggesting occasional design changes.

Mechanical Trobleshooting and Related Functions

These technicians typically require less mathematics knowledge than the design and development technicians. The basic subject knowledge requirement is mathematics through trigonometry, for calculations required for testing and repair of mechanical instruments and machines; general physics, to introduce the principles of mechanics, electricity, magnetism,heat, light, and sound; machine shop theory and practice,for making simple machine parts such as links and pins for repair and tools and fixtures, because of their wide use in the operation and construction of machinery.

Required in a substantial proportion of cases is a knowledge of general chemistry for background; basic electricity and electronics, for understanding, testing, and adjusting motors, relays, switches, etc.

A knowledge of advanced algebra is occasionally required for the presentation of certain test data; mechanics, strength of material, and machine design, to understand the operation of machines and to be able to suggest design modifications where failure in service has occurred; metallurgy, to select and heat treat, if necessary, a metal repair part when a replacement is not readily available; hydraulics and pneumatics, for an understanding of the use, testing, adjusting, and repair of instruments and components based on gas or liquid flow when used as part of the mechanical design.

ELECTRO-MECHANICAL ENGINEERING TECHNICIANS

The electro-mechanical engineering technician's field of work includes various electro-mechanical instruments and controls, such as aircraft displays (integrated instruments), airborne navigational computer systems, ground and ground-support equipment, simulator and training devices for radar, sonar, and micromation devices (data convertors and remote indicators); servo-control instruments for all-weather aircraft landing systems; inertial guidance systems for space vehicles, auto pilots, aircraft and naval fire-control systems; telephone and telegraph switchgear; electrohydraulic and electropneumatic instruments for the measurement and control of load, thrust, torque, flow, level, displacement, temperature, pressure, humidity, dew point, density, etc.; instruments and controls for medical treatment and research, such as artificial heart, kidney, and lung; business machines, such as calculators, accounting machines, card-handling machines.

Electro-mechanical Design

The functions of electro-mechanical design technicians include one or more of the following:

These technicians work from engineering specifications, sketches, ideas, written and verbal instructions, schematic drawings, and related drawings of existing parts to design new electro-mechanical systems, instruments, and controls, or make revisions, alterations, and improvements of existing units.

Visualize electrical, electronic, and mechanical aspects of project and consider operating functions and performance requirements.

Make preliminary studies and investigations relative to design assignments to determine such design factors as size, shape, and space limitations, coordination of electrical, electronic, and mechanical components; standardization; and facility of repair and maintenance.

Determine sequence of manufacturing operations, costs, etc.

Make preliminary sketches, drawings, and layouts, and note items that require additional development such as dimensions, location of components, and provision for heat dissipation.

Submit preliminary design for discussion, review, and approval.

Determine whether purchased electrical, hydraulic, or pneumatic units may be incorporated in the design.

Obtain data and information on components from sources such as trade and technical publications, sales, service, and shop.

Use charts, handbooks, and tables to make the necessary calculations to determine loads, stresses, movement required, mechanisms, gear trains, speeds, weights, fits, and clearances of parts.

Prepare complete layouts, detailed working or assembly drawings; may supervise other personnel in the preparation of the drawings.

Less frequently:

Prepare and issue bills of material and part lists; assign and record part numbers.

Supervise and assist in the development of prototype models.

Observe test tryout of system, instrument, or control and make necessary modifications to eliminate any defects revealed by the test.

Consult and counsel appropriate engineering and manufacturing personnel on the effect of the design on production and raw material.

Collaborate with sales, service, shop, quality control, and others to consider and appraise suggestions and recommendations relating to improvements and cost reduction.

Assist in solution of problems in manufacturing, customer complaints, field service, etc., which have been referred to engineering.

Technical skills required include:

Ability to read blueprint and schematic drawings.

Ability to read and understand scientific or engineering data found in notes, sketches, reports, reference books, technical manuals, handbooks, standards, and periodicals.

Ability to write technical and progress reports regarding design projects, customer complaints, surveys in the field, etc.

Ability to use the standard instruments (see chapter I). Occasional use of mechanical precision measuring instruments such as micrometers, calipers, and comparators; electrical and electronic test instruments, such as voltmeter, ammeter, ohmmeter, and oscilloscope.

Electro-mechanical Development

The functions of electro-mechanical development technicians include one or more of the following:

They confer with engineers and designers for the purpose of determining specifications for the development of electro-mechanical devices.

Work from sketches, engineering drawings, specifications, electrical and electronic schematic drawings, verbal and written instructions.

Interpret schematic and line diagrams relating to fluid systems (hydraulic and pneumatic) such as fuel control systems, actuators, pressurization systems, feed back controls, etc., and check individual components as required.

Construct or supervise the construction of complete prototype, developmental, or initial production models which may involve assembly of a variety of devices such as gear trains, variable speed drives, link and cam mechanisms, servo controls, hydraulic and pneumatic systems, AC and DC machines, electrical and electronic circuits.

Troubleshoot, diagnose, and locate malfunctions and then correct internal electrical and mechanical defects in prototype unit under test.

Write reports of tests and development projects including preparation of charts, diagrams, and graphs.

Less frequently:

Align, calibrate, maintain, and repair electronic, electrical, and mechanical test equipment and measuring instruments.

Make recommendations to the designer for changes in design for more efficient production, operation, or maintenance of the product.

Set up reliability or environmental test equipment (such as humidity, vibration, temperature, endurance, etc.) and run qualification tests using this equipment.

Develop tests and equipment to be used for control of the quality of manufactured product or of incoming raw material.

Are responsible for recording changes found necessary during construction or repair of prototype for the purpose of modifying drawings.

Help coordinate efforts of engineering, sales, procurement, and manufacturing departments to expedite new products from the development stage to factory production including follow-up through purchasing, model-testing, tooling, cost-study, and pilot-run stages of development.

Cooperate with engineering and other personnel in formulating test procedures, interpreting test standards or specifications, and evaluating test data during the development of new product designs or modification of existing designs to ensure satisfactory performance.

<u>Technical skill</u> requirements include:

Ability to read and interpret engineering drawings, electrical and electronic wiring and schematic drawings, hydraulic and pneumatic line drawings.

Ability to write technical reports concerning laboratory tests, evaluation of new designs, etc.

Ability to use the following tools and instruments: hand and power tools such as pliers, screw driver, wrench, electric drill, grinder, and power brake; soldering iron; precision mechanical measuring tools such as micrometers and vernier calipers; electronic and electrical instruments and equipment such as ammeter, wattmeter, voltmeter, vacuum tube voltmeter, oscilloscope, continuity testers, DC power supplies, insulation testers, impedance bridges, and tube and semi-conductor testers. Occasional use of the following tools and instruments: dead weight tester; pyrometer; hydraulic and pneumatic simulators; synchroscope; low frequency generators; impulse generators; differential voltmeters; noise generators; stroboscopes; electrical shock excitation generators; reliability and environmental test equipment such as ovens, humidity chambers, vibration testers, shock testers, salt spray cabinets, low temperature chambers, etc.

<u>Electro-mechanical Troubleshooting and Related Functions</u>

The <u>functions</u> of these technicians include one or more of the following:

They adjust, test, and troubleshoot complete electro-mechanical systems and components. This includes diagnosing the malfunction to determine whether the defect is in the mechanical, electrical, or electronic components of the system. Particularly for electrical and electronic sections, it may be possible to correct the malfunction by adjustment of the components or by replacing the entire section to allow a rapid return to normal operation of the system. In the case of mechanical defects, such as worn gears and cam, failed linkages, loss of pressure in hydraulic or pneumatic components, etc., it is generally necessary to determine the particular defective part.

Requisition new parts or repair the faulty equipment, or return the equipment for repair.

Test, repair, maintain, or modify electronic, electrical, mechanical, electromechanical, and environmental test equipment to satisfy specifications.

Less frequently:

Certify, calibrate, and align test equipment and make adjustments to jigs and fixtures as required to perform a particular job.

Keep written records of calibration of equipment or test data as required.

Wire special test equipment from schematics and diagrams.

Design and construct simple mechanical aids to production.

Perform environmental tests such as heat, cold, corrosion resistance, vibration, shock, etc. on production units.

Work with quality control technicians to determine the cause of excessive number of rejects.

Select and set up test equipment for a particular job.

Do preventive maintenance as required by scheduling the testing or replacing at regular intervals of components which experience has shown to have a fixed reliable lifetime.

Install or supervise the installation and troubleshooting of company equipment in the field, particularly of complex aircraft instrumentation.

Keep inventory and disbursement records and control movement of all test instruments.

Recommend purchase or replacement of defective test equipment.

Troubleshoot and repair equipment in the field.

These technicians work from engineering drawings, sketches, samples, schematics, wiring drawings, and verbal or written instructions.

Technical skills required include:

Ability to read and interpret engineering drawings, electrical and electronic wiring and schematic drawings, hydraulic and pneumatic line drawings.

Ability to write technical reports concerning laboratory tests, evaluation of new designs, etc.

Ability to use the following tools and instruments: hand and power tools such as pliers, screw driver, wrench, electric drill, grinder, and power brake; soldering iron; precision mechanical measuring tools such as micrometers, vernier calipers, etc.; electronic and electrical instruments and equipment such as ammeter, wattmeter, voltmeter, vacuum tube voltmeter, oscilloscope, continuity testers, DC power supplies, insulation testers, resistance and impedance bridges, and tube and semi-conductor testers. Occasional use of the following tools and instruments: dead weight tester; pyrometer; hydraulic and pneumatic simulators; synchroscope; low frequency generators; impulse generators; differential voltmeter; noise generators; stroboscopes; electrical shock excitation generators; reliability and environmental test equipment such as ovens, humidity chambers, vibration testers, shock testers, salt spray cabinets, and low temperature chambers.

ELECTRO-MECHANICAL SUBJECT KNOWLEDGE

Reports of employers concerning knowledge needed by electro-mechanical technicians named some subjects more often than others, as Table III-E shows.

Electro-mechanical Design

Subject matter needs of these technicians generally include knowledge of mathematics through advanced algebra, for calculations necessary to determine load, stresses, movement required, gear trains, weights, tolerances, etc., of parts; general physics, for background; technical drawing, for reading and preparing layouts and drawings; mechanics, strength of materials, and machine design, for the design of mechanical components; basic electricity and electronics and circuits, to incorporate switches, relays amplifiers, etc. into the electro-mechanical design. Instrumentation forms an important part of the electro-mechanical field.1/

Required in a substantial proportion of cases is a knowledge of calculus and general chemistry for background; metallurgy, for the selection and heat treatment of metal parts used in mechanical components; kinematics, for the design of mechanisms to give a required movement; machine shop theory and practice and manu-

1. A suggested two-year post-high-school curriculum in instrumentation is set forth in: Instrumentation Technology A Suggested 2-Year Post High School Curriculum (Technical Education Program Series No. 6), issued by the U.S. Department of Health, Education, and Welfare in 1964.

Table III-E. SUBJECT MATTER KNOWLEDGE NEEDED BY ELECTRO-MECHANICAL ENGINEERING TECHNICIANS

Subject	Design	Development	Troubleshooting and related functions
Mathematics			
Trigonometry	XXX	XXX	XXX
Advanced algebra	XXX	XX	X
Calculus	XX	XX	-
Differential equations	X	-	-
Science			
Chemistry, general	XX	XX	XX
Metallurgy	XX	-	-
Physics, general	XXX	XXX	XXX
Hydraulics	XX	XX	XX
Pneumatics	XX	XX	XX
Optics	X	X	X
Technology			
Technical drawing	XXX	XXX	X
Basic electricity	XXX	XXX	XXX
Basic electronics	XXX	XXX	XXX
Mechanics and strength of materials	XXX	XXX	XXX
Instrumentation	XXX	XXX	XXX
Manufacturing processes	XX	-	-
Machine shop theory and practice	XX	XX	XX
Machine design	XXX	X	-
Computers	X	X	X
Mechanisms	XX	XX	XX

Key: XXX = generally needed; XX = needed in substantial number of cases; X = occasionally needed.

facturing processes, for design reflecting efficient use of available production facilities; hydraulics and pneumatics for the principles of fluid and gas flow and for understanding many electro-mechanical devices such as pneumatic telemetering, integrators, pressure gauges, etc.

Occasionally a knowledge of differential equations is required for an understanding of servomechanisms; and a knowledge of optics for applications in which optical analyzers (spectrometer, infra-red analyzer) are used, such as in furnace atmosphere control and combustion control. Knowledge of computer technology is also needed occasionally.

Electro-mechanical Development

The basic subject knowledge requirement for these technicians is mathematics through trigonometry, for many of the calculations in the construction of prototypes; general physics, in order to cover the principles involved in many environmental tests, such as humidity and temperature; mechanics, for an understanding of the forces involved in instrumentation; technical drawing, for the purpose of making sketches; instrumentation, for reading and interpreting line diagrams relating to fluid systems and understanding the operation of various instruments; basic electricity and electronics and circuits, in order to understand the use of such components as relays, switches, and potentiometers in electro-mechanical development.

Subject knowledge needed in a substantial proportion of cases includes advanced algebra, for the presentation of test data and for electrical calculations that involve exponentials, such as the charge on a condenser as a function of time; calculus, not so much for use but rather to aid in understanding the theory of differential controls and analog computers; general chemistry, for background; hydraulics and pneumatics, to understand the use of fluid gas flow principles in electro-mechanical devices; machine shop theory and practice, to be able to use machine tools in the construction of prototypes; mechanisms, to understand the use and assembly of various mechanical components such as gear trains, variable speed drives, and link and cam combinations.

Occasionally needed is a knowledge of strength of materials and machine design, to be able to suggest occasional design modifications of mechanical components. Depending upon the product or industry, other specialized knowledge may be required; for example, computers in electronic data-processing systems and optics in chemical process streams that use optical analyzers.

Electro-mechanical Troubleshooting and Related Functions

These technicians typically need less knowledge of mathematics than the design and development technicians do.

The basic subject knowledge needed is mathematics through trigonometry, general physics, to cover the principles of electricity, magnetism, mechanics, heat, light, and sound; mechanics, for understanding the forces involved in electro-mechanical devices; basic electronics and electricity and circuits, to cover the principles involved in the operation and use of electronic and electrical instruments and devices; instrumentation, to understand the interrelation of mechanical, electronic, and electrical components, to be able to calibrate and align electro-mechanical instruments, and to read and interpret line drawings relating to fluid systems.

Subject knowledge needed in a substantial proportion of cases include general chemistry for background; mechanisms, for an understanding of the use of linkages, cams, and gears; machine shop theory and practice, to use machine tools and precision mechanical measuring instruments, for testing and repair; hydraulics and pneumatics, to understand fluid and gas flow principles in the operation and repair of many electro-mechanical instruments and devices.

Infrequently needed is a knowledge of advanced algebra for the determination of certain properties, such as the time constant of a measuring instrument. As mentioned previously in the case of development technicians, depending upon industry or product some specialized knowledge may be required such as an introduction to computer theory or optics.

Approximately 70 percent of the electro-mechanical technicians are in troubleshooting and related functions. The two largest groups in this category are telephone switchmen and computer-service technicians. Although the duties of telephone switchmen are primarily electrical, the telephone industry generally requires these people to have both electrical and mechanical knowledge. Mechanical knowledge is useful in testing and adjusting relays, cross bar switches, and stepping switches, and for troubleshooting wiring circuits that include these mechanical elements.

Computer-service technicians need a basic introduction to computer operation including the organization and logic of the machines, and a knowledge of mechanisms.

GRADE STRUCTURE

Information was obtained as to whether or not a technical occupation involved major supervisory responsibilities over other technicians; and, if not, whether it was a single-grade job or one of several grades.

Table III-F shows that, excluding the supervisory jobs, more technicians are in single-grade jobs than in jobs in multi-grade structures.

Table III-F. PERCENT DISTRIBUTION OF ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS ACCORDING TO GRADE, BY FIELD

Grade	All fields	Electronic	Electrical	Mechanical	Electro-mechanical
All grades: Number	42,031	10,791	8,794	8,461	13,985
Percent distribution					
All grades: Percent	100.0	100.0	100.0	100.0	100.0
Supervisory grades	5.0	5.1	4.1	3.9	6.1
Nonsupervisory grades:					
Single grade only	56.1	50.1	55.4	49.7	64.9
Multi-grade:					
Lowest grades	14.7	16.0	16.9	17.4	10.8
Middle grades	7.6	8.2	7.8	9.6	5.8
Highest grades	16.6	20.6	15.8	19.4	12.4

Further details are given in table III-6, at the end of the chapter. These details show the influence of the size of the establishment. The proportion of electro and mechanical engineering technicians in single-grade jobs is greatest in smallest establishments. As establishment-size rises the proportion of technicians in multiple-grade jobs also tends to rise. Generally, single-grade jobs predominate among establishments of less than 500 workers, multiple-grade jobs in the larger establishments.1/

Note that the level of difficulty and responsibility of jobs at any grade level -- low, middle, or high -- may vary from one firm to another. No effort was made in the survey to slot jobs of like level of difficulty and responsibility into the same grade level. The grade levels reflect the designations of employers.

Analysis of the jobs shows the following to be the main elements by which nonsupervisory jobs are distinguished from each other in the case of electro and mechanical engineering technician jobs:

..Directness or closeness of supervision and checking of results of work.
..Extent to which instructions are standardized or spelled out in writing.
..Extent of initiative, discretion, and judgment exercised.
..Complexity, intricacy, and component-multiplicity of product or equipment dealt with.
..Variety of products and equipment dealt with.
..Knowledge of product and equipment and related technologies.
..Knowledge of company's products and policies.

In addition to these general elements, technicians at the lowest grade tend in a greater degree than technicians of higher grade to perform the craft aspects of technician jobs, especially repair work, assembly, component-construction, and installation, and tend to spend a larger proportion of time on routine or standardized testing.

The content of single-grade jobs varies considerably among establishments but on the average probably is more comparable to the middle and upper grades of multiple-grade systems than to their lower-grade jobs. This situation is reflected in the amount of education and experience that employers require when they are hiring (see the next section).

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1. Table III-6 shows that in the largest establishments -- those employing 5,000 or more workers -- the percentage of technicians in multiple-grade jobs is somewhat less than in establishments of 500 to 5,000 workers. This reversal of trend is explained by a few big firms which have single-grade jobs in which large numbers of technicians are employed.

EDUCATION AND EXPERIENCE REQUIRED

Employers of the majority (56 percent) of electro and mechanical engineering technicians require some education beyond high school as a condition of employment in these occupations. Although the employers of 44 percent require no post-high-school education many require experience along with high-school graduation, or state that they would prefer applicants with post-high-school education.

Education Requirements

Among the technicians for whom post-high-school education is a requirement, the largest concentration (around 32 percent of all the technicians) work for employers whose requirement is study at a technical institute or community college. Graduation is almost always required.

For another 5 percent of all the technicians the requirement is education in an engineering or general four-year college. Apprenticeship or armed-forces technical training is required for about 8 percent of the technicians. For 11 percent the type of post-high-school education required is not specified.

Technical or vocational high-school education is specifically indicated for three-tenths of the technicians for whom a high-school education is required. (Table III-G, part 1.)

Post-high-school education is required for a lower proportion of electrical technicians than for the other three fields, and for a lower proportion of technicians with troubleshooting and related functions than for those engaged in design or development. (Table III-G, parts 2 and 3; more detail in table III-7, and III-8, at the end of the chapter.)

Table III-G. PERCENT DISTRIBUTION OF ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS ACCORDING TO EDUCATION EMPLOYERS REQUIRE, BY FIELD AND BY FUNCTION

Over-all (education levels in detail)

Education required	Number	Percent
All levels	42,031	100.0
Post-high-school	23,613	56.2
Engineering college	1,373	3.3
Graduation	225	0.5
Less than graduation	1,148	2.8
College, general	708	1.7
Graduation	74	0.2
Less than graduation	634	1.5
Technical institute or community college	13,495	32.1
Graduation	12,735	30.3
Less than graduation	760	1.8
Type not specified	4,512	10.7
Apprenticeship or armed forces school	3,525	8.4
High school	18,418	43.8
Technical or vocational	5,550	13.2
Other and not specified	12,868	30.6

By field

Education required	Electronic	Electrical	Mechanical	Electro-mechanical
All levels: Number	10,791	8,794	8,461	13,985
Percent distribution				
All levels: Percent	100.0	100.0	100.0	100.0
Post-high-school	62.6	42.4	57.2	59.3
College, general and engineering	2.4	5.7	7.4	5.0
Technical institute or community college	38.7	20.8	29.5	35.7
Apprenticeship or armed forces school	9.4	5.3	8.1	9.7
All other post-high-school	12.1	10.6	12.2	8.9
High school	37.4	57.6	42.8	40.7

By function

Education required	Design	Development	Troubleshooting and related
All levels: Number	7,689	11,936	22,406
Percent distribution			
All levels: Percent	100.0	100.0	100.0
Post-high-school	61.5	67.3	48.4
College, general and engineering	9.3	8.6	1.4
Technical institute or community college	26.5	44.5	27.5
Apprenticeship or armed forces school	14.0	1.4	10.2
All other post-high-school	11.7	12.8	9.3
High school	38.5	32.7	51.6

Taking each of the three functions within each of the four fields yields twelve job groups. The list below shows for which of them post-high-school education is more likely to be required by the employer:

Post-high-school education is required by employers of 70 percent or more of the technicians in -

Electronic design
Electro-mechanical development
Electrical design

Post-high-school education is required by employers of 55 to 70 percent of the technicians in -

Electronic development
Electrical development
Electro-mechanical design
Mechanical design
Mechanical troubleshooting

Post-high-school education is required by employers of less than 55 percent (mostly 50-55 percent) in -

Electronic troubleshooting
Electro-mechanical troubleshooting
Mechanical development
Electrical troubleshooting

Employers require post-high-school education for a higher proportion of technicians in the middle and highest grades than for the lowest grades, in multi-grade structures. Post-high-school education also figures more prominently in the requirement for single grades than it does in the lowest grades of multiple-job lines:

Grade	Percent for whom post-high-school education is required
All grades	56.2
Supervisory grades	41.8(a)
Nonsupervisory grades:	
Single grade only	55.7
Multi-grade:	
Lowest grades	45.9
Middle grades	69.0
Highest grades	65.2

a. Persons appointed to supervisory jobs are usually required to have considerable experience; some employers are more concerned with type of experience than educational background.

Preferred vs. Required Education

Many of the employers who said that they required only high-school education of their engineering technicians stated that they nevertheless preferred some type of post-high-school education. Nearly half of the technicians designated in the high-school category shift over to the post-high-school group when employer preferences are considered. The change is especially marked in the case of electro-mechanical technicians, as the following figures show (details in table III-7 and table III-8 at the end of the chapter):

Field	Percent of technicians for whom post-high-school education is - required	preferred
All fields	56.2	76.9
Electronic	62.6	77.8
Electrical	42.4	60.5
Mechanical	57.2	72.9
Electro-mechanical	59.3	89.0

Technical-institute (or community-college) graduation is the most common preference of employers who, while requiring only high-school education, prefer some type of post-high-school education. (See table III-9 at the end of the chapter.)

Experience Requirements

Employers of the vast majority of electro and mechanical engineering technicians require that applicants have some experience in the same line or a related line of work. Experience in the same job or same kind of job is most likely to be required where a person is recruited from outside the firm. "Related job experience," which is required both in cases of recruitment and upgrading, includes lower-grade jobs of the same type; related technician jobs; craft jobs (maintenance or production); and various other production jobs.

Employers of only 18 percent of the technicians require no experience. The number of years of required experience is greatest for supervisory grades and tends to be greater for the higher nonsupervisory grades than for the lower ones.

On the average, experience requirements are higher for design technicians than for development technicians and troubleshooting and related technicians. (See table III-10 at the end of the chapter.)

The number of years of experience required is related to the kind of education required. In general, post-high-school education may be said to be equivalent in terms of requirements to approximately two years of experience, since the median years of experience asked by employers for jobs for which some type of post-high-school education is required is 3.1 years, while the number asked for jobs for which only high school is required is 4.9. (The over-all median is 3.8 years.) Table III-4 shows that a similar relationship is found in most of the particular field groupings and function groupings; the valuation of education is especially high in the electronics field. The premium on education also varies as between grade classifications; it averages especially high in the single-grade cases.

Table III-H. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS IN RELATION TO EDUCATION EMPLOYERS REQUIRE (1) BY FIELD, (2) BY FUNCTION, AND (3) BY GRADE

Field; function; grade	All levels	Post-high-school	High school
All fields, all functions, all grades	3.8	3.1	4.9
Field			
Electronic	3.1	2.1	4.6
Electrical	3.9	3.3	4.4
Mechanical	4.3	3.5	5.4
Electro-mechanical	3.9	3.6	5.1
Function			
Design	5.1	4.3	5.9
Development	3.2	3.0	3.9
Troubleshooting and related	3.6	2.4	4.7
Grade			
Supervisory grades	6.7	6.3	6.9
Nonsupervisory grades:			
Single grade only	3.1	1.7	4.5
Multi-grade:			
Lowest grades	2.4	1.8	2.7
Middle grades	4.2	4.1	4.3
Highest grades	5.3	4.8	5.7

A comparison of the education and experience requirements and the education and experience preferences of employers in respect to electro and mechanical engineering technician jobs indicates that the most common preference is for more education even if the employer has to settle for less experience. The typical case is the employer who requires high-school education, plus some experience, and who would trade off some or all of the experience for more education.

This is shown in table III-I in terms of number of technicians employed (for percentages, see table III-11 at the end of the chapter).

Table III-I. NUMBER OF ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS ACCORDING TO EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE, BY EDUCATION EMPLOYERS REQUIRE

Kind of preference	All levels	Post-high-school	High school
Total	42,031	23,613	18,418
No preference expressed	28,745	19,730	9,015
All preferences	13,286	3,883	9,403
Required education, more experience	1,625	1,542	83
More than required education, less experience	7,943	865	7,078
More than required education, same experience	3,149	1,157	1,992
More than required education, more experience	569	319	250

Judging by their experience requirements, employers think well of high-school technical curriculums in the electrical, electronic, and mechanical fields. Employers' reports show that they require substantially less work experience of graduates of technical curriculums than they do of graduates of other high-school curriculums. And in respect to experience requirements, high-school technical curriculum graduates in the electrical field compare favorably with students of technical institutes.

TESTS AND LICENSES

Intelligence, achievement, or aptitude tests were reported as a means of determining qualifications in the case of 29 percent of the electro and mechanical engineering technicians. Tests most often reported were intelligence tests for design and development technicians and company subject matter tests or achievement tests for troubleshooters and related technicians. Some employers also reported giving subject matter or achievement tests for design and development technicians. Civil service examinations were required for 2.4 percent of the technicians, and government permits or certificates for about 2 percent. The survey encountered no cases in which certification by a professional or technical society was required.

SOURCES OF WORKERS

Methods of Obtaining Workers

To obtain workers qualified to perform the functions of electro and mechanical engineering technician, employers during a representative period preceding the survey used upgrading a good deal more often than they used recruitment from outside the firm. Organized training was comparatively unimportant in the upgrading process.

All methods	100.0%
Recruited from outside the firm	42.1
Upgraded, total	57.9
With organized training	10.0
Without organized training	47.9

That upgrading was the predominant way of obtaining technicians in each of the engineering fields and in each of the functional subgroups is seen in table III-J. What stands out in the data of table III-J is the relatively high proportion of technicians who received organized training in connection with the upgrading process in the electrical and electro-mechanical fields, and in the troubleshooting and related functions. These high proportions largely reflect the programs of a few large operating agencies of the federal and New York City governments and of a few large communication companies. Such differences in industry practice show up in the industry data at the end of the table.

As has been pointed out elsewhere in this report, the extent of upgrading is considerably affected whether or not the firm has a multi-grade system.

Table III-J. PERCENT OF ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS OBTAINED BY UPGRADING WITH AND WITHOUT TRAINING ORGANIZED BY EMPLOYER

Field; function; industry division	With organized training	Without organized training
All fields; all functions; all industries	10.0	47.9
By field		
Electronic	2.7	51.8
Electrical	20.4	46.1
Mechanical	3.9	52.0
Electro-mechanical	12.9	43.6
By function		
Design	3.3	60.9
Development	4.8	54.6
Troubleshooting and related	15.2	39.9
By industry division		
Manufacturing	1.9	58.9
Construction	-	14.3
Transportation, communication, and public utilities	25.4	38.4
Private medical services	-	15.4
Research laboratories and engineering services	0.4	46.3
Private colleges and schools	-	19.7
Government	53.3	33.8
All other	4.2	19.7

Table III-K. PERCENT DISTRIBUTION OF ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS ACCORDING TO METHOD OF OBTAINING THEM, BY GRADE

Grade	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All grades	100.0	42.1	10.0	47.9
Supervisory grades	100.0	8.3	1.8	89.9
Nonsupervisory grades:				
Single grade only	100.0	51.3	14.8	33.9
Multi-grade:				
Lowest grades	100.0	51.5	3.3	45.2
Middle grades	100.0	22.5	6.4	71.1
Highest grades	100.0	21.7	4.0	74.3

Substantially higher proportions of workers in upper grades are obtained by upgrading than is true of lower grades, or of jobs having only a single grade. (See table III-K.)

College and Technical Institute Graduates

Of the total of 42,031 electro and mechanical engineering technicians, 12,859 (roughly 31 percent) are graduates of one-year, two-year, or three-year post-high-school technical-institution programs (mostly of technical-institute or community-college technical programs). Only 904 (2.2 percent) are four-year college graduates. The proportions vary from field to field and from function to function (table III-L).

Table III-L. PERCENT OF TECHNICIANS WHO ARE GRADUATES OF COLLEGES OR OF TECHNICAL INSTITUTES BY FIELD AND BY FUNCTION

Field; function	College graduates	Technical institute graduates
All fields; all functions	2.2	30.6
Field		
Electronic	1.3	39.6
Electrical	2.6	25.6
Mechanical	5.0	33.5
Electro-mechanical	0.8	25.0
Function		
Design	7.2	33.7
Development	1.8	43.4
Troubleshooting and related	0.6	22.7

In the middle and upper grades of establishments with multi-grade structures, the proportion of electro and mechanical engineering technicians who are graduates of colleges and of technical-institution programs is higher than in the lower grades.

PROMOTIONAL LINES

Employers were asked to indicate promotional lines both to and from the jobs in question. Many had or reported none.

The most common promotional line reported involved different grades of the same line or of related lines of technician jobs in establishments having multi-grade classifications. There were besides, a number of lower-level jobs from which electro and mechanical engineering technicians were reported with some frequency to have been promoted, with or without formal training. These include the following:

Design and development jobs	Troubleshooting and related jobs
Draftsman	Maintenance mechanic
Tool and die maker	Electrician
Instrument or model maker	Machinist
Other production jobs (e.g., wireman, assembler)	Pipe fitter
	Inspector or tester
	Other production jobs (e.g., assembler, solderer, wireman)

Engineering jobs were most often reported as jobs to which electro and mechanical engineering technicians were promoted (aside from higher grades of the same or related lines of technician jobs). Management jobs were next in importance; they were mentioned relatively more often in connection with design and development jobs than in connection with troubleshooting and related jobs.

Electro and Mechanical Engineering Technicians

Table III-1. NUMBER IN EACH FUNCTION, BY FIELD

Field	All functions	Design	Development				Troubleshooting and related			
			Total	Development only	Design and development	Design, development, installation, troubleshooting	Total	Troubleshooting and related	Installation	Troubleshooting and installation
All fields	42,031	7,689	11,936	6,803	1,392	3,741	22,406	18,880	458	3,068
Electronic	10,791	489	4,873	2,764	698	1,411	5,429	5,013	215	201
Electrical	8,794	1,006	2,497	1,067	250	1,180	5,291	3,331	18	1,942
Electrical	3,618	689	1,577	646	135	796	1,352	753	5	594
Electronic-electrical	5,176	317	920	421	115	384	3,939	2,578	13	1,348
Mechanical	8,461	4,450	2,092	1,397	246	449	1,919	1,441	203	275
Electro-mechanical	13,985	1,744	2,474	1,575	198	701	9,767	9,095	22	650
Electronic-mechanical	12,709	1,557	2,113	1,420	166	527	9,039	8,498	9	532
Electrical-mechanical and electrical-electronic-mechanical	1,276	187	361	155	32	174	728	597	13	118

Electro and Mechanical Engineering Technicians

Table III-2. NUMBER IN EACH FIELD, BY PRODUCT OR EQUIPMENT WORKED ON

Product or equipment worked on	All fields	Electronic	Electrical	Mechanical	Electro-mechanical
All products or equipment worked on	42,031	10,791	8,794	8,461	13,985
Instruments and electronic and science laboratory equipment	23,090	10,065	2,352	2,618	8,055
Electronic equipment and instruments	15,845	8,822	1,604	783	4,636
Communications equipment	4,673	3,982	335	109	247
Radio, television, audio	1,694	1,441	105	23	125
Radar, sonar, microwave	1,133	1,038	32	22	41
Other and combinations	1,846	1,503	198	64	81
Digital computers	5,045	1,129	270	351	3,295
Testing, measuring, and control instruments	1,725	945	533	110	137
Electronic components	1,577	1,136	172	78	191
General and other	2,825	1,630	294	135	766
Electronic-mechanical instruments	4,629	869	694	303	2,763
Industrial servo-control instruments, fire control, guidance, and other analog applications	2,791	603	213	271	1,704
Testing, measuring, and control instruments, other than servo	1,173	109	481	30	553
General and other	665	157	-	2	506
Mechanical instruments	1,470	12	27	1,112	319
Testing, measuring, and control instruments	655	-	-	587	68
General	427	-	-	363	64
Hydraulic, pneumatic, and other	228	-	-	224	4
Optical and photographic instruments	633	12	11	368	242
General and other	182	-	16	157	9
Science laboratory equipment n.e.c.	1,146	362	27	420	337
Chemical laboratory	34	4	1	29	-
Physics laboratory, nuclear	742	277	-	141	324
Physics laboratory, other	64	3	14	42	5
Biological or medical laboratory	44	7	10	22	5
General	262	71	2	186	3
Machinery, electrical and mechanical equipment	15,223	472	5,497	4,709	4,545
Electrical equipment	10,981	392	5,451	951	4,187
Telephone, teletype, and related equipment	6,057	295	1,844	210	3,708
Electric power plant equipment	1,709	1	968	657	83
Electrical control and signaling equipment	1,441	-	1,430	-	11
Electrical equipment, parts, and components n.e.c.	1,499	96	1,030	82	291
Combination: control, signaling, and other equipment n.e.c.	275	-	179	2	94

Continued

Table III-2 (concluded)

Product or equipment worked on	All fields	Electronic	Electrical	Mechanical	Electro-mechanical
Machinery, electrical and mechanical equipment (continued)					
Nonelectrical machinery and other metal equipment	4,242	80	46	3,758	358
Tool and die	1,833	-	-	1,833	-
Manufacturing and mining machinery and equipment n.e.c.	1,089	65	29	855	140
Chemical processing machinery and equipment	335	-	4	311	20
Construction machinery and equipment	15	-	-	15	-
Agricultural machinery and equipment	21	-	-	20	1
Warehouse and other material moving machinery and equipment	56	-	-	56	-
Heating, air conditioning, and related machinery and equipment	451	-	13	325	113
General and other	442	15	-	343	84
Transportation equipment, aircraft, and ordnance	3,372	240	930	934	1,268
Aircraft and missile parts and equipment n.e.c.	2,784	234	897	411	1,242
Aircraft electronic-electrical systems n.e.c.	996	155	831	-	10
Jet engine	76	6	14	5	51
Rocket engine	111	-	-	1	110
Other aircraft engine	34	-	14	19	1
Aircraft mechanical equipment and systems	233	-	17	215	1
Missile equipment	280	53	21	132	74
General	1,054	20	-	39	995
Transportation vehicles and equipment n.e.c.	508	-	33	452	23
Ships and ship equipment	110	-	20	76	14
Motor vehicles and equipment	285	-	12	264	9
Railroad vehicles and equipment	113	-	1	112	-
Ordnance	80	6	-	71	3
Other products and equipment	346	14	15	200	117
Nonmetal cartons and containers	114	-	-	114	-
Other	232	14	15	86	117

Electro and Mechanical Engineering Technicians

Table III-3. NUMBER IN EACH FUNCTION, BY PRODUCT OR EQUIPMENT WORKED ON

Product or equipment worked on	All functions	Design	Development	Trouble-shooting and related
All products or equipment worked on	42,031	7,689	11,936	22,406
Instruments and electronic and science laboratory equipment	23,090	2,729	8,083	12,278
Electronic equipment and instruments	15,845	1,589	4,929	9,327
Communications equipment	4,673	193	1,720	2,760
Radio, television, audio	1,694	37	675	982
Radar, sonar, microwave	1,133	58	450	625
Other and combinations	1,846	98	595	1,153
Digital computers	5,045	454	818	3,773
Testing, measuring, and control instruments	1,725	66	585	1,074
Electronic components	1,577	162	800	615
General and other	2,825	714	1,006	1,105
Electronic-mechanical instruments	4,629	604	1,871	2,154
Industrial servo-control instruments, fire control, guidance, and other analog applications	2,791	356	1,290	1,145
Testing, measuring, and control instruments, other than servo	1,173	66	281	826
General and other	665	182	300	183
Mechanical instruments	1,470	372	595	503
Testing, measuring, and control instruments	655	165	159	331
General	427	77	83	267
Hydraulic, pneumatic, and other	228	88	76	64
Optical and photographic instruments	633	166	386	81
General and other	182	41	50	91
Science laboratory equipment n.e.c.	1,146	164	688	294
Chemical laboratory	34	-	33	1
Physics laboratory, nuclear	742	133	462	147
Physics laboratory, other	64	12	29	23
Biological or medical laboratory	44	4	34	6
General	262	15	130	117
Machinery, electrical and mechanical equipment	15,223	4,173	2,933	8,117
Electrical equipment	10,981	1,411	2,262	7,308
Telephone, teletype, and related equipment	6,057	102	749	5,206
Electric power plant equipment	1,709	909	707	93
Electrical control and signaling equipment	1,441	23	85	1,333
Electrical equipment, parts, and components n.e.c.	1,499	362	678	459
Combination: control, signaling, and other equipment n.e.c.	275	15	43	217

Continued

Table III-3 (concluded)

Product or equipment worked on	All functions	Design	Development	Trouble-shooting and related
Machinery, electrical and mechanical equipment (continued)				
Nonelectrical machinery and other metal equipment	4,242	2,762	671	809
Tool and die	1,833	1,670	41	122
Manufacturing and mining machinery and equipment n.e.c.	1,089	592	288	209
Chemical processing machinery and equipment	335	121	145	69
Construction machinery and equipment	15	-	2	13
Agricultural machinery and equipment	21	15	-	6
Warehouse and other material moving machinery and equipment	56	46	2	8
Heating, air conditioning, and related machinery and equipment	451	60	61	330
General and other	442	258	132	52
Transportation equipment, aircraft, and ordnance	3,372	517	878	1,977
Aircraft and missile parts and equipment n.e.c.	2,784	273	707	1,804
Aircraft electronic-electrical systems n.e.c.	996	102	277	617
Jet engine	76	6	-	70
Rocket engine	111	1	110	-
Other aircraft engine	34	-	-	34
Aircraft mechanical equipment and systems	233	106	73	54
Missile equipment	280	49	200	31
General	1,054	9	47	998
Transportation vehicles and equipment n.e.c.	508	187	168	153
Ships and ship equipment	110	16	7	87
Motor vehicles and equipment	285	112	155	18
Railroad vehicles and equipment	113	59	6	48
Ordnance	80	57	3	20
Other products and equipment	346	270	42	34
Nonmetal cartons and containers	114	93	8	13
Other	232	177	34	21

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Table III-4. NUMBER IN EACH FIELD, BY INDUSTRY GROUP

Industry group	All fields	Electronic	Electrical	Mechanical	Electro-mechanical
All industries	42,031	10,791	8,794	8,461	13,985
Manufacturing	23,632	7,840	3,546	6,503	5,743
Durable goods	22,964	7,809	3,520	5,931	5,704
Ordnance and accessories	2,139	631	393	533	582
Furniture and wood products	26	-	-	25	1
Stone, clay, and glass products	125	54	11	52	8
Primary metal industries	167	5	58	92	12
Fabricated metal products	642	78	13	420	131
Machinery, except electrical	4,432	1,010	292	2,047	1,083
Electrical machinery and equipment	7,720	3,308	1,897	903	1,612
Transportation equipment	3,426	1,073	685	1,060	608
Instruments; photographic and optical goods	4,287	1,650	171	799	1,667
Nondurable goods	668	31	26	572	39
Food and kindred products	60	-	4	52	4
Textile mill products	11	2	1	7	1
Paper and allied products	245	12	2	227	4
Printing, publishing,,and allied industries	33	1	15	14	3
Chemical and allied products	91	15	1	48	27
Petroleum refining and related industries	76	-	-	76	-
Rubber and miscellaneous plastics products	66	-	2	64	-
Leather and leather products	12	-	-	12	-
Miscellaneous manufacturing industries	74	1	1	72	-
Nonmanufacturing	18,399	2,951	5,248	1,958	8,242
Mining	2	-	1	-	1
Contract construction	154	2	-	152	-
General building contractors	58	2	-	56	-
Special trade contractors	96	-	-	96	-
Transportation, communication, and public utilities	8,911	390	3,594	380	4,547
Railroad transportation	652	6	634	12	-
Local and interurban passenger transportation	3	2	1	-	-
Air transportation	1,917	289	730	27	871
Communication	5,209	79	1,408	153	3,569
Electric, gas, and sanitary services	1,130	14	821	188	107

Continued

Table III-4 (concluded)

Industry group	All fields	Electronic	Electrical	Mechanical	Electro-mechanical
Nonmanufacturing (continued)					
Wholesale and retail trade	2,980	122	111	151	2,596
Wholesale trade	2,947	89	111	151	2,596
Retail trade	33	33	-	-	-
Finance, insurance, and real estate	13	12	-	1	-
Insurance carriers	12	12	-	-	-
Holding and other investment companies	1	-	-	1	-
Services and miscellaneous	3,833	1,376	490	1,057	910
Miscellaneous business services	1,962	771	292	383	516
Advertising, news, credit, duplicating, building, and related services	8	-	-	-	8
Business services n.e.c.	1,954	771	292	383	508
Research, development, testing laboratories	1,257	590	163	139	365
Business and management consulting services	408	62	106	211	29
Other business services n.e.c.	289	119	23	33	114
Miscellaneous repair services	188	128	-	60	-
Amusement and recreation, except motion pictures	4	4	-	-	-
Voluntary hospitals	13	3	-	9	1
Private colleges and schools	583	148	123	272	40
Nonprofit membership organizations	6	-	-	-	6
Miscellaneous services	1,077	322	75	333	347
Engineering and architectural services	498	52	72	208	166
Nonprofit educational and scientific research	579	270	3	125	181
Government	2,506	1,049	1,052	217	188
County	7	3	3	1	-
Hospitals	2	1	1	-	-
Colleges	5	2	2	1	-
New York State	67	9	26	22	10
Hospitals	9	-	6	3	-
Colleges	36	8	7	14	7
Other	22	1	13	5	3
New York City	1,032	2	1,006	23	1
Colleges	28	2	12	13	1
Other	1,004	-	994	10	-
Federal	1,400	1,035	17	171	177
Hospitals	1	1	-	-	-
Colleges	2	2	-	-	-
Arsenals and navy yards	493	201	15	165	112
Other	904	831	2	6	65

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Table III-5. NUMBER IN EACH FUNCTION, BY INDUSTRY GROUP

Industry group	All functions	Design	Development	Trouble-shooting and related
All industries	42,031	7,689	11,936	22,406
Manufacturing	23,632	6,073	8,873	8,686
Durable goods	22,964	5,725	8,664	8,575
Ordnance and accessories	2,139	392	591	1,156
Furniture and wood products	26	15	10	1
Stone, clay, and glass products	125	23	15	87
Primary metal industries	167	58	61	48
Fabricated metal products	642	321	106	215
Machinery, except electrical	4,432	1,695	1,171	1,566
Electrical machinery and equipment	7,720	1,603	3,727	2,390
Transportation equipment	3,426	659	978	1,789
Instruments; photographic and optical goods	4,287	959	2,005	1,323
Nondurable goods	668	348	209	111
Food and kindred products	60	51	4	5
Textile mill products	11	5	3	3
Paper and allied products	245	148	78	19
Printing, publishing, and allied industries	33	7	1	25
Chemicals and allied products	91	15	34	42
Petroleum refining and related industries	76	-	76	-
Rubber and miscellaneous plastics products	66	62	3	1
Leather and leather products	12	-	-	12
Miscellaneous manufacturing industries	74	60	10	4
Nonmanufacturing	18,399	1,616	3,063	13,720
Mining	2	-	-	2
Contract construction	154	2	2	150
General building contractors	58	2	2	54
Special trade contractors	96	-	-	96
Transportation, communication, and public utilities	8,911	273	479	8,159
Railroad transportation	652	6	30	616
Local and interurban passenger transportation	3	-	-	3
Air transportation	1,917	-	128	1,789
Communication	5,209	8	129	5,072
Electric, gas, and sanitary services	1,130	259	192	679

Continued

Table III-5. (concluded)

Industry group	All functions	Design	Development	Trouble-shooting and related
Nonmanufacturing (continued)				
Wholesale and retail trade	2,980	87	54	2,839
Wholesale trade	2,947	87	54	2,806
Retail trade	33	-	-	33
Finance, insurance, and real estate	13	-	-	13
Insurance carriers	12	-	-	12
Holding and other investment companies	1	-	-	1
Services and miscellaneous	3,833	1,132	1,884	817
Miscellaneous business services	1,962	709	980	273
Advertising, news, credit, duplicating, building, and related services	8	-	6	2
Business services n.e.c.	1,954	709	974	271
Research, development testing laboratories	1,257	250	870	137
Business and management consulting services	408	323	67	18
Other business services n.e.c.	289	136	37	116
Miscellaneous repair services	188	-	6	182
Amusement and recreation, except motion pictures	4	-	4	-
Voluntary hospitals	13	-	9	4
Private colleges and schools	583	33	357	193
Nonprofit membership organizations	6	-	6	-
Miscellaneous services	1,077	390	522	165
Engineering and architectural services	498	346	126	26
Nonprofit educational and scientific research	579	44	396	139
Government	2,506	122	644	1,740
County	7	-	2	5
Hospitals	2	-	1	1
Colleges	5	-	1	4
New York State	67	5	10	52
Hospitals	9	3	2	4
Colleges	36	1	6	29
Other	22	1	2	19
New York City	1,032	-	356	676
Colleges	28	-	6	22
Other	1,004	-	350	654
Federal	1,400	117	276	1,007
Hospitals	1	-	1	-
Colleges	2	-	-	2
Arsenals and navy yards	493	104	104	285
Other	904	13	171	720

Table III-6. GRADE IN RELATION TO SIZE OF ESTABLISHMENT AND FIELD IN WHICH TECHNICIANS ARE EMPLOYED

(Percent distribution of technicians according to grade)

Size of establishment (number of employees); field	All grades	Supervisory grades	Nonsupervisory grades				Grading system not reported (a)
			Single grade only	Multi-grade			
				Lowest grades	Middle grades	Highest grades	
All establishments	100.0	5.0	47.8	14.7	7.6	16.6	8.3
Electronic technicians	100.0	5.1	36.2	16.0	8.2	20.6	13.9
Electrical technicians	100.0	4.1	50.8	16.9	7.8	15.8	4.6
Mechanical technicians	100.0	3.9	44.7	17.4	9.6	19.4	5.0
Electro-mechanical technicians	100.0	6.1	56.6	10.8	5.8	12.4	8.3
1 to 3 workers	100.0	-	100.0	-	-	-	-
Electronic	-	-	-	-	-	-	-
Electrical	-	-	-	-	-	-	-
Mechanical	100.0	-	100.0	-	-	-	-
Electro-mechanical	100.0	-	100.0	-	-	-	-
4 to 19 workers	100.0	5.2	89.0	1.0	1.5	3.3	-
Electronic	100.0	7.7	84.4	0.4	2.2	5.3	-
Electrical	100.0	-	97.4	1.3	1.3	-	-
Mechanical	100.0	4.6	95.4	-	-	-	-
Electro-mechanical	100.0	0.8	89.3	4.6	1.5	3.8	-
20 to 49 workers	100.0	7.9	80.5	4.4	1.0	5.6	0.6
Electronic	100.0	18.1	58.8	6.0	2.5	12.5	2.1
Electrical	100.0	1.2	85.4	8.5	3.7	1.2	-
Mechanical	100.0	4.9	90.8	2.1	0.1	2.1	-
Electro-mechanical	100.0	3.0	86.4	5.7	-	4.9	-
50 to 99 workers	100.0	3.5	79.0	8.0	1.3	8.2	-
Electronic	100.0	4.2	67.6	14.5	0.2	13.5	-
Electrical	100.0	3.9	79.0	4.9	7.3	4.9	-
Mechanical	100.0	0.7	82.4	6.4	1.1	9.4	-
Electro-mechanical	100.0	4.0	88.7	3.0	1.3	3.0	-

Continued

Table III-6 (concluded)

Size of establishment (number of employees); field	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Multi-grade: Lowest grades	Multi-grade: Middle grades	Multi-grade: Highest grades	Grading system not reported (a)
100 to 199 workers	100.0	3.3	68.8	9.1	4.7	14.0	0.1
Electronic	100.0	5.0	38.2	19.8	11.8	25.2	-
Electrical	100.0	3.2	79.2	6.4	1.6	9.6	-
Mechanical	100.0	4.3	74.1	4.9	5.4	11.3	-
Electro-mechanical	100.0	2.1	76.2	7.5	2.1	11.8	0.3
200 to 499 workers	100.0	3.7	60.0	15.3	5.1	15.0	0.9
Electronic	100.0	2.8	46.0	21.7	6.7	21.9	0.9
Electrical	100.0	5.5	60.8	10.1	7.1	15.8	0.7
Mechanical	100.0	2.6	66.5	15.2	2.2	13.0	0.5
Electro-mechanical	100.0	4.7	71.0	11.0	4.4	7.4	1.5
500 to 999 workers	100.0	7.3	41.5	17.7	6.0	23.8	3.7
Electronic	100.0	5.7	40.6	17.0	10.9	17.7	8.1
Electrical	100.0	5.7	41.8	21.4	1.0	25.0	5.1
Mechanical	100.0	5.8	40.9	22.1	4.2	25.8	1.2
Electro-mechanical	100.0	11.3	42.4	11.2	7.7	26.0	1.4
1,000 to 1,999 workers	100.0	8.0	32.0	19.9	13.1	22.1	4.9
Electronic	100.0	8.5	7.0	19.7	25.2	34.4	5.2
Electrical	100.0	8.0	57.7	12.6	4.2	13.5	4.0
Mechanical	100.0	5.3	41.9	21.0	8.8	18.7	4.3
Electro-mechanical	100.0	10.6	29.5	27.2	9.5	17.0	6.2
2,000 to 4,999 workers	100.0	4.6	33.9	18.0	9.1	20.4	14.0
Electronic	100.0	1.5	4.9	20.4	8.7	27.2	37.3
Electrical	100.0	3.7	35.8	22.8	7.2	22.1	8.4
Mechanical	100.0	5.0	23.9	24.2	16.0	22.3	8.6
Electro-mechanical	100.0	6.8	54.4	10.9	7.4	14.4	6.1
5,000 or more workers	100.0	4.3	42.6	15.0	8.8	16.1	13.2
Electronic	100.0	4.3	39.0	13.7	4.4	17.0	21.6
Electrical	100.0	2.9	50.4	17.6	11.0	13.7	4.4
Mechanical	100.0	2.6	16.1	23.4	17.8	29.4	10.7
Electro-mechanical	100.0	6.0	50.1	10.5	6.3	11.8	15.3

a. Elsewhere in this chapter, these technicians were included in "single grade only."

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Table III-7. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER, BY FIELD

(Percent distribution of technicians according to level of education required and preferred)

Level of education	All fields		Electronic		Electrical		Mechanical		Electro-mechanical	
	Required	Preferred	Required	Preferred	Required	Preferred	Required	Preferred	Required	Preferred
All levels	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	56.2	76.9	62.6	77.8	42.4	60.5	57.2	72.9	59.3	89.0
Engineering college	3.3	6.6	1.6	4.3	4.9	6.8	4.8	12.9	2.6	4.5
Graduation	0.5	3.6	(a)	2.0	0.7	2.8	0.9	9.5	0.6	1.7
Less than graduation	2.8	3.0	1.6	2.3	4.2	4.0	3.9	3.4	2.0	2.8
College, general	1.7	3.3	0.8	4.2	0.8	2.4	2.6	4.1	2.4	2.7
Graduation	0.2	0.8	0.1	0.8	0.1	0.8	0.7	1.9	-	-
Less than graduation	1.5	2.5	0.7	3.4	0.7	1.6	1.9	2.2	2.4	2.7
Technical institute or community college	32.1	48.2	38.7	49.7	20.8	34.7	29.5	39.7	35.7	60.7
Graduation	30.3	46.7	36.7	47.8	19.2	34.1	27.7	37.7	33.9	59.1
Less than graduation	1.8	1.5	2.0	1.9	1.6	0.6	1.8	2.0	1.8	1.6
Type not specified	10.7	10.6	12.1	12.2	10.6	11.3	12.2	8.1	8.9	10.5
Apprenticeship or armed forces school	8.4	8.2	9.4	7.4	5.3	5.3	8.1	8.1	9.7	10.5
High school	43.8	23.1	37.4	22.2	57.6	39.5	42.8	27.1	40.7	11.0
Technical or vocational	13.2	9.2	15.5	8.4	16.6	14.0	12.1	7.2	10.0	7.9
Other and not specified	30.6	13.9	21.9	13.8	41.0	25.5	30.7	19.9	30.7	3.1

a. Less than 0.05 of a percent.

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Table III-8. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER, BY FUNCTION

(Percent distribution of technicians according to level of education required and preferred)

Level of education	All functions		Design		Development		Troubleshooting and related	
	Required	Preferred	Required	Preferred	Required	Preferred	Required	Preferred
All levels	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	56.2	76.9	61.5	83.7	67.3	78.3	48.4	73.9
Engineering college	3.3	6.6	6.6	17.8	5.6	8.7	0.8	1.7
Graduation	0.5	3.6	0.8	12.9	0.7	2.5	0.4	1.0
Less than graduation	2.8	3.0	5.8	4.9	4.9	6.2	0.4	0.7
College, general	1.7	3.3	2.7	4.9	3.0	6.2	0.6	1.2
Graduation	0.2	0.8	0.5	1.6	0.3	0.6	(a)	0.5
Less than graduation	1.5	2.5	2.2	3.3	2.7	5.6	0.6	0.7
Technical institute or community college	32.1	48.2	26.5	35.3	44.5	49.9	27.5	51.7
Graduation	30.3	46.7	25.6	34.3	42.3	47.7	25.6	50.4
Less than graduation	1.8	1.5	0.9	1.0	2.2	2.2	1.9	1.3
Type not specified	10.7	10.6	11.7	11.8	12.8	12.9	9.3	9.0
Apprenticeship or armed forces school	8.4	8.2	14.0	13.9	1.4	0.6	10.2	10.3
High school	43.8	23.1	38.5	16.3	32.7	21.7	51.6	26.1
Technical or vocational	13.2	9.2	8.4	4.4	9.8	7.5	16.7	11.7
Other and not specified	30.6	13.9	30.1	11.9	22.9	14.2	34.9	14.4

a. Less than 0.05 of a percent.

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Table III-9. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Percent distribution of technicians according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require											
				Post-high-school									High school		
				Post-high-school, total	Engineering college		College, general		Technical institute		Type not specified	Apprenticeship or armed forces school	High school, total	Technical or vocational	Other and not specified
					Graduation	Less than graduation	Graduation	Less than graduation	Graduation	Less than graduation					
All levels	100.0	72.1	27.9	26.8	3.1	0.9	0.6	1.1	18.6	0.5	1.5	0.5	1.1	1.1	(a)
Post-high-school	100.0	89.2	10.8	10.8	3.9	1.3	0.7	1.5	3.1	0.1	-	0.2	(a)	-	(a)
Engineering college	100.0	80.8	19.2	18.8	18.8	-	-	-	-	-	-	-	0.4	-	0.4
Graduation	100.0	97.8	2.2	-	-	-	-	-	-	-	-	-	2.2	-	2.2
Less than graduation	100.0	77.5	22.5	22.5	22.5	-	-	-	-	-	-	-	-	-	-
College, general	100.0	93.9	6.1	6.1	2.0	-	4.1	-	-	-	-	-	-	-	-
Graduation	100.0	98.6	1.4	1.4	1.4	-	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	93.4	6.6	6.6	2.1	-	4.5	-	-	-	-	-	-	-	-
Technical institute or community college	100.0	90.5	9.5	9.5	2.1	1.6	1.1	2.5	1.8	-	-	0.4	(a)	-	(a)
Graduation	100.0	92.6	7.4	7.4	2.0	1.2	1.1	2.7	-	-	-	0.4	(a)	-	(a)
Less than graduation	100.0	55.3	44.7	44.7	2.4	9.1	0.4	1.2	31.6	-	-	-	-	-	-
Type not specified	100.0	85.6	14.4	14.4	8.4	1.4	-	(a)	4.5	-	-	0.1	-	-	-
Apprenticeship or armed forces school	100.0	91.0	9.0	9.0	-	0.4	-	-	8.0	0.6	-	-	-	-	-
High school	100.0	50.2	49.8	47.4	2.0	0.4	0.4	0.6	38.7	1.1	3.3	0.9	2.4	2.4	-
Technical or vocational	100.0	61.6	38.4	38.4	2.2	0.1	0.1	0.3	33.5	1.8	0.2	0.2	-	-	-
Other and not specified	100.0	45.4	54.6	51.2	1.9	0.5	0.5	0.8	40.9	0.8	4.6	1.2	3.4	3.4	-

a. Less than 0.05 of a percent.

Electro and Mechanical Engineering Technicians

Table III-10. YEARS OF EXPERIENCE EMPLOYERS REQUIRE, BY FUNCTION AND BY GRADE

(Percent distribution of technicians according to years of experience required)

Function; grade	Total	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 4	4 and under 5	5 and under 7	7 and under 10	10 and over
All functions	100.0	18.1	3.7	9.7	13.7	10.9	9.7	23.2	6.0	5.0
Supervisory grades	100.0	0.5	(a)	0.2	1.6	3.1	10.4	38.1	30.0	16.1
Nonsupervisory:										
Single grade only	100.0	26.7	4.9	7.3	13.8	10.2	8.7	22.8	3.0	2.6
Multi-grade:										
Lower grade	100.0	18.0	4.6	24.0	21.5	6.6	9.2	10.4	1.5	4.2
Higher grades(b)	100.0	2.1	1.2	8.7	11.2	16.8	12.4	28.0	11.0	8.6
Design function	100.0	6.7	0.6	5.4	6.1	13.8	9.6	26.0	14.9	16.9
Supervisory grades	100.0	0.3	0.3	-	2.2	1.2	1.5	31.7	19.4	43.4
Nonsupervisory:										
Single grade only	100.0	17.6	0.9	3.7	4.7	13.0	7.6	29.0	12.1	11.4
Multi-grade:										
Lower grades	100.0	2.6	0.8	14.5	15.1	5.8	17.8	26.2	4.1	13.1
Higher grades(b)	100.0	0.1	0.2	2.1	2.4	20.7	7.4	22.7	23.3	21.1
Development function	100.0	13.0	4.4	10.5	22.0	14.0	9.5	19.5	4.1	3.0
Supervisory grades	100.0	-	-	0.2	0.2	3.9	11.8	51.6	15.2	17.1
Nonsupervisory:										
Single grade only	100.0	13.5	5.5	10.9	26.1	15.0	7.9	14.4	4.1	2.6
Multi-grade:										
Lower grades	100.0	33.4	5.4	18.7	19.2	9.1	8.2	4.9	0.9	0.2
Higher grades(b)	100.0	3.7	2.3	7.2	17.7	15.7	13.1	32.5	4.4	3.4
Troubleshooting and related function	100.0	24.7	4.4	10.8	11.9	8.3	9.9	24.0	4.1	1.9
Supervisory grades	100.0	0.7	-	0.3	1.9	3.3	12.2	35.4	37.0	9.2
Nonsupervisory:										
Single grade only	100.0	34.3	5.4	6.4	9.7	7.5	9.3	25.6	0.8	1.0
Multi-grade:										
Lower grades	100.0	18.8	6.5	33.2	27.1	5.7	4.1	3.6	0.2	0.8
Higher grades(b)	100.0	2.2	1.0	14.9	12.4	14.7	15.5	28.5	7.3	3.5

a. Less than 0.05 of a percent.
b. Middle grades plus highest grades.

Electro and Mechanical Engineering Technicians

Table III-11. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE
(Percent distribution of technicians according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
All levels	100.0	68.4	31.6	3.9	18.8	7.5	1.4
Post-high-school	100.0	83.6	16.4	6.4	3.7	4.9	1.4
Engineering college	100.0	73.5	26.5	1.3	14.4	5.0	5.8
Graduation	100.0	77.8	22.2	2.7	-	-	19.5
Less than graduation	100.0	72.6	27.4	1.0	17.3	6.0	3.1
College, general	100.0	91.5	8.5	2.4	2.1	3.6	0.4
Graduation	100.0	94.6	5.4	4.0	-	-	1.4
Less than graduation	100.0	91.2	8.8	2.2	2.4	3.9	0.3
Technical institute or community college	100.0	86.3	13.7	6.5	2.4	3.9	0.9
Graduation	100.0	88.3	11.7	6.6	2.3	2.4	0.4
Less than graduation	100.0	51.8	48.2	3.8	3.7	30.4	10.3
Type not specified	100.0	84.9	15.1	0.4	7.4	5.3	2.0
Apprenticeship or armed forces school	100.0	73.7	26.3	17.3	-	8.3	0.7
High school	100.0	48.9	51.1	0.5	38.4	10.8	1.4
Technical or vocational	100.0	60.6	39.4	0.9	24.2	12.4	1.9
Other and not specified	100.0	43.9	56.1	0.2	44.7	10.1	1.1

Chapter IV

MATHEMATICS TECHNICIANS

The prime function of mathematics technicians is to relieve the professional scientist, engineer, or researcher of the task of doing numerical calculations. These technicians take the raw data gathered in the laboratory, perform the necessary calculations, and organize the data in an appropriate form, such as tables, graphs, and charts. The final evaluation and interpretation of the data is not usually the responsibility of the technician.

The number of mathematics technicians employed in New York State at all grade levels is a little over 800. Of this number, over 600 are employed in durable-goods manufacturing, with large concentrations in the aerospace industry and in firms producing engineering, laboratory, and science and research instruments and equipment. The rest are in service industries -- the largest numbers in engineering and architectural services (around 90) and private colleges (around 55). A few are employed in government, and the remainder in research, development, and testing laboratories. Table IV-1, at the end of the chapter, tells of other industries that employ mathematics technicians.

About 81 percent of the mathematics technicians are supervised by professional mathematicians, engineers, or scientists, 18 percent are supervised by technicians of higher grade, and 1 percent work under persons in other occupations.

FUNCTIONS

Generally speaking, the functions of mathematics technicians will include one or more of the activities listed below.

Performing calculations by the use of standard formulas to determine such quantities as moment of inertia, center of gravity, loading of beams, volt-amperes, and hysteresis losses.

Determining dimensions of parts, using standard formulas and references as, for example, in gear design, counter-weighting, etc.

Extracting data from engineering drawings; for example, weights of parts to be used in subsequent calculations.

Solving original mathematical problems arising in the course of research and development.

Reducing data to intelligible form by preparing tables, charts, graphs, etc.

Assisting in the preparation of technical reports and manuals.

Preparing programs for electronic digital computers.

Technical skills needed include:

Ability to use the slide rule and a variety of desk calculators.

Ability to use simple drafting tools such as T-square and French curve, in the preparation of graphs.

In the aerospace industries, mathematics technicians are most usually found in the following ten fields.1/ The figures include other industries, but the large majority of technicians in these fields are in the aerospace industry.

Aerodynamics	57
Flutter and vibration	36
Stress	30
Weight	23
Flight test	85
Electrical test	24
Design safety and reliability	19
Thermodynamics	13
Dynamics	6
Analog computers	5

The figure in each case represents the number reported in the survey as working in the given field. It does not represent the total who work there, since some firms did not report this breakdown.

1. The duties of technicians in the first four fields in the list are described in a bulletin of the U.S. Bureau of Employment Security, Technical Occupations in Research, Design, and Development, BES No. E-194 (February 1961), pages 44-50.

A technician employed in one of these specialties has to know not only the mathematical principles involved but also the applicable engineering and physical science principles. He participates as a member of the engineer-technician team engaged in making the tests and assists in interpretation and in writing up the technical reports giving the final results.

GRADE STRUCTURE

Among nonsupervisory mathematics technicians, two work in a single-grade establishment for every one who works in a multi-grade establishment:

All grades	831	100.0%
Supervisory grades	46	5.5
Nonsupervisory grades	785	94.5
Single-grade only	514	61.9
Multi-grade	271	32.6
Lowest grades	129	15.5
Middle grades	85	10.2
Highest grades	57	6.9

In firms having multi-grade classifications, the lowest-grade technicians perform less sophisticated tasks, such as tabulation of data and preparation of charts and graphs. Persons in either the lower or the middle grades may do calculations using standard formulas, with the aid of a calculator. An example is the technician who takes the rough field notes of a surveyor and uses them to calculate areas, volumes, cut and fill, traverses, etc.

The middle or higher-grade technician may be required to extract data from engineering drawings, determine dimensions of parts, and make calculations for beam loading, moment of inertia, etc., which may involve the use of calculus.

A mathematical problem not subject to standardized treatment, for example one involving the application of statistical procedures or differential equations, would probably be assigned to a higher-grade technician. Occasionally a higher-level mathematics technician prepares programs for electronic digital computers.

Where several technicians are employed by a firm using the single-grade classification, the complexity of the work a technician does may vary with his knowledge, specialization, experience, and seniority. However, in some firms all the work is about at the same level: one may require only relatively simple mathematical calculations, whereas another may be concerned with problems regularly requiring the use of calculus and the original application of mathematical techniques.

SUBJECT MATTER KNOWLEDGE

On the matter of knowledge the mathematics technician needs to do his job properly, the statements of employers may be summarized as follows:

Generally needed	Needed in a substantial number of cases	Occasionally needed
Trigonometry	Advanced algebra	Differential equations
Calculus	Analytic geometry	Chemistry, general
Physics, general		Technical drawing
Mechanical technology, orientation		Basic electricity
		Basic electronics
		Computer programming

As to the first category: Trigonometry is widely used in all types of calculation involving angular functions; calculus in those involving moment of inertia of unusual geometric shapes, stress analysis, heat exchanger problems, etc.

General physics includes heat, light, sound, mechanics, electricity, and magnetism. It prepares the technician to approach with understanding problems involving physical principles, for example the making of physical measurements in the areas of heat, light, electricity, sound, or mechanics.

If the technician's work relates to mechanical engineering he may need a more intensive knowledge of mechanics than is ordinarily presented in the physics course. Calculations involving pressure distribution, stress, strain, gear ratios, etc. require a knowledge of mechanical technology.

Knowledge often needed: Employers frequently cited advanced algebra and analytic geometry (though the technician who knows calculus will probably have studied these first). They are useful in the analysis of test data, for example in determining the equation of a curve or the center of gravity of irregular shapes.

Knowledge occasionally needed: The subjects mentioned in the third category reflect the fact that a mathematics technician may function in an area that requires special knowledge and services. A knowledge of technical drawing helps him to extract data and information from drawings. A knowledge of the elementary theory of electricity or electronics will help him in working on calculations in those fields.

EDUCATION AND EXPERIENCE REQUIRED

Employers require much less experience in the case of applicants for mathematics technician jobs than in the case of other technicians (especially those in engineering and physical science -- chapters III and V). The employer expects the applicant to have gone to college (less often, technical school) but not necessarily to have finished. The subject knowledge considered important for the job is likely to be narrower than in the case of other technicians. Women constitute a larger proportion of mathematics technicians than of any other group studied except biological and medical technicians.

Education Requirements

Four-fifths of the mathematics technicians have employers who said that they required the applicant to have education beyond high school; however, as to technicians in the lower and middle grades of multi-grade systems, the employers of only about half required more than high-school graduation. In the case of technicians in single-grade classifications, the employers of 96 percent required

Table IV-A. PERCENT DISTRIBUTION OF MATHEMATICS TECHNICIANS ACCORDING TO EDUCATION EMPLOYERS REQUIRE, BY GRADE

Education required	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Nonsupervisory grades: Multi-grade: Lowest grades	Nonsupervisory grades: Multi-grade: Middle grades	Nonsupervisory grades: Multi-grade: Highest grades
All levels	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	81.2	95.7	96.1	39.5	52.9	71.9
Engineering college	2.3	4.3	2.7	0.8	-	3.5
College, general						
Graduation	12.8	-	20.6	-	-	-
Less than graduation	46.2	67.5	47.5	32.5	49.4	45.6
Technical institute, graduation	12.3	23.9	13.8	5.4	-	22.8
Other post-high-school	7.6	-	11.5	0.8	3.5	-
High school	18.8	4.3	3.9	60.5	47.1	28.1

education beyond high school; and this is true also for mathematics technicians in supervisory grades. (See table IV-A; detail in table IV-2, at the end of the chapter.)

The data in the table point to a widespread expectation that the applicant will have taken mathematics at the college level. However, none of the employers with multi-grade systems requires the student to have completed the work for a B.S. or a B.A. Employers rarely specify attendance at an engineering college or technical institute.

Though calculus is regularly mentioned as desirable, it is not required of all applicants for these technician jobs. Some lower-grade jobs can be filled by a high-school graduate if he has trigonometry and advanced algebra.

Experience Requirements

For mathematics technicians, experience is considered somewhat less important than for other types of technician. In respect to jobs that require high-school graduation, the average (median) experience required is half a year at the entrance level, as represented by the lowest grades in establishments with multi-grade structures. For jobs at the entrance level that require some education beyond high school, no experience is required in the average case. The high-school graduate who aspires to a middle-range job must have had, not half a year, but two and a half years of experience, in the average case; but if he has had college mathematics courses the employer expects little or no experience.

Almost all supervisory jobs require education beyond high school, and in the average (median) case the applicant is expected to have between 5 and 6 years of experience in addition. The highest-grade nonsupervisory jobs also require a substantial amount of experience. (Table IV-B gives medians and table IV-3 at the end of the chapter gives percent distribution in terms of the number of workers involved.)

Table IV-B. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR MATHEMATICS TECHNICIANS IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY GRADE

Education required	All grades	Supervisory grades	Nonsupervisory grades			
			Single grade only	Multi-grade		
				Lowest grades	Middle grades	Highest grades
All levels	1.5	5.6	0.0	0.0	2.5	3.6
Post-high-school	1.0	5.6	0.0	0.0	(a)	(a)
High school	1.9	(a)	(a)	0.5	2.5	(a)

a. Not computed because of small number involved.

Preferred vs. Required Education

Employers who would like to make their requirements stiffer are almost always interested in applicants having more education; much less often in their having more experience.

The employers of 21 of the 156 technicians for whose jobs only high school was required reported that they would have liked to impose higher requirements on applicants. This small number suggests again that in this field there are jobs for which a substantial amount of high-school mathematics is adequate preparation.

In each of these cases the preference was for more education, typically some college study. The employers of 9 of the 21 said that they would take less experience if they could get more education.

