A WOOD-ELEMENT HYGROSTAT

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A WOOD-ELEMENT HYGROSTAT

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Introduction

Several types of wood-element hygrostats[2,3] have been made and used by the Forest Products Laboratory. All have demonstrated their usefulness in maintaining accurate control of relative humidity in dry kilns and conditioning rooms, particularly when conditions of constant equilibrium moisture content are desired. All operate on the same basic principle, the inherent tendency of wood to absorb or lose moisture with changes in relative humidity, which causes the controlling wood element to shrink or swell.

In this article is presented information on the functioning of these hygrostats; their operational faults, and corrective measures used in overcoming them; and details of their construction and methods of calibrating.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] "A Sensitive Wood Element Hygrostat," by W. Karl Loughborough and R. C. Rietz. INSTRUMENTS, June 1932.

[3] "Moisture Fluctuations in Lumber Within Closed Storage Sheds Controlled with Electrical Equipment," Forest Products Laboratory Report No. R1140.

Operation

An early type of Forest Products Laboratory hygrostat controls humidity conditions by means of a wood element installed with a slight curvature (fig. 1). One end of the wood element is fastened to a fixed block "i," the other end to an adjustable block "j." As the humidity increases, the wood element absorbs moisture and begins to swell. Because it is securely fastened at both ends, its degree of curvature increases as it swells. This causes the lever arm "a," pivoted at "b" and connected to the wood element by linkage "c," to move away from the air nozzle "d" which is connected to the bellows "e" by means of a small copper tube "f." The opening of the air nozzle "d" releases the air pressure in the bellows "e," causing it to contract and pull on pin "g," to which it is attached. Flanges attached to pin "g" are pulled against an air port in the auxiliary air mechanism "h," shutting off the air supply to the air-operated diaphragm valve "n" which controls the flow of steam into the steam spray lines. The release of air pressure against the diaphragm of valve "n" allows the compression spring attached to the valve stem to close the valve, thereby shutting off the steam spray. As the humidity within the dry kiln or conditioning room decreases, the wood element loses moisture and begins to shrink, decreasing the amount of curvature which results in the closing of air nozzle "d" by the lever arm "a." This builds up pressure in bellows "e," expanding it and pushing pin "g" with its attached flanges clear of the air port in the auxiliary air mechanism "h." Air pressure on the diaphragm of the air-operated valve overcomes the resistance offered by the compression spring attached to the valve stem, thus opening the valve and allowing steam to flow again into the spray pipe within the dry kiln or conditioning room. The relative humidity can be increased or decreased by controlling the curvature of the wood element by means of the adjusting knob "k" attached to the adjusting rod "m," which is threaded into the sliding block "j."

The auxiliary air mechanism "h" is similar to that used in some commercial temperature recorder-controllers. It may also be used to control a diaphragm motor that operates the ventilating dampers of a kiln or conditioning room.

This principle of humidity control can also be used in conjunction with electrically operated equipment by installing contact points connected by wires to a motor-operated valve on the steam spray line. One of these points is in a fixed position, the other attached to the wood element. As the curvature of the wood element increases or decreases in response to changes in moisture content, the movable contact point makes or breaks contact with the fixed point, thereby causing the motor to open or close the steam spray valve. A single (2-wire) or double (3-wire) contact system may be required, depending on the type of control valve being used.

Operational Precautions

Extreme changes in relative humidity conditions will occasionally cause severe distortion, reversal of curvature, or breakage of the wood element in this instrument. When the instrument is thus thrown out of adjustment, kiln conditions will be upset. Because of the danger that the instrument will be so affected, it is impossible to calibrate the instrument so that the desired relative humidity conditions can be rapidly attained.

These faults are difficult to overcome but can be minimized by gradually increasing or decreasing relative humidity conditions. Furthermore, if a drying chamber that is operated at a high relative humidity is to be entered for extended periods of time, with the door left open, the wood element should be covered with a damp cloth so that it will not break as a result of rapid drying and shrinking.

Improved Hygrostats

Design

To overcome the difficulty caused by the breakage of the curved wood element, another instrument was designed with a straight, free-floating wood element (figs. 2 and 3). This hygrostat was designed to be mounted through the roof of a drying compartment, with the wood element inside and the control arms and contact points outside the kiln. Figure 2 shows the design with electrical contact points while figure 3 shows an arrangement suitable for air control. Although quite suitable for interior drying compartments, this hygrostat cannot be calibrated for rapid adjustments

of relative humidity conditions because the control points are located above the roof.

These disadvantages are largely overcome in the design shown in figures 4 and 5. A patent application on this design has been made by the Forest Products Laboratory for free use by the public.

The straight wood element in this hygrostat is installed in a vertical position, with its support rod resting upon a cam and the upper connecting rod free to move up or down as the wood element swells or shrinks with changes in relative humidity.

A feature of this hygrostat is the cam (No. 2 in fig. 4) upon which the support rod rests. By turning the control rod, which is attached to the cam shaft and extends outside the drying or conditioning room, the wood element can be raised or lowered to any desired setting on the indicator dial (No. 19 in fig. 4). The dial is numbered from 1 to 100 so that the instrument can be calibrated in terms of equilibrium moisture content. The calibration procedure is described later in this report.

All parts are numbered on figure 4. By corresponding numbers, each part is described in the parts list given in the appendix. All dimensions necessary for assembly are shown in figure 4.

Location and Assembly

The hygrostat is mounted in a vertical position (fig. 4) to an inside wall of the drying or conditioning room in such a manner that the air can circulate freely around the wood element at all times. A hole is then drilled through the kiln wall for the adjusting rod. This hole must be in line with the cam shaft of the hygrostat.

A panel board containing a hole slightly larger than the adjusting rod is fastened on the outside of the kiln with the hole in line with the hygrostat cam shaft and the hole drilled through the kiln wall.

