There have been thirteen meetings of the Junior Academy, including the November, 1954, meeting, which was held at George Peabody College in Nashville. Reports of these meetings have appeared each year in the Journal of the Tennessee Academy of Science. Since its inception, the Junior Academy has been affiliated with Science Clubs of America.

An examination of records of programs and exhibits indicates a multiplicity of science interests among Junior Academy members. On occasion students have presented their collections of insects, flowers, shells, minerals, reptiles, mosses and ferns. Some have shown apparatus constructed in their own laboratories and have used various devices to perform experiments in light beam transmission, photography, and radio communication. Other students have brought and displayed living plants and animals, including an ant colony, trap-door spiders, hybrid fruit flies, and reptiles, both in cages and jars. At each of the meetings students have availed themselves of the opportunity to meet other boys and girls who share common interests and the desire to communicate ideas concerning scientific work.

Under present regulations any secondary school student may attend the annual meeting of the Junior Academy of Science, and any student sponsored by a teacher or other adult may appear on the program. At any given meeting the boy and the girl judged by a committee to have made the best contribution to the program are given, each, one of the two awards of the American Association for the Advancement of Science—an honorary membership for one year and a subscription to Science News Letter or to the Scientific Monthly. Each also receives for one year the Journal of the Tennessee Academy of Science. To those receiving Honorable Mention there are small prizes.

From the outset the efforts of the sponsors and the efforts of the many teachers who have worked with them have been directed toward achieving the aims of the Junior Academy as outlined previously. As a result, the membership and activities of the Junior Academy have had a healthy growth throughout the period of development. Sincere tribute is due Dr. Frances Bottum for the inspirational leadership and encouragement which she has provided for both teachers and students.

AUTOMATION AND THE SCIENCE TEACHER

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From this title the high school teacher may perhaps derive visions of "automatic laboratories," of "robot report readers," or of "automatic grade computers." Legitimate though such aspirations may be, they are not the concern of this article. The purpose here is to direct attention to the rapidly growing field of technology associated with concepts of automation, instrumentation, and cybernetics. Science instructors in secondary schools may look to this field for means of stimulating student interest, for new ideas on laboratory or demonstration work, and for information on an ever-widening career opportunity for technically-inclined students.

The Meaning of Automation – An essential feature of our mass-production technology has always been the precise control of the manufacturing process. In the past this has been achieved largely by employment of skilled, trained labor. Each workman, carrying out his own relatively small part of the total production process, exerted direct personal control over his own task. His efforts and those of other workmen were coordinated partly by the individuals themselves, based on their training, and partly by foremen or other overseers. Thus the typical factory of the past has been a group of many workers, each one working with a small machine or a small number of tools, with inter-worker relationship and communication cementing the small, separate efforts into a productive joint enterprise.

But there is another way to build a factory—a way that is now being followed more and more. This is to build the entire factory as *one* giant machine. Instead of many workers doing small separate jobs, one now has many parts of the machine; instead of relationship and communication between workers, relationship and communication between machine elements. It is clear that in order to design and build such an automatic factory, one would need to know at least some of the answers to two questions: First, how can one make machine elements capable of doing precisely controlled work? And second, what is is to be understood by "communication" between such elements?

But these same two questions are quite pertinent in relation to human beings. How is it that we human beings (or, more generally, any animals) can make precisely controlled actions. How do we communicate with each other? For that matter, how do we communicate within ourselves? (How are nerve signals transmitted and rendered effective?) These questions are at the heart of the domain recently (1948) labeled "cybernetics," the science of control and communication in the animal and in the machine.

Instrumentation is another term more or less synonymous with automation. The classic description of instrumentation is is "the art and science of measurement and control." It is interesting to compare the instrumentation wordpair (measurement and control), with that of cybernetics (communication and control). The emphasis on measurement has been characteristic of the so-called "process" industries, of which an oil refinery would be a typical example. Historically, such plants were first equipped with indicating instruments, by which the human operators were guided in taking suitable controlling actions; later, the instruments were augmented to include automatic recording on paper charts; and finally the instrument concept was further extended to include the means for automatically taking required control actions. Today a highly-instrumented process plant is essentially a push-button factory—the human operator has very little to do.

An Example: House Heating Control—Ordinary thermostatic control of room temperature in a modern dwelling furnishes an example which not only illustrates basic aspects of cybernetic science but also suggests some ways of introducing this subject into regular science classes, particularly of physics and of general science.

All automatic control systems are constructed in a typical feedback pattern, a closed circular chain of cause and effect, in which large actions result from small causes, and in which the small causes derive from the results of the large actions. In house temperature control, the small cause is the action of the wall thermostat and the large resulting action is the heating up of the furnace. This large action in turn results in heating up the house and changing its temperature, from which is derived the action of the thermostat.

The basic components of the control pattern in this example are related as shown in Fig. 1. The typical closed loop is made evident by the arrowhead on the lines: control unit to heating plant to house space to thermometer and back again to control unit. In addition it is important to note the connections of this system to the "outside," indicated by single-ended lines. The one labeled "disturbance" signifies all the reasons why house temperature might change (opening of doors, loss of heat through walls, etc.) and why a control system is therefore needed. Fuel input to heating plant is what makes possible the big result from the small cause. Setting of desired temperature is obviously something put into the control unit by the householder. The temperature of the house space is also shown open-ended, since it may effect other things (the human occupants of the house, for instance) than just the thermometer. In addition, though not indicated in Fig. 1, there is the electricity going into the control unit to operate its relays and motors.

