United States
Department of
Agriculture

Forest Service

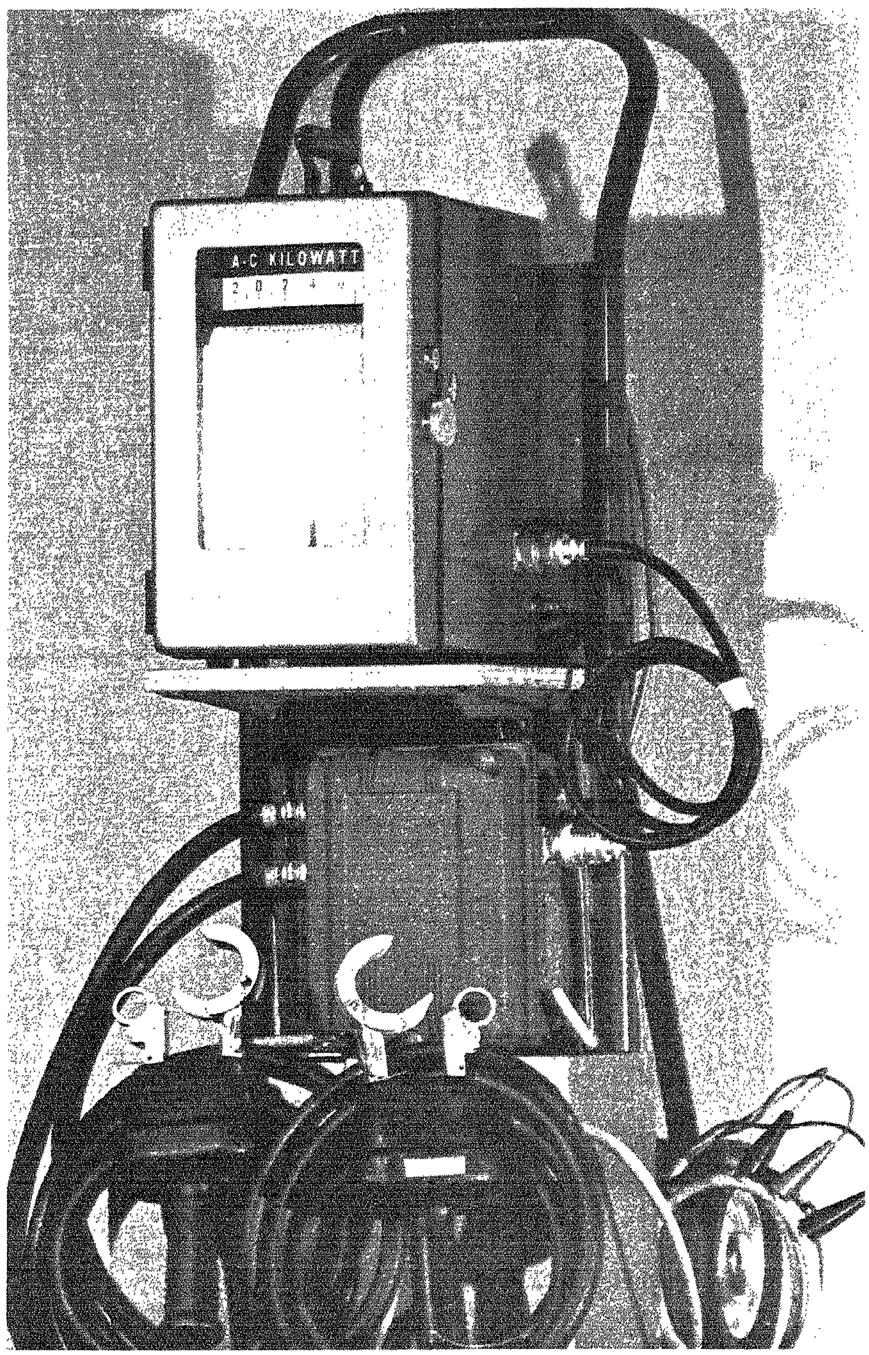
**Northeastern Forest
Experiment Station**

General Technical
Report NE-71

1982

Using a Recording Watt/Varmeter to Measure Power Consumption of Sawmill Equipment

Edward L. Adams



The Author

Edward L. Adams is a research forester with the Northeastern Forest Experiment Station's Forestry Sciences Laboratory at Princeton, West Virginia. He received a B.S. degree in forest management and an M.S. degree in forest mensuration at West Virginia University. He worked for the USDA Forest Service in Oregon from 1960 to 1963 and joined the Northeastern Station in 1968.

Manuscript received for publication 13 April 1981.

Abstract

A recording meter system for measuring both watts and vars on sawmill systems and components is described. Sections are presented on (1) equipment needed for the system, (2) using the system, (3) testing the system, and (4) possible uses of the output. The system is easy to use and provides output satisfactory for a wide range of applications.