The dial is fastened to this panel board by means of small screws, so that the hole in the center of the dial is directly over the hole drilled in the panel board. The zero marking on the dial should be vertically above the adjusting rod, which runs through the holes provided and is attached to the hygrostat cam shaft (No. 23 in fig. 4) by means of the adjusting rod coupling (No. 24 in fig. 4).

In order to comply with the calibration procedure given in this report, the cam should be placed on the cam shaft so that by turning the adjusting knob to the left (counterclockwise) the wood element is raised. The tip of the air nozzle should be level with the top of the pivot mounting (No. 14 in fig. 4) so that the lever arm will be horizontal when in contact with the tip of the air nozzle, thereby reducing the possibility of air leakage. The pivot mounting should be securely fastened by a lock nut, so that the lever arm is fixed directly over the air nozzle.

Calibration

For convenience in calibrating this hygrostat, it is suggested that the moisture content of the wood element first be brought to approximately 7 to 8 percent.

Turn the adjusting knob to the left (counterclockwise) until the small projection on the high point of the cam strikes against the support rod. The indicator can then be moved until it points to zero on the dial and be securely fastened in this position by means of lock nuts. Set the indicator at 30 on the dial. Enter the drying or conditioning chamber and turn the projecting nut down or up so that the lever arm just clears the air nozzle. Place a good hygrometer adjacent to the hygrostat and leave the kiln.

The steam can now be turned on and the hygrostat will be calling for steam spray. Maintain this setting until the steam-spray control valve has opened and closed several times. Again enter the chamber and read the temperatures on the hygrometer. If these readings result in an equilibrium moisture content of 7.5 percent, as found in table 1, no further adjustment is necessary. If the readings show an equilibrium moisture content lower than 7.5 percent, the projecting nut should be turned down until the proper condition is reached. If the readings show an equilibrium moisture content greater than 7.5 percent, the projecting nut should be turned up. Give the wood element plenty of time to reach equilibrium. As soon as the drying condition is definitely at 7.5 percent equilibrium moisture content, the projecting nut is securely locked in place with the lock nut. Be careful that it is not moved, as this initial setting, if properly made, will eliminate later adjustments of the wood element.

From this point on, the dial settings given in table 2 can be employed. The data given in this table, however, are based on average values, and consequently the dial settings shown are only reliable to within ±1.5 percent equilibrium moisture content. To obtain the desired conditions, the operator will have to make minor adjustments by means of the adjusting knob, checking the dial readings against hygrometer readings. When the desired condition is obtained however, the hygrostat will accurately maintain this condition until another change is necessary.

By keeping an accurate record of the dial settings and resultant equilibrium moisture content conditions, the operator will soon have sufficient data which will reduce, if not entirely eliminate, minor adjustments in the dial settings of his particular instrument in order to obtain a given equilibrium moisture content condition.

If the wood element must be replaced, the entire calibration procedure must be repeated and new dial settings obtained.

Operation

The indicator is set at a point on the indicator dial that will give the desired equilibrium moisture content as determined from table 1. As already pointed out, it may be necessary to adjust the indicator until the wet- and dry-bulb temperatures show that the desired conditions have been obtained. As soon as the relative humidity falls below that desired, the wood element will begin to shrink and the projecting nut will move downward against the lever arm, which is pivoted at the pivot mounting. This movement will raise the lever arm clear of the air nozzle, thereby opening the steam-spray contol valve. As the relative humidity within the dry kiln or conditioning room increases, the wood element begins to swell, raising the projecting nut and allowing the lever arm to contact and close the air nozzle and thereby the steam-spray control valve.

The relative humidity can be controlled by turning the adjusting knob. The dial settings, with their approximate equilibrium moisture content values as determined by means of table 1, will assist in making changes during drying operations.

This hygrostat operates the same air mechanism described for the original hygrostat. It can also be connected to a diaphragm motor that operates ventilating dampers.

It has been found that the wood element will reach practical equilibrium with the drying atmosphere in approximately 30 minutes for a 2 percent, and in approximately 1 hour for a 4 percent equilibrium moisture content change.

This instrument can also be used to control the opening or closing of electrically operated spray valves or vent damper motors by employing a sensitive electric switch (figs. 4 and 5, A). The switch is wired to a motor operating the control mechamism. The principle of operation is identical to that of air operation. The counterweight (figs. 4 and 5, A) is necessary, as the wood element and its attachments are not heavy enough to operate the switch.

Operational Precautions

The wood element will not become distorted under normal drying conditions. It should not, however, be subjected to extended periods of uncontrolled steaming and should never be wrapped or covered with wet cloths, as these treatments will cause distortion of the wood element and subsequent binding of the support and connecting rods at the holes in the top and bottom guide plates.

Under certain conditions, dirt may accumulate or corrosion may occur on the support and connecting rods and in the holes through which they move. In this event, they should be cleaned by fine steel wool, sandpaper, or emery cloth. Lubricating oils should never be used, as they will collect dust which will eventually prevent free movement of the rods.

If an electrical hook- up is used and the counterweight (fig. 4) is not heavy enough to trip the switch control, improper control will result. Furthermore, this counterweight should not at any time be allowed to rest upon the nuts on the frame rods located just above the base plate. If this occurs, the support rod will not engage the cam and proper conditions cannot be obtained.

The instrument will accurately control drying conditions within a 1° F. wet-bulb depression once they have been established, between 3 and 19 percent equilibrium moisture content. Good control cannot be assured, however, above 19 percent equilibrium moisture content.

Horizontal Placement of Hygrostat

The hygrostat controlling air-operated valves can be mounted in a horizontal position and operated from the roof of the kiln by adding a compression spring to hold the support rod firmly against the cam and by changing the location of the pivot mounting and air-tube support. The compression spring should be placed over the support rod between the bottom guide plate and a pin inserted through a 1/16-inch hole drilled in the rod just above the frame. A 1/4-inch hole should be drilled in the top plate for the air tube support and pivot mounting, so that the lever arm when in position will extend downward. The lever arm, however, should be slightly less than vertical when in contact with the air nozzle. A small counterweight, such as a drop of solder, added to the lever arm near the air nozzle will reduce the possibility of air leakage.

