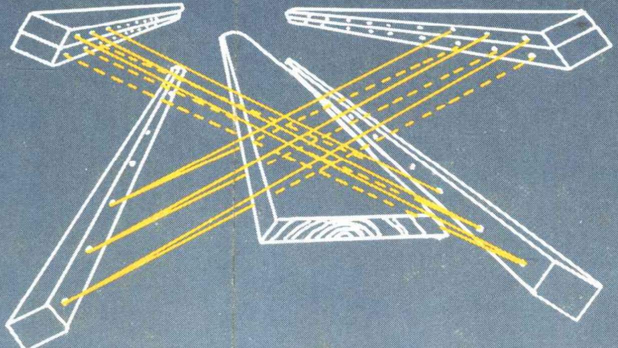
COMPUTER CONTROL SYSTEMS FOR LOG PROCESSING AND LUMBER MANUFACTURING



ED M. WILLISTON

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A FOREST INDUSTRIES BOOK

Library of Congress Catalog Card Number: 85-62602
International Standard Book Number: 0-87930-163-5

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Printed in the United States of America.

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Preface

During the past 20 years, the process needs of the worldwide lumber industry have radically changed. Raw material cost has increased tenfold or more. In addition, it has become necessary to sustain high throughput rates while maximizing the amount and value of lumber recovered from each individual log. Fortunately, coinciding with these new needs has been the emergence of new technology for gathering information and intelligence and for implementing decisions based on the resulting data.

This new lumber industry technology had its origins in the early 1960s. Richard Davis of Unico, Inc., took a small model of a DC electroservo unit with a digital readout to the USDA Forest Products Laboratory at Madison, Wisconsin. This unit had the capability of dividing a single rotation into 5,000 equal parts, and it utilized feedback to monitor its rotational position and correct torque error. Hiram Hallock at the laboratory suggested that this device had the makings of an ideal setworks. As Softwood Lumber Development Department Manager for Weyerhaeuser, I was among those who encouraged Davis to pursue the subject. Davis then went to Filer and Stowell Co., which utilized a version of the Unico device together with a ball screw drive for precision setting of carriage knees. Cascade Locks Lumber Co., Cascade Locks, Oregon, then Weyerhaeuser Company and others were among the early users. Mechanical and optical scanners, together with controlling calculators and computer programs that simulated the sawing process, were then utilized to control log, board and cant breakdown. Most if not all of the sawing process simulations were based on Hallock and Lewis's renowned Best Opening Face program, developed at the USDA Forest Products Laboratory. These developments ultimately revolutionized lumber manufacturing process control.

This book responds to the industry need for information on this general subject. Mills in western Canada and the Pacific Northwest are finding it difficult to compete with the mills of Asia, Europe, Indonesia, Australia and New Zealand for overseas and certain domestic markets. Billions of board feet of logs are being shipped overseas for conversion to lumber. In the Pacific Northwest, domestic stumpage and timberlands are being sold to foreign interests, for future harvesting and shipping overseas in log form. Mills in both the northwest and southeast USA are unable to compete with the Canadians, who in turn find the Scandinavians, Austrians, Soviets and others outselling them in Europe, the Levant and Arab nations. It seems likely that lumber will follow other smokestack industries out of North America unless the present trend can be reversed by utilizing state-of-the-art technology.

This book is intended for use by those who plan, design, operate and maintain lumber manufacturing facilities. It was written with the hope that it will contribute to the preservation of the industry, especially in North America where the need is greatest, but worldwide as well. Its use elsewhere will occur whether we like it or not. My first book on lumber manufacture, for instance, has been translated into Russian and Chinese. The technology described in this new text is being exported worldwide from Scandinavia. There are few secrets in this age of information. For this reason, we must stay abreast of the competition if we hope to survive as a large and thriving industry.