With the increasing cost of electricity, managers are becoming more concerned about the power requirements for different types of sawmill equipment and for sawmills in general. This concern has resulted in the search for answers to a number of questions. For example, does a gang resaw require more power to produce 1 Mbf (1,000 board feet) of lumber than a line-bar resaw? If it is estimated that a machine will be down for a half hour, can money be saved by shutting down the other machines? If a mill is built to a specific design, what will be the estimated power requirements? Will capacitors reduce the electric bill enough to pay for installing them at the mill site?

The total load (kilovolt-amperes) of an electrical circuit can be divided into two components: one is kilowatts and the other is kilovolt amperes reactive (kilovars). A watt/varmeter that measures both of these components can provide the information needed to answer the above questions. Although such a meter system is relatively easy to use, it can provide some difficulty for a person not familiar with the equipment. This report includes a discussion of: (1) equipment needed for the recording meter system, (2) use of the system, (3) a procedure for testing the system, and (4) practical applications for outputs from the system.

System Equipment

The meter system consists of a General Electric CH-11 Portable Polyphase Watt/Varmeter and support equipment. It has an expressed accuracy of 3 percent of the full-scale reading, which is satisfactory for most situations. The following list of equipment, catalog numbers, and approximate 1980 prices provide information needed to obtain and operate comparable equipment for sawmill applications.

Equipment	*General Electric catalog number*	*Approximate 1980 price*
● CH-11 Portable Polyphase Watt/Varmeter Recorder (ink type)	8CH11DAB202	$1,180.00
● Transducer	50-233123AAAC	860.00
● Current Transformer 8.7 KV (Max 5KV line to ground)	50-233391AGAA	260.00
● Potential Transformer (GE type JUZ-O), ration 4:1 and 2:1 (Secondary 120 volts)	760x33G4	260.00

On the basis of these prices, the cost of a meter system to measure kilowatts and kilovars on a 480-volt 3-wire 3-phase circuit is approximately $3,080. This includes the cost of two potential transformers and two current transformers. Since most sawmills use 3-wire 3-phase circuits, this system will handle most situations. However, if you wish to measure kilowatts and kilovars on 480-volt 4-wire 3-phase circuits, it will be necessary to have two additional current transformers; if so, the system's cost would be approximately $3,600.

CH-11 Recorder

The CH-11 (Fig. 1) records either kilowatts or kilovars on a strip chart that is 4.5 inches wide and 110

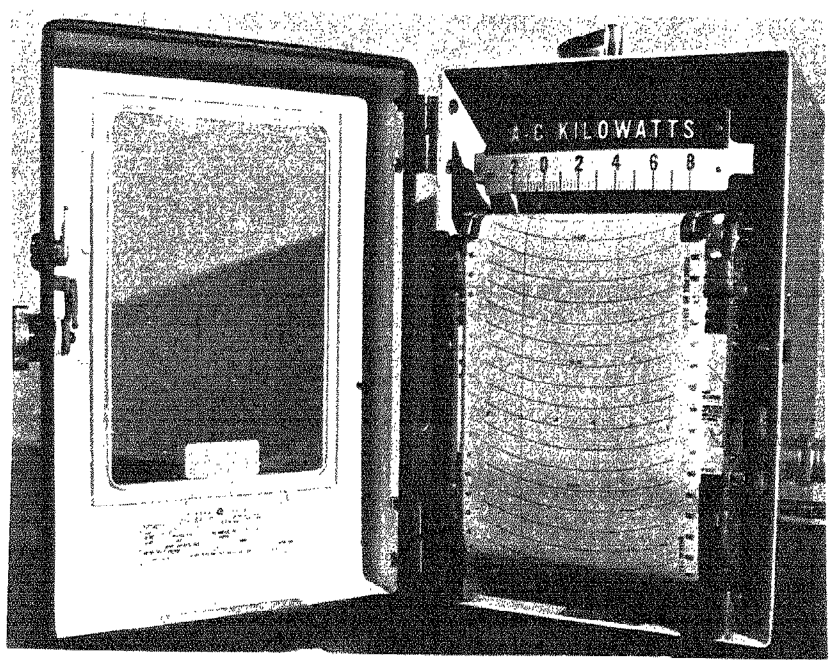


Figure 1.—Portable polyphase watt/varmeter.

feet long. It includes a set of drive gears that move the strip chart at a speed of either 3 inches per hour or 3 inches per minute depending on the setting of the chart speed switch. Optional gears are available for a wide range of speeds and allow flexibility in data collection. The best chart speed will depend on the use of the data. For most of my work, I prefer a speed of 6 inches per minute. At this speed, one recording strip will last approximately 3 hours.