All that is required for horizontal placement and operation of the hygrostat equipped to control electrically operated valves, is a compression spring just sufficiently strong to hold the support rod firmly against the cam while the shrinking wood element trips the control switch. This spring is mounted in the same manner as described in the preceding paragraph.

APPENDIX

Parts List for Forest Products Laboratory Improved Hygrostat

Part No.	Number required	Part name	Size and description[1]
1	1	Wood element	5/32" x 1" x 10".[2]
2	1	Cam	1/16" thick. Minimum radius 1". Maximum radius 1-3/4".
3	2	Coupling	5/16" by 5/16" by 1". Slotted 5/8" deep for wood element and drilled for connecting bolts on one end; tapped for attaching the support and connecting rods on the other end.
4	1	Adjusting rod	1/4" diameter. Any length desired. Threaded on one end for adjusting knob and for lock nuts on each side indicator.
5	1	Air tube support	3/8" x 3/8" x 1-5/8" slotted on one end for attachment to top plate and drilled at other end for air line.
6	1	Support rod	1/4" x 3-1/4" threaded one end for coupling and slotted 1/4" deep and 1/8" wide on other end.
7	1	Lever arm (air)	1/32" x 1/4" x 4" fitted with pivot pin attachment 11/16" from one end.
8	1	Air nozzle	Any type with small air opening.
9	1	Projecting nut (provided with lock nut)	1/8" thick by 3/4" wide threaded for connecting rod.
10	1	Switch support	Size to be determined by size of switch.
11	1	Lever arm (electric)	1/4" x 1/4" x 3-3/8" channel with pivot pin attachment on one end.
12	1	Air line	1/8" copper tubing cut to required length.

Parts List for Forest Products Laboratory Improved Hygrostat
(continued)

Part No.	Number required	Part name	Size and description[1]
13	1	Connecting rod	1/4" x 4-1/4" threaded both ends.
14	1	Pivot mounting	1/2" x 5/8" tapped for frame rod and slotted on one end for lever arm and pivot pin. Pivot pin 1/16" diameter.
15	1	Frame	1/8" x 2-3/8" x 11-3/4 " bent as shown and drilled for base plate, cam shaft, frame rods, and support rod.
16	1	Top plate	1/8" x 2-3/8" x 6" drilled for frame rods, connecting rod, air tube support, and wall bracket.
17	2	Frame rods	1/4" x 15-1/2" threaded approximately 2-1/2 inches on each end.
18	2	Connecting bolts	1/8" x 1/2", screw head.
19	1	Indicator dial	1/16" x 3" numbered from 1 to 100.
20	1	Indicator	Any size or shape desired.
21	2	Top and bottom guide plates	1/8" x 1-1/8" x 2-3/8" drilled for frame rods and connecting and support rods.
22	1	Base plate	1/8" x 2-3/8" x 6" drilled for frame and wall bracket.
23	1	Cam shaft	5/16" x 2-1/4".
24	1	Adjusting rod coupling	1/2" x 3/4". Threaded on cam shaft and fastened to adjusting rod with a lock screw.

Parts List for Forest Products Laboratory Improved Hygrostat
(continued)

Part No.	Number required	Part name	Size and description[1]
25	1	Cam collar	Any size allowing free movement of shaft; fastened to cam shaft with lock screw and riveted to cam.
26	1	Cam shaft collar	5/16" x 1-1/2" drilled to fit cam shaft and attached to it by a lock screw.
27	1	Adjusting knob	1/4" x 1" threaded on adjusting rod.
28	1	Counterweight for electric hook-up	Of a size to insure free movement between frame rods and heavy enough to trip the control switch.

[1] All parts are of brass unless otherwise specified.

[2] Can be of spruce, birch, basswood, or maple. Maple is preferred. Consists of a transverse section cut from a flat-sawn 1-inch board, 10 inches in width. Thickness of 5/32 inch is recommended.