The employers of 305 of the 675 technicians whose jobs called for education beyond high school reported that they would like to impose higher requirements. Only 14 were working for employers who would have preferred the same education plus more experience. All the rest wanted more education (12 wanted more experience too). In the typical case the employer required some college education and said that he would prefer college graduation. (See table IV-C, and the greater detail in table IV-4, and also tables IV-5, and IV-6, at the end of the chapter.)

Table IV-C. PERCENT DISTRIBUTION OF MATHEMATICS TECHNICIANS ACCORDING TO EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

Education required	Total	No preference expressed	Preference where one was expressed				
			All preferences	Required education, more experience	More than required education		
					Less experience	Same experience	More experience
Post-high-school	100.0	54.8	45.2	2.1	0.4	40.9	1.8
College, general	100.0	59.5	40.5	0.4	-	40.1	-
Graduation	100.0	98.1	1.9	1.9	-	-	-
Less than graduation	100.0	48.8	51.2	-	-	51.2	-
Technical institute, graduation	100.0	68.6	31.4	11.8	-	19.6	-
Type not specified	100.0	6.3	93.7	-	-	93.7	-
High school	100.0	86.5	13.5	-	5.8	7.7	-

SOURCES OF WORKERS

Employers' reports, relating to a current representative period, indicate that, over-all, three-fifths of mathematics technicians were recruited from outside the firm, the rest coming to their current jobs by being upgraded within the firm. Organized training by the employer played virtually no role at all in the upgrading process. Upgrading was more prominent in the upper grades than in the lower, as the following percent distribution shows:

Grade	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All grades	100.0	60.9	1.0	38.1
Supervisory grades	100.0	-	-	100.0
Nonsupervisory grades	100.0	64.5	1.0	34.5
Single grade only	100.0	74.7	1.4	23.9
Multi-grade:				
Lowest grades	100.0	71.3	-	28.7
Middle grades	100.0	22.4	1.2	76.4
Highest grades	100.0	19.3	-	80.7

To a greater extent than engineering or physical science technicians, mathematics technicians employed in New York State had college degrees:

All mathematics technicians	831	100.0%
College graduates	256	30.8
Technical institute graduates	164	19.7

TESTS AND LICENSES

A few employers reported the use of intelligence tests and mathematics aptitude tests in hiring mathematics technicians. Some also used mechanical aptitude tests. No license or certificate requirements were found in this occupation.

PROMOTIONAL LINES

In some establishments it is the policy of the employer to promote to mathematics technician persons who are serving in a lesser capacity. Jobs most often reported as ones from which personnel may advance to the mathematics technician level are engineering aide, other lower-grade technician, and clerks.

Promotion from mathematics technician may be to a higher-grade mathematics job, mathematician, engineer, programmer, engineering aide, or another type of technician.

Mathematics Technicians

Table IV-1. NUMBER, BY INDUSTRY GROUP

Industry group	Number
All industries	831
Manufacturing	621
Durable goods	621
Ordnance and accessories	11
Primary metal industries	1
Fabricated metal products	15
Machinery, except electrical	71
Electrical machinery and equipment	41
Transportation equipment	309
Instruments; photographic and optical goods	173
Nonmanufacturing	210
Services and miscellaneous	200
Business services n.e.c.	51
Research, development, testing laboratories	50
Business and management consulting services	1
Voluntary hospitals	1
Private colleges and schools	56
Engineering and architectural services	92
Government, federal	10
Arsenals and navy yards	3
Other	7

Mathematics Technicians

Table IV-2. EDUCATION EMPLOYERS REQUIRE, BY GRADE

(Number and percent distribution of technicians according to level of education required)

Education required	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Multi-grade: Lowest grades	Multi-grade: Middle grades	Multi-grade: Highest grades
			Number			
All levels	831	46	514	129	85	57
Post-high-school	675	44	494	51	45	41
Engineering college	19	2	14	1	-	2
Graduation	4	-	4	-	-	-
Less than graduation	15	2	10	1	-	2
College, general	491	31	350	42	42	26
Graduation	106	-	106	-	-	-
Less than graduation	385	31	244	42	42	26
Technical institute or community college, graduation	102	11	71	7	-	13
Type not specified	63	-	59	1	3	-
High school	156	2	20	78	40	16
			Percent distribution			
All levels	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	81.2	95.7	96.1	39.5	52.9	71.9
Engineering college	2.3	4.3	2.7	0.8	-	3.5
Graduation	0.5	-	0.8	-	-	-
Less than graduation	1.8	4.3	1.9	0.8	-	3.5
College, general	59.0	67.5	68.1	32.5	49.4	45.6
Graduation	12.8	-	20.6	-	-	-
Less than graduation	46.2	67.5	47.5	32.5	49.4	45.6
Technical institute or community college, graduation	12.3	23.9	13.8	5.4	-	22.8
Type not specified	7.6	-	11.5	0.8	3.5	-
High school	18.8	4.3	3.9	60.5	47.1	28.1

Mathematics Technicians

Table IV-3. YEARS OF EXPERIENCE EMPLOYERS REQUIRE, BY GRADE

(Percent distribution of technicians according to years of experience required)

Experience required	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Multi-grade: Lowest grades	Multi-grade: Middle grades	Multi-grade: Highest grades
Total: Number	831	46	514	129	85	57
Percent distribution						
Total: Percent	100.0	100.0	100.0	100.0	100.0	100.0
No experience	54.1	-	68.2	72.9	-	8.8
Under 1 year	0.5	-	-	3.1	-	-
1 and under 2	17.4	-	20.4	21.7	14.1	-
2 and under 3	8.2	-	4.9	-	45.9	7.0
3 and under 4	6.5	-	1.8	-	36.5	24.6
4 and under 5	4.7	30.4	4.1	-	-	7.0
5 and under 7	7.1	69.6	0.6	-	3.5	36.8
7 and under 10	1.0	-	-	-	-	14.0
10 and over	0.5	-	-	2.3	-	1.8

Mathematics Technicians

Table IV-4. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number and percent distribution of technicians according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	More than required education: Same experience	More than required education: More experience
			Number				
All levels	831	505	326	14	12	288	12
Post-high-school	675	370	305	14	3	276	12
Engineering college	19	4	15	-	3	-	12
Graduation	4	4	-	-	-	-	-
Less than graduation	15	-	15	-	3	-	12
College, general	491	292	199	2	-	197	-
Graduation	106	104	2	2	-	-	-
Less than graduation	385	188	197	-	-	197	-
Technical institute or community college, graduation	102	70	32	12	-	20	-
Type not specified	63	4	59	-	-	59	-
High school	156	135	21	-	9	12	-
			Percent distribution				
All levels	100.0	60.8	39.2	1.7	1.4	34.7	1.4
Post-high-school	100.0	54.8	45.2	2.1	0.4	40.9	1.8
Engineering college	100.0	21.1	78.9	-	15.8	-	63.1
Graduation	100.0	(a)	-	-	-	-	-
Less than graduation	100.0	-	100.0	-	20.0	-	80.0
College, general	100.0	59.5	40.5	0.4	-	40.1	-
Graduation	100.0	98.1	1.9	1.9	-	-	-
Less than graduation	100.0	48.8	51.2	-	-	51.2	-
Technical institute or community college, graduation	100.0	68.6	31.4	11.8	-	19.6	-
Type not specified	100.0	6.3	93.7	-	-	93.7	-
High school	100.0	86.5	13.5	-	5.8	7.7	-

a. Not computed because of small number involved.

Mathematics Technicians

Table IV-5. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Number and percent distribution of technicians according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require: Post-high-school, total	Post-high-school: Engineering college graduation	Post-high-school: College, general: Graduation	Post-high-school: College, general: Less than graduation	Post-high-school: Technical institute graduation
Number								
All levels	831	577	254	254	23	198	17	16
Post-high-school	675	442	233	233	23	198	-	12
Engineering college	19	4	15	15	3	-	-	12
Graduation	4	4	-	-	-	-	-	-
Less than graduation	15	-	15	15	3	-	-	12
College, general	491	294	197	197	-	197	-	-
Graduation	106	106	-	-	-	-	-	-
Less than graduation	385	188	197	197	-	197	-	-
Technical institute or community college, graduation	102	82	20	20	20	-	-	-
Type not specified	63	62	1	1	-	1	-	-
High school	156	135	21	21	-	-	17	4
Percent distribution								
All levels	100.0	69.4	30.6	30.6	2.8	23.9	2.0	1.9
Post-high-school	100.0	65.5	34.5	34.5	3.4	29.3	-	1.8
Engineering college	100.0	21.1	78.9	78.9	15.8	-	-	63.1
Graduation	100.0	(a)	-	-	-	-	-	-
Less than graduation	100.0	-	100.0	100.0	20.0	-	-	80.0
College, general	100.0	59.9	40.1	40.1	-	40.1	-	-
Graduation	100.0	100.0	-	-	-	-	-	-
Less than graduation	100.0	48.8	51.2	51.2	-	51.2	-	-
Technical institute or community college, graduation	100.0	80.4	19.6	19.6	19.6	-	-	-
Type not specified	100.0	98.4	1.6	1.6	-	1.6	-	-
High school	100.0	86.5	13.5	13.5	-	-	10.9	2.6

a. Not computed because of small number involved.

Mathematics Technicians

Table IV-6. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of technicians according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	831	831	100.0	100.0
Post-high-school	675	696	81.2	83.8
Engineering college	19	27	2.3	3.2
Graduation	4	27	0.5	3.2
Less than graduation	15	-	1.8	-
College, general	491	509	59.0	61.3
Graduation	106	304	12.8	36.6
Less than graduation	385	205	46.2	24.7
Technical institute or community college, graduation	102	98	12.3	11.8
Type not specified	63	62	7.6	7.5
High school	156	135	18.8	16.2

Chapter V

PHYSICAL SCIENCE TECHNICIANS

The major fields in which physical science technicians work are chemistry, metallurgy, physics, meteorology, and geology (minerals and soil). In many instances the technician is required to function in multiple related fields, for example, in chemistry and physics or in physics and metallurgy. In a broad field, such as chemistry, it is not uncommon for the technician to specialize in a specific area such as pharmaceuticals or fuels.

The basic function of the physical science technician is to perform a variety of physical, chemical, mechanical, and electrical tests on raw materials, intermediate products, and manufactured articles. The tests performed may involve routine standardized procedures prescribed by regulatory or advisory agencies, company practice, or original techniques demanded by specialized conditions. There is no significant difference in job function between the physical science technicians involved in quality control and production and those assisting in research and development.

Approximately 9,000 physical science technicians are employed in New York State. The largest concentrations are in the manufacture of chemical products, metals and machinery, stone-clay-glass products, instruments and photographic and optical goods and food products; and, in the nonmanufacturing field, in research laboratories, colleges, and government agencies. In the chemical field the most numerous type works with industrial chemicals. Outside the chemical field physics-chemical technicians are the most numerous type. (For details, see tables V-A and V-B on the following page and table V-1, at the end of the chapter.)

Table V-A. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS BY INDUSTRY GROUP

Industry group	All occupations	Chemical and related technicians	Other physical science technicians
All industries: Number	8,969	5,162	3,807
Percent distribution			
All industries: Percent	100.0	100.0	100.0
Manufacturing	75.3	80.3	68.6
Stone, clay, and glass products	7.2	1.6	14.7
Primary metal industries	4.6	2.3	7.7
Machinery, except electrical	4.1	2.2	6.6
Electrical machinery and equipment	3.8	4.1	3.5
Instruments; photographic and optical goods	14.6	6.2	26.0
Food and kindred products	6.1	10.7	-
Chemicals and allied products	23.0	40.0	0.1
Other manufacturing	11.9	13.2	10.0
Nonmanufacturing	24.7	19.7	31.4
Research, development, testing laboratories (a)	6.1	4.8	7.8
Private colleges and schools	7.2	6.4	8.4
Government	6.2	2.6	11.1
All other nonmanufacturing	5.2	5.9	4.1

a. Includes two smaller groups: architectural and engineering service enterprises and business and management consulting services.

Table V-B. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS BY OCCUPATION

Occupation	Number	Percent
All occupations	8,969	100.0
Chemical and related	5,162	57.6
Pharmaceuticals	363	4.0
Fuels	338	3.8
Beverages and other food products	478	5.3
Industrial and other chemicals	3,983	44.5
Other physical science technicians	3,807	42.4
Metallurgical and related	987	11.0
Physics-chemical	1,638	18.1
Physics, radiation, and nuclear	761	8.5
Meteorology	185	2.1
Minerals and soil	140	1.6
Other	96	1.1

FUNCTIONS

In general the functions of physical science technicians consist of:

Obtaining samples of material for test and analysis from raw materials, intermediate or final products.

Preparing samples for analysis. May involve weighing, volumetric measurement, solution, sectioning and polishing, incubation, etc., depending on nature of test or analysis.

Conducting tests or analyses according to standardized procedures established by laboratory director, regulatory or advisory agencies such as the American Society for Testing and Materials, Association of Official Agricultural Chemists, United States Pharmacopoeia, National Formulary, etc. Test or analysis may involve qualitative and/or quantitative analysis, determination of physical properties such as specific gravity, tensile strength, electrical resistance, and hardness.

Recording test or analysis results, usually in a notebook, or on a standard form prescribed by laboratory director. May involve calculations using arithmetic, algebra, graphs, and logarithms. Except for the highest level technician, interpretation, decision making, and judgment are not usually required for reports of test and analysis.

Maintaining laboratory in a safe, clean condition.

Maintaining inventory and stock of materials.

Maintaining, within the scope of technician ability, all equipment and instruments in the laboratory.

Calibrating, when necessary, precision equipment such as volumetric flasks, burettes, hardness testers, electrical meters, thermostats, and radiation counters.

Receiving and storing supplies following safety regulations to reduce fire and health hazards.

The work of the physical science technician usually is supervised by a scientist or engineer. However, the supervisory responsibility may be delegated to a senior-grade technician, especially in large organizations. In some cases the technician may be responsible directly to the plant manager, a department manager, or other personnel. (Table V-C.)

Chemical and Related Technicians

Chemical technicians work with the following kinds of product: inorganic and organic chemicals, including acids, bases, salts, complex compounds, plastics,

Table V-C. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS BY OCCUPATION OF SUPERVISOR

Occupation	Total	Occupation of supervisor: Scientist or engineer	Technician (a)	Other
All occupations	100.0	75.3	15.3	9.4
Chemical and related	100.0	80.6	11.2	8.2
Metallurgical and related	100.0	60.1	15.6	24.3
Physics-chemical	100.0	73.4	19.5	7.1
Physics, radiation, and nuclear	100.0	72.1	26.3	1.6
Meteorology	100.0	18.4	61.1	20.5
Minerals and soil	100.0	100.0	-	-
Other	100.0	80.2	6.3	13.5

a. Physical science technician or other technician.

textiles, foods, pharmaceuticals, metals, rubbers, resins, paints, varnishes, radioactive materials, beverages, ceramics, and synthetic materials.

The general functions of chemical technicians include:

Obtaining material for analysis.

Preparing a representative sample and coding for identification.

Employing qualitative and/or quantitative chemical analytical procedures under direction of chief chemist or supervisory technician.

Preparing and standardizing analytical reagent solutions.

Calibrating and maintaining, when necessary, precision measuring apparatus such as pH meters, volumetric flasks, analytical balances, and thermometers.

Their technical skills include:

Ability to use the following general laboratory apparatus and equipment: test tubes, beakers, flasks, pipettes, burettes, wash bottles, funnels, grinders and pulverizers, graduates, distillation apparatus, evaporating dishes, thermometers, melting point apparatus, filters, reflux columns, separatory funnels, crucibles, colorimeter, centrifuge, analytical balance, pH meter, ovens, stirrers and mixers, vacuum pumps, water and oil baths, siphons, miscellaneous laboratory hardware such as stands, clamps, etc.; small hand tools such as hammers, wrenches, pliers, cork and stopper borers, tubing expanders, glass cutters, files, hand shears; and the slide rule.

Ability to use reference flow charts and handbooks.

Ability to write technical reports of varying complexity ranging from the entry of numbers on a standard form to the preparation of a complete report including graphs, charts, tables, conclusions, and recommendations.

Chemical technicians should possess an accurate sense of taste and smell and be free of color blindness.

Pharmaceutical Technicians

Products: Raw, intermediate, and final pharmaceutical products including drugs, narcotics, vitamins, antiseptics, emetics, aerosols, etc.

Specific Functions

Determination of capsule and tablet weight.
Time check on disintegration period of medicinals.
Vitamin assay for content and potency.
Toxicity tests on animals, of drugs and medicinals.
Effect of pharmaceuticals on bacterial cultures.
Determination of index of refraction of pharmaceuticals.
Sugar content determination.
Spectral analysis of raw and finished products.
Color matching against standards.
Conduct pilot plant runs.

Special Technical Skills

Ability to use the following instruments, apparatus and equipment: blending and tableting machines, pH meter, culture media and dishes, pharmaceutical containers, sieves, power stirrers, homogenizer, roller mill, ion-exchange column, drum and vacuum tray dryers, autoclave, microscope, polarimeter, auto-analyzer, spectrophotometer, gas chromatograph, viscosimeter, refractometer, and Westphal balance.

Ability to use specific handbooks and manuals such as the United States Pharmacopoeia, National Formulary, Association of Official Agricultural Chemists, and the Merck Index.

Fuel Technicians

Products: Petroleum base fuels, manufactured and natural gas, asphalts, boiler feed water, boiler water, steam, river water.

Specific Functions

Perform tests on fuels and oils to determine flash point, specific gravity, color, heating value, copper strip corrosion, pour, vapor pressure, octane number, carbon residue, aniline numbers, moisture, sediment, gums, chloride content, odor level, etc.

Perform tests on flux and asphalts to determine softening point, flash, penetration, Furol viscosity, ductility, solubility in carbon tetrachloride, evaporation, specific gravity, oliensis, compatibility, etc.

Analysis of water for hardness, acidity, turbidity.

Combustion tests to determine efficiency of fuel practices in plant.

May assist in maintenance of octane engines.

May operate water softeners.

Special Technical Skills

Ability to operate gas analyzers, (Cooperative Fuel Research) engine, gum bath, catalyst testing machine, flash point apparatus, viscosimeter.

Check, repair, and adjust meters, regulators, and controls used in connection with combustion equipment.

Ability to use American Society for Testing and Materials handbook.

Beverages and Other Food Product Technicians

Products: Sugars, fruit juices, fruit sauces, beer, candy, cereals, flour, chocolate and cocoa products, powdered drink products, food concentrates, milk, ice cream.

Specific Functions

Check products for micro-organisms such as yeast, mold, bacteria, and spores using culture media.

Analyze products for sugar content, consistency, grain, taste, acidity, alcohol content, butter fat, shelf-life, iodine reaction, moisture content, color, viscosity, salt content, sediment, protein content, vitamin content, ash content.

Water analysis for purity, hardness, acidity, turbidity.

Special Technical Skills

Ability to prepare bacterial cultures and identify micro-organisms.

Ability to use fluoroscope, pilot size grain mill, precision moisture-temperature recorder, pasteurizing equipment, homogenizer, densitometer, viscosimeter, vacuum oven, photographic enlarger, gelometer, auto-analyzer, calculator, paper testing equipment, blender, pycnometer, turbidometer, sterilizer.

Industrial and Other Chemical Technicians

Products: Wide variety of materials including inorganic and organic chemicals, ceramics, paper, testiles, plastics, ores, paints, glues, adhesives, metals, and minerals other than pharmaceuticals, fuels, and foods.

Specific Functions

Perform a wide variety of chemical inorganic and organic qualitative and quantitative analysis for metals as iron, cobalt, chromium, sodium, etc.; nonmetals as chlorine, nitrogen, oxygen, carbon dioxide, etc.; alcohols, ketones, esters, substitution products, etc.

Analyze water for dissolved gases, hardness, acidity, suspended materials, etc.

Conduct physical tests as measurement of viscosity, specific gravity, hardness, brittleness, porosity, printability, opacity, fibre formation, absorption, color matching, moisture content, plating thickness, etc.

Prepare batches of raw materials for pilot production runs.

Construct and assemble laboratory set-ups for special non-routine analytical or testing procedures.

Specific Technical Skills

Glass bending and working.

Ability to use specialized testing equipment as spectrophotometer, gas chromatograph, viscosimeter, refractometer, colorimeter, fadeometer, laundrometer, adhesion and cohesion test devices, electrometric titration apparatus, densitometer, max-mix, grinder mills, bench printing press, William's freeness tester, microscope.

Ability to use reference handbooks and manuals.

Metallurgical and Related Technicians

Products: Ores, bar and sheet stock of ferrous and nonferrous metals, alloys, inorganic salts, plated materials.

Functions

Determination of plating depth.

Physical and chemical tests involving compression, shear, elongation, fracture, hardness, corrosion resistance, bonding, electrical resistance, etch, impact, fatigue, buffing characteristics, lustre, grain size, hardenability, brittleness, hardness, specific gravity, elasticity, abrasion, and wear.

Microscopic examination of metal structure.

Photomicrographic analysis of crystal structure.

Nondestructive tests such as X-ray, zyglo, magnaflux, etc.

Measurement of acidity and alkalinity: pH.

Quantitative and qualitative analysis for elements such as carbon, manganese, silicon, tungsten, titanium, chromium, vanadium, nickel, molybdenum, phosphorus, sulfur, etc.

Preparation of photographic prints.

Preparation of plating baths and control of the electroplating process.

Heat treatment of metals and alloys.

Prepare special set-ups required by non-routine tests and projects.

Technical Skills

Ability to use the following tools, instruments, and apparatus: general laboratory glassware (see "technical skills" of Chemical Technicians on page 157); muffle and electric furnaces; machines to determine hardness, tensile strength, fatigue, shear, and impact; cameras and dark room equipment; metallograph; mechanical and electrolytic polishing devices; apparatus for vacuum deposition of metals; electroplating baths; anodizing equipment; electroplating power supplies; welding equipment; grinders; metal saws; micrometer; calipers; precision linear scales; microscope; spectrograph; electrical meters; pH meter; sprayers; punches; pyrometers; etc.

Elementary metal working skills such as drilling, turning, planing, polishing, etc.

Preparation of elementary mechanical drawings.

Read blueprints and schematics.

Use reference handbooks.

Physics-chemical Technicians

Products: Variety of inorganic and organic raw materials and manufactured products such as storage batteries, gypsum, abrasives, rubber, etc.

Functions

The work of these technicians cuts across the boundaries of both chemistry and physics, but requires the technicians to perform only the more elementary chemical and physical tests. Typical duties include:

Preparation and standardization of reagent solutions.

Preparation of samples for analysis.

Simple volumetric, gravimetric, and colorimetric analysis.

Formulation of materials such as rubber compounds, photo-processing chemicals, etc.

Simple electrical measurements of current, voltage, power.

Physical tests to determine specific gravity, grain size, solubility, texture, adhesive qualities, heat and electrical insulating properties, hardness, abrasive qualities, compression-bending-tensile strength, etc.

Technical Skills

Ability to use the basic laboratory glassware, hardware, and tools listed above under Chemical Technicians.

Use of basic physical measurement equipment such as the micrometer, light meter, densitometer, refractometer, colorimeter, voltmeter, ammeter, wattmeter, pH meter, and tension, compression, and torsion test equipment.

Physics, Radiation, and Nuclear Technicians

Products: Storage batteries, vacuum systems, concrete, steel, dyes, fabrics, temperature recording and control devices, electronic amplifiers, photo electric systems, radioactive isotopes, radioactive contamination, radioactive waste, radiation monitoring equipment, radiotherapy apparatus.

A distinction is made between the physics technicians and the radiation technicians on the basis of the products dealt with and duties performed. The general physics technician will work in the areas of heat, light, mechanics, and electricity. The radiation technician, variously designated as a health physics, waste and reclamation, and scanner technician, among other terms, works only in the area of radioactivity and radiation.

Physics Technicians

Functions

Perform a wide variety of physical tests on raw materials and on intermediate and final products involving the measurement of temperature, pressure, density, color, crystal and grain structure, tensile strength, index of refraction, photo-emission, electrical resistance, voltage, current, electrical power, fluid flow, etc.

Calibrate test instruments.

Assist in the development of procedures and techniques in tests requiring non-standard operations.

Interpret test data, prepare graphs and charts when needed, and make written reports.

Technical Skills

Ability to use general laboratory glassware, voltmeter, ammeter, wattmeter, oscilloscope, temperature recorder (gas, liquid, thermo-electric), pressure gauge and manometer, vacuum gauge, dial gauge, calipers, compression tester, impact tester, column loading tester, densitometer, camera, X-ray machine, photo-electric equipment, electron microscope, radiation monitoring equipment, microtome, microscope, flow meter, and small hand tools such as wrenches, screw drivers, etc.

Technical report writing.

Reading schematics and blueprints.

Manual dexterity.

Optical Technicians

Another field within the category of physics technician is optics. The products and duties are sufficiently specialized to warrant separate consideration.

Products: Lenses, filters, dichroic mirrors, gratings, masers and complex assembled optical systems such as trackers, radiometers, telescopes, etc.

Functions

Perform experimental grinding, polishing, figuring, assembly, and testing of optical details and assemblies of any optical and/or infra-redmaterial.

Fabricate, assemble, calibrate, and collimate optical systems such as trackers, radiometers, telescopes, scanners, etc.

Set-up, operate, and monitor thin film deposition equipment for fabrication of optical coatings, filters, gratings, dichroic mirrors, etc.

Set-up, adjust, and operate optical maser light pumping system.

Measure optical characteristics of modulators, multipliers, optical masers, etc.

Set-up, calibrate, and operate ultraviolet and visible infra-red spectrophotometer equipment.

Assist engineer in resolving optical manufacturing and test problems.

Prepare reports on results of experimental measurements.

Technical Skills

Ability to use optical grinding and polishing equipment, polarimeter, manual and automatic collimator, flexure monitor, axicon instruments, stroboscopic light sources, precision measuring instruments, small hand and general machine shop tools, spectrophotometer, colorimeter, photometer, calculator, voltmeter, ammeter.

Use of handbooks.

Reading blue prints and schematics.

Sketching.

May require limited instructional ability.

Radiation and Nuclear Technicians

Functions

Make routine and specialized radiation and safety surveys by air sampling and smear survey techniques.

Measure external radiation by standard survey instruments.

Conduct neutron surveys.

Assist with radioactive waste disposal and reclamation.

Recommend proper protective equipment and techniques against radiation.

Handle hazardous radioactive materials and chemicals.

Repair and maintain a wide variety of mechanical and electrical equipment.

Assist in construction of concrete vaults for radioactive waste disposal.

Calibrate survey and radiotherapy instruments.

Troubleshoot survey and monitoring equipment.

Scan and identify tracks on emulsions caused by radiation in cloud or bubble chambers.

Prepare periodic reports; analyze and evaluate data from films and charts.

May be required to provide instruction on radiation hazards and protective devices and techniques.

Technical Skills

Ability to use Geiger counters, scalers, electroscopes, film badges, sand blasters, vacublasters, filters, pumps, lift machinery, gas cutting equipment, wide variety of hand tools, voltmeters, ammeters, air sampling equipment, chemical laboratory glassware, microscope, photographic developing equipment, projector, temperature and pressure measuring devices, fluoroscopes, X-ray machines, slave units and other remote control apparatus, scintillation crystals, ionization chamber.

Preparation and interpretation of graphs.

Interpretation of photographic emulsion patterns produced by radiation in cloud or bubble chambers.

Reading schematics and blueprints.

Technical report writing.

May require limited instructional ability.

Meteorology Technicians

Functions

Functions vary depending on the field of specialization, education, and experience. In Federal civil service, responsibility is assigned according to technician grade level and service may be on land or aboard ship. These technicians are also classified according to their major work areas as follows:

Observation: Measurement, evaluation, recording, compilation, computation, coding, and transmission of meteorological data.

Charting: Decoding, interpreting, and charting meteorological data on surface and upper air maps, charts, graphs, and diagrams.

Verification: Review, evaluation, correction, and/or final certification of meteorological data and records for accuracy, quality control, and related purposes.

Forecasting: Analysis of data on synoptic charts, maps, diagrams, prognostic charts, and other graphical aids and the application of procedures, methods, and techniques in the preparation of long- and short-term forecasts and weather elements.

Climatology: Collection, analysis, and interpretation of historical and current weather data to describe the climate of geographical areas.

Hydrology: Collection, analysis, and interpretation of meteorological and hydrological data used in prediction of floods, river stages, stream flow, and variations in water supply.

General: Perform the duties of more than one of the specializations described above and meteorological technician functions not dealing with any of the aforementioned specialists. Examples are: Radar operation and observation for detection, analysis, and forecasting of the severity and extent of storms; coordination of observations reported by Coast Guard, ships at sea, and Weather Bureau.

Technical Skills

Ability to prepare and interpret maps, charts, graphs, and diagrams.

Ability to use specialized equipment such as teletype, radar, automatic rain weighing gauges, psychrometer, hygrometer, anemometer, aneroid and mercury barometer, micro-barograph, radiosonde, meteorological balloon, theodolite, maximum-minimum thermometer, river gauge.

Ability to use Weather Bureau manuals.

Effective oral and written communication.

Tact and diplomacy in meeting the public.

Technical report writing.

Minerals and Soil Technicians

Under this heading there are two groups of technicians who are distinctly different in terms of the products with which they work and in terms of their duties and responsibilities.

The larger group are the hydraulics engineering technicians. They are concerned with ground water and streams, and work under the immediate supervision of a geologist, hydraulic engineer, or engineering aid of higher grade.

Laboratory technicians -- field, physical, and soil testing -- are concerned with construction materials, soils, rocks, and earthwork construction. These technicians usually work under the immediate supervision of an engineering supervisor.

Hydraulics Engineering Technicians

Functions

Collect data on existing wells to include: depth, diameter, construction features, types of pumps used, well capacity, drawdown, use of water, quality of water, formation drilled, unusual phenomena, periodic water level, etc.

Make measurements to include: stream flow, rain gauge, crest stage, sedimentation for particle size suspended and rate deposited.

Operate and maintain crest stage stations.

Perform or assist in land surveys.

Direct or assist with repairs of instruments such as recorder clocks, instruments shelters, cableways, crest stage pipes, and intake pipes. Do routine painting.

Direct or assist with the installation, adjustment, and calibration of instruments such as automatic water level recorders and other scientific instruments.

Drafting well logs, field location stages, maps, graphs, and data tables.

Make computations and direct or assist in analysis and compilation of data for publication and distribution.

Assist the engineer in preliminary design and cost estimate for new construction.

Technical Skills

Ability to use instruments and tools such as: automatic water-level recorders, recorder clocks, linear measuring scales, rain gauges, flow recorders, thermometers, sedimentation apparatus, analytical balances, surveying instruments, current meters, stage discharge instruments, sounding weights, calculating machines, slide rules, basic drafting instruments, lettering devices, common hand tools used in wood and metal working and plumbing.

Drafting, sketching.

Interpretation of technical data.

Technical report writing.

Laboratory Technician: Field Testing, Physical Testing, Soil Testing

Function

Collect samples of soils and rocks at proposed or existing construction sites.

Direct the making of test borings.

Determine the extent and formation of various sub-surface materials at construction sites.

Identify and classify soil samples.

Prepare mixtures of bituminous and Portland cement concrete and determine their properties.

Make field determinations of moisture content, density, and degree of soil compaction.

Conduct plate-bearing and other large scale loading tests.

Conduct tests to measure stresses and strains in parts of structures or in unusual materials.

Conduct non-routine physical tests developed by the engineer in charge, to meet special needs.

Compute and plot results of tests, aid in interpretation of test results, and draft special and routine reports.

Compare test results with specifications and identify discrepancies.

May be required to instruct subordinate laboratory technicians in testing procedures.

Technical Skills

Ability to use instruments such as consolidometers, single shear and triaxial testing machines, gauges, scales, moisture recording instruments, compression test equipment, triple beam balance, standard soil testing kits, microscope, rock saws, index of refraction apparatus.

Develop new procedures in testing.

Calibrate test equipment.

Prepare comprehensive reports involving calculation, interpretation, recommendation.

Prepare charts, tables, graphs.

Other Physical Science Technicians

The "other" category consists almost entirely of museum technicians. They are on the borderline between technician and skilled craftsman because their duties and responsibilities overlap both categories.

Products: Biological and geological models and exhibits.

Functions

Prepare materials for museum exhibits and collections involving work in the following areas:

Taxidermy - collect, preserve, and prepare biological specimens for mounting and exhibit; prepare skeletal materials for study or exhibit.

Accessory work - collect, preserve, and color accessory material for exhibits (rocks, plants, leaves, grasses, moss, and soil) and assist in mounting and installing accessory material.

Cabinet, wax, and plaster work - prepare casts and models of animals, plants, and rocks in wax, plaster, gelatin, and celluloid. Construct supporting framework.

General - prepare backgrounds for painting, execute simple decorative designs, pack and ship loan material.

Technical Skills

Manual dexterity to use a wide variety of dissection instruments and hand tools for wood, metal, and plaster working; scales, calipers; preservative baths; molds; paint mixers, artist's tools; glass cutters.

SUBJECT MATTER KNOWLEDGE

Employers were asked to indicate the subject matter knowledge that physical science technicians need to perform their jobs. The responses have been summarized in table V-D. They represent a cross-section of opinion of hundreds of employers, who employ 8,969 physical science technicians. They are classified in terms of basic general subject matter needed to do the job, subjects that are needed in a substantial number of cases, and finally, the subjects needed only occasionally for a particular specialized technician function. This last group is not to be interpreted as being all-inclusive.

The technician grading structure influences subject matter requirements. The data indicate that employers using only a single grade of technician require significantly more subject matter and at a higher level than do employers who have multi-grade structures. The contrast is most pronounced between the single grade technician and the lowest of the multi-grade technicians. (See section on Grade Structure, below.)

Table V-D. SUBJECT MATTER KNOWLEDGE NEEDED BY PHYSICAL SCIENCE TECHNICIANS BY OCCUPATION

Subject	Chemical and related technicians				Other physical science technicians				
	Pharmaceuticals	Fuels	Beverages and other food products	Industrial and other chemicals	Metallurgical and related	Physics-chemical	Physics, radiation, and nuclear	Meteorology	Minerals and soil
Mathematics									
Trigonometry	XX	-	XX	XX	XX	XX	XX	XXX	XXX
Advanced algebra	XX	-	XX	XX	XX	XX	XXX	-	XXX
Geometry, solid	-	-	X	-	X	X	-	-	XX
Geometry, analytic	-	-	XX	X	-	X	XX	-	-
Calculus	XX	-	XX	X	X	-	XX	-	XX
Differential equations	-	-	X	-	-	-	-	-	-
Science									
Chemistry									
General	XXX	XXX	XXX	XXX	XXX	XXX	XXX	-	XX
Organic	XXX	-	X	XXX	X	XX	-	-	-
Inorganic	XX	-	-	X	XX	X	-	-	-
Qualitative and quantitative analysis	XXX	XX	XX	XXX	X	XX	-	-	-
Physical	X	-	X	X	X	-	-	-	-
Industrial	-	XX	X	X	-	-	-	-	-
Polymer	-	-	XX	X	X	-	X	-	-
Metallurgy	-	-	-	-	XXX	X	XX	-	-
Physics									
General	XXX	-	XXX	XXX	XXX	XXX	XXX	XXX	XXX
Advanced	-	-	-	X	XX	-	-	-	-
Optics	-	-	-	-	-	X	-	-	-
Meteorology	-	-	-	-	-	-	-	XXX	-
Biology									
General	X	-	XXX	X	-	X	-	-	-
Bacteriology	XX	-	XXX	X	-	X	-	-	-
Technology									
Technical drawing	-	-	XX	XX	XX	XX	XXX	XX	XXX
Electrical technology, orientation	-	-	X	X	XX	X	XX	-	-
Basic electricity	-	-	-	-	X	-	X	-	-
Basic electronics	-	-	-	X	X	X	XX	X	-
Mechanical technology, orientation	-	-	-	-	-	XX	XX	-	-
Mechanics and strength of materials	-	-	-	X	X	-	X	-	-
Chemical technology including manufacturing processes	XX	-	XXX	X	X	X	X	-	-
Instrumentation	XXX	-	XX	X	X	-	-	-	-
Electro-mechanical design, orientation	-	-	-	X	X	-	XX	-	-

Key: XXX = generally needed; XX = needed in a substantial number of cases; X = occasionally needed.

Chemical and Related Technicians

Although there exists a common core of subject knowledge needed by this group of technicians, there are differences dependent upon the major area of work and the grading system used.

Pharmaceuticals technicians. Basic general requirements include general chemistry, qualitative and quantitative analysis, elementary organic chemistry, general physics, and instrumentation. The greatest employer need appears to be for technicians who have a basic knowledge of chemistry and can apply it in terms of the instrumentation employed in the pharmaceutical field. Qualitative and quantitative analysis and organic chemistry, while not ranking as high as the two aforementioned subjects, are valuable for the pharmaceutical technician, who must make organic and inorganic analyses and who also engages in the synthesis of drugs, narcotics, and other organic pharmaceuticals.

The multi-grade structure characterizes the pharmaceutical field. When hiring at the entrance level much of the subject matter requirement is waived by some employers. A knowledge of general chemistry and physics is most useful for the beginning technician.

Subjects needed in a substantial proportion of cases include inorganic chemistry, advanced algebra, calculus, bacteriology, manufacturing processes. Technicians in the pharmaceutical field may be involved in work requiring a knowledge of advanced inorganic chemistry, particularly if they function in the highest grades. Advanced algebra is the most frequently cited mathematics requirement, but again it is the most useful to the upper-grade technician. Calculus is useful principally to the highest grade and supervisory technician engaged in product development and production control. Bacteriology is essential to the technician working in the areas of drugs, antibiotics, antiseptics, etc. One of the prime concerns of the pharmaceutical field is production. Consequently, for technicians engaged in this area of work, a knowledge of manufacturing processes is important.

Subjects occasionally needed include physical chemistry and general biology. Relatively few employers require these subjects and they may be regarded as being necessary to meet a specialized need of only a small number of technicians.

Fuels technicians. General requirements: General chemistry and general science. For the entry job, some employers will waive these requirements and accept high-school graduates.

Required in a substantial proportion of cases: Qualitative and quantitative analysis and industrial chemistry. These subjects are valuable to the intermediate through supervisory classifications.

Employers reported no other subject matter requirements. Fuels technicians operate in a relatively narrow field of specialization. (See functions for details.)

Beverages and other food products technicians. General requirements: General chemistry, general physics, food chemistry, general biology, and bacteriology. These subjects provide the basic working knowledge needed to enable these technicians to perform in the areas of quality control and production and to advance to higher grades through practical job experience. Certain employers will accept high-school graduation plus one to five years of work experience in the plant in lieu of these basic subject requirements.

Required in a substantial proportion of cases: Analytical chemistry, polymer chemistry, instrumentation, analytic geometry, calculus, advanced algebra, trigonometry, and technical drawing.

Quality control of the raw and finished products requires the use of analytical chemistry. With the advent of automated production techniques in the industry, a knowledge of instrumentation takes on increased significance. Some of the higher-level technicians in this field in a sense are chemical engineering technicians who set up, operate, and evaluate pilot plant operations. The industrial processes and instrumented control involved require the use of more advanced mathematics than do the analytical procedures used by other chemical technicians. Consequently analytic geometry and calculus are required for the technicians functioning in this higher level capacity. The engineering aspects of this technician's functions also require proficiency in technical drawing to facilitate sketching and layout and the reading of prints and schematics.

Subjects occasionally required: Orientation in electrical technology; solid geometry; differential equations; organic, physical, and industrial chemistry. The need for these subjects varies with the technician's function. With the exception of organic and physical chemistry, these subjects are of importance mostly to persons functioning as engineering technicians. Specialized job responsibilities, such as organic analysis and research, could make organic and physical chemistry mandated subjects.

Industrial and other chemical technicians. General requirements: General chemistry and physics, analytical chemistry, organic chemistry. These technicians function in a diversified but related cluster of occupations. The required subjects form the core of basic knowledge which enable the technicians to function in any one of a number of industrial product subdivisions of the chemical field.

In this category, there is wide variation in the level at which technicians function and in the consequent subject matter required. Some personnel are hired on the basis of a general high-school education; others are required to have completed high-school chemistry or a high-school industrial chemical technical curriculum; high school plus advanced work in chemistry at the college level is demanded in other jobs. The above listing of subjects reflects prevailing employer opinion but this must not be interpreted as meaning employers are inflexible and will not hire unless the person has completed these subjects. Many technicians qualify for entry into the field primarily through related plant experience.

Subjects required in a substantial proportion of cases: Trigonometry, advanced algebra, technical drawing. In a number of jobs, this technician takes on functions approaching the work of engineering technicians, which requires sketching, flow chart preparation, diagrams, layouts, etc., and print reading. These needs are generally met by a course in technical drawing.

Subjects occasionally needed: Analytic geometry; calculus; advanced inorganic, physical, industrial, and polymer chemistry; advanced general physics; general biology; bacteriology; basic electronics; orientation in electrical technology; strength of materials; dyes; ceramics; textiles; instrumentation; orientation; electro-mechanical design.

Physical Science Technicians Other Than Chemical

Metallurgical and related technicians. General requirements: General chemistry, general physics, and metallurgy. Although in general they are all fundamental to this work the need varies with the area of job specialization. Along with a facility in laboratory technology, this fundamental knowledge requirement enables the technician to perform effectively in a wide variety of related occupations.

Although single grade classification prevails in this field, there are wide variations in levels of job difficulty from firm to firm. As with the chemical group, some employers will accept high-school graduates for the entry job and provide the required on-the-job training and education to make the person proficient.

Subjects needed in a substantial proportion of cases: Advanced inorganic chemistry, orientation in electrical technology, technical drawing, trigonometry, and advanced algebra. The technicians performing more sophisticated chemical and physical tests and electroplating operations need advanced chemistry and physics. Orientation in electrical technology is valuable to electroplaters and persons making electrical measurements and using electric furnaces and auxiliary equipment. The technician frequently becomes involved in technical sketching, layout, and print reading. Technical drawing may be required in this case. The technician involved with formulation, analysis of crystal structure, X-ray diffraction, etc., needs to have facility in trigonometry and advanced algebra. Others may need only basic arithmetic, to do percentage and ratio and proportion calculations.

Subjects needed only occasionally: Solid geometry; calculus; organic, analytical, physical, and polymer chemistry; basic electronics; electrical wiring and circuitry; strength of materials; instrumentation; manufacturing processes; ceramics; electro-mechanical design. The nature of these subjects indicates how varied are the special functions these technicians are expected to serve. Those with the most difficult responsibilities may require higher mathematics, strength of materials, orientation in electro-mechanical design, and manufacturing processes. It is probable that in the future electronics and instrumentation will increase in importance.

Physics-chemical technicians. General requirements: General chemistry and physics. This group of occupations is primarily concerned with making elementary physical and chemical tests. Chemistry and physics are therefore the common requirements to provide background and laboratory know-how.

Subjects needed in a substantial proportion of cases: Organic and analytical chemistry, orientation in mechanical technology, technical drawing, trigonometry, and advanced algebra. Some of these technicians devote most of their time to chemistry, approaching the type of work done by the chemistry technician, and spendonly a small amount of time on tasks characteristic of the physics technician. For those, organic chemistry may be essential. Others will do only minor tasks in chemistry and specialize in physical testing. For this group, mechanical technology and technical drawing become significant. Higher mathematics is required for the middle- and higher-grade technicians, whether they function in a single- or multi-grade structure.

Subjects required occasionally: Solid geometry, analytic geometry, advanced inorganic chemistry, metallurgy, optics, general biology, bacteriology, basic electronics, orientation in electrical technology, manufacturing processes, textiles. The widely diversified areas of specialization into which these technicians advance is reflected by the greatly varied subject matter requirements in this category.

Physics, radiation, and nuclear technicians. General requirements: General chemistry and physics, technical drawing, advanced algebra. Although classified together in this study, in the section on functions, a distinction was made between physics and radiation technicians because the products with which they work and the functions they perform differ considerably. The above-listed subjects represent the basic requirement for a cross-section of the entire group. However, for the radiation technician, orientation in electrical technology, basic electronics, orientation in mechanical technology, orientation in electro-mechanical design, and calculus may well appear as basic requirements.

A considerable number of technicians in the physics-radiation-nuclear group are required to make layouts, elementary working drawings and sketches, and to read prints and schematics. Technical drawing is therefore one of the subjects mentioned with sufficient frequency to warrant it being considered a general requirement.

Subjects needed in a substantial proportion of cases: Orientation in mechanical technology, metallurgy, basic electronics, orientation in electrical technology, orientation in electro-mechanical design, trigonometry, analytic geometry, and calculus. These subjects are needed by specialized technicians, as in the case of the radiation technician mentioned above. They are more likely to be required of the upper-level technician.

Subjects needed only occasionally: Polymer chemistry, manufacturing processes, electrical wiring and circuitry, strength of materials. These are specializations required for relatively few technicians in this category.

Meteorology technicians. General requirements: Trigonometry, general physics, meteorology. The work of these technicians is limited to a relatively narrow field of subject matter. Of prime importance is meteorology, followed closely by general physics. The physics background provides a knowledge of the general principles applied in meteorology and also helps develop the skills required in making quantitative measurement of physical quantities. The trigonometry enables the technician to perform the mathematical calculations which characterize meteorological reports and predictions.

Subject required in a substantial proportion of cases: Technical drawing. The meteorology technician frequently is involved in the preparation and interpretation of charts, maps, graphs, etc. For this, technical drawing provides the requisite knowledge and hand skills.

Subjects required occasionally: Basic electronics and instrument analysis. Some of these technicians use electronic equipment and instruments, such as radar, teletype, radiosonde, etc. Minor maintenance of this type of equipment may be required.

Minerals and soil technicians. General requirements: General physics, technical drawing, trigonometry, advanced algebra. Although this group consists of two distinct occupations -- the hydraulic engineering technician and the field testing, physical testing, and soil testing technician -- the same subject knowledge is basic to both. Each makes wide application of the basic principles of physics, with emphasis on mechanics. Similarly, drawing skill and the ability to read prints and schematics are common requirements. The hydraulics engineering technician makes additional applications of drawing skill and knowledge and of trigonometry when he assists in surveying operations.

Subjects required in a substantial proportion of cases: General chemistry, solid geometry, calculus. A knowledge of chemistry is required for those technicians who make elementary chemical tests on soils and rocks and on water to determine its purity and quality. Not all technicians in this group are required to perform these functions.

The mathematics requirement is primarily for the hydraulics engineering technician in the higher grades.

Other technicians. As mentioned elsewhere, this category is largely limited to museum work and is borderline between technician and craft work. This job requires considerable related technical information on biological preservatives, and working properties of wax, plaster, gelatin, etc., information not included in the formal physical science disciplines.

GRADE STRUCTURE

Table V-E shows that more physical science technicians are employed in multi-grade than in single-grade structures. The metallurgical field, the physics, radiation, and nuclear field, and the beverages and other food products field are among the exceptions.

The allocation of particular jobs to the grade levels shown in the table is based on employers' designations. For example, one establishment's "middle grades" may differ from the "middle grades" of another in difficulty and responsibility.

In the case of these physical science technicians, as in the case of other technical occupations, elements that distinguish one nonsupervisory grade from another include, among others: how close the supervision is; the extent

Table V-E. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS ACCORDING TO GRADE, BY OCCUPATION

Occupation	All grades	Supervisory grades	Nonsupervisory grades			
			Single grade only	Multi-grade		
				Lowest grades	Middle grades	Highest grades
All occupations	100.0	2.6	40.7	24.9	16.5	15.3
Chemical and related	100.0	1.7	43.7	24.3	14.0	16.3
Pharmaceuticals	100.0	-	30.3	19.8	8.0	41.9
Fuels	100.0	5.0	13.6	45.9	20.4	15.1
Beverages and other food products	100.0	-	55.7	25.3	9.4	9.6
Industrial and other chemicals	100.0	1.8	46.0	22.8	14.6	14.8
Metallurgical and related	100.0	2.5	58.6	15.0	11.4	12.5
Physics-chemical	100.0	1.9	12.9	40.1	30.4	14.7
Physics, radiation, and nuclear	100.0	3.0	57.9	17.3	11.0	10.8
Meteorology	100.0	31.3	26.5	7.6	17.3	17.3
Minerals and soil	100.0	4.3	29.3	9.3	19.3	37.8
Other	100.0	-	77.1	14.6	3.1	5.2

to which instructions are spelled out in writing; the extent of initiative, discretion, and judgment the worker exercises; the complexity and intricacy of the products and equipment dealt with; the knowledge of related technologies required. In addition, technicians in the lower grades spend a larger proportion of their time than do those in higher grades on routine or standardized testing.

EDUCATION AND EXPERIENCE REQUIRED

Employers of 62 percent of physical science technicians require some post-high-school education of these technicians; 38 percent have educational requirements that do not go beyond the completion of high school.

Many employers who do not require post-high-school education require one or more years of experience, and many expressed a preference for some schooling beyond high school.

Education Requirements

Study at a technical institute or community college was given as their minimum education requirement by the employers of 37 percent of the physical

Table V-F. NUMBER AND PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS BY EDUCATION EMPLOYERS REQUIRE

Education required	Number	Percent
All levels	8,969	100.0
Post-high-school	5,570	62.1
Engineering college	132	1.5
Graduation	30	0.3
Less than graduation	102	1.2
College, general	1,450	16.2
Graduation	704	7.8
Less than graduation	746	8.4
Technical institute or community college	3,363	37.4
Graduation	3,235	36.0
Less than graduation	128	1.4
Type not specified	624	7.0
Apprenticeship or armed forces school	1	(a)
High school	3,399	37.9
Technical or vocational	310	3.5
Other and not specified	3,089	34.4

a. Less than 0.05 of a percent.

science technicians. No other type of educational requirement above the high-school level was as important as this. Next in importance is the four-year-college category, with 16 percent of the total (graduation is required in the case of 8 percent). (Table V-F.)

The lowest proportion (37 percent) of cases where education beyond high school is required is found among technicians in the lowest grades of firms having multi-grade structures. The figures below indicate the percentage of physical science technicians, by grade, with jobs for which employers require some post-high-school education:

Grade	Percent
All grades	62.1
Supervisory grades	63.5
Nonsupervisory grades	62.1
Single grade only	68.3
Multi-grade:	
Lowest grades	37.2
Middle grades	73.6
Highest grades	73.5

Table V-G. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS ACCORDING TO EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

Occupation	All levels	Post-high-school					High school
		Post-high-school, total	College, general: Graduation	College, general: Less than graduation	Technical institute, graduation	Other	
All occupations	100.0	62.1	7.8	8.4	36.0	9.9	37.9
Pharmaceuticals	100.0	50.7	5.5	20.4	24.0	0.8	49.3
Fuels	100.0	32.5	-	5.3	16.8	10.4	67.5
Beverages and other food products	100.0	59.0	4.0	6.3	30.1	18.6	41.0
Industrial and other chemicals	100.0	67.7	8.2	12.0	37.9	9.6	32.3
Metallurgical and related	100.0	57.5	2.2	10.2	37.1	8.0	42.5
Physics-chemical	100.0	61.1	1.0	0.8	45.9	13.4	38.9
Physics, radiation, and nuclear	100.0	78.6	27.9	3.8	39.4	7.5	21.4
Meteorology	100.0	31.9	29.2	2.7	-	-	68.1
Minerals and soil	100.0	29.3	2.9	0.7	11.4	14.3	70.7
Other	100.0	32.3	30.2	-	2.1	-	67.7

Post-high-school education is required for a higher proportion of industrial chemical technicians than for other chemical technicians. Among non-chemical technicians, the highest proportion with a post-high-school requirement is in the physics, radiation, and nuclear category. (Table V-G, based on table V-2 at the end of the chapter.)

Preferred vs. Required Education

The fact that an employer requires a certain level of education does not necessarily mean that this is what he prefers. A limited supply of technicians may force him to accept technicians with less education than he considers to be desirable. While 62 percent of physical science technicians work for employers who require education beyond high school, 80 percent have employers who prefer applicants to have had such education. (See table V-3, at end of chapter.)

Those employers who require graduation from an educational institution above the high-school level in general appear to be satisfied with what they have.

Table V-H. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS ACCORDING TO EDUCATION EMPLOYERS PREFER, BY EDUCATION EMPLOYERS REQUIRE

Education required	Total	Required and preferred are the same	Education employers prefer, where it differs from what they require: Total where preference	Engineering college graduation	College, general: Graduation	College, general: Less than graduation	Technical institute, graduation	Other
All levels	100.0	73.4	26.6	2.1	3.2	5.2	13.9	2.2
Engineering college								
Graduation	100.0	100.0	-	-	-	-	-	-
Less than graduation	100.0	94.1	5.9	5.9	-	-	-	-
College, general								
Graduation	100.0	97.6	2.4	2.4	-	-	-	-
Less than graduation	100.0	77.2	22.8	0.5	4.6	-	17.7	-
Technical institute or community college								
Graduation	100.0	90.8	9.2	3.7	4.9	0.5	-	0.1
Less than graduation	100.0	46.9	53.1	-	5.4	0.8	34.4	12.5(a)
Other post-high-school	100.0	67.1	32.9	2.6	5.9	15.1	9.0	0.3
High school	100.0	52.3	47.7	0.6	1.5	10.4	29.9	5.3

a. Engineering college; less than graduation.

For 86 percent of their employees they prefer and require the same educational level. The attitude of employers who require some post-high-school study but do not specify graduation is different, particularly in the cases where their requirement is study at a technical institute. In this last category, employers of 53 percent of the technicians prefer a different level from what they require. The predominant preference is for the applicant to be a technical-institute graduate, but a good many mention study (less than graduation) at an engineering school instead of at an institute as their preference. (See table V-H and also table V-4 at the end of the chapter.)

Experience Requirements

Employers of 71 percent of the physical science technicians require that persons appointed to these jobs have some related work experience. The

Table V-I. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS, ACCORDING TO YEARS OF EXPERIENCE EMPLOYERS REQUIRED, BY GRADE

Grade	Total	No experience	Under 2 years	2 and under 3	3 and under 5	5 and over
All grades	100.0	28.6	17.0	16.2	23.5	14.7
Supervisory grades	100.0	2.1	1.3	-	32.6	64.0
Nonsupervisory grades:						
Single grade only	100.0	51.6	9.2	12.0	20.2	7.0
Multi-grade:						
Lowest grades	100.0	23.4	32.5	24.0	13.9	6.2
Middle grades	100.0	2.0	24.8	11.0	40.9	21.3
Highest grades	100.0	10.0	6.9	23.1	27.3	32.7

number of years of required experience is greatest for supervisory grades, and is greater for higher nonsupervisory grades than for lower ones. (Table V-I, taken from table V-5, at the end of the chapter.)

No experience is required for 23 percent of all jobs in the lowest grades of multi-grade systems. In the industrial-chemical group the percent is close to the over-all average, but it is 55 percent in the beverage-food group and 12 percent in the physics-chemical group:

Occupation	All grades	Lowest grades(a)	Single grade only
All occupations	28.6	23.4	51.6
Pharmaceuticals	18.2	33.3	38.2
Fuels	7.7	4.5	15.2
Beverages and other food products	52.3	55.3	62.0
Industrial and other chemicals	36.1	23.8	62.0
Metallurgical and related	27.9	40.5	27.4
Physics-chemical	14.1	12.2	71.6
Physics, radiation, and nuclear	27.9	40.9	35.8
Meteorology	8.1	7.1	28.6
Minerals and soil	24.3	-	82.9
Other (mostly museum)	32.3	(b)	18.9

a. In establishments with multi-grade structures.
b. Not computed because of small number involved.

The general pattern in respect to physical science technicians, as with other technical occupations, is for employers to require less experience from an

Table V-J. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR PHYSICAL SCIENCE TECHNICIANS IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY GRADE

Education required	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Nonsupervisory grades: Multi-grades: Lowest grades	Nonsupervisory grades: Multi-grades: Middle grades	Nonsupervisory grades: Multi-grades: Highest grades
All levels	2.3	5.5	0.0	1.7	3.4	3.8
Post-high-school	1.9	5.2	0.0	1.4	3.1	3.2
High school	2.7	5.8	2.4	1.9	4.4	4.8

applicant if he has had some education beyond high school. The average (median) years of experience required, shown in table V-J, indicate that, over-all, about one more year of experience is required if the applicant did not go beyond high school. In the single-grade system the difference in the medians is 2.4 years.

The difference in the medians for the supervisory grade is relatively small -- about 7 months. Technicians who qualify on the basis of high-school graduation may achieve supervisory status within about six years, on the average. Probably technicians who have post-high-school training could achieve supervisory status in less than six years if they were employed in an occupation requiring high-school graduation initially. But the fact that technicians with a high-school background can achieve supervisory status indicates that job experience is a highly significant factor for promotion to supervisory levels.

That education is not equated with experience uniformly in all categories of physical science technician is evident from the following:

Occupation	All levels	Post-high-school	High school
All occupations	2.3	1.9	2.7
Chemical and related	2.2	1.9	2.6
Metallurgical and related	2.6	2.3	2.9
Physics-chemical	1.8	1.9	1.6
Physics, radiation, and nuclear	1.9	2.3	1.6
Meteorology	3.9	1.6	4.6
Minerals and soil	3.5	0.0	4.2
Other (mostly museum)	3.2	0.0	3.5

These data give an occupation-by-occupation comparison of median years of required experience for jobs for which high-school graduation is required, in contrast with jobs requiring more education. In the chemical and metallurgical categories, where study at a technical institute is very likely to be the educational requirement beyond high school that is specified, a post-high-school requirement on the average reduces the amount of experience required by not much more than half a year, on the average; the implication is that formal education cannot replace practical on-the-job experience entirely.

The data for the physics-chemical and physics-radiation-nuclear technicians show that more experience is required where post-high-school education is specified than where high school is specified. The explanation for this apparently anomalous relationship seems to be found in a wide disparity in the duties and responsibilities of technicians classified within these groups. For example, a physics technician may be required only to perform relatively simple tests involving primarily the measurement of current and voltage. The radiation technician, on the other hand, may, as an example, be required to calibrate survey and radiotherapy instruments, tasks requiring both college-level training and considerable experience. Persons having high-school education do not readily get into jobs requiring college-level education.

A comparison of the education-plus-experience required and the education-plus-experience preferred by employers indicates that, in respect to physical science technicians, the most common preference is for more education and the same experience or, if necessary, less experience. (Table V-K on next page.)

Evidently a substantial segment of employers of college and technical institute graduates are satisfied with the present experience-education requirements if employer failure to express a preference is indicative. Further detail is found in table V-6, at the end of the chapter. That table shows that 80 percent

Table V-K. NUMBER OF PHYSICAL SCIENCE TECHNICIANS ACCORDING TO EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE, BY EDUCATION EMPLOYERS REQUIRE

Kind of preference	All levels	Post-high-school	High school
Total	8,969	5,570	3,399
No preference expressed	5,986	4,313	1,673
All preferences	2,983	1,257	1,726
Required education, more experience	397	313	84
More than required education, less experience	1,121	227	894
More than required education, same experience	1,089	489	600
More than required education, more experience	376	228	148

of the physical science technicians who worked on jobs requiring graduation from a college have employers who expressed no preference for a different experience-education formula. For technicians whose employers specified graduation from a technical institute, the figure is 85 percent.

TESTS AND LICENSES

Few employers reported that they gave intelligence or aptitude tests as a means of determining qualifications of prospective physical science technicians. In some plants, especially in industrial chemicals, tests to ascertain the applicant's visual color sensitivity are given. Freedom from color blindness and ability to distinguish between different hues of the same color are critical in colorimetric analysis.

Government license requirements are found only in the food and beverage group, mainly requirements of the New York State Department of Agriculture and Markets for persons involved in testing milk and cream.

SOURCES OF WORKERS

Method of Obtaining Workers

Recruitment from outside the firm and upgrading are of about equal importance as methods of obtaining workers qualified to perform the functions of physical science technicians.

Table V-L. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS ACCORDING TO METHOD OF OBTAINING THEM, BY OCCUPATION

Occupation	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All occupations	100.0	52.3	2.0	45.7
Chemical and related	100.0	59.4	1.6	39.0
Pharmaceuticals	100.0	55.6	0.3	44.1
Fuels	100.0	55.9	-	44.1
Beverages and other food products	100.0	62.8	-	37.2
Industrial and other chemicals	100.0	59.6	2.1	38.3
Metallurgical and related	100.0	36.7	9.8	53.5
Physics-chemical	100.0	39.8	-	60.2
Physics, radiation, and nuclear	100.0	48.9	0.1	51.0
Meteorology	100.0	62.7	0.5	36.8
Minerals and soil	100.0	34.3	-	65.7
Other	100.0	77.1	-	22.9

Table V-L shows the extent to which the proportions varied among the different physical science occupations. The relatively high proportion who receive organized training in the metallurgical group stands out, in these figures. It largely reflects training programs in some large government installations and in a few metal and machinery manufacturing firms.

At the supervisory level a large majority of physical science technician and specialist jobs are filled by upgrading; organized training is rarely used in upgrading. In the highest and middle grades of multi-grade systems, nearly three-quarters of the jobs are filled by upgrading without organized training. (Table V-M.)

Table V-M. PERCENT DISTRIBUTION OF PHYSICAL SCIENCE TECHNICIANS ACCORDING TO METHOD OF OBTAINING THEM, BY GRADE

Grade	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All grades	100.0	52.3	2.0	45.7
Supervisory grades	100.0	7.7	0.4	91.9
Nonsupervisory grades:				
Single grades only	100.0	67.2	1.4	31.4
Multi-grade:				
Lowest grades	100.0	68.7	2.5	28.8
Middle grades	100.0	22.5	2.5	75.0
Highest grades	100.0	25.7	2.8	71.5

College and Technical Institute Graduates

More than a third of the 8,969 physical science technicians (35.9 percent) are graduates of post-high-school technical institution programs (mostly two-year technical-institute or community-college technical program graduates). About 11 percent are four-year-college graduates. The remaining 53 percent have an education that does not go beyond high school, or took some post-high-school courses but not sufficient for graduation, or are graduates of armed-forces schools.

TABLE V-N. PERCENT OF PHYSICAL SCIENCE TECHNICIANS WHO ARE GRADUATES OF COLLEGES OR TECHNICAL-INSTITUTES

Occupation	College graduates	Technical-institute graduates
All occupations	11.2	35.9
Chemical and related	12.0	38.6
Pharmaceuticals	12.4	12.9
Fuels	2.1	8.0
Beverages and other food products	16.5	42.7
Industrial and other chemicals	12.2	43.0
Metallurgical and related	3.3	47.7
Physics-chemical	4.0	24.4
Physics, radiation, and nuclear	27.5	39.2
Meteorology	26.5	-
Minerals and soil	5.0	42.9
Other	28.1	2.1

PROMOTIONAL LINES

The most common promotional lines involve different grades of the same or related technician jobs in establishments that have multi-grade classifications. Other than these, lower-level jobs from which a significant number of physical science technicians were reported as being promoted (with or without formal training) include tester and inspector.

Chemists and other professional-level science jobs, including engineers in the fields of industrial chemistry and metallurgy and the physics-radiation-nuclear fields, and foremen and supervisors are the principal occupations to which physical science technicians advance up the occupational ladder.

Physical Science Technicians

Table V-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

A. Chemical and Related Technicians

Industry group	All occupations	Chemical and related technicians				
		Total	Pharma-ceuticals	Fuels	Beverages and other food products	Industrial and other chemicals
All industries	8,969	5,162	363	338	478	3,983
Manufacturing	6,756	4,143	347	335	465	2,996
Durable goods	3,471	928	-	36	-	892
Ordnance and accessories	40	4	-	-	-	4
Lumber and wood products, except furniture	1	1	-	-	-	1
Furniture and fixtures	2	2	-	-	-	2
Stone, clay, and glass products	646	85	-	-	-	85
Primary metal industries	414	119	-	36	-	83
Fabricated metal products	109	4	-	-	-	4
Machinery, except electrical	368	116	-	-	-	116
Electrical machinery and equipment	344	210	-	-	-	210
Transportation equipment	236	65	-	-	-	65
Instruments; photographic and optical goods	1,311	322	-	-	-	322
Nondurable goods	3,285	3,215	347	299	465	2,104
Food and kindred products	551	551	-	-	453	98
Tobacco manufactures	-	-	-	-	-	-
Textile mill products	170	115	-	-	-	115
Apparel and other finished fabric products	-	-	-	-	-	-
Paper and allied products	115	115	-	-	-	115
Printing, publishing, and allied industries	16	16	-	-	-	16
Chemicals and allied products	2,067	2,063	347	-	12	1,704
Petroleum refining and related industries	305	305	-	299	-	6
Rubber and miscellaneous plastics products	21	10	-	-	-	10
Leather and leather products	29	29	-	-	-	29
Miscellaneous manufacturing industries	11	11	-	-	-	11
Nonmanufacturing	2,213	1,019	16	3	13	987
Mining	13	6	-	-	-	6
General building contractors	5	5	-	-	-	5

Continued

Table V-1, part A (concluded)

Industry group	All occupations	Chemical and related technicians: Total	Pharma-ceuticals	Fuels	Beverages and other food products	Industrial and other chemicals
Nonmanufacturing (continued)						
Transportation and public utilities	125	96	-	2	-	94
Railroad transportation	7	7	-	-	-	7
Air transportation	29	-	-	-	-	-
Electric, gas, and sanitary services	89	89	-	2	-	87
Wholesale and retail trade	206	153	2	-	7	144
Wholesale trade	197	146	2	-	-	144
Retail trade	9	7	-	-	7	-
Insurance carriers	1	1	-	-	-	1
Services and miscellaneous	1,303	622	7	1	4	610
Business services n.e.c.	506	239	1	1	3	234
Research, development, testing laboratories	456	198	1	1	1	195
Business and management consulting services	41	32	-	-	2	30
Other business services n.e.c.	9	9	-	-	-	9
Motion pictures	3	3	-	-	-	3
Voluntary hospitals	10	-	-	-	-	-
Private colleges and schools	650	330	5	-	1	324
Miscellaneous services	134	50	1	-	-	49
Engineering and architectural services	50	20	1	-	-	19
Nonprofit educational and scientific research	84	30	-	-	-	30
Government	560	136	7	-	2	127
County	18	17	-	-	-	17
Colleges	5	4	-	-	-	4
Other	13	13	-	-	-	13
New York State	88	38	5	-	2	31
Hospitals	1	-	-	-	-	-
Colleges	47	32	-	-	2	30
Other	40	6	5	-	-	1
New York City	170	55	2	-	-	53
Hospitals	3	-	-	-	-	-
Colleges	106	55	2	-	-	53
Other	61	-	-	-	-	-
Cities other than New York City	3	2	-	-	-	2
Federal	281	24	-	-	-	24
Hospitals	4	3	-	-	-	3
Colleges	1	-	-	-	-	-
Arsenals and navy yards	34	17	-	-	-	17
Other	242	4	-	-	-	4

Table V-1 (continued)

B. Physical Science Technicians Other Than Chemical

Industry group	Metallurgical and related	Physics-chemical	Physics, radiation, and nuclear	Meteorology	Minerals and soil	Other
All industries	987	1,638	761	185	140	96
Manufacturing	822	1,549	242	-	-	-
Durable goods	821	1,480	242	-	-	-
Ordnance and accessories	18	18	-	-	-	-
Lumber and wood products, except furniture	-	-	-	-	-	-
Furniture and fixtures	-	-	-	-	-	-
Stone, clay, and glass products	22	512	27	-	-	-
Primary metal industries	290	-	5	-	-	-
Fabricated metal products	100	-	5	-	-	-
Machinery, except electrical	117	107	28	-	-	-
Electrical machinery and equipment	104	1	29	-	-	-
Transportation equipment	146	13	12	-	-	-
Instruments; photographic and optical goods	24	829	136	-	-	-
Nondurable goods	1	69	-	-	-	-
Food and kindred products	-	-	-	-	-	-
Tobacco manufactures	-	-	-	-	-	-
Textile mill products	-	55	-	-	-	-
Apparel and other finished fabric products	-	-	-	-	-	-
Paper and allied products	-	-	-	-	-	-
Printing, publishing, and allied industries	-	-	-	-	-	-
Chemicals and allied products	1	3	-	-	-	-
Petroleum refining and related industries	-	-	-	-	-	-
Rubber and miscellaneous plastics products	-	11	-	-	-	-
Leather and leather products	-	-	-	-	-	-
Miscellaneous manufacturing industries	-	-	-	-	-	-
Nonmanufacturing	165	89	519	185	140	96
Mining	7	-	-	-	-	-
General building contractors	-	-	-	-	-	-

Continued

Table V-1, part B.(concluded)

Industry group	Metallurgical and related	Physics-chemical	Physics, radiation, and nuclear	Meteorology	Minerals and soil	Other
Nonmanufacturing (continued)						
Transportation and public utilities	-	-	-	29	-	-
Railroad transportation	-	-	-	-	-	-
Air transportation	-	-	-	29	-	-
Electric, gas, and sanitary services	-	-	-	-	-	-
Wholesale and retail trade	2	51	-	-	-	-
Wholesale trade	-	51	-	-	-	-
Retail trade	2	-	-	-	-	-
Insurance carriers	-	-	-	-	-	-
Services and miscellaneous	129	11	452	30	34	25
Business services n.e.c.	105	8	139	-	15	-
Research, development, testing laboratories	96	8	139	-	15	-
Business and management consulting services	9	-	-	-	-	-
Other business services n.e.c.	-	-	-	-	-	-
Motion pictures	-	-	-	-	-	-
Voluntary hospitals	-	-	10	-	-	-
Private colleges and schools	14	-	251	25	5	25
Miscellaneous services	10	3	52	5	14	-
Engineering and architectural services	10	3	3	-	14	-
Nonprofit educational and scientific research	-	-	49	5	-	-
Government	27	27	67	126	106	71
County	-	-	1	-	-	-
Colleges	-	-	1	-	-	-
Other	-	-	-	-	-	-
New York State	-	23	16	-	5	6
Hospitals	-	-	1	-	-	-
Colleges	-	-	14	-	-	1
Other	-	23	1	-	5	5
New York City	-	2	48	-	2	63
Hospitals	-	-	3	-	-	-
Colleges	-	-	45	-	2	4
Other	-	2	-	-	-	59
Cities other than New York City	-	1	-	-	-	-
Federal	27	1	2	126	99	2
Hospitals	-	-	-	-	-	1
Colleges	-	-	-	-	-	1
Arsenals and navy yards	15	-	2	-	-	-
Other	12	1	-	126	99	-

Physical Science Technicians

Table V-2. EDUCATION EMPLOYERS REQUIRE BY OCCUPATION
(Percent distribution of technicians according to level of education required)

Education required	All occupation	Chemical and related technicians: Pharmaceuticals	Fuels	Beverages and other food products	Industrial and other chemicals
All levels: Number	8,969	363	338	478	3,983
Percent distribution					
All levels: Percent	100.0	100.0	100.0	100.0	100.0
Post-high-school	62.1	50.7	32.5	59.0	67.7
Engineering college	1.5	-	-	-	2.1
Graduation	0.3	-	-	-	0.7
Less than graduation	1.2	-	-	-	1.4
College, general	16.2	25.9	5.3	10.3	20.2
Graduation	7.8	5.5	-	4.0	8.2
Less than graduation	8.4	20.4	5.3	6.3	12.0
Technical institute or community college	37.4	24.8	16.8	30.1	39.8
Graduation	36.0	24.0	16.8	30.1	37.9
Less than graduation	1.4	0.8	-	-	1.9
Type not specified	7.0	-	10.4	18.6	5.6
Apprenticeship or armed forces school	(a)	-	-	-	-
High school	37.9	49.3	67.5	41.0	32.3
Technical or vocational	3.5	-	-	6.5	4.8
Other and not specified	34.4	49.3	67.5	34.5	27.5

Education required	Other physical science technicians: Metallurgical and related	Physics-chemical	Physics, radiation, and nuclear	Meteorology	Minerals and soil	Other
All levels: Number	987	1,638	761	185	140	96
Percent distribution						
All levels: Percent	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	57.5	61.1	78.6	31.9	29.3	32.3
Engineering college	2.2	0.8	1.2	-	4.3	-
Graduation	0.1	-	0.1	-	-	-
Less than graduation	2.1	0.8	1.1	-	4.3	-
College, general	12.4	1.8	31.7	31.9	3.6	30.2
Graduation	2.2	1.0	27.9	29.2	2.9	30.2
Less than graduation	10.2	0.8	3.8	2.7	0.7	-
Technical institute or community college	40.2	46.1	40.5	-	15.7	2.1
Graduation	37.1	45.9	39.4	-	11.4	2.1
Less than graduation	3.1	0.2	1.1	-	4.3	-
Type not specified	2.7	12.4	5.1	-	5.7	-
Apprenticeship or armed forces school	-	-	0.1	-	-	-
High school	42.5	38.9	21.4	68.1	70.7	67.7
Technical or vocational	6.9	0.3	2.0	-	-	-
Other and not specified	35.6	38.6	19.4	68.1	70.7	67.7

a. Less than 0.05 of a percent.