I first became aware of the application of computer control to machinery in the mid-1960s, during a visit to a marine machine shop in downtown Tacoma, Washington, a few hundred yards from the main office of Weyerhaeuser, by whom I was employed. There I saw four machine tools shaping large gears to precise dimensions directed solely by a computer receiving inputs from a punched tape. Since then I have traveled the world, including many visits to Scandinavia, seeking new technology. I have attended, conducted and sponsored seminars for Miller Freeman Publications, the University of Washington and my own consulting firm seeking and imparting information on the subject.

Industry manufacturers and suppliers here and abroad have cooperated wholeheartedly in making knowledge available. Especially valuable contributions have been made by North American Controls, Lumber Systems Inc., Totem Equipment Co., Opcon Inc., Tusk Digital Controls, Applied Theory Associates, Unico Inc., Albany International Industries, Saab Systems Inc., Pekka U. Repo of A. Ahlstrom OY, CAE Machinery Ltd., Norbert Ott of Linck GmbH, and Accuray Corp. James Talbot of US-USSR Marine Resources Company Inc. made it possible for me to visit the Soviet Union. Other official sources included the USDA Forest Products Laboratory at Madison, Wisconsin, the USDA Pacific Northwest Range and Experiment Station at Portland, Oregon, the Consulate General of Finland, the Finnish Trade Association and the Swedish Trade Office of Atlanta. I also thank Judith Brown and others at Miller Freeman Publications, Andrew L. Alden, who edited this text, and finally my wife, Janet, who contributed substantially to the subject matter.

Introduction

During and after World War I, large sawmills built on the west coast of North America were considered to be marvels of materials handling efficiency. Some of these mills produced as many as 36,000 pieces of finished lumber in a 420-minute shift while handling perhaps three times that many individual pieces of wood. While these mills were very efficient, they were not highly automated as we understand the term today. The purpose of mechanical handling was to reduce labor costs. Although this was accomplished, a large number of human judgments were still required. Consequently, while physical effort was dramatically reduced, mental effort was drastically increased. This development, plus continuing competition, created a need for technology to make measurements and collect the data required to direct actions and report on machine performance.

Metals manufacturing and pulp and paper production are similar industries that use automatic information-gathering devices to direct, observe and report on performance. This information is then utilized in conjunction with programable logic controllers, computers and similar hardware to control the process, in conformance with predetermined operating standards, to produce a specified product.

There are over 1,600 pulp and paper mills worldwide that use computerized process control systems. The resulting savings in wood fiber is 1 to 4%. In comparison, a completely computerized lumber mill can save 25% or more on raw material costs. Since raw material amounts to as much as 90% of the total cost of sales, the potential is enormous. Those who are unwilling or unable to adopt these improved methods of process control can hardly remain competitive for increasingly costly logs.

BASIC PROCESS CONTROL

Lumber manufacture is much like any other raw material conversion process. Raw material enters one end of the process and emerges from the other end in the form of one or more finished products. At the various unit operations within the mill (the merchandiser, headrig, edger and so forth), the operation is monitored and feedback provided to indicate whether or not performance standards are being met; if not, corrective action is taken.

The sawmiller has always been involved in process control. In the past, the individual machine operator controlled the process manually based on common sense, experience or instruction from others. Because speed has accelerated, full control has passed beyond the capability of unaided humans. Whereas the headrig of yesterday processed 200 large logs per shift, the mill of today may process several thousand small logs. In addition, raw material costs and other costs have increased severalfold. The twin pressures of higher speed and greater efficiency have necessitated a shift from manual to automatic control. The operator's job has changed from manual control to supervision of an automatic process control system. The skills that were formerly learned by experience must now be duplicated by automatic control equipment. As part of the new systems, sophisticated electronic devices have been introduced. These are able to take a large number of precise measurements over a short period of time, often without contacting the object measured. This change results in greater accuracy, lower cost and increased productivity. It also facilitates direct process control without human intervention, thus completing the feedback loop automatically.

