divide his time between being a college professor and a business executive.

In conclusion, it is safe to predict that the subject of electronics will be even more important within the university of 2012 than it is today, that the importance of the leading professors in the field will be greatly enhanced, and that educational institutions with strong graduate programs in electronics will be regarded as great economic plumes because of this fact. The distribution of the strong graduate programs will determine the geographical distribution of growth in the ever expanding field of electronics.

Engineering Education—Circa 2012 A.D.

**W. L. Everitt** Fellow IRE

"For I dipt into the future far as human eye could see..."

Tennyson, Locksley Hall

Engineering will be acknowledged as the most learned profession by 2012 A.D. The explosion in the breadth of knowledge needed for its practice will have made preparation for an engineering career both rigorous and extensive. Full professional recognition will be available, except in unusual cases, only to those who have completed formal educational programs in residence at universities, equivalent to or exceeding our present doctorates. However, the time required by a student to reach this goal will vary widely, because educational methods will be adjusted to the capabilities of the individual.

**EDUCATION VS TRAINING** Engineering curricula in educational institutions will be recognized as having two important and distinct functions which must be carried on concurrently—"training" and "education." Training is defined here as the inculcation of methods of procedure, the development of adequate vocabularies and skill in communication, facility in locating information, expertness in computation and in manipulation of mathematical processes, and similar skills developed through the general procedure of explanation and demonstration, followed by typical exercises with definite solutions or measures of performance. Education, on the other hand, is defined as the broader development of the mind and personality—a guided enlargement of creative ability and understanding. Education develops the ability to meet new situations with confidence and with a degree of wisdom limited only by the inherent capabilities of the individual.

**TRAINING METHODS** The training portion of engineering curricula will make extensive use of teaching aids, such as teaching machines. However, the teaching machines of the twenty-first century will have a sophistication far beyond that now envisioned. They will serve as tutors which are very responsive to individual needs, so that each student can acquire training at the most rapid rate which he is able, or willing, to absorb. Such teaching machines will present lectures from recorded television tapes in short sequences, with feedback from the student, who will be required to respond with answers to appropriate questions or by working out the solution of illustrative problems. Depending upon the adequacy and insight of these answers, the lecture procedure will be modified to meet the needs of the student. The entire operation will be under the control of computer techniques for the storage and interpretation of information. Testing and examinations of the results of training will also be done by machine.

Every student and practicing engineer will have access to adequate computers and information storage. Moderate capacity computers will be miniaturized and reduced in cost, so that each individual will have his own, as he now has his slide rule. As his needs arise he will also have ready access, through wire or radio communication channels, to computers and memory systems of any required complexity. Training of all engineers in the use of computers will be extensive.

**LIBRARIES AND PUBLICATIONS** Perhaps the most dramatic changes will come in the "library" of the twenty-first century. The information explosion of the twentieth century will have made necessary the development of entirely new means for the storage and retrieval
of the material in what we now refer to as "publications." Such publications will be stored in "memories" and elaborate and largely automatic means of classification and identification will make the search for a particular item of information rapid and certain, and its display available at any location. Instruction in how to give directions to the information storage systems to acquire the desired information will be an important and not consequential portion of the "training" of the engineer. On the other hand, visual reading of books, current literature, and video displays will be so important that training for rapid reading rates of one thousand or more words per minute will be universal in the grade schools.

EDUCATION But, as in the twentieth century, the important part of the preparation of the engineer will be his "education." Here the personal contact between student and teacher will still be paramount. The comment of Booker T. Washington will be as valid as ever, "I am convinced that there is no education one can get from books and costly apparatus that is equal to that which can be gotten from contact with great men and women."

Relieved of the necessity of spending most of their time on the training function, devoted teachers will be able to concentrate their efforts on "education." Personal contact with students will be increased, because our society will recognize the importance of this relationship and support it. In spite of the use of teaching aids, the student/teacher ratio will not be increased. Instead, such aids will make it possible for faculty members to devote more time to the development of the individual student. The more efficient methods used will increase the amount of education per student rather than the output in degrees per teacher. However, the student himself will be expected to assume more responsibility for his own educational development than was common in the first half of the twentieth century.

CREATIVITY AND SYNTHESIS Since much of the instruction in analysis can be programmed on teaching machines, the engineer of the future will be given more education for creativity and synthesis. The case or project method will be emphasized and laboratory work will require originality and the ability to relate theory to the physical world in arrangements novel to the experimenter. "Cook book" experiments will be a thing of the past. Early participation in research projects will be the rule rather than the exception. Many advanced group laboratory experiments will be interdisciplinary in character, so that individuals with different backgrounds may contribute to team solutions of problems more complex than those possible for a single individual. The guidance of such a program will call for teaching ability and insight of the highest order.

Continuing education throughout a career will be normal, accomplished to a large extent by regular sabbatical year exchanges. During such exchanges, industry and government engineers will either return to universities for further study or will exchange positions with colleagues in other organizations. Engineers on faculties will participate, through similar exchanges, in industrial research, government service, or programs of other universities.

FACULTY RESEARCH The primary responsibility of the faculty in engineering education will be to develop creativity in their students, so they must themselves be creative. Noncreativity on the part of a faculty member will be recognized at an early stage and such individuals will be diverted to nonteaching activities within or outside the university. The creative programs of the faculty will provide means for the integration of students at all levels into progressively increasing responsibility in engineering teams.

ENGINEERING CURRICULA The trends in engineering curricula which began in the twentieth century will continue. The early part of all curricula will have more in common, emphasizing basic science, mathematics, and fundamental principles of analysis and synthesis common to all engineering. Only after a student has demonstrated the thorough understanding of mathematical, scientific and economic fundamentals necessary for creativity at twenty-first century levels will he be permitted to continue toward his professional goal as an engineer. The essential unity of engineering as a profession will be recognized. But his advanced program will require that he develop an insight into the methods of solving hard problems. As the student progresses, he will study some individual area more intensively, although the divisions in engineering will not be those now common. By pursuing certain areas in depth, he will learn to solve and contribute to team solutions of difficult and complex problems. Hence, he will need to choose an area of emphasis such as the "Processing of Information," the "Processing of Energy," the "Processing of Materials," or "Biophysical Engineering." Sufficient common material in all these areas and in the principles of "System Synthesis" and "Human Engineering" will provide for communication between the members of engineering groups, but too much breadth of subject matter will not be obtained at the expense of shallowness.

The importance of emphasis on the humanities and social sciences will be recognized from the grade school on through the highest levels of engineering education, as society relies more and more on engineers for leadership in business and affairs of state. Intensive efforts made to develop interpretive programs in these areas will also stimulate more engineers to pursue programs of self education in these fields throughout their careers.

With the continued growth of engineering applications, instruction in manufacturing processes and specific technological areas and skills will be recognized as a training function which industry must assume entirely.

CONCLUSION If these predictions do come to pass, and I feel sure they will, engineering will deserve its designation as a "learned profession."