DRY-BULB TEMPERATURE (°F.)	WET-BULB DEPRESSION (°F.)																																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	38	40	45	50
30	88 15.9	78 12.9	67 10.8	57 9.0	46 7.4	36 5.7	27 3.9	17 1.6	6																												
35	90 16.8	81 13.9	72 11.9	63 10.3	54 8.8	45 7.4	37 6.0	28 4.5	19 2.9	11 0.8	3																										
40	92 17.6	83 14.8	75 12.9	66 11.2	60 9.9	52 8.6	45 7.4	37 6.2	29 5.0	22 3.5	15 1.9	8																									
45	93 18.3	85 15.5	78 13.7	72 12.0	64 10.7	58 9.5	51 8.5	44 7.5	37 6.5	31 5.3	25 4.2	19 2.9	12 1.5	6																							
50	93 19.0	86 16.3	80 14.4	74 12.7	68 11.5	62 10.3	56 9.4	50 8.5	44 7.6	38 6.7	32 5.7	27 4.8	21 3.9	16 2.8	10 1.5	5																					
55	94 19.5	88 16.9	82 15.1	76 13.4	70 12.2	65 11.0	60 10.1	54 9.3	49 8.4	44 7.6	39 6.8	34 6.0	28 5.3	24 4.5	19 3.6	14 2.5	9 1.3	5																			
60	94 19.9	89 17.4	83 15.6	78 13.9	73 12.7	68 11.6	63 10.7	58 9.9	53 9.1	48 8.3	43 7.6	39 6.9	34 6.3	30 5.6	26 4.9	21 4.1	17 3.2	13 2.3	9 1.3	5 0.2	1															
65	95 20.3	90 17.8	84 16.1	80 14.4	75 13.3	70 12.1	66 11.2	61 10.4	56 9.7	52 8.9	48 8.3	44 7.7	39 7.1	35 6.5	32 5.8	27 5.2	24 4.5	20 3.8	16 3.0	13 2.3	8 1.4	6 0.4	2													
70	95 20.6	90 18.2	86 16.5	81 14.9	77 13.7	72 12.5	68 11.6	64 10.9	59 10.1	55 9.4	51 8.8	48 8.3	44 7.7	40 7.2	36 6.6	33 6.0	29 5.5	25 4.9	22 4.3	19 3.7	15 2.9	12 2.3	9 1.5	6 0.7	3											
75	95 20.9	91 18.5	86 16.8	82 15.2	78 14.0	74 12.9	70 12.0	66 11.2	62 10.5	58 9.8	54 9.3	51 8.7	47 8.2	44 7.7	41 7.2	37 6.7	34 6.2	31 5.6	28 5.1	24 4.7	21 4.1	18 3.5	15 2.9	12 2.3	10 1.7	7 0.9	4 0.2	1								
80	96 21.0	91 18.7	87 17.0	83 15.5	79 14.3	75 13.2	72 12.3	68 11.5	64 10.9	61 10.1	57 9.7	54 9.1	50 8.6	47 8.1	44 7.7	41 7.2	38 6.8	35 6.3	32 5.8	29 5.4	26 5.0	23 4.5	20 4.0	18 3.5	15 3.0	12 2.4	10 1.8	7 1.1	5 0.9	3						
85	96 21.2	92 18.8	88 17.2	84 15.7	80 14.5	78 13.5	73 12.5	70 11.8	66 11.2	63 10.5	59 10.0	56 9.5	53 9.0	50 8.5	47 8.1	44 7.6	41 7.2	38 6.7	35 6.3	33 6.0	30 5.6	28 5.2	25 4.8	23 4.3	20 3.9	18 3.4	15 3.0	13 2.4	11 1.7	9 0.9	4					
90	96 21.3	92 18.9	89 17.3	85 15.9	81 14.7	78 13.7	74 12.8	71 12.0	68 11.4	65 10.7	61 10.2	58 9.7	55 9.3	52 8.8	49 8.4	47 8.0	44 7.6	41 7.2	38 6.8	36 6.5	34 6.1	31 5.7	29 5.3	26 4.9	24 4.6	22 4.2	19 3.8	17 3.3	15 2.8	13 2.3	9 1.3	6 0.4	5	1			
95	96 21.3	93 19.0	89 17.4	85 16.1	82 14.9	79 13.9	76 12.9	72 12.2	69 11.6	66 11.0	63 10.5	60 10.0	57 9.5	55 9.1	52 8.7	49 8.2	46 7.9	44 7.5	42 7.1	39 6.8	37 6.4	34 6.1	32 5.7	30 5.3	28 5.1	26 4.8	24 4.4	22 4.0	20 3.6	17 3.0	14 2.3	10 1.5	8 0.6	6	2		
100	96 21.3	93 19.0	89 17.5	86 16.1	83 15.0	80 13.9	77 13.1	73 12.4	70 11.8	68 11.2	65 10.8	62 10.1	59 9.6	56 9.2	54 8.9	51 8.5	48 8.1	46 7.8	44 7.4	41 7.0	39 6.7	37 6.4	35 6.1	33 5.7	30 5.4	28 5.2	26 4.9	24 4.6	22 4.2	21 3.8	17 3.1	13 2.4	10 1.6	7 0.7	4	
105	96 21.4	93 19.0	90 17.5	87 16.2	83 15.1	80 14.0	77 13.2	74 12.6	71 11.9	68 11.3	65 10.8	63 10.3	60 9.8	58 9.4	55 9.0	53 8.7	50 8.3	48 7.9	46 7.6	44 7.3	42 6.9	40 6.7	37 6.4	35 6.1	34 5.7	31 5.4	29 5.2	28 4.8	26 4.6	24 4.2	20 3.6	17 3.1	14 2.4	11 1.8	8	
110	97 21.4	93 19.0	90 17.5	87 16.2	84 15.1	81 14.1	78 13.3	76 12.6	73 12.0	70 11.4	67 10.8	65 10.4	62 9.9	60 9.5	57 9.2	55 8.8	52 8.4	50 8.1	48 7.7	46 7.5	44 7.2	42 6.8	40 6.6	38 6.3	36 6.0	34 5.7	32 5.4	30 5.2	28 4.8	26 4.5	23 4.0	20 3.5	17 3.0	14 2.5	11 1.1	4	
