Hines Digital Sundial, p. 1/2 (wEarth)

https://www.hineslab.com/optical-projects/digital-sundial/

HinesLab grants the right to construct one Digital Sundial.

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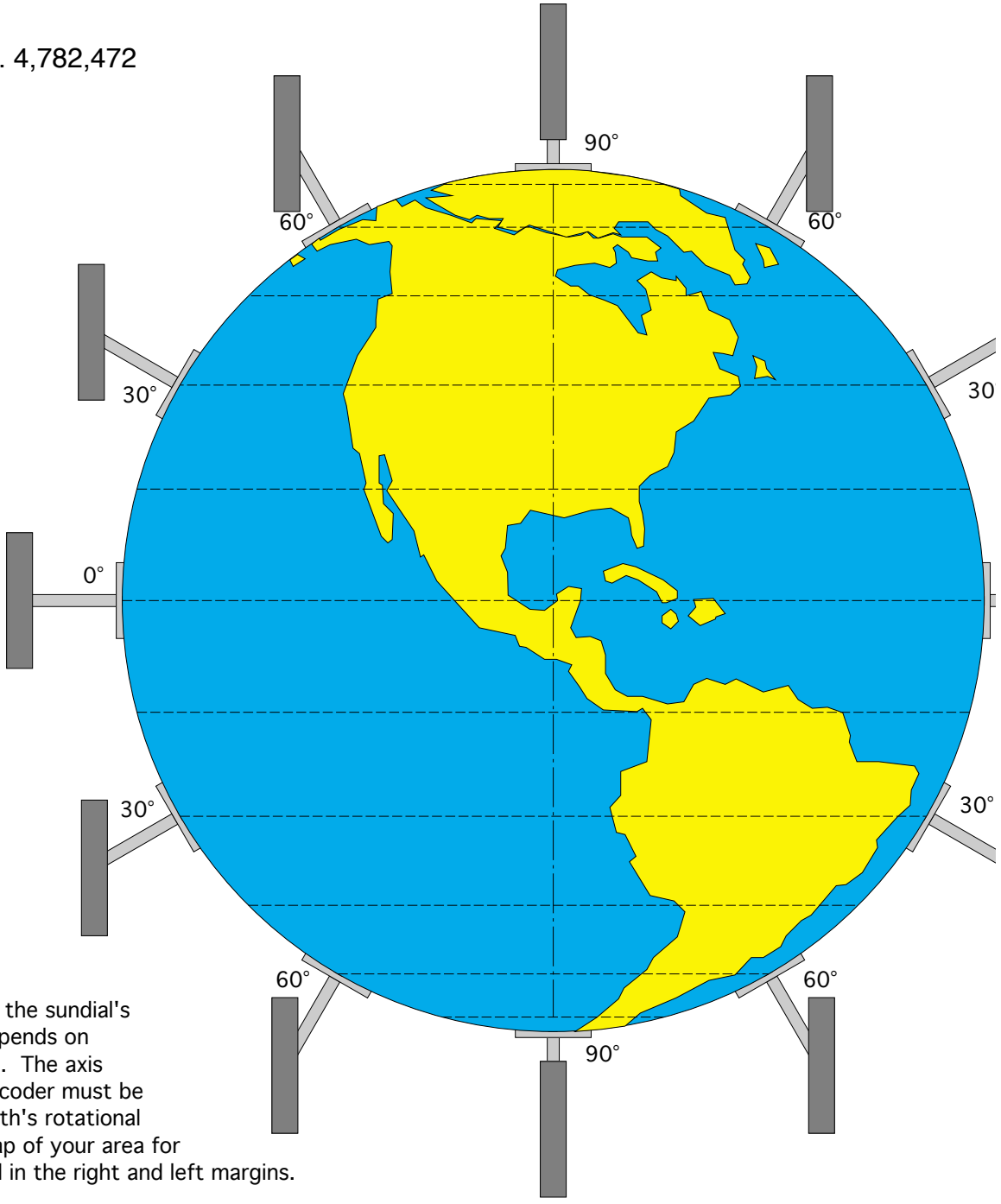
email: Steve@HinesLab.com

Dec. 21, 1984
Nov. 1, 1988, U.S. Pat. 4,782,472
August 27, 1994
Sept. 17, 2007
May 6, 2025



The angle of the sundial's encoder cylinder depends on its latitude on Earth. The axis of the cylindrical encoder must be parallel with the Earth's rotational axis. Refer to a map of your area for the latitude, printed in the right and left margins.