Transducer

The transducer (Fig. 2) is activated by a 120-volt potential and the secondary output of the current transformers to provide a DC current input to the recording meter. For each 10-minute cycle, this input reflects 2 minutes of kilovars and 8 minutes of kilowatts. The kilovars can be omitted by opening the front of the transducer case and removing the disk that operates the var switch. There also is a switch inside this cover that allows the use of the recorder on 2-wire single phase, 3-wire 3-phase, or 4-wire 3-phase electrical circuits.

Current Transformers

The current transformers are the hook-on Butyl molded type. Since they can be attached to the wires with wraparound clips, it is usually not necessary to disturb a sawmill's electrical connections when collecting data. However, I should point out that these transformers cannot be placed around metal conduits. They must be placed around circuit wires in a switch or starter box (Fig. 3). Only one current transformer is needed to measure kilowatts on a 2-wire single-phase circuit. Two current transformers are needed to measure either kilowatts or kilovars on a 3-wire 3-phase circuit. And four current transformers are needed to measure either kilowatts or kilovars on a 4-wire 3-phase circuit.

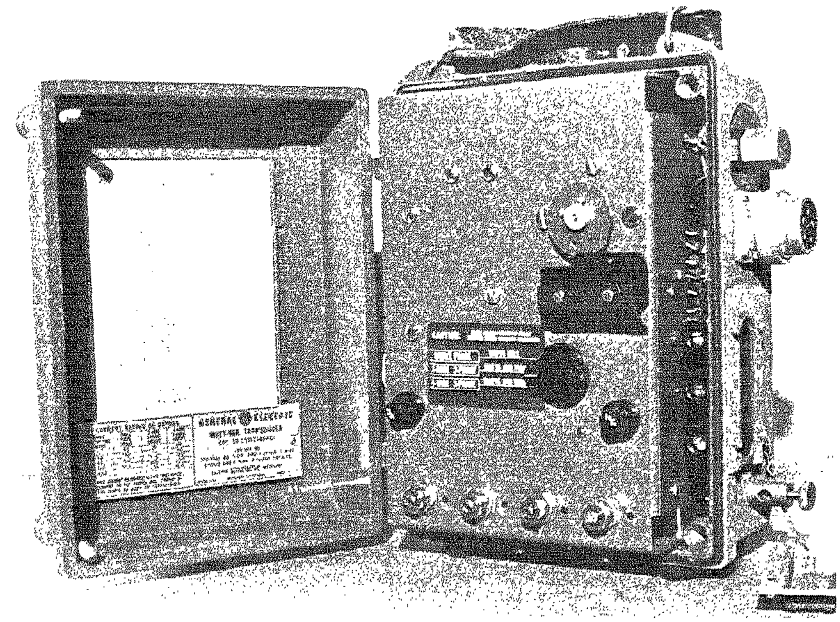


Figure 2.—Transducer to be used with portable polyphase watt/varmeter.

Potential Transformers

Potential transformers are required when using the recording meter on a circuit with more than 120 volts. Only one transformer is needed for 2-wire single phase circuits. However, two transformers are needed for both 3-wire 3-phase circuits and 4-wire 3-phase circuits. The potential transformer indicated in the equipment list can be wired for either a 2:1 ratio or a 4:1 ratio. This allows the recording meter to be used on 120-, 240-, and 480-volt circuits. Two transformers will provide the flexibility needed to collect both watt and var data on most sawmills and their equipment.

System Use

Two instruction manuals are available for the CH-11 Portable Polyphase Watt/Var Recording System. The recorder manual (GE 198 4557K10-001K) covers only the operation and maintenance of the CH-11 recorder. The system manual (GE 198 4557K13-001B) covers the operation and maintenance of the entire meter system excluding the information covered in the recorder manual. The information found in these manuals will not be discussed here. However, in this section I discuss additional information to be considered when using the recording system.

Wire Size

The system manual states that No. 12 or larger diameter wire should be used to ground the recording system. But no wire size is given for the connection between the circuit to be measured and the transducer. Although other wire sizes may be adequate, No. 16 wire will provide satisfactory results. I al-