115	97 21.4	93 19.0	90 17.5	88 16.2	85 15.1	82 14.1	79 13.4	76 12.7	74 12.1	71 11.5	68 10.9	66 10.4	63 10.0	61 9.6	58 9.3	56 8.9	54 8.5	52 8.2	50 7.8	48 7.6	45 7.3	43 7.0	41 6.7	40 6.5	38 6.2	36 5.9	34 5.6	32 5.4	31 5.2	28 4.7	26 4.3	23 3.9	20 3.4	17 2.9	14 1.7	6 0.4	2
120	97 21.4	94 19.0	91 17.4	88 16.2	85 15.1	82 14.1	80 13.4	77 12.7	74 12.1	72 11.5	69 11.0	67 10.5	65 10.0	62 9.7	60 9.4	58 9.0	55 8.7	53 8.3	51 7.9	49 7.7	47 7.4	45 7.2	43 6.8	41 6.6	40 6.3	38 6.1	36 5.8	34 5.6	33 5.4	31 5.0	28 4.6	25 4.2	22 3.7	19 3.3	17 2.3	10 1.1	5
125	97 21.2	94 18.9	91 17.3	88 16.1	86 15.0	83 14.0	80 13.4	77 12.7	75 12.1	73 11.5	70 11.0	68 10.5	65 10.0	63 9.7	61 9.4	59 9.0	57 8.7	55 8.3	53 8.0	51 7.7	48 7.5	47 7.2	45 7.0	43 6.7	41 6.5	39 6.2	38 6.0	36 5.8	35 5.5	33 5.2	30 4.8	27 4.4	24 4.0	22 3.6	19 2.7	13 1.6	6
130	97 21.0	94 18.8	91 17.2	89 16.0	86 14.9	83 14.0	81 13.4	78 12.7	76 12.1	73 11.5	71 11.0	69 10.5	67 10.0	64 9.7	62 9.4	60 9.0	58 8.7	56 8.3	54 8.0	52 7.8	50 7.6	48 7.3	47 7.0	45 6.8	43 6.6	41 6.4	40 6.1	38 5.9	37 5.6	35 5.3	32 4.9	29 4.6	26 4.2	24 3.8	21 3.0	15 2.0	10
140	97 20.7	95 18.6	92 16.9	89 15.8	87 14.8	84 13.8	82 13.2	79 12.5	77 11.9	75 11.4	73 10.9	71 10.4	68 10.0	66 9.6	64 9.4	62 9.0	60 8.7	58 8.4	56 8.0	54 7.8	53 7.6	51 7.3	49 7.1	47 6.9	46 6.6	44 6.4	43 6.2	41 6.0	40 5.8	38 5.5	35 5.1	32 4.8	30 4.4	27 4.1	25 3.4	19 2.6	14
150	98 20.2	95 18.4	92 16.6	90 15.5	87 14.5	85 13.7	82 13.0	80 12.4	78 11.8	76 11.2	74 10.9	72 10.3	70 9.9	68 9.5	66 9.2	64 8.9	62 8.6	60 8.3	58 8.0	57 7.8	55 7.5	53 7.3	51 7.1	49 6.9	48 6.7	46 6.4	45 6.2	43 6.0	42 5.8	41 5.5	38 5.2	35 4.9	33 4.5	30 4.2	28 3.6	23 2.9	18
160	98 19.8	95 18.1	93 16.2	90 15.2	88 14.2	86 13.4	83 12.7	81 12.1	79 11.5	77 11.0	75 10.6	73 10.1	71 9.7	69 9.4	67 9.1	65 8.8	64 8.5	62 8.2	60 7.9	58 7.7	57 7.4	55 7.2	53 7.0	52 6.8	50 6.7	49 6.4	47 6.2	46 6.0	44 5.8	43 5.5	41 5.2	38 4.9	35 4.6	33 4.3	31 3.7	25 3.2	21
170	98 19.4	96 17.7	93 15.9	91 14.8	89 13.9	86 13.2	84 12.4	82 11.8	80 11.3	78 10.8	76 10.4	74 9.9	72 9.6	70 9.2	69 9.0	67 8.6	65 8.4	63 8.0	62 7.8	60 7.6	58 7.3	57 7.2	55 6.9	53 6.7	52 6.6	51 6.4	49 6.2	48 6.0	47 5.7	45 5.5	43 5.2	40 4.9	38 4.6	35 4.4	33 3.7	28 3.2	24
180	98 18.9	96 17.3	94 15.5	91 14.5	89 13.7	87 12.9	85 12.2	83 11.6	81 11.1	79 10.6	77 10.1	76 9.7	74 9.4	72 9.0	70 8.8	69 8.4	67 8.1	66 7.8	64 7.6	62 7.4	61 7.2	59 7.0	57 6.8	56 6.5	55 6.4	53 6.2	52 6.0	51 5.8	50 5.7	48 5.4	47 5.2	45 4.8	42 4.6	40 4.3	38 3.8	35 3.3	30 3.3	26
190	98 18.5	96 16.9	94 15.2	92 14.2	90 13.4	88 12.7	86 12.0	84 11.4	82 10.9	80 10.5	78 10.0	76 9.6	75 9.2	73 8.9	71 8.6	69 8.2	68 7.9	66 7.7	65 7.4	63 7.2	62 7.0	60 6.8	58 6.6	57 6.4	56 6.2	54 6.0	53 5.9	51 5.7	50 5.5	49 5.3	46 5.0	44 4.8	42 4.5	39 4.0	37 3.6	32 3.3	26
200	98 18.1	96 16.4	94 14.9	92 14.0	91 13.2	89 12.4	86 11.8	84 11.2	82 10.8	80 10.3	79 9.8	77 9.4	75 9.1	74 8.8	72 8.4	70 8.1	69 7.7	67 7.5	66 7.2	64 7.0	63 6.9	61 6.6	60 6.4	58 6.2	57 6.0	55 5.9	54 5.7	53 5.6	52 5.4	51 5.2	48 4.9	46 4.7	43 4.5	41 4.3	39 3.8	34 3.3	30
210	98 17.7	96 16.0	94 14.6	92 13.8	90 13.0	88 12.2	86 11.7	85 11.1	83 10.6	81 10.0	79 9.7	78 9.2	76 9.0	75 8.7	73 8.3	71 8.0	70 7.6	68 7.4	67 7.1	65 6.9	64 6.8	63 6.5	61 6.3	60 6.1	59 5.9	57 5.8	56 5.5	54 5.4	53 5.3	52 5.1	50 4.8	47 4.6	45 4.4	43 4.2	41 3.7	36 3.2	32