Theory:

Sundial clocks have been made for centuries. Traditionally, light shines past a gnomor the sun moves in the sky, the shadow of the gnomon moves across the numbers on the dial, continuously sweeping shadow. This is the classic analog sundial.

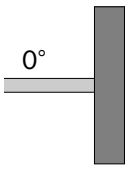
In the Hines Digital Sundial, sun shines through the cut outs of a cylindrical mask, onto transmit light to appropriate segments of a 7-segment numerical display. This constitutes tl converter.

Analog-to-digital converters are commonly used in electronic circuits. As a further pa the optical fibers, from the encoding cylinder to the display, constitutes optical "OR gates". segment display of the hours numeral is illuminated by fibers from the appropriate openings or 9, or 0. The plans provide a design for a readout until 4 PM, therefore the 5 is not used ir

The principles used in the digital sundial could also be used to give angular readout of

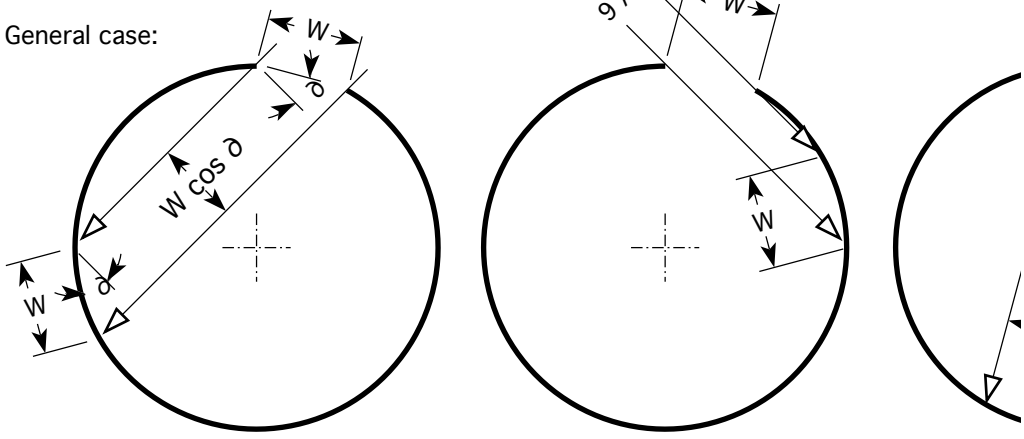
If you prefer you can extend the hours of operation to earlier than 9 AM, and/or later adding openings and fibers. The 9 AM to 4 PM range was chosen to keep from having the in which would reduce the contrast of the segments of the display. Even the "dark" fibers are problem can be helped if you devise a partition in the encoder between sections.

The limit of accuracy of any sundial, analog or digital, is ±2 minutes, or 4 minutes. Th of the sun, as seen from Earth. The sun measures approximately 1/2° across its diameter. buildings, etc. Each 1° of angular motion of the sun represents 4 minutes of time (1,440 mi minutes of time for the trailing edge of the sun to reach the position of the leading edge. Be the limit of measurement cannot exceed 1/2 of the resolution of the measurement system, than every 4 minutes. Because digital displays are read in 10-minute increments, the "units- state "0", rather than in 4-minute increments.



G E O M E T R Y:

General case:



The use of the cylinder as the encoder provides the means c the cylinder, remains constant during the day.

As the sun sweeps across the sky the width of the light bea (W), is narrow in the early morning, equal to the width of the opening midday, and nar

As shown in the example of the hours' encoder above, at 1 identical to the width of the opening. At 9 AM, the width of light is reduced because

n onto a circular dial, marked with hours. As
and time is read from the position of the

the receiving ends of optical fibers which
he only known optical analog-to-digital

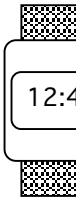
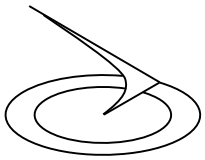
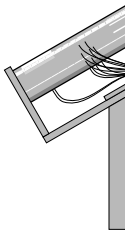
rallel to electronic circuits, the routing of
For example, the top segment of the 7-
in the encoder for 2, or 3, or 6, or 7, or 8,
n this series.

the sun's position.