Physical Science Technicians

Table V-3. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of technicians according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	8,969	8,969	100.0	100.0
Post-high-school	5,570	7,149	62.1	79.7
Engineering college	132	328	1.5	3.7
Graduation	30	214	0.3	2.4
Less than graduation	102	114	1.2	1.3
College, general	1,450	2,016	16.2	22.5
Graduation	704	974	7.8	10.9
Less than graduation	746	1,042	8.4	11.6
Technical institute or community college	3,363	4,281	37.4	47.7
Graduation	3,235	4,184	36.0	46.6
Less than graduation	128	97	1.4	1.1
Type not specified	624	523	7.0	5.8
Apprenticeship or armed forces school	1	1	(a)	(a)
High school	3,399	1,820	37.9	20.3
Technical or vocational	310	171	3.5	1.9
Other and not specified	3,089	1,649	34.4	18.4

a. Less than 0.05 of a percent.

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Table V-4. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Percent distribution of technicians according to level of education preferred)

Education required	Total	Required and preferred are the same	Education employers prefer, where it differs from what they require: Total where preference	Post-high-school: Post-high-school, total	Engineering college: Graduation	Engineering college: Less than graduation	College, general: Graduation	College, general: Less than graduation	Technical institute: Graduation	Technical institute: Less than graduation	Type not specified	High school: High school, total	High school: Technical or vocational	Other and not specified
All levels	100.0	73.4	26.6	26.1	2.1	0.2	3.2	5.2	13.9	0.4	1.1	0.5	0.5	(a)
Post-high-school	100.0	86.3	13.7	13.7	2.9	0.3	4.3	2.0	4.2	-	(a)	(a)	-	(a)
Engineering college	100.0	95.5	4.5	4.5	4.5	-	-	-	-	-	-	-	-	-
Graduation	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	94.1	5.9	5.9	5.9	-	-	-	-	-	-	-	-	-
College, general	100.0	87.1	12.9	12.9	1.5	-	2.3	-	9.1	-	-	-	-	-
Graduation	100.0	97.6	2.4	2.4	2.4	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	77.2	22.8	22.8	0.5	-	4.6	-	17.7	-	-	-	-	-
Technical institute or community college	100.0	89.2	10.8	10.8	3.6	0.5	4.9	0.5	1.3	-	(a)	-	-	-
Graduation	100.0	90.8	9.2	9.2	3.7	0.1	4.9	0.5	-	-	(a)	-	-	-
Less than graduation	100.0	46.9	53.1	53.1	-	12.5	5.4	0.8	34.4	-	-	-	-	-
Type not specified	100.0	67.1	32.9	32.6	2.6	-	5.9	15.1	9.0	-	-	0.3	-	0.3
Apprenticeship or armed forces school	100.0	(b)	-	-	-	-	-	-	-	-	-	-	-	-
High school	100.0	52.3	47.7	46.5	0.6	-	1.5	10.4	29.9	1.1	3.0	1.2	1.2	-
Technical or vocational	100.0	41.9	58.1	58.1	-	-	1.9	7.7	47.8	-	0.7	-	-	-
Other and not specified	100.0	53.3	46.7	45.4	0.6	-	1.5	10.7	28.1	1.2	3.3	1.3	1.3	-

a. Less than 0.05 of a percent.
b. Not computed because of small number involved.

Physical Science Technicians

Table V-5. YEARS OF EXPERIENCE EMPLOYERS REQUIRE, BY GRADE

(Percent distribution of technicians according to years of experience required)

Grade	Total	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 4	4 and under 5	5 and under 7	7 and under 10	10 and over
					All occupations					
All grades	100.0	28.6	6.1	10.9	16.2	15.2	8.3	10.1	3.4	1.2
Supervisory grades	100.0	2.1	-	1.3	-	12.9	19.7	52.0	3.0	9.0
Nonsupervisory grades:										
Single grade only	100.0	51.6	3.6	5.6	12.0	12.1	8.1	4.4	1.9	0.7
Multi-grade:										
Lowest grades	100.0	23.4	14.5	18.0	24.0	10.4	3.5	6.2	(a)	-
Middle grades	100.0	2.0	6.3	18.5	11.0	33.1	7.8	14.2	7.1	-
Highest grades	100.0	10.0	-	6.9	23.1	12.3	15.0	19.8	8.6	4.3
					Pharmaceuticals					
All grades	100.0	18.2	2.8	3.6	26.7	24.2	0.8	21.2	1.7	0.8
Supervisory grades	-	-	-	-	-	-	-	-	-	-
Nonsupervisory grades:										
Single grade only	100.0	38.2	3.6	2.7	19.1	25.5	-	10.9	-	-
Multi-grade:										
Lowest grades	100.0	33.3	8.3	-	5.6	48.6	4.2	-	-	-
Middle grades	100.0	-	-	34.5	-	65.5	-	-	-	-
Highest grades	100.0	-	-	-	47.4	3.9	-	42.8	3.9	2.0
					Fuels					
All grades	100.0	7.7	-	8.6	5.9	43.4	23.4	2.1	8.6	0.3
Supervisory grades	100.0	-	-	-	-	-	58.8	41.2	-	-
Nonsupervisory grades:										
Single grade only	100.0	15.2	-	19.6	-	-	-	-	63.0	2.2
Multi-grade:										
Lowest grades	100.0	4.5	-	12.3	-	83.2	-	-	-	-
Middle grades	100.0	-	-	-	-	-	100.0	-	-	-
Highest grades	100.0	23.5	-	2.0	39.2	35.3	-	-	-	-
					Beverages and other food products					
All grades	100.0	52.3	-	2.1	33.9	2.1	1.5	7.7	-	0.4
Supervisory grades	-	-	-	-	-	-	-	-	-	-
Nonsupervisory grades:										
Single grades only	100.0	62.0	-	3.8	23.3	-	-	10.5	-	0.4
Multi-grade:										
Lowest grades	100.0	55.3	-	-	33.9	8.3	2.5	-	-	-
Middle	100.0	-	-	-	100.0	-	-	-	-	-
Highest grades	100.0	39.1	-	-	30.4	-	8.7	19.6	-	2.2

Continued

Table V-5 (continued)

Grade	Total	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 4	4 and under 5	5 and under 7	7 and under 10	10 and over
				Industrial and other chemicals						
All grades	100.0	36.1	2.9	9.3	19.0	14.8	6.6	8.3	1.3	1.7
Supervisory grades	100.0	5.5	-	2.7	-	17.8	9.6	54.8	1.4	8.2
Nonsupervisory grades:										
Single grade only	100.0	62.0	3.1	5.4	10.6	9.1	5.5	3.1	0.4	0.8
Multi-grade:										
Lowest grades	100.0	23.8	2.0	14.4	47.4	4.5	5.6	2.3	-	-
Middle grades	100.0	0.3	6.9	15.9	2.2	48.5	5.3	20.9	-	-
Highest grades	100.0	13.0	-	8.1	20.5	15.1	12.4	15.4	7.4	8.1
				Metallurgical and related						
All grades	100.0	27.9	1.8	10.0	16.9	12.3	13.1	10.6	6.7	0.7
Supervisory grades	100.0	4.0	-	-	-	8.0	32.0	48.0	4.0	4.0
Nonsupervisory grades:										
Single grade only	100.0	27.4	0.3	6.4	18.9	15.1	15.9	9.2	5.9	0.9
Multi-grade:										
Lowest grades	100.0	40.5	5.4	24.3	16.9	0.7	10.8	0.7	0.7	-
Middle grades	100.0	22.1	7.1	14.2	23.0	15.9	0.9	4.4	12.4	-
Highest grades	100.0	24.4	-	8.1	5.7	10.6	9.8	27.6	13.0	0.8
				Physics - chemical						
All grades	100.0	14.1	19.8	20.7	5.3	11.0	5.1	15.1	8.4	0.5
Supervisory grades	100.0	-	-	-	-	29.0	29.0	19.4	16.1	6.5
Nonsupervisory grades:										
Single grade only	100.0	71.6	-	4.7	3.8	5.7	11.8	2.4	-	-
Multi-grade:										
Lowest grades	100.0	12.2	42.5	24.8	-	2.0	0.8	17.7	-	-
Middle grades	100.0	-	9.0	26.5	4.4	23.9	1.2	16.7	18.3	-
Highest grades	100.0	-	-	14.1	23.6	11.2	16.2	15.4	17.0	2.5
				Physics, radiation, and nuclear						
All grades	100.0	27.9	10.9	11.6	14.6	15.0	10.6	6.3	1.3	1.8
Supervisory grades	100.0	-	-	4.3	-	26.1	4.3	13.0	-	52.3
Nonsupervisory grades:										
Single grade only	100.0	35.8	15.9	2.7	5.7	19.8	18.0	1.6	-	0.5
Multi-grade:										
Lowest grades	100.0	40.9	9.8	40.2	9.1	-	-	-	-	-
Middle grades	100.0	-	-	26.2	64.3	8.3	-	1.2	-	-
Highest grades	100.0	-	-	-	24.4	17.1	1.2	45.1	12.2	-

Continued

Table V-5 (concluded)

Grade	Total	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 4	4 and under 5	5 and under 7	7 and under 10	10 and over
				Meteorology						
All grades	100.0	8.1	-	13.5	13.5	17.3	22.2	25.4	-	-
Supervisory grades	100.0	-	-	-	-	-	19.0	81.0	-	-
Nonsupervisory grades:										
Single grade only	100.0	28.6	-	51.0	20.4	-	-	-	-	-
Multi-grade:										
Lowest grades	100.0	7.1	-	-	92.9	-	-	-	-	-
Middle grades	100.0	-	-	-	6.3	93.7	-	-	-	-
Highest grades	100.0	-	-	-	-	6.3	93.7	-	-	-
				Minerals and soil						
All grades	100.0	24.3	-	1.4	17.1	13.6	39.3	4.3	-	-
Supervisory grades	100.0	-	-	-	-	-	-	(b)	-	-
Nonsupervisory grades:										
Single grade only	100.0	82.9	-	-	17.1	-	-	-	-	-
Multi-grade:										
Lowest grades	100.0	-	-	-	69.2	30.8	-	-	-	-
Middle grades	100.0	-	-	7.4	3.7	55.6	33.3	-	-	-
Highest grades	100.0	-	-	-	13.2	-	86.8	-	-	-
				Other						
All grades	100.0	32.3	-	2.1	1.0	61.5	2.1	-	1.0	-
Supervisory grades	-	-	-	-	-	-	-	-	-	-
Nonsupervisory grades:										
Single grade only	100.0	18.9	-	-	1.4	79.7	-	-	-	-
Multi-grade:										
Lowest grades	100.0	100.0	-	-	-	-	-	-	-	-
Middle grades	100.0	(b)	-	-	-	-	-	-	-	-
Highest grades	100.0	-	-	(b)	-	-	(b)	-	(b)	-

a. Less than 0.05 of a percent.
b. Not computed because of small number involved.

Physical Science Technicians

Table V-6. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number and percent distribution of technicians according to preference)

Education required	Total	No preference expressed	All preferences	Preference where one was expressed: Required education, more experience	More than required education: Less experience	More than required education: Same experience	More than required education: More experience
Number							
All levels	8,969	5,986	2,983	397	1,121	1,089	376
Post-high-school	5,570	4,313	1,257	313	227	489	228
Engineering college	132	99	33	-	5	1	27
Graduation	30	5	25	-	-	-	25
Less than graduation	102	94	8	-	5	1	2
College, general	1,450	1,105	345	11	29	155	150
Graduation	704	564	140	8	1	14	117
Less than graduation	746	541	205	3	28	141	33
Technical institute or community college	3,363	2,783	580	215	98	220	47
Graduation	3,235	2,741	494	196	95	185	18
Less than graduation	128	42	86	19	3	35	29
Type not specified	624	325	299	87	95	113	4
Apprenticeship or armed forces school	1	1	-	-	-	-	-
High school	3,399	1,673	1,726	84	894	600	148
Technical or vocational	310	81	229	49	44	93	43
Other and not specified	3,089	1,592	1,497	35	850	507	105
Percent distribution							
All levels	100.0	66.7	33.3	4.4	12.5	12.2	4.2
Post-high-school	100.0	77.4	22.6	5.6	4.1	8.8	4.1
Engineering college	100.0	75.0	25.0	-	3.8	0.8	20.4
Graduation	100.0	16.7	83.3	-	-	-	83.3
Less than graduation	100.0	92.2	7.8	-	4.9	1.0	1.9
College, general	100.0	76.2	23.8	0.8	2.0	10.7	10.3
Graduation	100.0	80.1	19.9	1.1	0.2	2.0	16.6
Less than graduation	100.0	72.5	27.5	0.4	3.8	18.9	4.4
Technical institute or community college	100.0	82.8	17.2	6.4	2.9	6.5	1.4
Graduation	100.0	84.7	15.3	6.1	2.9	5.7	0.6
Less than graduation	100.0	32.8	67.2	14.8	2.4	27.3	22.7
Type not specified	100.0	52.1	47.9	13.9	15.2	18.1	0.7
Apprenticeship or armed forces school	100.0	(a)	-	-	-	-	-
High school	100.0	49.2	50.8	2.5	26.3	17.7	4.3
Technical or vocational	100.0	26.1	73.9	15.8	14.2	30.0	13.9
Other and not specified	100.0	51.6	48.4	1.1	27.5	16.4	3.4

a. Not computed because of small number involved.

Chapter VI

BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS

This chapter is concerned with persons engaged in biological, medical, dental, and related work who support medical or other scientists by performing tests or assisting with treatment. About 17 percent of all technical workers in the survey are in this group -- which is outranked only by the electro and mechanical engineering group.

The survey covered all types of technical occupations in the biological, medical, and dental fields, ranging from operating room technician, central supply technican, and dental assistant, which require comparatively little technical training, to jobs such as medical record librarian and physical therapist, which are generally considered to be above the technician level. It also includes dental mechanics, who are sometimes classified as craftsmen. Registered and practical nurses and medical photographers were excluded from the survey.

The largest group among the 25,445 technical workers covered by this chapter are those employed in biological and medical laboratory occupations. As table VI-A shows, there are 9,898 of them -- 38.8 percent of the over-all figure. Other important technical occupations covered by this chapter are X-ray technician, dental hygienist, general medical assistant in a doctor's office, electrocardiograph technician, and electroencephalograph technician.

Some of the 9,898 technical workers who are employed in biological and medical laboratories are technologists, who typically have had four years of college training and received a bachelor's degree or else have had three years of college and one or more years at a hospital school of medical technology.

Table VI-A. NUMBER AND PERCENT DISTRIBUTION OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS, BY OCCUPATION

Occupation	Number	Percent
All occupations	25,445	100.0
Agricultural and related	340	1.3
Biological and medical laboratory	9,898	38.8
Bacteriology (microbiology)	727	2.9
Biochemistry	837	3.3
Tissue (histology)	428	1.7
Cytology	122	0.5
Hematology	617	2.4
Blood bank	380	1.5
Serology	106	0.4
General and other	6,681	26.1
General medical assistants, doctor's office	1,114	4.4
X-ray and related equipment technicians	3,013	11.8
Other medical technicians	1,801	7.1
Electrocardiograph	548	2.2
Electroencephalograph	159	0.6
Inhalation therapy	153	0.6
Other	941	3.7
Therapists	1,883	7.4
Physical	1,003	3.9
Occupational, recreational, and other	880	3.5
Medical record librarians	347	1.4
Dental laboratory technicians	2,844	11.2
Dental hygienists	1,874	7.4
Dental assistants	2,331	9.2

Others are technicians, some with one to two years of training in a four-year college, a community college, a hospital school, or a commercial school of medical technology, and some with a high-school education. (Also see page 247.)

Of the nearly 10,000 persons in biological and medical laboratory technical work, two-thirds are here classified as "general and other." The remaining third are classified in specialized categories such as blood bank,1/ bacteriology, and cytology. (See table VI-A.)

1. Because of the characteristics of the sample, it is probable that the figures for this category are understated.

Large institutions often hire biological and medical laboratory technicians and technologists for a particular specialty field. In some cases they are employed in more than one specialty field, among which they rotate. Workers who rotate were classified in the field in which they were working at the time of the survey, if it was known. In smaller establishments, technicians and technologists often are general workers who are called on to work in any field, as the need arises.

Some establishments, including some of the large ones, assign workers who have little experience to general duties, to do the more routine procedures. After they gain experience they are advanced to work in a special field.

The "general and other" category of biological and medical laboratory workers includes (1) all-round general workers, who account for most of the employees in the category; (2) those who are employed in a specialty field but for whom no details on type of specialization were reported; (3) those who work in two or more specialties without rotation; and (4) supervisory personnel in large institutions -- typically chief technologists -- who are in charge of two or more specialty branches.

The largest number of technical jobs in this chapter -- about 41 percent -- are in voluntary, proprietary, and government hospitals.1/ An additional 43 percent are employed in various other medical and health services, primarily in offices of physicians, surgeons, and dentists, and in medical and dental laboratories. About 10 percent are employed by schools and colleges; some of these are engaged in research; some are technical assistants to instructors of laboratory subjects; and some, employed by medical schools, are engaged in clinical work in the hospital connected with the school. The remaining 6 percent

1. Voluntary hospitals are operated by nonprofit associations and church groups; proprietary hospitals are operated for profit.

Table VI-B. NUMBER AND PERCENT DISTRIBUTION OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS, BY INDUSTRY GROUP

Industry group	Number	Percent
All industries	25,445	100.0
Manufacturing	488	1.9
Chemicals and allied products	335	1.3
Other manufacturing	153	0.6
Nonmanufacturing	24,957	98.1
Nongovernment	19,568	76
Private medical services	16,454	64.7
Offices of physicians and surgeons	2,173	8.5
Offices of dentists and dental surgeons	3,284	12.9
Hospitals	7,363	29.0
Medical and dental laboratories	3,143	12.4
Other medical and health services	491	1.9
Private colleges and schools	2,199	8.6
Nonprofit educational and scientific research	378	1.5
Other nongovernment	537	2.1
Government	5,389	21.2
Hospitals	3,083	12.1
Colleges and schools	435	1.7
Other government (a)	1,871	7.4

a. Primarily medical and dental laboratories (clinical and research) and medical and dental clinics.

work for nonprofit educational and research organizations, in chemical and other manufacturing plants, in other nongovernment establishments, or in medical units operated by business establishments to provide health care for their employees. (See table VI-B, which is based on table VI-1 at the end of the chapter.)

Of all technical workers in the biological, medical, and dental fields, 79 percent are employed by private industry and 21 percent by government. Of those employed in hospitals, 65 percent work for voluntary hospitals, 5 percent for proprietary hospitals, and 30 percent for hospitals operated by the Federal government, the State, or by counties, cities, towns, or villages.

Traditionally, women have filled the occupations treated in this chapter, except for the jobs of dental technician and agricultural technician. Some

Table VI-C. PERCENT DISTRIBUTION OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS, BY OCCUPATION OF SUPERVISOR

Occupation group	Total	Occupation of supervisor		
		Scientist	Technician (a)	Other
All occupations	100.0	24.5	38.0	37.5
Agricultural and related	100.0	43.8	36.2	20.0
Biological and medical laboratory	100.0	48.1	43.9	8.0
General medical assistants, doctor's office	100.0	-	-	100.0
X-ray and related equipment technicians	100.0	38.3	56.0	5.7
Other medical technicians	100.0	8.6	19.7	71.7
Therapists	100.0	-	39.1	60.9
Medical record librarians	100.0	0.3	27.1	72.6
Dental laboratory technicians	100.0	0.1	61.2	38.7
Dental hygienists	100.0	0.1	0.1	99.8
Dental assistants	100.0	-	24.8	75.2

a. Biological, medical, dental, or related technician, technologist, or specialist, or other technician.

of these jobs, such as medical assistant in a doctor's office and dental hygienist, are almost entirely woman-employing. In recent years a certain number of men have been going into a number of jobs such as therapist and medical laboratory technician or technologist, but these still employ women primarily. Probably the largest influx of men has been into the X-ray field.

About 14,600 or 80 percent of the 18,300 women in technical occupations in New York State are in the biological-medical-dental field; 57 percent of all workers in that field are women.

Many of the male workers entering these traditionally woman-employing occupations are members of minority groups.

As table VI-C shows, almost two technicians, technologists, and specialists out of every five in the whole group work under the immediate supervision of other technical workers; 25 percent work directly under laboratory or research scientists, (pathologists, radiologists, chemists, etc.); 38 percent have "other" types of supervision. For the purpose of the survey, practitioners who are primarily engaged in clinical work directly with patients are classified as "other." Cardiologists, who supervise electrocardiograph technicians, neurosurgeons and neurologists, who supervise electroencephalograph technicians, and medical specialists in physical medicine, who are responsible for the supervision of therapists, are in the "other" group. Institution administrators, who customarily supervise medical record librarians, also are in the "other" category, as are managerial personnel responsible for the supervision of technicians, technologists, and specialists.

In some of the larger establishments, medical technicians and technologists frequently are supervised directly by unit chiefs or by chief technologists, who in turn are responsible to pathologists or other scientists; and X-ray technicians are supervised by chief X-ray technicians under the direction of radiologists. In smaller establishments the technicians may be under the immediate supervision of the scientist.

FUNCTIONS

Biological and Medical Laboratory Technicians and Technologists

This group consists primarily of medical technicians and technologists who perform the wide variety of laboratory tests and procedures that are used in the detection, diagnosis, and treatment of diseases, and in medical research. It also includes a small number of biological technicians who assist college teachers of laboratory classes or who perform biological laboratory tests. The functions described below relate to medical laboratory technicians and technologists.1/

The study presents a separate description of the functions and characteristics of the technical occupation in each of the main specialties in the

1. Laboratory aides or helpers who assist in the laboratory by performing routine functions such as washing and sterilizing glassware and equipment, preparing solution and culture media, caring for laboratory animals, and other relatively simple operations were not included.

clinical laboratory, namely bacteriology (microbiology), biochemistry, histology (tissue), cytology, hematology, blood bank, and serology.

The bacteriology specialty often involves work in parasitology, mycology, virology, and/or epidemiology. In the survey all of these groups were classified under bacteriology.

Essentially the same basic training, technical skills, and special aptitudes are required for all branches of the clinical laboratory group, with the possible exception of histology and cytology. Also, much of the equipment, and many of the methods, techniques, and materials employed are similar for several of the specialty groups.

Manual dexterity and eye-hand coordination, for handling precision instruments and other equipment and for working with minute amounts of material, are important qualities in clinical laboratory technicians. Visual acuity and good color discrimination are also desirable. (Color discrimination is becoming less important since the trend in laboratories now is to make colorimetric determinations with photoelectric equipment rather than by visual comparisons.)

Because these technicians and technologists frequently work directly with patients who may be ill or under stress and because errors may have serious consequences certain personality and temperament traits are important: these people should be able to work under pressure, and should have work habits that are precise in every procedure; they should have a sense of responsibility to the patient and an interest in working with people. For technicians and technologists engaged in research an interest in science and resourcefulness are essential.

The basic equipment for the group as a whole includes such precision instruments as microscopes, centrifuges, electronic counters, photoelectric colorimetric apparatus, automatic analyzers, autoclaves, balances, microtomes, etc.;

and laboratory glassware such as test tubes, slides, pipettes, burettes, etc.

Bacteriology Technicians and Technologists. These technicians and technologists cultivate, isolate, and help identify bacteria and other microorganisms in body fluids, exudates, skin scrapings, autopsy and surgical specimens, and other materials. They also determine the efficacy of antibiotics against various bacteria.

As part of their functions bacteriology technicians and technologists:

Receive patient specimens such as blood, body fluids, tissue, excretions, etc., or collect directly swabs and smears from patients. May take blood directly from patient by venipuncture.

Perform routine clerical duties necessary for proper labeling of specimens and recording of essential data.

Set up apparatus and equipment required for various procedures.

Prepare cultures from specimens, selecting appropriate media and following standard procedures.

Identify bacteria in cultures by microscopic examination and by determination of culture requirements and reaction to media.

Identify pathological organisms by microscopic examinations of standard smears.

Prepare various culture media, stains, and reagents in accordance with standard formulas.

Perform antibiotic sensitivity tests to determine the sensitivity of bacteria to antibiotic substances.

Make agglutination, precipitation, and other special tests such as antistreptolysin, heterophile, etc.

May inoculate animals with materials derived from patients either directly or from cultures to observe and identify disease produced in animals. Verify and identify bacteria in animal autopsies.

Keep records and make reports on findings.

Clean and sterilize equipment.

May be responsible for maintaining and ordering supplies.

May perform cultures at regular intervals on baby formulas.

May cultivate and identify fungi, Rickettsiae, protozoa, and viruses.

At higher levels may verify findings of lower-level technicians that indicate bacteria of less common types.

The technical skills desired of this specialty group include:

Skill in methods and procedures of collecting smears and other body specimens; in preparing cultures; and in typing, grouping, and identifying microorganisms.

Technical proficiency in the use of the microscope and, in research, the electron microscope and the fluorescence microscope.

Proficiency in the use of other instrumentation and equipment of the bacteriology laboratory, such as -

Centrifuge, incubator, evaporator, pH meter, agitator, bacteria colony counter, balance, spectrophotometer, autoclave, sterilizer, water bath, isolator, etc.

Slides, culture dishes, pipettes, inoculating loops, anaerobic jars, slide holders, bacteriological filters, etc.

Biochemistry Technicians and Technologists. These technicians and technologists perform chemical analyses and tests of body fluids, exudates, and other materials to assist in the diagnosis and treatment of diseases. The large majority of tests are concerned with the analysis of blood and urine, but other materials such as spinal fluid, feces, and gastric contents also are analyzed. The analytic methods employed in clinical chemistry, traditionally, are divided into four basic groups: gravimetric, volumetric (titrimetric), gasometric (volumetric and manometric), and colorimetric (visual and photoelectric).

More recently, new methods have been introduced for the most part associated with the development of automated or electronic equipment. These include: flame photometry, fluorimetric, electrophoretic, potentiometric, and chromatographic.

A profound effect on methods and procedures in clinical chemistry has resulted from the introduction of the automatic analyzer -- an apparatus that can, for a large number of routine clinical chemistry tests, handle the complete processing (sampling, preparation, analysis, and reporting). The apparatus can be set up to perform repeated analyses of a single test on a number of samples, or to handle a number of different tests in rotation. Attachments have been developed to increase the number of types of tests that can be performed and to increase the conversions that may be made to readouts.

The essential functions performed by biochemistry technicians and technologists are the following:

Receive patient specimens taken by other hospital personnel or collect specimens directly from patients. Take blood from patient by venipuncture.

Perform routine clerical duties necessary for proper labeling of specimen and recording of essential data.

Set up apparatus, instruments, and equipment required in performing various tests and procedures.

Monitor instrumentation used; make minor repairs if necessary.

Prepare reagents and other materials needed.

Perform tests (complete analysis, in accordance with prescribed procedures). This may include any of the following steps:

Preparing specimens by adding specified quantities of appropriate reagents or solutions, then heating, filtering, or centrifuging in accordance with prescribed procedures.

Noting appearance, change of color, or resulting precipitate, or examining results by means of microscope, blood gas apparatus, colorimetric instruments, and other apparatus.

Titrating specimens against standard reagents to make quantitative determinations. May use titration machine.

Where titration machines are used in making determinations, calculating results by using appropriate standards or graphs.

Recording results and preparing reports on tests.

In institutions with automatic analyzers technicians and technologists prepare biological fluid by centrifuging; subject prepared specimen to analysis by automatic analyzer; and calculate results by using appropriate standards and graphs.

Technical skills necessary for the biochemistry group are:

Skill in drawing blood by venipuncture.

Proficiency in the use of instrumentation and equipment of the biochemistry laboratory, such as -

Automatic analyzer, balances (analytical, metric, trip), blood gas apparatus (manometric, volumetric), centrifuge, colorimetric instruments (colorimeter, flame photometer), electrophoresis apparatus, microscope, pH apparatus, potentiometer, protein-bound iodine apparatus, respirometer, titrator, automatic titrator, water bath, automatic pipetting machine, etc.

Test tubes, pipettes, burettes, filters, flasks, beakers, graduates, etc.

Histology Technicians. These technicians prepare human and animal tissue specimens for microscopic examinations in thin section for use in diagnosing pathological conditions and changes arising from such conditions. They may also process autopsy specimens.

As part of their functions they:

Receive tissue specimens and perform routine clinical duties necessary for proper labeling of specimen and recording of essential data.

Set up apparatus, instruments, and equipment required for various procedures.

Perform necessary steps involved in routine preparation of specimens; including dehydration, fixing, and infiltrating. If an autotechnicon (automatic tissue processing apparatus) is used, the machine automatically dehydrates, fixes, and infiltrates with paraffin or other materials.

Decalcify bones.

Cut thin sections of specimen using microtome; stain sections; mount on slides. Label and record each slide.

May prepare specimens by frozen section method, using special microtome and carbon dioxide or other quick freeze system such as Freon.

May prepare ophthalmological and bone specimens by celloiden or other special methods.

May process bone marrow.

Prepare necessary solutions and stains in accordance with standard procedures. Change solutions in autotechnicon.

Sharpen microtome knives; maintain laboratory equipment and instruments; make minor repairs; file slides and autopsy blocks in cabinets, etc.

In the absence of the cytotechnologist, histology technicians process Papanicolaou smears.

Keep records and make reports of findings.

Technical skills required include:

Proficiency in the use of instrumentation and equipment of the histology laboratory, such as:

Autotechnicon (automatic tissue processing apparatus), frozen section machine, microscope, dark-field condenser for microscope, microscope camera, microtomes (rotary, sliding, freezing), microtome knife sharpener, water bath, polarizing screens, etc.

Slides, cover glasses, bottles, molds, embedding rings, embedding boxes, embedding blocks, etc.

Skill in sharpening microtome knives.

Cytology Technicians and Cytotechnologists. These technicians and technologists do the preparation and microscopic examination of body cell smears for detection of cancer.

Cytology, one of the newer specialties in medical technology, was originally concerned with cell diagnosis for uterine cancer, and a large proportion of work in cytology is of this type, using the Papanicolaou method of cancer cell detection. More recently the laboratory techniques of cytotechnology have been applied to the detection of cancer in other areas of the body, including the respiratory tract, the urinary tract, the digestive system, and other body cavities.

The essential functions of these technicians and technologists include:

Setting up apparatus and equipment required for various procedures.

Preparing necessary stains and solutions.

Receiving smears (some may be mailed from doctors' offices) and performing routine clerical work necessary for proper labeling of specimen and recording of essential data.

Preparing smears in accordance with standard procedures; centrifuging fluid specimens.

Preparing slides for microscopic examination from smears by fixing, dehydrating, staining, counterstaining, and coverslipping.

Preparing filter discs from fluids, using Millipore apparatus; mounting filter discs on slides for staining and coverslipping.

Making microscopic examination of slides for the presence of abnormal cells.

Marking areas in which abnormal cells are detected for evaluation by professional persons.

Maintaining equipment and instruments.

Making out preliminary report forms. If findings of abnormality are positive, checking files for previous slides and records for comparisons.

Filing slides in permanent record file.

The technical skills needed include:

Proficiency in the use of instrumentation and equipment of the cytology specialty, such as -

Centrifuge, microscope, Millipore filtration apparatus, cytoviewer, cytoanalyzer.

Slides, cover glasses, jars, and other assorted glassware.

Hematology Technicians and Technologists. They examine the cellular constituents of the blood, their number and concentration, the relative distribution of various types of cells, the presence of abnormal cells, and specified qualitative features for use in the diagnosis and treatment of disease.

Among the functions performed by these workers are the following:

Receiving patient specimens or collecting venous or capillary blood directly from patient by venipuncture or fingerstick method.

Performing routine clerical duties necessary for proper labeling of specimen and recording of essential data.

Setting up apparatus, instruments, and equipment required for various tests and procedures.

Preparing solutions, reagents, and other materials as required.

Preparing specimens for examination following standard procedures. This includes preparation and staining of slides and other preliminary work.

Performing all steps of a variety of blood tests and morphological studies in accordance with standard procedures. These may include the following:

Complete blood counts, erythrocyte counts, leukocyte counts, leukocyte differentials, platelet counts, hemoglobin estimations, sedimentation rate, coagulation time, bleeding time, prothrombin time, clot retraction time, reticulocyte counts, eosin counts, sickle cell preparations, lupus erythematosus preparations, fragility tests.

Calculating various indices, such as:

Color index, volume index, hematocrits, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, mean corpuscular volume.

Making cerebrospinal fluid cell counts.

Preparing smears from pleural fluids, abdominal fluids.

Preparing and examining blood film slides for malarial and other parasites.

May examine slides of bone marrow specimens.

Keeping records and making reports on findings.

Cleaning, sterilizing, and maintaining equipment.

Requisitioning supplies.

In some institutions the hematology specialty rotates with serology and/or blood bank; in others the functions are combined.

The technical skills associated with these jobs include:

Proficiency in the use of instrumentation and equipment of the hematology specialty, such as:

Microscope, autocytometer, blood cell calculator, hemacytometer, and other counting chambers, hemoglobinometer, centrifuge, hemacrit centrifuge, hemophotometer, electronic micro-hematocrit, hemacrit reader, colorimeter.

Pipettes, slides, cover glasses, tubes, assorted glassware, syringes, vacutainers, etc.

Skill in drawing blood by venipuncture or fingerstick.

Blood Bank Technicians and Technologists. Blood bank technicians and technologists perform necessary procedures and tests for collecting, banking, and dispensing blood for transfusion, and make tests to ensure compatibility of blood of donor and recipient. In some institutions the blood bank specialty rotates with serology and/or hematology; in others the functions are combined without rotation.

As part of their functions blood bank technicians do the following:

Set up apparatus, instruments, and equipment required for various tests and procedures.

Make preliminary examination of pulse, temperature, blood pressure, and medical history of blood donor; make hemoglobin determination; and perform serologic tests on donor's blood.

Perform tests to determine blood group, Rh type, Du factor, etc., on blood from donor and recipient, and on cord blood.

Crossmatch blood from donor with that of recipient.

Collect blood from donor into prepared sterile vacuum containers, by venipuncture.

Label pilot tubes and blood container with blood group, Rh factor, and identification number.

Perform routine clerical duties necessary for recording essential data.

Perform Coombs tests, prothrombin tests, tests for atypical antibodies, and antibody titers.

Process whole blood by centrifuging in order to separate plasma and red cells.

Test plasma for presence of bacteria by means of cultures and microscopic examination.

Are responsible for the care of the blood refrigerator.

Clean laboratory equipment.

Order necessary supplies.

Prepare records of donor and recipient, transfusion reactions, disposition of plasma, and other required blood bank records.

If institution banks blood, they may be responsible for maintaining adequate blood supply of appropriate types in the blood bank. If institution does not bank blood, they may be responsible for obtaining blood from outside blood banks.

If institution has a blood donor program, they may interview donors to obtain necessary information for screening purposes, record hemoglobin and temperature readings, and check donor's condition after donations, before allowing him to leave blood bank.

At higher levels may be responsible for recommending specific blood for a specific patient; and responsible for temperature recording charts for blood refrigerator; etc.

The <u>technical skills</u> needed for this job are:

Skill in drawing blood by venipuncture. Proficiency in the use of instrumentation and equipment of the blood bank specialty, such as:

Microscope, centrifuge, water baths, receiving box, blood collection apparatus, transfusion equipment, sphygmomanometer, stethoscope.

Blood bank refrigerator.

Pipettes, syringes.

Serology Technicians and Technologists. They perform serodiagnostic tests for syphilis and other diseases, prepare serums and vaccines used for diagnosis and treatment of disease and used to confer immunity against infectious diseases. In some institutions the serology specialty may rotate with blood bank and/or hematology; in some the functions are combined without rotation. In other institutions certain aspects of the serology specialty may be combined with bacteriology.

Functions performed by serology technicians include the following:

Setting up apparatus, instruments, and equipment required for various serological tests.

Preparing solutions, reagents, and other materials.

Receiving specimens and performing routine clerical work necessary for proper labeling and recording of essential data.

Collecting venous blood from patients.

Preparing specimens for testing by centrifuging and inactivating sera.

Performing tests for diagnosis of syphilis in accordance with standard procedures. Tests are of three general types - flocculation tests, complement fixation tests, and treponemal tests. Among the tests used are the following: Boerner-Jones-Lukens, Eagle, Hinton, Kohn, Kline, Kolmer, Mazzini, Rein-Bossak, Reiter protein, VDRL.

Performing serodiagnostic tests for diagnosis of diseases other than syphilis, including bacterial, parasitic, Rickettsial, and virus diseases. Among the tests are: Widal reaction for typhoid and paratyphoid, agglutination tests for brucellosis and for tularemia, Weil-Felix reaction in Rickettsial diseases, cold agglutinins, heterophile agglutinations, serologic tests for rheumatoid arthritis, colloidal gold tests, antistreptolysin O titers, tests for trichinosis, tests for C-reactive protein.

Preparing serums by injecting antigens of immune agents into laboratory animals, bleeding animals, and removing blood serum.

Preparing autogenous and other vaccine by planting and incubating bacterial cultures in suitable media.

May perform immunology tests, such as pollen sensitization tests by injection of antigen into patient.

May perform pregnancy tests.

Keeping records and making reports on test results.

Cleaning, sterilizing, and maintaining equipment.

Requisitioning supplies.

The technical skills required for this specialty are:

Proficiency in the use of instrumentation and equipment associated with the serology specialty, such as:

Serological water baths, rotator, shaking machine, refrigerator, centrifuge and centrifuge tachometer, automatic pipetting machine, microscope, incubator.

Syringes, slide holders, ringmakers, pipettes, glassware such as tubes, vials, flasks, bottles, slides, etc.

Skill in drawing blood by venipuncture.

General Medical Assistants, Doctor's Office (other than nurse or secretary)

Medical assistants are persons who do both technical and clerical work in doctors' offices. Employees in doctors' offices who spend all or almost all of their time as laboratory technicians or X-ray technicians are classified under these specialties and not as general medical assistants. Employees in doctors' offices who spend more than two-thirds of their time on office work and registered nurses performing nursing duties are excluded from the survey.

Medical assistants may perform some or all of the following functions:

Preparing patients for physical examinations; taking pulse, temperature, and respiration, etc.

Doing medical laboratory tests, such as blood counts and blood chemistry, urinalysis, gastric analyses, pregnancy tests; operating basal metabolism machines and calculating basal metabolic rates; etc.

Taking and developing electrocardiograms; operating X-ray equipment and developing films.

Office management and record keeping.

Related duties may include caring for and sterilizing instruments, keeping equipment ready for use, maintaining an inventory of supplies and ordering additional supplies, etc.

Technical skills that are required may include:

Ability to use equipment such as a basal metabolism machine, electrocardiograph machine, X-ray machine, microscope, sterilizer, typewriter, etc., and glassware.

X-ray Technicians and Radioisotope Technicians

X-ray technicians operate radiant-energy equipment for diagnostic or therapeutic purposes; and assist radiologists in the handling of radium, radioisotopes, and other radioactive substances.

X-ray technicians may perform some or all of the following functions:

Operate X-ray equipment to obtain photographs for diagnostic purposes. Perform standardized or routine as well as special examinations, such as bronchography, cholangiography, gastrointestinal tract series, laminography of chest, pneumoarthography, kymography, angiography, etc.

Prepare and position patients correctly for radiologic exposure for specific examinations or for therapy. Safeguard patients from direct or secondary radiation by using proper and adequate protective measures.

Manipulate and set controls, adjust equipment, turn current on and off; observe patients during radiological procedures to prevent movement and discomfort; watch control panels for fluctuation of current during exposure and to obtain (in diagnostic procedures) correct exposure of film in accordance with technical and safety standards.

Maintain and transport photofluorographic equipment in a mobile unit for mass chest X-ray surveys.

Develop and process X-ray film (where necessary); label film for identification.

Prepare opaque media, used in various examinations for diagnostic purposes, such as gastro-intestinal work, intravenous pyelography, barium enemas, etc.

Keep equipment cleaned and oiled; detect defective equipment; make minor repairs, adjustments, and replacements.

Perform various administrative and clerical functions, such as keeping records of individual patients; compiling daily report of radiation or radioisotopes administered to each patient or exposures made; compiling daily and monthly reports of activities; requisitioning and maintaining adequate inventory of chemicals, films, drugs, and other supplies.

Radioisotope technicians may be required to:

Dilute and assay radioactive material for injection, calculate amount of radioactivity in solution.

Assist in administering radioactive materials directly to patient and carry out various measurements with complex electronic instruments, such as renograms, liver scans, thyroid scans, and metastasis scans.

Obtain blood specimens and perform analyses of blood which has been treated with radioisotopes.

Technical skills include:

Ability to operate and use all diagnostic, superficial therapy, and deep therapy equipment; photofluoroscopic and mobile X-ray equipment; image intensifier; cobalt machine; various specialized equipment, such as Geiger counter, isotope scanner, spectrometer, scintillator, electroscope, etc., and accessories such as X-omat processing units, timers, illuminators, etc.

Ability to use accessories, such as X-ray tubes of various types, cassettes, sand bags, bollus bags, lead shields, film paper, stencils, barium, and various other radio-opaque materials.

Other Medical Technicians

Electrocardiograph Technicians. These technicians take electrocardiograms (EKG or ECG) which are graphically recorded electrical currents emanating from the heart muscle for use in diagnosis of heart ailments. In small establishments technicians who take EKG's may also take X-rays, electroencephalograms, basal metabolisms, etc.

The essential functions of EKG technicians are to:

Operate electrocardiographic or other specialized amplification equipment for recording graphically electrical currents emanating from the heart muscle; prepare and position patient for test; paste or strap electrodes to body and remove them after test; calibrate or standardize recording equipment; manipulate switches and move electrodes across chest to record heart action graphically; observe patient and apparatus to prevent occurrence of artifacts.

Work as part of a medical team to assist with difficult or special tests such as tests during surgery, esophageal lead tests, master exercise tolerance tests, carotid and sinus stimulation tests, phonocardiograms, ballistocardiograms, tests involving the use of drugs and medications, and special tests for research purposes.

Develop, wash, and dry exposed film (if machine is type that records tracings on sensitized paper); and prepare tracings for physician's interpretation.

Reload machine with film or paper; keep equipment oiled and cleaned; make adjustments, replacements, and minor repairs.

Duplicate tracings taken on certain cardiographs by using duplicating machine.

Assemble tracings for physician.

File reports in permanent record file.

Requisition and maintain necessary supplies and equipment.

May also be required to take dictation and type.

The technical skills that EKG technicians need include ability to use:

Electrocardiographic machines and various specialized equipment such as polygraphs, cardioscopes, ballistocardiographs, vectorcardiographs, phonocardiographs, pulse recorders, electromanometers, and band pass filters.

Paper cutters, spatulas, electrodes, photographic paper dryers, duplicators, measuring devices, photometers, heart sound recorders, sphygmometers, vital capacity machines, etc.

Electroencephalograph Technicians. These technicians (EEG) measure with an electroencephalograph impulse frequency and electrical potential between various areas of the brain for use in diagnosis of brain disorders. In small establishments and in doctors' offices EEG technicians may take X-rays, EKG's, basal metabolism, and do some laboratory tests.

EEG technicians perform some or all of the following functions:

Operate EEG equipment; calibrate or standardize recording equipment by making certain that all channels to be used are set to record symmetrically.

Prepare patient for test; attach electrodes to specified positions on patient's head and remove them after test; turn on and rotate switches to obtain tracings of impulses from various parts of brain; observe patient and apparatus during examination to prevent occurrence of artifacts caused by movement, interference, or malfunctioning; observe and record clinical symptoms of patients during test (seizures, convulsions, etc.); mark on tracings time of occurrences of abnormalities and pinpoint location of abnormality by use of additional electrodes; cut and mount tracings for physician's interpretation.

Work as part of a medical team to assist in special EEG examinations such as:

Activated studies requiring the use of controlled stimuli. The technical worker assists with the administering of stimuli such as the following and operates the EEG equipment, to obtain tracings:

(a) Audio-photo stimulation, to evoke abnormal patterns.

(b) Sleep-producing stimuli, to obtain complete wake-sleep brain tracings of patients.

(c) Metrazol, photometrazol, and other drug studies. Duties of technical worker include giving aid to patients in order to counteract convulsive and other effects of the drug.

(d) Subjecting patients to hyperventilation.

Electrocorticography, which includes special procedures for operating EEG equipment in order to obtain tracings during brain surgery.

Electroretinography, under the direction of an ophthalmologist, which includes special procedures for operating the EEG equipment together with a photic stimulator to study the physiology and pathology of the retina (to determine whether cataract surgery is practical, etc.).

Assist physician in use of electroencephalograph and other electrographic equipment for experimental and research work in electromyography, tremography etc. (Generally, highly trained and expert technicians with a great deal of experience and ability are selected for these projects.)

Assist medical personnel in research projects by assembling unusual tracings, data, etc.

Keep equipment oiled and cleaned; make adjustments, replacements, and minor repairs.

File reports in permanent record file.

Requisition and maintain necessary supplies.

May also be required to take dictation and type.

Technical skills required include:

Ability to use equipment such as the electroencephalograph, photic stimulator, cortical electrodes, fetal EEG electrodes, voltmeter, ammeter, oscilloscope, and surface needle, and tools such as soldering irons and wrenches.

Inhalation Therapy Technicians. Inhalation therapists administer oxygen and other designated gases and aerosols in order to restore to normal a pathophysiologic alteration of gas exchange in the cardiopulmonary systems - or to attain adequate oxygenation as well as proper elimination of carbon dioxide. This is done either for therapeutic or for diagnostic purposes. The technicians work under the supervision of a physician, who designates the gas, amount of pressure, and frequency of treatment.

The <u>functions</u> of inhalation therapists consist of:

Administration to patient of medicinal gases by catheter, tents, hoods, etc.

Application of expiratory pressure masks, respirators, and pressure devices for IPPB (intermittent positive pressure breathing), resuscitation (mouth-to-mouth or by mechanical devices), etc.

Administration of aerosol therapy by various methods, using nebulized medications, such as penicillin, broncho-dilator drugs, steroids, proteolytic enzymes, and silicones.

Pulmonary function evaluations -- measuring vital capacity, timed vital capacity, and mid-expiratory flow rate.

Maintaining and repairing equipment.

In addition to the technicians who do various kinds of inhalation therapy work as described above, this job title includes some workers who do only routine administering of oxygen by catheter, tent, or hood.

Technicians must be able to use various inhalation therapy and resuscitation equipment such as:

Oxygen tents, oxygen tanks, face masks, tracheotomy masks, reducing valves, flowmeters, and regulators, humidifiers, various types of aerosol apparatus, nasal catheters, nasal cannulae, resuscitators, respirators, blood pressure machine, suction equipment, pressure breathing apparatus, anesthetizing machine, IPPB apparatus for treatment of disease and for artificial ventilation, ex-sufflators, airways, y tubes, incubators, croupettes, and central oxygen supply manifolds.

<u>Other Medical Technicians</u>. This miscellaneous group includes the following five types of technicians:

<u>Central supply technicians</u> are responsible for the distribution of supplies in a hospital (linens, drugs, instruments, etc.), including sterilizing, preparing, processing, and packaging; checking on electrical medical equipment; and keeping an inventory of supplies.

<u>Orthopedic technicians</u> do plaster cast and traction work for patients; making molds for braces; assisting surgeon in application of casts and traction during and after operative procedures; maintaining supplies and equipment for plaster work.

<u>Cardiopulmonary technicians</u> mainly perform specialized analyses of blood and gas samples obtained from patients having pulmonary function tests and cardiac catheterizations (also from experimental animals); determine tensions of carbon dioxide and oxygen in arterial blood and other fluids; do spirometry, that is,

determination of basic lung volume and lung-volume ratio; prepare laboratory stock solutions and reagents used in blood and gas analyses; help set up, calibrate, and standardize equipment, and assist during catheterization and in collecting blood and gas samples.

Operating room technicians perform and/or assist in carrying out specifically detailed duties before, during, and after surgery, being careful to observe aseptic techniques. They may prepare the operating room with the necessary sterile supplies and equipment; set up the sterile instrument table; pass instruments and other supplies to the surgeon during the operation; maintain supply of sponges and take sponge count; control location of contaminated instruments and supplies; sterilize instruments and equipment and clean operating room.

Orthoptic technicians teach strabismic (cross-eyed) patients, most often children, to use their eyes together correctly and comfortably. They may perform orthoptic and pleoptic evaluation, diagnosis, and treatment of patients having real or suspected extraocular muscle anomalies; teach patient orthoptic theory and practical application; prepare reference classifications of strabismic patients, etc.

Medical illustrators illustrate graphically in black and white or in color medical and surgical procedures and findings, physiological and anatomical conditions and processes, surgical and technical instruments, etc., for publications, exhibits, etc. May make plaster and wax castings; take photographs; construct scientific exhibits; lay out charts, tables, and mechanical plans to accompany publications; etc.

Therapists

Therapists are engaged in the physical and mental rehabilitation of patients. They were included in the survey even though they are considered to be above the technician level.1/ (Information on the functions of therapists given below is largely based on Position Classification Standards, a publication of the U.S. Civil Service Commission.)

A particular course of therapy, usually medically prescribed, integrates a specialized knowledge with the whole rehabilitation plan of the patient. The therapist is usually a member of a rehabilitation team, which is directed by a physician. It may include a nurse, a clinical social worker, a psychologist, a vocational counselor, and/or other specialists.

1. A very small number included in the survey are at the technician or aide level, trained for and assigned to limited tasks.

Physical therapists are the most numerous. There are also occupational therapists -- they are the second largest group -- and recreational, manual-arts, corrective, and speech-and-hearing therapists. In small organizations an occupational therapist may also do work that is characteristic of one of the other therapies.

These therapies differ somewhat in purpose and in the activities, devices, and procedures used to achieve their objective, and therefore in the knowledge they require. But some knowledge and some skills are common to all the therapies.

Physical therapists. In aiding persons with an injury or a disease involving a muscle, nerve, joint, or bone, physical therapists use various physical agents. Their work includes diagnostic testing and also treatment and prevention. Their rehabilitation activities assist the patient on the path to physical independence by developing strength and dexterity; in some instances they include training in self-care.

Treatments and tests may be given by the therapists in hospitals to in-patients and out-patients, in doctors' offices, in health centers, and in some cases at home. Some physical therapists treat all types of patients, while others specialize in working with children, with amputees, with paraplegics, or with victims of poliomyelitis, cerebral palsy, arthritis, or muscular dystrophy.

As part of their functions, physical therapists may do any or all of the following:

Administer thermotherapy (infra-red, paraffin baths).

Administer ultraviolet radiation.

Administer electrotherapy and diagnosis (diathermy, microwave, ultrasound, electrical stimulation, chronaxie, strength duration curve, medical galvanism, ion transfer).

Administer hydrotherapy (whirlpool, contrast or thermal baths, hot or cold packs, Hubbard tank, sprays, douches, hydrogalvanic baths, showers, therapeutic pool, brine tank, moist air).

Administer massage.

Administer therapeutic exercise (muscle reeducation, progressive resistance, gait training, relaxation, breathing, posture, facilitation, coordination, activities of daily living).

Perform tests and measurements (manual muscle and nerve tests; electrodiagnostic, skin temperature, and resistance tests; posture, oscillometric, and reflex heat tests; strength, volumetric, and daily activities tests; chest girth and measurement of joint range of motion).

Give prosthetic training and supportive therapy (compression bandaging of stumps of limbs of amputees; application of slings, splints, braces, and other prosthetic or orthotic appliances).

Teach patients how to perform exercises and use and care for braces, crutches, and artificial limbs.

Show members of patients' families how to continue treatments at home.

Perform various administrative and record keeping functions; enter in patient's record the treatments given, dosages, completion of treatment, referrals, etc.; write progress reports; keep daily, monthly, or annual records of all treatments given by type of treatment.

Maintain equipment by cleaning, testing, and making adjustments and minor repairs.

Requisition and maintain adequate supplies and equipment.

Technical skills include ability to use equipment -- electrical, mechanical, gymnastic, and other treatment and testing devices. Physical therapists need unusual physical stamina.

Occupational, recreational, and other therapists. This group consists mainly of occupational therapists, but also includes some recreational therapists and a few manual-arts, speech-and-hearing, and other therapists. Occupational therapists assist in the treatment and rehabilitation of patients in order to restore them to the fullest mental and physical capacity compatible with their abilities and disabilities.

Occupational therapists, working in accordance with physicians' instruction, may exercise the following functions:

Plan, develop, and administer treatment by utilizing educational, vocational, and recreational activities and activities of daily living designed to meet the specific needs of the patient.

The purpose of the specific activities is: (1) to restore, improve, or maintain joint motion and muscular strength; develop muscular control and coordination; develop ability to carry on activities of daily living; provide diagnostic information to physician to augment psychotherapy; develop constructive habits; provide outlet for tension; provide opportunity for work accomplishment and a source of socialization, etc.; (2) to control patients' physical activity at a level commensurate with the stage of their disease; to evaluate and develop work capacity within the limitations of the disease or disability; and (3) to maintain "muscle tone" and/or "mental tone" to prevent disease atrophy in unaffected parts; to aid patients to adjust to their abilities, to maintain work habits, and to develop new interests and group cooperation.

To achieve the goals mentioned above, occupational therapists utilize various activities, among which are the teaching of manual and creative arts, such as art, ceramics, bookbinding, leather work, printing, woodwork, and also business and industrial skills such as typing, operating business machines, and using power tools. The therapists also design and make special equipment or splints and train patients in self-care and daily living.

Recreational therapists may perform some of the functions of the occupational therapist, but they are usually engaged in helping to plan, organize, and direct recreational activities to provide patients with mental and physical stimulation, help them overcome specific disabilities, and provide a socially normal atmosphere. These therapists provide and participate with patients in activities such as games (checkers, dominoes, card games), sports (badminton, ping pong, shuffle board), crafts, dances, dramatics, and music.

Therapists in all fields may also be required to:

Prepare various reports on activities and progress reports on patients; maintain proper inventory of supplies and equipment and estimate budgetary requirements for these; see that tools and equipment are properly maintained; make adjustments and minor repairs; see that proper provisions are made for safety; etc.

Medical Record Librarians

Medical record librarians are responsible for the preparation, maintenance, and analysis of records on diseases and treatments of patients admitted to hospitals and other medical facilities.

A small institution may employ only one medical record librarian, who performs his or her functions with only clerical assistance. A large institution may have a medical record department made up of medical record librarians, medical record technicians, code clerks, and other clerical workers.

The medical record librarian category includes both record librarians, who are considered to be professional rather than technical workers, and a few medical record technicians, a relatively new occupation. Medical record technicians do technical medical record work but have less responsibility than full-fledged medical record librarians, and perform no management functions.

Medical record librarians perform some or all of the following functions:

Maintain files of original clinical records dealing with patients' admission; physician's examination, orders, and progress notes; diagnosis, treatment, and surgical procedures; nurse's notes; laboratory and X-ray reports; autopsy reports; discharge or transfer; etc.

In cooperation with the medical staff, determine (1) what continuous secondary records should be kept, such as patient's name index, disease index, operations index, tumor follow-up registry, physician's index, etc., and (2) what special indexes should be developed for which there is a temporary need.

Are responsible for the coding, indexing, and cross-referencing of medical records in accordance with nomenclature and classification systems. Make decisions on how to code or cross-reference new diagnostic terms, treatments, drugs, and therapies, and make sure that interpretations are in keeping with common usage.

Review and analyze clinical records to determine if they are complete, if the terminology used by the physician follows accepted nomenclature, and if the contents appear to be accurate and internally consistent. Call any apparent omissions and inconsistencies to the attention of the physician, who makes the final determination.

Prepare periodic reports on vital statistics, utilization of the hospital, etc., for the guidance of administrators. Have responsibility for handling birth and death certificates.

Prepare statistical reports on types of cases treated, etc., which are needed by the medical staff and others to evaluate the quality of care provided.

Abstract data from case histories for research, insurance, medico-legal purposes, and for other special reports. Assist the medical staff in research involving use of medical records.

Be responsible for the release of information on patient's records to the hospital medical staff and accounting office, outside doctors, insurance companies, lawyers, and other hospitals and agencies in accordance with hospital policies and statutes on privileged communications. Represent the hospital in court cases involving the subpoena of clinical records.

Participate in staff meetings and serve on committees, such as the medical record committee.

Related duties may include devising methods of clinical records preservation and coordination, developing new forms and procedures, preparing old records for microfilming, keeping abreast of latest medical techniques, orienting incoming house staff on record room procedures, etc.

If the librarians have management responsibilities, they will hire, train and supervise the staff of the medical record department; prepare departmental budget; select equipment, etc.

The <u>technical skills</u> required by medical record librarians include:

Ability to understand medical terminology, procedures, and diagnoses and to classify and analyze medical record data.

Ability to see possible legal implications of record contents and to show discretion in releasing information.

Ability to operate microfilm projection equipment.

Ability to operate a typewriter, adding machine, desk calculator, and other office equipment. (More important for a medical record technician than a full-fledged medical record librarian.)

Dental Technicians

Dental technicians typically construct or repair full or partial dentures, bridges, crowns, inlays, and prosthetic appliances. The majority of these technicians are employed in dental laboratories; some are employed in hospitals or dental clinics operated by the government or by a nongovernment agency. These technicians do not deal directly with patients, but receive prescriptions from dentists, which are often accompanied by impressions of patients' mouths.

In the larger establishments, the dental technician may work on only one process rather than doing all the work necessary to complete a dental replacement. Those with limited experience may be plastermen, who mix and pour plaster into casts and molds. Others may be gold men who prepare partial plates, steel men who work with nonprecious metals instead of gold alloys, ceramists who put porcelain covers on the gold bases, denture men who work with acrylic plastics and may be concerned only with full sets of teeth. In some establishments, specialization is by process, such as casing or polishing. The type of work performed by a specialist may vary from establishment to establishment, depending upon the size of the establishment, and the medium used.

Dental technicians may perform one or more of the following functions:

Fabricate models and molds from impressions taken by dentists and build bite blocks.

Do duplication in connection with rugae reproduction, refractory casts used in casting metal dental appliances, or other processes.

Cast metals, such as gold alloys and cobalt-chromium alloys, and process metal framework such as bars, clasps, rests, space retainers, bite raisers, and other attachments.

Block out master casts for partial dentures.

Mount models, casts, and processed dentures on articulator.

Set up teeth by selecting those of proper shade, size, and shape to achieve proper articulation and bite and attach them to dentures.

Process acrylic dentures, bridges, and crowns, including carving the wax, investing, casting, flasking, packing, curing, fitting, finishing, and polishing.

Make veneer porcelain crowns, inlays, facings, and teeth, including firing and glazing.

Polish dentures and other prosthetic appliances with abrasive and polishing materials such as pumice, tripoli, rouge, tin oxide, cuttle fish, garnet, silicon carbide, etc. Finish and pack.

Design, fabricate, or repair special prosthetic appliances, such as obturators, implants to restore portions of the mandible, splints, and protective devices.

Have responsibility for care and maintenance of tools and equipment.

Dental technicians may need technical skills such as the following:

High degree of manual dexterity and motor coordination to handle and manipulate tools, equipment, dentures, etc. Ability to work to close tolerances and to read and follow detailed specifications.

Visual acuity and spatial and form perception. Good color perception to match teeth.

Ability and judgment in mixing, molding, and heating materials such as wax, plaster, gold, chrome, silver, platinum, acrylic resins, and porcelain. Skill in carving wax teeth.

In performing their tasks, dental laboratory technicians may use the following:

Small hand tools, electric lathes and drills, high-heat furnaces, and other kinds of specialized laboratory equipment, which may include: articulator, buffer, burnisher, caliper, casting machine, crucible, curing machine, dental engine, electric vibrator, electroplating equipment, emery wheel, file, flask, gauge, hydroscopic investor, jeweler's saw, knife, mallet, melting pot, micrometer, motor with cutting discs, oven, pliers, polisher, press, sand blasting machine, scalpel, shade guide, soldering iron, spatula, surveyor's table, tongs, ultrasonic cleaner, welding torch, etc.

Dental Hygienists

Dental hygienists contribute to oral health by helping to prevent tooth decay and promoting better mouth care. Most dental hygienists are employed in private offices; some work in clinics, hospitals, schools, institutions, and industrial plants.

A dental hygienist is primarily concerned with the following functions:

Giving dental prophylactic treatment, which includes scaling calcareous deposits, accretions, and stains from natural and restored surfaces of teeth; mixing cleansing compounds and polishing teeth; charting cavities and recording irritations and infections for final diagnosis by the dentist; advising patients on proper diet and home care of teeth.

Taking caries-prevention measures such as applying fluoride solutions to children's teeth.

Under the supervision of a dentist, treating abnormal gum conditions by the administration of medicaments.

Teaching dental hygiene principles or promoting dental health through educational activities in schools, clinics, and institutions.

If employed in a dental office, they may perform some of the duties of a dental assistant, which are described below.

Dental hygienists require technical skills such as:

High degree of finger dexterity and eye-hand coordination to manipulate dental instruments within the confines of the mouth.

Ability to use tools and instruments such as dental scalers, mouth mirrors, air syringes, brushes, rubber cups, blow back guns, dappen dishes, curettes, post-polisher explorers, dental mixing instruments such as mortar and pestle, dental spatula, mixing slab.

Dental Assistants

Dental assistants are persons employed in dental offices who do some technical work in combination with office work. Persons who spend more than two-thirds of their time on office duties or other nontechnical work were omitted from the survey.

Dental assistants may perform one or more of the following functions:

Assist dentist at chairside during examination by anticipating dentist's need for particular instruments or materials; prepare syringe for administration of local anesthetic; determine pulse, respiration, facial coloration, and pupillary reflex of patient; operate suction equipment; mix amalgam, cements, silicates, or other materials; etc.

Operate X-ray machine and develop and mount films.

May assist dentist in prosthetic work by mixing impression material; making artificial stone models from impressions; assisting in construction and repair of dentures, inlays, bridges, and crowns according to dentist's prescription.

Do office management and record keeping.

Related duties may include cleaning and maintaining equipment; preparing and sterilizing instruments; keeping an inventory and ordering additional supplies; etc.

Dental assistants need technical skills such as:

Ability to operate an X-ray machine and to develop films and the ability to operate a typewriter.

Familiarity with equipment and tools, such as autoclave or sterilizer; centrifugal casting machine; suction equipment; X-ray and X-ray film illuminator; dental mixing instruments such as mortar and pestle, dental spatula, mixing slabs, etc.; typewriter; etc.

Agricultural and Related Technicians

This group is a heterogeneous group of technicians with a wide range of background and skills, employed in agriculture, forestry, animal laboratories, and plant and forest pest control. The majority are employed by colleges and universities and the State and Federal governments. Their functions vary greatly, but may include one or more of the following:

Performing various laboratory tests, including research, for control and eradication of pests on plants, animals, farm crops, etc. May do testing for research purposes in connection with sprays, insecticides, dusts, and diseases of animals or plants.

Maintaining fungi cultures.

Performing chemical testing on experimental animals for research purposes. Doing analyses of urine, blood, and tissue.

Making analyses of food materials.

SUBJECT MATTER KNOWLEDGE

Biological and Medical Laboratory Technicians and Technologists

Chemistry and biology provide the basis for work in all fields in the clinical laboratory, with the possible exception of cytology, which is essentially biology-oriented, and histology, where a less formal type of education is required. In general, grounding in inorganic and qualitative chemistry is important, and quantitative and organic chemistry and biochemistry are desirable. General biology and bacteriology are the most significant background areas of biology.

Certain of the specialty branches of the clinical laboratory may place greater importance on one basic field than another. For example, the biochemistry technologist needs a knowledge of the major subdivisions of chemistry, whereas for his counterpart in biology a knowledge of microbiology, bacteriology, serology, immunology, parasitology, and mycology would be important and a knowledge of epidemiology and virology also would be desirable. For other branches, such as hematology, serology, and blood bank a knowledge of general chemistry and biology would be adequate, and for histology this knowledge, while not required, would be desirable.

Some employers indicated a need for some knowledge of anatomy and physiology; others, in institutions where work was being done with radioisotopes, considered a knowledge of physics to be important. Several employers indicated that some knowledge of genetics was helpful for work in blood banking. For research a knowledge of trigonometry, calculus, and other types of higher mathematics may be required.

In addition to the basic sciences, for each of the technician-technologist jobs, a knowledge of medical laboratory technology -- the procedures, routines, and terminology of laboratory medicine -- is essential. Typically, areas covered under medical technology include the following: biochemistry, bacteriology (microbiology), parasitology, serology, hematology, urinalysis, blood banking, and histologic techniques. For a technician-technologist specializing in a single area, knowledge in some depth in that area is required. For example, the hematology technician is required to have considerable knowledge of the methods of obtaining blood, and of making various types of blood count and must also be familiar with special pathology of the blood. He might also need a knowledge of urinalysis and serology.

General Medical Assistants, Doctor's Office

Generally needed are a knowledge of medical office procedures and practices, medical terminology, and medical secretarial duties. Needed in a substantial number of cases are elementary physiology, medical laboratory technology, and X-ray technology.

X-ray and Related Technicians

Generally needed by an X-ray technician is a knowledge of the construction and operation of X-ray equipment, X-ray techniques, and X-ray therapy, with elementary anatomy and physiology and general physics as background.

Subjects needed in a substantial proportion of cases include general chemistry and biology.

Subjects occasionally needed include trigonometry and an orientation in electrical technology.

Radioisotope technicians, who were included with X-ray technicians, need advanced algebra, more advanced knowledge of physics and chemistry than the others need, and a knowledge of radioisotopes.

Electrocardiograph Technicians

General requirements include a knowledge of electrocardiographic equipment and heart anatomy, and medical terminology related to them. General physics is needed occasionally.

Electroencephalograph Technicians

Generally needed is a knowledge of electroencephalography and brain anatomy, and medical terminology relating to them. Subjects occasionally required include neuroanatomy and electrophysics.

Inhalation Therapy Technicians

A knowledge of inhalation therapy techniques is fundamental. General physics, elementary physiology, general chemistry, anesthesiology, and medical terminology are required in a substantial number of cases.

Physical Therapists

Basic knowledge needed includes anatomy, biology, physiology, pathology, clinical medicine, and physical therapy.

Other subjects reported as needed include general chemistry, general physics, principles of electricity, physical medicine, psychology, neurology, and various specialized physical therapy courses.

Occupational Therapists

Basic requirements include the health sciences and occupational skills. Generally needed are science subjects including anatomy, physiology, neurology, and psychology; clinical subjects covering general medical and surgical conditions, tuberculosis, and heart diseases; application of the principles and practice of occupational therapy in pediatrics, psychiatry, orthopedics, and general medicine and surgery depending on job assignment. Other subjects needed are creative arts, skills,and crafts (ceramics, leather, textiles, plastics, etc.), educational subjects, and recreational activities.

Medical Record Librarians

General background knowledge needed for the job includes anatomy, general biology, and physiology. Generally needed also is a knowledge of medical record science and procedures, medical terminology, medical jurisprudence. Statistics and medical stenography are needed occasionally.

Dental Laboratory Technicians

The basic subject knowledge needed by dental technicians is dental laboratory technology, including the properties of dental materials, with oral anatomy as background. Other knowledge that is useful as background is general chemistry, metallurgy, and ceramics. For a ceramist a knowledge of ceramics is a basic requirement.

Dental Hygienists

Basic knowledge needed for this occupation is dental science, especially oral anatomy and oral hygiene. X-ray technology is needed in a substantial number of cases. Needed also as background are general chemistry, histology, bacteriology, pharmacology, pathology, and nutrition, since they are included in the examination for State license for dental hygienist.

Dental Assistants

Dental assistants need a technical knowledge of dental assisting (instrumentation, sterilization, etc.) and of typing and bookkeeping. X-ray technology is needed in a substantial number of cases.

GRADE STRUCTURE

In the nonsupervisory grades of biological, medical, dental, and related science technicians, technologists, and specialists, there are three workers in single grades to every one in a multi-grade system -- mainly because many establishments employ only a small number of workers in any one occupation, sometimes only one or two. One-third of those in multi-grade systems are government employees; of the two-thirds in private industry, most are in large voluntary hospitals.

Table VI-D. PERCENT DISTRIBUTION OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS, ACCORDING TO GRADE

Occupation group	Total number	Percent distribution					
		All grades	Supervisory grades	Nonsupervisory grades			
				Single grade only	Multi-grade		
					Lowest grades	Middle grades	Highest grades
All occupations	25,445	100.0	4.1	68.8	12.6	4.8	9.7
Agricultural and related	340	100.0	0.6	36.4	35.0	1.8	26.2
Biology and medical laboratory	9,898	100.0	4.8	56.0	18.3	7.3	13.6
General medical assistants, doctor's office	1,114	100.0	-	100.0	-	-	-
X-ray and related equipment technicians	3,013	100.0	6.7	56.1	20.2	4.2	12.8
Other medical technicians	1,801	100.0	2.5	79.9	8.4	3.3	5.9
Therapists	1,883	100.0	8.0	56.7	17.4	9.9	8.0
Medical record librarians	347	100.0	15.9	62.3	13.8	1.7	6.3
Dental laboratory technicians	2,844	100.0	3.7	77.3	4.4	2.0	12.6
Dental hygienists	1,874	100.0	0.1	98.3	0.6	0.7	0.3
Dental assistants	2,331	100.0	(a)	97.6	0.4	1.8	0.2

a. Less than 0.05 of a percent.

The proportion in different grades in each of the occupation groups is shown in table VI-D.

In establishments with multi-grade systems, workers in higher grades typically are responsible for performing newer or more complex procedures, and may assist in the development and application of new methods and procedures. They may spot-check the work of lower-level technicians or may check and verify abnormal or unusual findings. In some areas, higher-level workers may be expected to have more scientific background than lower-level workers, and to understand the medical applications of tests and procedures performed in order to distinguish between normal and abnormal results. Workers in supervisory grades may assist in on-the-job training of new employees.