Table 2. --Dial settings with corresponding equilibrium moisture content values for improved Forest Products Laboratory hygrostat[1]

Dial setting	Equilibrium moisture content of wood[2]
	Percent
20	5
24	6
28	7
32	8
36	9
40	10
44	11
47	12
51	13
54	14
58	15
61	16
64	17
67	18
70	19

[1]A maple wood element was used.

[2]Average values within ±1.5 percent.

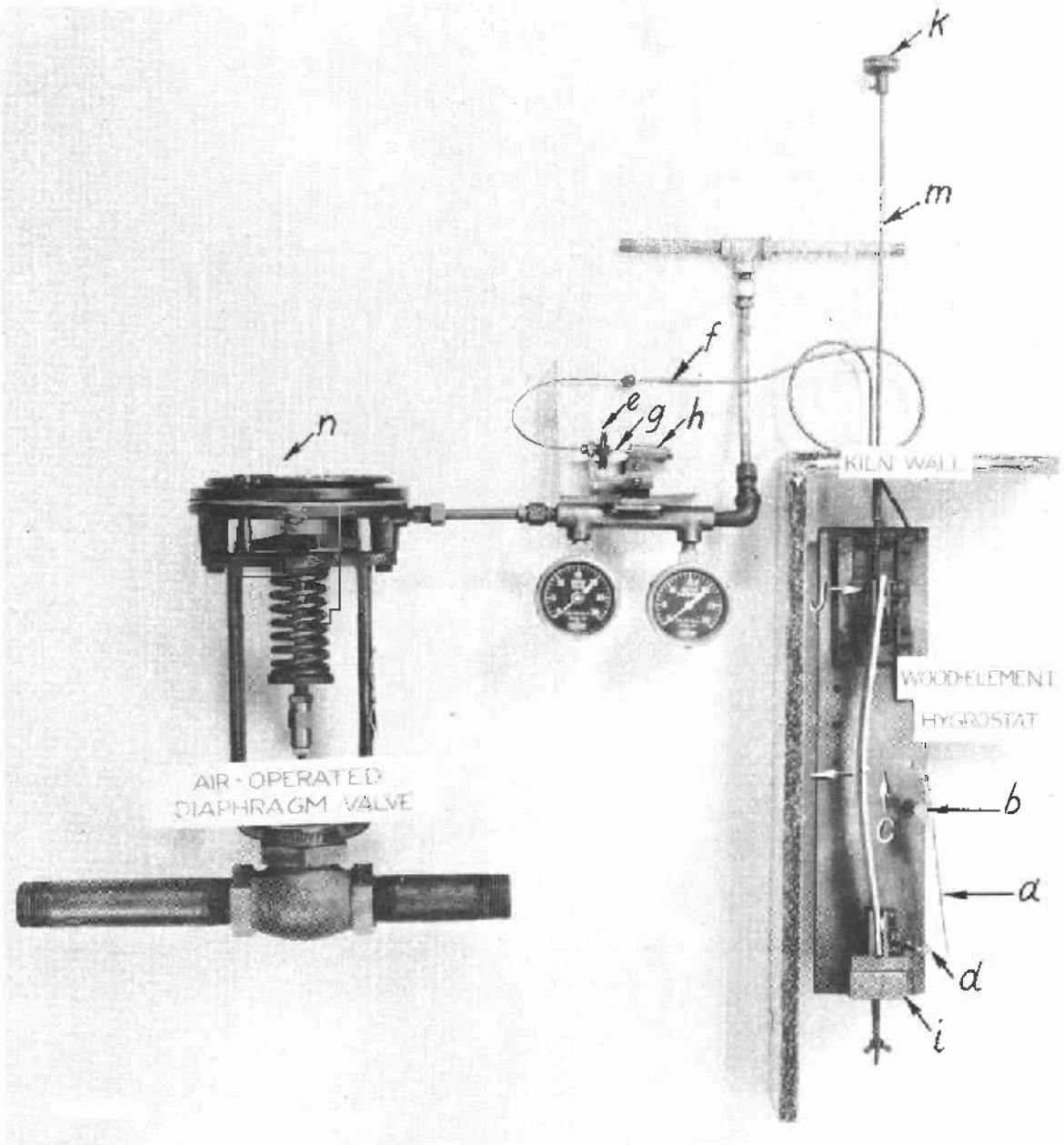
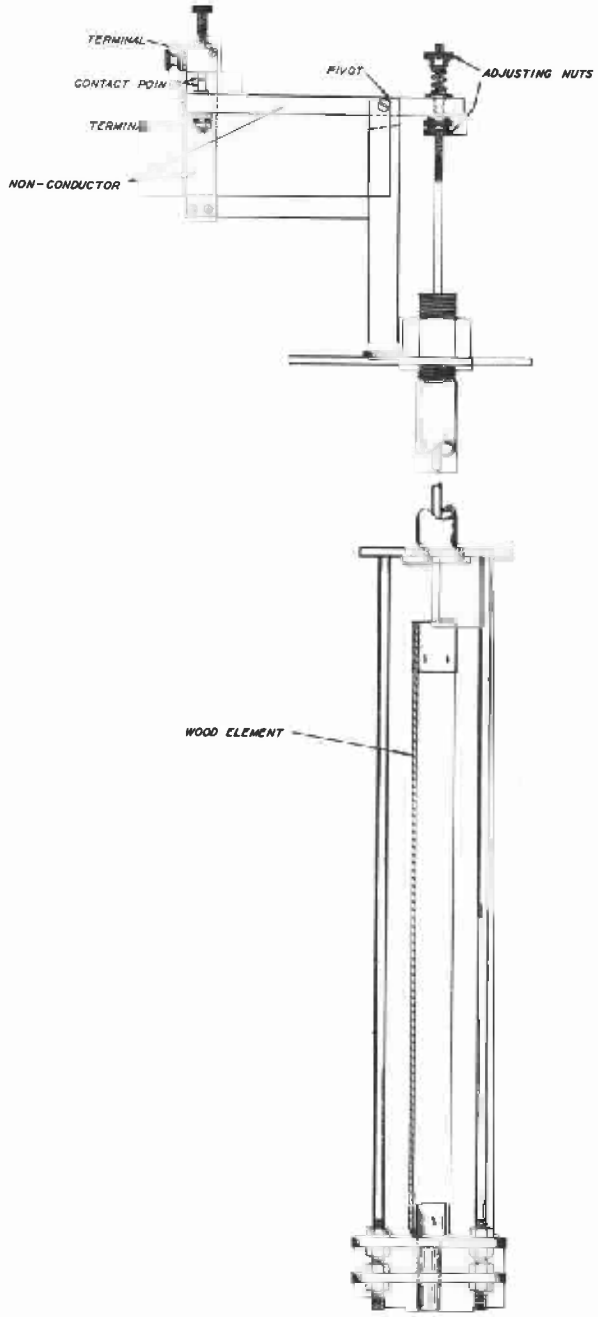