than the 4 PM range shown in the plans, by
terior of the encoder flooded with light
looking up at bright blue sky. This contrast

is is due to the width and subtended angle
This is the cause of fuzzy shadows from tall
n./day ÷ 360°). Therefore, it takes 2
ecause of the Nyquist principle, which says
sun dials cannot be read more accurately
minutes" display is left to read a steady

Time-keeping devices:

	Analog	Digit
Conventional clocks and watches.	 countless versions	 countless
Sundials	 hndreds of versions	Hines Digital Sundial  the only dig

How optical fiber

Optical fiber
large core, and a th
the thin outer clad
refracted (bent) ar

Light rays, w
cladding and reflec
only losses come fr

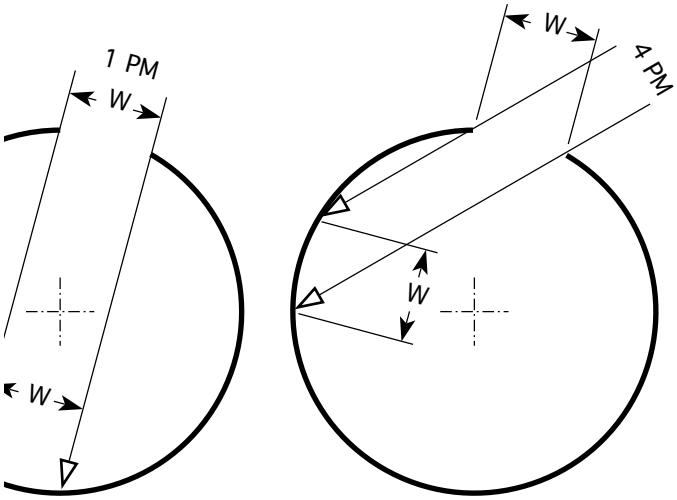
The effect is
reflects light, giving

Strands of e
as well as optical fi
oil, water, tape or
remaining to be tra

The optics of the P

The Plexiglas
low refractive inde
any materials whic
paper between the

*The effect



f assuring that the width of the illuminated area, inside

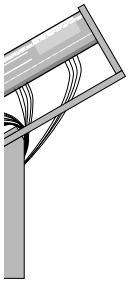
m (W cos ∂), which passes through the cylinder opening
row again in the late afternoon.

PM, the width of the lighted area inside the cylinder is
is entering the encoder from the side. When the light

al

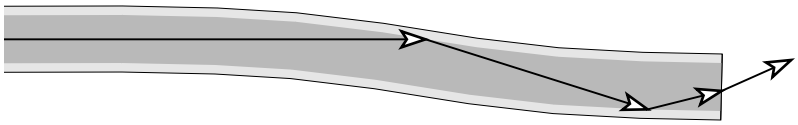
40

versions



gital sundial

s transmit light:



s are flexible, optically clear strands of glass or plastic which have a relatively in outer coating. The core is denser and has a higher refractive index than ding. The "refractive index" is a key factor in determining how light is nd reflected in a transparent material.

which transmit through the inner core hit the inner surface of the outer t back into the interior core. The efficiency of the reflection is 100%. The rom surface scratches, and any color density in the optical fiber.

s analogous to the way low-refractive-index hot air rising from a desert g the shimmering appearance of water.

qually transparent uncoated plastic rod (Plexiglas, etc.) would transmit light bers, however if anything which made optical contact with the rod, such as epoxy would bleed off the light, greatly reducing the amount of light ansmitted.

Plexiglas used in the numerical display:

s, used to form the numerals of the 7-segment display, does not have the x outer coating which is used on the optical fibers. Therefore, avoid using h forms a wetting contact*, such as paint or tape. Use strips of dry black segments to optically isolate them.

of making optical contact can be seen as the dark contact area on the

Materials needed

clear cast (not extruded)
24" L. x 4" outside diame

transparent clear or anti-
glass, or Plexiglas, 3-7/1

3/16 thk. x 1-1/2 L. x 3/4 i
3/16 thk. x 1-1/2 L. x 9/16
3/16 thk. x 1-1/2 L. x 1/2 i
3/16 thk. x 1-1/2 L. x 5/16
3/16 dia. rod x 1-1/2 in. L

Optical fibers (69 e
1.5 - 2mm (0.06 - 0.078"
Unsheathed fibers recon

AZIMOM, 12¢/ft.

CHINLY, 5 - 7¢/ft.

ESKA, ?¢/ft.

EVESOAR, 4-11¢/ft.

