write information into a standard form to cope with the problem of alternate and redundant ways of expressing the same meaning. As an example, the terms "my father's brother" and "my uncle" refer to the same person. Using the demodulation procedure, the program would rewrite such information in a standard form, simplifying and consolidating the data.

Researchers also formulated *inference rules*, or small scale strategies, as ways the program can be instructed to reason. One such inference rule, called *paramodulation*, enables the program to understand equality; in particular, various properties of equality, such as transitivity (deducing that $a = c$, knowing that $a = b$ and $b = c$) need not be stated explicitly. The use of this inference rule permits a program to complete assignments in a few seconds that would otherwise require many minutes or hours. Other inference rules developed include *negative paramodulation* and *negative hyperparamodulation* which aid in coping with the problem of reasoning from inequalities, and *hyperparamodulation* which directs the program to avoid taking insignificant steps in reasoning through a problem.

Using these inference rules, strategies, and procedures, the Argonne researchers designed and implemented several very powerful automated theorem and automated reasoning programs. One such program, AURA (Automated Reasoning Assistant), developed in conjunction with Northern Illinois University, is considered the most powerful automated reasoning program to date. The program has been used to evaluate nuclear power plant systems designs to assist in proving that a sequence of potentially dangerous events will not result in the failure of the backup system. Another program, ITP (Interactive Theorem Process), can be used on different machines and is considered the most flexible and portable automated reasoning program available.

Over the past decade, these programs have been used to solve a number of practical problems faced by scientists and mathematicians in research and in industry. For example:

- General Motors Corporation has collaborated with Argonne scientists in applying automated reasoning techniques to the problem of sequencing cars with different options on the assembly line. The collaborative work resulted in the design of a system that permits the user to experiment with alternative methods for sequencing cars in the most efficient manner. The system combines total reliability with the flexibility to incorporate possible future improvements in assembly line functioning.

- Scientists at the Illinois Institute of Technology have used an automated reasoning program to verify the correctness of the design of a computer circuit used to add two 16-bit numbers together. The logical nature of the arguments supplied by such a program, coupled with the complete history justifying each conclusion, makes reliance on the assistance of a reasoning program most attractive for this application.

- Engineers at Hanford Engineering Development Laboratory have used the Argonne-developed software to select operation modes for the Fast Flux Text Facility (an experimental nuclear reactor).

- Draper Laboratories has collaborated with Argonne on applying automated reasoning techniques to the verification of fault-tolerance properties of the design of an instrument that will enable additional years of service to be obtained from the Department of Energy breeder reactor facility operated by Argonne in Idaho.

Automated reasoning has become one of the fastest growing and most significant branches of computer science. The number of applications for the techniques developed are multiplying daily in many different disciplines. Other countries are devoting substantial national resources to further the development of this field and to search for new applications. In Japan, for example, automated reasoning is the major thrust of the supercomputer development program. The Basic Energy Sciences-supported research at Argonne has contributed significantly to bring progress to its current state and, with continued effort and support, promises exciting new developments for the future.