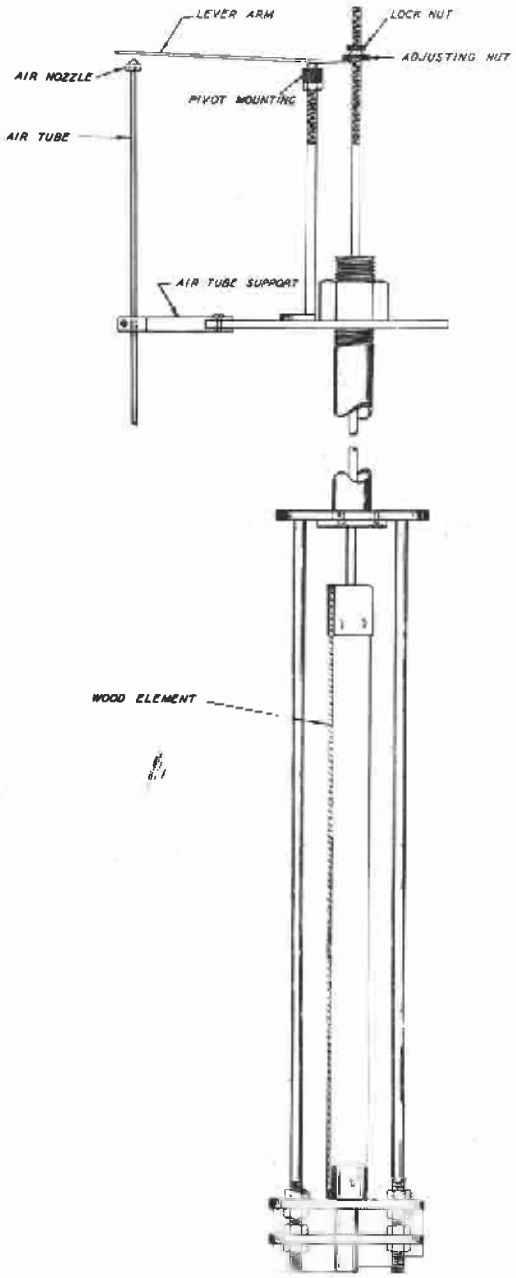
Figure 1.--Early type of F.P.L. hygrostat showing curved wood element and method of connecting hygrostat to auxiliary air mechanism and air-operated diaphragm valve. Parts as labeled are: a, lever arm; b, pivot; c, linkage; d, air nozzle; e, bellows; f, copper tube; g, pin; h, auxiliary air mechanism; i, fixed block; j, adjustable block; k, adjusting knob; m, adjusting rod; n, control valve.

Z M 66676 F



ELECTRIC CONTROL

Figure 2.--Improved F.P.L. hygrostat to be used with electrically operated control valves and free-floating wood element.



AIR CONTROL

Figure 3.--Improved F.P.L. hygrostat with free-floating wood element, to be used with air-operated control valves.