FIREWORK, 4 - 9¢/ft.

INDUSTRIAL FIBER OP

1/4 in. thk. hard wood

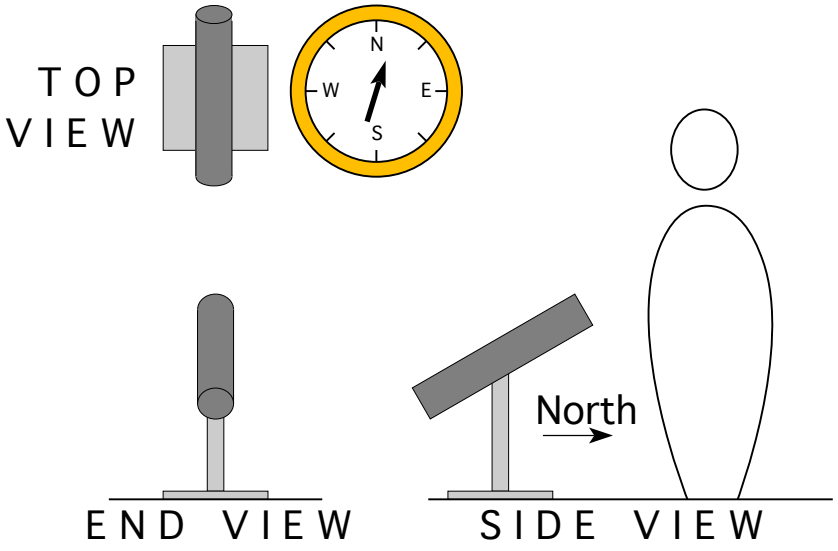
1/2 in. thk. plywood

3/4 in. thk. hard wood an

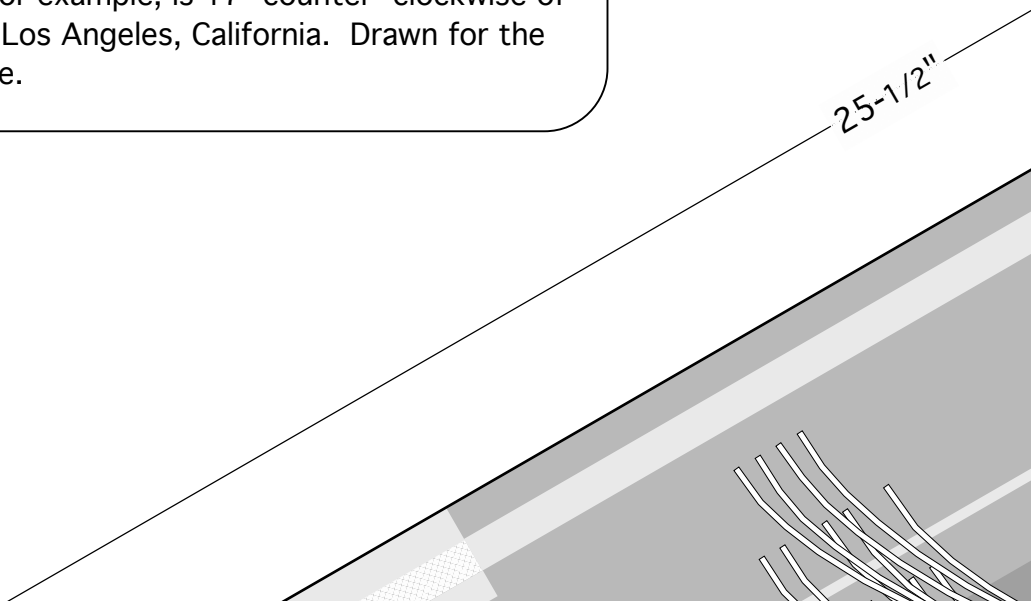
:	Used for	Quantity	Suppliers:
Plexiglas cylinder eter, 1/8" thk. wall	encoder (gnomon)	1	Professional Plastics https://www.professionalplastics.com
reflection (museum) 6 x 5-7/16 x ≈1/8" thk.	window	1	Plastics Depot Burbank, CA, USA www.PlasticDepotOfBurbank.com
n. W. clear Plex in. W. n. W. in. W. .	7-segment display	8 6 6 2 2	McMaster-Carr Supply Co. https://www.McMaster.com 1x12" flat, #1227T819 3/16" dia. round: #8531K12
equal-length fibers required):) dia. Larger=brighter. nmended	to connect the encoder to the 7-bar segments in the display	500 ft. fiber allows 7 ft. separation between encoder and display 1,000 ft. allows 15 ft. separation 2,000 ft. allows 29 ft. separation	
			www.amazon.com
			www.amazon.com
			http://www.Calsak.com
			www.amazon.com
			www.amazon.com
TICS, 17-38¢/ft.			https://www.i-fiberoptics.com
	display housing		local lumber yard
	encoder end caps, and support stand		
d plywood	pull-out drawer of display, and support stand		