THERE ARE MANY VARIABLES TO BE CONTROLLED

Wood is a highly variable raw material. For example, the density of wood can vary by 50% or more along the length of the tree stem and along the cross section from periphery to pith. In addition, there are dozens of machine variables, both dependent and independent. For instance, it is well known that the cutting ability of a saw decreases in use as it dulls. This in turn will increase power consumption, sawing variation and effective kerf width. It is less well known that superimposed on this deterioration (which is reversed by filing) there will be a longer term, less noticeable decay. Likewise, the University of California has demonstrated that very slight temperature gradients across the radius of a circular saw can cause great increases in sawing variation. These are only two examples of the many process and product variables that are involved in attempting to control the lumber manufacturing process. With the capabilities brought about by modern process control equipment, even subtle effects can be measured and taken into account.

AREAS OF EMPHASIS

Primary emphasis in this book is placed on maintaining a materials balance: the finished product produced as compared to the raw material processed. Where metric units are used, the cubic volume of lumber, chips or fuel produced is divided by the cubic volume of logs brought into the plant, expressing the result as a percent. Thus, if 50 cubic meters of lumber, 30 cubic meters of chips and 20 cubic meters of fuel are produced from 100 cubic meters of rough wood, then the relative percentages are 50, 30 and 20. Where American Lumber Standard (ALS) units are used, lumber recovery is expressed in terms of board feet of lumber divided by cubic feet of rough wood into the mill. Chips and hog fuel are expressed in terms of units of various sizes per cubic feet or board feet log scale into the mill. Needless to say, the metric system is much more accurate and meaningful. Piece count standards are provided for various unit operations, where appropriate, for purposes of comparison. Productivity is expressed in terms of volume produced divided by man-hours used.

READER AIDS

Detailed performance standard tables, a glossary, a speed conversion table, a sample size table and checklists of quality control duties are provided in the text and appendixes for ready reference.

Computers are no longer the blank, inscrutable machines they once were. Furthermore, even an untutored reader probably knows more about them than he or she thinks. Still, some readers may desire a primer. Although there are hundreds of texts, magazines and the like available in bookstores and computer outlets, many of them are poorly written or too complicated for those without some familiarity with the subject. Many are both; many others are neither. Consequently, I am unable to make a firm recommendation.

For those who want to become familiar with the lumber manufacturing process, there are only two texts written in the English language. They are my *Lumber Manufacturing: The Design and Operation of Sawmills and Planermills* and my *Small Log Sawmills: Profitable Product Selection, Process Design and Operation,* both published by Miller Freeman Publications. *Der Rundholz Platz* (DRW-Verlag Weinbrenner-KG) by Carl Fronius, a well-known European authority, is available in German. Obviously, there is a woeful lack of textbooks in this field.

It should be noted that the lumber manufacturing process has changed rapidly in the last 20 years largely as a result of rising raw material costs and decreasing log diameters. Technology has been developed that will reduce manufacturing costs in light of these changes, but it has not been widely adopted in many producing regions. New basic advances in the technology are unlikely in the next decade or two.

There seems always to be a fear of this year's computer being obsolete next year. Although we can expect that new computer hardware and software will continue to evolve at a rapid rate, the changes are expected to involve greatly increased memory capacity and operating speed, higher-level, more easily understood languages, and greater user friendliness. Present-day systems will continue to be useful for many years to come in the light of these anticipated changes.

FUNDAMENTALS SUMMARIZED

In summary, modern process control consists of a series of instrumented, automated subsystems that periodically or continuously control and measure the raw material and the process machine variables through the various stages of manufacture. Product and process measurements can be reported in readout form for comparison with predetermined standards of performance so that corrective action can be taken if required. Alternatively, readings can be compared directly to standards and corrective action taken automatically via a feedback loop. The elements used for modern process control consist of various devices for gathering, reporting and processing information, comparing this information against performance standards and controlling various operations to ensure compliance with the standards.

Since wood is a highly variable raw material processed through a series of relatively complex machine centers, there are a great many variables that must be monitored and controlled. The more important variables include:

- Actual vs. target size
- Fiber usage per sawline
- Conversion efficiency in terms of volume in vs. volume out
- Productivity (volume produced per man hour expended)

As a consequence, these have been emphasized in the development of process control systems, and they receive the most attention in this book.