Recently, some of the larger hospitals, when establishing salary structures, have adopted multi-grade systems for various jobs including technical jobs. Job evaluations which underlie these grading systems typically are based on education and work experience as well as on the duties, responsibilities, and working conditions of the job.

The grading systems adopted by hospitals vary in respect to the number of grades into which technical jobs are classified and the level at which a particular job is slotted. However, the example below gives some indication of how a hospital might classify technical jobs for wage structure purposes:

Grade 1 - electrocardiograph technician
electroencephalograph technician
Grade 2 - medical laboratory technician
X-ray technician
Grade 3 - medical laboratory technologist
Grade 4 - occupational therapist
physical therapist
Grade 5 - senior X-ray technician
Grade 6 - senior medical laboratory technologist
Grade 7 - chief physical therapist
chief medical laboratory technologist
chief X-ray technician

The primary purpose of such a grading system is to assure that workers in initial recruitment are hired at the proper levels and that workers already employed are paid at similar salary levels for jobs of like responsibility and skill.

There are some hospitals which, in order to attract technical workers with good educational and experience backgrounds, hire well-qualified workers at grades above the entrance level, while workers with minimum requirements are hired at the lowest level.

EDUCATION AND EXPERIENCE REQUIRED

In 1962, at the time of the survey, biological, medical, dental, and related science technicians, technologists, and specialists were about equally divided between those for whom the employer required high-school graduation and those for whom more advanced education was required; the latter group had a slight edge.

Half of the biological-medical-dental group were employed in occupations for which some experience was a prerequisite to hiring.

Education Requirements

Graduation from a technical institute or community college1/ was the most usual requirement for those for whom some education beyond high school was specified. College graduation2/ was also required in a substantial number of cases. (See table VI-E below, and table VI-3 at the end of the chapter.)

1. Includes two-year training in a community college leading to an Associate degree in Applied Science (medical technology) and includes the completion of two-year training for X-ray technician in an approved hospital school.

2. Includes four-year training for medical technologist (ASCP), which involves three years of approved collegiate training plus 12 months of training in an approved school of medical technology.

Table VI-E. PERCENT DISTRIBUTION OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS ACCORDING TO EDUCATION EMPLOYERS REQUIRE, BY GRADE

Education required	All grades	Supervisory grades	Nonsupervisory grades		
			Single grade only	Multi-grade	
				Lower grades	Higher grades(a)
All levels	100.0	100.0	100.0	100.0	100.0
Post-high-school	51.7	66.5	50.9	45.5	56.3
College, general					
Graduation	18.2	39.1	13.6	19.9	32.7
Less than graduation	3.0	4.1	2.7	3.4	3.4
Technical institute or community college					
Graduation	24.7	18.8	28.0	16.3	17.3
Less than graduation	3.5	3.2	3.5	5.3	2.0
Other	2.3	1.3	3.1	0.6	0.9
High school	48.3	33.5	49.1	54.5	43.7

a. Middle grades plus highest grades.

As might be expected, the educational requirements vary depending on the grade of the job. At the highest levels, not only were employers more likely to require education beyond high school, but the emphasis was on graduation from a four-year college rather than from a technical institute or community college. Education beyond high school was a requirement for 46 percent of the jobs in the lowest grades, compared with 67 percent for supervisory jobs. In the lowestgrades, college graduation or college training was specified for 51 percent of the jobs for which education beyond high school was required; in the supervisory grades, for 65 percent.

There were also wide variations in educational requirements among the different technical occupations constituting the biological-medical-dental group. For some occupations the minimum requirement was typically high-school graduation, while for others college or technical-institute graduation was the usual requirement.

Table VI-F. PERCENT DISTRIBUTION OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS ACCORDING TO EDUCATION EMPLOYERS R[illegible]RE, BY OCCUPATION

Occupation	All levels	Post-high-school, total	-high-school			High school
			Technical institute graduation	College graduation	Other (a)	
All occupations	100.0	51.7	24.7	18.2	8.8	48.3
Agricultural and related	100.0	70.9	41.8	27.0	2.1	29.1
Biological and medical laboratory	100.0	60.0	19.0	28.2	12.8	40.0
General medical assistants, doctor's office	100.0	46.5	31.6	-	14.9	53.5
X-ray and related equipment	100.0	61.0	46.7	1.9	12.4	39.0
Electrocardiograph	100.0	16.2	5.1	1.9	9.2	83.8
Electroencephalograph	100.0	13.8	3.1	4.4	6.3	86.2
Inhalation therapy	100.0	19.0	15.7	1.3	2.0	81.0
Other medical technicians	100.0	14.9	3.0	5.4	6.5	85.1
Physical therapists	100.0	88.2	-	86.8	1.4	11.8
Occupational, recreational, and other therapists	100.0	92.4	0.5	87.6	4.3	7.6
Medical record librarians	100.0	42.4	18.7	15.6	8.1	57.6
Dental laboratory technicians	100.0	14.3	12.4	-	1.9	85.7
Dental hygienists	100.0	100.0	100.0	-	-	-
Dental assistants	100.0	9.3	2.4	-	6.9	90.7

a. Mostly college or technical institute courses.

As table VI-F shows, high school was the minimum educational requirement for over 80 percent of persons employed in electrocardiograph, electroencephalograph, and inhalation therapy work, and also in the case of dental assistants and dental mechanics. For most of these jobs, employers were willing to hire graduates with little experience. However, in the case of dental mechanics, employers often were more interested in the applicant's experience than in his educational background -- a median of almost three years of experience was the usual requirement for an applicant with a high-school education. For inhalation therapy, experience was also sometimes required.

About half of the general medical assistants were employed by doctors who were willing to hire high-school graduates and train them on the job. The remainder had employers who wanted a technical-institute graduate or someone who had taken a post-high-school course. Few employers required applicants to be experienced.

For X-ray technician, graduation from a hospital school or other type of technical institute was the most usual requirement, but a considerable number (40 percent) were employed in establishments that hired high-school graduates. High-school graduates typically needed two or three years of work experience to meet minimum hiring requirements. This experience may have been obtained in another hospital, where they were trained on the job.

Educational requirements were most diversified for the biological and medical laboratory category, which includes both technicians and technologists. Forty percent in this category had employers who specified high-school graduation as their minimum job requirement. On the other hand, 28 percent worked for employers who wanted four-year college graduates, 19 percent had employers who wanted graduates of a technical institute or a community college, and the employers of the remaining 13 percent specified post-high-school courses without requiring graduation.

Dental hygienists typically were required to have graduated from a technical institute and therapists from a college.

Physical therapists are legally required to be college graduates. However, there is an exception for persons already established as therapists in 1950 (see "State Licenses," below); they are referred to as permit holders or "green-card holders." Where an employer stated that he did not require college graduation for a physical therapist job, he presumably was referring to green-card holders or physical therapy technicians or aids.

Preferred vs. Required Education

The level of education that an employer specified as a minimum job requirement was not necessarily what he preferred. A limited supply of technical workers may have forced him to accept applicants with less education than he thought desirable. Whereas 52 percent of the biological, medical, and dental technicians, technologists, and specialists were employed where education beyond high school was a minimum job requirement, 65 percent had employers who preferred such training. (See table VI-5, at the end of the chapter.)

The majority of employers who expressed preferences had high school as their minimum standard. For such employers, the most usual preference was graduation from a technical institute or a community college. (See table VI-6, at the end of the chapter.)

In general, employers who specified education beyond high school as a prerequisite to hiring seem to have been satisfied with their workers' backgrounds. However, in a number of instances where gradu^tion from a technical institute was the minimum requirement, employers expressed a preference for college graduation.

Experience Requirements

For half of all biological, medical, dental, and related science technicians, technologists, and specialists, employers required applicants to have some work experience as a condition of appointment to the job. Such experience would usually be in the same line of work, but at a lower level. The most usual experience requirement amounted to less than two years, especially for workers in single-grade structures and at the lowest levels of a multi-grade structure. In the highest grades and at supervisory levels, 3 or more years of experience were usually required. Many employers wanted supervisors to have at least 5 years of experience. (See table VI-G.)

Table VI-G. PERCENT DISTRIBUTION OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS ACCORDING TO YEARS OF EXPERIENCE REQUIRED, BY GRADE

Grade	Total	No experience	Under 2 years	2 and under 3	3 and under 5	5 and over
All grades	100.0	49.3	20.8	13.0	10.3	6.6
Supervisory grades	100.0	7.9	11.6	18.2	21.5	40.8
Nonsupervisory grades:						
Single grade only	100.0	60.2	21.0	9.6	5.6	3.6
Multi-grade:						
Lowest grades	100.0	42.7	28.5	18.2	8.2	2.4
Middle grades	100.0	26.0	27.7	26.1	17.9	2.3
Highest grades	100.0	8.9	10.1	21.8	37.9	21.3

Table VI-H. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY GRADE AND BY SELECTED OCCUPATION

Grade; occupation	All levels	Post-high-school	High school
All grades; all occupations	0.0	0.0	1.2
Grades			
Supervisory grades	3.9	3.3	5.7
Nonsupervisory grades:			
Single grade only	0.0	0.0	0.0
Multi-grade:			
Lowest grades	1.1	0.0	1.9
Middle grades	2.3	1.6	2.8
Highest grades	3.3	2.5	3.9
Selected occupations			
Agricultural and related	2.1	0.0	2.4
Bacteriology (microbiology)	1.9	1.5	2.8
Biochemistry	1.6	1.0	2.6
Tissue (histology)	1.0	1.1	2.3
Cytology	2.0	0.5	2.9
Hematology	1.5	0.9	2.6
Blood bank	1.6	1.3	2.1
Serology	0.5	0.0	2.3
General biological and medical laboratory	1.6	0.9	2.3
X-ray and related equipment technicians	1.2	0.0	2.6
Medical record librarians	2.7	1.2	2.9
Dental ceramists	3.8	1.0	4.3
Dental mechanics	2.2	0.0	2.7

Table VI-H indicates that in general employers required less experience from applicants for whom post-high-school education was specified than for those for whom high-school graduation was the minimum requirement. Over-all, about one more year of experience was required if the applicant was only a high-school graduate (based on median years of experience required). The table shows -- for the various grades and also for thirteen selected occupations -- the difference between the average experience required of those who only went to high school and those who went further.

For supervisory grades, the difference was about two years. In the single-grade category the "high school" median was the same as the "post-high-school" median (in both groups the years of experience required were zero in the middle case). The lack of difference is attributable in part to the fact that among occupations covered by this chapter are some, such as dental assistant and dental technician, for which almost all employers required only high-school education, and others, such as dental hygienist, for which all employers required further education. As a result the occupational composition of the "high-school education required" group differs from that of the "post-high-school education required" group, and this obscures the connection between education required and experience required.

Table VI-I. NUMBER OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS ACCORDING TO EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

Kind of preference	Education required		
	All levels	Post-high-school	High school
Total	25,445	13,143	12,302
No preference expressed	18,153	10,135	8,018
All preferences	7,292	3,008	4,284
Required education, more experience	1,690	957	733
More than required education, less experience	2,355	608	1,747
More than required education, same experience	2,568	1,136	1,432
More than required education, more experience	679	307	372

A comparison of employer requirements and preferences concerning education plus experience indicates that the most common preference was for more education and the same experience. (Table VI-I, based on table VI-7 at the end of the chapter.)

Recent Trends in Education and Experience Requirements

Many institutions, including some of the largest and best-equipped hospitals, have heretofore placed great value on heavy work-experience, that is, on long experience in an outstanding hospital or other institution. In hiring, people with this kind of experience were often preferred to those with more education but no experience.

Recent advances in medicine and a great increase in research activity have resulted in considerable expansion in the volume of work and an increase in the complexity of procedures in the clinical laboratory, the X-ray laboratory, the medical record department, etc. These factors, as well as greater mechanization, have made employers re-evaluate their policies as to the type of worker needed and the relative importance of work experience vs. formal training.

For the clinical laboratory, for example, some establishments will now hire only college graduates for all types of testing (with the exception of histology and cytology), while others use college graduates primarily in supervisory capacities -- frequently as section heads or chief technologists -- or to perform the more complicated and unusual procedures. Often a college degree or certification by a professional society may be required for clinical laboratory work in chemistry and bacteriology, while less training is called for in other specialties. Although this trend in upgrading was apparent at the time of the survey, it has continued since the field work on the survey was completed.

Another factor that has been instrumental in raising requirements in some establishments is the recent New York State and New York City legislation regulating clinical laboratories; the technical performance standards of workers in these laboratories; and standards for X-ray technicians. Although some employers with sub-minimum standards were aware of the impending legislation at the time of the survey and made upward adjustments in their educational and experience requirements for laboratory technician and X-ray technician in anticipation of the legislation, others did not make adjustments until after the field survey was completed. (See the next section for details.)

Considering all these factors it is probable that educational requirements are somewhat higher today than at the time of the field survey, especially for certain technical workers in biological and medical laboratories, X-ray technicians, and medical record librarians.

Recent State and Local Regulation of Laboratory Services and X-ray Technology

The organization of clinical laboratories in New York State -- whether in hospitals or elsewhere -- and their staffing patterns have been influenced in some degree by State and local regulations adopted in 1963 and 1964.1/ An additional law, enacted in 1964, has also affected standards and hiring practices in X-ray technology.

New York City, 1963. In line with "the general demand for higher standards in clinical laboratory practices and in technical performance" and "the recognized need for better trained technical personnel," the New York City Board of Health in 1963 revised Article 13 of the New York City Health Code, which is concerned with clinical laboratories. The revised article, which became effective December 1, 1963, defines a clinical laboratory and requires the owner to obtain a permit from the Commissioner of Health after complying with specified conditions.

1. These exclude clinical laboratories maintained by New York State and the Federal government.

The Code defines technical and professional workers at various levels and prescribes, for the first time, the minimum educational and experience requirements for each level. The specific classifications are: clinical laboratory director, clinical laboratory associate director, supervisor, technologist, technician, and trainee, and histology technician. For employment in each of these jobs, except histology technician, a certificate of qualification is needed, issued by the Commissioner of Health.

The Code defines a "clinical laboratory technologist" as "an individual who, under general supervision, performs clinical laboratory tests which require the exercise of independent judgment." A "clinical laboratory technician" is defined as "an individual who carries out laboratory procedures which require limited technical skill and responsibility and who, during the major portion of his working time, performs under direct supervision."

For the job of clinical laboratory technologist, requirements for a certificate are:

a. A bachelor's degree with a major in one of the biological, chemical, or physical sciences plus one year of approved employment as a clinical laboratory technician or trainee or one year of approved clinical laboratory internship as part of the college curriculum; or
b. Registration by a national board sponsored by a national professional society acceptable to the Department of Health.
c. For persons employed prior to February 4, 1963, when this regulation was adopted, high-school graduation plus 10 years of experience as a clinical laboratory technician. (15 approved college credit hours may be substituted for each year of employment up to 8 years.)

For the job of clinical laboratory technician, requirements for a certificate are:

a. Sixty semester hours in an institution accredited by the Association of American Universities, or by an acceptable equivalent accrediting agency, which include courses in general chemistry, mathematics, and biology or microbiology, plus one year of employment as a laboratory technician or trainee in an approved clinical laboratory (six months experience as a laboratory technician immediately prior to February 4, 1963), or
b. For persons employed as laboratory technicians for at least six months immediately prior to February 4, 1963, high-school graduation plus five years of employment as a laboratory technician in an approved laboratory, or

c. High-school graduation and subsequent to graduation two years of experience as a technician trainee in a clinical laboratory with an approved training program.
d. High-school graduation and passing a written, oral, and practical examination.

Two years is the normal training period of a clinical laboratory trainee. Before entering on it, he must obtain a certificate of qualification, showing that his training will be obtained at a laboratory approved by the Department of Health as a training laboratory.

New York State, 1964. The New York State Public Health Law was amended in 1964 to require the licensing of clinical laboratories and blood banks, to establish minimum qualifications for laboratory directors, and to require that procedures in clinical laboratories and blood banks meet minimum standards approved by the State Health Department. The law provides that, outside New York City, laboratory permits and certificates of qualifications for laboratory directors are to be issued by the State Department of Health; in New York City permits and certificates of qualification are to be issued by the City Department of Health under the New York City Health Code. The State law, which will go into effect on July 1, 1965, makes no provision for regulation of technical personnel.

Another amendment to the State Public Health Law in 1964, whose purpose was to provide safeguards "against the harmful effects of excessive and improper exposure to ionizing radiation," establishes standards of education, training, and experience for X-ray technicians and provides for licensing of practitioners of X-ray technology by the State Department of Health.

Effective October 1, 1965, all X-ray technicians will be required to have licenses issued by the State Department of Health and must pass a written examination. To be eligible to take the examination, the applicant must have:

a. graduated from high school. and
b. completed a 24-month course of study in X-ray technology in a registered school of X-ray technology.

The law specifies the subjects to be included in the school curriculum and requires that registered schools of X-ray technology be affiliated with general hospitals for the purpose of providing students with the requisite clinical experience.

TESTS, LICENSES, AND PROFESSIONAL ACCREDITATION

In 1962, one-fourth (24.4 percent) of the biological, medical, and dental technicians, technologists, and specialists were required to take a test or have a government license[1] or accreditation from a professional society as a prerequisite for hiring. These workers were distributed as follows:

10.7 percent - State license (required of all physical therapists and dental hygienists). Figure includes therapists who were also required to have professional accreditation.

10.0 percent - civil service examination. Figure does not include physical therapists or dental hygienists who were required to take a civil service examination as well as have a license.

3.7 percent - accreditation from a professional society. (Such accreditation was specified as a minimum job requirement for 18 percent of medical record librarians, 14 percent of X-ray technicians, 4 percent of medical laboratory technologists, and 7 percent of occupational therapists. In addition there were a number of employers who expressed a preference for workers with accreditation but did not require it.)

State Licenses

Physical therapist. A physical therapist must have a license from the State Education Department to administer physiotherapy. To qualify for such a license, the physical therapist must be a graduate of an approved physical therapy program in a four-year college and pass a written and practical examination.

1. Requirements for a certificate of qualification to be a clinical laboratory technician and technologist in New York City or an X-ray technician, throughout the State, (outlined in the preceding section on recent regulations) are not included in this section because the laws in question became effective after the field work on the survey was completed.

This requirement went into effect July 1, 1954. However, a worker is allowed to administer physical therapy with a permit ("green card") rather than a license if he has on file with the Education Department satisfactory proof that he was employed as a physical therapist for two years before April 10, 1950. Under this grandfather clause, the "green-card holder", who generally does not meet educational requirements for a license, may continue to administer physical therapy, but only under the control of a licensed physician or licensed physical therapist.

Dental hygienist. As a condition of employment a dental hygienist must have a license from the State Education Department. To qualify for a license, an applicant must be a graduate of an approved one-year post-high-school course in dental hygiene and pass a written and practical examination. The examination covers subjects such as anatomy, physiology, nutrition, preventive dentistry, materia medica, dental hygiene, pathology, and bacteriology.

Accreditation by a Professional Society

Medical technologist. The Board of Registry of Medical Technologists of the American Society of Clinical Pathologists grants accreditation or professional certification to medical technologists who fulfill certain educational requirements and pass an examination given by the Board of Registry. General certification MT (ASCP) is the most usual type of certification. For this, educational requirements are three years of college training with specified courses in chemistry, biological sciences, and mathematics, plus at least 12 months of training in a school of medical technology approved by the Council on Medical Education and Hospitals of the American Medical Association. (When the technology school is affiliated with a college or university this four-year training may lead to a B.S. in Medical Technology.)

The Registry of Medical Technologists recently has revised requirements for general certification, so that technologists who have college degrees including courses in biology and chemistry which meet the present requirements in these subjects may be considered for examination even though they have had no training in an approved school of medical technology. These technologists, however, must have had five years of experience in an acceptable medical laboratory, with at least two years under the supervision of a pathologist certified by the American Board of Pathology and a registered Medical Technologist (ASCP).

In addition to the general certification, several other classifications have been established by the Registry of Medical Technologists. The certificate in Blood Banking requires general certification MT (ASCP) plus one year of training in an approved center for blood bank training. Training and examination are given in association with the American Association of Blood Banks.

The Board of Registry also grants limited certification following examination, for chemistry technologist and microbiology technologist (basic requirements are a bachelor's degree in the specialty) and for histologic techniques. For the latter certificate, HT (ASCP), a high school diploma, a year of supervised training in a clinical pathology laboratory, and the passing of both a written and practical examination are required.

For certification in exfoliative cytotechnology, two years of college, including 12 semester hours of biology, are required, plus six months of training in an approved laboratory school and six months of full-time work under supervision in an approved cytology laboratory. Upon completion of training students are eligible for the certifying examination for CT (ASCP).

X-ray technologist.[1] The American Registry of Radiologic Technologists, the certifying board sponsored by the American College of Radiology and

1. Since 1962, the Registry also conducts examinations and grants certification in radiation therapy technology and nuclear medicine technology.

the American Society of Radiologic Technologists, grants a certificate of registration to X-ray technologists who are high-school graduates, have had two years of training and experience under a recognized medical radiologist, and have passed a written examination given by the Registry. The examination covers anatomy and physiology, X-ray physics and electricity, radiographic techniques, darkroom procedures, and medical terminology. Those who are granted the certificate may use the title "Registered X-ray Technologist" or its abbreviation RT (ARRT).

After July 1, 1966, the applicant for registration will be required to have completed a two-year post-high-school program of formal tr- ning approved by the Council on Education of the American Medical Association.

Physical therapist. Hospitals and other agencies sometimes require registration by the American Registry of Physical Therapists. Qualifications for such registration are the completion of a four-year college course in physical therapy in a school approved by the American Medical Association in collaboration with the American Physical Therapy Association, and the passing of an examination in physical therapy given by the Board of Registry.

The curriculum of approved schools includes the humanities and social studies; sciences such as anatomy, physiology, pathology, and psychology; physical therapy theory and clinical training.

Occupational therapist. Requirements for accreditation by the American Occupational Therapy Association, OTR (AOTA), include graduation from a four-year college whose curriculum in occupational therapy is approved by the American Medical Association and the American Occupational Therapy Association, and passing an examination given by the latter Association.

The curriculum of approved schools includes liberal arts; science courses such as anatomy, kinesiology, neuroanatomy, physiology, and psychology;

theory of occupational therapy; technical training in fine and applied arts, recreation, and special education; and clinical training.

Medical record librarians and technicians. Librarians are eligible for registration (RRL) by the American Association of Medical Record Librarians, if they are graduates of an approved school for medical record librarians and pass an examination given by the Association. The curriculum of an approved school leads to a bachelor's degree or a certificate in medical record science. (Until January 1, 1965, a combination of education and experience could be substituted for graduation from an approved school.) The curriculum includes anatomy, physiology, bacteriology, fundamentals of medical science, medical record science and administration, medical terminology, organization and administration of hospitals and other health agencies, legal aspects of medical record science, and directed practice experience.

Medical record technicians are eligible for accreditation (ART) by the Association of Medical Record Librarians if they are graduates of an approved school for medical record technicians or have completed the Association's correspondence course for medical record personnel, and passed an examination given by the Association. An approved course of training for technicians includes not less than 9 months of practical hospital experience and theoretical instruction in subjects such as anatomy, medical terminology, and medical records.

SOURCES OF WORKERS

During a two-year period preceding the survey (or other representative current period), four out of every five (82 percent) biological, medical, and dental technicians, technologists, and specialists were obtained by recruitment from outside the establishment; the remainder were upgraded. Organized training sponsored by the employer plays a small role in the upgrading process, although many workers learn their skills by informal on-the-job training. A beginning

Table VI-J. PERCENT DISTRIBUTION OF BIOLOGICAL, MEDICAL, DENTAL, AND RELATED TECHNICIANS, TECHNOLOGISTS, AND SPECIALISTS ACCORDING TO METHOD OF OBTAINING THEM, BY GRADE AND BY SELECTED OCCUPATION

Grade; occupation	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All grades; all occupations	100.0	81.5	1.2	17.3
<u>Grade</u>				
Supervisory	100.0	49.9	1.3	48.8
Nonsupervisory:				
Single grade only	100.0	90.7	1.2	8.1
Multi-grade:				
Lowest grades	100.0	83.2	1.8	15.0
Middle grades	100.0	43.7	0.7	55.6
Highest grades	100.0	46.2	0.8	53.0
<u>Selected occupation</u>				
Biological and medical laboratory	100.0	76.9	0.8	22.3
General medical assistants, doctor's office	100.0	99.9	-	0.1
X-ray and related equipment technicians	100.0	79.0	2.9	18.1
Electrocardiograph	100.0	72.2	0.4	27.4
Electroencephalograph	100.0	80.5	1.9	17.6
Therapists	100.0	80.0	0.4	19.6
Medical record librarians	100.0	80.4	1.2	18.4
Dental laboratory technicians	100.0	82.2	0.1	17.7
Dental hygienists	100.0	99.1	-	0.9
Dental assistants	100.0	98.5	-	1.5

worker may first be shown how to perform simple routine procedures. When he gains some proficiency, he may be taught more advanced procedures. (See table VI-J.)

A number of hospitals in New York State operate schools in which students are given academic and clinical training in technical occupations such as laboratory technologist and X-ray technician. These trainees do not necessarily become employees of the hospital in which they are trained. (For further details, see volume 1, chapter IX.)

Recruitment is more important as a method of obtaining workers in the biological, medical, and dental fields than for any other technical-occupation category. This may be attributable in part to the relatively small proportion of workers in this occupational group who are in multi-grade structures and to the fact that in general there is not much upgrading from nontechnical to technical jobs in these fields.

As shown, in table VI-J, even at the supervisory levels and at the middle and highest grades in multi-grade structures, a substantial proportion of the technical jobs are filled by recruitment. This suggests that there is considerable turnover among these workers.

There is considerable variation from occupation to occupation in method of obtaining workers. For certain jobs, such as general assistant in a doctor's office or dental assistant, almost all workers are recruited, since there is often only one employee. About a fourth of the workers are obtained by upgrading in the numerically most important occupation -- biological and medical technician and technologist.

PROMOTIONAL LINES

Promotion is not a factor in a number of technical jobs in the biological, medical, and dental fields. Workers in occupations such as general medical assistant in a doctor's office, dental laboratory technician, dental hygienist, and dental assistant are usually recruited from the outside and have little opportunity for advancement because there are few senior-level jobs in these areas. Some of these workers, however, such as dental technician, may be required to perform more complex procedures as they gain in experience.

The most common promotional lines involve different grades of the same or related technician jobs in establishments that have multi-grade classifications. In departments of nongovernmental hospitals, for example, a worker may move from trainee to X-ray technician, to senior technician, to supervisor and chief technician. In clinical laboratories, in some instances a technician starts as a general worker and is promoted to a specialty field such as bacteriology, biochemistry, or blood bank. From these jobs he may be promoted to supervisor, section head, or chief technologist. On some of the higher levels, workers must satisfy educational requirements before they can be advanced. In the clinical laboratory, technicians and technologists may move to professional jobs such as biochemist or bacteriologist if they meet educational requirements. On lower levels, an avenue of promotion for nurses' aides and orderlies (usually with operating room experience) is to the job of operating room or surgical technician. Nurses' aides may also be promoted to the job of electrocardiograph technician. X-ray department orderlies or clinical laboratory assistants may occasionally be promoted to technician jobs.

Biological, Medical, Dental, and Related Science Technicians, Technologists, and Specialists

Table VI-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

A. Agricultural and Biological and Medical Laboratory Technicians and Technologists

Industry group	All occupations	Agricultural and related	Biological and medical laboratory								
			Total	Bacteriology (microbiology)	Biochemistry	Tissue (histology)	Cytology	Hematology	Blood bank	Serology	General and other
All industries	25,445	340	9,898	727	837	428	122	617	380	106	6,681
Manufacturing	488	37	331	150	73	3	-	-	-	-	105
Durable goods	131	-	18	1	-	-	-	-	-	-	17
Ordnance and accessories	1	-	-	-	-	-	-	-	-	-	-
Stone, clay, and glass products	2	-	-	-	-	-	-	-	-	-	-
Primary metal industries	4	-	2	-	-	-	-	-	-	-	2
Machinery, except electrical	5	-	5	-	-	-	-	-	-	-	5
Electrical machinery and equipment	6	-	2	-	-	-	-	-	-	-	2
Transportation equipment	7	-	-	-	-	-	-	-	-	-	-
Instruments; photographic and optical goods	106	-	9	1	-	-	-	-	-	-	8
Nondurable goods	357	37	313	149	73	3	-	-	-	-	88
Food and kindred products	13	4	5	3	-	-	-	-	-	-	2
Paper and allied products	2	-	1	1	-	-	-	-	-	-	-
Printing, publishing, and allied industries	2	-	2	-	-	-	-	-	-	-	2
Chemicals and allied products	335	33	302	145	73	3	-	-	-	-	81
Petroleum refining and related industries	5	-	3	-	-	-	-	-	-	-	3
Nonmanufacturing	24,957	303	9,567	577	764	425	122	617	380	106	6,576
Transportation, communication, and public utilities	12	-	8	-	-	-	-	-	-	-	8
Air transportation	5	-	4	-	-	-	-	-	-	-	4
Communication	7	-	4	-	-	-	-	-	-	-	4
Wholesale trade	54	-	52	2	-	-	-	-	-	-	50
Finance, insurance, and real estate	69	1	36	-	1	-	-	-	-	-	35
Banking	3	-	1	-	-	-	-	-	-	-	1
Insurance carriers	60	1	32	-	1	-	-	-	-	-	31
Insurance agents, brokers, and services	4	-	2	-	-	-	-	-	-	-	2
Holding and other investment companies	2	-	1	-	-	-	-	-	-	-	1

Continued

Table VI-1, part A (concluded)

Industry group	All occupations	Agricultural and related	Biological and medical laboratory: Total	Bacteriology (microbiology)	Biochemistry	Tissue (histology)	Cytology	Hematology	Blood bank	Serology	General and other
Nonmanufacturing (continued)											
Services and miscellaneous	19,433	174	7,396	475	615	338	108	513	346	73	4,928
Business services n.e.c.	75	-	74	9	18	4	-	4	-	-	39
Research, development, testing laboratories	74	-	73	9	18	4	-	4	-	-	38
Business and management consulting services	1	-	1	-	-	-	-	-	-	-	1
Private medical services	16,454	-	4,992	412	526	305	102	477	345	73	2,752
Offices of physicians and surgeons	2,173	-	407	51	1	2	7	25	-	-	321
Offices of dentists and dental surgeons	3,284	-	-	-	-	-	-	-	-	-	-
Hospitals (nongovernment)	7,363	-	3,932	341	493	295	90	427	262	66	1,958
Proprietary hospitals	568	-	325	16	20	29	-	30	13	10	207
Voluntary hospitals	6,795	-	3,607	325	473	266	90	397	249	56	1,751
Medical and dental laboratories	3,143	-	476	20	32	8	5	25	6	7	373
Offices of osteopathic physicians, chiropractors, and health and allied services n.e.c.	491	-	177	-	-	-	-	-	77	-	100
Private colleges and schools	2,199	166	1,885	47	63	22	1	31	-	-	1,721
Nonprofit membership organizations	327	-	77	6	6	-	-	-	-	-	65
Nonprofit educational and scientific research	378	8	368	1	2	7	5	1	1	-	351
Government	5,389	128	2,075	100	148	87	14	104	34	33	1,555
County	667	8	388	31	23	16	6	22	12	18	260
Hospitals	309	-	144	20	22	6	1	20	10	5	60
Other	358	8	244	11	1	10	5	2	2	13	200
New York State	1,106	90	600	19	29	36	2	11	-	-	503
Hospitals	469	-	138	1	12	12	1	11	-	-	101
Colleges	397	21	364	7	17	22	-	-	-	-	318
Other	240	69	98	11	-	2	1	-	-	-	84
New York City	1,760	-	607	6	28	3	-	31	14	3	522
Hospitals	1,258	-	433	6	15	3	-	31	14	1	363
Colleges	35	-	35	-	-	-	-	-	-	-	35
Other	467	-	139	-	13	-	-	-	-	2	124
Cities other than New York City	262	1	72	-	-	4	-	4	1	1	62
Hospitals	48	-	19	-	-	-	-	-	-	-	19
Other	214	1	53	-	-	4	-	4	1	1	43
Towns and villages	458	-	24	-	-	-	-	-	-	-	24
Hospitals	48	-	24	-	-	-	-	-	-	-	24
Other	410	-	-	-	-	-	-	-	-	-	-
Federal	1,136	29	384	44	68	28	6	36	7	11	184
Hospitals	951	-	329	35	58	28	6	36	7	11	148
Colleges	3	-	1	-	-	-	-	-	-	-	1
Arsenals and navy yards	4	-	1	-	-	-	-	-	-	-	1
Other	178	29	53	9	10	-	-	-	-	-	34

Table VI-1 (continued)

B. X-ray and Other Medical Technicians

Industry group	General medical assistants, doctor's office (a)	X-ray and related equipment technicians	Other medical technicians: Total	Electrocardiograph	Electroencephalograph	Inhalation therapy	Other
All industries	1,114	3,013	1,801	548	159	153	941
Manufacturing	2	30	84	2	-	-	82
Durable goods	1	26	84	2	-	-	82
Ordnance and accessories	-	1	-	-	-	-	-
Stone, clay, and glass products	-	2	-	-	-	-	-
Primary metal industries	-	1	1	-	-	-	1
Machinery, except electrical	-	-	-	-	-	-	-
Electrical machinery and equipment	-	1	3	-	-	-	3
Transportation equipment	-	7	-	-	-	-	-
Instruments; photographic and optical goods	1	14	80	2	-	-	78
Nondurable goods	1	4	-	-	-	-	-
Food and kindred products	-	2	-	-	-	-	-
Paper and allied products	1	-	-	-	-	-	-
Printing, publishing, and allied industries	-	-	-	-	-	-	-
Chemicals and allied products	-	-	-	-	-	-	-
Petroleum refining and related industries	-	2	-	-	-	-	-
Nonmanufacturing	1,112	2,983	1,717	546	159	153	859
Transportation, communication, and public utilities	-	4	-	-	-	-	-
Air transportation	-	1	-	-	-	-	-
Communication	-	3	-	-	-	-	-
Wholesale trade	-	-	2	-	-	-	2
Finance, insurance, and real estate	1	9	3	3	-	-	-
Banking	1	1	-	-	-	-	-
Insurance carriers	-	7	3	3	-	-	-
Insurance agents, brokers, and services	-	-	-	-	-	-	-
Holding and other investment companies	-	1	-	-	-	-	-
Services and miscellaneous	1,111	2,253	1,260	458	117	94	591
Business services n.e.c.	-	1	-	-	-	-	-
Research, development, testing laboratories	-	1	-	-	-	-	-
Business and management consulting services	-	-	-	-	-	-	-

Continued

Table VI-1, part B (concluded)

Industry group	General medical assistants, doctor's office (a)	X-ray and related equipment technicians	Other medical technicians: Total	Electrocardiograph	Electroencephalograph	Inhalation therapy	Other
Nonmanufacturing (continued)							
Services and miscellaneous (continued)							
Private medical services	1,111	2,163	1,204	451	114	74	565
Offices of physicians and surgeons	1,100	480	112	81	31	-	-
Offices of dentists and dental surgeons	-	3	-	-	-	-	-
Hospitals (nongovernment)	-	1,521	1,059	340	83	73	563
Proprietary hospitals	-	149	58	33	6	5	14
Voluntary hospitals	-	1,372	1,001	307	77	68	549
Medical and dental laboratories	1	36	5	4	-	1	-
Offices of osteopathic physicians, chiropractors, and health and allied services n.e.c.	10	123	28	26	-	-	2
Private colleges and schools	-	52	31	7	3	-	21
Nonprofit membership organizations	-	36	25	-	-	20	5
Nonprofit educational and scientific research	-	1	-	-	-	-	-
Government	-	717	452	85	42	59	266
County	-	96	46	8	2	5	31
Hospitals	-	73	26	8	2	3	13
Other	-	23	20	-	-	2	18
New York State	-	95	23	-	9	-	14
Hospitals	-	59	19	-	9	-	10
Colleges	-	8	3	-	-	-	3
Other	-	28	1	-	-	-	1
New York City	-	334	194	46	19	50	79
Hospitals	-	285	194	46	19	50	79
Colleges	-	-	-	-	-	-	-
Other	-	49	-	-	-	-	-
Cities other than New York City	-	31	8	2	-	2	4
Hospitals	-	21	4	2	-	2	-
Other	-	10	4	-	-	-	4
Towns and villages	-	18	-	-	-	-	-
Hospitals	-	18	-	-	-	-	-
Other	-	-	-	-	-	-	-
Federal	-	143	181	29	12	2	138
Hospitals	-	127	124	24	11	2	87
Colleges	-	1	-	-	-	-	-
Arsenals and navy yards	-	-	-	-	-	-	-
Other	-	15	57	5	1	-	51

Table VI-1 (continued)

C. Therapists, Medical Record Librarians, and Dental Technicians

Industry group	Therapists: Total	Therapists: Physical	Therapists: Occupational, recreational, and other	Medical record librarians	Dental laboratory technicians: Total	Dental laboratory technicians: Ceramists	Dental laboratory technicians: Dental mechanics	Dental hygienists	Dental assistants
All industries	1,883	1,003	880	347	2,844	216	2,628	1,874	2,331
Manufacturing	2	2	-	-	-	-	-	2	-
Durable goods	2	2	-	-	-	-	-	-	-
Ordnance and accessories	-	-	-	-	-	-	-	-	-
Stone, clay, and glass products	-	-	-	-	-	-	-	-	-
Primary metal industries	-	-	-	-	-	-	-	-	-
Machinery, except electrical	-	-	-	-	-	-	-	-	-
Electrical machinery and equipment	-	-	-	-	-	-	-	-	-
Transportation equipment	-	-	-	-	-	-	-	-	-
Instruments; photographic and optical goods	2	2	-	-	-	-	-	-	-
Nondurable goods	-	-	-	-	-	-	-	2	-
Food and kindred products	-	-	-	-	-	-	-	2	-
Paper and allied products	-	-	-	-	-	-	-	-	-
Printing, publishing, and allied industries	-	-	-	-	-	-	-	-	-
Chemicals and allied products	-	-	-	-	-	-	-	-	-
Petroleum refining and related industries	-	-	-	-	-	-	-	-	-
Nonmanufacturing	1,881	1,001	880	347	2,844	216	2,628	1,872	2,331
Transportation, communication, and public utilities	-	-	-	-	-	-	-	-	-
Air transportation	-	-	-	-	-	-	-	-	-
Communication	-	-	-	-	-	-	-	-	-
Wholesale trade	-	-	-	-	-	-	-	-	-
Finance, insurance, and real estate	4	4	-	-	1	-	1	12	2
Banking	-	-	-	-	-	-	-	-	-
Insurance carriers	4	4	-	-	1	-	1	10	2
Insurance agents, brokers, and services	-	-	-	-	-	-	-	2	-
Holding and other investment companies	-	-	-	-	-	-	-	-	-
Services and miscellaneous	945	616	329	271	2,790	216	2,574	1,050	2,183
Business services n.e.c.	-	-	-	-	-	-	-	-	-
Research, development, and testing laboratories	-	-	-	-	-	-	-	-	-
Business and management consulting services	-	-	-	-	-	-	-	-	-

Continued

Table VI-1, part C (concluded)

Industry group	Therapists: Total	Therapists: Physical	Therapists: Occupational, recreational, and other[a]	Medical record librarians	Dental laboratory technicians: Total	Dental laboratory technicians: Ceramists	Dental laboratory technicians: Dental mechanics	Dental hygienists	Dental assistants
Nonmanufacturing (continued)									
Services and miscellaneous (continued)									
Medical and other health services	744	543	201	265	2,769	216	2,553	1,043	2,163
Offices of physicians and surgeons	46	46	-	-	-	-	-	4	24
Offices of dentists and dental surgeons	-	-	-	-	142	9	133	1,016	2,123
Hospitals (nongovernment)	557	356	201	253	6	-	6	22	13
Proprietary hospitals	6	6	-	28	-	-	-	2	-
Voluntary hospitals	551	350	201	225	6	-	6	20	13
Medical and dental laboratories	-	-	-	-	2,621	207	2,414	1	3
Offices of osteopathic physicians, chiropractors, and health and allied services n.e.c.	141	141	-	12	-	-	-	-	-
Private colleges and schools	29	15	14	-	16	-	16	-	20
Nonprofit membership organizations	171	57	114	6	5	-	5	7	-
Nonprofit educational and scientific research	1	1	-	-	-	-	-	-	-
Government	932	381	551	76	53	-	53	810	146
County	94	64	30	10	-	-	-	25	-
Hospitals	52	32	20	10	-	-	-	4	-
Other	42	32	10	-	-	-	-	21	-
New York State	250	94	156	4	6	-	6	36	2
Hospitals	216	68	148	4	5	-	5	28	-
Colleges	1	1	-	-	-	-	-	-	-
Other	33	25	8	-	1	-	1	8	2
New York City	311	140	171	47	-	-	-	178	89
Hospitals	286	126	160	47	-	-	-	13	-
Colleges	-	-	-	-	-	-	-	-	-
Other	25	14	11	-	-	-	-	165	89
Cities other than New York City	5	5	-	1	-	-	-	144	-
Hospitals	3	3	-	1	-	-	-	-	-
Other	2	2	-	-	-	-	-	144	-
Towns and villages	4	4	-	2	-	-	-	410	-
Hospitals	4	4	-	2	-	-	-	-	-
Other	-	-	-	-	-	-	-	410	-
Federal	268	74	194	12	47	-	47	17	55
Hospitals	255	67	188	12	44	-	44	13	47
Colleges	-	-	-	-	1	-	1	-	-
Arsenals and navy yards	3	-	3	-	-	-	-	-	-
Other	10	7	3	-	2	-	2	4	8

a. Other than nurse or secretary.

Biological, Medical, Dental, and Related Science Technicians, Technologists, and Specialists

Table VI-2. OCCUPATION OF SUPERVISORS

(Percent distribution of technicians, technologists, and specialists according to supervisor's occupation)

Occupation	Total number	Occupation of supervisor		
		Scientist	Technician (a)	Other
All occupations	100.0	24.5	38.0	37.5
Agricultural and related	100.0	43.8	36.2	20.0
Biological and medical laboratory	100.0	48.1	43.9	8.0
Bacteriology (microbiology)	100.0	61.9	36.6	1.5
Biochemistry	100.0	54.6	44.2	1.2
Tissue (histology)	100.0	43.2	53.5	3.3
Cytology	100.0	44.3	54.1	1.6
Hematology	100.0	42.9	52.1	5.0
Blood bank	100.0	36.1	51.8	12.1
Serology	100.0	46.2	51.9	1.9
General and other	100.0	47.4	42.5	10.1
General medical assistants, doctor's office (other than nurse or secretary)	100.0	-	-	100.0
X-ray and related equipment technicians	100.0	38.3	56.0	5.7
Other medical technicians	100.0	8.6	19.7	71.7
Electrocardiograph	100.0	17.2	21.9	60.9
Electroencephalograph	100.0	18.2	18.2	63.6
Inhalation therapy	100.0	2.6	6.5	90.9
Other	100.0	3.0	20.8	76.2
Therapists	100.0	-	39.1	60.9
Physical	100.0	-	39.8	60.2
Occupational, recreational, and other	100.0	-	38.4	61.6
Medical record librarians	100.0	0.3	27.1	72.6
Dental laboratory technicians	100.0	0.1	61.2	38.7
Ceramists	100.0	-	62.5	37.5
Dental mechanics	100.0	0.1	61.1	38.8
Dental hygienists	100.0	0.1	0.1	99.8
Dental assistants	100.0	-	24.8	75.2

a. Biological, medical, dental, or related science technician, technologist, or specialist, or other technician.

Biological, Medical, Dental, and Related Science Technicians, Technologists, and Specialists

Table VI-3. EDUCATION EMPLOYERS REQUIRE, BY GRADE

(Number and percent distribution of technicians, technologists, and specialists according to level of education required)

Education required	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Nonsupervisory grades: Multi-grade: Lower grades	Nonsupervisory grades: Multi-grade: Higher grades (b)
Number					
All levels	25,445	1,039	17,508	3,216	3,682
Post-high-school	13,143	691	8,914	1,464	2,074
College, general	5,378	449	2,847	750	1,332
Graduation	4,623	406	2,371	640	1,206
Less than graduation	755	43	476	110	126
Technical institute or community college	7,173	229	5,540	695	709
Graduation	6,276	196	4,919	526	635
Less than graduation	897	33	621	169	74
Type not specified	582	12	518	19	33
Apprenticeship or armed forces school	10	1	9	-	-
High school	12,302	348	8,594	1,752	1,608
Technical or vocational	6	-	4	1	1
Other and not specified	12,296	348	8,590	1,751	1,607
Percent distribution					
All levels	100.0	100.0	100.0	100.0	100.0
Post-high-school	51.7	66.5	50.9	45.5	56.3
College, general	21.2	43.2	16.3	23.3	36.1
Graduation	18.2	39.1	13.6	19.9	32.7
Less than graduation	3.0	4.1	2.7	3.4	3.4
Technical institute or community college	28.2	22.0	31.5	21.6	19.3
Graduation	24.7	18.8	28.0	16.3	17.3
Less than graduation	3.5	3.2	3.5	5.3	2.0
Type not specified	2.3	1.2	3.0	0.6	0.9
Apprenticeship or armed forces school	(a)	0.1	0.1	-	-
High school	48.3	33.5	49.1	54.5	43.7
Technical or vocational	(a)	-	(a)	(a)	(a)
Other and not specified	48.3	33.5	49.1	54.5	43.7

a. Less than 0.05 of a percent.

b. Middle grades plus highest grades.

Biological, Medical, Dental, and Related Science Technicians, Technologists, and Specialists

Table VI-4. EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

(Percent distribution of technicians, technologists, and specialists according to level of education required)

Education required	All occupations	Agricultural and related	Biological and medical laboratory	General medical assistants, doctor's office (a)	X-ray and related equipment technicians	Other medical technicians: Total	Electrocardiograph	Electroencephalograph	Inhalation therapy	Other
All levels: number	25,445	340	9,898	1,114	3,013	1,801	548	159	153	941
Percent distribution										
All levels: percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	51.7	70.9	60.0	46.5	61.0	16.9	16.2	13.8	19.0	14.9
College, general	21.2	28.5	34.5	-	2.1	6.6	2.4	7.5	1.3	7.1
Graduation	18.2	27.0	28.2	-	1.9	5.3	1.9	4.4	1.3	5.4
Less than graduation	3.0	1.5	6.3	-	0.2	1.3	0.5	3.1	-	1.7
Technical institute or community college	28.2	41.8	24.2	35.0	54.7	8.5	11.2	5.0	15.7	6.3
Graduation	24.7	41.8	19.0	31.6	46.7	4.7	5.1	3.1	15.7	3.0
Less than graduation	3.5	-	5.2	3.4	8.0	3.8	6.1	1.9	-	3.3
Type not specified	2.3	0.6	1.3	11.5	4.2	1.3	2.6	1.3	1.3	0.6
Apprenticeship or armed forces school	(b)	-	(b)	-	-	0.5	-	-	0.7	0.9
High school	48.3	29.1	40.0	53.5	39.0	83.1	83.8	86.2	81.0	85.1
Technical or vocational	(b)	-	-	-	-	0.3	0.4	-	-	0.4
Other and not specified	48.3	29.1	40.0	53.5	39.0	82.8	83.4	86.2	81.0	84.7

Continued

Table VI-4 (concluded)

Education required	Therapists: Total	Therapists: Physical	Therapists: Occupational, recreational, and other	Medical record librarians	Dental laboratory technicians: Total	Dental laboratory technicians: Ceramists	Dental laboratory technicians: Dental mechanics	Dental hygienists	Dental assistants
All levels: number	1,883	1,003	880	347	2,844	216	2,628	1,874	2,331
Percent distribution									
All levels: percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	90.2	88.2	92.4	42.4	14.3	19.9	13.9	100.0	9.3
College, general	89.3	87.8	90.8	17.9	-	-	-	-	2.1
Graduation	87.3	86.8	87.6	15.6	-	-	-	-	-
Less than graduation	2.0	1.0	3.2	2.3	-	-	-	-	2.1
Technical institute or community college	0.2	-	0.5	23.3	12.9	19.9	12.3	100.0	2.4
Graduation	0.2	-	0.5	18.7	12.4	19.9	11.7	100.0	2.4
Less than graduation	-	-	-	4.6	0.5	-	0.6	-	-
Type not specified	0.7	0.4	1.1	1.2	1.4	-	1.6	-	4.8
Apprenticeship or armed forces school	-	-	-	-	-	-	-	-	-
High school	9.8	11.8	7.6	57.6	85.7	80.1	86.1	-	90.7
Technical or vocational	-	-	-	-	-	-	-	-	-
Other and not specified	9.8	11.8	7.6	57.6	85.7	80.1	86.1	-	90.7

a. Other than nurse or secretary.
b. Less than 0.05 of a percent.

Biological, Medical, Dental, and Related Science Technicians, Technologists, and Specialists

Table VI-5. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of technicians, technologists, and specialists, according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	25,445	25,445	100.0	100.0
Post-high-school	13,143	16,428	51.7	64.6
College, general	5,378	7,602	21.2	29.9
Graduation	4,622	6,484	18.2	25.5
Less than graduation	756	1,118	3.0	4.4
Technical institute or community college	7,173	7,784	28.2	30.6
Graduation	6,276	7,159	24.7	28.1
Less than graduation	897	625	3.5	2.5
Type not specified	582	1,018	2.3	4.0
Apprenticeship or armed forces school	10	24	(a)	0.1
High school	12,302	9,017	48.3	35.4
Technical or vocational	6	131	(a)	0.5
Other and not specified	12,296	8,886	48.3	34.9

a. Less than 0.05 of a percent.

Biological, Medical, Dental, and Related Science Technicians, Technologists, and Specialists

Table VI-6. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Number and percent distribution of technicians, technologists, and specialists according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require: Post-high-school: Post-high-school, total	College, general: Graduation	College, general: Less than graduation	Technical institute: Graduation	Technical institute: Less than graduation	Type not specified	Apprenticeship or armed forces school	High school: High school, total	High school: Technical or vocational	High school: Other and not specified
Number													
All levels	25,445	20,176	5,269	5,135	1,862	619	1,868	250	514	22	134	125	9
Post-high-school	13,143	11,293	1,850	1,841	1,354	72	415	-	-	-	9	-	9
College, general	5,378	5,121	257	257	251	-	6	-	-	-	-	-	-
Graduation	4,622	4,622	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	756	499	257	257	251	-	6	-	-	-	-	-	-
Technical institute or community college	7,173	5,666	1,507	1,507	1,079	58	370	-	-	-	-	-	-
Graduation	6,276	5,291	985	985	942	43	-	-	-	-	-	-	-
Less than graduation	897	375	522	522	137	15	370	-	-	-	-	-	-
Type not specified	582	504	78	77	24	14	39	-	-	-	1	-	1
Apprenticeship or armed forces school	10	2	8	-	-	-	-	-	-	-	8	-	8
High school	12,302	8,883	3,419	3,294	508	547	1,453	250	514	22	125	125	-
Technical and vocational	6	6	-	-	-	-	-	-	-	-	-	-	-
Other and not specified	12,296	8,877	3,419	3,294	508	547	1,453	250	514	22	125	125	-
Percent distribution													
All levels	100.0	79.3	20.7	20.2	7.3	2.4	7.4	1.0	2.0	0.1	0.5	0.5	(a)
Post-high-school	100.0	85.9	14.1	14.0	10.3	0.5	3.2	-	-	-	0.1	-	0.1
College, general	100.0	95.2	4.8	4.8	4.7	-	0.1	-	-	-	-	-	-
Graduation	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	66.0	34.0	34.0	33.2	-	0.8	-	-	-	-	-	-
Technical institute or community college	100.0	79.0	21.0	21.0	15.0	0.8	5.2	-	-	-	-	-	-
Graduation	100.0	84.3	15.7	15.7	15.1	0.6	-	-	-	-	-	-	-
Less than graduation	100.0	41.8	58.2	58.2	15.3	1.7	41.2	-	-	-	-	-	-
Type not specified	100.0	86.6	13.4	13.2	4.1	2.4	6.7	-	-	-	0.2	-	0.2
Apprenticeship or armed forces school	100.0	20.0	80.0	-	-	-	-	-	-	-	80.0	-	80.0
High school	100.0	72.2	27.8	26.8	4.1	4.4	11.9	2.0	4.2	0.2	1.0	1.0	-
Technical and vocational	100.0	(b)	-	-	-	-	-	-	-	-	-	-	-
Other and not specified	100.0	72.2	27.8	26.8	4.1	4.4	11.9	2.0	4.2	0.2	1.0	1.0	-

a. Less than 0.05 of a percent.
b. Not computed because of small number involved.

Biological, Medical, Dental, and Related Science Technicians, Technologists, and Specialists

Table VI-7. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number and percent distribution of technicians, technologists, and specialists according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
			Number				
All levels	25,445	18,153	7,292	1,690	2,355	2,568	679
Post-high-school	13,143	10,135	3,008	957	608	1,136	307
College, general	5,378	4,418	960	504	212	187	57
Graduation	4,622	3,956	666	472	140	17	37
Less than graduation	756	462	294	32	72	170	20
Technical institute or community college	7,173	5,318	1,855	339	382	896	238
Graduation	6,276	4,956	1,320	326	203	623	168
Less than graduation	897	362	535	13	179	273	70
Type not specified	582	397	185	106	14	53	12
Apprenticeship or armed forces school	10	2	8	8	-	-	-
High school	12,302	8,018	4,284	733	1,747	1,432	372
Technical or vocational	6	6	-	-	-	-	-
Other and not specified	12,296	8,012	4,284	733	1,747	1,432	372
			Percent distribution				
All levels	100.0	71.3	28.7	6.6	9.3	10.1	2.7
Post-high-school	100.0	77.1	22.9	7.3	4.6	8.7	2.3
College, general	100.0	82.1	17.9	9.4	3.9	3.5	1.1
Graduation	100.0	85.6	14.4	10.2	3.0	0.4	0.8
Less than graduation	100.0	61.1	38.9	4.2	9.5	22.6	2.6
Technical institute or community college	100.0	74.1	25.9	4.7	5.3	12.6	3.3
Graduation	100.0	79.0	21.0	5.2	3.2	9.9	2.7
Less than graduation	100.0	40.4	59.6	1.4	20.0	30.4	7.8
Type not specified	100.0	68.2	31.8	18.2	2.4	9.1	2.1
Apprenticeship or armed forces school	100.0	20.0	80.0	80.0	-	-	-
High school	100.0	65.2	34.8	6.0	14.2	11.6	3.0
Technical or vocational	100.0	(a)	-	-	-	-	-
Other and not specified	100.0	65.2	34.8	6.0	14.2	11.6	3.0

a. Not computed because of small number involved.

Chapter VII

INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS

About 5 percent of all workers in technician and related occupations are concerned with industrial processes, methods, planning, estimating, scheduling, and related functions. Broadly, they are divided into -

Industrial engineering technicians
Quality control and reliability technicians
Production planners, estimators, and related specialists
Equipment specialists

These four groups cover fifteen types of technician or specialist occupations.

Most of the industrial engineering technicians and related specialists work in establishments that make durable goods, especially plants that manufacture metal goods, machinery, and transportation equipment, and in government agencies, particularly in arsenals and navy yards. Their distribution by industry is seen in detail in Table VII-1, at the end of this chapter. Table VII-A gives the information in summary form, for each occupation studied in this chapter.

About half of the industrial engineering technicians and related specialists are supervised by engineers, one-fourth of them by other technicians and specialists in this field or some other field, and the remaining fourth by executives, production foremen, or persons in other capacities:

Occupation group	Total	Engineer or scientist	Technician	Other
All occupations	100.0	47.4	26.5	26.1
Industrial engineering technicians	100.0	59.9	18.3	21.8
Quality control and reliability technicians	100.0	47.3	33.2	19.5
Production planners, estimators, and related specialists	100.0	39.1	28.9	32.0
Equipment specialists	100.0	40.6	31.7	27.7

Table VII-A. NUMBER OF INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS BY OCCUPATION AND BY INDUSTRY DIVISION

Occupation	All industries	Manufacturing: Durable goods	Manufacturing: Nondurable goods	Government	All other
All occupations	6,901	4,753	477	1,145	526
Industrial engineering technicians	2,224	1,801	245	101	77
Time and motion study men and standards setters	1,104	949	134	9	12
Industrial process methods men	825	735	52	7	31
General	295	117	59	85	34
Quality control and reliability technicians	1,279	736	90	388	65
Production planners, estimators, and related specialists	2,918	2,133	135	429	221
Production planners	993	809	19	131	34
Production cost estimators	395	332	32	1	30
Production schedulers, coordinators, and expediters	515	403	24	56	32
Parts, equipment, and materials estimators, standardizers, coordinators, and catalogers	623	442	56	8	117
General	392	147	4	233	8
Equipment specialists	480	83	7	227	163
Electro equipment and systems	132	11	2	59	60
Industrial machinery, equipment, and tools	39	31	3	5	-
Ship and marine equipment	57	-	-	45	12
Aircraft, missiles, and automotive equipment	26	8	-	1	17
Ordnance	44	-	-	44	-
General and other	182	33	2	73	74

FUNCTIONS

Following are summary descriptions of the functions of the industrial engineering technicians and specialists.

Time and Motion Study Men and Standards Setters

Investigate and analyze operations being performed preparatory to making time studies from the standpoint of methods, utilization of equipment, materials, accuracy requirements, working conditions, operator skill and effort, including making allowances for items which cannot be corrected.

Using standard time-study procedure, they compile standard data, formulas, man-machine charts, flow charts, frequency charts, and station layouts.

They may also do one or more of the following:

Recommend the means to be used in developing standards, whether stop watch, MTM (method-time-measurement), micromotion, work sampling, synthetic standards, or a combination of these.

Plot statistical curves on speeds and feeds, performance, labor effectiveness figures, etc.

Suggest changes in method or equipment to obtain greater production at lower unit cost.

Establish or recommend standards of performance for wage determinations.

Establish or recommend wage incentive rates and allowances.

Review all existing work standards for incentive jobs to assure accuracy and reasonableness.

Explain and interpret work standards and incentive system proposals to union and management officials and others.

Review and prepare operation sheets, route sheets, and station layouts.

Investigate and analyze causes of bottlenecks and inefficient operations; this includes the making of time studies to check for and determine delays or idle time.

Prepare production engineering information for other departments to be used for cost estimating, production control, and engineering of new methods and processes.

Assist in the training of new operators for efficient time utilization.

Recommend safety measures.

Industrial Process Methods Men

Investigate manufacturing difficulties, such as machine operations that are not functioning properly; and analyze and correlate data to determine cause of difficulty and recommend corrective action.

Work with machine shop maintenance and tool design departments in the preparation of detail drawings and working blueprints.

Conduct test runs to check on changes in operations. Observe or obtain data on test runs. Accumulate and present data in report form to superior with recommendations for accepting, rejecting, or modifying proposed change.

Develop a knowledge of the methods of manufacturing the company's product. Maintain familiarity with company needs in respect to machinery and equipment and with new developments. Initiate studies to improve methods in company operations.

May make layout drawings of machines for new or revised method of manufacture.

May make space utilization studies in plant for various office departments.

General Industrial Engineering Technicians

These technicians are general assistants of industrial engineers. Assignments may include one or more of the following kinds of responsibility, among others:

Laying out and rearranging machinery and equipment.

Planning the flow of work.

Studying various production methods and their costs.

Conducting and interpreting time and motion studies. Carrying out work simplification analysis and related functions.

Determining work procedures.

Serving in coordinating capacity between production, personnel, and administration.

Conducting cost studies; preparing and modifying cost-estimating methods.

Estimating prices.

May do plant layout drafting.

May review employee suggestions for changes in methods and procedures.

Quality Control and Reliability Technicians

This classification includes two main types of work which may or may not be combined in the same job.

(1) One is the development and carrying out of statistical quality control procedures applied to products made and incoming materials. This involves the measurement of test and inspection results and the determination through use of statistical methods of how these results conform with established standards of quality and performance and permissible degrees of variability. It typically involves the establishment and supervision of sampling procedures and measurement of sampling errors and the forecasting of probabilities of poor quality.

(2) The other main type of work involves defining poor quality and then developing inspection and testing procedures for identifying the existence of poor quality, including characteristics to be checked and gauges and instruments to be used. It may involve modifying such procedures in the light of findings and may involve some supervision over inspection and testing procedures.

Quality control technicians, especially in government service, may be responsible for reviewing, evaluating, and maintaining surveillance over supplies and contractors' inspection procedures, their gauges and measuring instruments, inspection records, and quality control plans. They may advise or serve on teams having responsibility for acceptance of major military and other procurement items.

Production Planners, Estimators, and Related Specialists

This section deals with a grouping of several classes of related specialists: production planners; production cost estimators; production schedulers, coordinators, and expediters; parts, equipment, and materials estimators, standardizers, coordinators, and catalogers; and equipment specialists. Their functions overlap. An employee was classified in the group whose work occupied the largest part of his time.

Production Planners

Plan, develop, and coordinate production schedules. Plan sequence of operations; schedule work for individual departments and units in proper sequence; plan and chart flow of work through plant, considering available materials and shipping dates. May estimate personnel, materials, parts, utilities, and services needed. May make test runs of items.

Maintain data and graphs on production progress and backlogs. May monitor and observe operations.

Report on major difficulties, and may recommend changes in procedures and product design to facilitate production processes.

Production Cost Estimators

Estimate cost of parts, materials, and manufacturing processes, including labor, utility, tools, equipment, overhead, installation, etc. Compile and coordinate estimates from various departments. Obtain information from appropriate department or determine amounts of labor, parts, and materials required. May refer to blueprints, layouts, customer specifications, and standard processing time factors.

Maintain records and charts of costs. Keep superiors informed concerning trends in cost and requirements. Provide other departments with data for use in contract checking, pricing, procurement, etc.

Prepare appraisals in response to inquiries from customers, approval companies, and insurance firms.

May maintain working relationship with customer representatives to assure understanding and satisfaction.

Production Schedulers, Coordinators, and Expediters

Prepare schedules of completed products.

Follow progress of parts and materials through receiving, incoming inspection, stockroom, production points, and delivery. Check to assure that work is proceeding in accordance with specifications and delivery dates.

Maintain records and charts of progress and holdups in the production process.

Make recommendations concerning apportionment of available time, methods, and design.

Keep track of and help coordinate efforts of design, toolroom, purchasing, manufacturing, quality control, and other departments.

Parts, Equipment, and Materials Estimators, Standardizers, Coordinators, and Catalogers

Review existing inventories of materials and supplies to maintain standardization and reduce inventory. Maintain inventory control record.

Maintain stocks at proper level and in good order.

Analyze drawings, illustrations, and layouts to determine parts and material requirements in disassembly sequence.

Prepare detailed lists of spare parts and requirements.

Maintain master descriptions and lists of all materials and parts used. Maintain stock numbering system.

Work out timing of material needs and coordinate or initiate purchase requests in accordance with established schedules and job needs.

Take action to expedite deliveries.

Contact suppliers with respect to delivery failures and difficulties encountered with their products and recommend changes.

Equipment Specialists

Equipment specialists serve as a source of detailed information on specific equipment or types of equipment and their repair parts. They are found principally in federal agencies (especially arsenals and navy yards), where a class of "Equipment Specialist" titles exists in the job classification system. These persons work closely with engineers, scientists, technicians, production supervisors, inspectors, and representatives of manufacturers of equipment.

Their principal task is to supply such persons with information on how to operate a particular type of equipment; how to identify, test, inspect, repair, modify, rebuild, maintain, keep, obtain, salvage, appraise, and dispose of the equipment; also where to obtain information about it, what supporting parts or tools to keep with it, what to substitute for it.

They seek answers to questions about the equipment from technical libraries and other sources and confer with manufacturers or government agency representatives to give and obtain information on such matters as unsatisfactory design, performance, material changes, modification proposals, and maintenance techniques.

In addition to consulting, advising, and carrying on written and verbal communications, they may on occasion gather data, set up tests, prepare exhibits, engage in training and equipment operations.

TECHNICAL SKILLS

Almost any of these workers must be able to read blueprints, to use technical handbooks, to prepare flow charts, layouts, and graphs, and to use a slide rule, a stop watch, or a tachometer; these skills are common. The ability to read schematics is frequent, but less common. The survey findings on skills needed are summarized in the following list:

Technical skill needed	Industrial engineering technicians	Quality control and reliability technicians	Production planners, estimators, and related specialists	Equipment specialists
Blueprint reading	common	common	common	common
Schematics reading	frequent	frequent	occasional to frequent	occasional to frequent
Use technical handbooks	common	common	occasional to frequent	occasional to frequent
Prepare and use flow charts, layouts, and graphs	common	common	common	occasional
Use slide rule, stop watches, tachometers	common	common	common	occasional
Use micrometers, calipers, timers, cameras, projectors, etc.	occasional to frequent	occasional to frequent	occasional to frequent	occasional

TABLE VII-B. SUBJECT MATTER KNOWLEDGE NEEDED BY INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS

Subject	Time and motion study men and standards setters	Industrial process methods men	Quality control and reliability technicians	Production planners	Production cost estimators	Production schedulers, coordinators, and expediters	Parts and equipment specialists (a)
Mathematics							
Trigonometry	XX	XX	XXX	XXX	XXX	XXX	X
Advanced algebra	X	X	XX	X	X	X	-
Calculus	-	-	X	-	-	-	-
Statistics	XX	-	XXX	X	X	X	-
Science							
Chemistry, general	-	XX	XX	XX	XX	XX	XX
Metallurgy	X	XX	XX	XX	XX	X	XX
Physics, general	XX	XXX	XXX	XXX	XXX	XXX	-
Technology							
Technical drawing	-	XX	-	XX	XX	-	-
Electrical technology, orientation	X	X	-	-	X	-	-
Basic electricity	-	-	XX	X	-	X	XX
Basic electronics	-	-	XX	X	-	X	XX
Manufacturing processes	XX	XXX	XXX	XXX	XX	XXX	XX
Machine shop theory and practice	XX	XX	XX	XX	XX	XX	XX
Time and motion study	XXX	-	-	-	-	-	-

a. Parts and equipment specialists mainly need to have a knowledge of the products and equipment they deal with.

Key: XXX = generally needed; XX = needed in substantial number of cases; X = occasionally needed

SUBJECT MATTER KNOWLEDGE

Industrial engineering technicians and related specialists need to understand manufacturing processes in order to do production planning, cost estimating, manufacturing-methods analysis, etc. This knowledge is in general considered a basic need, as is a knowledge of general physics, for background

Needed in a substantial proportion of cases are mathematics through trigonometry, general chemistry and metallurgy, and machine shop theory and practice. A knowledge of technical drawing is also needed in some occupations.

Occasionally needed are advanced algebra for the presentation of and extrapolation of some test data; and orientation in electrical technology or a knowledge of basic electricity and electronics for an understanding of the role played by electrical and electronic instruments in manufacturing operations. Most types of industrial engineering technician occasionally need statistics, and for the quality control technician it is generally required.

GRADE STRUCTURE

There are about six nonsupervisory industrial engineering technicians and related specialists in single-grade salary structures for every four in a multi-grade system (detail in table VII-5 at the end of the chapter):

Grade	Number	Percent
All grades	6,901	100.0
Supervisory grades	590	8.5
Nonsupervisory grades	6,311	91.5
Single grade only	3,807	55.2
Multi-grade:		
Lowest grades	725	10.5
Middle grades	702	10.2
Highest grades	1,077	15.6

EDUCATION AND EXPERIENCE REQUIRED

Employers of the majority of these industrial engineering technicians and related specialists do not require applicants to have had education beyond high school. However, many prefer some education beyond high school, and in most cases an applicant who does not have it is required to present two or more years of experience in related work.

Table VII-C. PERCENT DISTRIBUTION OF INDUSTRIAL ENGINEERING TECHNICIANS AND SPECIALISTS BY EDUCATION EMPLOYERS REQUIRE

All levels	100.0
Post-high-school	45.0
Engineering college	4.0
Graduation	0.8
Less than graduation	3.2
College, general	4.2
Graduation	1.3
Less than graduation	2.9
Technical institute or community college	25.3
Graduation	24.5
Less than graduation	0.8
Type not specified	11.0
Apprenticeship or armed forces school	0.5
High school	55.0
Technical or vocational	5.0
Other and not specified	50.0

Education Requirements

Table VII-C shows that the employers of 55 percent of these 6,900 technicians require high-school graduation. The next largest figure (25 percent) refers to technical-institute graduation.

The proportion of the jobs for which the employer requires education beyond high school (45 percent over-all) ranges from none for equipment specialists on ordnance to 60 percent for parts, equipment, and materials estimators, standardizers, coordinators, and catalogers (for detail, see table VII-2 at end of chapter):

Time and motion study men and standards setters	49.2%
Industrial process methods men	47.5
General industrial engineering technicians	53.2
Quality control and reliability technicians	40.3(a)
Production planners	53.3
Production cost estimators	36.7
Production schedulers, coordinators, and expediters	46.6
Parts, equipment, and materials estimators, etc.	60.4
General production planners	8.9
Specialists in:	
Electro equipment and systems	40.9
Industrial machinery, equipment, and tools	59.0
Ship and marine equipment	3.5
Aircraft, missiles, and automotive equipment	50.0
Ordnance	0.0
General and other equipment	44.5

a. The figure is 58 percent for nongovernment jobs, which are about two-thirds of the total in this occupation. Government jobs do not require training beyond high school.

Preferred vs. Required Education

The employers of 15 percent of these technicians and specialists, while not requiring any education beyond high school, stated that they preferred to have some (they usually specified technical-school graduation). The employers of another 45 percent not only preferred but required education beyond high school. The employers of the remaining 40 percent required high school and expressed no preference for additional academic preparation. (Tables VII-3 and VII-4, at the end of the chapter.)

Experience Requirements

The employers of only 13 percent of these technicians and specialists stated that they required no related work experience.

Over-all, the employers of a majority required three or more years of experience in related work. Fewer years are required for the lower-grade jobs than for the higher. (The difference is shown in percent-distribution terms in

Table VII-D. PERCENT DISTRIBUTION
OF INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS
ACCORDING TO YEARS OF EXPERIENCE EMPLOYERS REQUIRE, BY GRADE

Grade	Total	No experience	Under 3 years	3 and under 5	5 and under 7	7 and over
All grades	100.0	13.2	23.0	24.2	27.1	12.5
Supervisory grades	100.0	2.7	2.7	13.1	56.8	24.7
Nonsupervisory grades:						
Single grade only	100.0	20.2	30.3	17.7	24.1	7.7
Multi-grade:						
Lowest grades	100.0	12.7	30.1	30.0	11.6	15.6
Middle grades	100.0	2.7	12.4	73.3	8.4	3.2
Highest grades	100.0	1.2	10.6	17.2	43.8	27.2

table VII-D for all the jobs combined; and table VII-5 at the end of the chapter gives parallel data for each of the various types. Both tables give the information separately for the various grade levels.)

Table VII-E, in which such differences are stated in terms of the average (median) number of years of experience required, shows that employers tend to require about 1.5 to 2.5 additional years of applicants who have not gone beyond high school; establishments with single-grade systems are likely to require 2.5 years more, while in establishments with multi-grade systems the difference for any grade is likely to be 1 to 1.5 years.

The employers of most workers in this field did not name any pattern that they would prefer over their existing requirements; this was especially true of employers who required some level of education beyond high school. In both groups, almost all employers who stated some preference would have liked applicants to bring more education with the same amount of experience or, if necessary, with less experience. (Table VII-F; for further detail, see table VII-6 at the end of the chapter.)