E N C O D E R

(GNOMON)



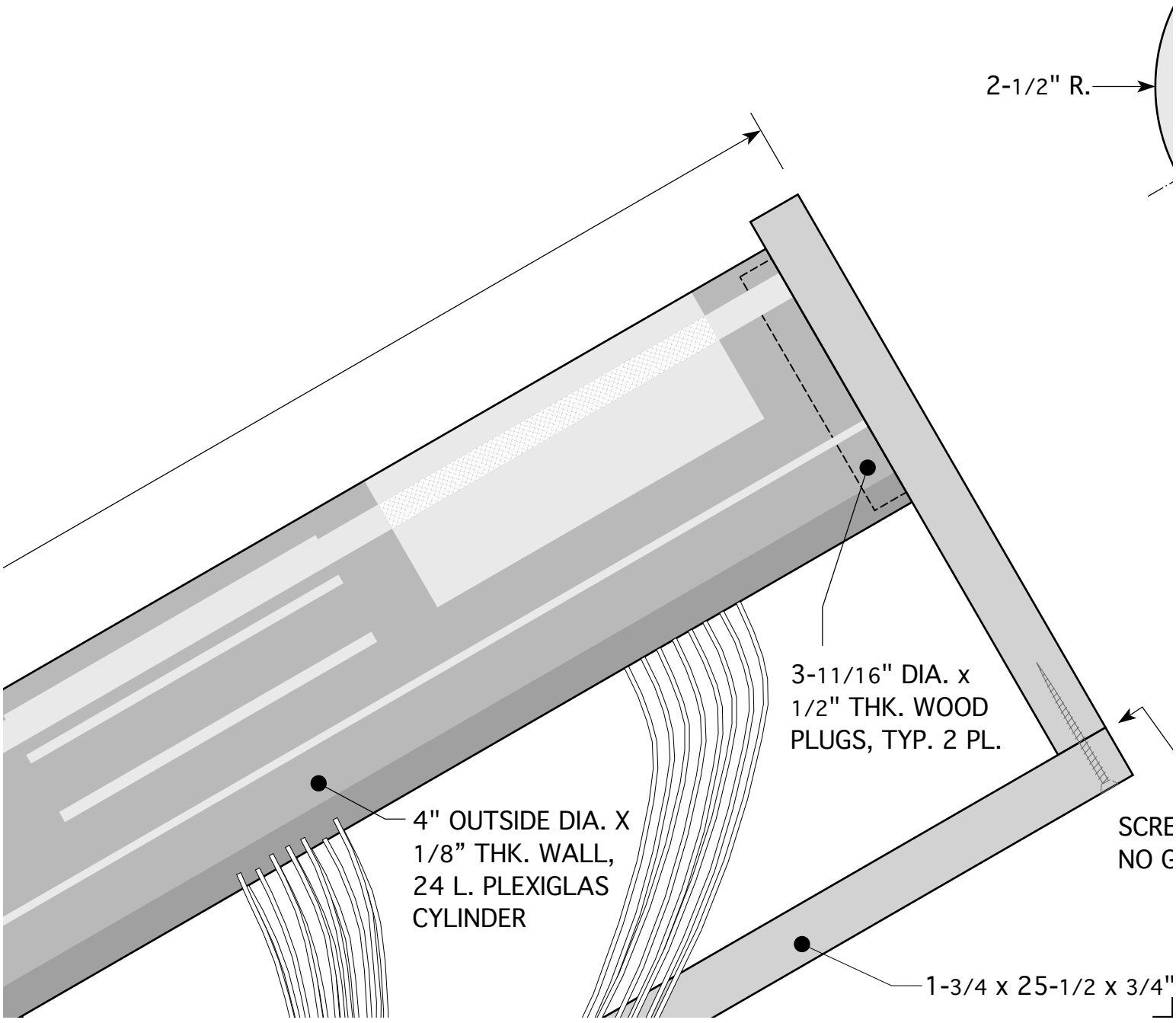
Rotate the Digital Sundial so that it is aligned with true North, which, for example, is 17° counter- clockwise of magnetic North for Los Angeles, California. Drawn for the northern hemisphere.



identical to the width of the opening. At 9 AM, the width of light is reduced because
strikes the inside of the cylinder it is elongated to a width equal to the opening.