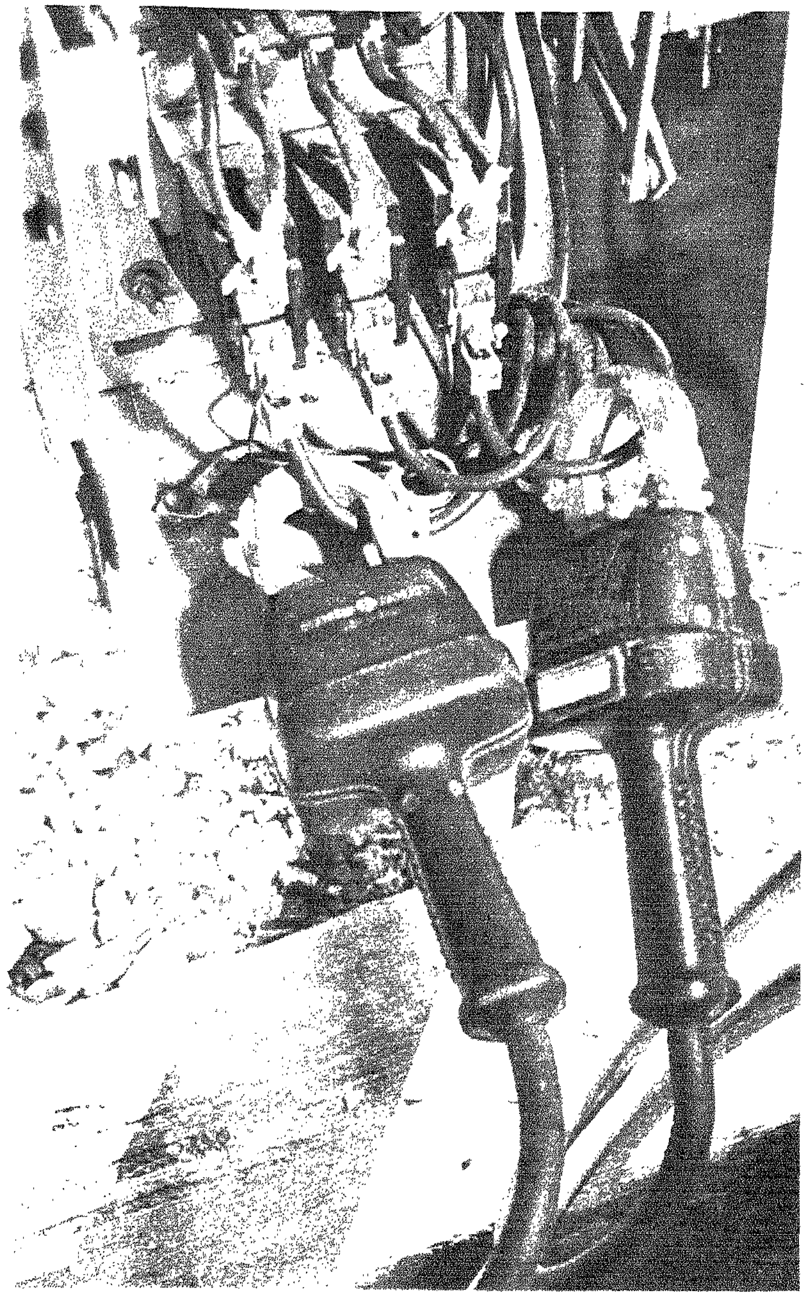


Figure 3.—Current transformer hookup.

so use this size for wiring together the potential transformers.

Wiring Potential Transformers

The system manual shows the proper hookup for single-ratio transformers but it does not consider hookups for the double-ratio transformers recommended in the equipment list. Figure 4 shows these hookups for the different circuit situations that a user may encounter. The symbols used in this figure are identified as:

PT = potential transformer; CT = current transformer; H_1 = primary terminal marker; X_1 = secondary terminal marker.

Zero Adjustment of Recorder Pen

The procedure for zeroing the recorder pen is discussed in the recorder instruction manual. But it is not made clear that electricity must be flowing through the transducer and the recorder before this adjustment can be made properly. This is accomplished by making the potential connections on the line (source) side of the switch or starter in the motor circuit for which data are to be collected. This allows electricity to flow through the meter system even if the switch or starter is turned off. Since the location of the current transformers will have no effect on the zeroing process, they can be attached on either the line or the load side of the switch or starter.

Safety Precautions

Both instruction manuals discuss safety procedures to follow when using the meter system. In addition, I recommend the following:

1. If you have no experience working with circuits carrying up to 480 volts, have a qualified electrician hook the recording system to the power circuits. Most sawmills have a person capable of working with the voltages used in the mills. This employee usually is available to make the required hookups.