Table VII-E. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY GRADE AND OCCUPATION

Grade; occupation	All levels	Post-high-school	High-school
All grades; all occupations	3.9	2.8	4.9
Grades:			
Supervisory grades	6.1	5.3	6.5
Nonsupervisory grades:			
Single grade only	3.3	2.1	4.5
Multi-grade:			
Lowest grades	2.5	1.8	2.9
Middle grades	4.2	3.1	4.5
Highest grades	5.5	4.5	5.8
Occupations:			
Time and motion study men and standards setters	2.3	1.8	2.7
Industrial process methods men	4.2	2.9	5.2
General industrial engineering technicians	3.7	0.3	4.5
Quality control and reliability technicians	4.7	2.9	5.5
Production planners	5.7	4.4	6.1
Production cost estimators	3.6	2.9	3.7
Production schedulers, coordinators, and expediters	3.9	2.4	3.7
Parts, equipment, and materials estimators, etc.	3.7	3.1	4.3
General production planners	4.7	6.0	4.6
Electro equipment and systems specialists(a)	5.0	3.7	4.3

a. Data not computed for other equipment specialists groups, because of small number.

Table VII-F. NUMBER OF INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS ACCORDING TO EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

Kind of preference	All levels	Post-high-school	High-school
Total	6,901	3,105	3,796
No preference expressed	5,172	2,502	2,670
All preferences	1,729	603	1,126
Required education, more experience	115	54	61
More than required education, less experience	964	320	644
More than required education, same experience	549	201	348
More than required education, more experience	101	28	73

TESTS AND LICENSES

About 8 percent of the industrial engineering technicians and specialists work for companies which, in judging applicants, administer a formal test that measures intelligence, aptitude, or achievement, and a few others are in civil service jobs that require an examination. (Table VII-G.)

Table VII-G. PERCENT DISTRIBUTION OF INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS ACCORDING TO TESTS REQUIRED

Occupation group	Total	None	Civil service examination	Company formal test
All occupations	100.0	90.7	1.5	7.8
Industrial engineering technicians	100.0	91.8	0.3	7.9
Quality control and reliability technicians	100.0	86.5	6.9	6.6
Production planners, estimators, and related specialists	100.0	90.1	0.2	9.7
Equipment specialists	100.0	97.9	0.2	1.9

SOURCES OF WORKERS

The jobs of industrial engineering technicians and related specialists are more likely to be filled by upgrading within the firm than by recruitment from outside. Of those who are upgraded, fewer than one in four have participated in an employer-organized training program. The percent distributions in table VII-H indicate that equipment specialists (many of whom are employed in federal arsenals, navy yards, and other federal installations) are more likely than the other categories to come from within the organization, and to have had employer-organized training. The filling of lower and middle grades, in establishments with multi-grade classifications, is much more likely to be by outside recruiting than is the case with the highest grade classifications.

As table VII-I shows, about 26 percent of industrial engineering technicians and related specialists are graduates of a technical institute or

Table VII-H. PERCENT DISTRIBUTION OF INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS ACCORDING TO METHOD OF OBTAINING THEM BY GRADE AND BY OCCUPATION GROUP

Grade; occupation group	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All grades; all occupation groups	100.0	36.6	14.3	49.1
__Grades__:				
Supervisory grades	100.0	18.5	37.3	44.2
Nonsupervisory grades:				
Single grade only	100.0	42.1	13.1	44.8
Multi-grade:				
Lowest grades	100.0	40.1	3.0	56.9
Middle grades	100.0	44.2	5.7	50.1
Highest grades	100.0	19.6	19.0	61.4
__Occupations__:				
Industrial engineering technicians	100.0	39.1	8.0	52.9
Quality control and reliability technicians	100.0	33.7	17.7	48.6
Production planners, estimators, and related specialists	100.0	38.1	14.2	47.7
Equipment specialists	100.0	23.1	34.8	42.1

Table VII-I. PERCENT OF INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS WHO ARE GRADUATES OF COLLEGES OR TECHNICAL INSTITUTES

Occupation group	Technical institute graduates	College graduates
All occupations	25.5	8.7
Industrial engineering technicians	26.9	8.0
Quality control and reliability technicians	25.5	18.0
Production planners, estimators, and related specialists	25.2	5.1
Equipment specialists	21.7	9.4

community college, and 9 percent are four-year-college graduates. Quality control technicians are especially likely to have college degrees.

PROMOTIONAL LINES

A number of production workers of various kinds, especially product testers and inspectors, had been promoted to industrial engineering technician or a related specialist job by the employers surveyed. Technicians and specialists in the lower grades of these and related jobs had been promoted to higher grades. Some equipment specialists had been promoted from clerical jobs.

Promotion out of technician-level work of these sorts was for the most part to an engineering job or to foreman, supervisor, or some other management position.

Industrial Engineering Technicians and Related Specialists

Table VII-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

A. Industrial Engineering and Quality Control Technicians

Industry group	All occupations	Industrial engineering technicians: Total	Time and motion study men and standards setters	Industrial process methods men	General	Quality control and reliability technicians
All industries	6,901	2,224	1,104	825	295	1,279
Manufacturing	5,230	2,046	1,083	787	176	826
Durable goods	4,753	1,801	949	735	117	736
Ordnance and accessories	306	173	60	113	-	41
Lumber and wood products, except furniture	1	-	-	-	-	-
Furniture and fixtures	125	43	41	2	-	6
Stone, clay, and glass products	93	51	30	21	-	20
Primary metal industries	215	127	100	20	7	26
Fabricated metal products	245	86	53	26	7	38
Machinery, except electrical	1,286	547	297	238	12	119
Electrical machinery and equipment	917	262	156	103	3	163
Transportation equipment	1,122	331	128	116	87	87
Instruments; photographic and optical goods	443	181	84	96	1	236
Nondurable goods	477	245	134	52	59	90
Food and kindred products	74	19	15	2	2	34
Textile mill products	43	31	21	4	6	5
Apparel and other finished fabric products	29	29	11	8	10	-
Paper and allied products	60	14	4	3	7	12
Printing, publishing, and allied industries	75	17	12	1	4	-
Chemicals and allied products	59	38	15	19	4	8
Petroleum refining and related industries	3	2	-	-	2	1
Rubber and miscellaneous plastics products	42	21	12	7	2	15
Leather and leather products	34	26	17	4	5	7
Miscellaneous manufacturing industries	58	48	27	4	17	8
Nonmanufacturing	1,671	178	21	38	119	453
Transportation, communication, and public utilities	120	14	-	4	10	-
Railroad transportation	22	-	-	-	-	-
Motor freight transportation and warehousing	1	1	-	1	-	-
Water transportation	8	-	-	-	-	-
Air transportation	70	4	-	3	1	-
Communication	9	5	-	-	5	-
Electric, gas, and sanitary services	10	4	-	-	4	-
Wholesale trade	94	4	4	-	-	6
Services and miscellaneous	312	59	8	27	24	59
Personal services	12	12	-	-	12	-
Business services n.e.c.	246	35	8	27	-	58
Research, development, testing laboratories	138	18	-	18	-	55
Business and management consulting services	74	11	6	5	-	3
Other business services n.e.c.	34	6	2	4	-	-
Private colleges and schools	19	12	-	-	12	-
Engineering and architectural services	35	-	-	-	-	1
Government	1,145	101	9	7	85	388
New York State	5	-	-	-	-	-
Colleges	4	-	-	-	-	-
Other	1	-	-	-	-	-
New York City	2	-	-	-	-	-
Colleges	1	-	-	-	-	-
Other	1	-	-	-	-	-
Federal	1,138	101	9	7	85	388
Hospitals	1	-	-	-	-	-
Arsenals and navy yards	629	86	9	7	70	5
Other	508	15	-	-	15	383

Table VII-1 (continued)

B. Production Planners, Estimators, and Related Specialists

Industry group	Total	Production planners	Production cost estimators	Production schedulers (a)	Parts and equipment estimators (b)	General
All industries	2,918	993	395	515	623	392
Manufacturing	2,268	828	364	427	498	151
Durable goods	2,133	809	332	403	442	147
Ordnance and accessories	92	33	11	27	21	-
Lumber and wood products, except furniture	1	-	-	1	-	-
Furniture and fixtures	76	30	40	-	6	-
Stone, clay, and glass products	11	4	6	-	-	1
Primary metal industries	61	10	35	8	3	5
Fabricated metal products	119	14	49	20	22	14
Machinery, except electrical	605	125	85	139	230	26
Electrical machinery and equipment	489	211	36	91	55	96
Transportation equipment	659	380	61	112	101	5
Instruments; photographic and optical goods	20	2	9	5	4	-
Nondurable goods	135	19	32	24	56	4
Food and kindred products	18	-	18	-	-	-
Textile mill products	6	6	-	-	-	-
Apparel and other finished fabric products	-	-	-	-	-	-
Paper and allied products	34	-	6	8	20	-
Printing, publishing, and allied industries	58	6	5	14	32	1
Chemicals and allied products	13	6	2	-	3	2
Petroleum refining and related industries	-	-	-	-	-	-
Rubber and miscellaneous plastics products	3	-	1	-	1	1
Leather and leather products	1	-	-	1	-	-
Miscellaneous manufacturing industries	2	1	-	1	-	-
Nonmanufacturing	650	165	31	88	125	241
Transportation, communication, and public utilities	59	10	-	23	18	8
Railroad transportation	-	-	-	-	-	-
Motor freight transportation and warehousing	-	-	-	-	-	-
Water transportation	-	-	-	-	-	-
Air transportation	49	10	-	19	12	8
Communication	4	-	-	4	-	-
Electric, gas, and sanitary services	6	-	-	-	6	-
Wholesale trade	3	-	-	1	2	-
Services and miscellaneous	159	24	30	8	97	-
Personal services	-	-	-	-	-	-
Business services n.e.c.	122	24	20	1	77	-
Research, development, testing laboratories	52	21	2	1	28	-
Business and management consulting services	58	3	6	-	49	-
Other business services n.e.c.	12	-	12	-	-	-
Private colleges and schools	7	-	-	7	-	-
Engineering and architectural services	30	-	10	-	20	-
Government	429	131	1	56	8	233
New York State	1	-	-	-	1	-
Colleges	1	-	-	-	1	-
Other	-	-	-	-	-	-
New York City	2	-	-	-	2	-
Colleges	1	-	-	-	1	-
Other	1	-	-	-	1	-
Federal	426	131	1	56	5	233
Hospitals	1	-	1	-	-	-
Arsenals and navy yards	406	131	-	56	-	219
Other	19	-	-	-	5	14

Table VII-1 (concluded)

C. Equipment Specialists

Industry group	Total	Electro-equipment and systems	Industrial machinery, equipment, and tools	Ship and marine equipment	Aircraft, missiles, and automotive equipment	Ordnance	General and other
All industries	480	132	39	57	26	44	182
Manufacturing	90	13	34	-	8	-	35
Durable goods	83	11	31	-	8	-	33
Ordnance and accessories	-	-	-	-	-	-	-
Lumber and wood products, except furniture	-	-	-	-	-	-	-
Furniture and fixtures	-	-	-	-	-	-	-
Stone, clay, and glass products	11	-	5	-	6	-	-
Primary metal industries	1	-	-	-	-	-	1
Fabricated metal products	2	-	2	-	-	-	-
Machinery, except electrical	15	1	14	-	-	-	-
Electrical machinery and equipment	3	2	-	-	1	-	-
Transportation equipment	45	3	9	-	1	-	32
Instruments; photographic and optical goods	6	5	1	-	-	-	-
Nondurable goods	7	2	3	-	-	-	2
Food and kindred products	3	2	-	-	-	-	1
Textile mill products	1	-	1	-	-	-	-
Apparel and other finished fabric products	-	-	-	-	-	-	-
Paper and allied products	-	-	-	-	-	-	-
Printing, publishing, and allied industries	-	-	-	-	-	-	-
Chemicals and allied products	-	-	-	-	-	-	-
Petroleum refining and related industries	-	-	-	-	-	-	-
Rubber and miscellaneous plastics products	3	-	2	-	-	-	1
Leather and leather products	-	-	-	-	-	-	-
Miscellaneous manufacturing industries	-	-	-	-	-	-	-
Nonmanufacturing	390	119	5	57	18	44	147
Transportation, communication, and public utilities	47	-	-	8	17	-	22
Railroad transportation	22	-	-	-	-	-	22
Motor freight transportation and warehousing	-	-	-	-	-	-	-
Water transportation	8	-	-	8	-	-	-
Air transportation	17	-	-	-	17	-	-
Communication	-	-	-	-	-	-	-
Electric, gas, and sanitary services	-	-	-	-	-	-	-
Wholesale trade	81	42	-	-	-	-	39
Services and miscellaneous	35	18	-	4	-	-	13
Personal services	-	-	-	-	-	-	-
Business services n.e.c.	31	18	-	-	-	-	13
Research, development, testing laboratories	13	2	-	-	-	-	11
Business and management consulting services	2	-	-	-	-	-	2
Other business services n.e.c.	16	16	-	-	-	-	-
Private colleges and schools	-	-	-	-	-	-	-
Engineering and architectural services	4	-	-	4	-	-	-
Government	227	59	5	45	1	44	73
New York State	4	-	-	-	-	-	4
Colleges	3	-	-	-	-	-	3
Other	1	-	-	-	-	-	1
New York City	-	-	-	-	-	-	-
Colleges	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-
Federal	223	59	5	45	1	44	69
Hospitals	-	-	-	-	-	-	-
Arsenals and navy yards	132	35	5	44	-	44	4
Other	91	24	-	1	1	-	65

a. Production schedulers, coordinators, and expediters.

b. Parts, equipment, and materials estimators, standardizers, coordinators, and catalogers.

Industrial Engineering Technicians and Related Specialists

Table VII-2. EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

(Percent distribution of technicians and specialists according to level of education required)

A. Industrial Engineering and Quality Control Technicians

Education required	All occupations	Industrial engineering technicians: Time and motion study men and standards setters	Industrial process methods men	General	Quality control and reliability technicians
All levels: Number	6,901	1,104	825	295	1,279
Percent distribution					
All levels: Percent	100.0	100.0	100.0	100.0	100.0
Post-high-school	45.0	49.2	47.5	53.2	40.3
Engineering college	4.0	6.6	6.8	6.8	1.5
Graduation	0.8	0.7	0.2	6.8	0.8
Less than graduation	3.2	5.9	6.6	-	0.7
College, general	4.2	3.7	2.2	10.5	5.3
Graduation	1.3	0.4	1.6	9.1	2.1
Less than graduation	2.9	3.3	0.6	1.4	3.2
Technical institute or community college	25.3	23.8	32.1	34.5	21.0
Graduation	24.5	22.2	30.2	34.5	20.3
Less than graduation	0.8	1.6	1.9	-	0.7
Type not specified	11.0	15.1	4.5	1.4	12.4
Apprenticeship or armed forces school	0.5	-	1.9	-	0.1
High school	55.0	50.8	52.5	46.8	59.7
Technical or vocational	5.0	5.5	3.9	2.0	3.6
Other and not specified	50.0	45.3	48.6	44.8	56.1

Table VII-2 (continued)

B. Production Planners, Estimators, and Related Specialists

Education required	Production planners	Production cost estimators	Production, schedulers, coordinators, expediters	Parts and equipment estimators (a)	General
All levels: Number	993	395	515	623	392
Percent distribution					
All levels: Percent	100.0	100.0	100.0	100.0	100.0
Post-high-school	53.3	36.7	46.6	60.4	8.9
Engineering college	1.7	7.3	2.1	0.3	1.3
Graduation	0.8	0.5	-	0.3	-
Less than graduation	0.9	6.8	2.1	-	1.3
College, general	0.6	4.8	6.8	6.4	2.0
Graduation	0.3	1.0	2.1	-	-
Less than graduation	0.3	3.8	4.7	6.4	2.0
Technical institute or community college	46.9	15.0	24.9	20.2	5.1
Graduation	46.9	15.0	24.7	18.9	5.1
Less than graduation	-	-	0.2	1.3	-
Type not specified	3.0	9.6	12.8	33.5	0.5
Apprenticeship or armed forces school	1.1	-	-	-	-
High school	46.7	63.3	53.4	39.6	91.1
Technical or vocational	0.1	3.3	10.5	5.0	24.0
Other and not specified	46.6	60.0	42.9	34.6	67.1

Table VII-2 (concluded)

C. Equipment Specialists

Education required	Electro equipment and systems	Industrial machinery, equipment, and tools	Ship and marine equipment	Aircraft, missiles, and automotive equipment	Ordnance	General and other
All levels: Number	132	39	57	26	44	182
Percent distribution						
All levels: Percent	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	40.9	59.0	3.5	50.0	-	44.5
Engineering college	31.8	-	3.5	3.8	-	0.5
Graduation	-	-	3.5	-	-	-
Less than graduation	31.8	-	-	3.8	-	0.5
College, general	0.8	20.5	-	42.4	-	0.5
Graduation	-	-	-	-	-	-
Less than graduation	0.8	20.5	-	42.4	-	0.5
Technical institute or community college	3.8	33.3	-	3.8	-	18.1
Graduation	2.3	33.3	-	3.8	-	18.1
Less than graduation	1.5	-	-	-	-	-
Type not specified	4.5	2.6	-	-	-	21.6
Apprenticeship or armed forces school	-	2.6	-	-	-	3.8
High school	59.1	41.0	96.5	50.0	100.0	55.5
Technical or vocational	0.8	-	-	23.1	-	-
Other and not specified	58.3	41.0	96.5	26.9	100.0	55.5

a. Parts, equipment, and materials estimators, standardizers, coordinators, and catalogers.

Industrial Engineering Technicians and Related Specialists

Table VII-3. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of technicians and specialists according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	6,901	6,901	100.0	100.0
Post-high-school	3,105	4,069	45.0	59.0
Engineering college	278	804	4.0	11.6
Graduation	54	548	0.8	7.9
Less than graduation	224	256	3.2	3.7
College, general	287	506	4.2	7.3
Graduation	89	248	1.3	3.6
Less than graduation	198	258	2.9	3.7
Technical institute or community college	1,747	1,885	25.3	27.4
Graduation	1,693	1,840	24.5	26.7
Less than graduation	54	45	0.8	0.7
Type not specified	757	849	11.0	12.3
Apprenticeship or armed forces school	36	25	0.5	0.4
High school	3,796	2,832	55.0	41.0
Technical or vocational	345	299	5.0	4.3
Other and not specified	3,451	2,533	50.0	36.7

Industrial Engineering Technicians and Related Specialists

Table VII-4. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Percent distribution of technicians and specialists according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require: Post-high-school: Post-high-school, total	Engineering college: Graduation	Engineering college: Less than graduation	College, general: Graduation	College, general: Less than graduation	Technical institute: Graduation	Technical institute: Less than graduation	Type not specified	High school: High school, total	High school: Technical or vocational	High school: Other and not specified
All levels	100.0	77.1	22.9	21.9	7.2	0.8	2.3	1.1	7.3	0.4	2.8	1.0	0.9	0.1
Post-high-school	100.0	82.4	17.6	17.5	11.9	0.8	2.3	0.1	2.4	-	-	0.1	-	0.1
Engineering college	100.0	91.4	8.6	8.2	8.2	-	-	-	-	-	-	0.4	-	0.4
Graduation	100.0	98.1	1.9	-	-	-	-	-	-	-	-	1.9	-	1.9
Less than graduation	100.0	89.7	10.3	10.3	10.3	-	-	-	-	-	-	-	-	-
College, general	100.0	92.7	7.3	7.3	1.7	-	4.9	-	0.7	-	-	-	-	-
Graduation	100.0	97.8	2.2	2.2	2.2	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	90.4	9.6	9.6	1.5	-	7.1	-	1.0	-	-	-	-	-
Technical institute or community college	100.0	77.7	22.3	22.3	17.3	1.4	2.5	0.1	1.0	-	-	-	-	-
Graduation	100.0	79.3	20.7	20.7	17.8	0.2	2.6	0.1	-	-	-	-	-	-
Less than graduation	100.0	27.8	72.2	72.2	-	40.7	-	-	31.5	-	-	-	-	-
Type not specified	100.0	86.7	13.3	12.9	4.8	-	1.8	-	6.3	-	-	0.4	-	0.4
Apprenticeship or armed forces school	100.0	69.4	30.6	30.6	13.9	-	-	-	16.7	-	-	-	-	-
High school	100.0	72.8	27.2	25.5	3.3	0.8	2.3	2.0	11.2	0.8	5.1	1.7	1.7	-
Technical or vocational	100.0	68.4	31.6	31.6	8.7	1.4	1.7	-	18.1	1.7	-	-	-	-
Other and not specified	100.0	73.3	26.7	24.9	2.8	0.7	2.4	2.2	10.5	0.7	5.6	1.8	1.8	-

Industrial Engineering Technicians and Related Specialists

Table VII-5. YEARS OF EXPERIENCE EMPLOYERS REQUIRE, BY GRADE

(Percent distribution of technicians and specialists according to years of experience required)

Grade	Total number	Total percent	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 4	4 and under 5	5 and under 7	7 and under 10	10 and over
					All occupations						
All grades	6,901	100.0	13.2	1.6	8.9	12.5	14.3	9.9	27.1	7.5	5.0
Supervisory grades	590	100.0	2.7	1.0	0.3	1.4	9.2	3.9	56.8	16.6	8.1
Nonsupervisory grades:											
Single grade only	3,807	100.0	20.2	2.6	11.7	16.0	10.7	7.0	24.1	3.5	4.2
Multi-grade:											
Lowest grades	725	100.0	12.7	1.2	18.6	10.3	17.2	12.8	11.6	2.6	13.0
Middle grades	702	100.0	2.7	-	1.7	10.7	44.5	28.8	8.4	2.6	0.6
Highest grades	1,077	100.0	1.2	-	1.8	8.8	8.2	9.0	43.8	23.2	4.0
					Time and motion study men and standards setters						
All grades	1,104	100.0	23.1	2.9	11.2	19.8	14.9	9.1	10.6	7.3	1.1
Supervisory grades	32	100.0	-	18.8	-	-	-	21.9	31.2	28.1	-
Nonsupervisory grades:											
Single grade only	691	100.0	25.2	3.2	10.7	20.3	17.2	7.8	10.1	5.2	0.3
Multi-grade:											
Lowest grades	153	100.0	38.0	2.6	24.8	12.4	7.2	9.8	-	5.2	-
Middle grades	63	100.0	28.6	-	19.0	39.7	3.2	9.5	-	-	-
Highest grades	165	100.0	2.4	-	-	21.2	19.4	11.5	22.4	17.0	6.1
					Industrial process methods men						
All grades	825	100.0	11.0	-	6.3	14.3	10.2	11.8	25.0	16.7	4.7
Supervisory grades	24	100.0	-	-	4.2	-	8.3	-	29.2	41.6	16.7
Nonsupervisory grades:											
Single grade only	380	100.0	19.5	-	5.8	8.7	11.6	5.8	37.6	4.7	6.3
Multi-grade:											
Lowest grades	127	100.0	7.1	-	22.8	3.1	20.5	35.4	8.7	2.4	-
Middle grades	61	100.0	1.6	-	-	59.0	-	-	3.3	29.5	6.6
Highest grades	233	100.0	3.0	-	-	19.3	5.2	12.9	18.5	38.1	3.0
					Industrial engineering technicians: general						
All grades	295	100.0	16.9	1.0	3.1	6.1	10.8	12.9	45.1	3.1	1.0
Supervisory grades	49	100.0	12.2	-	-	-	2.0	-	75.6	10.2	-
Nonsupervisory grades:											
Single grade only	95	100.0	46.1	3.2	9.5	13.7	9.5	9.5	3.2	2.1	3.2
Multi-grade:											
Lowest grades	33	100.0	-	-	-	-	66.6	-	27.3	6.1	-
Middle grades	33	100.0	-	-	-	-	-	87.9	12.1	-	-
Highest grades	85	100.0	-	-	-	5.9	-	-	94.1	-	-

Continued

Table VII-5 (continued)

Grade	Total number	Total percent	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 4	4 and under 5	5 and under 7	7 and under 10	10 and over
Quality control and reliability technicians											
All grades	1,279	100.0	11.6	0.1	1.5	6.6	3.7	13.0	46.1	8.1	9.3
Supervisory grades	257	100.0	-	-	-	1.6	5.1	4.7	77.7	5.8	5.1
Nonsupervisory grades:											
Single grade only	505	100.0	27.5	0.2	3.8	11.5	3.4	5.1	40.6	6.3	1.6
Multi-grade:											
Lowest grades	186	100.0	4.3	-	-	11.8	9.1	1.6	22.0	0.5	50.7
Middle grades	128	100.0	-	-	-	-	-	90.6	9.4	-	-
Highest grades	203	100.0	1.0	-	-	0.5	-	4.4	64.5	27.6	2.0
Production planners											
All grades	993	100.0	3.2	-	18.5	1.2	29.4	4.6	33.9	2.3	6.9
Supervisory grades	42	100.0	23.8	-	-	-	11.9	-	28.6	9.5	26.2
Nonsupervisory grades:											
Single grade only	520	100.0	2.9	-	27.1	1.2	5.2	7.9	44.7	0.2	10.8
Multi-grade:											
Lowest grades	69	100.0	10.1	-	52.3	-	11.6	7.2	14.5	4.3	-
Middle grades	260	100.0	-	-	-	-	96.9	-	3.1	-	-
Highest grades	102	100.0	-	-	6.9	5.9	-	-	70.5	14.7	2.0
Production cost estimators											
All grades	395	100.0	13.4	2.5	8.4	13.4	23.6	5.6	18.7	7.6	6.8
Supervisory grades	14	100.0	-	-	-	-	7.1	-	7.1	64.4	21.4
Nonsupervisory grades:											
Single grade only	321	100.0	16.5	3.1	9.7	15.6	27.0	2.5	15.6	2.5	7.5
Multi-grade:											
Lowest grades	16	100.0	-	-	12.5	18.8	31.2	6.3	31.2	-	-
Middle grades	17	100.0	-	-	-	-	-	76.5	23.5	-	-
Highest grades	27	100.0	-	-	-	-	-	-	51.9	48.1	-
Production schedulers, coordinators, and expediters											
All grades	515	100.0	10.3	11.3	9.3	16.5	18.0	14.0	12.6	1.2	6.8
Supervisory grades	27	100.0	-	-	3.7	-	14.8	11.1	40.8	-	29.6
Nonsupervisory grades:											
Single grade only	373	100.0	13.4	14.5	4.3	20.9	16.9	13.9	12.1	1.1	2.9
Multi-grade:											
Lowest grades	47	100.0	6.4	8.5	40.4	10.6	-	27.7	2.1	4.3	-
Middle grades	24	100.0	-	-	-	8.3	91.7	-	-	-	-
Highest grades	44	100.0	-	-	27.3	-	9.1	9.1	18.2	-	36.3

Continued

Table VII-5 (continued)

Grade	Total number	Total percent	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 4	4 and under 5	5 and under 7	7 and under 10	10 and over
Parts, equipment, and materials estimators, standardizers, coordinators, and catalogers											
All grades	623	100.0	29.1	1.1	20.4	4.3	19.4	2.9	18.3	2.1	2.4
Supervisory grades	39	100.0	-	-	-	10.3	17.9	-	43.6	10.3	17.9
Nonsupervisory grades:											
Single grade only	448	100.0	39.1	1.3	26.1	1.3	6.7	2.9	18.8	2.0	1.8
Multi-grade:											
Lowest grades	45	100.0	13.3	2.2	22.2	17.8	26.7	8.9	8.9	-	-
Middle grades	43	100.0	-	-	-	14.0	86.0	-	-	-	-
Highest grades	48	100.0	-	-	-	6.3	72.8	2.1	18.8	-	-
Production planners, estimators, and related specialists: general											
All grades	392	100.0	0.3	0.5	2.6	49.1	6.1	11.2	15.1	15.1	-
Supervisory grades	48	100.0	-	-	-	-	27.1	-	66.6	6.3	-
Nonsupervisory grades:											
Single grade only	221	100.0	0.5	0.9	4.1	78.1	1.4	11.8	-	3.2	-
Multi-grade:											
Lowest grades	18	100.0	-	-	5.6	77.7	16.7	-	-	-	-
Middle grades	39	100.0	-	-	-	15.4	-	15.4	69.2	-	-
Highest grades	66	100.0	-	-	-	-	7.6	18.2	-	74.2	-
Equipment specialists: electro equipment and systems											
All grades	132	100.0	-	-	-	17.4	6.8	10.6	62.2	3.0	-
Supervisory grades	10	100.0	-	-	-	-	40.0	-	20.0	40.0	-
Nonsupervisory grades:											
Single grade only	101	100.0	-	-	-	22.8	5.0	5.9	66.3	-	-
Multi-grade:											
Lowest grades	2	100.0	-	-	-	-	-	(a)	-	-	-
Middle grades	8	100.0	-	-	-	-	-	(a)	(a)	-	-
Highest grades	11	100.0	-	-	-	-	-	-	100.0	-	-
Equipment specialists: industrial machinery, equipment, and tools											
All grades	39	100.0	10.3	-	23.1	5.1	-	28.2	30.7	2.6	-
Supervisory grades	-	-	-	-	-	-	-	-	-	-	-
Nonsupervisory grades:											
Single grade only	32	100.0	9.4	-	28.1	6.3	-	28.1	25.0	3.1	-
Multi-grade:											
Lowest grades	1	100.0	(a)	-	-	-	-	-	-	-	-
Middle grades	1	100.0	-	-	-	-	-	(a)	-	-	-
Highest grades	5	100.0	-	-	-	-	-	(a)	(a)	-	-

Continued

Table VII-5 (concluded)

Grade	Total number	Total percent	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 4	4 and under 5	5 and under 7	7 and under 10	10 and over
Equipment specialists: ship and marine equipment											
All grades	57	100.0	3.5	-	-	47.4	7.0	-	24.6	14.0	3.5
Supervisory grades	8	100.0	-	-	-	-	(a)	-	(a)	-	-
Nonsupervisory grades:											
Single grade only	39	100.0	5.1	-	-	69.3	-	-	-	20.5	5.1
Multi-grade:											
Lowest grades	-	-	-	-	-	-	-	-	-	-	-
Middle grades	-	-	-	-	-	-	-	-	-	-	-
Highest grades	10	100.0	-	-	-	-	-	-	100.0	-	-
Equipment specialists: aircraft, missiles, and automotive equipment											
All grades	26	100.0	-	-	-	-	34.6	19.2	34.7	7.7	3.8
Supervisory grades	2	100.0	-	-	-	-	-	-	-	(a)	(a)
Nonsupervisory grades:											
Single grade only	8	100.0	-	-	-	-	(a)	-	(a)	(a)	-
Multi-grade:											
Lowest grades	11	100.0	-	-	-	-	72.7	27.3	-	-	-
Middle grades	-	-	-	-	-	-	-	-	-	-	-
Highest grades	5	100.0	-	-	-	-	-	(a)	(a)	-	-
Equipment specialists: ordnance											
All grades	44	100.0	-	-	-	-	-	20.5	63.6	15.9	-
Supervisory grades	7	100.0	-	-	-	-	-	-	-	(a)	-
Nonsupervisory grades:											
Single grade only	-	-	-	-	-	-	-	-	-	-	-
Multi-grade:											
Lowest grades	-	-	-	-	-	-	-	-	-	-	-
Middle grades	9	100.0	-	-	-	-	-	(a)	-	-	-
Highest grades	28	100.0	-	-	-	-	-	-	100.0	-	-
Equipment specialists: general and other											
All grades	182	100.0	22.0	-	-	1.1	8.8	20.9	15.9	17.6	13.7
Supervisory grades	31	100.0	-	-	-	-	-	3.2	6.5	87.1	3.2
Nonsupervisory grades:											
Single grade only	73	100.0	54.9	-	-	2.7	5.5	-	2.7	6.8	27.4
Multi-grade:											
Lowest grades	17	100.0	-	-	-	-	70.6	11.8	17.6	-	-
Middle grades	16	100.0	-	-	-	-	-	100.0	-	-	-
Highest grades	45	100.0	-	-	-	-	-	42.2	48.9	-	8.9

a. Not computed because of small number involved.

Industrial Engineering Technicians and Related Specialists

Table VII-6. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number and percent distribution of technicians and specialists according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	More than required education: Same experience	More than required education: More experience
Number							
All levels	6,901	5,172	1,729	115	964	549	101
Post-high-school	3,105	2,502	603	54	320	201	28
Engineering college	278	237	41	8	8	25	-
Graduation	54	40	14	6	-	8	-
Less than graduation	224	197	27	2	8	17	-
College, general	287	264	23	2	7	8	6
Graduation	89	87	2	-	-	-	2
Less than graduation	198	177	21	2	7	8	4
Technical institute or community college	1,747	1,339	408	24	224	140	20
Graduation	1,693	1,324	369	24	222	109	14
Less than graduation	54	15	39	-	2	31	6
Type not specified	757	637	120	20	70	28	2
Apprenticeship or armed forces school	36	25	11	-	11	-	-
High school	3,796	2,670	1,126	61	644	348	73
Technical or vocational	345	226	119	10	73	23	13
Other and not specified	3,451	2,444	1,007	51	571	325	60
Percent distribution							
All levels	100.0	74.9	25.1	1.7	13.9	8.0	1.5
Post-high-school	100.0	80.6	19.4	1.7	10.3	6.5	0.9
Engineering college	100.0	85.3	14.7	2.9	2.9	8.9	-
Graduation	100.0	74.1	25.9	11.1	-	14.8	-
Less than graduation	100.0	87.9	12.1	0.9	3.6	7.6	-
College, general	100.0	92.0	8.0	0.7	2.4	2.8	2.1
Graduation	100.0	97.8	2.2	-	-	-	2.2
Less than graduation	100.0	89.4	10.6	1.0	3.5	4.1	2.0
Technical institute or community college	100.0	76.6	23.4	1.4	12.9	8.0	1.1
Graduation	100.0	78.2	21.8	1.4	13.2	6.4	0.8
Less than graduation	100.0	27.8	72.2	-	3.7	57.4	11.1
Type not specified	100.0	84.1	15.9	2.6	9.3	3.7	0.3
Apprenticeship or armed forces school	100.0	69.4	30.6	-	30.6	-	-
High school	100.0	70.3	29.7	1.6	17.0	9.2	1.9
Technical or vocational	100.0	65.5	34.5	2.9	21.1	6.7	3.8
Other and not specified	100.0	70.8	29.2	1.5	16.6	9.4	1.7

Chapter VIII

CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS

This group of technicians and technical specialists is the fourth largest of the technical occupation groups covered by the survey. In 1962 there were 13,464 persons in the group in New York State, around 9 percent of all persons in technical occupations.

Civil engineering and construction technicians and specialists have been classified into four main subgroups, namely, surveying, civil engineering and construction technician, construction inspection, and construction specification writer and cost estimator.[1] The number of persons working in each of these groups and in their subdivisions are shown in table VIII-1, at the end of this chapter; table VIII-A, on the next page, gives the information in summary form.

Roughly one-half of these technicians and specialists work under the supervision of an engineer. About one-quarter work under a technician or specialist of higher grade. The remainder work under persons in other occupations. (See table VIII-2 for detail.)

Ninety-nine percent of the civil engineering and construction technicians and specialists are employed in nonmanufacturing industries. About 43 percent are employed by construction contractors, 34 percent by government agencies, and 16 percent by firms that perform engineering, architectural, or other services. Almost half of those employed in contract construction work for general

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1. Specification writers in industries other than construction are included in chapter X. Cost estimators in industries other than construction are included in chapter VII.

Table VIII-A. NUMBER AND PERCENT DISTRIBUTION OF CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS BY OCCUPATION

Occupation	Number	Percent
All occupations	13,464	100.0
Surveyors and related specialists	2,381	17.7
Surveyors	1,171	8.7
Instrumentmen	1,007	7.5
General and other	203	1.5
Civil engineering and construction technicians	4,932	36.6
Buildings	1,765	13.1
Highway, street, and other heavy construction	983	7.3
General and other	2,184	16.2
Construction inspectors	2,804	20.8
Building structures	1,126	8.3
Electrical and mechanical equipment	498	3.7
Plumbing	214	1.6
Heating, air conditioning, and related equipment	54	0.4
General and other	912	6.8
Construction specification writers and cost estimators	3,347	24.9
Specification writers	117	0.9
Architectural and structural	72	0.6
Mechanical and electrical	25	0.2
Highway, street, and related construction	20	0.1
Cost estimators	2,898	21.5
Architectural and structural	1,426	10.6
Mechanical and electrical	841	6.2
Highway, street, and related construction	361	2.7
General	270	2.0
Combination: specification writing and cost estimating	332	2.5
Architectural and structural	92	0.7
Mechanical and electrical	161	1.2
Highway, street, and related construction	64	0.5
General and other	15	0.1

contractors in building construction industries, the remainder being divided about equally between general contractors engaged in construction other than buildings and special trade contractors. The State of New York and the City of New York each employ about one-third of those working for government, with the remaining third divided between counties, other cities, towns and villages, and the federal government. The industry picture is summarized in table VIII-B (taken from table VIII-1, at the end of this chapter).

Table VIII-B. PERCENT DISTRIBUTION OF CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS BY INDUSTRY GROUP

Industry group	All occupations	Surveyors and related specialists	Civil engineering and construction technicians	Construction inspectors	Construction specification writers and cost estimators
All industries	100.0	100.0	100.0	100.0	100.0
Manufacturing	1.0	0.2	0.5	1.1	2.1
Nonmanufacturing	99.0	99.8	99.5	98.9	97.9
Contract construction	42.8	34.9	43.3	4.7	79.7
Transportation and public utilities	4.9	5.2	5.3	2.6	6.2
Engineering and architectural services (a)	16.1	47.9	5.4	19.5	6.5
Government	34.4	11.8	45.3	72.1	2.8
All other	0.8	(a)	0.2	(b)	2.7

a. Includes a small proportion of specialists in business services n.e.c. and private colleges and schools.
b. Less than 0.05 of a percent.

FUNCTIONS

The following pages describe the functions performed by each of the types of civil engineering and construction technicians and specialists covered by the survey.

Surveyors

Surveyors are employed to supply exact measurements and locations of points, areas, lines, elevations, and contours of the earth's surface for such purposes as supplying guide lines, reference marks, and other control data for construction work, map making, establishment of land and subdivision of boundaries, and description of property for deeds and transfer of title.

Surveyors work from architectural plans, structural drawings, project plans, erection and installation drawings, plats and maps (subdivisions, industrial property, and real estate display maps; contour, profile, relief, and other topographic maps; highway maps; geographical maps; hydrographic maps; cadastral maps; engineering maps; photogrammetric maps; and military maps), deeds, historical records, field notes, sketches, statistical or tabulated data, technical books, engineering handbooks and tables, technical reports, direct measurements with surveying instruments and equipment. The foregoing may have been originated or prepared by engineers, architects, governmental agencies, designers, draftsmen, contractors, clients, other surveyors, members of the survey party, the surveyor himself, or others.

They make calculations and record information needed to conduct the survey from notes, maps, plans, deeds, established bench mark locations and elevations, etc.

Make calculations to verify the accuracy of field notes and identify errors, if any, for recheck.

Check and adjust with the aid of instrumentmen, the accuracy of instruments for collamation of cross-hair, level bubble accuracy, horizontal rotation in standards, etc. Remove defective instruments from service and send them to manufacturer for correction and rehabilitation.

Acting as chief of survey party, surveyors supervise, direct, and are responsible for the quality and accuracy of the work of members of the party. They record field notes, make sketches, make field calculations, take some instrument readings, direct the placement of reference lines, marks (grade stakes, guard takes, etc.), and check notes and readings made by others. They are responsible for the exact location, measurement, and layout of points, lines, elevations, tangents, simple and compound curves, spirals, areas, grades, traverse stations and contours, and the pre-field work planning.

Write reports of survey findings, personnel progress, time records, deed descriptions, etc.

Deal with engineers, architects, contractors, governmental officials, clients, skilled workers, and laborers on construction sites.

May, if licensed, certify and file maps and plats for recording with public officials, banks, and title companies, and may serve as expert witnesses in legal contests.

When self-employed (usually licensed), they perform office, business, sales, and other functions in addition to those stated above.

<u>Technical skills</u> needed include:

Ability to use drafting and surveying instruments.

Ability to use a desk calculator, slide rule, stadia rule, planimeter, etc.

Ability to read and interpret all types of construction drawings, maps, etc., and visualize spatial relationships from two dimensional symbols, notes, figures, etc.

Ability to write survey reports, legal survey documents, and other communications.

Instrumentmen

Working under the direct supervision of a surveyor, instrumentmen use surveying instruments such as transit, engineer's level, alidade, plane table, and geodometer to establish, measure, or lay out lines, angles (bearing, vertical, horizontal, azimuth, deflection), offsets, stadia, elevations, etc.

Instrumentmen also may direct and assist in the chaining of distances; record data and make sketches; reduce field notes for checking accuracy of survey; make adjustment of instruments to maintain accuracy; act as chief of party in a small group, directing the movement and action of less experienced survey party members in clearing, measuring, placing of rods and plumb lines, etc.; reduce field notes and make calculations for office use and records, and read drawings, plats, and maps of various types; make some office calculations and drawings on earthwork, plats, and maps and write survey finding reports when inclement weather does not permit field work; instruct the chainmen, rodmen, and other party members in the use of instruments.

Their technical skills include:

Ability to use all types of surveying instruments and drafting equipment.

Ability to make accurate sketches and clearly record data and notes.

Ability to read and interpret maps, plats, field and office notes, and other data relative to surveys of all types.

Ability to ascertain the difficulties encountered by obstructions and other factors in making measurements and the ability to alternate methods to obtain data.

Civil Engineering and Construction Technicians

Two kinds of civil engineering and construction technicians are included in this group: one is the construction superintendent; the other is the civil engineering aid. Often the same person performs both jobs.

Construction superintendents: - The work of construction superintendents involves on-site direction of construction projects, including buildings of various kinds, and streets, highways, bridges, tunnels, dams, incinerators and sewage treatment plants, utilities (water, gas, drainage,) etc. They perform duties intermediate between construction foremen, craftsmen, and laborers and the construction engineer. Some large construction projects are directed by the construction engineer without the assistance of a technician. House construction may be directed by the contractor personally, without use of an engineer or technician.

Most construction superintendents have responsibility for an entire construction project, including completion on schedule and within estimated costs.

They work from architectural, structural, erection, and installation plans and drawings, specifications, survey data, cost estimates, maps and plats, notes, and verbal instructions prepared by architects, engineers, designers, draftsmen, surveyors, other superintendents and managers, clients, contractors, inspectors, public officials, and others.

They schedule and assign foremen and construction trade workmen; ensure availability of materials; provide liaison with clients, contractors, inspectors, management, etc.; keep records of costs, labor, materials, time; write progress reports; interpret plans, drawings, and specifications for foremen and others; maintain necessary permits; approve minor changes to expedite construction; make simple sketches; ensure adherence to safety standards; determine acceptability of workmanship and materials and adherence to construction specifications; and may do elementary surveying to lay out the work or check the results.

Project managers and general superintendents, included in this classification, usually have broader responsibilities, such as supervision of several construction superintendents and simultaneous responsibility for several projects. They usually divide their time between field and office. They may also negotiate contracts and sub-contracts, resolve differences between construction and specifications, plan schedules for optimum economy, conduct business correspondence, review field progress reports, review laboratory test reports on materials, etc.

Technical skills needed include:

Working knowledge of heavy machinery, light machinery, power tools, and hand tools used on the construction job (e.g., diesel shovel, crane, pile driver, bulldozer, road building machinery, mortar mixer, vibrator, air hammer, torque wrench, as well as tools used by the plumbers, sheet metal workers, carpenters, masons, plasterers, lathers, etc.).

Ability to use surveying instruments, such as transit, level, tape.

Civil engineering aids: - These persons do field and office civil engineering work. They inspect portions of construction projects and inspect materials being supplied for such projects.

Reduce and plot field notes; make engineering computations, and check the computations of others.

Perform laboratory tests requiring technical skill and knowledge.

They may also engage in architectural, structural, and map drafting; draw charts and plot graphs from engineering data, progress reports, and records; estimate and prepare bids; prepare schedules for materials and labor; coordinate installation drawings for various trades; design elementary structural elements; inspect and supervise demolition of small structures; serve as chief of surveying party or instrumentman.

Technical skills needed include:

Ability to use drafting instruments and equipment, surveying instruments, desk calculators, slide rules, planimeters.

General knowledge of construction and excavation machinery, tools, and equipment; American Society for Testing and Materials testing instruments and equipment for soil tests; concrete, cement, and aggregate tests; timber, brick, and steel tests, etc.; knowledge of equipment for both laboratory and field tests, including universal testing machines (tension, compression, flexure, shear), torsion testers, hardness testers (Rockwell, Brinell), portable concrete cylinder testers, vicat apparatus (consistency, initial set), test boring equipment, strain gauges, extensometers, scales, timers, etc.

Construction Inspectors

Construction inspectors may specialize in particular fields, such as building structure, plumbing, electrical and mechanical equipment, etc., or they may have responsibility in several construction fields. (See table VIII-1, at the end of the chapter.)

Two types of construction inspectors may be distinguished -- those who work for private employers and those who work for government agencies.

(1) Private employers of construction inspectors principally include architects, engineers, and general contractors. Some are employed by other contractors and by businesses, such as electric utilities, on whose account construction is taking place.

These construction inspectors are employed to inspect foundations, buildings, including iron and concrete work, plastering, glazing, painting, carpentry, floor covering, etc.; to check materials used for quality; and to ensure adherence to plans and specifications of the architect or contractor. In addition, inspectors may assist contractors in the interpretation of plans and specifications; check construction schedules; and make reports on progress.

(2) Government agencies employ construction inspectors mainly to ensure adherence to applicable statutes, codes, and regulations. They determine whether legal requirements concerning materials, construction methods, quality, and other standards are complied with and, in the event of violations, they issue orders to comply or prepare or assist in preparing the case for hearing or prosecution. They may testify in legal proceedings. In some jurisdictions, construction inspectors also may review plans and specifications for construction, issue construction permits and licenses, and educate and advise contractors concerning building and sanitary codes.

Construction Specification Writers

Most specification writers are employed by private architectural firms and government agencies.

They develop, write, and review specifications for structures and for mechanical and electrical equipment of buildings and other construction. Their specifications are reviewed by engineers or architects for completeness and to coordinate the specifications with the design phase of construction.

Their specifications cover the composition, finish, and qualities of materials, and the construction methods to be used. They determine and describe the specific items to be used, their availability and sources, and substitutions and modifications of items as necessary. They may carry on research concerning alternative materials and equipment and make or recommend choices. They consider availability and cost in making choices.

Construction Cost Estimators

Most construction cost estimators are employed by construction firms. Others are employed by government agencies, and manufacturing, public utility, and other establishments for which construction is carried out.

Estimators visualize each step in the construction process and determine the most effective and economical way of performing each phase of construction. They may recommend design changes to reduce building costs and may make comparative studies of construction costs.

Working with engineering and architectural formulas and guides, estimators determine from building plans, working drawings, and specifications the quantity of materials and labor going into such items as concrete, plaster, brick, filling and grading work. They estimate the unit price of material and labor for the various elements of the project and then arrive at estimates of gross costs. They refigure and re-estimate as needed. They review and integrate cost figures of lower ranking estimators. They maintain files of catalogs, unit cost, and related data for construction materials and processes; and prepare data on factors and trends entering into projections of construction costs.

SUBJECT MATTER KNOWLEDGE

Surveyors

Generally needed. In addition to trigonometry and technical drawing, a knowledge of surveying is needed. Surveying topics covered in the New York State examination for Land Surveyor include: theory of surveying, practice of surveying, limits of precision, use and care of instruments, adjustment of instruments, surveying computations, traverses, computations of area and error of closure, base lines and triangulation, land boundaries and monuments, and such specialized or advanced topics as mapping, precision surveying, city surveying, highway surveying, railroad surveying, geodetic surveying, determination of true meridian,

Table VIII-C. SUBJECT MATTER KNOWLEDGE NEEDED BY CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS IN SELECTED OCCUPATIONS

Subject	Surveyors and related specialists		Civil engineering and construction technicians		Construction inspectors			
	Surveyors	Instrument men	Buildings	Highway, steel and other heavy construction	Building structures	Electrical and mechanical equipment	Plumbing	Heating, air conditioning and related equipment
Mathematics								
Trigonometry	XXX	XX	XXX	XXX	X	X	X	X
Advanced algebra	X	X	X	-	-	-	-	-
Solid geometry	X	X	X	-	-	-	-	-
Analytic geometry	-	-	X	-	-	-	-	-
Calculus	X	-	X	X	-	-	-	-
Engineering mathematics	-	-	X	XX	-	-	-	-
Science								
Chemistry, general	X	X	X	X	X	X	XX	-
Physics, general	XX	X	XXX	XXX	X	X	X	X
Hydraulics	X	-	X	X	-	-	-	-
Geology	X	-	-	X	-	-	X	-
Technology								
Technical drawing	XXX	XX	XXX	XXX	-	-	-	-
Basic electricity	-	-	X	-	-	XX	-	-
Electrical code, wiring, and installation	-	-	-	-	-	XXX	-	-
Basic electronics	-	-	-	-	-	XX	-	-
Mechanical technology, orientation	-	-	-	-	-	XX	-	-
Mechanics and strength of materials	-	-	X	XX	-	-	-	-
Heating, ventilating, air conditioning, refrigeration, and related codes	-	-	X	-	X	-	-	XXX
Construction technology, orientation	XX	-	XXX	XXX	XX	X	-	X
Concrete and steel	-	-	XXX	XXX	X	-	-	-
Surveying	XXX	XXX	X	XX	X	-	-	-
Plumbing and sanitary codes	-	-	-	-	-	-	XXX	-
Building codes n.e.c.	-	-	XXX	-	XXX	-	-	-

Key: XXX = generally needed; XX = needed in a substantial number of cases; X = occasionally needed.

declination and variation, determination of latitude and longitude, hydrographic surveying, subdivisions of lands, deed descriptions and conveyancing, and surveying law.

Technicians classified as surveyors or party chiefs are expected to be competent in all or most of the above-listed subjects. Instrumentmen, and lower grade members of survey parties do not require advanced or specialized knowledge at the outset.

Trigonometry is fundamental to surveying, which is concerned with linear and curvilinear distances; plane and compound surfaces and angular relationships between points and lines therein. The trigonometry of plane triangles and polygons is most often applied by surveyors, although advanced trigonometric topics are required for several of the specialized areas.

All members of survey parties and their office counterparts have to read, interpret, and occasionally make drawings of various types and, therefore, require basic training in technical drawing,

<u>Needed in a substantial number of cases</u>. General physics, particularly statical mechanics, light, and heat, is an important background subject. Surveyors use the physics of light and heat in their work with telescopic instruments and thermal expansion effects in measurement with tapes and chains. Construction technology related to either buildings, structures, or civil engineering is cited by many employers as needed by technicians in this category. The particular technology depends upon the technical area in which the employer functions.

<u>Needed only occasionally</u>. Advanced algebra, solid geometry, calculus, hydraulics, general chemistry, and geology have been indicated as desirable preparation by a small proportion of employers of surveyors. The advanced mathematics topics are not normally applied in routine surveying and construction control work but are useful in dealing with compound curves, spirals, contours, areas, and

volume computations. These topics and their applications to surveying are included in the State examination for Land Surveyors.

Chemistry provides the basis for understanding properties of materials such as soils, concrete, and steel, and reactions such as corrosion of metals, decay of timber, and hydration of cement. It is usually a prerequisite to a study of hydraulics, sewage systems, geology, and soils. Although the surveyor may not make direct use of these sciences in his work, they may enlarge his understanding of events and problems which he encounters in his work.

Lower-grade surveying technicians are often high-school graduates who work up from such positions as rodman, chainman, and ax man by on-the-job training sometimes combined with part-time course work. Continued advancement is accelerated by and is frequently contingent upon further educational preparation. Elementary surveying practice can be mastered by field experience under the direction of a surveyor, provided the technician has a basic knowledge of mathematics, physics, and drafting.

Civil Engineering and Construction Technicians

Although the two groups of technicians in this category -- construction superintendents and civil engineering aids -- perform different functions, they may with certain exceptions be treated as a single group in the discussion of subject matter needs. The general minimum requirements of trigonometry, general physics, and technical drawing apply to the entire category. In addition there are specialized subjects in each field.

A. Building Construction Technicians

Generally needed. In addition to a knowledge of mathematics through trigonometry, general physics, technical drawing, and building codes, an orientation in construction technology is needed. Construction technology subjects include architectural and structural drafting, construction methods and practices, materials of construction, and materials testing. Knowledge of specialized drafting is needed to read drawings, plats, and maps, and to interpret them to contractors and construction personnel. Engineering aids are often called upon to make drawings for construction projects and, therefore, require more skill with drafting instruments than construction superintendents.

Needed only occasionally. Advanced algebra, solid geometry, analytic geometry, calculus, engineering mathematics, general chemistry, hydraulics, mechanics and strength of materials, surveying, basic electricity, and heating, ventilating, and air conditioning.

B. Highway, Street, and Other Heavy Construction Technicians

Generally needed. In addition to a knowledge of mathematics through trigonometry, general physics, and technical drawing, an orientation in construction technology is needed. Construction technology subjects include structural steel detailing, architectural and structural drafting, construction methods and practices, materials of construction, materials testing, drainage and sewage systems, highway engineering, soil mechanics, reinforced concrete and steel, and elementary structural design. The importance of each of the above courses depends upon the field of specialization. Construction superintendents generally need more experience than engineering aids, while the latter need more training in drafting and design.

Needed in a substantial number of cases. Engineering mathematics, mechanics and strength of materials, and surveying were often indicated by employers as useful subjects for technicians. Engineering aids have more opportunities than construction superintendents to apply advanced mathematics, especially when calculating complex cut or fill cross-sections and reducing data for computer programming.

Needed only occasionally. A few employers reported that their technicians need a knowledge of one or more of the following subjects: calculus, general chemistry, hydraulics, and geology.

Construction Inspectors

Generally needed. Building construction inspectors require a thorough knowledge of building codes. Inspectors of electrical installations, plumbing, and heating, ventilating, and air conditioning require familiarity with related codes.

Needed in a substantial number of cases. An orientation in construction technology (construction methods and practices, materials of construction, design specifications and standards) in the case of building construction inspectors; electrical theory, wiring, installation, electric machines, basic electronics in the case of electrical inspectors; orientation in mechanical technology (mechanics, thermodynamics, heat, power) in the case of mechanical equipment inspectors; general chemistry by plumbing inspectors, particularly where corrosion and reaction problems are common and when pipe material may contaminate drinking water.

Needed only occasionally. Mathematics through trigonometry and general physics are needed by all types of construction inspectors. General physics is useful for all inspectors, since they frequently work with weights, volumes, and measurements, as well as materials of various densities, structures, and equipment of various kinds. Trigonometry may be needed by inspectors who check survey data, earthwork, piping, ducting, drainage and sewage systems, and highways.

General chemistry is needed by building inspectors if their work involves unpaved concrete, corrosion inspection, plated materials, storage facilities, fire protecting systems, etc. Inspectors of electrical and mechanical installations also occasionally need general chemistry.

Needed occasionally is familiarity with the use of surveying instruments to check alignments, deflections, and locations of footings, pilings, columns, and structural steel work. Generally, inspectors specializing in one field may occasionally need knowledge of the technology of another field. For example, an orientation in construction technology may be useful in some cases to electrical and mechanical equipment inspectors; some building construction inspectors need a working knowledge of heating, ventilating, and air conditioning systems, since the piping and ducting of such systems is integrated into the structure of modern high-rise buildings and industrial plants.

GRADE STRUCTURE

Table VIII-D shows that a majority of civil engineering and construction technicians and specialists with no major supervisory responsibilities are in single-grade jobs. Construction inspectors constitute the main exception. Most construction inspectors are employed by government agencies, where multi-grade structures are common. Also among civil engineering technicians those in multi-grades have a slight edge over those in single grades.

Table VIII-D. PERCENT DISTRIBUTION OF CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS ACCORDING TO GRADE, BY OCCUPATION GROUP

Grade	All occupations	Surveyors and related specialists	Civil engineering and construction technicians	Construction inspectors	Construction specification writers and cost estimators
All grades: Number	13,464	2,381	4,932	2,804	3,347
Percent distribution					
All grades: Percent	100.0	100.0	100.0	100.0	100.0
Supervisory grades	3.7	6.3	3.4	2.9	2.8
Nonsupervisory grades:					
Single grade only	59.0	84.3	45.1	38.6	78.9
Multi-grade:					
Lowest grades	16.4	3.6	21.9	30.0	6.0
Middle grades	7.9	1.6	11.5	10.9	4.5
Highest grades	13.0	4.2	18.1	17.6	7.8

Table VIII-E. NUMBER AND PERCENT DISTRIBUTION OF CIVIL ENGINEERING AND CONSTRUCTION SPECIALISTS BY EDUCATION EMPLOYERS REQUIRE

Education required	Number	Percent
All levels	13,464	100.0
Post-high-school	3,662	27.2
Engineering college	631	4.7
Graduation	386	2.9
Less than graduation	245	1.8
College, general	481	3.6
Graduation	325	2.4
Less than graduation	156	1.2
Technical institute or community college	1,574	11.7
Graduation	1,547	11.5
Less than graduation	27	0.2
Type not specified	892	6.6
Apprenticeship or armed forces school	84	0.6
High school	9,802	72.8
Technical or vocational	361	2.7
Other and not specified	9,441	70.1

The level of difficulty and responsibility of jobs at any grade level may vary from one firm to another. No effort was made in the survey to slot jobs of like level of difficulty and responsibility into the same grade level. The grade levels reflect the designations of employers.

EDUCATION AND EXPERIENCE REQUIRED

Almost three-quarters (72.8 percent) of these technicians and specialists have jobs for which high-school education is the minimum requirement.

Many employers who do not require education beyond high school, however, prefer it, and many require work experience along with high-school graduation.

For all workers, a median of 4.5 years of experience is the requirement.

Education Requirements

Where education beyond high school is a minimum job requirement, the type of education most often specified is graduation from a technical institute.

Courses in or graduation from an engineering college or general four-year college were mentioned in a smaller proportion of cases. (See table VIII-3, at the end of the chapter.)

As shown by the figures below, post-high-school education is required for a higher proportion of construction specification writers and cost estimators than for other major categories of civil engineering and construction specialists:

Occupation group	Post-high-school	High school
All occupations	27.2%	72.8%
Surveyors and related specialists	27.5	72.5
Civil engineering and construction technicians	23.1	76.9
Construction inspectors	7.1	92.9
Construction specification writers and cost estimators	49.9	50.1

Preferred vs. Required Education

Because an employer requires a certain level of education it does not necessarily mean that he would not prefer a worker with a better education. Technicians and specialists may be in short supply making it necessary for the employer to accept workers with less education than he wants. Whereas 27 percent of civil engineering and construction technicians and specialists work for employers who require post-high-school education, 44 percent have employers who prefer applicants with such a background. (See table VIII-4, at the end of the chapter for details.)

Technical institute or community college education is the most common preference of employers who require high-school education but prefer some type of post-high-school education. (See table VIII-5, at the end of the chapter.)

Experience Requirements

Employers of 80 percent of civil engineering and construction technicians and specialists require persons hired for these jobs to have some experience in the same or related line of work.

Such experience might be in lower grades of the same or related technician or specialist jobs, in related construction craft jobs, or, in the case of specification writers and cost estimators, in clerical, accounting, and other related jobs.

As might be expected, the number of years of required experience is greatest for supervisory grades and tends to be greater for the higher nonsupervisory grades than for the lower ones.

Table VIII-F. PERCENT DISTRIBUTION OF CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS ACCORDING TO YEARS OF EXPERIENCE REQUIRED, BY GRADE

Grade	Total	No experience	Under 3 years	3 and under 5	5 and under 7	7 and over
All grades	100.0	19.5	15.9	20.9	23.1	20.6
Supervisory grades	100.0	1.6	3.8	10.1	33.5	51.0
Nonsupervisory grades:						
Single grade only	100.0	23.6	17.4	14.8	22.2	22.0
Multi-grade:						
Lowest grades	100.0	20.5	25.4	19.3	32.7	2.1
Middle grades	100.0	7.4	4.0	70.2	8.0	10.4
Highest grades	100.0	12.6	7.7	23.9	20.7	35.1

In general post-high-school education is equivalent in terms of employer requirements to approximately two years of experience. The median years of experience required by employers for all civil engineering and construction technicians and specialists is 4.5. The number required for jobs for which some type of post-high-school education is specified is 2.3, while for jobs for which high school is required the median is 5.5 years.

It is evident from table VIII-G that the extent to which education is equated with experience is not the same for all occupations in the civil engineering and construction technician and specialist category.

Table VIII-G. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS IN RELATION TO EDUCATION EMPLOYERS REQUIRE, (1) BY OCCUPATION AND (2) BY GRADE

Occupation; grade	All levels	Post-high-school	High school
All occupations; all grades	4.5	2.3	5.5
Occupation (a)			
Surveyors and related specialists			
Surveyors	4.8	2.2	6.0
Instrumentmen	2.8	1.5	2.9
General and other	2.6	0.0	2.9
Civil engineering and construction technicians			
Buildings	6.4	4.8	6.9
Highways, street, and other heavy construction	10.2	6.3	10.6
General and other	3.8	2.9	3.9
Construction inspectors			
Building structures	3.9	4.3	3.9
General and other (b)	5.1	4.5	5.6
Construction specification writers			
Architectural and structural	6.5	6.3	6.7
Construction cost estimators			
Architectural and structural	4.3	1.6	5.3
Mechanical and electrical	1.7	1.0	1.7
Highway, street, and related construction	3.2	0.0	10.2
General	2.4	0.0	3.9
Grade			
Supervisory grades	7.2	4.8	7.5
Nonsupervisory grades:			
Single grade only	4.4	1.8	5.5
Multi-grade:			
Lowest grades	3.0	0.1	3.8
Middle grades	4.3	4.5	4.0
Highest grades	5.8	2.8	6.5

a. Occupational categories in which the number of cases is too small for significant comparison are omitted from the list.

b. Excludes electrical and mechanical equipment, plumbing, and heating, air conditioning, and related equipment inspectors.

A comparison of the education and experience requirements and the education and experience preferences of employers for civil engineering and construction technicians and specialists indicates that the most common preference is for more education and less experience. That is, the employer is willing to accept less experience in exchange for more education. (See table VIII-H on next page and also table VIII-6, at the end of the chapter.)

Table VIII-H. NUMBER OF CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS ACCORDING TO EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE, BY EDUCATION EMPLOYERS REQUIRE

Kind of preference	All levels	Post-high-school	High school
Total	13,464	3,662	9,802
No preference expressed	8,612	1,593	7,019
All preferences	4,852	2,069	2,783
Required education, more experience	359	166	193
More than required education, less experience	2,494	562	1,932
More than required education, same experience	1,507	940	567
More than required education, more experience	492	401	91

TESTS AND LICENSES

Formal intelligence, achievement, or aptitude tests were reported as a means of determining the qualifications of very few civil engineering and construction technicians and specialists. However, civil service examinations were required for 32 percent and State licenses for 3 percent (land surveyors).

SOURCES OF WORKERS

Method of Obtaining Workers

Of the two methods of obtaining workers qualified to perform the functions of civil engineering and construction technicians and specialists, employers use recruitment more often than upgrading:

Recruited from outside the firm	60.5
Upgraded, total	39.5
With organized training	2.8
Without organized training	36.7

Recruitment is the predominant method not only for the group as a whole, but for each of the occupational categories as shown by table VIII-I, (which is based on table VIII-7, at the end of the chapter).

Table VIII-I. PERCENT DISTRIBUTION OF CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS ACCORDING TO METHOD OF OBTAINING THEM (1) BY OCCUPATION GROUP AND (2) BY GRADE

Occupation group; grade	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All occupations; all grades	100.0	60.5	2.8	36.7
Occupation group				
Surveyors and related specialists	100.0	64.6	1.8	33.6
Civil engineering and construction technicians	100.0	54.4	3.2	42.4
Construction inspectors	100.0	65.4	5.3	29.3
Construction specification writers and cost estimators	100.0	62.8	0.6	36.6
Grade				
Supervisory grades	100.0	27.8	12.4	59.8
Nonsupervisory grades:				
Single grade only	100.0	69.5	0.8	29.7
Multi-grade:				
Lowest grades	100.0	75.9	0.6	23.5
Middle grades	100.0	40.7	11.5	47.8
Highest grades	100.0	21.9	6.3	71.8

Substantially higher proportions of civil engineering and construction technicians and specialists in upper grades are obtained by upgrading - both with and without organized training sponsored by the employer - than is true of those in lower grades or with jobs in a single grade.

College and Technical Institute Graduates

Of the total of 13,464 civil engineering and construction technicians and specialists, roughly 25 percent are one-year, two-year, or three-year post-high-school technical institution program graduates (mostly two-year technical institute or community college technical program graduates). About 14 percent are college graduates.

Of the various kinds of technicians and specialists in the civil engineering field, the highest proportion of college and technical institute graduates is found among the specification writers and cost estimators:

	College graduates	Technical institute graduates
All occupations	13.6%	25.4%
Surveyors and related specialists	9.6	25.3
Civil engineering and construction technicians	9.9	28.1
Construction inspectors	4.8	20.2
Construction specification writers and cost estimators	29.3	26.0

(See table VIII-8 for further detail.)

PROMOTIONAL LINES

Apart from lower grades of the same occupation, jobs most often mentioned as being ones from which civil engineering and construction technicians and specialists were promoted include draftsman; other kinds of technical jobs in the construction field (for example, from construction inspector to construction technician); construction trades craftsman and construction trades foreman (especially to construction inspector); and clerical jobs (especially to specification writer and cost estimator).

Jobs most often reported as ones to which these technicians and specialists were promoted (other than higher grades of the same or related occupations) include engineering, supervisory, and management jobs.

Civil Engineering and Construction Technicians and Specialists

Table VIII-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

A. Surveyors, Civil Engineering and Construction Technicians, and Construction Inspectors

Industry group	All occupations	Surveyors and related specialists				Civil engineering and construction technicians				Construction inspectors					
		Total	Surveyors	Instrumentmen	General and other	Total	Buildings	Highway, street, and other heavy construction	General and other	Total	Building structures	Electrical and mechanical equipment	Plumbing	Heating, air conditioning, and related equipment	General and other
All industries	13,464	2,381	1,171	1,007	203	4,932	1,765	983	2,184	2,804	1,126	498	214	54	912
Manufacturing	130	5	4	1	-	23	-	-	23	31	1	-	-	-	30
Stone, clay, and glass products	6	3	3	-	-	3	-	-	3	-	-	-	-	-	-
Primary metal industries	7	1	-	1	-	2	-	-	2	-	-	-	-	-	-
Fabricated metal products	101	1	1	-	-	6	-	-	6	31	1	-	-	-	30
Machinery, except electrical	12	-	-	-	-	12	-	-	12	-	-	-	-	-	-
Chemicals and allied products	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nonmanufacturing	13,334	2,376	1,167	1,006	203	4,909	1,765	983	2,161	2,773	1,125	498	214	54	882
Mining	2	1	1	-	-	1	1	-	-	-	-	-	-	-	-
Contract construction	5,765	832	390	442	-	2,135	1,353	486	296	133	2	12	-	40	79
General building contractors	2,573	244	106	138	-	1,360	1,221	-	139	10	2	6	-	-	2
Heavy construction	1,450	460	226	234	-	562	2	486	74	10	-	-	-	-	10
Special trade contractors	1,742	128	58	70	-	213	130	-	83	113	-	6	-	40	67
Transportation and public utilities	664	123	44	59	20	262	-	246	16	72	-	23	-	1	48
Railroad transportation	154	29	10	19	-	78	-	62	16	44	-	14	-	1	29
Air transportation	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric, gas, and sanitary services	508	94	34	40	20	184	-	184	-	28	-	9	-	-	19
Wholesale and retail trade	77	-	-	-	-	1	-	-	1	-	-	-	-	-	-
Wholesale trade	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Retail trade	67	-	-	-	-	1	-	-	1	-	-	-	-	-	-
Building materials, hardware, farm equipment	66	-	-	-	-	1	-	-	1	-	-	-	-	-	-
Food stores	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Finance, insurance, and real estate	23	-	-	-	-	7	7	-	-	1	1	-	-	-	-
Banking	7	-	-	-	-	7	7	-	-	-	-	-	-	-	-
Insurance carriers	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Real estate	15	-	-	-	-	-	-	-	-	1	1	-	-	-	-
Services and miscellaneous	2,170	1,140	636	404	100	264	91	39	134	547	174	52	-	6	315
Business services n.e.c.	79	10	-	-	10	7	2	2	3	12	2	-	-	-	10
Research, development, testing laboratories	12	-	-	-	-	-	-	-	-	12	2	-	-	-	10
Business and management consulting services	19	-	-	-	-	5	-	2	3	-	-	-	-	-	-
Other business services n.e.c.	48	10	-	-	10	2	2	-	-	-	-	-	-	-	-
Private colleges and schools	16	-	-	-	-	11	2	-	9	5	-	2	-	-	3
Engineering and architectural services	2,075	1,130	636	404	90	246	87	37	122	530	172	50	-	6	302
Government	4,633	280	96	101	83	2,239	313	212	1,714	2,020	948	411	214	7	440
County	374	73	29	25	19	120	-	21	99	181	1	-	4	-	176
Colleges	1	-	-	-	-	1	-	-	1	-	-	-	-	-	-
Other	373	73	29	25	19	119	-	21	98	181	1	-	4	-	176
New York State	1,788	72	37	35	-	1,463	2	1	1,460	168	128	-	-	-	40
Colleges	5	-	-	-	-	5	1	-	4	-	-	-	-	-	-
Other	1,783	72	37	35	-	1,458	1	1	1,456	168	128	-	-	-	40
New York City	1,435	8	8	-	-	456	278	167	11	967	419	395	88	6	59
Hospitals	14	-	-	-	-	-	-	-	-	14	9	3	2	-	-
Colleges	10	-	-	-	-	10	1	-	9	-	-	-	-	-	-
Other	1,411	8	8	-	-	446	277	167	2	953	410	392	86	6	59
Cities other than New York City	340	51	3	-	48	52	-	1	51	237	112	8	58	1	58
Towns and villages	419	17	9	6	2	18	-	8	10	383	288	2	64	-	29
Federal	277	59	10	35	14	130	33	14	83	84	-	6	-	-	78
Arsenals and navy yards	15	-	-	-	-	2	-	-	2	13	-	6	-	-	7
Other	262	59	10	35	14	128	33	14	81	71	-	-	-	-	71

Table VIII-1 (concluded)

B. Construction Specification Writers and Cost Estimators

Industry group	Total	Specification writers				Cost estimators					Combination: specification writing and cost estimating				
		Total	Architectural and structural	Mechanical and electrical	Highway, street, and related construction	Total	Architectural and structural	Mechanical and electrical	Highway, street, and related construction	General	Total	Architectural and structural	Mechanical and electrical	Highway, street, and related construction	General and other
All industries	3,347	117	72	25	20	2,898	1,426	841	361	270	332	92	161	64	15
Manufacturing	71	-	-	-	-	71	43	3	-	25	-	-	-	-	-
Stone, clay, and glass products	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Primary metal industries	4	-	-	-	-	4	-	-	-	4	-	-	-	-	-
Fabricated metal products	63	-	-	-	-	63	42	3	-	18	-	-	-	-	-
Machinery, except electrical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chemicals and allied products	4	-	-	-	-	4	1	-	-	3	-	-	-	-	-
Nonmanufacturing	3,276	117	72	25	20	2,827	1,383	838	361	245	332	92	161	64	15
Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Contract construction	2,665	-	-	-	-	2,525	1,287	792	323	123	140	80	-	60	-
General building contractors	959	-	-	-	-	879	837	-	4	38	80	80	-	-	-
Heavy construction	418	-	-	-	-	358	-	62	221	75	60	-	-	60	-
Special trade contractors	1,288	-	-	-	-	1,288	450	730	98	10	-	-	-	-	-
Transportation and public utilities	207	19	-	-	19	27	-	-	27	-	161	2	159	-	-
Railroad transportation	3	-	-	-	-	3	-	-	3	-	-	-	-	-	-
Air transportation	2	-	-	-	-	-	-	-	-	-	2	2	-	-	-
Electric, gas, and sanitary services	202	19	-	-	19	24	-	-	24	-	159	-	159	-	-
Wholesale and retail trade	76	-	-	-	-	76	-	10	-	66	-	-	-	-	-
Wholesale trade	10	-	-	-	-	10	-	10	-	-	-	-	-	-	-
Retail trade	66	-	-	-	-	66	-	-	-	66	-	-	-	-	-
Building materials, hardware, farm equipment	66	-	-	-	-	66	-	-	-	66	-	-	-	-	-
Food stores	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Finance, insurance, and real estate	15	-	-	-	-	15	15	-	-	-	-	-	-	-	-
Banking	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Insurance carriers	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Real estate	14	-	-	-	-	14	14	-	-	-	-	-	-	-	-
Services and miscellaneous	219	47	46	1	-	147	49	36	11	51	25	10	-	4	11
Business services n.e.c.	50	-	-	-	-	50	-	36	2	12	-	-	-	-	-
Research, development, testing laboratories	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Business and management consulting services	14	-	-	-	-	14	-	-	2	12	-	-	-	-	-
Other business services n.e.c.	36	-	-	-	-	36	-	36	-	-	-	-	-	-	-
Private colleges and schools	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Engineering and architectural services	169	47	46	1	-	97	49	-	9	39	25	10	-	4	11
Government	94	51	26	24	1	37	32	-	-	5	6	-	2	-	4
County	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colleges	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New York State	85	47	22	24	1	36	32	-	-	4	2	-	2	-	-
Colleges	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	85	47	22	24	1	36	32	-	-	4	2	-	2	-	-
New York City	4	-	-	-	-	-	-	-	-	-	4	-	-	-	4
Hospitals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colleges	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	4	-	-	-	-	-	-	-	-	-	4	-	-	-	4
Cities other than New York City	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Towns and villages	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-
Federal	4	4	4	-	-	-	-	-	-	-	-	-	-	-	-
Arsenals and navy yards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	4	4	4	-	-	-	-	-	-	-	-	-	-	-	-

Civil Engineering and Construction Technicians and Specialists

Table VIII-2. OCCUPATION OF SUPERVISORS
(Percent distribution of technicians and specialists according to supervisor's occupation)

Occupation	Total number	Occupation of supervisor: Total	Engineer or scientist	Technician (a)	Other
All occupations	13,464	100.0	51.3	24.9	23.8
Surveyors and related specialists	2,381	100.0	50.6	33.9	15.5
Surveyors	1,171	100.0	55.5	18.6	25.9
Instrumentmen	1,007	100.0	39.5	55.8	4.7
General and other	203	100.0	77.3	13.3	9.4
Civil engineering and construction technicians	4,932	100.0	67.4	18.9	13.7
Buildings	1,765	100.0	53.3	27.8	18.9
Highway, street, and other heavy construction	983	100.0	70.9	2.3	26.8
General and other	2,184	100.0	77.2	19.2	3.6
Construction inspectors	2,804	100.0	33.5	38.2	28.3
Building structures	1,126	100.0	32.5	38.1	29.4
Electrical and mechanical equipment	498	100.0	13.1	55.6	31.3
Plumbing	214	100.0	5.6	30.4	64.0
Heating, air conditioning, and related equipment	54	100.0	14.8	9.3	75.9
General and other	912	100.0	53.6	32.3	14.1
Construction specification writers and cost estimators	3,347	100.0	42.8	16.3	40.9
Specification writers	117	100.0	43.6	44.4	12.0
Architectural and structural	72	100.0	52.8	37.5	9.7
Mechanical and electrical	25	100.0	12.0	88.0	-
Highway, street, and related construction	20	100.0	50.0	15.0	35.0
Cost estimators	2,898	100.0	41.6	14.7	43.7
Architectural and structural	1,426	100.0	38.4	25.7	35.9
Mechanical and electrical	841	100.0	23.5	4.3	72.2
Highway, street, and related construction	361	100.0	69.2	1.7	29.1
General	270	100.0	78.2	7.0	14.8
Combination: specification writing and cost estimating	332	100.0	52.1	20.5	27.4
Architectural and structural	92	100.0	90.3	4.3	5.4
Mechanical and electrical	161	100.0	46.0	37.9	16.1
Highway, street, and related construction	64	100.0	6.3	-	93.7
General and other	15	100.0	80.0	20.0	-

a. Civil engineering or construction technician or specialist, or other technician.

