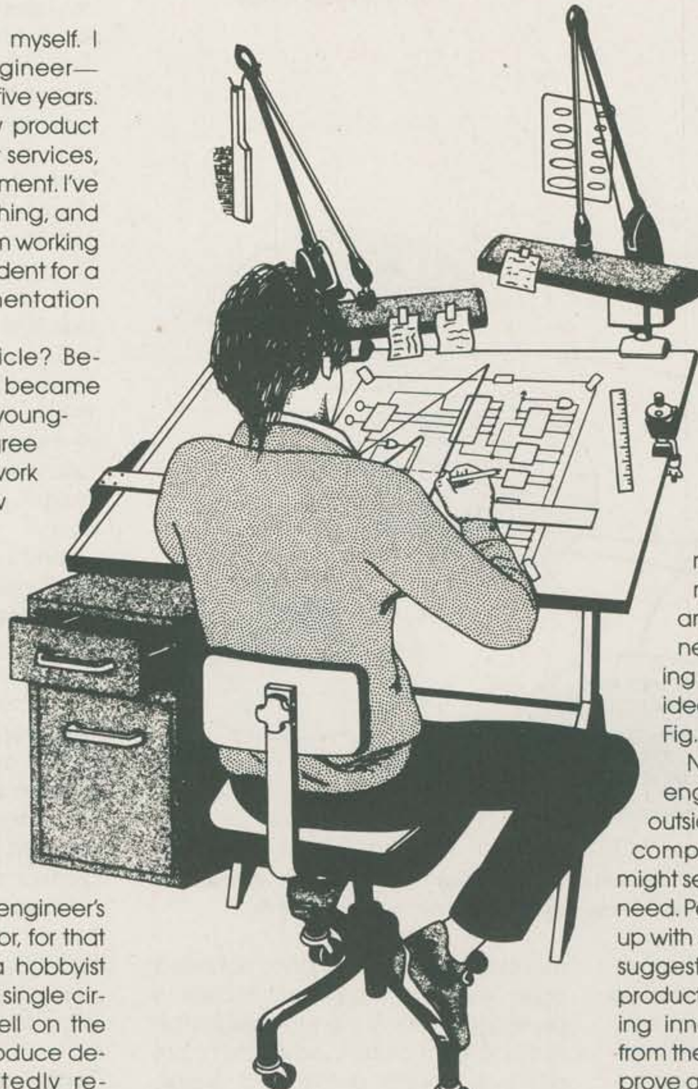
# What Do Electrical Engineers Do?



BY HARRY L. TRIETLEY

*What does an electrical engineer do? Read this article to find out, and maybe learn if a career as an engineer is right for you.*

Allow me to introduce myself. I am an electrical engineer—have been for twenty five years. I've worked in research, new product design, engineering-support services, and various levels of management. I've also done some writing, teaching, and speaking on the side. Today I'm working as the engineering vice-president for a young and growing instrumentation company.

Why am I writing this article? Because, probably like you, I became "hooked" on electronics as a youngster. I got my engineering degree because I knew I wanted to work in electronics, but I knew nothing about what an engineer actually did. Twenty five years later, I think I've found out! I've enjoyed it, and hope this article will help you figure out if you would, too.

**Engineers, Technicians, and Hobbyists.** There is no single answer to the question, "What do electrical engineers do?" We can, however, contrast an engineer's work to that of a technician or, for that matter, a hobbyist. Where a hobbyist might be happy to create a single circuit or device that works well on the bench, an engineer must produce designs that can be repeatedly reproduced. Component values generally cannot be "tweaked" but, instead, must be carefully calculated to work despite component tolerances, temperature extremes, line-voltage changes, and the like. The calculations and designs must be verified by multiple tests of both prototypes and production units.

Engineers generally do the bulk of the theoretical-design work and are held ultimately responsible for their designs. Technicians, on the other hand, often translate paper designs into reality through breadboarding, model building, programming, testing, troubleshooting, PC-board layouts, etc. The relationship between an engineer and his or her technician is much like that of a doctor and nurse, or architect and carpenter. The nurse or carpenter might perform much of the hands-on work, but the doctor or architect is responsible for the outcome.