This book is designed to provide the author's opinion on the subject matter covered, based on data available to him at the time of publication. To the best of the author's knowledge, the information contained in this book is reliable and complete, but no warranty is made in this regard. All expressions of opinion are subject to change without notice. Because trees are infinitely variable organic products and are subjected to an exceptionally large number of controlled and uncontrolled processing variables during manufacture, the author and publisher expressly disclaim any liability for any risk, loss or damage incurred as a consequence of the use and application, either directly or indirectly, of any advice or information presented herein.

PART ONE:
Process Control Equipment

Control systems consist of hardware and software. *Hardware* is made up of input devices for gathering and inputting information, data processing and controlling devices such as microprocessors or minicomputers, and output devices such as printers, digital displays and a variety of peripherals for communicating with or manipulating the control system.

A second class of hardware includes data input and mass storage peripherals such as paper tape punch readers, magnetic cassette tape and magnetic disks. Both punched tape and cassette tapes are slow to read and access and lack durability; consequently, the trend has been to plastic disks coated with magnetic oxide. The present-day 5.5-inch (14 cm) double-sided double-density disk can hold 360,000 characters and can be accessed rapidly at any chosen location.

Process control circuit boards serve as a communication interface between the computer and the process hardware being controlled, such as setworks.

Software is the category that includes programs consisting of instructions to the computer in language that the computer can understand. There are different languages and even dialects of these languages to complicate things further. So-called higher level languages are more like English and more readily understood. The documentation necessary for troubleshooting, debugging or reprograming is also software.

The basic principle behind process control is *the feedback loop*. This refers to a method by which deviation from a desired result triggers a mechanism that brings the system back to the desired result.

Computers are explained in detail in Chapter 1, including their relationship to software. Programable logic controllers (PLCs) are also described since these are supplementing or replacing computers in many applications. Input devices such as operator interfaces and similar peripherals are included here. The comparative advantages and disadvantages of PLCs and computers are discussed in detail, and typical applications are described. The subject of single control computers as compared to individual machine process controllers and minicomputers is covered in some detail since "distributed intelligence" is an important trend.

Software is explained in depth in Chapter 2, including the more important languages in common use. Types of software programs and their uses are discussed. The procedures for buying or developing software are described.

Chapter 3 defines various applications for computers in process control, including data collection, sequence control, supervisory process control and direct digital control. Also covered is the process of designing the right system, as well as staffing it.

Basic input and output devices such as photoelectric controls, cameras, lasers, rotary and linear encoders, speed measuring systems, input converters, DC servo drive subsystems, roller screws and ball screws, as well as servo positioners and valves have gradually replaced many manual operations. They are described in some detail in Chapters 4 and 5. The actual deployment of these devices in the mill is the subject of Part 2.

Moisture and grade measurement devices are described in Chapter 6. Technology developed in Scandinavia can automatically visually grade lumber at very high speeds, moving process control technology over the last frontier—the grader's eye.

• 1 •
Computers

The lumber industry first used computers for business operations. These included such things as ordinary accounting, inventory tracking, payrolls, order and invoice processing, and so on. Next, the computer was adopted by engineering and technical personnel for complex computations, mathematical modeling, simulation and similar applications. Finally, computers were adapted to process monitoring and control. There are three primary ways in which the process computer is used in wood products manufacturing operations. These are:

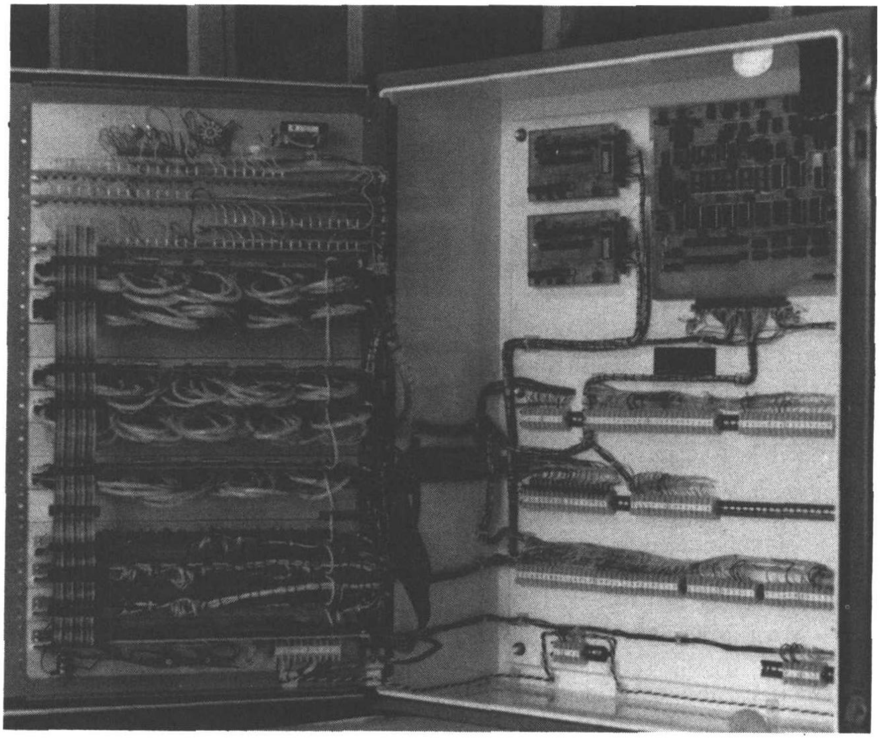
- Collecting and reporting data; for example, log diameters, lengths and volume over time, as in a shift report.
- Monitoring and controlling a process with a human operator pulling the levers.
- Monitoring and controlling a process without operator intervention.

The first two require an operator to close the control loop; consequently, they may be thought of as open-loop control. The third is a true closed-loop control operation.

HOW THE COMPUTER WORKS

The computer is a problem-solving tool just as the slide rule, the abacus, the adding machine or the household calculator are. In the case of the computer, its workings consist of many thousands of microscopic two-way electronic switches printed on a tiny silicon chip—the *Microchip.* A large professional desktop computer might have about 1 million electronic switches; by comparison, the human brain has 10 billion nerve cells. Consequently, at this stage at least, the computer in no way compares to the human brain. Furthermore, it can do nothing that it is not told to do. The computer requires that an electrical charge be routed through the electronic switches, which serve as gates that are either open or closed, just like a knife switch. In this manner, a two-digit or binary system of mathematics can be used to solve problems. The digits are represented on microchips by open or closed gates called *bits*, for "binary digits."

In an eight-bit computer (as many small computers are today), the binary digits are organized in groups of eight. The group is called a *byte.* Each byte has eight gates, which by manipulating the pattern of open and closed gates can be used to represent a number or letter. A series of configured bytes, in turn, can be used to represent a word or a number with several digits.



Electronics are an important part of the modern sawmill complex—open panel view.

The computer operator commands the machine through a keyboard by using words or phrases. Within the machine, the letters or numbers contained in the command must be translated into binary digits by means of a special permanent program called an *interpreter* or *compiler*. Each machine brand or model is tailored to use certain interpreters or compilers that handle only specific computer languages. The function of the interpreter is to translate each command and pass it on to the microchip, also called the *microprocessor* or central processing unit (CPU).

An interpreter comes either as a software program, usually on a floppy disk, or as *firmware*, a small circuit board that plugs into a slot on the machine's main circuit board. When the machine is turned on, the interpreter is automatically loaded into memory and the machine is ready to go to work.

Work is accomplished by the operator typing instructions on a keyboard, or by feeding instructions to the CPU from a tape cassette or disk. To use a prerecorded program, two things are needed: a *controller board* to join the computer to the disk drive or other storage device, and a software *operating system*, a program that enables the CPU to handle additional software.

Where a number of microchips or microprocessors are utilized, they may be fastened to a common platform called a *mother board*. This board is also re-