Civil Engineering and Construction Technicians and Specialists

Table VIII-3. EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION GROUP

(Percent distribution of technicians and specialists according to level of education required)

Education required	All occupations	Surveyors and related specialists	Civil engineering and construction technicians	Construction inspectors	Construction specification writers and cost estimators
All levels: Number	13,464	2,381	4,932	2,804	3,347
Percent distribution					
All levels: Percent	100.0	100.0	100.0	100.0	100.0
Post-high-school	27.2	27.5	23.1	7.1	49.9
Engineering college	4.7	4.9	7.1	1.1	4.0
Graduation	2.9	3.9	3.8	1.0	2.3
Less than graduation	1.8	1.0	3.3	0.1	1.7
College, general	3.6	0.3	0.5	0.7	12.8
Graduation	2.4	0.1	0.1	0.7	8.9
Less than graduation	1.2	0.2	0.4	-	3.9
Technical institute or community college	11.7	17.2	4.8	3.9	24.5
Graduation	11.5	16.9	4.8	3.9	23.9
Less than graduation	0.2	0.3	-	-	0.6
Type not specified	6.6	5.1	9.5	0.5	8.6
Apprenticeship or armed forces school	0.6	-	1.2	0.9	-
High school	72.8	72.5	76.9	92.9	50.1
Technical or vocational	2.7	3.9	1.7	1.5	4.2
Other and not specified	70.1	68.6	75.2	91.4	45.9

Civil Engineering and Construction Technicians and Specialists

Table VIII-4. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of technicians and specialists according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	13,464	13,464	100.0	100.0
Post-high-school	3,662	5,963	27.2	44.3
Engineering college	631	2,415	4.7	17.9
Graduation	386	2,133	2.9	15.8
Less than graduation	245	282	1.8	2.1
College, general	481	770	3.6	5.7
Graduation	325	599	2.4	4.4
Less than graduation	156	171	1.2	1.3
Technical institute or community college	1,574	2,331	11.7	17.3
Graduation	1,547	2,274	11.5	16.9
Less than graduation	27	57	0.2	0.4
Type not specified	892	371	6.6	2.8
Apprenticeship or armed forces school	84	76	0.6	0.6
High school	9,802	7,501	72.8	55.7
Technical or vocational	361	375	2.7	2.8
Other and not specified	9,441	7,126	70.1	52.9

Civil Engineering and Construction Technicians and Specialists

Table VIII-5. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Percent distribution of technicians and specialists according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require											
				Post-high-school									High school		
				Post-high-school, total	Engineering college		College, general		Technical institute		Type not specified	Apprenticeship or armed forces school	High school, total	Technical or vocational	Other and not specified
					Graduation	Less than graduation	Graduation	Less than graduation	Graduation	Less than graduation					
All levels	100.0	67.0	33.0	31.3	13.1	0.7	3.9	0.3	12.6	0.3	0.3	0.1	1.7	1.5	0.2
Post-high-school	100.0	47.8	52.2	51.6	25.5	0.4	11.3	0.1	13.8	-	0.5	-	0.6	-	0.6
Engineering college	100.0	90.6	9.4	9.4	8.9	-	-	0.5	-	-	-	-	-	-	-
Graduation	100.0	99.2	0.8	0.8	-	-	-	0.8	-	-	-	-	-	-	-
Less than graduation	100.0	77.1	22.9	22.9	22.9	-	-	-	-	-	-	-	-	-	-
College, general	100.0	42.2	57.8	57.8	51.2	1.2	2.7	-	2.7	-	-	-	-	-	-
Graduation	100.0	24.0	76.0	76.0	72.0	-	-	-	4.0	-	-	-	-	-	-
Less than graduation	100.0	80.1	19.9	19.9	7.7	3.8	8.4	-	-	-	-	-	-	-	-
Technical institute or community college	100.0	37.4	62.6	61.1	35.1	0.2	25.4	-	0.4	-	-	-	1.5	-	1.5
Graduation	100.0	37.2	62.8	61.3	35.2	0.2	25.9	-	-	-	-	-	1.5	-	1.5
Less than graduation	100.0	48.1	51.9	51.9	29.7	-	-	-	22.2	-	-	-	-	-	-
Type not specified	100.0	36.3	63.7	63.7	8.9	0.4	-	-	54.4	-	-	-	-	-	-
Apprenticeship or armed forces school	100.0	76.2	23.8	23.8	-	-	-	-	-	-	23.8	-	-	-	-
High school	100.0	74.2	25.8	23.7	8.3	0.8	1.1	0.4	12.3	0.4	0.3	0.1	2.1	2.0	0.1
Technical or vocational	100.0	50.4	49.6	46.8	14.4	0.6	-	-	29.8	1.4	0.6	-	2.8	-	2.8
Other and not specified	100.0	75.1	24.9	22.9	8.1	0.8	1.1	0.5	11.6	0.4	0.3	0.1	2.0	2.0	-

Civil Engineering and Construction Technicians and Specialists

Table VIII-6. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number of technicians and specialists according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
All levels	13,464	8,612	4,852	359	2,494	1,507	492
Post-high-school	3,662	1,593	2,069	166	562	940	401
Engineering college	631	519	112	29	46	23	14
Graduation	386	351	35	20	-	8	7
Less than graduation	245	168	77	9	46	15	7
College, general	481	197	284	19	22	243	-
Graduation	325	72	253	19	-	234	-
Less than graduation	156	125	31	-	22	9	-
Technical institute or community college	1,574	504	1,070	103	441	507	19
Graduation	1,547	491	1,056	103	436	498	19
Less than graduation	27	13	14	-	5	9	-
Type not specified	892	309	583	15	33	167	368
Apprenticeship or armed forces school	84	64	20	-	20	-	-
High school	9,802	7,019	2,783	193	1,932	567	91
Technical or vocational	361	145	216	47	98	68	3
Other and not specified	9,441	6,874	2,567	146	1,834	499	88

Civil Engineering and Construction Technicians and Specialists

Table VIII-7. METHOD OF OBTAINING TECHNICIANS AND SPECIALISTS, BY OCCUPATION

(Percent distribution according to method of obtaining them)

Occupation	Total number	Percent distribution: Total	Recruited from outside the firm	Upgraded with organized training	Upgraded without organized training
All occupations	13,464	100.0	60.5	2.8	36.7
Surveyors and related specialists	2,381	100.0	64.6	1.8	33.6
Surveyors	1,171	100.0	61.5	0.9	37.6
Instrumentmen	1,007	100.0	68.7	3.2	28.1
General and other	203	100.0	61.6	-	38.4
Civil engineering and construction technicians	4,932	100.0	54.4	3.2	42.4
Buildings	1,765	100.0	60.2	2.8	37.0
Highway, street, and other heavy construction	983	100.0	52.4	0.1	47.5
General and other	2,184	100.0	50.6	5.0	44.4
Construction inspectors	2,804	100.0	65.4	5.3	29.3
Building structures	1,126	100.0	71.0	-	29.0
Electrical and mechanical equipment	498	100.0	57.2	15.5	27.3
Plumbing	214	100.0	67.3	-	32.7
Heating, air conditioning, and related equipment	54	100.0	63.0	-	37.0
General and other	912	100.0	62.7	7.8	29.5
Construction specification writers and cost estimators	3,347	100.0	62.8	0.6	36.6
Specification writers	117	100.0	41.0	-	59.0
Architectural and structural	72	100.0	59.7	-	40.3
Mechanical and electrical	25	100.0	20.0	-	80.0
Highway, street, and related construction	20	100.0	-	-	100.0
Cost estimators	2,898	100.0	69.5	0.7	29.8
Architectural and structural	1,426	100.0	61.5	0.1	38.4
Mechanical and electrical	841	100.0	72.0	2.4	25.6
Highway, street, and related construction	361	100.0	89.8	-	10.2
General	270	100.0	76.7	-	23.3
Combination: specification writing and cost estimating	332	100.0	12.0	-	88.0
Architectural and structural	92	100.0	16.3	-	83.7
Mechanical and electrical	161	100.0	8.1	-	91.9
Highway, street, and related construction	64	100.0	6.3	-	93.7
General and other	15	100.0	53.3	-	46.7

Civil Engineering and Construction Technicians and Specialists

Table VIII-8. GRADUATES OF COLLEGES OR TECHNICAL INSTITUTES, BY OCCUPATION

(Percent who are graduates)

Occupation	College graduates	Technical institute graduates
All occupations	13.6	25.4
Surveyors and related specialists	9.6	25.3
Surveyors	16.0	29.8
Instrumentmen	3.0	21.4
General and other	5.4	18.7
Civil engineering and construction technicians	9.9	28.1
Buildings	17.6	18.3
Highway, street, and other heavy construction	6.7	5.9
General and other	5.1	45.9
Construction inspectors	4.8	20.2
Building structures	9.5	20.7
Electrical and mechanical equipment	2.4	14.3
Plumbing	-	17.8
Heating, air conditioning, and related equipment	-	5.6
General and other	1.8	24.3
Construction specification writers and cost estimators	29.3	26.0
Specification writers	29.1	12.8
Architectural and structural	43.1	16.7
Mechanical and electrical	12.0	4.0
Highway, street, and related construction	-	10.0
Cost estimators	31.8	29.0
Architectural and structural	28.1	33.3
Mechanical and electrical	44.7	14.9
Highway, street, and related construction	31.0	39.6
General	12.2	37.0
Combination: specification writing and cost estimating	6.9	3.3
Architectural and structural	2.2	3.3
Mechanical and electrical	0.6	3.1
Highway, street, and related construction	23.4	3.1
General and other	33.3	6.7

Chapter IX

SALES AND SERVICE TECHNICIANS

A comparatively small group of technicians -- about 2,000 -- carry on a wide variety of activities in the field of customer sales and service.

FUNCTIONS

Most of the activities of sales or service technicians are related to three broad functions: (1) promoting and selling technically complex products; (2) serving as a source of information concerning the kinds of needs customers have in the product field in which the company operates; (3) assisting customers in the installation, use, and maintenance of such products. Some technicians concentrate on one of these functions; others are active in all three.

More specifically, sales and service technicians may do one or more of the following:

(1) Check territory for new prospects, new products, and general market conditions; demonstrate items produced for sale and publicize and explain products by customer contacts and in other ways; check customer specifications against those available, making modifications as required and carrying on related negotiations; prepare quotations on price and delivery; help customer to determine his needs and assist him in preparing proposals; analyze customer complaints and see that they are taken care of; negotiate with customer on charge backs, returned goods, refunds, etc.; evaluate customer use of products and recommend modifications; help coordinate production and delivery commitments; investigate new and alternative uses of company's products.

(2) Be alert to customers' reactions on price, delivery, quality, and performance, and report them to company. Serve as liaison between customers and company's engineering department on matters of efficiency of equipment operation, design, and development; keep abreast of technical developments, including competitive products and developments; assist or give advice in connection with testing of products under conditions found in field; review proposed changes in product design from viewpoint of servicing; report on customers' operation of company's equipment and performance and servicing problems encountered.

(3) Install or assist in the installation of company's equipment in customers' plants and perform related operations such as calibration; perform preventive maintenance and troubleshoot such equipment to fit customers' needs; may do repair work; train customer personnel in the installation, calibration, operation, troubleshooting, maintenance, and repair of company's equipment; recommend to customer what equipment and instruments should be repaired and what replaced.

This last group of functions is closely related to those performed by electro and mechanical engineering technicians engaged in troubleshooting and related functions. (See chapter III, above.) If a technician's work was entirely confined to these technical operations, he was classified as an electro or mechanical troubleshooting technician.

The sales and service technician typically is supervised by higher-level sales-promotion or management personnel, rather than by an engineer or higher-grade technician. About 13 percent are supervised by engineers, 9 percent by technicians, and 78 percent by persons in other occupations.

INDUSTRY

Approximately half the sales and service technicians are classified as being in wholesale trade. Most of the remainder are classified in manufacturing industries, as is seen in the following figures (they are taken from table IX-1, at the end of the chapter, which gives further detail):

Industry group	Number	Percent
All industries	1,932	100.0
Manufacturing	813	42.1
Machinery, except electrical	105	5.4
Electrical machinery and equipment	179	9.3
Transportation equipment	114	5.9
Instruments; photographic and optical goods	118	6.1
All other manufacturing	297	15.4
Nonmanufacturing	1,119	57.9
Wholesale trade	954	49.4
All other nonmanufacturing	165	8.5

Some, if not most, of the sales and service technicians classified in wholesale trade were employed in manufacturers' sales offices. Under the standard industrial classification code used in this study, these offices are classified in wholesale trade when they are separately established, apart from the firm's operation.

SUBJECT MATTER KNOWLEDGE

Sales and service technicians need to have familiarity with company equipment; manufacturing, engineering, shipping, and invoice procedures; and contract interpretation. This knowledge is usually obtained by on-the-job experience.

Combining as they do technical functions with sales promotion, sales and service technicians have need for technical subject matter knowledge corresponding to that of electro and mechanical engineering technicians.

Their basic subject requirement is mathematics through trigonometry, for calculations required in preparing cost estimates of field repairs; and general physics to cover the principles of mechanics, heat, light, sound, electricity, and magnetism, necessary for background in the engineering technologies.

Ability to read blueprints and schematics is a basic requirement, and technical drawing may be needed in some cases.

Specific needs for additional subject matter depend upon the industry or the product dealt with. For example:

Beverages: analytical chemistry (for color, taste, etc.).

Industrial machinery: mechanics; machine design; machine shop theory and practice.

Electrical-electronic equipment: basic electricity; basic electronics.

Electronic-medical equipment: basic electronics; general biology; anatomy.

Medical and dental equipment: general biology; bacteriology; anatomy.

Ultrasonic equipment: basic electronics; sound.

Welding equipment and supplies: welding technology; metallurgy.

Pumps, compressors: hydraulics; thermodynamics; mechanics.

Prime metal supplier: metallurgy; foundry; sand casting; die casting.

Optical equipment: optics; basic electronics.

Paints: qualitative and quantitative chemistry; pigment chemistry.

Oil industry: advanced chemistry; qualitative and quantitative chemistry.

GRADE STRUCTURE

Multi-grade structures for sales and service technicians are uncommon. About 90 percent of nonsupervisory employees are in single grades, as is seen in the following data on number of technicians (taken from table IX-2):

All grades	1,932
Supervisory grades	46
Nonsupervisory grades:	
Single grade only	1,695
Multi-grade:	
Lowest grades	111
Middle grades	3
Highest grades	77

EDUCATION AND EXPERIENCE REQUIRED

Employers of the majority of sales and service technicians (54 percent) require some post-high-school education as a condition for employment in this occupation. Employers of the other 46 percent have education requirements that do not go beyond completion of high school. Many of these employers who do not require post-high-school education prefer it.

Many employers require several years of experience, in addition to education.

Education Requirements

Attendance at an engineering college (not graduation) is the type of education most frequently specified for jobs that require some education beyond high school, as the following percent distribution shows (more detail in table IX-2, at the end of the chapter):

Education required	Percent
All levels	100.0
Post-high-school	53.8
Engineering college: less than graduation	17.3
College, general: graduation	9.2
less than graduation	8.5
Technical institute graduation	10.6
All other post-high-school	8.2
High school	46.2

Preferred vs. Required Education

If educational qualifications are viewed from the standpoint of what employers prefer rather than what they require, the proportion of jobs in the post-high-school category becomes substantially greater -- rising from 54 to 88 percent of the total of 1,932 sales and service technician jobs. Most of those who were in the high-school-required group move to the technical-institute-preferred group, while most of those in the less-than-college-degree group move into the degree group. (See tables IX-3 and IX-4 at the end of the chapter.)

Experience Requirements

Employers of the large majority of sales and service technicians require that persons appointed to these jobs have some experience in the same line or in a related line of work. No experience is required in the case of 29 percent of the technicians. Three or more years of experience is required for approximately 56 percent:

Experience required	Percent
Total	100.0
No experience	29.2
Under 1 year	1.7
1 and under 2	5.0
2 and under 3	8.4
3 and under 4	29.0
4 and under 5	6.4
5 and under 7	15.4
7 and under 10	3.7
10 years and over	1.2

A firm that requires post-high-school education may not require the applicant to have had as much experience as a firm that requires high-school graduation. On the basis of the requirements reported for this group of technicians, post-high-school education is rated as worth around 3.5 years of experience, on the average. (Table IX-A).

Table IX-A. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR SALES AND SERVICE TECHNICIANS IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY GRADE

Grade	All levels	Post-high-school	High school
All grades	3.4	1.9	5.4
Supervisory grades	5.7	(a)	(a)
Nonsupervisory:			
Single grade only	3.2	2.1	4.6
Multi-grade:			
Lowest grades	4.5	1.5	5.8
Middle grades	(a)	(a)	-
Highest grades	7.4	(a)	7.7

a. Not computed because of small number involved.

When employers' education and experience preferences are compared with their requirements, it appears that, in respect to the 1,331 jobs as to which any preference was reported, almost all choices were in favor of more education. While, as to 587 jobs, the preference was for more education with the same experience requirement, in about the same number of cases (633) the employer was willing to accept less experience in order to get more educational background. (Table IX-5 at the end of the chapter.)

TESTS AND LICENSES

A substantial number of employers reported that they gave intelligence, aptitude, and achievement tests as an aid to determining qualifications for sales and service technician positions. No license requirements for these technicians were reported in the survey.

SOURCES OF WORKERS

Recruiting outside the firm was used almost three times as often as upgrading to obtain employees qualified to perform the functions of sales and service technicians, during a representative period preceding the survey. In terms of the number of technicians employed at the time of the survey, upgrading involved about 500, of whom only about 20 were upgraded by means of training organized by the employer:

Method of obtaining workers	Number	Percent
All methods	1,932	100.0
Recruited from outside the firm	1,429	74.0
Upgrading, total	503	26.0
With organized training	22	1.1
Without organized training	481	24.9

Over a third (34 percent) of the sales and service technicians employed at the time of the survey were four-year-college graduates. About half that number (16 percent) were graduates of technical institutes or community colleges.

PROMOTIONAL LINES

Lower-level jobs from which sales and service technicians are reported to have been promoted include craft jobs, foreman jobs, and some other production jobs. A person in a related occupation, for example a trouble-shooting technician, may get a boost in grade in the process of shifting to sales or service technician.

Jobs to which sales and service technicians are promoted are most often reported as supervisory jobs, sales management jobs, and engineering jobs.

Sales and Service Technicians

Table IX-1. NUMBER, BY INDUSTRY GROUP

Industry group	Number
All industries	1,932
Manufacturing	813
Durable goods	666
Ordnance and accessories	1
Furniture and fixtures	1
Stone, clay, and glass products	48
Primary metal industries	15
Fabricated metal products	85
Machinery, except electrical	105
Electrical machinery, and equipment	179
Transportation equipment	114
Instruments; photographic and optical goods	118
Nondurable goods	147
Food and kindred products	28
Textile mill products	24
Paper and allied products	19
Chemicals and allied products	45
Petroleum refining and related industries	19
Rubber and miscellaneous plastics products	2
Leather and leather products	10
Nonmanufacturing	1,119
Contract construction	86
General building contractors	18
Heavy construction	11
Special trade contractors	57
Wholesale trade	954
Services and miscellaneous	27
Business services n.e.c.	13
Research, development, testing laboratories	2
Other business services n.e.c.	11
Amusement and recreation, except motion pictures	6
Medical and dental laboratories	1
Engineering and architectural services	7
Government	52
New York City	44
Federal	8

Sales and Service Technicians

Table IX-2. EDUCATION EMPLOYERS REQUIRE, BY GRADE

(Percent distribution of technicians according to level of education required)

Education required	All grades	Supervisory grades	Nonsupervisory grades			
			Single grade only	Multi-grade		
				Lowest grades	Middle grades	Highest grades
All levels: Number	1,932	46	1,695	111	3	77
Percent distribution						
All levels: Percent	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	53.8	54.3	55.6	54.1	(a)	(a)
Engineering college	20.9	2.2	20.7	45.1	(a)	-
Graduation	3.6	2.2	0.9	45.1	(a)	-
Less than graduation	17.3	-	19.8	-	-	-
College, general	17.7	45.6	18.4	4.5	-	(a)
Graduation	9.2	45.6	8.8	4.5	-	(a)
Less than graduation	8.5	-	9.6	-	-	(a)
Technical institute or community college	11.8	4.3	13.2	2.7	-	-
Graduation	10.6	2.2	11.8	2.7	-	-
Less than graduation	1.2	2.1	1.4	-	-	-
Type not specified	2.4	-	2.2	1.8	(a)	(a)
Apprenticeship or armed forces school	1.0	2.2	1.1	-	-	-
High school	46.2	45.7	44.4	45.9	-	(a)
Technical or vocational	2.8	-	2.8	2.7	-	(a)
Other and not specified	43.4	45.7	41.6	43.2	-	(a)

a. Not computed because of small number involved.

Sales and Service Technicians

Table IX-3. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of technicians according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	1,932	1,932	100.0	100.0
Post-high-school	1,039	1,699	53.8	87.9
Engineering college	405	615	20.9	31.7
Graduation	69	607	3.6	31.3
Less than graduation	336	8	17.3	0.4
College, general	341	431	17.7	22.3
Graduation	177	367	9.2	19.0
Less than graduation	164	64	8.5	3.3
Technical institute or community college	228	553	11.8	28.7
Graduation	204	295	10.6	15.3
Less than graduation	24	258	1.2	13.4
Type not specified	46	81	2.4	4.2
Apprenticeship or armed forces school	19	19	1.0	1.0
High school	893	233	46.2	12.1
Technical or vocational	54	16	2.8	0.8
Other and not specified	839	217	43.4	11.3

Table IX-4. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Number and percent distribution of technicians according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from requirement (a)							
				Post-high-school							Type not specified
				Post-high-school, total	Engineering college		College, general		Technical institute		
					Graduation	Less than graduation	Graduation	Less than graduation	Graduation	Less than graduation	
Number											
All levels	1,932	666	1,266	1,266	538	6	195	49	205	234	39
Post-high-school	1,039	433	606	606	469	-	123	2	12	-	-
Engineering college	405	71	334	334	334	-	-	-	-	-	-
Graduation	69	69	-	-	-	-	-	-	-	-	-
Less than graduation	336	2	334	334	334	-	-	-	-	-	-
College, general	341	187	154	154	30	-	112	-	12	-	-
Graduation	177	172	5	5	5	-	-	-	-	-	-
Less than graduation	164	15	149	149	25	-	112	-	12	-	-
Technical institute or community college	228	114	114	114	101	-	11	2	-	-	-
Graduation	204	90	114	114	101	-	11	2	-	-	-
Less than graduation	24	24	-	-	-	-	-	-	-	-	-
Type not specified	46	42	4	4	4	-	-	-	-	-	-
Apprenticeship or armed forces school	19	19	-	-	-	-	-	-	-	-	-
High school	893	233	660	660	69	6	72	47	193	234	39
Technical or vocational	54	16	38	38	-	2	-	26	10	-	-
Other and not specified	839	217	622	622	69	4	72	21	183	234	39
Percent distribution											
All levels	100.0	34.5	65.5	65.5	27.9	0.3	10.1	2.5	10.6	12.1	2.0
Post-high-school	100.0	41.7	58.3	58.3	45.1	-	11.8	0.2	1.2	-	-
Engineering college	100.0	17.5	82.5	82.5	82.5	-	-	-	-	-	-
Graduation	100.0	100.0	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	0.6	99.4	99.4	99.4	-	-	-	-	-	-
College, general	100.0	54.8	45.2	45.2	8.8	-	32.9	-	3.5	-	-
Graduation	100.0	97.2	2.8	2.8	2.8	-	-	-	-	-	-
Less than graduation	100.0	9.1	90.9	90.9	15.2	-	68.4	-	7.3	-	-
Technical institute or community college	100.0	50.0	50.0	50.0	44.3	-	4.8	0.9	-	-	-
Graduation	100.0	44.1	55.9	55.9	49.5	-	5.4	1.0	-	-	-
Less than graduation	100.0	100.0	-	-	-	-	-	-	-	-	-
Type not specified	100.0	91.3	8.7	8.7	8.7	-	-	-	-	-	-
Apprenticeship or armed forces school	100.0	100.0	-	-	-	-	-	-	-	-	-
High school	100.0	26.1	73.9	73.9	7.7	0.7	8.1	5.3	21.6	26.1	4.4
Technical or vocational	100.0	29.6	70.4	70.4	-	3.7	-	48.2	18.5	-	-
Other and not specified	100.0	25.9	74.1	74.1	8.2	0.5	8.6	2.5	21.8	27.9	4.6

a. All employers who expressed a preference mentioned some post-high-school level of education; none mentioned high school.

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Table IX-5. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE
(Number and percent distribution of technicians according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
			Number				
All levels	1,932	601	1,331	62	633	587	49
Post-high-school	1,039	373	666	60	148	444	14
Engineering college	405	21	384	50	3	331	-
Graduation	69	19	50	50	-	-	-
Less than graduation	336	2	334	-	3	331	-
College, general	341	185	156	2	40	100	14
Graduation	177	172	5	-	-	5	-
Less than graduation	164	13	151	2	40	95	14
Technical institute or community college	228	106	122	8	101	13	-
Graduation	204	82	122	8	101	13	-
Less than graduation	24	24	-	-	-	-	-
Type not specified	46	42	4	-	4	-	-
Apprenticeship or armed forces school	19	19	-	-	-	-	-
High school	893	228	665	2	485	143	35
Technical or vocational	54	16	38	-	10	2	26
Other and not specified	839	212	627	2	475	141	9
			Percent distribution				
All levels	100.0	54.6	45.4	5.2	24.3	10.5	5.4
Post-high-school	100.0	66.4	33.6	7.8	13.9	10.5	1.4
Engineering college	100.0	84.5	15.5	3.6	5.4	3.8	2.7
Graduation	100.0	94.6	5.4	5.4	-	-	-
Less than graduation	100.0	64.6	35.4	-	16.1	11.2	8.1
College, general	100.0	72.5	27.5	14.3	9.0	3.2	1.0
Graduation	100.0	71.6	28.4	20.4	4.6	3.4	-
Less than graduation	100.0	74.3	25.7	1.6	18.4	2.6	3.1
Technical institute or community college	100.0	36.2	63.8	3.4	30.9	28.1	1.4
Graduation	100.0	36.4	63.6	1.3	32.0	28.9	1.4
Less than graduation	100.0	31.8	68.2	59.1	-	9.1	-
Type not specified	100.0	83.8	16.2	10.7	5.2	0.3	-
Apprenticeship or armed forces school	100.0	77.3	22.7	-	-	22.7	-
High school	100.0	32.9	67.1	0.4	43.1	10.6	13.0
Technical or vocational	100.0	22.6	77.4	2.7	74.7	-	-
Other and not specified	100.0	34.5	65.5	-	38.2	12.3	15.0

Chapter X

TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS

In 1962 there were 3,034 technical writing and illustration specialists in New York State, which is 2 percent of all persons in technical occupations.1/ The following figures indicate the groups into which these specialists were classified:

Occupation	Number	Percent
All occupations	3,034	100.0
Technical writers and editors	1,669	55.0
Specification writers (other than construction)	237	7.8
Technical illustrators	1,082	35.7
General and other	46	1.5

The majority of these specialists are employed in manufacturing industries, especially in the production of books and periodicals, communication equipment, ordnance, aircraft and aerospace equipment, and engineering, laboratory, scientific, and research instruments; some are in units of the petroleum refining industry. Those in nonmanufacturing lines are found especially in the field of engineering and architectural services and of business management consulting services. The latter includes some firms that supply temporary manpower to manufacturing plants and other firms. (See table X-A on page 343 and table X-1 at end of chapter.)

About 42 percent of the specialists are supervised by technical specialists of higher rank, 27 percent by engineers or scientists, and 31 percent by other persons, usually sales department executives or other management officials. (Table X-B, on page 344.)

1. Writers of technical and scientific articles who are primarily journalists and require little or no background in mathematics or science were excluded from the survey.

Table X-A. NUMBER AND PERCENT DISTRIBUTION OF TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS BY INDUSTRY GROUP

Industry group	Number	Percent
All industries	3,034	100.0
Manufacturing	2,205	72.7
Ordnance and accessories	124	4.1
Machinery, except electrical	88	2.9
Electrical machinery and equipment	398	13.1
Transportation equipment	390	12.9
Instruments; photographic and optical goods	383	12.6
Printing, publishing, and allied industries	677	22.3
Petroleum refining and related industries	127	4.2
Other manufacturing	18	0.6
Nonmanufacturing	829	27.3
Transportation and public utilities	35	1.2
Wholesale and retail trade	9	0.3
Services and miscellaneous	707	23.2
Research, development, testing laboratories	64	2.1
Business and management consulting services	276	9.0
Business services n.e.c.	81	2.7
Private colleges and schools	11	0.4
Engineering and architectural services	275	9.0
Government	78	2.6

FUNCTIONS

Technical Writers and Editors

The role of technical writers and editors is to present technical information in a simple, clear, and factual manner so that it can be readily understood by readers who do not have technical backgrounds. The writer prepares the technical text; the editor prepares the manuscript for publication. Many writers also perform the editorial function.

Most technical writers specialize in a particular subject matter field. (1) Some of these need only a limited knowledge of the field. They were included in this chapter provided that their job called for some background in science or mathematics. (2) Some are required to have knowledge equivalent to that of a person fully trained in the field. These too were included here, unless

Table X-B. PERCENT DISTRIBUTION OF TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS BY OCCUPATION OF SUPERVISOR

Occupation	Total	Occupation of supervisor		
		Engineer or scientist	Techni-cian(a)	Other
All occupations	100.0	27.3	41.7	31.0
Technical writers and editors	100.0	32.3	39.8	27.9
Specification writers (other than construction)	100.0	16.9	73.0	10.[illegible]
Technical illustrators	100.0	22.6	38.0	39.4
General and other	100.0	13.0	32.6	54.4

a. Technical writing or illustration specialist or other technician.

they were engineers, technicians, or other technical specialists who did a considerable amount of writing but whose primary activity is something other than writing.

Various kinds of material are prepared by technical writers. They may prepare manuals and handbooks, which give detailed physical descriptions of complicated machines, components, and parts, and which explain in detail operational sequences, assembly and disassembly, installation, test methods, and performance standards, maintenance, servicing, etc. They may prepare brochures, promotional and sales literature, drafts of contract proposals, publicity releases on technical developments, etc. They may write for engineering or scientific books or periodicals. Most writers included in the survey work either on engineering manuals or on both engineering manuals and publications.

The functions of technical writers and editors may include the following:

Compile, write, rewrite, or edit technical material, keeping in mind such factors as accuracy, adequacy, consistency, spelling, punctuation, grammar, and format, and make sure that the level of concepts, expression, and vocabulary is appropriate to the audience to which the written material is directed.

Obtain the information for their write-ups by (1) observing operations and processes; (2) interviewing engineers and technical personnel concerned with the manufacture of the product; (3) working with equipment, parts, tools, etc.; (4) interpreting specifications, contracts, work orders; handbooks, blueprints, sketches, catalogs, schematics, etc.; (5) doing independent reading of technical reports, journals, etc.

May work on the physical make-up of the report and arrange for the preparation of art work and photographs. May prepare rough sketches as guides to technical illustrators, estimate the cost of publication, etc.

May do related work such as preparing tables and charts, preparing bibliographies, doing specification writing, proofreading, and maintaining a file of pertinent trade publications, part lists, etc.

The technical skills required by technical writers may include:

Ability to read and understand technical data found in notes, sketches, reports, technical manuals, handbooks, reference books, periodicals, etc. Ability to read blueprints and schematics.

Ability to do technical drawing and designing.

Ability to use the following instruments and tools: slide rules, drawing equipment, precision measuring tools, hand tools, etc. May sometimes use electrical and electronic measuring equipment.

Specification Writers (other than construction)

Specification writers develop, write, and review process and material specifications to provide information for suppliers and sub-contractors, other technicians, engineers, managers, salesmen, and officials in the places where they work.

The functions of specification writers include one or more of the following:

Prepare process and material specifications for manufacturing purposes, including a description of the processes involved, the components and materials to be used, the physical and chemical composition and the quality and quantity of these components and materials, etc.

Determine the availability and sources of the components and materials and also suggest substitutes and modification, when necessary. They gather information for the bills of material from engineering notes, blueprints, technical and trade publications, specifications of other companies, government agencies, etc.

Draw rough sketches to illustrate the processing operations.

Determine which components and materials are suitable for standardization.

Compile and issue process change bulletins, material bulletins, etc.

Give engineering personnel advice on useful new products or processes, etc.

May also be required (1) to check specifications of purchased materials or parts for conformity with required standards; (2) to estimate costs; (3) to maintain a file of all material and part specifications and changes, etc.

The technical skills that specification writers need may include:

Knowledge of and the ability to work with technical publications and handbooks.

Ability to read blueprints and schematics.

Ability to do technical drawing and designing and to use drawing equipment.

Technical Illustrators 1/

Using artistic ability, technical illustrators lay out and execute technical illustrations in black and white or color and do related tasks. These illustrators, who usually specialize, produce pictorial representations covering a broad range of subject matter by using various art media (pencil, pen and ink, tempera, oils, wash, airbrush, etc.). The medium used depends upon the method of reproduction (photostat, photoprint, ozalid, offset, letterpress, silk screen, etc.), its cost, the fineness of detail, the quality of color reproduction, size, and other factors.

Doing such things, technical illustrators may perform one or more of the following functions:

Prepare technical and scientific illustrations for reproduction in publications, posters, filmstrips, slides, exhibits, displays, signs, or other means of communication.

Work from reference data (drawings, sketches, blueprints, written or oral specifications, actual equipment, etc.) to prepare cutaway drawings; exploded views; isometric, orthographic, and section projections; block diagrams; schematic diagrams; etc. of parts, subassemblies, assemblies, systems, components, equipment, and processes for operation instructions, manuals, parts catalogs, bulletins, etc.

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1. Medical illustrators are included in chapter VI.

Create illustrations to explain to the customer procedures for assembling, operating, or servicing various products.

Present statistical findings in the form of charts, graphs, etc.

Prepare layouts for publications, displays, etc.

Do art work for animated movies.

Prepare visual aspects of information programs including pictorial displays, models, cartoons, charts, graphs, etc.

If employed by a museum, design museum exhibits of scientific subjects.

Execute designs of sculpture or other ornamentation for buildings and structures.

Related duties may include: (1) selecting type, paper, illustrations, processes, and binding in publications, and estimating job costs; (2) using airbrush, oils, or other media to touch up photographs to bring out features of objects that the photographic process does not reflect, to correct faults, etc.; (3) working with others, especially technical writers and management, in order to determine optimum content and layout for ease of visualization and comprehension; (4) doing statistical drafting work, etc.

The technical skills that technical illustrators require may include:

Ability to read blueprints and schematics.

Ability to work with technical handbooks.

Ability to do designing, technical drawing, and drafting.

Ability to use artist's equipment such as airbrushes, pen and ink, pencils, etc.; drafting tools; lettering guides and sets; precision measuring instruments such as calipers, templates, triangles, scribers, etc.; may sometimes be required to use standard machine shop tools; photographic equipment, etc.

SUBJECT MATTER KNOWLEDGE

Technical Writers and Editors

According to reports of employers, the subject matter knowledge needed by technical writers and editors is usually knowledge related to the company's products. Need varies considerably depending upon the field of specialization in which the writer is employed; for example, if his assignments are concerned primarily with electrical or electronic equipment, he uses different technologies or sciences than if he writes primarily on mechanical engineering subjects.

The writer generally needs to know engineering or scientific terminology in the field of specialization.

Many technical writers need technical subject matter knowledge corresponding to that for electrical, electronic, and mechanical engineering technicians. (See chapter III.) Additional requirements for technical writers depend upon the specific industry or products dealt with. According to employer reports, such additional subjects most often are basic electronics, basic electricity, designing, and publication production methods.

A few employers reported that technical writers need a knowledge of one or more of the following: mathematics (advanced algebra, solid geometry, analytic geometry, calculus, engineering mathematics); science (general chemistry, metallurgy, general biology, advanced physics, optics, hydraulics, thermodynamics); and technologies (strength of materials, heating, ventilating, and air conditioning, manufacturing processes, machine shop theory and practice, computer technology, etc.).

Specification Writers (other than construction)

Although the specification writer is helped if he has considerable technical training and experience, the subject knowledge that is most useful depends upon the specific materials and products with which he works.

Some employers reported that the following subjects are needed in certain instances: mathematics such as trigonometry, advanced algebra, solid geometry, and calculus; general and advanced physics; general chemistry; electrical technology such as orientation, basic electricity, and electrical codes.

Technical Illustrators

According to employer reports, technical drawing is the basic subject needed for this job. Other subjects mentioned by a few employers include graphics (art reproduction methods and techniques, photography, etc.), designing, trigonometry, general chemistry, general physics, and orientation in electrical technology.

GRADE STRUCTURE

Somewhat more than half of the technical writing and illustration specialists at nonsupervisory levels are employed in establishments with single-grade structures. Table X-C shows that the proportion is greater in the case of specification writers.

Table X-C. PERCENT DISTRIBUTION OF TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS ACCORDING TO GRADE, BY OCCUPATION

Grade	All occupations	Technical writers and editors	Specification writers (a)	Technical illustrators	General and other
All grades: Number	3,034	1,669	237	1,082	46
Percent distribution					
All grades: Percent	100.0	100.0	100.0	100.0	100.0
Supervisory grades	8.4	10.6	5.5	5.5	13.0
Nonsupervisory grades	91.6	89.4	94.5	94.5	87.0
Single grade only	50.8	44.3	85.2	53.0	65.3
Multi-grade:					
Lowest grades	17.7	19.9	3.0	18.0	4.3
Middle grades	7.0	7.2	1.7	7.9	2.2
Highest grades	16.1	18.0	4.6	15.6	15.2

a. Excludes construction specification writers.

At the lowest grade the scope for originality and initiative is usually limited. Technical writers, for example, generally receive specific assignments at this level; source materials are readily available, and the supervisor may be consulted when new problems arise. At intermediate levels, technical writers work with a greater degree of independence and must have a broader subject matter knowledge. At the upper levels, they may need a knowledge and understanding of the most advanced theories and concepts in the subject matter field in order to be able to plan and supervise the project and carry out the more difficult or unusual assignments.

EDUCATION AND EXPERIENCE REQUIRED

Post-high-school education supplemented by experience is typically required for employment as a technical writing or illustration specialist. Almost 65 percent of these specialists are employed in establishments where post-high-school education is required; the remaining 35 percent work where educational requirements do not go beyond high school. About 86 percent work for employers who require experience as a prerequisite to hiring.

Education Requirements

About 24 percent of the technical writing and illustration specialists work for employers who require graduation from engineering school or from a four-year college. This requirement covers the largest number within the group of jobs for which more than a high-school education is required.

For an additional 12 percent of these specialists the requirement is training in an engineering or four-year college, but not necessarily graduation. Graduation from a technical institute or community college is required for 18 percent; and some other type of post-high-school training, such as specialized courses, for about 11 percent.

Table X-D shows that the proportion of jobs for which such education beyond high school is required is substantially higher in the case of technical writers and editors than it is in the case of specification writers and of technical illustrators.

Table X-D. PERCENT DISTRIBUTION OF TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS ACCORDING TO EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

Education required	All occupations	Technical writers and editors	Specifications writers (b)	Technical illustrators
All levels	100.0(a)	100.0	100.0	100.0
Post-high-school	64.9	84.5	21.9	44.5
Engineering college				
Graduation	10.4	18.1	5.8	-
Less than graduation	5.3	7.6	5.5	1.7
College, general				
Graduation	13.5	22.5	3.0	1.1
Less than graduation	6.3	6.8	0.4	6.5
Technical institute or community college				
Graduation	18.4	24.6	3.0	13.0
Less than graduation	0.7	0.2	-	1.7
All other post-high-school	10.3	4.7	4.2	20.5
High school	35.1	15.5	78.1	55.5

a. Includes "general and other" workers, for whom no separate distribution is shown.
b. Excludes construction specification writers.

Post-high-school education is specified more often for those in the higher grades:

Supervisory grades:	87.5%
Nonsupervisory grades:	
Single grade only	56.9
Multi-grade:	
Lowest grades	65.5
Middle grades	70.6
Highest grades	75.4

Table X-2, at the end of the chapter, gives -- for each grade level -- the number of specialists for whom various educational levels are required.

Preferred vs. Required Education

Many employers who are willing to hire technical writing and illustration specialists with only a high-school education, nevertheless prefer applicants with some education beyond high school. Whereas 65 percent of the specialists are employed in establishments where post-high-school education is required, 86 percent work where it is preferred. (See tables X-3 and X-4 at end of chapter.)

Graduation from a technical institute or community college is the most common preference of those employers who, although requiring a high-school education, prefer some type of more advanced training. A number prefer engineering college graduates.

Experience Requirements

Employers of the vast majority (86 percent) of technical writing and illustration specialists require an applicant to have had some experience in the same or a related line of work. The average (median) years of required experience are 3.2. For 14 percent of the jobs the requirement is less than 2 years; for 20 percent it is 5 or more years. Such high-level requirements are associated with the higher-level jobs. For specialists with major supervisory responsibilities the average is 5.8 years, compared with 1.5 years for those in the lowest grades; for one-third of these, no experience is required.

Table X-E. MEDIAN YEARS OF EXPERIENCE
REQUIRED FOR TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS
IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY GRADE

Grade	All levels	Post-high-school	High school
All grades	3.2	2.9	3.9
Supervisory grades	5.8	5.6	6.3
Nonsupervisory grades:			
Single grade only	2.7	2.3	3.7
Multi-grade:			
Lowest grades	1.5	0.9	2.4
Middle grades	3.4	3.3	3.8
Highest grades	4.8	4.6	5.1

The average experience requirement is higher for technical illustrators (an average of 3.9 years) than for technical writers and editors (2.9 years) and specification writers (2.3 years).

As to jobs for which some type of post-high-school education is required, employers specify an average of 2.9 years of experience compared with 3.9 years for jobs for which only high school is required. At the entrance grade, employers tend to require 1.5 additional years of experience of applicants who have not gone beyond high school. At the higher levels less than a year's additional experience is required. (Table X-E.)

A comparison of employer requirements and preferences in respect to technical writing and illustration specialists indicates that the most common preference is for more education even if the employer has to settle for less experience. Typically employers who require high-school education plus experience are willing to offset some or all of this experience in favor of more education. (Table X-F; more detail in table X-5 at the end of the chapter.)

Table X-F. NUMBER OF TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS ACCORDING TO EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE, BY EDUCATION EMPLOYERS REQUIRE

Kind of preference	All levels	High school	Technical institute	Other post-high school
Total	3,034	1,065	580(a)	1,389
No preference expressed	1,658	350	210	1,098
All preferences	1,376	715	370	291
Required education, more experience	158	4	20	134
More than required education, less experience	734	460	179	95
More than required education, some experience	319	113	163	43
More than required education, more experience	165	138	8	19

a. In 558 cases the requirement was for graduation.

SOURCES OF WORKERS

Employers use recruitment more often than upgrading to obtain workers qualified to be technical writing and illustration specialists. Organized training sponsored by the employer plays only a very minor role in the upgrading process, as shown by the figures on the top of the next page.

Methods of obtaining workers	Number	Percent
All methods	3,034	100.0
Recruited from outside the firm	2,015	66.4
Upgraded, total	1,019	33.6
With organized training	21	0.7
Without organized training	998	32.9

About four-fifths of the workers in the lower grades of multi-grade structures and in single-grade systems are recruited outside the firm, but only about a fourth of the supervisors and the workers in the highest grades:

Grade	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
Supervisory grades	100.0	23.5	0.8	75.7
Nonsupervisory grades:				
Single grade only	100.0	83.5	0.1	16.4
Multi-grade:				
Lowest grades	100.0	79.5	-	20.5
Middle grades	100.0	41.7	-	58.3
Highest grades	100.0	30.9	3.7	65.4

Since technical writing and illustration specialists were included in the survey even when the job had high educational requirements, it is not surprising that the proportion of four-year-college graduates is higher in this group than in any other group with the exception of data-processing specialists and sales and service technicians. However, there is considerable variation by occupation. Whereas 54 percent of the technical writers and editors are college graduates, only 6 percent of the technical illustrators have such an educational background. Sizeable proportions in each occupation are graduates of technical institutes or community colleges.

Occupation	College graduates	Technical institute graduates
All occupations	32.8%	28.4%
Technical writers and editors	53.5	23.1
Specification writers (other than construction)	10.1	37.6
Technical illustrators	5.5	34.4
General and other	41.3	34.8

Technical Writing and Illustration Specialists

Table X-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

Industry group	All occupations	Technical writers and related specialists			Technical illustrators	General and other
		Total	Technical writers and editors	Specification writers (a)		
All industries	3,034	1,906	1,669	237	1,082	46
Manufacturing	2,205	1,375	1,306	69	814	16
Durable goods	1,393	848	804	44	530	15
Ordnance and accessories	124	71	67	4	53	-
Furniture and fixtures	1	-	-	-	-	1
Primary metal industries	1	1	1	-	-	-
Fabricated metal products	8	7	5	2	1	-
Machinery, except electrical	88	25	20	5	59	4
Electrical machinery and equipment	398	227	213	14	170	1
Transportation equipment	390	256	241	15	132	2
Instruments; photographic and optical goods	383	261	257	4	115	7
Nondurable goods	812	527	502	25	284	1
Paper and allied products	2	2	2	-	-	-
Printing, publishing, and allied industries	677	393	369	24	284	-
Chemicals and allied products	5	4	4	-	-	1
Petroleum refining and related industries	127	127	127	-	-	-
Rubber and miscellaneous plastics products	1	1	-	1	-	-
Nonmanufacturing	829	531	363	168	268	30
Transportation and public utilities	35	32	32	-	3	-
Air transportation	29	26	26	-	3	-
Electric, gas, and sanitary services	6	6	6	-	-	-
Wholesale trade	9	9	7	2	-	-
Services and miscellaneous	707	465	311	154	230	12
Business services n.e.c.	421	266	117	149	145	10
Research, development, testing laboratories	64	34	32	2	28	2
Business and management consulting services	276	191	53	138	77	8
Other business services n.e.c.	81	41	32	9	40	-
Private colleges and schools	11	6	6	-	3	2
Engineering and architectural services	275	193	188	5	82	-
Government	78	25	13	12	35	18
County	1	-	-	-	1	-
New York State	13	10	3	7	3	-
New York City	15	1	-	1	10	4
Colleges	4	-	-	-	-	4
Other	11	1	-	1	10	-
Federal	49	14	10	4	21	14
Arsenals and navy yards	7	6	6	-	1	-
Hospitals	1	-	-	-	1	-
Other	41	8	4	4	19	14

a. Excludes construction specification writers.

Technical Writing and Illustration Specialists

Table X-2. EDUCATION EMPLOYERS REQUIRE, BY GRADE

(Number and percent distribution of specialists according to level of education required)

Education required	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Nonsupervisory grades: Multi-grade: Lowest grades	Nonsupervisory grades: Multi-grade: Middle grades	Nonsupervisory grades: Multi-grade: Highest grades
	Number					
All levels	3,034	255	1,544	536	211	488
Post-high-school	1,969	223	878	351	149	368
Engineering college	477	85	163	43	66	120
Graduation	316	60	45	43	66	102
Less than graduation	161	25	118	-	-	18
College, general	600	82	140	188	28	162
Graduation	409	36	90	143	18	122
Less than graduation	191	46	50	45	10	40
Technical institute or community college	580	51	331	87	55	56
Graduation	558	51	324	72	55	56
Less than graduation	22	-	7	15	-	-
Type not specified	290	5	227	28	-	30
Apprenticeship or armed forces school	22	-	17	5	-	-
High school	1,065	32	666	185	62	120
Technical or vocational	146	1	61	49	2	33
Other and not specified	919	31	605	136	60	87
	Percent distribution					
All levels	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	64.9	87.5	56.9	65.5	70.6	75.4
Engineering college	15.7	33.3	10.6	8.0	31.2	24.6
Graduation	10.4	23.5	2.9	8.0	31.2	20.9
Less than graduation	5.3	9.8	7.7	-	-	3.7
College, general	19.8	32.2	9.1	35.2	13.3	33.2
Graduation	13.5	14.1	5.9	26.8	8.6	25.0
Less than graduation	6.3	18.1	3.2	8.4	4.7	8.2
Technical institute or community college	19.1	20.0	21.4	16.2	26.1	11.5
Graduation	18.4	20.0	20.9	13.4	26.1	11.5
Less than graduation	0.7	-	0.5	2.8	-	-
Type not specified	9.6	2.0	14.7	5.2	-	6.1
Apprenticeship or armed forces school	0.7	-	1.1	0.9	-	-
High school	35.1	12.5	43.1	34.5	29.4	24.6
Technical or vocational	4.8	0.4	4.0	9.1	0.9	6.8
Other and not specified	30.3	12.1	39.1	25.4	28.5	17.8

Table X-3. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Number and percent distribution of specialists according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require								
				Post-high-school								Technical or vocational high school
				Post-high-school, total	Engineering college		College, general		Technical institute		Type not specified	
					Graduation	Less than graduation	Graduation	Less than graduation	Graduation	Less than graduation		
Number												
All levels	3,034	1,859	1,175	1,133	461	17	129	25	324	4	173	42
Post-high-school	1,960	1,468	501	501	338	16	101	15	16	-	15	-
Engineering college	477	433	44	44	44	-	-	-	-	-	-	-
Graduation	316	316	-	-	-	-	-	-	-	-	-	-
Less than graduation	161	117	44	44	44	-	-	-	-	-	-	-
College, general	600	521	79	79	35	-	44	-	-	-	-	-
Graduation	409	376	33	33	33	-	-	-	-	-	-	-
Less than graduation	191	145	46	46	2	-	44	-	-	-	-	-
Technical institute or community college	580	223	357	357	259	16	52	15	-	-	15	-
Graduation	558	216	342	342	259	15	51	15	-	-	2	-
Less than graduation	22	7	15	15	-	1	1	-	-	-	13	-
Type not specified	290	274	16	16	-	-	5	-	11	-	-	-
Apprenticeship or armed forces school	22	17	5	5	-	-	-	-	5	-	-	-
High school	1,065	391	674	632	123	1	28	10	308	4	158	42
Technical or vocational	146	18	128	128	-	1	16	-	66	4	41	-
Other and not specified	919	373	546	504	123	-	12	10	242	-	117	42
Percent distribution												
All levels	100.0	61.3	38.7	37.3	15.1	0.6	4.3	0.8	10.7	0.1	5.7	1.4
Post-high-school	100.0	74.6	25.4	25.4	17.1	0.8	5.1	0.8	0.8	-	0.8	-
Engineering college	100.0	90.8	9.2	9.2	9.2	-	-	-	-	-	-	-
Graduation	100.0	100.0	-	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	72.7	27.3	27.3	27.3	-	-	-	-	-	-	-
College, general	100.0	86.8	13.2	13.2	5.8	-	7.4	-	-	-	-	-
Graduation	100.0	91.9	8.1	8.1	8.1	-	-	-	-	-	-	-
Less than graduation	100.0	75.9	24.1	24.1	1.0	-	23.1	-	-	-	-	-
Technical institute or community college	100.0	38.4	61.6	61.6	44.6	2.8	9.0	2.6	-	-	2.6	-
Graduation	100.0	38.7	61.3	61.3	46.4	2.7	9.1	2.7	-	-	0.4	-
Less than graduation	100.0	31.8	68.2	68.2	-	4.5	4.5	-	-	-	59.2	-
Type not specified	100.0	94.5	5.5	5.5	-	-	1.7	-	3.8	-	-	-
Apprenticeship or armed forces school	100.0	77.3	22.7	22.7	-	-	-	-	22.7	-	-	-
High school	100.0	36.7	63.3	59.4	11.5	0.1	2.6	0.9	29.0	0.4	14.9	3.9
Technical or vocational	100.0	12.3	87.7	87.7	-	0.7	11.0	-	45.2	2.7	28.1	-
Other and not specified	100.0	40.6	59.4	54.8	13.4	-	1.3	1.1	26.3	-	12.7	4.6

Technical Writing and Illustration Specialists

Table X-4. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of specialists according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	3,034	3,034	100.0	100.0
Post-high-school	1,969	2,601	64.9	85.7
Engineering college	477	911	15.7	30.0
Graduation	316	777	10.4	25.6
Less than graduation	161	134	5.3	4.4
College, general	600	675	19.8	22.2
Graduation	409	505	13.5	16.6
Less than graduation	191	170	6.3	5.6
Technical institute or community college	580	551	19.1	18.2
Graduation	558	540	18.4	17.8
Less than graduation	22	11	0.7	0.4
Type not specified	290	447	9.6	14.7
Apprenticeship or armed forces school	22	17	0.7	0.6
High school	1,065	433	35.1	14.3
Technical or vocational	146	60	4.8	2.0
Other and not specified	919	373	30.3	12.3

Table X-5. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number and percent distribution of specialists according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
Number							
All levels	3,034	1,658	1,376	158	734	319	165
Post-high-school	1,969	1,308	661	154	274	206	27
Engineering college	477	403	74	17	26	18	13
Graduation	316	299	17	17	-	-	-
Less than graduation	161	104	57	-	26	18	13
College, general	600	435	165	86	54	19	6
Graduation	409	293	116	83	19	14	-
Less than graduation	191	142	49	3	35	5	6
Technical institute or community college	580	210	370	20	179	163	8
Graduation	558	203	355	7	179	161	8
Less than graduation	22	7	15	13	-	2	-
Type not specified	290	243	47	31	15	1	-
Apprenticeship or armed forces school	22	17	5	-	-	5	-
High school	1,065	350	715	4	460	113	138
Technical or vocational	146	33	113	4	109	-	-
Other and not specified	919	317	602	-	351	113	138
Percent distribution							
All levels	100.0	31.1	68.9	3.2	32.8	30.4	2.5
Post-high-school	100.0	35.9	64.1	5.8	14.2	42.8	1.3
Engineering college	100.0	5.2	94.8	12.3	0.7	81.8	-
Graduation	100.0	27.5	72.5	72.5	-	-	-
Less than graduation	100.0	0.6	99.4	-	0.9	98.5	-
College, general	100.0	54.3	45.7	0.6	11.7	29.3	4.1
Graduation	100.0	97.2	2.8	-	-	2.8	-
Less than graduation	100.0	7.9	92.1	1.2	24.4	58.0	8.5
Technical institute or community college	100.0	46.5	53.5	3.5	44.3	5.7	-
Graduation	100.0	40.2	59.8	3.9	49.5	6.4	-
Less than graduation	100.0	100.0	-	-	-	-	-
Type not specified	100.0	91.3	8.7	-	8.7	-	-
Apprenticeship or armed forces school	100.0	100.0	-	-	-	-	-
High school	100.0	25.5	74.5	0.2	54.4	16.0	3.9
Technical or vocational	100.0	29.6	70.4	-	18.5	3.7	48.2
Other and not specified	100.0	25.3	74.7	0.2	56.6	16.8	1.1

Chapter XI

SAFETY AND SANITATION INSPECTORS AND RELATED SPECIALISTS

This group of technical specialists includes inspectors and related workers in the field of industrial safety and fire prevention, sanitation, and air safety. The 4,084 employees in this group constitute 3 percent of total technical-occupation employment in New York State.

The large majority of the safety and sanitation inspectors and specialists are employed by the State government and by New York City and other local governments. Most of the remainder are employees of insurance carriers, agents, or brokers, or manufacturing establishments. The few air safety specialists are employed by the Federal government. (Table XI-A, based on table XI-I at the end of the chapter.)

Somewhat more than half (55 percent) of the safety and sanitation inspectors are supervised by inspectors or specialists of a higher grade; 8 percent by engineers or scientists, mostly the former, and 37 percent by executives, foremen, and persons in similar capacities.

Occupation of supervisor	All occupations	Industrial safety and fire prevention	Sanitation	Air safety
Total	100.0	100.0	100.0	100.0
Engineer or scientist	8.2	5.7	11.6	3.3
Safety or sanitation inspector or related specialist, or other technician	55.2	40.2	73.3	80.0
Other	36.6	54.1	15.1	16./

Table XI-A. NUMBER OF SAFETY AND SANITATION INSPECTORS AND RELATED SPECIALISTS BY OCCUPATION AND INDUSTRY GROUP

Industry group	All occupations	Industrial safety and fire prevention	Sanitation	Air safety
All industries	4,084	2,253	1,771	60
Manufacturing	268	138	130	-
Durable goods	109	106	3	-
Nondurable goods:				
Food and kindred products	137	11	126	-
Other nondurable goods	22	21	1	-
Nonmanufacturing	3,816	2,115	1,641	60
Insurance carriers	462	462	-	-
Insurance agents, brokers, and services	49	49	-	-
Government:				-
County	309	9	300	-
New York State	1,169	987	182	-
New York City	1,317	462	855	-
Cities other than New York City	152	45	107	-
Towns and villages	42	32	10	-
Federal	251	39	152	60
Other nonmanufacturing	65	30	35	-

FUNCTIONS

Industrial Safety and Fire Prevention Specialists

The industrial safety and fire prevention group includes:

1. General industrial safety technicians, most of whom are employed by large manufacturers.
2. Safety inspectors, largely government employees, who specialize in one of the following fields: (1) factories, mercantile establishments, and other types of industrial establishments; (2) construction projects; (3) boilers; or (4) a combination of some or all of these fields.
3. Fire prevention specialists.
4. A small group of specialized government safety inspectors, mainly housing inspectors, and railroad track, structure, and equipment inspectors.

Details are given below about the functions of the first three groups (the last group includes only a few inspectors).

General industrial safety technicians. Most of these are employed by large firms as all-round safety men or assistants to safety engineers.

They make periodic safety inspections to detect hazardous working conditions and employee violations of company safety practices and government safety regulations; see that personnel is properly equipped with protective clothing and that safety equipment, such as machine guards, oven controls, ventilating hoods, etc., is properly installed; inspect lighting, ventilating systems, exhaust systems, wiring, etc., for safe operating conditions; test sprinkler systems and other fire protection equipment; suggest elimination of hazards.

Design or approve safety devices before purchase or installation.

Investigate accidents to ascertain cause and extent of casualty; develop measures to prevent recurrence. They may review or prepare accident reports, prepare accident statistics, and act as plant representative at Workmen's Compensation hearings.

They may be responsible for safety education; give talks on safety and organize safety training courses; stimulate interest in safety by the use of suggestion systems or through media such as slides, films, tape recordings, posters, displays, and bulletin board notices; organize fire brigades and arrange for fire drills; set up and maintain plant safety procedure manuals; advise management on problems involving plant protection and employee safety.

Factory and other industrial safety inspectors. Their primary responsibility is to visit industrial establishments to determine compliance with laws, rules, and regulations relating to safety. The large majority of these inspectors are State employees. Factory inspectors perform the following functions:

Make inspections of the construction, layout, and maintenance of establishments, including accessibility and adequacy of exits, adequacy of exhaust systems, lighting, sanitation, etc.; inspect machinery and equipment, including machine safeguards; inform management of safety hazards and of violations of the labor law and of industrial code

Ensure public and employee safety by inspecting places of public assembly, aerial performances, amusement devices, aerial tramways, etc.

At the intermediate level, State factory inspectors may be assigned to the safety consultant program for industries with relatively high accident rates. They may make plant safety surveys; analyze accidents and their causes and costs; identify and analyze hazards in processes, equipment, and machinery, plant layout, material handling methods, individual operations, etc.; develop program policies, including recommendations for the elimination of hazards not regulated by law and for safety training programs.

At the supervisory levels, State factory inspectors direct the activities of inspectors of lower grades; supervise training programs; give talks on safety; confer with industrial management, employee representatives, architects, contractors, and the public on matters relating to industrial safety; conduct tests of exhaust and ventilating systems; assist in the preparation of proposed industrial code rules; etc.

Construction inspectors. They perform functions similar to those of the factory inspector, except that they are concerned with safety at the construction site rather than within the plant or store.

In addition to inspecting buildings under construction, repair, or demolition, they may inspect mines, tunnels, quarries, caissons, storage facilities for explosives, and construction machinery and equipment. A few are blasting inspectors, who make inspections to obtain compliance with ordinances governing the use, storage, and transportation of explosives, and give examinations to applicants who wish certificates of fitness as blasters and magazine keepers. (The inspectors themselves must hold such certificates.)

Boiler inspectors. Boiler inspectors are employed both by government agencies and by insurance carriers. In New York State, high-pressure boilers must be inspected annually; and since January 1, 1964 this is true also of low-pressure boilers, except hot-water boilers in residences housing fewer than six families. In New York City and a few other cities, the required inspections are made by a city department; in other communities of the State inspections are the responsibility of the New York State Department of Labor. Insured boilers are inspected by insurance companies under the Labor Department standards. Those not insured are inspected by boiler inspectors employed by the Labor Department. The large majority of boiler inspectors included in the survey were employed by the State.

The functions of boiler inspectors include inspecting the condition, design, operation and installation of high-pressure and low-pressure steam boilers and other pressure vessels to ascertain their conformity with laws and regulations and to ensure safe operation by making internal and external inspections to determine tightness, the extent of pitting, incrustation, and corrosion, and the bursting point and safe working pressure of the boilers.

They also include determining the condition of braces, stays, tubes, shells, and other parts; calculating the strength of braces; making hydrostatic pressure tests on new and repaired boilers and inspecting boilers under construction to assure compliance with legal specifications; testing injectors, safety valves, and other equipment; inspecting arches and furnace walls, etc.; checking the safety condition of runways, ladders, stairways, etc., in boiler rooms; making special investigations of boiler accidents; advising management of violations and methods of correction.

At the supervisory level, the State boiler inspector may prepare and conduct examinations for insurance company boiler inspectors; give advice to management, labor, boiler manufacturers, and the public on safe operating methods; investigate new methods of boiler construction and installation, etc.

Fire prevention specialists. These persons make inspections to prevent and reduce the loss of life and property by fire. They see that fire protective equipment and devices are properly installed and maintained, and develop fire prevention programs. Most of these specialists are concerned with law enforcement and are employed by local government agencies; some are employed by insurance companies or brokers or by individual plants.

Fire prevention specialists perform some or all of the following functions:

Make inspections of factories and other buildings, piers, bridges, tunnels, and other structures to detect violations of laws, rules, and regulations intended to reduce or eliminate fire hazards. Make inspections of premises where explosives, inflammables, or combustible materials are stored. May take samples of inflammable materials for analysis.

Inspect oil burners, range burners, refrigerators, and air conditioning systems in business establishments.

Inspect fire alarm boxes, stand pipe and sprinkler systems, and fire extinguishers and other equipment for extinguishing fires to see that they are properly installed and maintained.

Determine the efficiency of new fire protective devices.

Investigate the qualifications of persons applying for certificates of fitness for oil burner installer, refrigerator installer, and blaster.

Organize and train personnel for fire prevention and protection by conducting fire drills; instruct plant brigades in the use and maintenance of fire protection equipment, first aid, salvage operations, ventilation, forced entry, and rescue operations; conduct fire mobilization programs in conjunction with volunteer, paid, or privately operated fire departments; develop fire training programs; etc.

Sanitation Inspectors

Most sanitation inspection is for the purpose of enforcing compliance with public health and sanitation laws, regulations, and codes. The group includes:

General sanitation inspectors

Air pollution inspectors

Water supply inspectors

Dairy and farm inspectors. (Many of the general sanitation inspectors also do some work in this field.)

Inspectors of eating places and hotels. (Many general sanitation inspectors also work in this field.)

Miscellaneous inspectors such as -

State inspectors of food and milk products, livestock feeds, and fertilizers who determine compliance with prescribed standards of sanitation and purity and check for evidences of misrepresentation.

Federal food and drug inspectors, who are responsible for protecting the public from harmful, contaminated, or improperly labeled products.

State surplus food distribution inspectors who are responsible mainly for the procurement of federal surplus foods and their distribution to low-income families and institutions.

State inspectors responsible for seeing that legal requirements are observed in the preparation and handling of kosher foods.

State employees who enforce the sanitary code and other provisions regulating the practice of embalming and funeral direction.

The functions outlined in the following paragraphs are representative of those performed by sanitation inspectors:

General sanitation inspectors. These inspectors are concerned with improving food, drug, and environmental sanitation, and with enforcing sanitation laws in respect to these matters. (Some of the functions below are performed by sanitation inspectors who are college graduates with a science major.) A general sanitation inspector may inspect a wide variety of establishments and installations, including:

Food and drug establishments engaged in manufacturing or in wholesale or retail trade, dairy farms, milk pasteurizing and distribution centers, warehouses, and slaughterhouses, to ensure a pure food and drug supply.

Multiple dwellings, institutions, schools, day camps, nurseries, swimming pools, bathing beaches, and other recreational areas, inspected for defective plumbing, inadequate water supply, overflowing cesspools, conditions of sewers, sufficiency of heat, condition of gas heating equipment, insect or rodent infestation, or noxious odors.

X-ray, fluoroscopic, and other installations to safeguard against radiation hazards.

Premises of purveyors of inhalation therapy and exterminating and fumigating equipment.

Freight cars, houses, lofts, and boats that have been fumigated.

General sanitation inspectors may also instruct manufacturers, processors, wholesalers, distributors, retailers, and food handlers in the principles of sanitary operation, including garbage storage and disposal and rodent and insect control; investigate outbreaks of food poisoning and complaints concerning insanitary conditions and impure food or water; assist local communities by reviewing their sanitary codes and standards and training their enforcement personnel.

Air pollution inspectors. These inspectors are employed by large cities to obtain compliance with legislation designed to reduce or eliminate conditions contributing to air pollution.

They may investigate complaints of smoke, cinders, fly-ash, coal gas fumes, odors, and other undesirable emissions into the atmosphere; inspect installations of equipment capable of emitting pollutants into the air for conformance to specifications and check on the operation of their combustion chambers; inspect coalyards, docks, and other unloading areas, and marine craft and stationary and mobile equipment for conditions contributing to air pollution; collect samples for the determination of fuel characteristics and sources of air pollution.

Water supply inspectors. Water supply inspectors, who are local government employees, are responsible for maintaining the purity of the water supply and for regulating the metering, sale, and use of water. Some of these inspectors are concerned with the protection of the water supply in the watershed, others at the point of use. They perform one or more of the following functions:

Inspect sanitary features on or adjacent to the watershed: take water and sewage samples from reservoirs, streams, gate houses, and sewage disposal plants; inspect garbage disposal and incinerator sites of communities in the watershed; inspect disposal systems in watersheds to see that methods and construction comply with rules and regulations; check to see that no sanitary nuisances are committed by the public.

