The theme of my presentation is the selection of kiln schedules and the means by which the kiln can be controlled. I wish to review briefly where we are today or where we were until very recently in this area, and in so doing try to identify some of the areas where we are deficient. Additionally, I will describe in various degrees of detail, some of the new developments in kiln control technology that have come forward in recent years.

First, let us assume that in your mill you have a new kiln operator, and you provide him with a reference text dealing with kiln drying. Very quickly he will come to a section that will deal with schedules. The schedule will likely tell him what conditions of dry bulb and wet bulb to use for a particular species and for a particular size of lumber and for how long to leave that lumber in the kiln. It makes no reference to the condition of the wood, by which I mean specifically, the moisture content of the wood. It makes no reference to the size or shape of the kiln or to the shape or size of the load in relation to the kiln. Likewise, it makes no reference to the air flow or sticker size. It tells him only temperature and times. And until very recently he would typically operate the kiln using a vapor-filled, pneumatically activated controller. This type of controller is very slow to respond in that while you may appear to have a good control of the kiln by virtue of straight line on the recorder chart, a more sensitive measuring instrument would indicate temperatures were up to 15 degrees on either side of that line.

Rigid time-based schedules are adequate provided that the lumber going into the kiln is essentially the same charge after charge. Particularly with respect to the SPF group however, we find varying proportions of the three species. Additionally, we have mixtures of sapwood and heartwood with varying levels of moisture content and ease of drying. We have mixtures of green lumber with air-dried lumber, and now mixtures of green lumber with bug-killed and fire-killed lumber. These are good reasons not to use a very rigid time based schedule. We therefore need a drying system that takes account of the state of the wood in the kiln, and it must be sensitive to the properties of the wood. Several attempts have been made to do this. The majority of them are computer-assisted or controlled and these are what are now described.

Of the eight samples I will describe, some are widely used, while of others, there may be only one or two examples. Gann, Hildebrand, Lignomat, and Bollmann are German, or originally German, Utec is Swedish, the Potlatch and Union Camp Companies in the U. S. have developed their own systems, and finally, there is the B. C. product, the Frank Controller. The German systems are essentially similar, using the same basic principles. Basically, they use an extension of what you recognize as a
resistance-type moisture meter. Probes are inserted in a selected number of boards in the kiln and an attempt is made to measure the moisture content of that wood by a moisture meter in the kiln control room. That data is input that can be used in a computer-assisted system.

One other pair of sensors is used to measure the EMC or the moisture content of a wafer of wood, or a wafer of cellulose which reacts very rapidly to changes in the kiln and gives a very good measure of the EMC.

The computer or microprocessor is normally set to run to a prescribed schedule, which instead of being given in terms of dry bulb temperature and wet bulb temperature, actually works on the basis of the ratio between the measured EMC of the wafer of wood and the measured average moisture content of those boards in the kiln that have the electrodes in them.

There are some limitations to this system however. One is that a resistance type moisture meter is accurate only at the fibre saturation point (25 to 30 percent MC) or less. Close control of the kiln is therefore only obtainable in the latter stages of drying when the wood is down to about 25 percent or less. Secondly, the very presence of electrodes in the boards can itself be a problem due to an additional contact resistance set up in the wood. Thirdly, care is required in the selection of boards from a charge that will be representative of the total charge.

The Union Camp Co. system was developed at one of its mills which was faced with a problem of warp due to overdrying of lumber. It was recognized that in order to control the degree of warp in the loads, far tighter control of the kiln was necessary. The kiln they developed is capable of controlling the temperatures in 12 different zones along the length of the kiln and up the height of the kiln. Based on a supposition that if they could control the rate of drying throughout all 12 zones to be the same, then moisture content of all the lumber at the end of drying would be the same. Moisture content is inferred by assuming that the rate of drying is related to the temperature drop across the kiln. That is, by measuring the dry bulb temperature on one side of the load at one point and then the exact opposite side, the temperature difference was an indication of how fast the wood in that zone was drying. Thus this kiln, via a computer, is controlled for drying at essentially similar rates throughout the total load.

A computer kiln control system developed at Potlatch Corporation was described at last year's annual meeting and details are available in the Proceedings (1).

The Swedish Utec system, of which we are now seeing one or two in B. C., is a rather interesting one. First, the kiln operator answers a set of questions posed to him by the computer with regard to the state of the wood going into the kiln. The computer asks, for example, for the species, the size, the volume of wood in the kiln, whether it has had any air drying, whether there is to be a conditioning period at the end of the schedule, and what the final moisture content is to be. After getting all that information, the meter selects one of a number of pre-programmed schedules which it thinks best suits that wood and the way it is to be dried. During drying it measures the air temperatures on both sides of the load and the humidity throughout the kiln, and
by application of a number of mathematical equations, it carefully controls the operation of the kiln to follow the schedule that has been set.

Over 30 computer-based kiln control systems have been installed in British Columbia by Frank Controls Ltd., a division of Q.M. Industries Ltd. of Prince George. This system carefully computes relative humidity of air entering and leaving a load, and is programmed to maintain these within limits by controlling venting intervals and venting times. The objective is to maximize capillary moisture movement to the wood surface and to maintain this condition by avoiding the use of too low a relative humidity or too high a dry bulb temperature in the kiln. Concurrently, moisture contents are inferred from temperature drop across the load. Approximated moisture contents are used to define fan reversal times and also to activate kiln shut-down.

Of course, it is necessary that a kiln be in good running order before success can be expected with sophisticated controllers in terms of reduced drying times and improved quality. By way of illustration, I will briefly describe a service to industry provided by Forintek that we call kiln evaluations. We send a team of people to mills that request this service and we very thoroughly instrument the kiln to measure air flow on both sides of the load, along the whole length and up the side of the loads at over a hundred locations. Throughout the whole drying period, dry bulb temperatures are measured on both sides of the load at regular intervals along the length of the kiln. We examine accuracy of kiln control instruments, and we measure the moisture content of dried lumber selected from locations where problems are found to exist. Our report to the mill includes recommendations for any changes or repairs that are required.

Two examples of problem areas that we have found show that no matter how good a computer-based system may be, if the kiln itself is not in good shape there is little chance of success in drying. First, one kiln had air flows from 60 feet per minute to 850 feet per minute. We found this to be not uncommon, particularly in line shaft kilns. So, clearly some upgrading was required. In another kiln where we were measuring dry bulb temperatures, there was a 50-degree spread end to end. So, again, any control system that was operating, perhaps by measuring the temperatures just at one spot along the length of the kiln, would have little chance of success.

**Literature Cited**