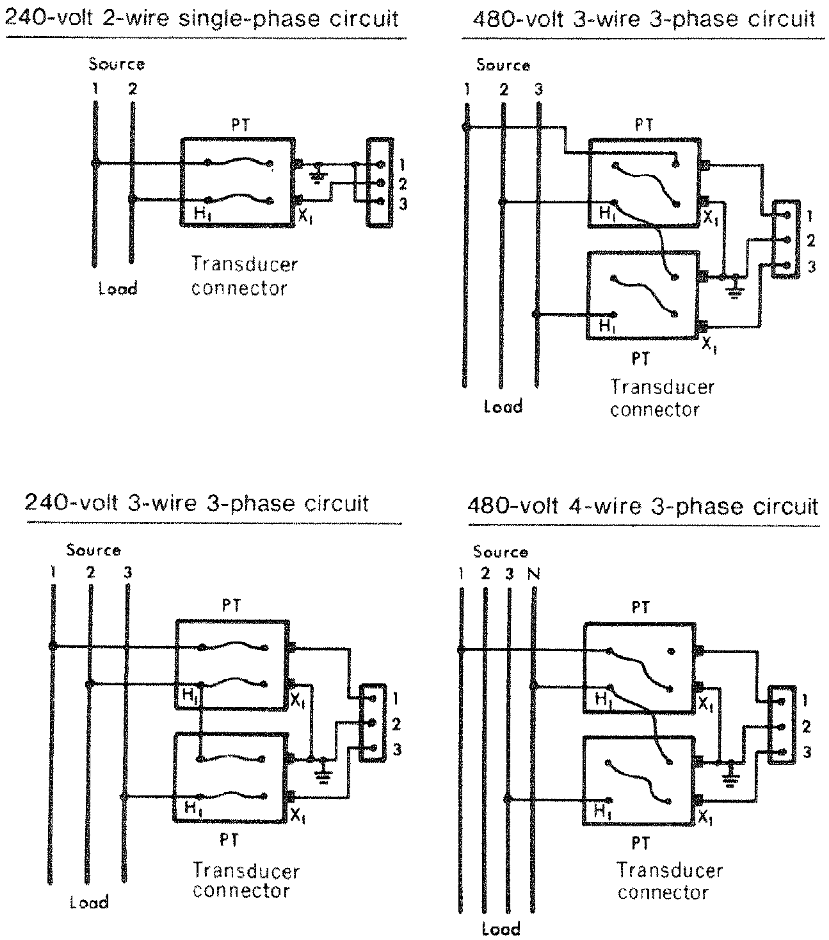


Figure 4.—Potential transformer hookups for different circuit situations (PT = potential transformer; CT = current transformer; H_1 = primary terminal marker; X_1 = secondary terminal marker).

2. Use rubber lineman's gloves with leather shells. When using the meter system in sawmills, it is often not possible to turn the power off at a necessary hookup point without turning the power off to the entire mill. In these situations, it is necessary to hookup and unhook with the power on. Lineman's gloves must be worn to do this.

3. Mount the potential transformers inside a wooden box so that the connection terminals cannot be touched accidentally. This is especially important where the transformers recommended in the equipment list are used. There are no protective caps on the terminals of these transformers.

4. Cover the switch box or starter box (whichever is used for the meter hookup) with a rubber mat approximately 3 feet wide and 6 feet long. Once the connections have been made, the doors on these boxes cannot be shut. The rubber mat can be hung over the box opening to reduce the possibility of personnel accidentally touching hot wires and connectors.

System Setup

To minimize the time required to hook up the meter system, all components except the meter should be mounted permanently to a hand truck (Fig. 5). The truck also should have a shelf for holding the meter. Not having the meter mounted permanently allows it to be hand carried to minimize jarring. Setting up components in this manner eliminates the need to disassemble the entire meter system when moving from machine to machine or mill to mill.

System Testing

Using the Ch-11 portable watt/varmeter on the sawmill equipment often requires moving system components from mill to mill and from point to point within a mill. I have found it impossible to make these moves without occasionally jarring the components. Although the components are fairly rugged, there is always a question of the accuracy of the system after one of these jarrings. The instruction manual for the recording system contains a section on making calibration checks on both the recorder and the transducer. However, unless the user already has the equipment needed to make these checks, I suggest the following method, one which allows the entire meter system to be tested under actual operating conditions on a 480-volt 3-wire 3-phase circuit.

Test Equipment

The meter used to test the recording system is a polyphase watt-hour type, herein referred to as the test meter. Unlike the recording meter, it is a widely used standard meter for which testing facilities are widely available. The error given by the manufacturer for this meter is less than 1 percent. However, since it is being used as a standard for testing the recording meter, it should be tested from time to time to assure its accuracy.