Inspect water facilities at the point of use: read and test water meters; inspect for possible hazards and sources of contamination within a structure; investigate complaints of insufficient supply, poor pressure, piping noises, water hammer, etc.; examine and test roof tanks and pressure tanks for the cause of water waste or overflow; inspect and pass on work done by licensed plumbers to ensure conformance with water supply regulations; inspect and index meters and other equipment; inspect new and old installations of commercial refrigeration and air conditioning systems, heat exchangers, water-cooling towers, evaporative condensers, etc. They may test water at various locations for purity, chlorine content, etc.

In addition, water inspectors in the higher grades may conduct tests of new equipment for water use and purification purposes; advise interested parties about rules and regulations relating to the installation and usage of newly developed water devices; direct campaigns to reduce the wasteful use of water; approve plans for installations of large meters, water systems for fire protection, air conditioning, refrigeration, swimming pools, etc.; review sewer rental charges and allowances; estimate cost of tap and wet connection installation and set up schedule of costs.

Dairy and farm inspectors. These inspectors are in most cases employed by government agencies or private businesses to inspect dairy products, dairy farms, milk receiving stations, and milk pasteurizing plants.

Government dairy products inspectors sample and test producers' milk delivered to milk plants to determine accuracy of plant tests; test milk and cream offered for sale by dealers for butterfat content and adulteration and that delivered to institutions to determine compliance with contract specifications; inspect dairy product manufacturing and storage plants for insanitary conditions; check for misrepresentation in labeling, advertising, use of substitutes, etc.; check complaints in regard to short weights and other unfair trade practices.

Inspectors who visit dairy farms may check on the sanitary conditions under which milk is handled; milk cooling practices and equipment; cleanliness of cattle and stables; water supply and sewage facilities.

Inspectors of milk processing plants may check plant sanitation and conditions under which milk is handled; sample milk awaiting shipment and observe flavor, odor, temperature, and presence or absence of sediment; collect milk samples for bacteriological analysis; exclude insanitary milk from the market.

Air Safety Inspectors

As part of the Federal Aviation Agency's responsibilities for assuring maximum air safety for the flying public, it employs inspectors concerned with the administration of Federal aviation regulations governing the manufacture and maintenance of aircraft and of electric and electronic aids to air navigation, and with the qualifications and competency of maintenance personnel. Representative of their functions are the following:

Inspections to determine the airworthiness of civil aircraft and related systems and equipment when they are being manufactured, maintained, or repaired; issuance of airworthiness certificates, development of manuals on maintenance procedures, etc.

Inspection and certification of repair facilities, parachute lofts, and mechanics schools.

Issuance of competency certificates to maintenance personnel; examination of maintenance training programs, etc.

Investigation of alleged violations of civil air regulations.

Investigation of air-carrier aircraft accidents.1/

SUBJECT MATTER KNOWLEDGE

The following paragraphs state in summary form what subject knowledge is needed by the various types of inspector and specialist covered by this chapter.

Industrial Safety Inspectors

Generally needed by these inspectors is a knowledge of subjects such as accident hazards; safety principles and methods, including methods of safety education and training and mechanical safeguards; government safety regulations; and accident investigation and reporting.

Needed in a substantial number of cases is knowledge of engineering handbooks and manuals; toxic materials; machine-guard design; production and construction techniques; boiler mechanics; and the Workmen's Compensation law.

Fire Prevention Specialists

Generally needed by these specialists is a knowledge of fire prevention techniques, including a knowledge of flammable matter, fireproofing materials, safe storage and distribution of gasoline, kerosene, dynamite, and other combustibles and explosives; fire protective equipment and devices, including design, installation, and maintenance; orientation in electrical technology; and laws and regulations governing fire prevention and control. Knowledge of general chemistry or general physics may be needed in some cases.

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1. Omitted from the survey were positions concerned primarily with investigating and conducting hearings on the probable cause of aircraft accidents. Such positions require a background in investigative techniques and legal procedures in addition to a technical knowledge of aviation.

Sanitation Inspectors

Generally needed by sanitation inspectors is a knowledge of the principles of sanitation and public health; government laws, rules, and regulations on these subjects; and general chemistry. Special sanitation inspectors must be acquainted with particular subject matter. For example, air pollution inspectors must be familiar with the technology of air cleaning and fuel burning equipment; water inspectors must know about plumbing systems, water pumping systems, water testing equipment, and the distribution of water; and dairy inspectors about dairy processing.

Some need a knowledge of general biology, bacteriology, and pharmacy.

Air Safety Inspectors

Generally needed is a knowledge of aeronautical technology, especially that relating to the manufacture, modification, maintenance, and repair of aircraft components and systems; and of Federal aviation regulations and manuals of procedure. Electronic inspectors also need advanced electronics. (See also "Experience Requirements for Air Safety Inspectors," below.)

GRADE STRUCTURE

Since many safety and sanitation inspectors are government employees, multi-grade job structures are prevalent in these occupations. Table XI-B shows that, among non-supervisory jobs, single-grade structures cover only about a third of the industrial safety inspectors, about a fifth of the sanitation inspectors, and none of the air safety inspectors. (See also table XI-2 at the end of the chapter.)

The nature and extent of authority to make decisions and the complexity of the activities to which inspectors are assigned determine the grade in which their jobs are classified.

Table XI-B. PERCENT DISTRIBUTION OF SAFETY AND SANITATION SPECIALISTS BY GRADE

Grade	All occupations	Industrial safety and fire prevention	Sanitation	Air safety
All grades: Number	4,084	2,253	1,771	60
Percent distribution				
All grades: Percent	100.0	100.0	100.0	100.0
Supervisory grades	6.8	6.3	6.0	45.0
Nonsupervisory grades:	93.2	93.7	94.0	55.0
Single grade only	28.4	35.2	20.8	-
Multi-grade:				
Lowest grades	42.8	42.1	45.2	-
Middle grades	4.2	2.8	5.8	11.7
Highest grades	17.8	13.6	22.2	43.3

EDUCATION AND EXPERIENCE REQUIRED

The typical inspector works for a government agency that does not require an applicant to have an education beyond high school but does require substantial specialized experience and a civil service examination.1/

Education Requirements

The proportion of jobs for which education beyond high school is required is noticeably greater in the case of sanitation inspectors (it is required for about 23 percent of these) than in the case of safety inspectors (about 8 percent). Graduation from a college or technical institute is required of 16 percent of the former and of about 2 percent of the latter. (Table XI-C.) Most of the jobs in this field of safety and sanitation for which college graduation is required are in the sanitation field.

1. Some government inspector jobs have no education requirements but ask only for specialized experience in a craft or related field. Such jobs were classified as requiring high school.

Table XI-C. PERCENT DISTRIBUTION OF SAFETY AND SANITATION SPECIALISTS BY EDUCATION EMPLOYERS REQUIRE

Education required	All occupations	Industrial safety and fire prevention	Sanitation	Air safety
All levels: Number	4,084	2,253	1,771	60
Percent distribution				
All levels: Percent	100.0	100.0	100.0	100.0
Post-high-school	14.6	8.2	23.3	-
Engineering college: less than graduation	1.0	1.7	-	-
College, general: graduation	3.5	0.7	7.1	-
less than graduation	4.9	3.5	7.0	-
Technical institute: graduation	4.4	1.2	8.7	-
Type not specified	0.8	1.1	0.5	-
High school	85.4	91.8	76.7	100.0

Preferred vs. Required Education

About 15 percent of the safety and sanitation inspectors worked for employers who required post-high-school education; 30 percent for employers who expressed a preference for such education. Since this chapter is heavily weighted with government personnel for whom an educational preference usually is not indicated, the differences between required and preferred educational requirements are no doubt not as great as if all preferences had been reported. (See table XI-3 and table XI-4 at the end of the chapter.)

Experience Requirements

On the average, employers of safety and sanitation inspectors require 4.6 years of related work experience for appointment to the job. In only 18 percent of the cases is no work experience required. Applicants for the job of industrial safety inspector, for example, must have had practical mechanical experience and also experience in caring for the safety of others.

Table XI-D. PERCENT DISTRIBUTION OF SAFETY AND SANITATION SPECIALISTS ACCORDING TO YEARS OF EXPERIENCE REQUIRED, BY GRADE

Grade	Total	No experience	Under 3 years	3 and under 5	5 and under 7	7 and over
All grades	100.0	17.6	13.2	22.4	39.6	7.2
Supervisory grades	100.0	-	6.1	4.4	55.2	34.3
Nonsupervisory grades:						
Single grade only	100.0	24.2	19.9	11.8	34.2	9.9
Multi-grade:						
Lowest grades	100.0	24.9	7.9	25.1	40.7	1.4
Middle grades(a)	100.0	-	62.0	29.2	5.3	3.5
Highest grades	100.0	-	6.3	38.1	48.0	7.6

a. This is a small group which includes some technicians and specialists for whose jobs the educational requirements are relatively high, but who are not required to have as much experience as workers for whom the educational requirement is lower.

Table XI-D indicates, in terms of percent distributions of inspector jobs, the extent to which higher grades call for additional experience, above that required for lower grades.

Table XI-E indicates this difference in terms of the median number of years of experience, and also shows that employers tend to require less experience of applicants whose education has gone beyond high school. The difference in the medians range from 3.5 fewer years of experience in the case of single-grade systems down to 1.5 fewer in the case of the lowest grades of multi-grade systems.

Many employers prefer education beyond high school, and would give preference to the better educated applicant, even if he has less than the minimum experience that is required for the high-school graduate.

Experience Requirements for Air Safety Inspectors

Air safety inspector jobs are ones for which there are detailed experience requirements, but no specific educational requirements. At the entrance level the Federal government requires four years of general experience and two years of specialized experience.

Table XI-E. MEDIAN YEARS OF EXPERIENCE
REQUIRED FOR SAFETY AND SANITATION SPECIALISTS
IN RELATION TO EDUCATION EMPLOYERS REQUIRE, BY GRADE

Grade	All levels	Post-high-school	High school
All grades	4.6	2.2	5.3
Supervisory grades	6.9	5.5	7.0
Nonsupervisory grades:			
Single grade only	3.8	1.6	5.1
Multi-grade:			
Lowest grades	2.9	2.4	3.9
Middle grades	2.1	1.5	4.2
Highest grades	5.8	4.4	6.0

For an inspector concerned with air carrier maintenance, for example, acceptable general experience would be aircraft maintenance work requiring a comprehensive knowledge of the techniques of maintaining and repairing aircraft, power plants, systems, and components. Acceptable specialized experience would be administrative or technical supervision over the maintenance of large transport aircraft or in a position requiring broad technical knowledge of such aircraft. College-level study in engineering, business administration, or law may be substituted at the rate of one year of study for six months of general experience up to a maximum of two years. No substitutions are accepted for the specialized experience.

For the electronics inspector, acceptable general experience is maintenance work on electrical and electronic systems of modern aircraft. Administrative or supervisory responsibility for such maintenance is accepted as specialized experience.

College-level study in electrical, radio, or electronic engineering may be substituted for the general experience on a year-for-a-year basis. Other engineering courses may be substituted at the rate of 1 year of study for 6 months of general experience (9 months in some cases), up to a maximum of 3 years.

TESTS AND LICENSES

The large majority (83 percent) of safety and sanitation inspectors are required to take a test or obtain a license in order to qualify for the job. Table XI-F indicates the type of licensing requirements by occupational group.

Table XI-F. PERCENT DISTRIBUTION OF SAFETY AND SANITATION SPECIALISTS ACCORDING TO TESTS AND LICENSES REQUIRED

Test and licensing requirement	All occupations	Industrial safety and fire prevention	Sanitation	Air safety
Total: Number	4,084	2,253	1,771	60
Percent distribution				
Total: Percent	100.0	100.0	100.0	100.0
None	16.6	21.9	9.9	18.3
Government license or permit	14.9(a)	10.1	18.7	81.7
Civil service examination	67.0	65.3	71.4	-
Company formal test	1.5	2.7	-	-

a. About 44 percent of these were also required to take a civil service examination.

Among the government licenses and certificates that technicians in this group may be required to have are the certificate of fitness for blasting inspectors; the certificate required for boiler inspectors employed by insurance companies; and the license required for sanitation inspectors who as part of their functions make bacterial counts on milk and cream. Also, air carrier maintenance inspectors and general aviation inspectors must have an airman certificate issued by the Federal Aviation Agency, with airframe mechanic and aircraft power plant mechanic ratings.

SOURCES OF WORKERS

Methods of Obtaining Workers

About two-thirds of the safety and sanitation inspectors obtained during a representative period preceding the survey, came through recruitment outside the establishment; one-third were obtained by upgrading within the establishment. Upgrading, as is shown by table XI-G, plays a somewhat more important role among government than among nongovernment workers. Organized training sponsored by the employer is significant in neither case.

Table XI-G. PERCENT DISTRIBUTION OF SAFETY AND SANITATION SPECIALISTS, ACCORDING TO METHOD OF OBTAINING THEM

Method of obtaining workers	Total	Non-government	Government
All methods: Number	4,084	844	3,240
Percent distribution			
All methods: Percent	100.0	100.0	100.0
Recruited from outside the firm	66.3	71.7	64.9
Upgraded, total	33.7	28.3	35.1
With organized training	2.7	3.8	2.4
Without organized training	31.0	24.5	32.7

College and Technical Institute Graduates

About 17 percent of safety and sanitation specialists are graduates of four-year colleges and 8 percent are graduates of technical institutes and community colleges:

	College graduates	Technical institute graduates
All occupations	17.2%	8.0%
Industrial safety and fire prevention	6.4	8.3
Sanitation	31.6	6.3
Air safety	-	48.3

A considerably higher proportion of sanitation inspectors than safety inspectors are college graduates. The sanitation group includes some government inspectors for whom college graduation is a requirement. Many air safety inspectors are technical institute graduates.

PROMOTIONAL LINES

Since the majority of safety and sanitation inspectors are part of a government grading system it is to be expected that the most common promotion lines involve different grades of the same job. In private industry some lower-level inspectors are upgraded from production jobs. Management or safety engineering positions are the jobs to which the top-level safety and sanitation inspectors are most likely to be promoted.

Safety and Sanitation Inspectors and Related Specialists

Table XI-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

Industry group	All occupations	Industrial safety and fire prevention	Sanitation	Air safety
All industries	4,084	2,253	1,771	60
Manufacturing	268	138	130	-
Durable goods	109	106	3	-
Ordnance and accessories	3	3	-	-
Lumber and wood products, except furniture	1	1	-	-
Stone, clay, and glass products	6	6	-	-
Primary metal industries	12	9	3	-
Fabricated metal products	12	12	-	-
Machinery, except electrical	21	21	-	-
Electrical machinery and equipment	11	11	-	-
Transportation equipment	29	29	-	-
Instruments; photographic and optical goods	14	14	-	-
Nondurable goods	159	32	127	-
Food and kindred products	137	11	126	-
Textile mill products	1	1	-	-
Paper and allied products	6	6	-	-
Printing, publishing, and allied industries	3	3	-	-
Chemicals and allied products	8	8	-	-
Petroleum refining and related industries	1	-	1	-
Miscellaneous manufacturing industries	3	3	-	-
Nonmanufacturing	3,816	2,115	1,641	60
Mining	2	2	-	-
Contract construction	8	8	-	-
General building contractors	3	3	-	-
Heavy construction	1	1	-	-
Special trade contractors	4	4	-	-
Transportation, communication, and public utilities	15	13	2	-
Railroad transportation	6	6	-	-
Motor freight transportation and warehousing	2	2	-	-
Communication	3	3	-	-
Electric, gas, and sanitary services	4	2	2	-

Continued

Table XI-1 (concluded)

Industry group	All occupations	Industrial safety and fire prevention	Sanitation	Air safety
Nonmanufacturing (continued)				
Wholesale trade	10	-	10	-
Finance, insurance, and real estate	511	511	-	-
Insurance carriers	462	462	-	-
Insurance agents, brokers, and services	49	49	-	-
Services and miscellaneous	30	7	23	-
Research, development, testing laboratories	21	-	21	-
Voluntary hospitals	1	1	-	-
Private colleges and schools	2	-	2	-
Engineering and architectural services	6	6	-	-
Government	3,240	1,574	1,606	60
County	309	9	300	-
New York State	1,169	987	182	-
Hospitals	364	364	-	-
Colleges	1	1	-	-
Other	804	622	182	-
New York City	1,317	462	855	-
Hospitals	33	-	33	-
Other	1,284	462	822	-
Cities other than New York City	152	45	107	-
Towns and villages	42	32	10	-
Federal	251	39	152	60
Hospitals	3	3	-	-
Arsenals and navy yards	2	2	-	-
Other	246	34	152	60

Safety and Sanitation Inspectors and Related Specialists

Table XI-2. EDUCATION EMPLOYERS REQUIRE, BY GRADE

(Number and percent distribution of inspectors and specialists according to level of education required)

Education required	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Nonsupervisory grades: Multi-grade: Lowest grades	Nonsupervisory grades: Multi-grade: Middle grades	Nonsupervisory grades: Multi-grade: Highest grades
	Number					
All levels	4,084	277	1,160	1,750	171	726
Post-high-school	596	34	317	97	33	115
Engineering college, less than graduation	39	-	39	-	-	-
College, general	343	12	201	69	33	28
Graduation	141	11	51	18	33	28
Less than graduation	202	1	150	51	-	-
Technical institute or community college, graduation	181	21	49	28	-	83
Type not specified	33	1	28	-	-	4
High school	3,488	243	843	1,653	138	611
Technical or vocational	2	-	2	-	-	-
Other and not specified	3,486	243	841	1,653	138	611
	Percent distribution					
All levels	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	14.6	12.3	27.3	5.5	19.3	15.8
Engineering college, less than graduation	1.0	-	3.4	-	-	-
College, general	8.4	4.3	17.3	3.9	19.3	3.9
Graduation	3.5	3.9	4.4	1.0	19.3	3.9
Less than graduation	4.9	0.4	12.9	2.9	-	-
Technical institute or community college, graduation	4.4	7.6	4.2	1.6	-	11.3
Type not specified	0.8	0.4	2.4	-	-	0.6
High school	85.4	87.7	72.7	94.5	80.7	84.2
Technical or vocational	(a)	-	0.2	-	-	-
Other and not specified	85.4	87.7	72.5	94.5	80.7	84.2

a. Less than 0.05 of a percent.

Safety and Sanitation Inspectors and Related Specialists

Table XI-3. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER
(Number and percent distribution of inspectors and specialists according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	4,084	4,084	100.0	100.0
Post-high-school	596	1,208	14.6	29.6
Engineering college	39	94	1.0	2.3
Graduation	-	51	-	1.2
Less than graduation	39	43	1.0	1.1
College, general	343	892	8.4	21.9
Graduation	141	697	3.5	17.1
Less than graduation	202	195	4.9	4.8
Technical institute or community college	181	189	4.4	4.6
Graduation	181	185	4.4	4.5
Less than graduation	-	4	-	0.1
Type not specified	33	33	0.8	0.8
High school	3,488	2,876	85.4	70.4
Technical or vocational	2	1	(a)	(a)
Other and not specified	3,486	2,875	85.4	70.4

a. Less than 0.05 of a percent.

Table XI-4. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Number and percent distribution of inspectors and specialists according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require(a): Post-high-school total	Post-high-school: Engineering college: Graduation	Engineering college: Less than graduation	College, general: Graduation	College, general: Less than graduation	Technical institute: Graduation	Technical institute: Less than graduation	Type not specified
Number											
All levels	4,084	3,292	792	792	51	4	557	66	109	4	1
Post-high-school	596	416	180	180	6	1	173	-	-	-	-
Engineering college, less than graduation	39	39	-	-	-	-	-	-	-	-	-
College, general	343	269	74	74	1	-	73	-	-	-	-
Graduation	141	140	1	1	1	-	-	-	-	-	-
Less than graduation	202	129	73	73	-	-	73	-	-	-	-
Technical institute or community college, graduation	181	76	105	105	5	-	100	-	-	-	-
Type not specified	33	32	1	1	-	1	-	-	-	-	-
High school	3,488	2,876	612	612	45	3	384	66	109	4	1
Technical or vocational	2	1	1	1	1	-	-	-	-	-	-
Other and not specified	3,486	2,875	611	611	44	3	384	66	109	4	1
Percent distribution											
All levels	100.0	80.6	19.4	19.4	1.2	0.1	13.7	1.6	2.7	0.1	(b)
Post-high-school	100.0	69.8	30.2	30.2	1.0	0.2	29.0	-	-	-	-
Engineering college, less than graduation	100.0	100.0	-	-	-	-	-	-	-	-	-
College, general	100.0	78.4	21.6	21.6	0.3	-	21.3	-	-	-	-
Graduation	100.0	99.3	0.7	0.7	0.7	-	-	-	-	-	-
Less than graduation	100.0	63.9	36.1	36.1	-	-	36.1	-	-	-	-
Technical institute or community college, graduation	100.0	42.0	58.0	58.0	2.8	-	55.2	-	-	-	-
Type not specified	100.0	97.0	3.0	3.0	-	3.0	-	-	-	-	-
High school	100.0	82.5	17.5	17.5	1.3	0.1	11.0	1.9	3.1	0.1	(b)
Technical or vocational	100.0	(c)	(c)	(c)	(c)	-	-	-	-	-	-
Other and not specified	100.0	82.5	17.5	17.5	1.3	0.1	11.0	1.9	3.1	0.1	(b)

a. All employers who expressed a preference mentioned some post-high-school level of education; none mentioned high school.
b. Less than 0.05 of a percent.
c. Not computed because of small number involved.

Chapter XII

PRODUCT TESTING AND INSPECTION SPECIALISTS

The group treated in this chapter consists primarily of persons who test or inspect for defects of materials used in production and for defects or malfunctions of finished products or equipment. The group as a rule excludes technicians who require more than 15 months of specialized training or who require substantial technical or scientific education. It also excludes persons whose job duties involve the development, installation, or administration of quality-control methods and procedures.

The product testing and inspection specialists group comprises 8,059 persons, which is 5 percent of all technicians and specialists covered by the survey.

About 85 percent of these testing and inspection specialists are employed in manufacturing establishments, mainly those making transportation equipment, electrical and other machinery, primary metal products, instruments, chemicals, and food products. The remaining 15 percent, not in manufacturing, are primarily in government and in services. Table XII-A indicates their distribution by industry (more detail in table XII-1 at the end of the chapter).

Product testing and inspection specialists have been divided by occupation -- that is, according to the product and process on which they work. One-third work on machinery, transportation equipment, and other metal equipment. (Table XII-A shows both on what products the specialists are employed and the industries they work in. Table XII-B shows the products they deal with in much greater detail; it is based on Table XII-1 at the end of the chapter.)

Table XII-A. NUMBER OF PRODUCT TESTING AND INSPECTION SPECIALISTS, BY OCCUPATION GROUP AND INDUSTRY GROUP

Industry group	All occupations	Instruments, meters, and related equipment	Machinery (a)	Chemical and other nonmetal products n.e.c.	Food and agricultural products	Industrial X-ray and related processes	General and other
All industries	8,059	2,335	2,762	1,926	563	308	165
Manufacturing	6,853	2,025	2,545	1,556	443	187	97
Ordnance and accessories	263	263	-	-	-	-	-
Furniture and fixtures	22	-	16	6	-	-	-
Stone, clay, and glass products	161	-	18	108	-	-	35
Primary metal industries	450	-	391	28	-	29	2
Fabricated metal products	125	10	98	5	-	12	-
Machinery, except electrical	556	106	425	3	-	21	1
Electrical machinery and equipment	1,171	709	338	66	-	37	21
Transportation equipment	1,672	374	1,212	6	-	58	22
Instruments; photographic and optical goods	646	563	6	41	-	28	8
Food and kindred products	459	-	-	12	443	-	4
Textile mill products	164	-	-	164	-	-	-
Paper and allied products	326	-	24	302	-	-	-
Chemicals and allied products	690	-	4	682	-	2	2
Other manufacturing	148	-	13	133	-	-	2
Nonmanufacturing	1,206	310	217	370	120	121	68
Contract construction and mining	14	-	-	13	-	-	1
Transportation, communication, and public utilities	77	45	6	11	-	15	-
Wholesale and retail trade	119	28	-	81	10	-	-
Services and miscellaneous	376	35	51	122	35	101	32
Government	620	202	160	143	75	5	35

a. Machinery, transportation and other metal equipment, and appliances n.e.c.

Table XII-B. NUMBER AND PERCENT DISTRIBUTION OF PRODUCT TESTING AND INSPECTION SPECIALISTS, BY OCCUPATION

Occupation	Number	Percent
All occupations	8,059	100.0
Instruments, meters, and related equipment	2,335	29.0
Testing, measuring, and control instruments	1,958	24.3
Electronic-electrical	1,659	20.6
General and other n.e.c.	299	3.7
Optical and photographic	145	1.8
Water, electric, and gas meters	64	0.8
Weights and measures	168	2.1
Machinery, transportation and other metal equipment, and appliances n.e.c.	2,762	34.3
Industrial machinery and equipment	755	9.4
Electronic-electrical	362	4.5
General and other n.e.c.	393	4.9
Aircraft equipment	998	12.3
Automotive equipment	152	1.9
Office equipment	139	1.7
Household appliances	112	1.4
Military equipment	86	1.1
Metal castings, machined parts, and related materials	520	6.5
Chemical and other nonmetal products n.e.c.	1,926	23.9
Chemical and related products	846	10.5
Chemical and petroleum	377	4.7
Other	469	5.8
Construction materials	216	2.6
Paper and related products	315	3.9
Paper and pulp	239	3.0
Wood and other	76	0.9
Rubber and plastic products	166	2.1
Textiles and related products	314	3.9
Cloth	170	2.1
Other	144	1.8
Other	69	0.9
Food and agricultural products	563	7.0
Milk and milk products	307	3.8
General and other	256	3.2
Industrial X-ray and related processes	308	3.8
General and other	165	2.0

Table XII-C. PERCENT DISTRIBUTION OF PRODUCT TESTING AND INSPECTION SPECIALISTS, BY OCCUPATION OF SUPERVISOR

Occupation group	Total number	Occupation of supervisor			
		Total	Engineer or scientist	Technician (a)	Other
All occupations	8,059	100.0	24.4	48.2	27.4
Instruments, meters, and related equipment	2,335	100.0	12.1	62.2	25.7
Machinery, transportation and other metal equipment, and appliances n.e.c.	2,762	100.0	11.4	60.3	28.3
Chemical and other nonmetal products n.e.c.	1,926	100.0	55.1	22.6	22.3
Chemical and related products	846	100.0	63.0	27.1	9.9
Construction materials	216	100.0	51.4	36.6	12.0
Paper and related products	315	100.0	68.3	21.9	9.8
Rubber and plastic products	166	100.0	25.9	21.1	53.0
Textiles and related products	314	100.0	35.4	3.8	60.8
Other	69	100.0	68.1	17.4	14.5
Food and agricultural products	563	100.0	34.5	24.3	41.2
Industrial X-ray and related processes	308	100.0	26.3	46.8	26.9
General and other	165	100.0	23.0	30.3	46.7

a. Product testing or inspection specialist, or other technician.

Nearly half of these specialists are supervised by other technicians or specialists; fewer than a fourth are supervised by engineers or scientists; over a fourth by persons in other occupations. Table XII-C shows that product testers and inspectors employed on chemical and other nonmetal products are more likely to be supervised by an engineer or scientist than are those working on metal products.

FUNCTIONS

The functions of the specialists included under product testing and inspection fall mainly into two broad product groups. These are described next, and then eight smaller groups are described.

(1) The first category, accounting for half of the total number of specialists, covers product testers and inspectors who do primarily visual, electrical, electronic, or mechanical testing and inspecting on incoming parts and

materials and on manufactured articles (including parts, components, equipment, systems, sub-assemblies, final assemblies, and end-products) to see that they conform to standards set forth in specifications, wiring diagrams, blueprints, drawings, etc. These testers and inspectors usually follow prescribed and fairly routine procedures, using common precision measuring instruments. They may be required to use technical handbooks and to read blueprints and schematics. They are concerned with products many of which fall into the following eight categories:

Electronic-electrical testing, measuring, and control instruments
General and other (n.e.c.) testing, measuring, and control instruments
Electronic-electrical industrial machinery and equipment
General and other (n.e.c.) industrial machinery and equipment
Aircraft equipment
Automotive equipment
Household appliances
Military equipment

The following are examples of the tools, instruments, and equipment that may be used by these specialists to do the testing or inspection: ammeters, blocks (form, gauge, etc.), bridges, brush analyzers, calculators, calipers (vernier, etc.), calibrators, comparators (optical, shadowgraph, etc.), decade boxes, drill presses, gauges (fixed, height, ratio, strain, surface, thickness, tolerance, etc.), generators, grinders, hand tools, indicators, jig bores, lathes, micrometers, magnifying glasses, meggers, meters (flow, light wave, voltage, etc.), ohmmeters, oscilloscopes, protractors, pyrometers, resistors, (decade, slide, etc.), scales, sine bars, sine plates, slide rules, templates, thermometers, vacuum tube testers, voltmeters, wiring tools.

(2) The second major category, accounting for 31 percent of the total number of workers, covers those primarily engaged in doing the simpler, more repetitive types of qualitative and quantitative chemical, physical-chemical, and physical testing on raw, intermediate, and in-process materials and on finished products, to determine composition and adherence to specifications.

These workers are found primarily in the following product groups:

Chemical and petroleum products
Other chemical and related products
Construction materials
Paper and pulp
Wood and other
Rubber and plastic products
Cloth
Other textiles and related products
Other nonmetal products
Milk and milk products
Other food and agricultural products (includes some government inspectors who inspect and grade farm products)

In connection with these products they test to determine such specific elements as:

abrasion
absorption
absorption of light
acid content
alkalinity
appearance
ash content
bacteria count
bending qualities
bond strength
bursting strength
butterfat content
carbon content
coarseness
color
color fastness
compression
crystallization
cutting qualities
dimensions
disintegration
durability
dyeability
evaporation
extensibility
fibre content
fineness
firmness
flash point
flexibility
folding qualities
freezing point
friction
gas content
gloss quality
hardness
impurities
iodine number
ion exchange
melting point
moisture
naphthalene content
oil content
oxidation reduction
particle size
penetration
permeability
phenol content
phosphate content
plasticity
porosity
precipitation
refractive index
resin content
resistance
rotation of polarized light
salt content
sediment
shrinkage
silica content
smoothness
solubility
specific gravity
stability
structure
tearing qualities
temperature
tensile strength
texture
viscosity
weight
wrinkle recovery quality

The instruments and equipment used by the technicians for these tests may include one or more of the following:

abrasion testing machine
Babcock tester
bending tester
brightness tester
burette
burst tester
calipers (vernier, etc.)
centrifuge
chromatograph
colorimeter
compression equipment
consolidometer
Coulter counter
cryoscope
densitometer
desk calculator
distilling apparatus
divider
durometer
fadometer
filtration equipment
fineness tester
furnace
gauge
glossometer
hand tools
hardness tester
homogenizer
immersion tester
lathe
launderometer
melting point apparatus
micrometer

microscope	refractometer	stiffness tester
moisture meter	saw	stretch tester
Mojonnier tester	scales	stress strain machine
ohmmeter	screen	tear machine
oven	scribe	tensile tester
penetrometer	sensitometer	test tube
pH meter	sieve	thermometer
pipette	sizer	tire testing machine
plastometer	slide rule	titration equipment
plybond tester	specific gravity bottle	vibroscope
polarimeter	spectrometer	viscometer
pulp classifier	spectrophotometer	voltmeter
reflectometer	spectroscope	yarn testing machine

(3) In addition to the two main groups just described, there are several small groups of product testing and inspection specialists. The optical and photographic instrument group includes persons who are primarily engaged in visual, mechanical, and optical testing and in the inspection of optical equipment and some who do chemical testing of films and other photographic materials. The office equipment group includes some testers who do mechanical inspections on typewriters and other office equipment, and others who perform chemical tests on inks and other office supplies. The metal castings, machined parts, and related materials group includes a substantial number of testers and inspectors in the metallurgical field.

The five remaining smaller groups have specialized characteristics:

Water, electric, and gas meters. Most of the persons in this group are employed by the New York State Public Service Commission to inspect and test gas and electric meters, to determine the content of various gases, to inspect and to test electrical and gas equipment and appliances, to investigate complaints, etc.

Weights and measures. This group is made up of employees of the State or of local governments who inspect and check the accuracy of various types of weighing and measuring devices to determine compliance with State and local laws.

Industrial X-ray and radiography. Industrial X-ray technicians make X-ray examinations of metal parts and materials such as castings, forgings, weldments, metal samples, armor plate, cannon components, turbine wheels, and die castings, and also sub-assemblies, assemblies, and finished products to detect imperfections such as cracks, porosity, foreign matter, shrinkage, etc. They may perform some of the following functions:

Select film, screen, cassettes, and exposure time, depending on size and shape of object and standards for acceptance.

Calculate the distance of the object from the tube, using standard formulas; determine the proper positioning of the object; mask out superfluous areas with lead fills, etc.

Develop and print films.

Analyze film for defects that must be removed.

Do gammagraphing or magnafluxing in addition to X-ray work.

Other industrial X-ray and related processes. This group includes spectroscopists, magnaflux operators and other types of magnetic inspectors, and fluorescent penetrant inspectors.

General and other product testers and inspection specialists. Workers who do not fit into the previous categories are classified in this one.

SUBJECT MATTER KNOWLEDGE

Most of those who do primarily visual, electrical, electronic, and mechanical product testing acquire the specific subject knowledge needed in connection with their work through on-the-job training or shop experience (often within the same plant). A few employers indicated that trigonometry, general physics, orientation in electrical technology, and technical drawing were desirable as a background.

Since the work of those who specialize in chemical testing involves the application of elementary chemistry and related laboratory techniques, a background in general high school chemistry is basic for this job. General physics was also cited by a substantial number of employers. A few employers reported that trigonometry and qualitative and quantitative analysis were useful in the job.

The industrial X-ray technician and the radiographer, spectroscopist, magnetic inspector, and fluorescent penetrant inspector need to acquire familiarity with the technology of the particular machine that they operate.

GRADE STRUCTURE

Generally, about half of the product testing and inspection specialists are employed in establishments with single-grade wage structures -- the proportion is largest in the chemical and food categories. (Table XII-D.)

Table XII-D. NUMBER OF PRODUCT TESTING AND INSPECTION SPECIALISTS ACCORDING TO GRADE, BY OCCUPATION GROUP

Grade	All occupations	Instruments (a)	Machinery (b)	Chemical (c)	Food (d)	Industrial X-ray (e)	General and other
All grades	8,059	2,335	2,762	1,926	563	308	165
Supervisory grades	366	115	120	95	11	13	12
Nonsupervisory grades	7,693	2,220	2,642	1,831	552	295	153
Single grade only	4,259	1,017	1,399	1,223	356	167	97
Multi-grade:							
Lowest grades	1,589	449	618	285	114	87	36
Middle grades	609	328	145	96	22	16	2
Highest grades	1,236	426	480	227	60	25	18

a. Instrument, meters, and related equipment. b. Machinery, transportation and other metal equipment and appliances n.e.c. c. Chemical and other nonmetal products n.e.c. d. Food and agricultural products. e. Industrial X-ray and related processes.

EDUCATION AND EXPERIENCE REQUIRED

As might be expected, the large majority (96 percent) of the product testing and inspection specialists are employed in establishments where no education beyond high school is required as a condition of their employment. Many employers, however, require some related work experience.

Education Requirements

The percentages below (based on table XII-2 at the end of the chapter) indicate how the 8,059 product testing and inspection specialists were distributed in respect to employers' minimum education requirements:

Education required	Percent
All levels	100.0
Post-high-school	4.1
Engineering college	0.1
College, general	0.8
Technical institute	
Graduation	1.7
Less than graduation	0.3
All other	1.2
High school	95.9
Technical or vocational	19.8
Other	76.1

Table XII-E. PERCENT DISTRIBUTION OF PRODUCT TESTING AND INSPECTION SPECIALISTS ACCORDING TO YEARS OF EXPERIENCE REQUIRED, BY GRADE

Grade	Total	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 5	5 and over
All grades	100.0	24.1	9.1	16.9	14.9	16.9	18.1
Supervisory grades	100.0	0.3	0.3	0.8	1.1	16.7	80.8
Nonsupervisory grades:							
Single grade only	100.0	35.0	8.6	12.8	12.0	10.3	21.3
Multi-grade:							
Lowest grades	100.0	25.7	23.2	30.0	8.7	11.6	0.8
Middle grades	100.0	0.3	-	48.1	34.2	14.4	3.0
Highest grades	100.0	3.7	-	3.6	27.7	47.6	17.4

Preferred vs. Required Education

A few of the employers who required high-school education of their product testers and inspectors stated that they nevertheless preferred some type of post-high-school education. If educational qualifications are considered on the basis of employer preference rather than minimum requirements, the proportion in the post-high-school group increases from 4 percent to 22 percent. The preference for technical-institute graduates accounts for most of the difference. (See tables XII-3 and XII-4 at the end of the chapter.)

Experience Requirements

Three-fourths of product testers and inspectors are employed on jobs for which some experience is a prerequisite; one-fourth have jobs requiring no experience. As is shown by table XII-E, experience requirements differ considerably from grade to grade. As might be expected, especially in view of the fact that product inspection and testing is essentially a beginner's job in the technical field, in single-grade wage structures and at the lowest levels in multi-grade structures a substantial proportion of jobs require either no experience or less than two years of experience.

Table XII-F. PERCENT DISTRIBUTION OF SINGLE-GRADE AND LOWEST-GRADE ' C JCT TESTING AND INSPECTION SPECIALISTS IN THREE SELECTED PRODUCT GROUPS BY YEARS OF EXPERIENCE REQUIRED

Grade	Total	No experience	Under 1 year	1 and under 2	2 and under 3	3 and under 5	5 and over
Instruments, meters, and related equipment							
Single grade only	100.0	18.4	4.5	22.4	17.6	7.9	29.2
Lowest grades	100.0	7.6	35.4	36.3	20.0	0.7	-
Machinery, transportation and other metal equipment, and appliances n.e.c.							
Single grade only	100.0	17.4	15.7	6.2	9.9	14.8	36.0
Lowest grades	100.0	19.3	14.6	45.0	6.1	13.1	1.9
Chemical and other nonmetal products n.e.c.							
Single grade only	100.0	57.7	6.3	14.6	9.0	7.8	4.6
Lowest grades	100.0	73.3	7.7	4.9	2.5	11.2	0.4

Furthermore, if experience requirements are examined on the basis of product, it is apparent from table XII-F that employers in metal-products groups (such as instruments, machinery, etc.) are more likely to require some experience for entrance-level jobs than are employers in the groups working with chemicals and other nonmetal products.

A substantial number of employers in the metal-products field like candidates for these beginning technical jobs to have several years of shop experience in their own plant. This experience does not necessarily have to be related to the technical job; general experience in the plant may be acceptable. In the chemical field, most employers are more interested in a high-school course in chemistry than in experience.

TESTS AND LICENSES

Employers of 15 percent of product testing and inspection specialists require these workers to take a test or obtain a license to qualify for their jobs:

Government license or permit	4.1%
Civil service examination	5.2
Company formal test	6.2

The need for tests and licenses varies considerably by product group. Listed here are the groups in which a substantial proportion of the workers are required to have some kind of license or to take a civil service test, together with the proportion of workers affected by such requirements:

Water, electric, and gas meters	42%	Civil service
Weights and measures	91	Civil service
Office equipment	27	Civil service
Wood and other	15	Civil service
Milk and milk products	76	License or certificate from government agency
General and other food and agricultural products	23	Civil Service
General and other product testers and inspection specialists	21	20 percent civil service, 1 percent license

Among the government licenses required of certain categories of testing and inspection specialists are the following: the New York State Department of Agriculture and Markets' license for persons who make bacterial counts of milk and cream (classified in the "milk and milk products" group); and the licenses for inspecting and grading farm products issued by the United States and the New York State departments of agriculture (these workers are classified in "other food and agricultural products").

SOURCES OF WORKERS

Employers use both recruiting and upgrading to obtain persons qualified to perform product testing and inspection work, with upgrading having a slight

Table XII-G. PERCENT DISTRIBUTION OF PRODUCT TESTERS AND INSPECTION SPECIALISTS ACCORDING TO METHOD OF OBTAINING THEM, BY INDUSTRY DIVISION

Method of obtaining workers	Total	Manufacturing	Nonmanufacturing
All methods: Number	8,059	6,853	1,206
Percent distribution			
All methods: Percent	100.0	100.0	100.0
Recruited from outside the firm	47.1	43.5	67.9
Upgraded total	52.9	56.5	32.1
With organized training	1.9	2.2	0.2
Without organized training	51.0	54.3	31.9

edge. Organized training plays only a minor role in the upgrading process. Manufacturing establishments upgrade workers more frequently than do those in the nonmanufacturing field. (Table XII-G.)

Within the manufacturing field there are considerable differences in policy. For example, upgrading is the method used to obtain 66 percent of the testers and inspectors on machinery, transportation equipment, and other metal equipment; it is used to obtain 57 percent of those on instruments, meters, and related equipment, and 44 percent of those on chemical and other nonmetal products. In the food and agricultural products branch, however, only 20 percent are upgraded.

Table XII-H. PERCENT DISTRIBUTION OF PRODUCT TESTERS AND INSPECTION SPECIALISTS ACCORDING TO METHOD OF OBTAINING THEM, BY GRADE

Grade	All methods	Recruited from outside the firm	Upgraded: With organized training	Upgraded: Without organized training
All grades	100.0	47.1	1.9	51.0
Supervisory grades	100.0	5.2	1.6	93.2
Nonsupervisory grades:				
Single grade only	100.0	52.3	2.4	45.3
Multi-grade:				
Lowest grades	100.0	68.3	1.1	30.6
Middle grades	100.0	27.8	0.2	72.0
Highest grades	100.0	24.0	1.9	74.1

As is to be expected, substantially higher proportions of workers in upper grades than at the entrance level are obtained by upgrading. (See table XII-H.)

Of the total of 8,059 product testers and inspectors, 819, or 10 percent, were graduates of a post-high-school technical institute or community college. An additional 146 were 4-year-college graduates.

PROMOTIONAL LINES

Employers frequently reported that these jobs were filled by upgrading persons in production jobs, especially those doing testing and inspection work on a sub-technician level. This was especially true in the metal-products branches in which testing was usually nonchemical.

Some of the lower-grade testing and inspection specialists advance to higher grades in the same occupations because they are part of a multi-grade classification system.

When a tester or inspector is promoted out of this title, he is usually going into some higher-level technical job. Many are promoted to engineering technician jobs, especially as troubleshooters; others become chemical technicians. Some are promoted to supervisory jobs. A few, provided they have the proper educational background, may advance to a chemist or engineering job.

Product Testing and Inspection Specialists

Table XII-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

A. Instruments, Meters, and Related Equipment

Industry group	All occupations	Total	Testing, measuring, and control instruments: Total	Testing, measuring, and control instruments: Electronic-Electrical	Testing, measuring, and control instruments: General and other n.e.c.	Optical and photographic	Water, electric and gas meters	Weights and measures
All industries	8,059	2,335	1,958	1,659	299	145	64	168
Manufacturing	6,853	2,025	1,859	1,606	253	143	23	-
Durable goods	5,066	2,025	1,859	1,606	253	143	23	-
Ordnance and accessories	263	263	263	163	100	-	-	-
Furniture and fixtures	22	-	-	-	-	-	-	-
Stone, clay, and glass products	161	-	-	-	-	-	-	-
Primary metal industries	450	-	-	-	-	-	-	-
Fabricated metal products	125	10	2	2	-	-	8	-
Machinery, except electrical	556	106	106	63	43	-	-	-
Electrical machinery and equipment	1,171	709	671	623	48	28	10	-
Transportation equipment	1,672	374	374	365	9	-	-	-
Instruments; photographic and optical goods	646	563	443	390	53	115	5	-
Nondurable goods	1,787	-	-	-	-	-	-	-
Food and kindred products	459	-	-	-	-	-	-	-
Textile mill products	164	-	-	-	-	-	-	-
Apparel and other finished fabric products	19	-	-	-	-	-	-	-
Paper and allied products	326	-	-	-	-	-	-	-
Printing, publishing, and allied industries	8	-	-	-	-	-	-	-
Chemicals and allied products	690	-	-	-	-	-	-	-
Petroleum refining and related industries	38	-	-	-	-	-	-	-
Rubber and miscellaneous plastics products	55	-	-	-	-	-	-	-
Leather and leather products	5	-	-	-	-	-	-	-
Miscellaneous manufacturing industries	23	-	-	-	-	-	-	-
Nonmanufacturing	1,206	310	99	53	46	2	41	168
Mining	2	-	-	-	-	-	-	-
Contract construction	12	-	-	-	-	-	-	-
General building contractors	2	-	-	-	-	-	-	-
Heavy construction	10	-	-	-	-	-	-	-
Transportation, communication, and public utilities	77	45	31	31	-	-	14	-
Air transportation	21	-	-	-	-	-	-	-
Communication	31	31	31	31	-	-	-	-
Electric, gas, and sanitary services	25	14	-	-	-	-	14	-
Wholesale and retail trade	119	28	28	-	28	-	-	-
Wholesale trade	114	28	28	-	28	-	-	-
Retail trade	5	-	-	-	-	-	-	-
Services and miscellaneous	376	35	33	22	11	2	-	-
Business services n.e.c.	326	35	33	22	11	2	-	-
Research, development, testing laboratories	306	16	16	12	4	-	-	-
Other business services n.e.c.	20	19	17	10	7	2	-	-
Motion pictures	8	-	-	-	-	-	-	-
Nonprofit membership organizations	4	-	-	-	-	-	-	-
Miscellaneous services	38	-	-	-	-	-	-	-
Engineering and architectural services	32	-	-	-	-	-	-	-
Accounting, auditing, bookkeeping, and other services n.e.c.	6	-	-	-	-	-	-	-
Government	620	202	7	-	7	-	27	168
County	113	96	-	-	-	-	-	96
New York State	160	41	7	-	7	-	27	7
New York City	116	-	-	-	-	-	-	-
Cities other than New York City	69	65	-	-	-	-	-	65
Federal	162	-	-	-	-	-	-	-
Arsenals and navy yards	98	-	-	-	-	-	-	-
Other	64	-	-	-	-	-	-	-

Table XII-1 (continued)

B. Machinery, Transportation and Other Metal Equipment, and Appliances n.e.c.

Industry group	Total	Industrial machinery and equipment: Total	Industrial machinery and equipment: Electronic-Electrical	Industrial machinery and equipment: General and other n.e.c.	Aircraft equipment	Automotive equipment	Office equipment	Household appliances	Military equipment	Metal castings, machined parts, and related materials
All industries	2,762	755	362	393	998	152	139	112	86	520
Manufacturing	2,545	753	362	391	992	122	101	88	-	489
Durable goods	2,504	734	362	372	992	122	87	80	-	489
Ordnance and accessories	-	-	-	-	-	-	-	-	-	-
Furniture and fixtures	16	-	-	-	-	-	7	8	-	1
Stone, clay, and glass products	18	-	-	-	-	12	-	-	-	6
Primary metal industries	391	198	146	52	-	-	-	-	-	193
Fabricated metal products	98	20	-	20	11	-	-	-	-	67
Machinery, except electrical	425	264	1	263	45	-	80	15	-	21
Electrical machinery and equipment	338	223	215	8	4	47	-	51	-	13
Transportation equipment	1,212	29	-	29	932	63	-	-	-	188
Instruments; photographic and optical goods	6	-	-	-	-	-	-	6	-	-
Nondurable goods	41	19	-	19	-	-	14	8	-	-
Food and kindred products	-	-	-	-	-	-	-	-	-	-
Textile mill products	-	-	-	-	-	-	-	-	-	-
Apparel and other finished fabric products	-	-	-	-	-	-	-	-	-	-
Paper and allied products	24	18	-	18	-	-	6	-	-	-
Printing, publishing, and allied industries	8	-	-	-	-	-	8	-	-	-
Chemicals and allied products	4	-	-	-	-	-	-	4	-	-
Petroleum refining and related industries	-	-	-	-	-	-	-	-	-	-
Rubber and miscellaneous plastics products	1	1	-	1	-	-	-	-	-	-
Leather and leather products	-	-	-	-	-	-	-	-	-	-
Miscellaneous manufacturing industries	4	-	-	-	-	-	-	4	-	-
Nonmanufacturing	217	2	-	2	6	30	38	24	86	31
Mining	-	-	-	-	-	-	-	-	-	-
Contract construction	-	-	-	-	-	-	-	-	-	-
General building contractors	-	-	-	-	-	-	-	-	-	-
Heavy construction	-	-	-	-	-	-	-	-	-	-
Transportation, communication, and public utilities	6	-	-	-	6	-	-	-	-	-
Air transportation	6	-	-	-	6	-	-	-	-	-
Communication	-	-	-	-	-	-	-	-	-	-
Electric, gas, and sanitary services	-	-	-	-	-	-	-	-	-	-
Wholesale and retail trade	-	-	-	-	-	-	-	-	-	-
Wholesale trade	-	-	-	-	-	-	-	-	-	-
Retail trade	-	-	-	-	-	-	-	-	-	-
Services and miscellaneous	51	2	-	2	-	28	-	21	-	-
Business services n.e.c.	49	-	-	-	-	28	-	21	-	-
Research, development, testing laboratories	49	-	-	-	-	28	-	21	-	-
Other business services n.e.c.	-	-	-	-	-	-	-	-	-	-
Motion pictures	-	-	-	-	-	-	-	-	-	-
Nonprofit membership organizations	-	-	-	-	-	-	-	-	-	-
Miscellaneous services	2	2	-	2	-	-	-	-	-	-
Engineering and architectural services	2	2	-	2	-	-	-	-	-	-
Accounting, auditing, bookkeeping, and other services n.e.c.	-	-	-	-	-	-	-	-	-	-
Government	160	-	-	-	-	2	38	3	86	31
County	-	-	-	-	-	-	-	-	-	-
New York State	4	-	-	-	-	-	4	-	-	-
New York City	60	-	-	-	-	2	34	-	-	24
Cities other than New York City	-	-	-	-	-	-	-	-	-	-
Federal	96	-	-	-	-	-	-	3	86	7
Arsenals and navy yards	93	-	-	-	-	-	-	-	86	7
Other	3	-	-	-	-	-	-	3	-	-

Table XII-1 (continued)

C. Chemical and Other Nonmetal Products n.e.c.

Industry group	Total	Chemical and related products: Total	Chemical and related products: Chemical and petroleum	Chemical and related products: Other	Construction materials	Paper and related products: Total	Paper and related products: Paper and pulp	Paper and related products: Wood and other	Rubber and plastics products	Textiles and related products: Total	Textiles and related products: Cloth	Textiles and related products: Other	Other
All industries	1,926	846	377	469	216	315	239	76	166	314	170	144	69
Manufacturing	1,556	745	344	401	97	304	239	65	166	192	49	143	52
Durable goods	263	103	49	54	89	24	9	15	36	2	-	2	9
Ordnance and accessories	-	-	-	-	-	-	-	-	-	-	-	-	-
Furniture and fixtures	6	2	-	2	-	2	-	2	-	2	-	2	-
Stone, clay, and glass products	108	-	-	-	89	-	-	-	19	-	-	-	-
Primary metal industries	28	26	18	8	-	-	-	-	-	-	-	-	2
Fabricated metal products	5	-	-	-	-	-	-	-	-	-	-	-	5
Machinery, except electrical	3	1	1	-	-	-	-	-	-	-	-	-	2
Electrical machinery and equipment	66	38	-	38	-	13	-	13	15	-	-	-	-
Transportation equipment	6	6	-	6	-	-	-	-	-	-	-	-	-
Instruments; photographic and optical goods	41	30	30	-	-	9	9	-	2	-	-	-	-
Nondurable goods	1,293	642	295	347	8	280	230	50	130	190	49	141	43
Food and kindred products	12	8	-	8	-	4	-	4	-	-	-	-	-
Textile mill products	164	-	-	-	-	-	-	-	18	146	31	115	-
Apparel and other finished fabric products	18	-	-	-	-	-	-	-	-	18	18	-	-
Paper and allied products	302	-	-	-	8	259	221	38	35	-	-	-	-
Printing, publishing, and allied industries	-	-	-	-	-	-	-	-	-	-	-	-	-
Chemicals and allied products	682	596	257	339	-	-	-	-	22	21	-	21	43
Petroleum refining and related industries	38	38	38	-	-	-	-	-	-	-	-	-	-
Rubber and miscellaneous plastics products	54	-	-	-	-	-	-	-	54	-	-	-	-
Leather and leather products	5	-	-	-	-	-	-	-	-	5	-	5	-
Miscellaneous manufacturing industries	18	-	-	-	-	17	9	8	1	-	-	-	-
Nonmanufacturing	370	101	33	68	119	11	-	11	-	122	121	1	17
Mining	1	1	1	-	-	-	-	-	-	-	-	-	-
Contract construction	12	-	-	-	12	-	-	-	-	-	-	-	-
General building contractors	2	-	-	-	2	-	-	-	-	-	-	-	-
Heavy construction	10	-	-	-	10	-	-	-	-	-	-	-	-
Transportation, communication, and public utilities	11	11	-	11	-	-	-	-	-	-	-	-	-
Air transportation	-	-	-	-	-	-	-	-	-	-	-	-	-
Communication	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric, gas, and sanitary services	11	11	-	11	-	-	-	-	-	-	-	-	-
Wholesale and retail trade	81	4	-	4	-	-	-	-	-	77	77	-	-
Wholesale trade	76	4	-	4	-	-	-	-	-	72	72	-	-
Retail trade	5	-	-	-	-	-	-	-	-	5	5	-	-
Services and miscellaneous	122	42	32	10	36	-	-	-	-	44	44	-	-
Business services n.e.c.	86	34	24	10	8	-	-	-	-	44	44	-	-
Research, development, testing laboratories	86	34	24	10	8	-	-	-	-	44	44	-	-
Other business services n.e.c.	-	-	-	-	-	-	-	-	-	-	-	-	-
Motion pictures	-	-	-	-	-	-	-	-	-	-	-	-	-
Nonprofit membership organizations	-	-	-	-	-	-	-	-	-	-	-	-	-
Miscellaneous services	36	8	8	-	28	-	-	-	-	-	-	-	-
Engineering and architectural services	30	2	2	-	28	-	-	-	-	-	-	-	-
Accounting, auditing, bookkeeping, and other services n.e.c.	6	6	6	-	-	-	-	-	-	-	-	-	-
Government	143	43	-	43	71	11	-	11	-	1	-	1	17
County	-	-	-	-	-	-	-	-	-	-	-	-	-
New York State	49	-	-	-	47	2	-	2	-	-	-	-	-
New York City	34	-	-	-	24	9	-	9	-	1	-	1	-
Cities other than New York City	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal	60	43	-	43	-	-	-	-	-	-	-	-	17
Arsenals and navy yards	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	60	43	-	43	-	-	-	-	-	-	-	-	17

Table XII-1 (concluded)

D. Food and Agricultural Products and Industrial X-ray

Industry group	Food and agricultural products: Total	Food and agricultural products: Milk and milk products	Food and agricultural products: General and other	Industrial X-ray and related processes: Total	Industrial X-ray and related processes: Industrial X-ray and radiography	Industrial X-ray and related processes: General and other	General and other (a)
All industries	563	307	256	308	223	85	165
Manufacturing	443	265	178	187	123	64	97
Durable goods	-	-	-	185	123	62	89
Ordnance and accessories	-	-	-	-	-	-	-
Furniture and fixtures	-	-	-	-	-	-	-
Stone, clay, and glass products	-	-	-	-	-	-	35
Primary metal industries	-	-	-	29	6	23	2
Fabricated metal products	-	-	-	12	11	1	-
Machinery, except electrical	-	-	-	21	20	1	1
Electrical machinery and equipment	-	-	-	37	35	2	21
Transportation equipment	-	-	-	58	23	35	22
Instruments; photographic and optical goods	-	-	-	28	28	-	8
Nondurable goods	443	265	178	2	-	2	8
Food and kindred products	443	265	178	-	-	-	4
Textile mill products	-	-	-	-	-	-	-
Apparel and other finished fabric products	-	-	-	-	-	-	1
Paper and allied products	-	-	-	-	-	-	-
Printing, publishing, and allied industries	-	-	-	-	-	-	-
Chemicals and allied products	-	-	-	2	-	2	2
Petroleum refining and related industries	-	-	-	-	-	-	-
Rubber and miscellaneous plastics products	-	-	-	-	-	-	-
Leather and leather products	-	-	-	-	-	-	-
Miscellaneous manufacturing industries	-	-	-	-	-	-	1
Nonmanufacturing	120	42	78	121	100	21	68
Mining	-	-	-	-	-	-	1
Contract construction	-	-	-	-	-	-	-
General building contractors	-	-	-	-	-	-	-
Heavy construction	-	-	-	-	-	-	-
Transportation, communication, and public utilities	-	-	-	15	15	-	-
Air transportation	-	-	-	15	15	-	-
Communication	-	-	-	-	-	-	-
Electric, gas, and sanitary services	-	-	-	-	-	-	-
Wholesale and retail trade	10	10	-	-	-	-	-
Wholesale trade	10	10	-	-	-	-	-
Retail trade	-	-	-	-	-	-	-
Services and miscellaneous	35	31	4	101	83	18	32
Business services n.e.c.	31	31	-	93	83	10	32
Research, development, testing laboratories	31	31	-	92	83	9	32
Other business services n.e.c.	-	-	-	1	-	1	-
Motion pictures	-	-	-	8	-	8	-
Nonprofit membership organizations	4	-	4	-	-	-	-
Miscellaneous services	-	-	-	-	-	-	-
Engineering and architectural services	-	-	-	-	-	-	-
Accounting, auditing, bookkeeping, and other services n.e.c.	-	-	-	-	-	-	-
Government	75	1	74	5	2	3	35
County	6	1	5	-	-	-	11
New York State	66	-	66	-	-	-	-
New York City	-	-	-	-	-	-	22
Cities other than New York City	2	-	2	-	-	-	2
Federal	1	-	1	5	2	3	-
Arsenals and navy yards	-	-	-	5	2	3	-
Other	1	-	1	-	-	-	-

a. Includes product testers and inspectors who do not fit into any of the other categories of the four parts of this table.

Product Testing and Inspection Specialists

Table XII-2. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of specialists according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	8,059	8,059	100.0	100.0
Post-high-school	334	1,800	4.1	22.3
Engineering college	9	30	0.1	0.3
Graduation	2	19	(a)	0.2
Less than graduation	7	11	0.1	0.1
College, general	66	366	0.8	4.6
Graduation	52	128	0.6	1.6
Less than graduation	14	238	0.2	3.0
Technical institute or community college	162	1,155	2.0	14.3
Graduation	137	1,027	1.7	12.7
Less than graduation	25	128	0.3	1.6
Type not specified	34	158	0.4	2.0
Apprenticeship or armed forces school	63	91	0.8	1.1
High school	7,725	6,259	95.9	77.7
Technical or vocational	1,599	1,343	19.8	16.7
Other and not specified	6,126	4,916	76.1	61.0

a. Less than 0.05 of a percent.

Table XII-3. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Number and percent distribution of specialists according to level of education preferred)

Education required	Total	Required and preferred are the same	Total where preference	Education employers prefer, where it differs from what they require											
				Post-high-school									High school		
				Post-high-school, total	Engineering college: Graduation	Engineering college: Less than graduation	College, general: Graduation	College, general: Less than graduation	Technical institute: Graduation	Technical institute: Less than graduation	Type not specified	Apprenticeship or armed forces school	High school, total	Technical or vocational	Other and not specified
							Number								
All levels	8,059	6,255	1,804	1,498	17	5	76	224	911	103	134	28	306	306	-
Post-high-school	334	302	32	32	1	-	21	-	10	-	-	-	-	-	-
Engineering college	9	8	1	1	1	-	-	-	-	-	-	-	-	-	-
Graduation	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	7	6	1	1	1	-	-	-	-	-	-	-	-	-	-
College, general	66	66	-	-	-	-	-	-	-	-	-	-	-	-	-
Graduation	52	52	-	-	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	14	14	-	-	-	-	-	-	-	-	-	-	-	-	-
Technical institute or community college	162	141	21	21	-	-	21	-	-	-	-	-	-	-	-
Graduation	137	116	21	21	-	-	21	-	-	-	-	-	-	-	-
Less than graduation	25	25	-	-	-	-	-	-	-	-	-	-	-	-	-
Type not specified	34	24	10	10	-	-	-	-	10	-	-	-	-	-	-
Apprenticeship or armed forces school	63	63	-	-	-	-	-	-	-	-	-	-	-	-	-
High school	7,725	5,953	1,772	1,466	16	5	55	224	901	103	134	28	306	306	-
Technical or vocational	1,599	1,343	256	256	2	-	22	16	164	6	46	-	-	-	-
Other and not specified	6,126	4,610	1,516	1,210	14	5	33	208	737	97	88	28	306	306	-
							Percent distribution								
All levels	100.0	77.6	22.4	18.6	0.2	0.1	0.9	2.8	11.3	1.3	1.7	0.3	3.8	3.8	-
Post-high-school	100.0	90.4	9.6	9.6	0.3	-	6.3	-	3.0	-	-	-	-	-	-
Engineering college	100.0	(a)	(a)	(a)	(a)	-	-	-	-	-	-	-	-	-	-
Graduation	100.0	(a)	-	-	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	(a)	(a)	(a)	(a)	-	-	-	-	-	-	-	-	-	-
College, general	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Graduation	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Technical institute or community college	100.0	87.0	13.0	13.0	-	-	13.0	-	-	-	-	-	-	-	-
Graduation	100.0	84.7	15.3	15.3	-	-	15.3	-	-	-	-	-	-	-	-
Less than graduation	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Type not specified	100.0	70.6	29.4	29.4	-	-	-	-	29.4	-	-	-	-	-	-
Apprenticeship or armed forces school	100.0	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-
High school	100.0	77.1	22.9	18.9	0.2	0.1	0.7	2.9	11.6	1.3	1.7	0.4	4.0	4.0	-
Technical or vocational	100.0	84.0	16.3	16.0	0.1	-	1.4	1.0	10.2	0.4	2.9	-	-	-	-
Other and not specified	100.0	75.3	24.7	19.7	0.2	0.1	0.5	3.4	12.0	1.6	1.4	0.5	5.0	5.0	-

a. Not computed because of small number involved.

Product Testing and Inspection Specialists

Table XII-4. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number and percent distribution of specialists according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
			Number				
All levels	8,059	5,897	2,162	297	756	883	226
Post-high-school	334	256	78	46	21	11	-
Engineering college	9	8	1	-	-	1	-
Graduation	2	2	-	-	-	-	-
Less than graduation	7	6	1	-	-	1	-
College, general	66	66	-	-	-	-	-
Graduation	52	52	-	-	-	-	-
Less than graduation	14	14	-	-	-	-	-
Technical institute or community college	162	95	67	46	20	1	-
Graduation	137	70	67	46	20	1	-
Less than graduation	25	25	-	-	-	-	-
Type not specified	34	24	10	-	1	9	-
Apprenticeship or armed forces school	63	63	-	-	-	-	-
High school	7,725	5,641	2,084	251	735	872	226
Technical or vocational	1,599	1,328	271	14	150	93	14
Other and not specified	6,126	4,313	1,813	237	585	779	212
			Percent distribution				
All levels	100.0	73.2	26.8	3.7	9.4	10.9	2.8
Post-high-school	100.0	76.6	23.4	13.8	6.3	3.3	-
Engineering college	100.0	(a)	(a)	-	-	(a)	-
Graduation	100.0	(a)	-	-	-	-	-
Less than graduation	100.0	(a)	(a)	-	-	(a)	-
College, general	100.0	100.0	-	-	-	-	-
Graduation	100.0	100.0	-	-	-	-	-
Less than graduation	100.0	100.0	-	-	-	-	-
Technical institute or community college	100.0	58.6	41.4	28.5	12.3	0.6	-
Graduation	100.0	51.1	48.9	33.6	14.6	0.7	-
Less than graduation	100.0	100.0	100.0	-	-	-	-
Type not specified	100.0	70.6	29.4	-	2.9	26.5	-
Apprenticeship or armed forces school	100.0	100.0	-	-	-	-	-
High school	100.0	73.0	27.0	3.2	9.5	11.4	2.9
Technical or vocational	100.0	83.1	16.9	0.9	9.3	5.8	0.9
Other and not specified	100.0	70.4	29.6	3.9	9.5	12.7	3.5

a. Not computed because of small number involved.

Chapter XIII

DATA-PROCESSING SYSTEMS ANALYSIS AND PROGRAMMING SPECIALISTS

This chapter is concerned with project planners, systems analysts, and programmers. These data-processing specialists were distributed as follows in the year 1962 in New York State:

All occupations	6,153	100.0%
Systems analysts	1,875	30.5
Programmers	3,205	52.1
Business and accounting	2,301	37.4
Engineering and scientific	553	9.0
Combination: business and engineering	351	5.7
Combination: systems analysis and programming	936	15.2
Project planners	137	2.2

Two-thirds of these specialists were in finance and insurance, wholesale trade, and other nonmanufacturing industries; one-third were in manufacturing establishments. Table XIII-A on the next page (based on table XIII-1 at the end of the chapter) gives more details on the distribution by industry of the various types of data-processing specialists.

From that table it can be seen that there were considerable differences in the distribution of occupations among industries. The largest group (39 percent) of systems analysts, for example, were employed in wholesale trade -- where the sales branches of the companies which rent out and service automated data-processing equipment are classified. Second and third in importance were banking and government, each of which gave employment to about 7 percent of the systems analysts. Also, half of all project planners were employed in two industry groups -- business and management consulting services and accounting and related

Table XIII-A. NUMBER OF DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS BY OCCUPATION AND INDUSTRY GROUP

Industry group	All occupations	Systems analysts	Programmers	Combination (a)	Project planners
All industries	6,153	1,875	3,205	936	137
Manufacturing	2,031	484	1,242	271	34
Machinery, except electrical	322	15	293	13	1
Electrical machinery and equipment	333	90	188	55	-
Transportation equipment	215	8	169	30	8
Instruments; photographic and optical goods	191	63	120	8	-
Other durable goods	283	51	121	109	2
Foods and kindred products	104	45	56	3	-
Printing, publishing, and allied industries	136	51	72	11	2
Chemicals and allied products	190	63	102	14	11
Petroleum refining and related industries	122	64	58	-	-
Other nondurable goods	135	34	63	28	10
Nonmanufacturing	4,122	1,391	1,963	665	103
Air transportation	140	10	112	18	-
Communication	188	17	76	95	-
Other transportation and public utilities	134	49	78	7	-
Wholesale trade	993	734	173	84	2
Retail trade	131	49	69	11	2
Banking	436	133	214	89	-
Security and commodity brokers, dealers, exchanges, and services	189	34	112	43	-
Insurance carriers	614	97	342	160	15
Other finance, insurance, and real estate	203	56	88	55	4
Miscellaneous business services	239	31	152	31	25
Private colleges and schools	138	9	123	-	6
Accounting, auditing, bookkeeping, and other services n.e.c.	176	40	82	12	42
Other nongovernment	129	7	80	42	-
Government	412	125	262	18	7

a. Combination systems analysis and programming.

services. Programmers, on the other hand, were distributed more evenly. The largest number (11 percent) worked for insurance carriers, with nonelectrical machinery manufacturing and government not very far behind.

Table XIII-B. PERCENT DISTRIBUTION OF DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS, BY OCCUPATION OF SUPERVISOR

Occupation	Total	Occupation of supervisor		
		Engineer or scientist	Technical specialist (a)	Management and other
All occupations	100.0	14.8	40.6	44.6
Systems analysts	100.0	5.5	27.6	66.9
Programmers	100.0	23.6	48.1	28.3
Business and accounting	100.0	11.6	55.9	32.5
Engineering and scientific	100.0	73.1	17.9	9.0
Combination: business and engineering	100.0	24.2	44.7	31.1
Combination: systems analysis and programming	100.0	5.3	44.7	50.0
Project planners	100.0	-	16.1	83.9

a. Data-processing analysis or programming specialist, or other technician.

About 41 percent of all data-processing systems analysis and programming specialists are supervised by data-processing technical specialists of higher grade, 15 percent by engineers or scientists, and 45 percent by executives or persons in similar capacities. As might be expected, programmers who work on engineering and scientific projects are usually supervised by an engineer or scientist, whereas the majority of systems analysts and project planners are directly responsible to management. (See table XIII-B.)

FUNCTIONS

Project Planners

A project planner plans and directs the systematic review of processing requirements that commonly precede and provide a basis for a decision whether or not a computer system should be installed or modified and what operations should be put on the computer. He may direct, guide, coordinate, and review the efforts of a special task force or supervise the activities of a planning unit investigating the design, installation, and initial operation of an electronic data-processing system.

Project planners included in the survey were of various types. Some were employed by large corporations to determine the feasibility of installing or revising electronic data-processing systems. Some were employed by management consultants to advise clients on the feasibility of installing or using various electronic data-processing systems or to evaluate the efficiency of existing computer installations. Some project planners were employed by the government to act as consultants to government departments and agencies. Some were heads of data-processing units in large firms, who, as one of their major responsibilities, determined the feasibility of processing data electronically. This latter group included some who were originally hired by the firm to review processing requirements prior to the installation of the computer and then became the head of the data-processing unit.

The project planners concerned with the installation of new systems may plan, conduct, and supervise surveys to determine (1) the feasibility of using various electronic processing systems to replace some or all of the existing tabulating system and (2) the possibility of extending computer processing to additional operations. As part of their functions they may:

Analyze the data-processing requirements of the organization in terms of what it does or should process to carry out its functions and provide a sound basis for management decisions.

Determine what equipment is now available; analyze the present procedures of the work activities under study; trace the flow of data from point of origin to point of final disposition; determine time required, present costs, etc.

Devise and test a new system for processing the data, including the designing of organizational, procedural, and workflow plans; the estimating of man and machine hours and of costs, etc.; give consideration to alternative possibilities; evaluate the benefits that would be realized from the new system; etc.

Propose a processing plan to management, including budget estimates and a recommendation on the specific equipment that would be needed.

Develop plans for and direct the installation of and initial operation of the new equipment, including the transition from existing procedures to any new procedures that may be required by scheduling workflow, developing program techniques, etc.

May assist in making decisions on personnel to staff new or revised electronic data-processing unit.

The skills required by project planners include:

Ability to do highly analytical and creative thinking, including the ability to obtain, classify, and analyze a large and complete variety of facts and conditions.

Verbal ability to analyze and present complex business and technical problems clearly and effectively.

Spatial ability to visualize the total computer system when planning machine modifications and designing workflow plans.

Ability to work with technical handbooks and to read schematics.

Numerical ability to understand mathematical principles involved in machine computations.

Ability to operate electronic data-processing systems and peripheral equipment.

Systems Analysts

Systems analysts study data requirements and operating methods. They formulate logical statements of business or scientific problems and devise procedures for solutions of these problems using electronic data-processing systems. They develop block diagrams and general flow charts; design forms; and devise data verification methods and controls. Ordinarily they do not work out detailed machine logic and program steps (done by programmers).

Systems analysts classified here fall into two major groups: (1) those employed by large firms who, on a continuing basis, evaluate existing operating procedures to determine whether automatic data-processing should be applied to additional operations or whether existing automatic data-processing systems designs can be made more efficient and economical, and (2) those who design a plan for a specific application.