**Engineers in Industry.** Just as a doctor might be a surgeon, a psychiatrist, a researcher, a teacher, or a general practitioner, an engineer might choose from among many specialties. You can get an idea of the variety of engineering jobs in industry by following a new product from the "raw-idea" stage to full production (see Fig. 1).

New product ideas, which spur engineering activity, often begin outside engineering. For example, a company's marketing department might see a competitive opportunity or need. Perhaps a salesmen might come up with some ideas, or customers might suggest or request new or modified products from him or her. Manufacturing innovations might be requested from the production department to improve a design and/or reduce costs. Of course, the engineering department might also come up with a hot idea or see a way to redesign products using new technology. No matter where a new idea starts, though, it usually winds up in an engineer's hands for initial evaluation. Defense or other contracts require highly technical proposals before a project is even begun.

Proposals involving new technology (or at least "new" to the company), or requiring fundamental technical investigation, might move first to a research department. Engineers and technicians involved in research seldom produce final designs. Their task is to

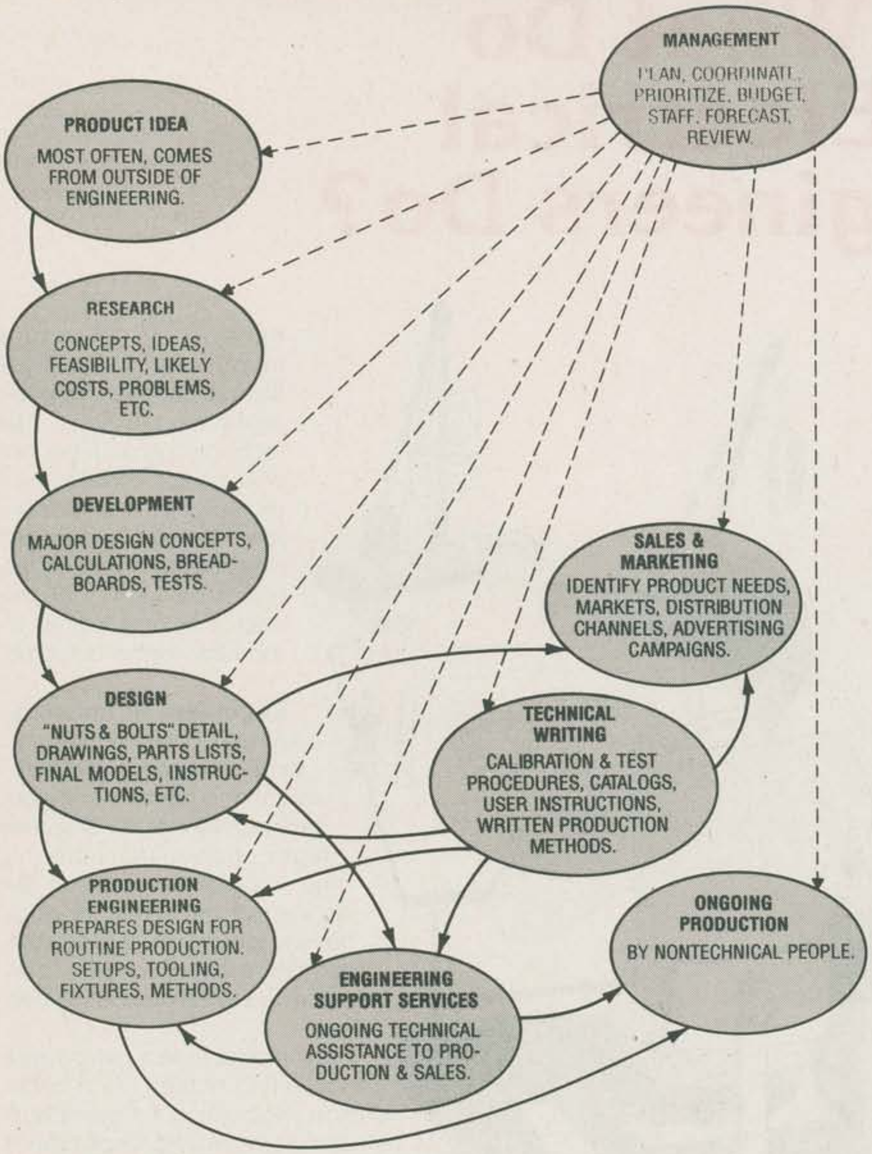



*Fig. 1. A product flows through many departments on its way from concept to manufacture and sale. All of these departments might require engineers and technical people.*