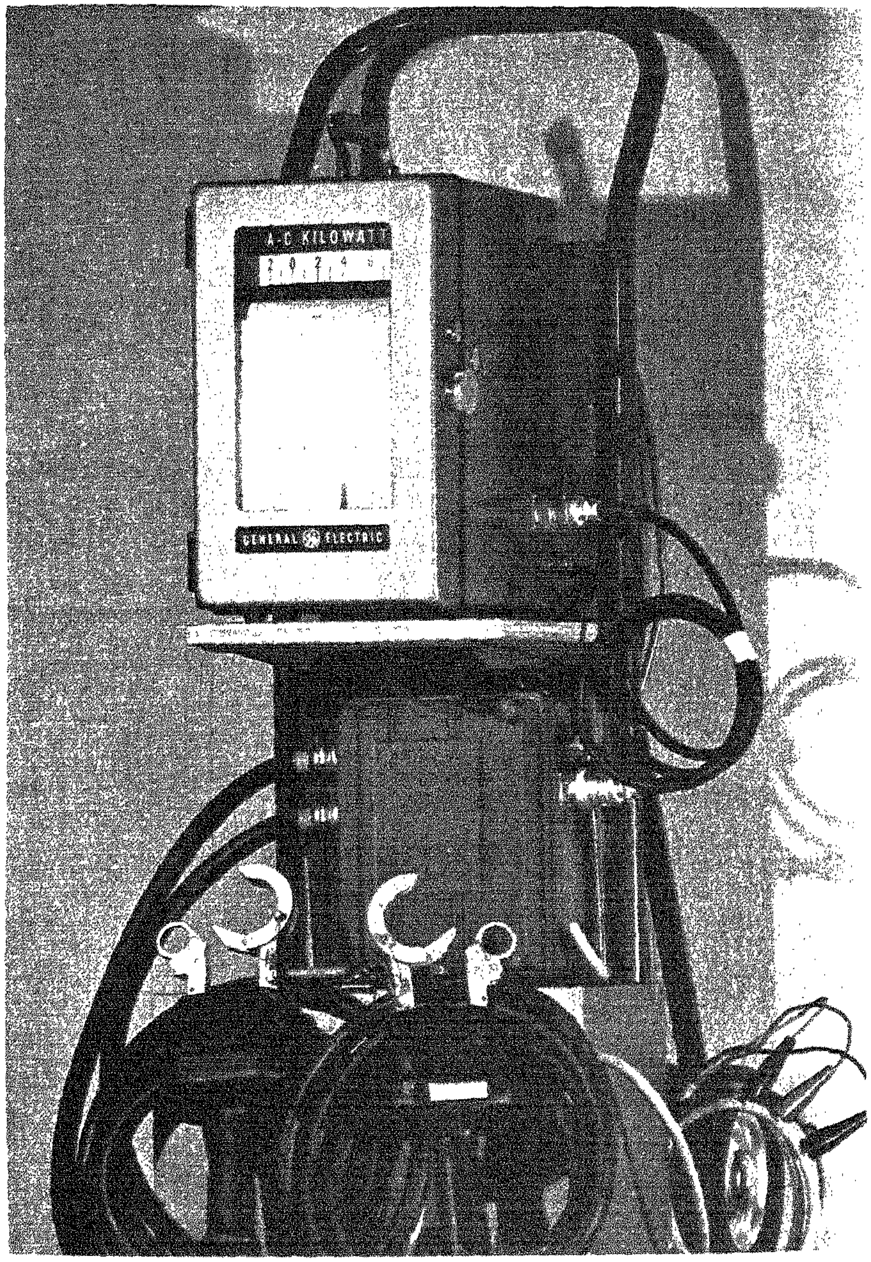


Figure 5.—Component setup for watt/varmeter system.

The following list shows the test meter and transformers needed for the test method, along with catalog numbers and approximate prices.

Equipment	*General Electric catalog number*	*Approximate 1980 price*
• General Electric Polyphase Watt-hour Meter (GE Type V-63-A)	700x14G1	$186.00
• Current Transformer (GE Type JCW-O), current ratio 200:5 (600 volts)	750x32G213	41.00
• Potential Transformer (GE Type JVP-O), ratio 4:1 (Secondary 120 volts)	760x32G4	100.00