This permits the fibers to be distributed evenly around the c
evenly distributed slits can be used in the tens-of-minutes' section.

This may seem obvious and self evident; however, without s
last 60 minutes at 1 PM, 62 minutes at noon and 2 PM, 69 minutes at 10 AM and 3 P

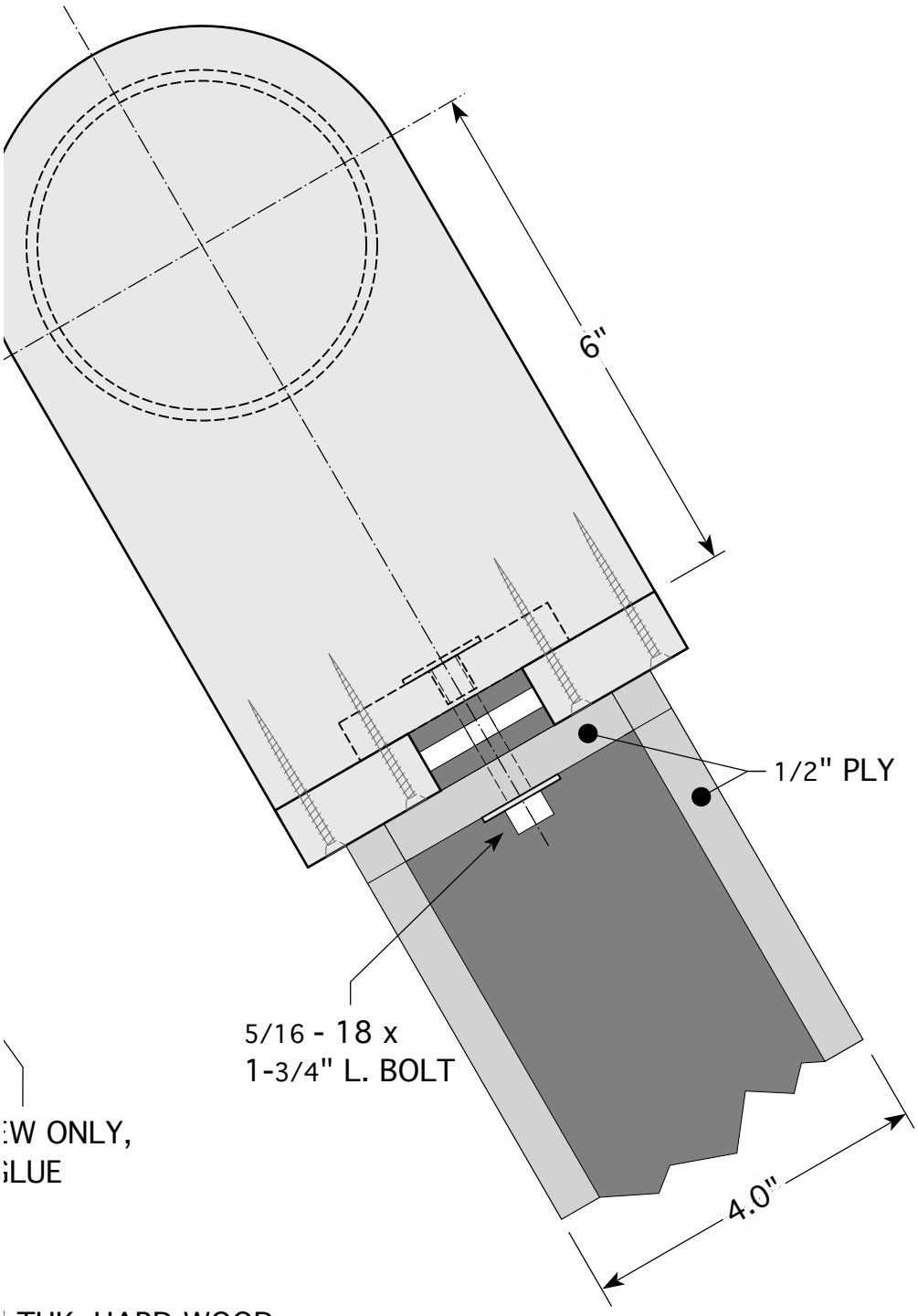


ct is entering the encoder from the side. When the light

ylinder in the hours' section, and that equal width,

uch fortuitous geometry, the display of "an hour" might
M, and 85 minutes at 9 AM and 4 PM.