investigate concepts, feasibilities, costs, likely problems, etc. and to come up with further proposals and recommendations. Their work may include literature searches, laboratory investigations, breadboarding and testing, but their final "product" is usually a report.

For some, this is the "fun" part of engineering since it involves less of the nitty-gritty details. Others find it frustrating, because their ideas are turned over to other engineers who, of course, "improve" them! (Ever hear of the "not-invented-here" syndrome?) Incidentally, proving an idea to be unworkable is a perfectly successful outcome, and might save the company from wasting considerable time and money on unworkable, unprofitable, or otherwise unsalable designs.

If further development is recommended or if the idea does not need basic research, the project moves to development and then to design. The development group creates the major design concepts, details, and design calculations, and builds and tests prototypes. The design department creates the final "nuts-and-bolts" design down to the last electrical, mechanical, and housing detail. The end result is a fully tested and documented design, including all necessary board layouts, mechanical designs, parts and assembly drawings, models, tests, reports, and calibration procedures. The lines between development and design departments are blurred and, in some organizations, do not really exist.

You might think this would be the end of the project, but it's not. The design generally advances on two parallel paths into marketing and manufacturing. In manufacturing it goes to a department with a name like "production engineering," "manufacturing engineering," or "methods engineering." The engineers in this group are less apt to be circuit-design experts, but instead concentrate on production tools and methods.

Production engineers are in tune with the latest in assembly techniques (electrical and mechanical) and create tooling, fixtures, test equipment, etc., that fit the company's equipment and expertise. They also produce step-by-step procedures, diagrams, etc., that make it possible for nontechnical production workers to produce the product. They might also be involved with automation, robots, and the like. When they are finished, production is ready to build the product.

Sales, marketing, and technical-writing departments all require engineers if the product is technical in nature. Engineers are also needed for applications assistance, technical marketing campaigns, instruction manuals, and advertising.

Most companies have one or more engineering support services groups. Those departments assist production with technical problems and revise, upgrade, or redesign products. They might be involved in submittals to Underwriters Laboratories and other approval agencies, and with customer problems. The people who do best in these departments tend to be people-oriented, outgoing types who can juggle many balls at once.

Finally, of course, engineers can be found in management positions throughout most technological companies, from project leaders and supervisors, to top management.

**Technical Specialization.** By reading **Popular Electronics** you know that there are many technical specialties in electronics. No one can be expert in all of them. My own career has specialized in measurement instruments and control systems. You might be more interested in communications, while someone else might live and breathe computers. Audio, power generation, microwaves, satellites, and defense electronics are other possibilities. Figure 2 illustrates how complex systems can require engineering expertise running from computers and satellites to controls and power distribution. Even within these areas there are specialties.