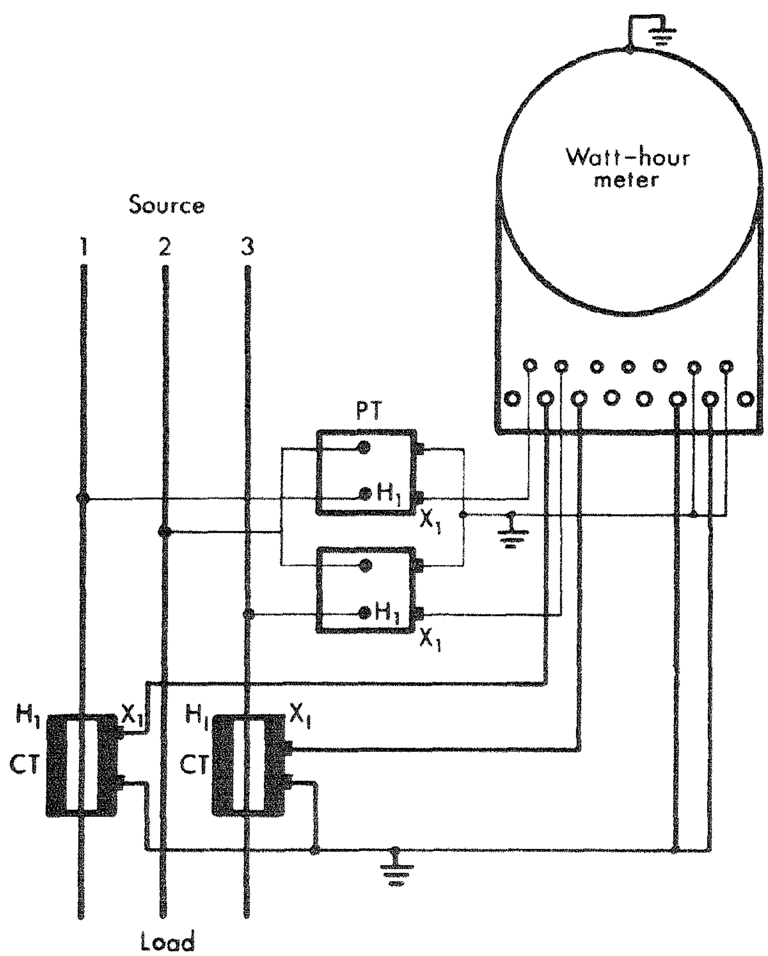


Figure 6.—Circuit diagram for test meter system.

The test method requires two each of both the current transformers and the potential transformer shown in the equipment list. On the basis of the prices shown, the cost of the equipment needed for the test meter system is approximately $468.

Test Meter Hookup

Figure 6 shows the test equipment circuit diagram for a 480-volt 3-wire 3-phase circuit (from a General Electric booklet entitled "Guide for Installing General Electric Watt-Hour Meter" (GET-2669G)). The actual test equipment, wired in accordance with this diagram, is shown in Figure 7.

To hook up the test system, a break must be made in the power circuit going to the motor being used for the test. The test circuit is then inserted into this break. The main wires in the test circuit running between the line (source) and the load (motor) must be at least as large as the wire in the power circuit of the motor. Number 12 wire is sufficient for the remainder of the test circuit.

Once the test system is hooked up, the recording meter system is hooked up to the same motor circuit. At this point, the test motor is started. When it has been determined that both the test meter and the recording meter are working properly, the test can be made.

Making the Test

To make the test, I recommend a motor rated at 50 horsepower or larger. With both meters hooked up and the motor running, turn the recording meter speed switch to the OFF position. As soon as the zero mark on the test meter disk lines up with the marker on the meter face, start a stopwatch and move the recording meter speed switch to the inches-per-hour position. Time the interval required for the test meter disk to make five revolutions. At the end of the fifth revolution, stop the watch and turn the recording meter speed switch to the OFF position.

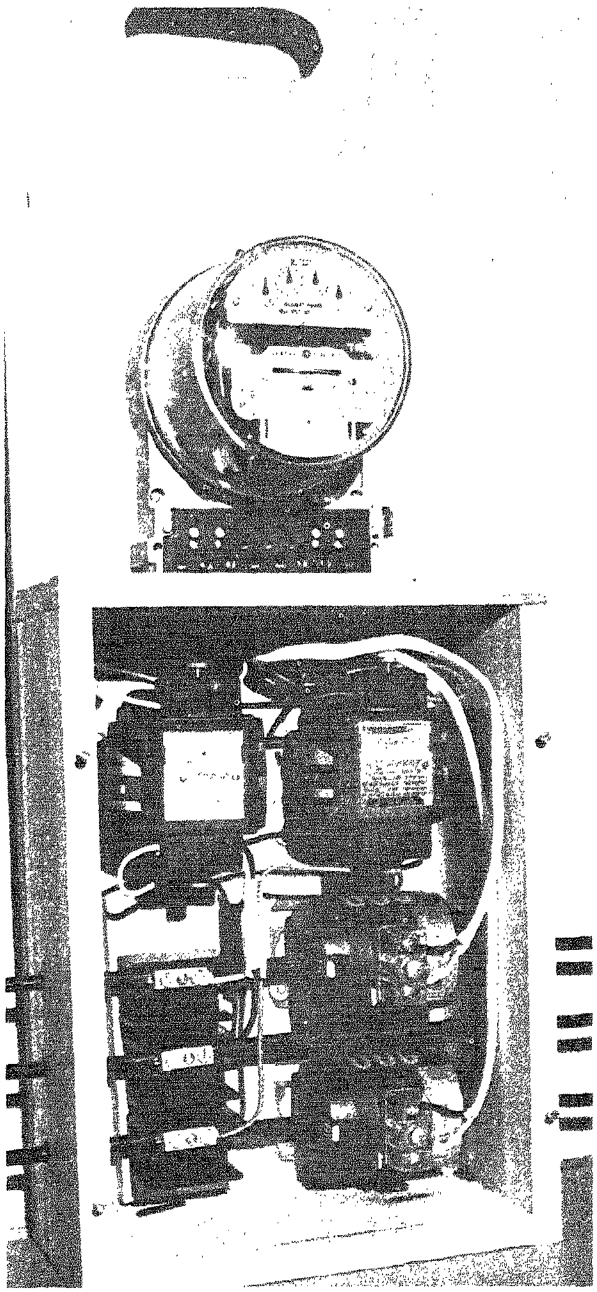


Figure 7.—Component setup for test meter system.