Applied more specifically to an oil-burner with forced circulation hot water, a detailed picture would have to include the relations between burner operation and water circulation, as well as safety features guarding against explosion or overheating. A science laboratory project might consist of simulating such a system in a small-scale "breadboard" model. This would involve exercise in such topics from heat as bimetal thermometer elements, heat capacity, and heat conduction; and from electricity, relays, switches, motors, high-voltage spark transformer and electrodes, and the advantage of 24-volt wiring over 110-volt for the control circuits. In addition, there would be exercise in the purely cybernetic concepts (feedback, communication, decision, etc.) which are completely missing from the usual science course, and which are highly suitable to the secondary school level.

Books, Magazines, and Other Aids — The interested high school teacher will find many publications bearing in one way or another on the fields of instrumentation, cybernetics, and automation. The problem is one of selecting and organizing material of high-school level.

The book which might be mentioned first is the history-making *Cybernetics*, by N. Wiener (John Wiley and Sons, New York, 1948). In reading this book, one need not pay undue attention to the mathematical portions or to misprints and errors, which, in the original edition at least, were numerous—the main body of text is accessible to all intelligent readers. The unique influence of this book—one of the few technical works approaching best-seller status — is due to its timeliness and breadth. Professor Wiener explores some sociological dimensions of automation in another book: *The Human Use of Human Beings* (by N. Wiener; Houghton, Mifflin and Co., Boston, 1950). Labor leaders are just now beginning to act on the implications of automation.

Most of the technical books in the field are at college level, but many of them contain ideas applicable on the secondary level. (An outstanding contribution would be made by production of a suitable high-school book covering this field; the present writer knows of none such.) Some college-level books which might be consulted for a sample of the technical aspects are: *Servomechanism Fundamentals*, by Lauer, Lesnick, and Matson, McGraw-Hill Book Company, New York, 1947; *Fundamentals of Automatic Control*, by G. H. Farrington, John Wiley and Sons, New York, 1951; *Response of Physical Systems*, by J. D. Trimmer, John Wiley and Sons, New York, 1950; *Principles of Automatic Controls*, by F. E. Nixon, Prentice-Hall, Inc., New York, 1954; *Information Theory and Its Engineering Applications;* by D. A. Bell, Sir Isaac Pitman and Sons, London, 1953; and *The Mathematical Theory of Communication*, by C. Shannon and W. Weaver, Univ. of Illinois Press, Urbana, Ill., 1949.

The special yearly issue of the monthly *Scientific American*, devoted to a single subject, was on automatic control in 1952 (issue of September, 1952). This collection of articles by outstanding experts gives an excellent general survey. The same magazine includes occasional articles on related topics, such as statistics (January, 1952), logic machines (March, 1952), quality control (March, 1953), psychology and the instrument panel (April, 1953), chemical analysis by infrared (October, 1953), probability (September, 1953), computers in business (January, 1954), linear programming (August, 1954), and game theory and decisions (February, 1955).

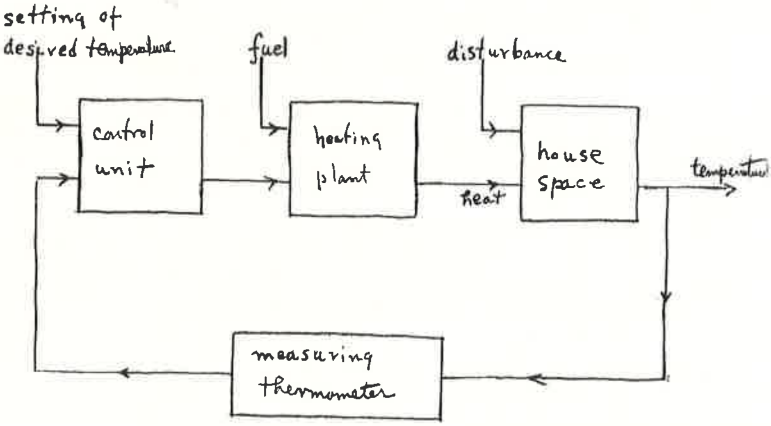

Fig. 1. Example of Automatic Feedback Control

The magazine *Control Engineering*, a monthly publication of the McGraw-Hill Company, is a good source of news and technical articles. It started with the September, 1954, issue. In the issues from November, 1954, to March, 1955, it carried a thoroughgoing series of bibliographic articles covering books and journals related to the broad field of automatic control. In contrast to this newcomer to the ranks, the monthly magazine *Instruments and Automation* (formerly *Instruments*), is a pioneering journal long calling for increased attention to this area. Now in its twenty-eighth volume, it is published by The Instruments Publishing Company, 845 Ridge Avenue, Pittsburgh 12, Penn. For some years, it included the publications of the Instrument Society of America, which is the one professional socity in this country devoted directly and exclusively to instrumentation. Recently the ISA decided to publish its own journal, the *ISA Journal*, now in its second year.

In addition to its Journal, the ISA has available other aids and services in instrumentation education. There is available a very good, hour-length film in color on the subject "Automatic Control." It can be shown by schools free of charge. Address: Instrument Society of America, 1319 Allegheny Avenue, Pittsburgh 33, Penn. The Society has an Education Committee (of which the present writer is a member) which would welcome suggestions from high school teachers on possible avenues of cooperation.