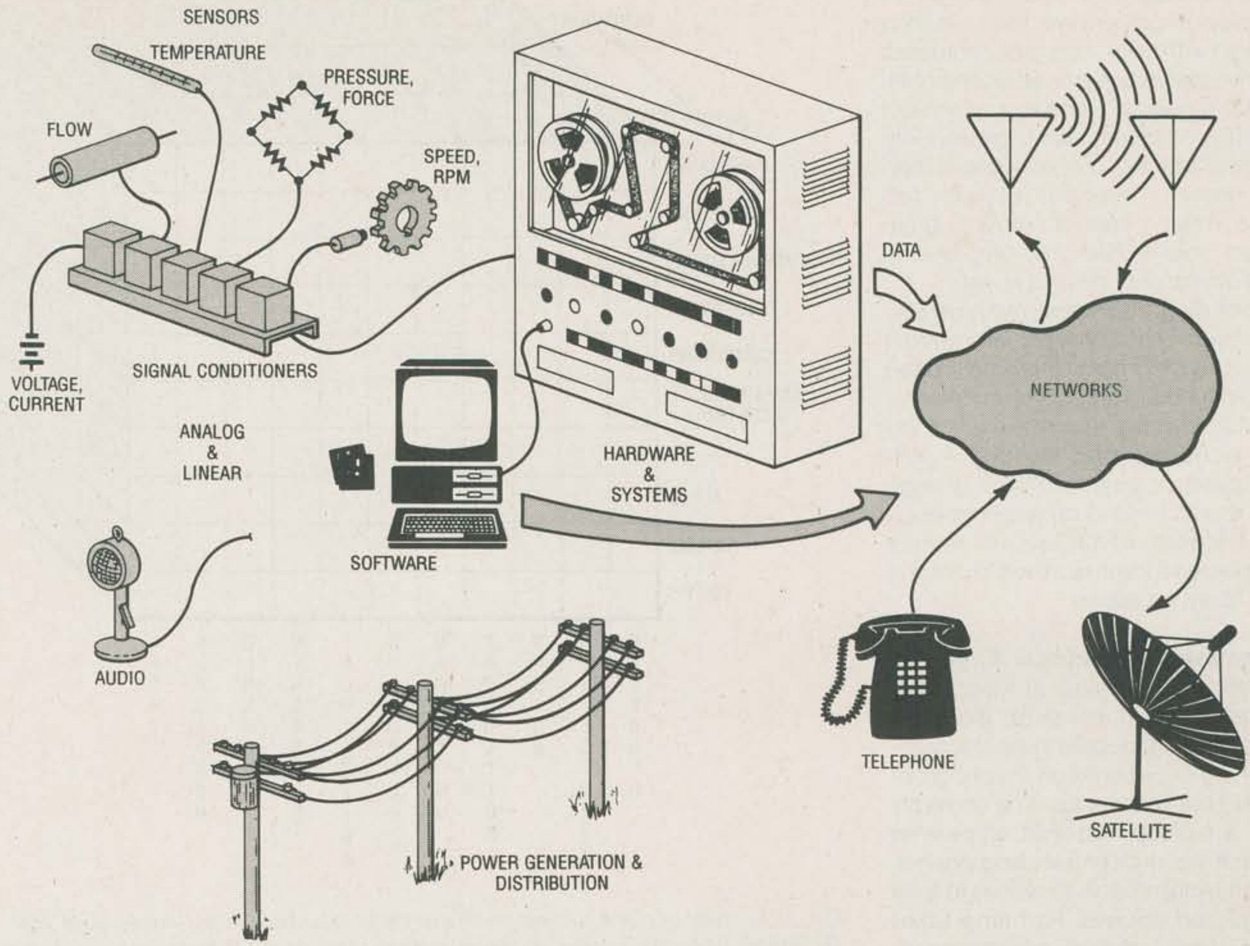



*Fig. 2. Electrical engineering runs the gamut from "glamour" areas such as computers and satellites to "bedrock" areas such as power and controls.*

Consider, for instance, computerized banking or airline-reservation systems. Integrated-circuit engineers design the necessary computer chips (some of which might be custom) that hardware engineers use to design circuitry. Systems engineers design, coordinate, and install the networks and computers that operate and communicate using programs designed by software engineers. All these people are "computer" engineers, but not one of them is an expert in all areas of computing. The project might be planned and managed under the direction of a generalist, someone whose knowledge is broad enough to understand what all the experts are doing but not deep enough to be able to specialize in any one area.

Other fields have sub-specialties as well. "Linear" designs run from measurement and controls to audio, RF, and microwaves, while "communications" includes circuitry, microwave and satellite antennas, networks, systems, and complex communications theory.