You will then have the data needed to check the accuracy of the recording meter system. The equation used to make this check is:

$$KW = (3.6 \times Rev \times K_h \times CTR \times PTR)/T$$

Where:

KW = Kilowatts used by motor during test period

Rev = Number of disk revolutions on test meter

K_h = Watt-hour constant printed on face of test meter

CTR = Current transformer ratio

PTR = Potential transformer ratio

T = Time in seconds for test meter disk to make the number of revolutions given for "Rev"

The following example, using actual data, demonstrates the test procedure. During the test, it took 953.38 seconds for the test meter disk to make five revolutions. The watt-hour constant from the face of the test meter was 1.2. The current transformer ratio was 200:5 and the potential transformer ratio was 4:1. Using these values in the equation produces a value of 3.62 kilowatts used by the motor during the test period. Since the error given by the manufacturer for the test meter is less than 1 percent, 3.62 kilowatts will be considered the true value for the purposes of this test.

During the test period, the recording meter showed the motor using an average of 4.2 kilowatts. Now it must be determined if the error between this 4.2 value and the 3.62 value from the test meter is reasonable. To do this, the percent error inherent in the recording meter system must be considered. The error given by the manufacturer of the system is 3 percent of the full-scale reading. For this test, the full-scale reading was 40 kilowatts (−8KW to +32KW). Three percent of 40 is 1.2. Therefore, if the recording meter system is working satisfactorily, the 4.2 kilowatt reading should be within a range of plus or minus 1.2 kilowatts of the test meter value. This range is from 2.42 kilowatts to 4.82 kilowatts (3.62 KW ± 1.2 KW). Since 4.2 kilowatts is within this range, we can conclude that the meter is working satisfactorily.

In a situation where the recording meter does not seem to be working properly, I would first have the test meter rechecked. If the test meter checks out, the recording meter and transducer should be sent to the manufacturer for calibration.

Uses of Recording Meter Output

The watt/var information from a recording meter system has many possible uses. This is especially true in sawmilling situations where little of this work has been done. In the past, the cost of electricity was low enough that this type of information was of little interest. But this situation has changed.

The output from a watt/varmeter can be used to answer many of the questions being asked by sawmill managers about power requirements and costs at their mills. One of the most important questions is: Will use of capacitors in a mill reduce the electricity cost enough to pay for their installation? The amount of capacitance needed can be determined by recording both kilowatts and kilovars for the mill's entire electrical system. Using this information and a chart provided in the system instruction manual, you can determine the power factor for the mill. The difference between the kilovars for this power factor and the kilovars required to raise the power factor to a desired figure is the var rating of the capacitors needed by the mill. With this information, the mill manager can easily determine if it pays to install the capacitors. Additional information on the capacitor problem is available in Santilli and Husway (1976) and Hopper (1978).

The recording meter system can also be used in research situations. The system is currently being used to determine the difference between the power required to saw-logs with a thin-kerf and a standard-kerf circular saw. Preliminary results indicate that the system is providing satisfactory data for this purpose.

The system also is being used in a study to determine the cost of converting different sizes and species of sawlogs into products. This has always been a problem when making economic analyses of sawmill operations. Knowing the power required by the different machines used to process these logs will enable a better estimate of these conversion costs.

Acknowledgment

I thank John W. Vermillion, superintendent of the Meter Department for the Appalachian Power Company, Bluefield, West Virginia, for technical assistance provided during the preparation of this report.

Literature Cited

Hopper, David L. **Wood products industries can save money on electrical bills.** South. Lumberman 237(2944):60–61; 1978.

Santilli, J. N.; Husway, M. J. **Investments in capacitors help cut electric bills.** For. Ind. 103(12):70–71; 1976.

Adams, Edward L. Using a recording watt/varmeter to measure power consumption of sawmill equipment. Broomall, PA: Northeast. For. Exp. Stn.; 1982; USDA For. Serv. Gen. Tech. Rep. NE-71. 8 p.

A recording meter system for measuring both watts and vars on sawmill systems and components is described. Sections are presented on (1) equipment needed for the system (2) using the system, (3) testing the system, and (4) possible uses of the output. The system is easy to use and provides output satisfactory for a wide range of applications.

ODC 832.11

Keywords: Sawmill; machinery; power

☆U.S. GOVERNMENT PRINTING OFFICE: 1982-505-012:23

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories are maintained at:

- Amherst, Massachusetts, in cooperation with the University of Massachusetts.
- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
- Delaware, Ohio.
- Durham, New Hampshire, in cooperation with the University of New Hampshire.
- Hamden, Connecticut, in cooperation with Yale University.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Princeton, West Virginia.
- Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
- University Park, Pennsylvania, in cooperation with the Pennsylvania State University.
- Warren, Pennsylvania.