Whereas a project planner is primarily responsible for the initial installation and over-all performance of a computer system, the major function of the systems analyst is to develop an ideal processing plan for a particular operation and to have continuing responsibility for methods and procedures modifications.

Systems analysts perform some of the following <u>functions</u>:

Study the structure and techniques of existing systems and procedures and evaluate them against the objective of the operation by:

Developing and analyzing alternative systems; selecting the one best suited to the objective from the standpoint of costs, efficiency, and improved service; preparing detailed reports on new proposals - including over-all processing plans - for management approvals. Such analyses may require management, organization, and procedure surveys; the preparation of time studies, manpower comparisons, workflow charts, cost estimates and other work measurement data; investigation and testing of new machines and equipment; analysis of forms, records, and reports; and space and layout surveys.

Installing and following up on the new methods.

Training personnel in the new methodology.

Design complete processing plans for one or more applications such as payroll, inventory, cost accounting, etc. by:

Determining the problems, type of data to be processed, and systems objectives from management.

Gathering facts concerning the problem by observing present procedures, studying operating manuals, etc., and analyzing problems in terms of capabilities of equipment. Formulating the system that is most feasible for processing the data, devising methods for efficiently carrying out such plans by determining the techniques to be used and the specific computer requirements; preparing flow charts and block diagrams to establish the sequence of computer operations, etc.

Systems analysts may also:

Supervise the programming and develop programming techniques.

Participate in making decisions concerning personnel staffing.

Prepare flow charts, operating instructions and manuals, etc., for training employees on new systems.

Be required to keep abreast of developments in systems, procedures, and data-processing equipment.

Revise clerical procedures in cooperation with department heads.

Schedule data-processing activities.

Prepare departmental reports and analysis on projects undertaken, etc.

Systems engineers, who are employed by manufacturers of data-processing equipment in the marketing area of the business, work with sales representatives. They survey, analyze, and define the data-processing problems of the customer and integrate machines, people, and procedures into working systems that solve these problems.

Systems engineers employed by data-processing manufacturers in the manufacturing area of the business are concerned with the customer's industrial engineering problems. For example, as the demand for existing products change, they forecast such factors as work scheduling, availability of human resources, reassignment and training. They may study techniques and devices that save time and labor. In connection with cost engineering, they may forecast cost data on improved processes, evaluating both new and traditional methods.

Systems analysts require the following skills:

High degree of numerical ability to understand mathematical principles involved in machine computations.

Ability to comprehend and define engineering, scientific, and technical problems and to outline procedures for their solution (if employed in an engineering or scientific field).

Ability to visualize the total computer system and the interrelationship of various components when devising computer systems requirements.

Ability to use technical handbooks and to read schematics. The ability to do blueprint reading, technical drawing, and designing are also sometimes required.

Ability to operate electronic data-processing equipment and peripheral equipment.

Programmers (other than numerical control programmers)

These programmers take the generalized plans, diagrams, and flow charts prepared by the systems analysts and convert them into the machine language necessary to give the computer minute and precise instructions on each step in the data-processing operation. How this is done depends on the nature of the problem being programmed. The programming techniques required in business and accounting work, for example, usually differ considerably from those employed in engineering and scientific work. The functions of these programmers may include:

Breaking down the statement of the problem into steps for solution.

Designing detailed programs, diagrams, and flow charts indicating sequence of machine operations necessary to carry out compilation and computation of data to solve problem. Translating flow charts and mathematical formulas into machine language.

Checking on whether the instructions to the computer have been correctly written and will produce the desired information by taking a sample of the data to be processed and reviewing step by step what happens as the computer follows the series of instructions in the program.

Revising the instructions or altering the sequence of operations to take care of any difficulties that have appeared; making a trial run on the computer; etc. May perform test case calculations with a desk calculator.

Preparing an instruction sheet for the console operator to follow when the program is run on the computer.

Evaluating and modifying existing programs to take into account changes in procedures or types of reports desired.

May do related work such as maintaining records and preparing reports; assisting in determining causes of machine stoppages; keeping abreast of developments in programming, data-processing equipment, etc.

Programmers in the higher grades may break down the program into several segments for assignment to individual programmers; train and supervise programmers at the lower levels; etc.

Scientific programmers translate mathematical formulas into machine language and may utilize specialized machine languages such as ALGOL or FORTRAN.

Research and development programmers do work that is exploratory in nature and that involves new ideas, usually not related to any immediate product development schedule. They investigate computer learning techniques. They work with engineers and other technical personnel to establish mathematical models of physical problems; they may conduct a logical or numerical analysis of the problem. They help to create and bring into being automatic programming systems.

Programmers (other than numerical control programmers) need essentially the same skills as the systems analyst, plus the ability to use specialized machine language.

Numerical Control (N/C) Programmers

Numerical control programming which comes within the general domain of process planning, is one of the functional links between the designer's drawing and the machine on the shop floor. Numerical control has been applied to a large variety of machine tools including drilling, milling, turning, tube bending, and terminal wire wrapping machines.

Programming methods vary from virtually automatic systems that produce a punch tape as a byproduct of making the first piece by essentially manual means to the more difficult process of producing a tape through the use of a computer. This latter process may involve the converting of a part's geometric description to coordinate dimensions compatible with the system of measurement used by the tool control system. The tape will also include machine instructions concerning a number of auxiliary functions such as turning the coolant off and on at appropriate times.

The functions of numerical control parts programmers may involve:

Preparation of program manuscripts using symbolic language for production of control tapes for parts fabrication and machining operations on numerically controlled equipment.

Analyzing engineering information, material specifications,and other reference material to plan the sequence of fabricating and machining operations, considering the capabilities and limitations of the equipment.

Calculating coordinates to define contours and establish layouts.

Evaluating such factors as the machinability properties of the material being processed, type and size of tools required, machine feeds and speeds, reference and transition points, machine commands, and other factors involved in enabling the machine to produce the finished part.

Responsibility for proving out the tooling complex of tape, fixtures, cutters, and associated tooling.

Designing conventional tools, cutters, and associated fixtures including basic configuration, orientation information, clamping, index holes, and coordinating tooling.

Among the skills required is -

Knowledge of special machine languages such as APT (Automatic Programming for Tools),Auto Prompt, Pronto, Split, or Waldo.

The approximately 50 numerical control programmers reported in the survey are employed by a few establishments. Over 90 percent of the establishments with numerically-controlled machine tools employ no one in this classification. In these establishments (which usually have one or two such tools) the programming functions generally are performed by tool or other engineers, tool designers, toolmakers, machinists, or draftsmen.

SUBJECT MATTER KNOWLEDGE

Subject knowledge generally needed by data-processing specialists is computer technology including a knowledge of the functions, capabilities, limitations, and costs of the various types of data-processing equipment to enable them to perform their duties by the most efficient method.

In business applications a knowledge of business administration and accounting is required ordinarily as is a knowledge of mathematics and/or statistics In engineering and scientific applications a knowledge of advanced mathematics as well as of the specific subject matter field is required typically. General physics, advanced physics, general chemistry, and metallurgy are examples of specialized fields cited by employers as necessary. Some employers also cited basic electronics as a requirement.

Numerical control programmers require a knowledge of machining practices and mathematics, including trigonometry and solid geometry, and descriptive geometry. More involved shapes and contouring applications may require a knowledge of analytic geometry, vector analysis, and matrix algebra.

GRADE STRUCTURE

About half the data-processing specialists who do not have major supervisory responsiblities are employed by firms with multi-grade structures. In addition to large data-processing departments, the establishments that have multigrade systems are primarily government agencies and management-consultant firms. (Most project planners in multi-grade structures are employees of management-consultant firms.) The relative importance of multi-grade systems in the data-processing field differs from occupation to occupation, as may be seen in table XIII-C (based on table XIII-2 at the end of the chapter).

Table XIII-C. PERCENT DISTRIBUTION OF DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS ACCORDING TO GRADE, BY OCCUPATION

Grade	All occupations	Systems analysts	Programmers	Combination: systems analysis and programming	Project planners
All grades: number	6,153	1,875	3,205	936	137
Percent distribution					
All grades: percent	100.0	100.0	100.0	100.0	100.0
Supervisory grades	10.5	14.7	5.1	18.4	25.5
Nonsupervisory grades	89.5	85.3	94.9	81.6	74.5
Single grade only	46.8	62.0	38.9	45.0	33.6
Multi-grade:					
Lowest grades	18.6	9.4	25.6	12.4	22.6
Middle grades	7.2	3.5	9.0	8.5	8.8
Highest grades	16.9	10.4	21.4	15.7	9.5

The level of a data-processing specialist's job depends on the technical complexity of the problems handled; the breadth of his assignment in terms of responsibility for an over-all application, or for a portion of one; the extent and depth of subject matter knowledge that he must use, the extent to which his assignment is supervised; and the supervisory responsibility that he exercises.

EDUCATION AND EXPERIENCE REQUIRED1/

Employers of the majority of data-processing specialists (68 percent) require college graduation or some other type of post-high-school education as a condition of employment.2/ The employers of the remaining 32 percent have educational requirements that do not go beyond high school. Employers who use computers

1. In December 1964, the U.S. Secretary of Labor approved a Manpower Development and Training Program designed to provide training and job opportunities for electronic data-processing technicians. Under this program, the Institute of Computer Technology, a nonprofit organization located in Silver Springs, Maryland, will work with the state employment service in 12 urban areas to survey needs for data-processing occupations and to assist in developing training programs to meet these needs.

2. All data-processing specialists employed by computer manufacturers or their sales offices are required to have some education beyond high school; for over 90 percent, the requirement is college graduation.

to process business records place somewhat less emphasis on the need for college training than those who use computers for engineering and scientific work.

Education requirements. College graduation is more likely to be a prerequisite for employing systems analysts and project planners than for programmers. However, programmers stand out among those for whom a degree from an engineering school is required, because it is likely to be needed by those programmers who are in engineering or in a scientific field. Table XIII-D (based on table XIII-2 at the end of the chapter) indicates differences in minimum education required for different occupations.

According to employer reports, some of the larger users of computer equipment have an informal job progression arrangement whereby employees move up from programming to systems analysis and then to project planning. Where such an arrangement exists, it is desirable that the programmer have a college degree.

Table XIII-D. PERCENT DISTRIBUTION OF DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS ACCORDING TO EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

Education required	All occupations	Systems analysts	Programmers	Combination: systems analysis and programming	Project planners
All levels: number	6,153	1,875	3,205	936	137
Percent distribution					
All levels: percent	100.0	100.0	100.0	100.0	100.0
Post-high-school	68.1	79.8	63.2	59.2	83.2
Engineering college graduation	3.9	0.4	7.0	0.9	0.7
College: graduation	48.6	65.7	38.2	46.2	71.5
less than graduation	8.8	10.1	9.4	4.4	8.8
Technical institute graduation	3.1	1.0	4.1	3.8	0.7
Other	3.7	2.6	4.5	3.9	1.5
High school	31.9	20.2	36.8	40.8	16.8

Preferred vs. required education. If educational requirements are considered from the standpoint of employer preferences rather than requirements, the proportion of data-processing specialists in the "post-high-school" category will increase from 68 to 83 percent. Most of this increase results from a shift of workers from the general-high-school-required group to the college-graduation-preferred group. In addition, many employers who are willing to hire persons with college training but no degree, nevertheless prefer a college degree. (See tables XIII-4 and XIII-5 at the end of the chapter.)

Experience requirements. Experience requirements at the time of the survey were no doubt influenced by the fact that electronic data-processing specialist work was a relatively new field in which few persons had had an opportunity to gain any substantial amount of experience. However, employers of 72 percent of the specialists require that applicants have some type of work experience. As is to be expected, experience requirements are influenced considerably by the grade in which the specialist is employed. At the lowest levels in a multi-grade structure, for example, experience is a prerequisite for hiring in only half the jobs; in the highest grades it is required for 96 percent. The establishments that are willing to hire data-processing specialists without experience directly into the highest grades typically have two grades plus a supervisory grade. The specialists hired for the highest nonsupervisory grade are required to have more education than those at the entrance level, but no experience. Those at the supervisory level, however, are required to have previous work experience. Table XIII-E indicates the number of years of experience required in various grades.

Table XIII-E. PERCENT DISTRIBUTION OF DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS ACCORDING TO YEARS OF EXPERIENCE REQUIRED, BY GRADE

Grade	Total	No experience	Under 2 years	2 and under 3	3 and under 5	5 and under 7	7 and over
All grades	100.0	28.3	15.4	18.8	17.6	14.9	5.0
Supervisory grades	100.0	0.8	1.6	1.6	21.2	49.2	25.6
Nonsupervisory grades:							
Single grade only	100.0	39.5	16.7	16.3	15.8	9.9	1.8
Multi-grade:							
Lowest grades	100.0	49.5	18.6	12.8	14.2	4.6	0.3
Middle grades	100.0	-	35.9	28.9	13.9	12.8	8.5
Highest grades	100.0	3.7	8.8	38.4	25.6	19.3	4.2

Experience requirements also vary somewhat by occupation. For example, at the lowest levels in a multi-grade structure, an applicant for a programmer job with post-high-school education usually is not required to have experience; for a systems analyst job, the median requirement is one year's experience.

On the average, for data-processing specialists at the nonsupervisory level post-high-school education was rated as worth around 1.5 to 2.5 years of experience, in terms of employer requirements. (Table XIII-F.)

Table XIII-F. MEDIAN YEARS OF EXPERIENCE REQUIRED FOR DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS IN RELATION TO EDUCATION EMPLOYERS REQUIRED BY GRADE

Grade	All levels	Post-high-school	High school
All grades	3.3	2.8	3.9
Supervisory grades	5.9	5.9	5.9
Nonsupervisory grades:			
Single grade only	2.3	1.6	3.2
Multi-grade:			
Lowest grades	1.5	0.0	2.6
Middle grades	2.6	2.3	4.5
Highest grades	3.7	3.3	4.7

A comparison of educational requirements and preferences shows that the most usual preference (involving 47 percent of those employed where some preference is expressed as to education or experience) is for more education and the same amount of experience. In addition, in a substantial number of cases employers prefer the additional education even if they have to settle for less experience. (See table XIII-6 at the end of the chapter.)

TESTS AND LICENSES

The proportion of job applicants required to take tests as an aid in determining their qualifications is higher for these specialists than for any other group in the survey, with the exception of the safety and sanitation inspectors, where civil service examinations are the rule. In all, 47 percent of data-processing specialists were required to take a test -- 43 percent took "PAT" (Programmers Aptitude Tests) or some type of intelligence, general information, or personality test, and 4 percent took civil service examinations. In the group required to take civil service examinations were a large proportion of the programmers who had combination jobs involving both engineering and business applications. Many of these programmers were located in Defense Department installations in New York State.

Although programming aptitude tests are most likely to be given to programmers in the business and accounting fields, they are also given to engineering and scientific programmers as well as to systems analysts and occasionally to project planners. (Table XIII-G.)

Table XIII-G. PERCENT DISTRIBUTION OF DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS ACCORDING TO TESTS AND LICENSES REQUIRED, BY OCCUPATION

Occupation	All tests and licenses	No test or license	Civil service examination	Company formal test
All occupations	100.0	53.6	3.5	42.9
Systems analysts	100.0	52.8	1.8	45.4
Programmers	100.0	53.1	5.2	41.7
Business and accounting	100.0	48.4	2.0	49.6
Engineering and scientific	100.0	85.3	0.4	14.3
Combination: business and engineering	100.0	32.5	34.2	33.3
Combination: systems analysis and programming	100.0	51.8	1.4	46.8
Project planners	100.0	87.6	3.6	8.8

SOURCES OF WORKERS

Methods of Obtaining Workers

During a recent representative period, half of all data-processing specialist jobs were filled by upgrading or reassigning workers employed in the establishment; the remainder were filled by outside recruitment. One of every five of those upgraded received organized training sponsored by the employer. (See table XIII-H.)

Table XIII-H. PERCENT DISTRIBUTION OF DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS ACCORDING TO METHOD OF OBTAINING THEM, BY OCCUPATION AND BY GRADE

Occupation; grade	All methods	Recruited from outside the firm	Upgraded	
			With organized training	Without organized training
All occupations; all grades	100.0	49.3	10.9	39.8
Occupation				
Systems analysts	100.0	59.5	6.4	34.1
Programmers	100.0	47.7	12.1	40.2
Business and accounting	100.0	44.0	11.5	44.5
Engineering and scientific	100.0	69.8	3.4	26.8
Combination: business and engineering	100.0	37.6	29.6	32.8
Combination: systems analysis and programming	100.0	34.7	15.6	49.7
Project planners	100.0	44.5	14.6	40.9
Grade				
Supervisory grades	100.0	20.3	10.2	69.5
Nonsupervisory grades:				
Single grade only	100.0	64.7	8.1	27.2
Multi-grade:				
Lowest grades	100.0	51.7	12.5	35.8
Middle grades	100.0	31.4	14.1	54.5
Highest grades	100.0	29.3	16.2	54.5

Table XIII-I. PERCENT OF DATA-PROCESSING ANALYSIS AND PROGRAMMING SPECIALISTS WHO ARE GRADUATES OF (1) COLLEGES AND OF (2) TECHNICAL INSTITUTES, BY OCCUPATION

Occupation	College graduates	Technical institute graduates
All occupations	63.5	4.7
Systems analysts	75.7	1.8
Programmers	56.5	6.3
Business and accounting	53.3	4.0
Engineering and scientific	76.1	9.9
Combination: business and engineering	47.0	16.2
Combination: systems analysis and programming	60.1	5.7
Project planners	83.9	1.5

In the engineering and scientific field some employers trained their engineering and scientific personnel in programming techniques and assigned them to this work on either a part-time or full-time basis. Firms with more elaborate processing requirements found it necessary to go outside the firm for programmers in a larger proportion of cases than did firms that utilized the equipment for business applications only.

College and Technical Institute Graduates

About 64 percent of data-processing specialists are college graduates and an additional 5 percent are technical institute or community college graduates.1/

As shown by table XIII-I, the proportion with college degrees is higher among systems analysts and project planners than among programmers. However, not all types of programmers have the same educational background -- in the engineering and scientific field three-fourths are college graduates compared with about a half in business and accounting.

1. Almost all (96 percent) of those employed by computer manufacturers or their sales offices are college graduates.

Data-Processing Systems Analysis and Programming Specialists

Table XIII-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

Industry group	All occupations	Systems analysts	Programmers: Total	Programmers: Business and accounting	Programmers: Engineering and scientific	Programmers: Combination: business and engineering	Combination: systems analysis and programming	Project planners
All industries	6,153	1,875	3,205	2,301	553	351	936	137
Manufacturing	2,031	484	1,242	753	323	166	271	34
Durable goods	1,344	227	891	458	293	140	215	11
Ordnance and accessories	71	-	66	22	42	2	4	1
Lumber and wood products, except furniture	6	-	-	-	-	-	6	-
Stone, clay, and glass products	58	13	21	11	-	10	24	-
Primary metal industries	82	22	8	5	1	2	52	-
Fabricated metal products	66	16	26	26	-	-	23	1
Machinery, except electrical	322	15	293	183	91	19	13	1
Electrical machinery and equipment	333	90	188	131	11	46	55	-
Transportation equipment	215	8	169	17	148	4	30	8
Instruments; photographic and optical goods	191	63	120	63	-	57	8	-
Nondurable goods	687	257	351	295	30	26	56	23
Food and kindred products	104	45	56	53	3	-	3	-
Tobacco manufactures	22	2	8	8	-	-	6	6
Textile mill products	26	13	13	13	-	-	-	-
Apparel and other finished fabric products	25	3	16	13	-	3	3	3
Paper and allied products	26	6	14	10	4	-	6	-
Printing, publishing, and allied industries	136	51	72	71	1	-	11	2
Chemicals and allied products	190	63	102	78	22	2	14	11
Petroleum refining and related industries	122	64	58	37	-	21	-	-
Rubber and miscellaneous plastics products	8	3	1	1	-	-	3	1
Leather and leather products	7	1	6	6	-	-	-	-
Miscellaneous manufacturing industries	21	6	5	5	-	-	10	-
Nonmanufacturing	4,122	1,391	1,963	1,548	230	185	665	103
Special trade contractors	1	-	1	1	-	-	-	-
Transportation, communication, and public utilities	462	76	266	266	-	-	120	-
Railroad transportation	55	41	14	14	-	-	-	-
Motor freight transportation and warehousing	6	-	3	3	-	-	3	-
Water transportation	12	2	8	8	-	-	2	-
Air transportation	140	10	112	112	-	-	18	-
Transportation services	4	1	3	3	-	-	-	-
Communication	188	17	76	76	-	-	95	-
Electric, gas, and sanitary services	57	5	50	50	-	-	2	-
Wholesale and retail trade	1,124	783	242	240	2	-	95	4
Wholesale trade	993	734	173	171	2	-	84	2
Retail trade	131	49	69	69	-	-	11	2
General merchandise stores	81	39	37	37	-	-	5	-
Food stores	21	5	10	10	-	-	6	-
Apparel and accessories	17	5	11	11	-	-	-	1
Furniture, home furnishings, and equipment	2	-	2	2	-	-	-	-
Eating and drinking places	8	-	7	7	-	-	-	1
Miscellaneous retail stores	2	-	2	2	-	-	-	-

(Continued)

Table XIII-1 (concluded)

Industry group	All occupations	Systems analysts	Programmers: Total	Programmers: Business and accounting	Programmers: Engineering and scientific	Programmers: Combination: business and engineering	Combination: systems analysis and programming	Project planners
Nonmanufacturing (continued)								
Finance, insurance, and real estate	1,442	320	756	756	-	-	347	19
Banking	436	133	214	214	-	-	89	-
Credit agencies other than banks	35	4	12	12	-	-	19	-
Security and commodity brokers, dealers, exchanges, and services	189	34	112	112	-	-	43	-
Insurance carriers	614	97	342	342	-	-	160	15
Insurance agents, brokers, and services	82	34	38	38	-	-	6	4
Holding and other investment companies	86	18	38	38	-	-	30	-
Services and miscellaneous	681	87	436	188	219	29	85	73
Hotels, rooming houses, camps, and other lodging places	30	-	-	-	-	-	30	-
Personal services	8	2	6	6	-	-	-	-
Miscellaneous business services	239	31	152	73	65	14	31	25
Advertising, news, credit, duplicating, building, and related services	33	1	27	27	-	-	4	1
Business services n.e.c.	206	30	125	46	65	14	27	24
Research, development, testing laboratories	70	6	61	2	59	-	3	-
Business and management consulting services	121	18	56	36	6	14	24	23
Other business services n.e.c.	15	6	8	8	-	-	-	1
Automobile repair, automobile services, garages	4	1	2	2	-	-	1	-
Motion pictures	18	-	10	8	2	-	8	-
Amusement and recreation, except motion pictures	4	-	4	4	-	-	-	-
Voluntary hospitals	11	2	9	7	2	-	-	-
Private colleges and schools	138	9	123	18	105	-	-	6
Miscellaneous services	229	42	130	70	45	15	15	42
Engineering and architectural services	26	2	22	-	19	-	2	-
Nonprofit educational and scientific research	27	-	26	-	26	-	1	-
Accounting, auditing, bookkeeping, and other services n.e.c.	176	40	82	70	-	12	12	42
Government	412	125	262	97	9	156	18	7
County	5	1	3	2	1	-	1	-
Colleges	1	-	1	-	1	-	-	-
Other	4	1	2	2	-	-	1	-
New York State	105	16	75	18	7	50	8	6
Colleges	19	-	19	12	5	2	-	-
Other	86	16	56	6	2	48	8	6
New York City	68	5	60	12	-	48	2	1
Federal	234	103	124	65	1	58	7	-
Colleges	1	-	1	-	1	-	-	-
Arsenals and navy yards	21	11	9	2	-	7	1	-
Other	212	92	114	63	-	51	6	-

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Table XIII-2. EDUCATION EMPLOYERS REQUIRE, BY GRADE

(Number and percent distribution of specialists according to level of education required)

Education required	All grades	Supervisory grades	Nonsupervisory grades			
			Single grade	Multi-grade		
				Lowest grades	Middle grades	Highest grades
	Number					
All levels	6,153	645	2,879	1,143	446	1,040
Post-high-school	4,191	371	2,014	771	271	764
Engineering college	243	5	223	7	1	7
Graduation	241	5	221	7	1	7
Less than graduation	2	-	2	-	-	-
College, general	3,530	334	1,543	703	258	692
Graduation	2,987	289	1,278	564	225	631
Less than graduation	543	45	265	139	33	61
Technical institute or community college	197	22	162	4	3	6
Graduation	188	22	153	4	3	6
Less than graduation	9	-	9	-	-	-
Type not specified	221	10	86	57	9	59
High school	1,962	274	865	372	175	276
Technical or vocational	17	-	13	4	-	-
Other and not specified	1,945	274	852	368	175	276
	Percent distribution					
All levels	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	68.1	57.5	70.0	67.5	60.8	73.5
Engineering college	3.9	0.8	7.7	0.6	0.2	0.7
Graduation	3.9	0.8	7.6	0.6	0.2	0.7
Less than graduation	(a)	-	0.1	-	-	-
College, general	57.4	51.7	53.7	61.6	57.9	66.5
Graduation	48.6	44.7	44.5	49.4	50.5	60.6
Less than graduation	8.8	7.0	9.2	12.2	7.4	5.9
Technical institute or community college	3.2	3.4	5.6	0.3	0.7	0.6
Graduation	3.1	3.4	5.3	0.3	0.7	0.6
Less than graduation	0.1	-	0.3	-	-	-
Type not specified	3.6	1.6	3.0	5.0	2.0	5.7
High school	31.9	42.5	30.0	32.5	39.2	26.5
Technical or vocational	0.3	-	0.5	0.3	-	-
Other and not specified	31.6	42.5	29.5	32.2	39.2	26.5

a. Less than 0.05 of a percent.

Table XIII-3. EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

(Percent distribution of specialists according to level of education required)

Education required	All occupations	Systems analysts	Programmers: Total	Programmers: Business and accounting	Programmers: Engineering and scientific	Programmers: Combination business and engineering	Combination systems analysis and programming	Project planners
All levels: Number	6,153	1,875	3,205	2,301	553	351	936	137
Percent distribution								
All levels: Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	68.1	79.8	63.2	57.5	92.2	54.7	59.2	83.2
Engineering college	3.9	0.4	7.0	0.2	38.9	1.7	1.1	0.7
Graduation	3.9	0.4	7.0	0.2	38.9	1.7	0.9	0.7
Less than graduation	(a)	-	-	-	-	-	0.2	-
College, general	57.4	75.8	47.6	51.8	38.5	33.1	50.6	80.3
Graduation	48.6	65.7	38.2	40.4	36.5	25.7	46.2	71.5
Less than graduation	8.8	10.1	9.4	11.4	2.0	7.4	4.4	8.8
Technical institute or community college	3.2	1.0	4.3	0.8	14.8	10.8	4.1	0.7
Graduation	3.1	1.0	4.1	0.7	14.6	9.9	3.8	0.7
Less than graduation	0.1	-	0.2	0.1	0.2	0.9	0.3	-
Type not specified	3.6	2.6	4.3	4.7	-	9.1	3.4	1.5
High school	31.9	20.2	36.8	42.5	7.8	45.3	40.8	16.8
Technical or vocational	0.3	0.2	0.4	0.6	-	-	-	-
Other and not specified	31.6	20.0	36.4	41.9	7.8	45.3	40.8	16.8

a. Less than 0.05 of a percent.

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Table XIII-4. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of specialists according to level of education required and preferred)

Level of education	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	6,153	6,153	100.0	100.0
Post-high-school	4,191	5,104	68.1	83.0
Engineering college	243	326	3.9	5.3
Graduation	241	324	3.9	5.3
Less than graduation	2	2	(a)	(a)
College, general	3,530	4,531	57.4	73.6
Graduation	2,987	4,184	48.6	68.0
Less than graduation	543	347	8.8	5.6
Technical institute or community college	197	127	3.2	2.1
Graduation	188	121	3.1	2.0
Less than graduation	9	6	0.1	0.1
Type not specified	221	120	3.6	2.0
High school	1,962	1,049	31.9	17.0
Technical or vocational	17	13	0.3	0.2
Other and not specified	1,945	1,036	31.6	16.8

a. Less than 0.05 of a percent.

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Table XIII-5. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Number and percent distribution of specialists according to level of education preferred)

Education required	Total	Required and preferred: are the same	Education employers prefer, where it differs from what they require							
			Total where preference	Post-high-school						High school
				Post-high-school, total	Engineering college graduation	College, general: Graduation	College, general: Less than graduation	Technical institute graduation	Type not specified	
Number										
All levels	6,153	4,639	1,514	1,510	84	1,221	180	5	20	4
Post-high-school	4,191	3,594	597	593	73	510	10	-	-	4
Engineering college	243	242	1	1	-	1	-	-	-	-
Graduation	241	240	1	1	-	1	-	-	-	-
Less than graduation	2	2	-	-	-	-	-	-	-	-
College, general	3,530	3,130	400	400	30	370	-	-	-	-
Graduation	2,987	2,963	24	24	24	-	-	-	-	-
Less than graduation	543	167	376	376	6	370	-	-	-	-
Technical institute or community college	197	122	75	75	43	32	-	-	-	-
Graduation	188	116	72	72	43	29	-	-	-	-
Less than graduation	9	6	3	3	-	3	-	-	-	-
Type not specified	221	100	121	117	-	107	10	-	-	4
High school	1,962	1,045	917	917	11	711	170	5	20	-
Technical or vocational	17	13	4	4	-	-	-	4	-	-
Other and not specified	1,945	1,032	913	913	11	711	170	1	20	-
Percent distribution										
All levels	100.0	75.4	24.6	24.5	1.4	19.8	2.9	0.1	0.3	0.1
Post-high-school	100.0	85.8	14.2	14.1	1.7	12.2	0.2	-	-	0.1
Engineering college	100.0	99.6	0.4	0.4	-	0.4	-	-	-	-
Graduation	100.0	99.6	0.4	0.4	-	0.4	-	-	-	-
Less than graduation	100.0	(b)	-	-	-	-	-	-	-	-
College, general	100.0	88.7	11.3	11.3	0.8	10.5	-	-	-	-
Graduation	100.0	99.2	0.8	0.8	0.8	-	-	-	-	-
Less than graduation	100.0	30.8	69.2	69.2	1.1	68.1	-	-	-	-
Technical institute or community college	100.0	61.9	38.1	38.1	21.9	16.2	-	-	-	-
Graduation	100.0	61.7	38.3	38.3	22.9	15.4	-	-	-	-
Less than graduation	100.0	(b)	(b)	(b)	-	(b)	-	-	-	-
Type not specified	100.0	45.2	54.8	53.0	-	48.5	4.5	-	-	1.8
High school	100.0	53.3	46.7	46.7	0.6	36.1	8.7	0.3	1.0	-
Technical or vocational	100.0	76.5	23.5	23.5	-	-	-	23.5	-	-
Other and not specified	100.0	53.1	46.9	46.9	0.6	36.5	8.7	0.1	1.0	-

a. No employer who expressed a preference mentioned technical or vocational high school.
b. Not computed because of small number involved.

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Table XIII-6. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Number and percent distribution of specialists according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
Number							
All levels	6,153	4,297	1,856	206	599	881	170
Post-high-school	4,191	3,311	880	170	234	448	28
Engineering college	243	233	10	8	1	1	-
Graduation	241	231	10	8	1	1	-
Less than graduation	2	2	-	-	-	-	-
College, general	3,530	2,863	667	151	121	390	5
Graduation	2,987	2,704	283	149	26	108	-
Less than graduation	543	159	384	2	95	282	5
Technical institute or community college	197	116	81	6	55	20	-
Graduation	188	110	78	6	52	20	-
Less than graduation	9	6	3	-	3	-	-
Type not specified	221	99	122	5	57	37	23
High school	1,962	986	976	36	365	433	142
Technical or vocational	17	13	4	-	4	-	-
Other and not specified	1,945	973	972	36	361	433	142
Percent distribution							
All levels	100.0	69.8	30.2	3.3	9.7	14.4	2.8
Post-high-school	100.0	79.0	21.0	4.1	5.6	10.6	0.7
Engineering college	100.0	95.9	4.1	3.3	0.4	0.4	-
Graduation	100.0	95.9	4.1	3.3	0.4	0.4	-
Less than graduation	100.0	(a)	-	-	-	-	-
College, general	100.0	81.1	18.9	4.3	3.4	11.1	0.1
Graduation	100.0	90.5	9.5	5.0	0.9	3.6	-
Less than graduation	100.0	29.3	70.7	0.4	17.5	51.9	0.9
Technical institute or community college	100.0	58.9	41.1	3.0	27.9	10.2	-
Graduation	100.0	58.5	41.5	3.2	27.7	10.6	-
Less than graduation	100.0	(a)	(a)	-	(a)	-	-
Type not specified	100.0	44.8	55.2	2.3	25.8	16.7	10.4
High school	100.0	50.3	49.7	1.8	18.6	22.1	7.2
Technical or vocational	100.0	76.5	23.5	-	23.5	-	-
Other and not specified	100.0	50.0	50.0	1.9	18.6	22.2	7.3

a. Not computed because of small number involved.

Chapter XIV

AIRWAY TOWER SPECIALISTS AND FLIGHT DISPATCHERS

In 1962 there were 1,373 airway tower specialists and flight dispatchers in New York State. They constituted about 1 percent of all persons in technical occupations.

These technicians fall into two major occupational groups -- 1,145 are airway tower specialists and the remaining 228 are flight dispatchers.

Among airway tower specialists, almost all (98 percent) are employees of the Federal Aviation Agency (FAA); the others are employed by manufacturers of aircraft. Flight dispatchers typically are employed by airlines, in airline dispatch centers at major air terminals.

About 94 percent of all specialists and dispatchers work under the supervision of a technician of higher rank. The other 6 percent are responsible to a person in some other capacity.

FUNCTIONS

Air Tower Specialists 1/

Airway tower specialists carry on air traffic control work that provides for the safe, orderly, and expeditious movement of aircraft along air routes and at airports. They also provide pre-flight and in-flight assistance service to pilots and develop, coordinate, and implement air traffic control programs. To accomplish its traffic-control program the FAA has established rules governing flight under various weather conditions and in various areas.

1. United States Civil Service Commission, Position Classification Standards, Air Traffic Control Series, GS-2152.

These control and flight-assistance services are conducted through a network of stations, centers, towers, and combined facilities, which are linked by an interphone network and are assigned radio frequencies for direct contact with pilots in flight. Specializations have been established to cover work in these various types of facilities, although some airway tower specialists have a combination of duties.

The stations, which provide flight assistance service to pilots prior to or during flight, are located along the airways, at airports or landing areas, and at whatever other locations may be required to give proper radio coverage to aircraft. A station concerned with aircraft flying within the United States serves an area about 100 miles in radius; one concerned with international flights services a larger area. The functions of airway tower specialists assigned to a station may include:

Providing pre-flight service to pilots, such as flight planning and giving information on routes, navigation aides, facilities, weather conditions, etc.

Providing similar information in flight, as well as relaying position reports, traffic control instructions, and other information between pilots and air traffic control facilities.

Rendering emergency assistance to pilots by giving instructions on actions to be taken to bring the aircraft under control; helping pilots orient themselves; obtaining, or having other facilities obtain, a bearing on the aircraft; and devising means to compensate for equipment failure.

Preparing reports and records.

Supervising technical training is done by higher-grade specialists.

The air route traffic control centers control the movement of air traffic along domestic air routes, in designated off-airways areas, over certain oceanic areas, and in terminal areas surrounding certain airports. Aircraft moving within these areas are subject to mandatory control by the center when weather conditions are so adverse as to require instrument flying. Aircraft is also subject to control in good weather, when pilots wish to fly under instrument flight rules. The functions of airway tower specialists at the air route traffic control center may include:

Issuing traffic control instructions, clearances, advice, and information to aircraft.

Using information on the movement of air traffic obtained from airport control towers, aircraft dispatch offices, air traffic communications stations, radar approach control facilities, air carrier radio stations, the weather bureau, etc., as a basis for traffic control instructions.

Estimating aircraft arrival times over navigation fixes.

Initiating search and rescue action for lost or overdue aircraft.

Reporting aircraft accidents and deviations from established regulations.

Coordinating traffic flow between sectors of the center, between centers, and between centers and terminal facilities.

Maintaining reports and records of flights and communications.

In the higher grades, coordinating traffic control activities with the control area, supervising technical training activities, establishing procedures, and maintaining liaison with aeronautical interests.

The tower controls air traffic within an area surrounding an airport. Its chief purpose is to prevent collisions, and to provide for the rapid movement of aircraft taking off, landing, approaching for a landing, or flying within the control area of the tower. There is close coordination between the operation of the tower and the air route traffic control center. The functions of airway tower specialists located at the tower may include:

Issuing traffic control instructions and giving flight assistance service to aircraft based on information on the movement of air traffic obtained from air route traffic control centers, air traffic communications stations, local aircraft operators, etc.

Transmitting information on the movement of traffic to and from the landing area to air route traffic control centers.

Operating airport lighting systems, traffic direction indicators, and other visual means of traffic control.

Preparing reports and records.

In the higher grades, coordinating local traffic with air route traffic. supervising technical training activities, and maintaining liaison with aeronautical interests.

Airway tower specialists, whether located at the station, center, or tower, must have the technical skills, needed to operate radio, radar, and other electronic equipment, and interphone, telephone, radiotelephone, teletypewriter, and other communications equipment. They must also be able to work under pressure at a very high speed and to give messages and instructions so clearly that they cannot be misinterpreted.

Flight Dispatchers

Flight dispatchers are typically employed by airlines to coordinate flight schedules and operations within an assigned area, and see that there is compliance with all Federal aviation regulations and company flight and safety regulations. Their functions may include:

Watching weather conditions and making a preliminary decision as to whether a flight may be safely undertaken.

Conferring with the pilot of the flight before the flight leaves the airport on details such as weather conditions, amount of fuel needed, the best route and altitude at which to fly, total flying time, alternate landing fields if landing at the scheduled airport is hazardous, etc.

Keeping a constant watch on weather conditions.

Plotting the progress of a flight on the basis of radio reports from the pilot at regular intervals, and keeping the pilot informed of changing weather and other conditions affecting his flight.

Giving airline clearances for alternate landings when ground or weather conditions do not permit landing at a scheduled airport.

Keeping records and checking such matters as availability of aircraft and equipment weight and balance of loaded cargo, amount of time flown by each plane, and number of hours flown by each crew member (especially if employed by smaller airlines).

Notifying passengers and crew of changes from scheduled departure time, etc.

SUBJECT MATTER KNOWLEDGE

Airway Tower Specialists

The basic subjects covered in the FAA's on-the-job training course for air traffic control certification are air traffic rules, aviation weather, navigation aids, communications procedures, flight assistance service procedures, air route traffic control procedures, airport approach control procedures, and radar air traffic control procedures.

Airway tower specialists must obtain a facility rating from the FAA to qualify them to work at the particular facility. To obtain such a rating, airway tower specialists must acquire a knowledge of the kind and location of radio aids to air navigation, the terrain and landmarks, the communications systems and circuits, and the procedures peculiar to the area covered by the facility. If they are transferred to a different facility or location, they must obtain new facility ratings.

Flight Dispatchers

The subjects generally needed by flight dispatchers are aviation weather, basic air navigation, air route traffic control procedures, and communications procedures. They must have a knowledge of Federal aviation regulations and company flight and safety regulations. They must also have a knowledge of landing and cruising speeds and other aircraft operational characteristics.

Dispatchers must be familiar with airline routes and navigational facilities. A licensed dispatcher is checked periodically by his employer to make sure that he is maintaining the skills required by the FAA. From time to time he may be required to "fly the line" as an observer over the portion of the system that he services in order to maintain first-hand familiarity with airline routes and flight operations. Dispatchers also receive special training so that they may become familiar with new flight procedures and with characteristics of new aircraft.

GRADE STRUCTURE

Since almost all airway tower specialists are government employees, a multi-grade structure is characteristic in this occupation. Only 1 percent, who are employed in private companies manufacturing aircraft, are in single-grade systems. On the other hand, flight dispatchers usually work for private companies, and 51 percent of them are in single-grade systems. Table XIV-A shows how these technical workers are distributed by grade.

The government grades airway tower specialist positions on the basis of the difficulty and responsibilities of the duties to be performed. The difficulty of performance is affected by factors such as the knowledge required, the degree to which guidelines can be used, the extent to which others are affected by the work, and the number, frequency, and difficulty of decisions required. The over-all volume of activity at the facility is an important measure of the difficulty of the control function and, therefore, is the major grade-differential factor.

Table XIV-A. PERCENT DISTRIBUTION OF AIRWAY TOWER SPECIALISTS AND FLIGHT DISPATCHERS, BY GRADE

Grade	All occupations	Airway tower specialists	Flight dispatchers
All grades: number	1,373	1,145	228
Percent distribution			
All grades: percent	100.0	100.0	100.0
Supervisory grades	13.8	14.2	11.8
Nonsupervisory grades	86.2	85.8	88.2
Single grade only	9.6	1.4	50.9
Multi-grade:			
Lowest grades (a)	23.0	24.9	13.6
Middle grades	16.0	18.3	4.4
Highest grades	37.6	41.2	19.3

a. Includes entrance-level grade.

EDUCATION AND EXPERIENCE REQUIRED

The technicians in the airway tower specialist and flight dispatcher group are required to have a high-school education supplemented by a number of years of specialized experience, as a basic minimum. Post-high-school education could be substituted for some or all of the required experience.

Airway Tower Specialists

At the time of the survey, in 1962, the FAA permitted an applicant for an entrance-level job as an airway tower specialist to qualify in either one of two ways:

(1) Those with experience in air traffic control or related fields, such as airplane pilot or navigator, might qualify on the basis of experience alone. (This alternative has been omitted from the qualification standards dated January 1964.)

(2) Those who had a college education or equivalent on-job experience could qualify on passing a written examination.

(1) Those qualifying on the basis of specialized experience alone had to meet one of the following four requirements:

(a) One year of experience as any one of these five: (1) a certificated or military air traffic control tower operator on active duty; (2) an operator of ground controlled approach radar actively engaged in controlling aircraft; (3) an operator of radar equipment in an approach control facility or air traffic control center actively engaged in controlling aircraft; (4) an air route traffic controller (center) on active duty; or (5) an FAA certificated dispatcher for an air carrier.

(b) Two and a half years of experience in a position with direct responsibility for the preparation, supervision, and control of scheduled or military flights, which demonstrated knowledge of weather observations, rules and procedures of air traffic control, use of radio aids, and communications rules and procedures.

(c) 500 hours of flight time as a pilot in command or a co-pilot, plus a private certificate or higher, if experience was not obtained in active duty in the armed forces.

(d) 250 hours of experience as a fully qualified navigator or navigator-bombardier in the armed forces or as a FAA certificated navigator.

(2) To be eligible for taking the written examination (which lasted two hours) under the alternative requirement, an applicant was required to have had three years of experience in administrative, professional, investigative, technical, or other work that would prepare him for a position of responsibility. However, each year of successfully completed college education could be substituted for nine months of experience. Thus, a college graduate without experience could qualify if he passed the written examination.

At the present time, under U.S. Civil Service Commission qualification standards dated January 1964, all candidates for an airway tower specialist job must pass a written test designed to measure ability to learn and perform the duties of an air traffic controller. They must also demonstrate that they have those personal characteristics that are needed for successful performance of air control duties, such as alertness, decisiveness, motivation, ability to speak distinctly and concisely, and poise.

Successful applicants are given eight weeks of formal training at an FAA school to learn the fundamentals of air traffic control. This is followed by on-the-job training. After working on the job for between a half-year and a year, they have the experience qualifications for promotion to the next level. To qualify for a top-level job requires 3 or 4 years of specialized experience.

Flight Dispatchers

Flight dispatchers typically are required to be graduates of technical or vocational high schools and to have 4.2 years of related work experience, in the average (median) case. Median years of required experience are 2.4 at the non-supervisory level compared with 7.8 for supervisors.

TESTS AND LICENSES

All airway tower specialists are required to have air traffic control specialist certificates. The eight-week training course given by the FAA for its newly hired specialists is designed to qualify participants for this certification. In addition the airway tower specialist must have a facility certificate or rating issued by the FAA to qualify him to work at the particular location.

Flight dispatchers are required to have FAA dispatcher certificates. To qualify for the written examination for this certificate, applicants must have one of the following:

(a) One year's experience in dispatching work under the supervision of a certified dispatcher. (Assistant dispatchers do not require certificates.)

(b) Completion of an FAA-approved dispatcher's course at a school or an airline training center.

(c) Work experience during two of the last three years in air traffic control work, or in such airline jobs as dispatch clerk, assistant dispatcher, or radio operator, or in similar work in military service.

The written examination covers subjects such as Federal aviation regulations, weather analysis, air navigation facilities, radio procedures, and airport and airway traffic procedures. This is followed by an oral examination in which the applicant must demonstrate his ability to interpret weather information, his knowledge of landing and cruising speeds and other aircraft operational characteristics, and his knowledge of airline routes and navigational facilities.

SOURCES OF WORKERS

Upgrading is a very important method of obtaining workers for airway tower specialist and flight dispatcher jobs. For 88 percent of such jobs filled during a representative period preceding the survey, employers used upgrading; 12 percent were filled by recruitment.

Organized training programs conducted by the Federal Communications Commission for airway tower specialists play an important role in upgrading these specialists.

Very few airway tower specialists and flight dispatchers employed at the time of the survey were college graduates, but over a third of the tower specialists had degrees from technical institutes.

Chapter XV

BROADCASTING, MOTION PICTURE, AND RECORDING STUDIO SPECIALISTS

This chapter covers three kinds of broadcasting, motion picture, and recording studio specialists -- studio technicians, video tape and kinescope technicians, and equipment and maintenance technicians. In small establishments, technicians may perform more than one kind of work. In large establishments jobs are likely to be specialized, although job assignments may change from day to day.

Table XV-A. NUMBER OF BROADCASTING, MOTION PICTURE AND RECORDING STUDIO SPECIALISTS, BY OCCUPATION AND INDUSTRY GROUP

Occupation	All industries	Phonograph record manufacturing etc.	Radio and television broadcasting	Motion picture production and other amusements	Government	All other
All occupations	2,920	184	2,297	197	97	145
Studio technicians	1,521	139	1,051	165	25	141
Technical directors	96	-	95	-	-	1
Light	87	-	40	44	3	-
Audio and acoustics	194	5	115	55	-	19
Sound effects	61	-	28	33	-	-
Video control	36	-	36	-	-	-
Recording	234	113	12	14	13	82
Studio field	713	21	647	19	-	26
General	100	-	78	-	9	13
Video tape and kinescope technicians	194	-	174	20	-	-
Equipment and maintenance technicians	1,205	45	1,072	12	72	4
Transmitter	431	28	328	12	63	-
Transmission	111	-	109	-	-	2
Maintenance	315	17	288	-	9	1
General	348	-	347	-	-	1

The group covers 2,920 specialists, or about 2 percent of all workers in technical occupations.

Most (79 percent) of these specialists are employed in the radio and television broadcasting industry. Some also are found in plants manufacturing phonograph records, in motion picture production, other business services, and in government. Table XV-A, based on table XV-1 at the end of the chapter, indicates how many of each type of specialist are found in these industries.

Two-thirds of the broadcasting, motion picture, and recording studio specialists are supervised by other specialists or technicians, 10 percent by engineers, and the remaining 23 percent by foremen, managerial personnel, or other officials.

	Total percent	Engineer or scientist	Technician or specialist	Other
All occupations	100.0	9.9	66.8	23.3
Studio technicians	100.0	7.0	66.2	26.8
Video tape and kinescope technicians	100.0	-	84.0	16.0
Equipment and maintenance technicians	100.0	15.2	64.9	19.9

FUNCTIONS

Studio Technicians

Below is a summary description of the functions and technical skills required by each of the various occupations included in the studio technician group: technical directors and light, audio and acoustics, sound effects, video control, recording, and studio field technicians.

Technical directors in the broadcasting industry are supervisors who have responsibilities for some or all of the following:

Engineering operations and technical personnel on studio programs during rehearsals and during air performances.

Operations of studio programs, including switching of cameras and directing of engineering crews during performances.

Quality of the transmitted picture and adjustments to compensate for poor picture quality.

Planning and arranging special engineering effects.

Checking on the characteristics of and recommending new equipment for better transmission.

Preparation of reports on studio programs, equipment performance, etc.

Technical directors need a knowledge of the operation of cameras, lights, and other broadcasting equipment.

Light technicians determine the amount and kind of light needed for television broadcasts, motion pictures, etc.

They may set up and position lights (spot, flood, incandescent, mercury vapor), reflectors, and other equipment.

Switch lights on and off; move lights during production; etc.

Keep records of lamp equipment, electricity used, etc.

Their technical skills include the ability to set up and operate lighting systems, etc.

Audio and acoustics technicians control all elements of sound in a show -- pickup, transmission, and switching. Such sound may originate from microphones on the floor, from film that is being projected in the television film room, from audio or video tape, or from network or remote pickups.

They do one or more of the following:

Adjust and place microphones for best sound pickup.

Connect sound equipment and control phones into control board; maintain proper volume of sound; blend sound.

Switch from live to magnetic tape; play phonograph records and switch reproduced sound into program according to script.

Transfer music or other sound to magnetic tape; mix various sound tapes to make a master tape; edit tapes.

The technical skills required include:

Ability to read and interpret schematic diagrams pertaining to sound recording and audio equipment.

Ability to operate sound equipment, phonographs, tape recording machines, etc.

A good ear for music and a sense of artistic values are essential.

Sound effects technicians originate and produce sounds by artificial means which, when reproduced over radio, television, and motion picture equipment, give the listener an impression of the action supposedly taking place.

They operate sound effects equipment used to create desired sound illusions during rehearsals and broadcasts in radio and television studios.

May run the console in a film studio and manipulate it so as to blend sound, voice, and picture. They may work with the film producer to develop desired moods and timing.

May develop, design, and construct new or improved sound effects techniques and equipment.

May maintain inventory records of sound effects equipment, etc.; may edit sound tape for films.

The technical skills needed include the ability to operate sound effects equipment. Sensitive hearing, sound distinction ability, and a good ear for music are essential.

Video control technicians operate the controls (video console) that regulate the quality, brightness, and contrast of television pictures.

Recording technicians operate sound-recording equipment used to record on discs, recording tape, and sound films. Their functions may include some or all of the following:

Set up and adjust equipment for recording; make wiring connections between microphones, amplifiers, etc., and recording machine. Set up the studio for the recording session by placing microphones, music stands, chairs, etc., in proper location for best acoustical effects.

Operate the recording machine; regulate the volume and quality of the recording. Use sound mixing console to properly mix and record narration, dialogue, sound effects, film strips, lip synchronization, music, etc.

Edit the recording or tape.

Transfer recordings from tape to tape, tape to disc, tape to film, film to disc, etc.

Test sound film (check density, adjust calibration controls, determine mathematically the amount of current to be used on the exposure lamp of the recording machine, etc.).

Incidental tasks include: hardening and cleaning records by wiping them with a chemically treated cloth; marking records for content; maintaining record files of recorded material for future reference; etc.

The technical skills of recording technicians include:

Ability to use sound recording and related equipment, such as amplifiers, disc machines, echo chambers, mixing consoles, microphones, noise suppressors, tape recorders, sound consoles, reproducing machines, reverberation chambers, syndromechanisms, etc.; various types of oscillators (audio, bias, pitch control, etc.), and various other types of electrical and electronic testing equipment.

Good auditory facilities and musical auditory responses.

Video Tape and Kinescope Technicians

Video tape technicians' functions:

They record electronic impulses of black and white and color television programs and commercials (video and audio) on magnetic tape, which can be used for instantaneous playback of television performances. The recording may be of a live show being broadcast or a prerecording of a program for future broadcast.

They may also edit tape for quality improvement and content; play back tapes for on-the-air broadcasts; etc.

Kinescope technicians may do one or more of the following:

Photograph with kinescope camera auditions and TV programs for rebroadcast or audition purposes.

Process "double system" films to ensure quality pictures and sound negative films for printing by laboratory. Develop "single system" films for immediate broadcast.

Prepare chemical solutions for the developing process.

Synchronize film on magnetic tape by advancing sound track as required for laboratory printing.

Make a final check of filmed prints for technical quality.

Do related work, such as recording the date and hour various processes were initiated on the screening log, compiling records of film stock used and on hand, maintaining kinescope files, compiling an engineering log after each recording and screening session.

Technical skills needed by video tape and kinescope technicians include:

Ability to operate picture and sound recording cameras, kinescope cameras, magnetic video tape recorders, etc.; and the ability to use chemical testing equipment, automatic developers, sensitometers, densitometers, etc.

Ability to read schematics is sometimes required.

Equipment and Maintenance Technicians

Transmitter technician, transmission technician, and maintenance technician are the three types found under the heading of equipment and maintenance technician. Below is a summary of the functions of each group, and the technical skills that they require.

Transmitter technicians are responsible for the proper operation of the transmitter of a radio or television station, and for monitoring and logging outgoing signals. Their functions include one or more of the following:

Control the operation of the transmitter and auxiliary equipment, so as to insure their continuous and efficient operation in accordance with Federal Communications Commission (FCC) regulations.

Listen to a program through a loudspeaker or headphone or view it through a television monitor; observe indicators; and monitor all transmissions for broadcasting quality and language standards in accordance with FCC rulings. If transmission is faulty, they inform studio or other source so that picture or sound can be corrected.

Make minor repairs and perform preventive maintenance on the transmitter and its various elements, meters, and indicating devices.

Keep an operating log of the transmitter, as required by the FCC, indicating transmission periods of programs, station breaks, commercials, etc.

Related functions may include maintaining hourly instrument logs as a check on transmitter operation, checking out and recommending new equipment, etc.

The technical skills required for this job include:

Ability to operate and adjust broadcast transmitters and to diagnose electronic difficulties rapidly and under pressure.

Ability to use auxiliary equipment: oscilloscopes; wave analyzers; ammeters, voltmeters, ohmmeters, and other meters and test equipment; hand tools; etc.

Ability to read schematics and blueprints and to work with technical manuals.

Transmission technicians perform the necessary technical functions at the master controls of a television station and route programs over the network. Their functions may include the following:

Set up network lines and circuits for network distribution of shows.

Monitor programs coming into master control room from studios and field to ensure proper balance, shading, and technical perfection.

Route programs over transmission lines by switching from studio to studio, as indicated by the daily program schedule so as to provide continuity of broadcast operation.

Their technical skills include:

Knowledge of pulse standards, in monochrome or color.

Ability to recognize the various forms of pulse and video distortions and the ability to analyze and photograph pulse phenomenon.

Maintenance technicians set up, maintain, and repair electronic broadcasting equipment. They may do some or all of the following:

Install, do preventive maintenance on, and repair television and radio broadcasting equipment in the studio, theatre, or elsewhere to ensure continuous efficient equipment operation and to ensure that an adequate supply of properly operating equipment is at each of the locations.

Perform modifications on technical equipment to incorporate new developments or improvements into existing equipment.

Compile data for equipment and development studies.

Compile records to facilitate repair and maintenance work.

They need technical skills such as:

Ability to read blueprints and schematics and to work with technical handbooks.

Ability to use mechanical TV service tools; and oscilloscopes, meters, gauges, and other electronic and electrical testing equipment.

SUBJECT MATTER KNOWLEDGE

Studio Technicians

Generally needed by all studio technicians is a background in basic electronics and in the technology of electricity and audio and video frequency, supplemented by general physics to cover the principles of magnetism, heat, light, and sound. Audio and video frequency technology encompasses the fields of acoustics, of circuitry for handling electrical signals representing sound and picture information, and of electro-optical and electro-acoustical devices.

Video Tape and Kinescope Technicians

A knowledge of video frequency technology, general physics, and photography and film technology (handling, exposures, negative printing, development processes, etc.) is needed as background. Some employers also said that basic electronics was needed.

Equipment and Maintenance Technicians

A transmitter technician must be proficient in the following subjects in order to qualify for the Radiotelephone First Class Operator License required for this job: construction and operation of transmission and receiving equipment, the characteristics of electro-magnetic waves, and federal and international regulations and practices governing broadcasting. He also needs a knowledge of basic electronics and basic electricity as background.

A few employers mentioned trigonometry, general physics, and general chemistry as subjects that are occasionally needed.

A maintenance technician needs a knowledge of communication electronics, with general physics and basic electronics and electricity as background. Some employers also mentioned mathematics, especially trigonometry and advanced algebra, and electrical codes.

GRADE STRUCTURE

About seven broadcasting, motion picture, and recording studio specialists without major supervisory responsibilities are employed in single grades for every two employed by firms with a multi-grade structure. However, in the video tape group, taken alone, the ratio is about seven to four. (Table XV-B.)

Table XV-B. PERCENT DISTRIBUTION OF BROADCASTING, MOTION PICTURE, AND RECORDING STUDIO SPECIALISTS ACCORDING TO GRADE, BY OCCUPATION GROUP

Grade	All occupations	Studio technicians	Video tape and kinescope technicians	Equipment and maintenance technicians
All grades	100.0	100.0	100.0	100.0
Supervisory grades	11.5	16.1	9.3	13.3
Nonsupervisory grades	88.5	83.9	90.7	86.7
Single grade only	69.0	65.1	58.2	68.6
Multi-grade:				
Lowest grades	16.0	15.3	25.8	15.3
Middle grades	0.2	0.3	0.5	-
Highest grades	3.3	3.2	6.2	2.8

EDUCATION AND EXPERIENCE REQUIRED

The majority (62 percent) of broadcasting, motion picture, and recording studio specialists work for employers who require some post-high-school education as a condition of employment. Although the employers of the remaining 38 percent have educational requirements that do not go beyond high school, many prefer post-high-school education.

Most employers require experience in addition to high school or post-high-school education.

Education Requirements

Almost all employers who require some post-high-school education want this training to be in a technical institute, but they usually do not insist upon graduation.

Table XV-C. PERCENT DISTRIBUTION
OF BROADCASTING, MOTION PICTURE, AND RECORDING STUDIO SPECIALISTS
ACCORDING TO EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION

Occupation	All levels	Post-high-school			High school
		Technical institute, graduation	Technical institute, non-graduation	Other	
All occupations	100.0	11.9	47.4	3.0	37.7
Studio technicians	100.0	18.1	41.8	5.6	34.5
Technical director	100.0	25.0	70.9	1.0	3.1
Light	100.0	-	35.6	-	64.4
Audio and acoustics	100.0	23.2	27.4	18.5	30.9
Sound effects	100.0	-	45.9	-	54.1
Video control	100.0	-	77.8	-	22.2
Recording	100.0	23.6	5.1	10.2	61.1
Studio field	100.0	20.2	50.5	3.4	25.9
General	100.0	8.0	56.0	-	36.0
Video tape and kinescope technicians	100.0	2.6	81.0	-	16.4
Equipment and maintenance technicians	100.0	5.6	49.1	0.2	45.1
Transmitter	100.0	12.1	29.7	-	58.2
Transmission	100.0	7.2	81.1	-	11.7
Maintenance	100.0	0.6	90.2	0.6	8.6
General	100.0	1.4	25.9	-	72.7

As shown by table XV-C (based on table XV-2 at the end of the chapter), employers' minimum educational requirements differ considerably from occupation to occupation. The highest proportion of jobs requiring some post-high-school education is found in the technical director, maintenance technician, and transmission technician categories.

Preferred vs. Required Education

In addition to their minimum education requirements employers also reported on the level of education they preferred applicants to have had. While some post-high-school education was required for 62 percent of the jobs described in this chapter it was preferred for 73 percent,with strong emphasis on graduation from technical school. Although technical-school graduation was specified for only 19 percent of the jobs requiring post-high-school education, it was specified for 75 percent of the jobs where post-high-school was preferred. This 75 percent takes in most of the jobs for which employers require as a minimum some technical-institute training, but not graduation; and also takes in a substantial number of the jobs for which the minimum requirement is only high-school graduation. (Tables XV-3 and XV-4 at the end of the chapter.)

Experience Requirements

The employers of 87 percent of the specialists of this chapter require that appointees to these jobs have some experience in the same or in a related line of work.

For those in the lowest grades the median requirement (for an applicant with the minimum education specified by the employer) is 2.6 years of experience, compared with 3.7 years for supervisors. A substantial proportion of those in the highest and supervisory grades are required to have 5 or more years of experience. For all grades combined, the median is 2.6 years of experience.

TESTS AND LICENSES

About 37 percent of all the specialists covered in this chapter are required to be licensed or certificated by the government. This includes some in government jobs for which civil service examinations are required, as well as licenses.

The FCC requires anyone who operates or adjusts a broadcast transmitter to hold a Radiotelephone First Class Operator License. To take care of emergencies, some stations prefer to have as many persons as possible legally qualified to operate the transmitter, and therefore require licenses of persons other than transmitter technicians.

To obtain a Radiotelephone First Class Operator License a candidate must pass a series of written examinations given by the FCC, covering the construction and operation of transmission and receiving equipment, the characteristics of electro-magnetic waves, and federal government and international regulations and practices governing broadcasting. There are no minimum educational requirements for entrance to this examination.

Of the 1,076 persons included in the survey who are required to be licensed, 37 percent are specialized transmitter technicians, 32 percent are general equipment and maintenance technicians who combine work on transmitters with some other broadcasting-equipment maintenance work, 12 percent are studio field technicians, and the remaining 19 percent are scattered throughout the various other broadcasting specialist jobs.

Table XV-D. PERCENT OF BROADCASTING, MOTION PICTURE AND RECORDING STUDIO SPECIALISTS WHO ARE GRADUATES OF COLLEGES OR TECHNICAL INSTITUTES, BY OCCUPATION

Occupation	Number	Percent who are graduates: College	Percent who are graduates: Technical institute
All occupations	2,920	7.0	50.8
Studio technicians	1,521	8.7	45.0
Technical director	96	10.4	69.8
Light	87	3.4	13.8
Audio and acoustics	194	7.2	40.7
Sound effects	61	52.5	21.3
Video control	36	5.6	33.3
Recording	234	4.7	42.7
Studio field	713	7.4	48.4
General	100	7.0	56.0
Video tape and kinescope technicians	194	7.2	56.7
Equipment and maintenance technicians	1,205	4.8	57.1
Transmitter	431	3.9	49.7
Transmission	111	5.4	64.9
Maintenance	315	7.3	69.8
General	348	3.4	52.3

SOURCES OF WORKERS

Three out of four broadcasting, motion picture, and recording studio specialists are obtained through recruitment from outside the firm; the remainder by upgrading. Very few receive organized training as part of the upgrading process; all of those that do are studio technicians.

Half of all broadcasting, motion picture, and recording studio specialists are technical-institute graduates -- a considerably higher proportion than is found in any other technical occupation group -- and an additional 7 percent are graduates of four-year colleges or engineering colleges. (See table XV-D.)

Broadcasting, Motion Picture, and Recording Studio Specialists

Table XV-1. NUMBER IN EACH OCCUPATION, BY INDUSTRY GROUP

Industry group	All occupations	Studio technicians									Video tape and kinescope technicians	Equipment and maintenance technicians				
		Total	Technical directors	Light	Audio and acoustics	Sound effects	Video control	Recording	Studio field	General		Total	Transmitter	Transmission	Maintenance	General
All industries	2,920	1,521	96	87	194	61	36	234	713	100	194	1,205	431	111	315	348
Manufacturing	184	139	-	-	5	-	-	113	21	-	-	45	28	-	17	-
Ordnance and accessories	1	-	-	-	-	-		-	-	-	-	1	-	-	1	-
Machinery, except electrical	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-
Phonograph record, etc.	181	138	-	-	5	-	-	112	21	-	-	43	28	-	15	-
Instruments; photographic and optical goods	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Nonmanufacturing	2,736	1,382	96	87	189	61	36	121	692	100	194	1,160	403	111	298	348
Radio and television broadcasting	2,297	1,051	95	40	115	28	36	12	647	78	174	1,072	328	109	288	347
Services and miscellaneous	342	306	1	44	74	33	-	96	45	13	20	16	12	2	1	1
Miscellaneous business services	127	124	-	-	18	-	-	69	24	13	-	3	-	2	1	-
Advertising, news, credit, duplicating, building, and related services	4	2	-	-	-	-	-	2	-	-	-	2	-	2	-	-
Business services n.e.c.	123	122	-	-	18	-	-	67	24	13	-	1	-	-	1	-
Motion picture production	170	161	-	44	55	33	-	10	19	-	9	-	-	-	-	-
Amusement and recreation, except motion pictures	27	4	-	-	-	-	-	4	-	-	11	12	12	-	-	-
Private colleges and schools	8	7	1	-	1	-	-	3	2	-	-	1	-	-	-	1
Nonprofit membership organizations	10	10	-	-	-	-	-	10	-	-	-	-	-	-	-	-
Government	97	25	-	3	-	-	-	13	-	9	-	72	63	-	9	-
New York City	71	8	-	3	-	-	-	-	-	5	-	63	63	-	-	-
Federal	26	17	-	-	-	-	-	13	-	4	-	9	-	-	9	-

Broadcasting, Motion Picture, and Recording Studio Specialists

Table XV-2. EDUCATION EMPLOYERS REQUIRE, BY OCCUPATION
(Percent distribution of specialists according to level of education required)

Education required	All occupations	Studio technicians								Video tape and kinescope technicians	Equipment and maintenance technicians			
		Technical directors	Light	Audio and acoustics	Sound effects	Video control	Recording	Studio field	General		Transmitter	Transmission	Maintenance	General
All levels: number	2,920	96	87	194	61	36	234	713	100	194	431	111	315	348
Percent distribution														
All levels: percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Post-high-school	62.3	96.9	35.6	69.1	45.9	77.8	38.9	74.1	64.0	83.6	41.8	88.3	91.4	27.3
Engineering college, graduation	0.7	-	-	4.1	-	-	5.1	-	-	-	-	-	-	-
College, general	0.9	1.0	-	0.5	-	-	5.1	1.7	-	-	-	-	-	-
Graduation	(a)	1.0	-	-	-	-	-	-	-	-	-	-	-	-
Less than graduation	0.9	-	-	0.5	-	-	5.1	1.7	-	-	-	-	-	-
Technical institute or community college	59.3	95.9	35.6	50.6	45.9	77.8	28.7	70.7	64.0	83.6	41.8	88.3	90.8	27.3
Graduation	11.9	25.0	-	23.2	-	-	23.6	20.2	8.0	2.6	12.1	7.2	0.6	1.4
Less than graduation	47.4	70.9	35.6	27.4	45.9	77.8	5.1	50.5	56.0	81.0	29.7	81.1	90.2	25.9
Type not specified	1.4	-	-	13.9	-	-	-	1.7	-	-	-	-	0.6	-
High school	37.7	3.1	64.4	30.9	54.1	22.2	61.1	25.9	36.0	16.4	58.2	11.7	8.6	72.7
Technical or vocational	4.5	-	-	3.6	-	-	-	0.8	-	8.2	3.9	-	3.2	21.8
Other and not specified	33.2	3.1	64.4	27.3	54.1	22.2	61.1	25.1	36.0	8.2	54.3	11.7	5.4	50.9

a. Less than 0.05 of a percent.

Broadcasting, Motion Picture, and Recording Studio Specialists

Table XV-3. EDUCATION EMPLOYERS REQUIRE AND EDUCATION THEY PREFER

(Number and percent distribution of specialists according to level of education required and preferred)

Education required	Number		Percent distribution	
	Required	Preferred	Required	Preferred
All levels	2,920	2,920	100.0	100.0
Post-high-school	1,820	2,138	62.3	73.2
Engineering college	20	37	0.7	1.3
Graduation	20	34	0.7	1.2
Less than graduation	-	3	-	0.1
College, general	26	91	0.9	3.1
Graduation	1	51	(a)	1.7
Less than graduation	25	40	0.9	1.4
Technical institute or community college	1,733	1,968	59.3	67.4
Graduation	348	1,595	11.9	54.6
Less than graduation	1,385	373	47.4	12.8
Type not specified	41	42	1.4	1.4
High school	1,100	782	37.7	26.8
Technical or vocational	132	156	4.5	5.3
Other and not specified	968	626	33.2	21.5

a. Less than 0.05 of a percent.

Broadcasting, Motion Picture, and Recording Studio Specialists

Table XV-4. EDUCATION EMPLOYERS PREFER IN RELATION TO EDUCATION THEY REQUIRE

(Percent distribution of specialists according to level of education preferred)

Education required	Total	Required and preferred are the same	Education employers prefer, where it differs from what they require									
			Total where preference	Post-high-school								Technical or vocational high school
				Post-high-school, total	Engineering college		College, general		Technical institute		Type not specified	
					Graduation	Less than graduation	Graduation	Less than graduation	Graduation	Less than graduation		
All levels	100.0	46.4	53.6	52.3	0.5	0.1	1.7	1.3	43.2	4.8	0.7	1.3
Post-high-school	100.0	33.6	66.4	66.4	0.7	-	2.1	-	62.5	1.1	-	-
Engineering college, graduation	100.0	100.0	-	-	-	-	-	-	-	-	-	-
College, general	100.0	7.7	92.3	92.3	-	-	92.3	-	-	-	-	-
Graduation	100.0	(a)	-	-	-	-	-	-	-	-	-	-
Less than graduation	100.0	4.0	96.0	96.0	-	-	96.0	-	-	-	-	-
Technical institute or community college	100.0	32.8	67.2	67.2	0.7	-	0.8	-	65.7	-	-	-
Graduation	100.0	96.6	3.4	3.4	3.4	-	-	-	-	-	-	-
Less than graduation	100.0	16.8	83.2	83.2	-	-	1.0	-	82.2	-	-	-
Type not specified	100.0	51.2	48.8	48.8	-	-	-	-	-	48.8	-	-
High school	100.0	67.5	32.5	29.0	0.2	0.3	1.1	3.5	11.1	10.9	1.9	3.5
Technical or vocational	100.0	88.6	11.4	11.4	-	-	-	-	11.4	-	-	-
Other and not specified	100.0	64.7	35.3	31.3	0.2	0.3	1.2	4.0	11.0	12.4	2.2	4.0

a. Not computed because of small number involved.

Broadcasting, Motion Picture, and Recording Studio Specialists

Table XV-5. EMPLOYERS' PREFERENCE FOR MORE THAN REQUIRED EDUCATION AS AGAINST MORE EXPERIENCE

(Percent distribution of specialists according to preference)

Education required	Total	No preference expressed	Preference where one was expressed: All preferences	Required education, more experience	More than required education: Less experience	Same experience	More experience
All levels	100.0	41.1	58.9	3.9	1.7	45.8	7.5
Post-high-school	100.0	28.4	71.6	3.1	1.6	63.6	3.3
Engineering college, graduation	100.0	100.0	-	-	-	-	-
College, general	100.0	7.7	92.3	-	-	92.3	-
Graduation	100.0	(a)	-	-	-	-	-
Less than graduation	100.0	4.0	96.0	-	-	96.0	-
Technical institute or community college	100.0	27.3	72.7	3.2	0.6	65.4	3.5
Graduation	100.0	75.0	25.0	10.1	2.9	0.6	11.4
Less than graduation	100.0	15.3	84.7	1.5	-	81.8	1.4
Type not specified	100.0	51.2	48.8	-	48.8	-	-
High school	100.0	62.3	37.7	5.4	1.9	16.0	14.4
Technical or vocational	100.0	88.6	11.4	-	0.8	10.6	-
Other and not specified	100.0	58.7	41.3	6.1	2.1	16.7	16.4

a. Not computed because of small number involved.