**Job Opportunities.** You might think of the opportunities in engineering as a large 3-D matrix (Fig. 3). Along the vertical axis are the technical specialties—power, analog, audio, computers, satellites, etc. Across the bottom we see areas of employment, from research and design to production engineering and the support areas. There are even related fields such as law and biomedical research (more on that in a minute).

Add to all of this a third dimension: specialist or generalist. As mentioned before, a true specialist is an expert in his or her area of technical concentration and is highly skilled in one or more related fields. Using the medical analogy again, a surgeon might specialize in heart, brain, or other surgery. Engineering specialists are most apt to be found in research and development.

As you'll recall, a generalist has broader knowledge, quite often including mechanical, chemical, or manufacturing engineering as well as electronics, but with less depth. A generalist is often a competent designer, but probably needs help for in-depth, complex state-of-the-art designs. Smaller companies generally cannot afford to hire a number of specialists and so hire mainly generalists, perhaps turning to outside consultants when specialized expertise is needed. In larger organizations, a generalist might direct, coordinate, or manage several specialists on large, complex projects.

So far we have looked at industry, but engineers serve in other areas as well. Many government positions are available, ranging from the military and NASA, to state and local positions. (State and local governments, however, are more apt to hire civil or environmental engineers than electrical.)

Furthermore, other areas include education, patent and technical law, research, and consultation. Although you generally need a Ph.D. (a doctorate) degree to become a full college professor, technical and trade schools offer other positions in education as well. (It should be noted that education generally pays engineers less than industry.) Lawyers with engineering backgrounds are needed in patent law, technical litigation (lawsuits involving technical claims), and other areas. Engineers with medical training are valuable in certain areas of medical research (artificial limbs, nerve stimulation, brain studies, sports medicine, etc.) and in medical-product development.

Consulting engineers might be self-employed or might work for contract and consulting firms. They most often work with industrial or governmental clients, but also serve as researchers, expert witnesses, and the like. A self-employed or senior consulting engineer should have a professional engineer's license, which requires several years experience in addition to passing state licensing exams.

**Becoming an Electrical Engineer.** First and most obvious, it takes a B.S. (Bachelor of Science) or B.E. (Bachelor of Engineering) degree in electrical engineering to become an electrical engineer. Four years of full-time university study is typically required, sometimes longer if the student is lacking pre-admission requirements or wishes to take specialized courses. Part-time takes much longer, but many companies offer tuition reimbursement plans to their employees and recognize scholastic progress at review time.

Most companies are firm in their requirements—you cannot be an engineer without a degree. Some will promote their best senior technicians to quasi-engineering positions with titles like "Designer" or "Engineering Associate." Smaller and less formal companies can be more flexible in their promotion policies.

I want to stress, from experience, that the degree might give you the title, but it alone does not make you an engineer. (You can't become a surgeon, or even learn to drive a car, without hands-on experience!) What the degree mostly does is give you the basics (lots of theory, math, and the like) and teaches you to think analytically. Speaking personally, I was not a competent engineer when I started my first job even though I had been a hobbyist since junior high school. I became an engineer by working side-by-side with a first-rate senior engineer and by association with other engineers and technical people in the company.