Z M 56677 F

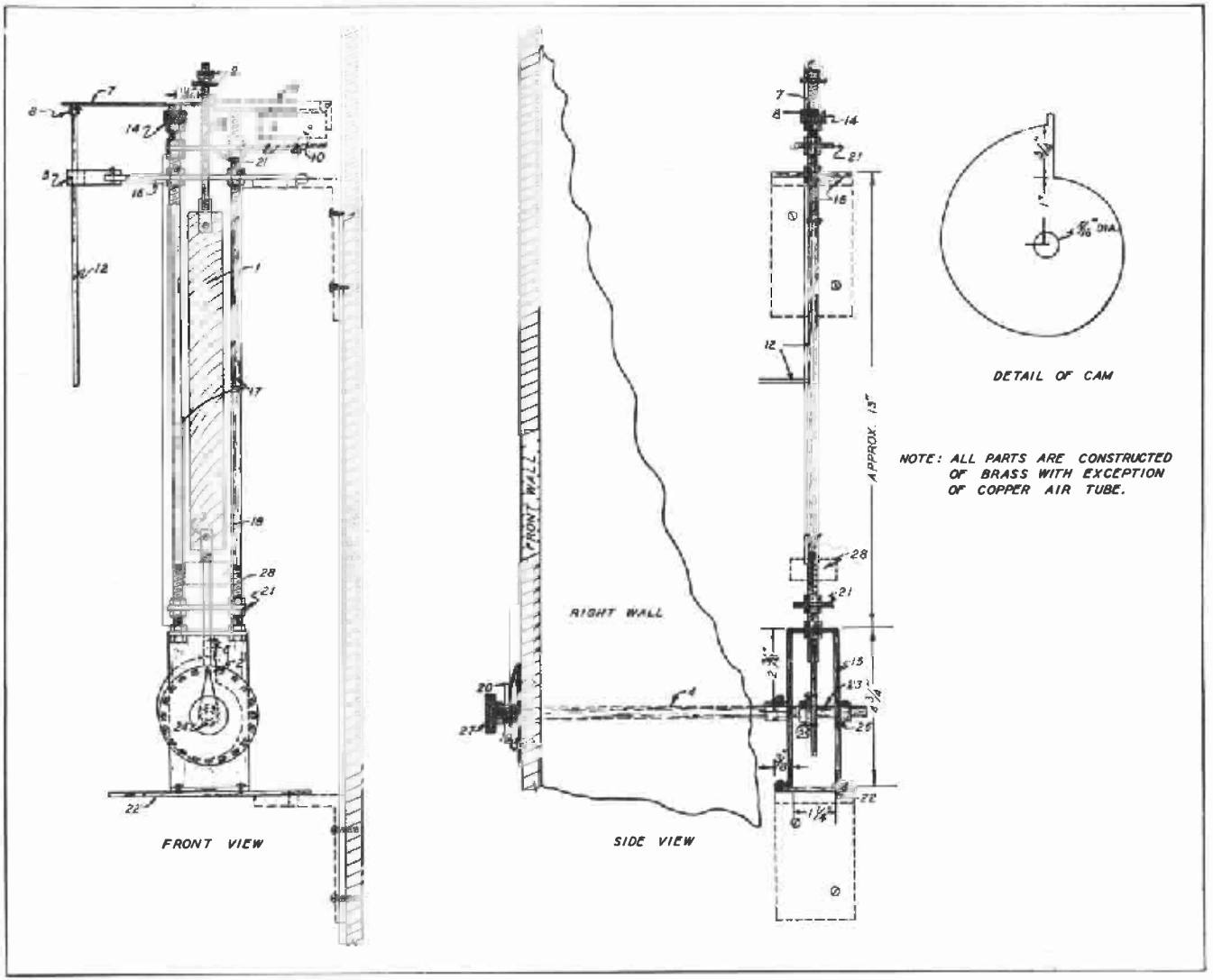


Figure 4.--Detail drawing and method of mounting improved F.P.L. free-floating wood-element hygrostat, with necessary dimensions and part numbers for construction purposes. Parts correspond by number to those described in parts list in appendix.

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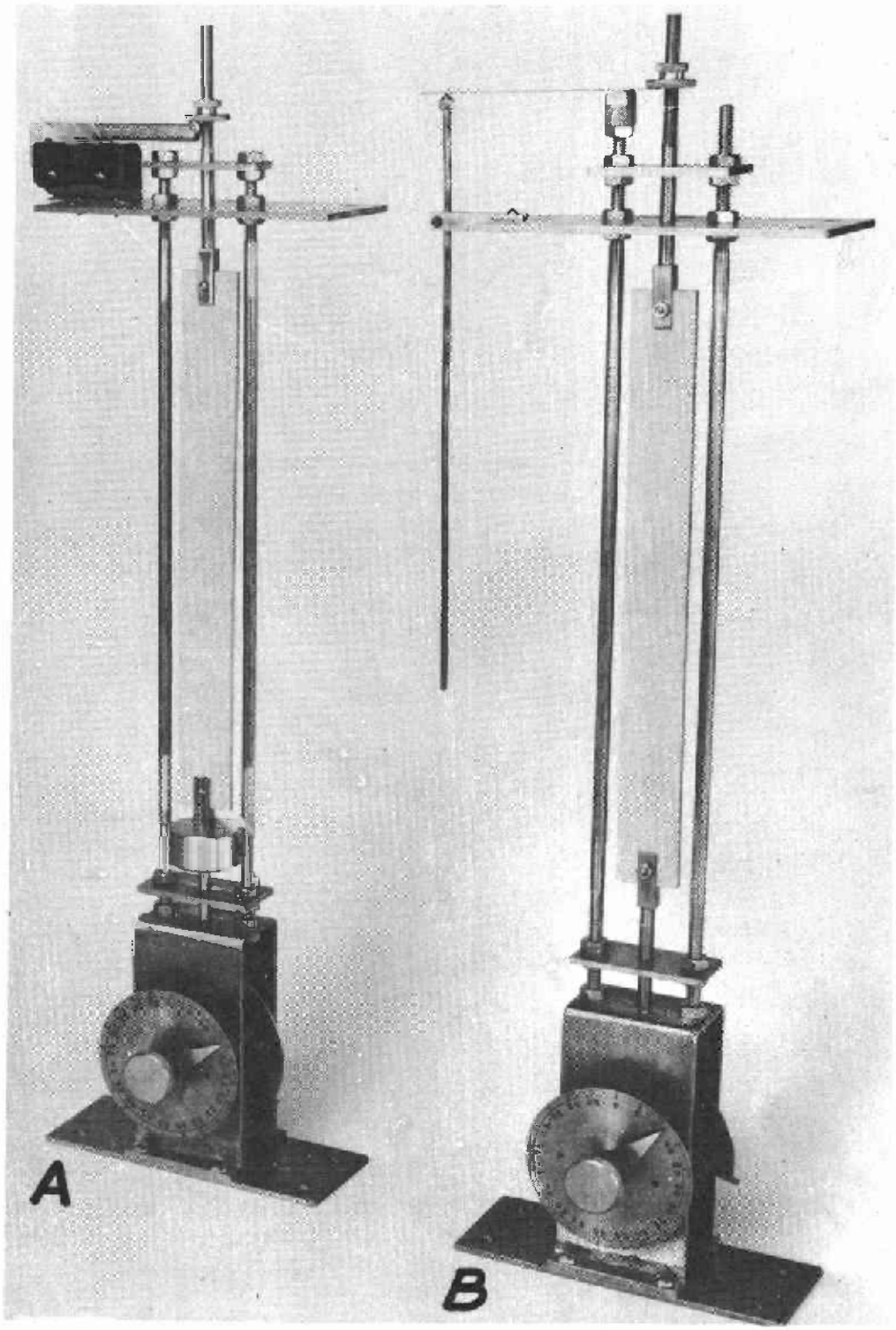

Figure 5.--A, Free-floating wood element hygrostat to be used with electrically operated control valves. B, similar hygrostat used with air-operated control valves.

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