I also want to stress, because it was

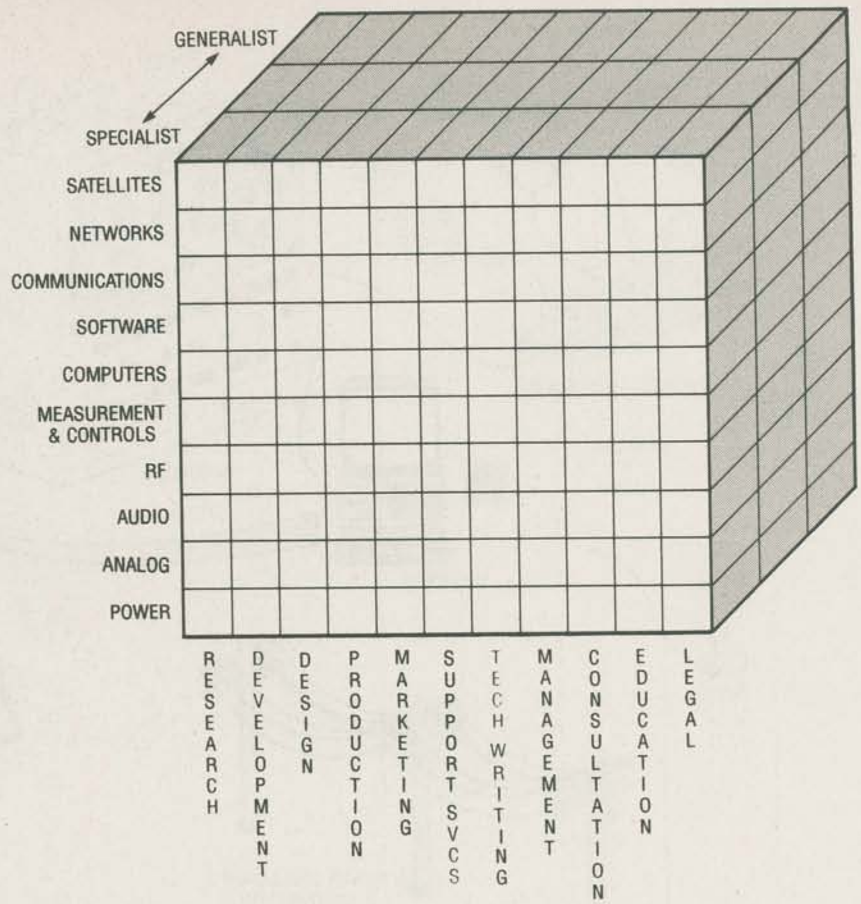



*Fig. 3. The field of electrical engineering might be visualized as a 3-dimensional grid. The generalist has knowledge of a broad portion of the grid, while the specialist has in-depth knowledge of a few areas.*

never taught to me during my education, that an engineer needs much more than a technical education. First and foremost, you need writing skills. Engineers are famous (or maybe infamous) for their lack of writing ability, sometimes lacking even basic grammar and spelling. You don't need to be an Art Buchwald or an Agatha Christie, but you do have to write proposals, reports, user instructions, and applications literature. You must be able to explain what you are doing (and why your employer should fund you) in non-technical terms. A person who can't spell or use proper grammar has a hard time being accepted as a professional.

No matter where you end up on the grid back in Fig. 3, you will need to do more than just design and build circuits. Projects need goals. An employer will not hire you to "do your own thing." He or she will need to know what you are doing and if it is worth his while to pay you to do it. You wouldn't hire an architect who couldn't tell you what he or she planned to build, how long it would take, or what the cost would be!

To progress very far you will need "people" skills. Whether you ever go into management or not, you almost certainly will end up supervising support people such as technicians and drafters. Most projects are team efforts, not one-man shows. Engineers must work cooperatively with production, marketing, and finance departments. Marketing needs to know what the end result of a project will be. The production department needs to know they will be able to build it at a competitive cost, and the finance group needs to know the end result will be profitable. The best designs in the world are no good if they cannot be produced and sold at a profit.

**What are the Rewards?** First, of course, income. Engineering is probably the best-paying profession available to a four-year college graduate. Starting salaries in industry generally parallel what a highly-experienced senior technician earns and rise 50% or more over the first several years.

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There is a flip side, though—pay scales tend to rise rapidly at first and then plateau after about ten years, unless you go into management. Also, there is the "engineering half-life." It has been said that half of what an engineer learns becomes obsolete in five years. I'm not sure I agree with the 5-year part, but it is a constant effort to keep up-to-date. As I look around the industry, I find that the majority of active design engineers are under forty. This does not mean that the rest of us have lost our jobs, but we have moved into management, sales, or other areas.

Will Rogers once said, "If you want to be successful, know what you are doing, love what you are doing, and believe in what you are doing." That is especially true in engineering. If someone you know is planning to go into engineering just for the money, tell them to forget it. They'll probably fail. The successful people I've known have been those who are in electronics because they love it. They're simply practicing their hobby! ■