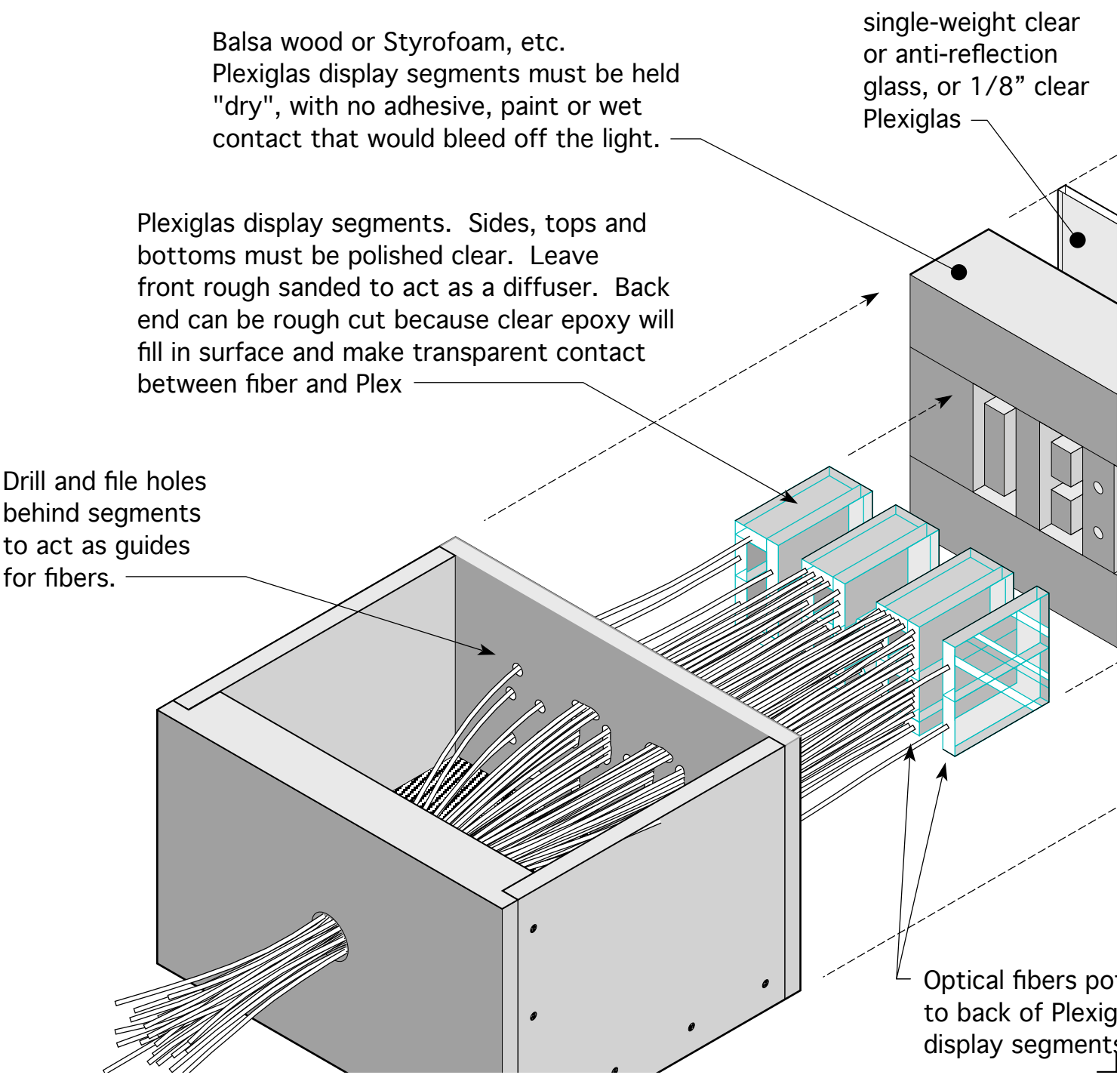
bottom of a water

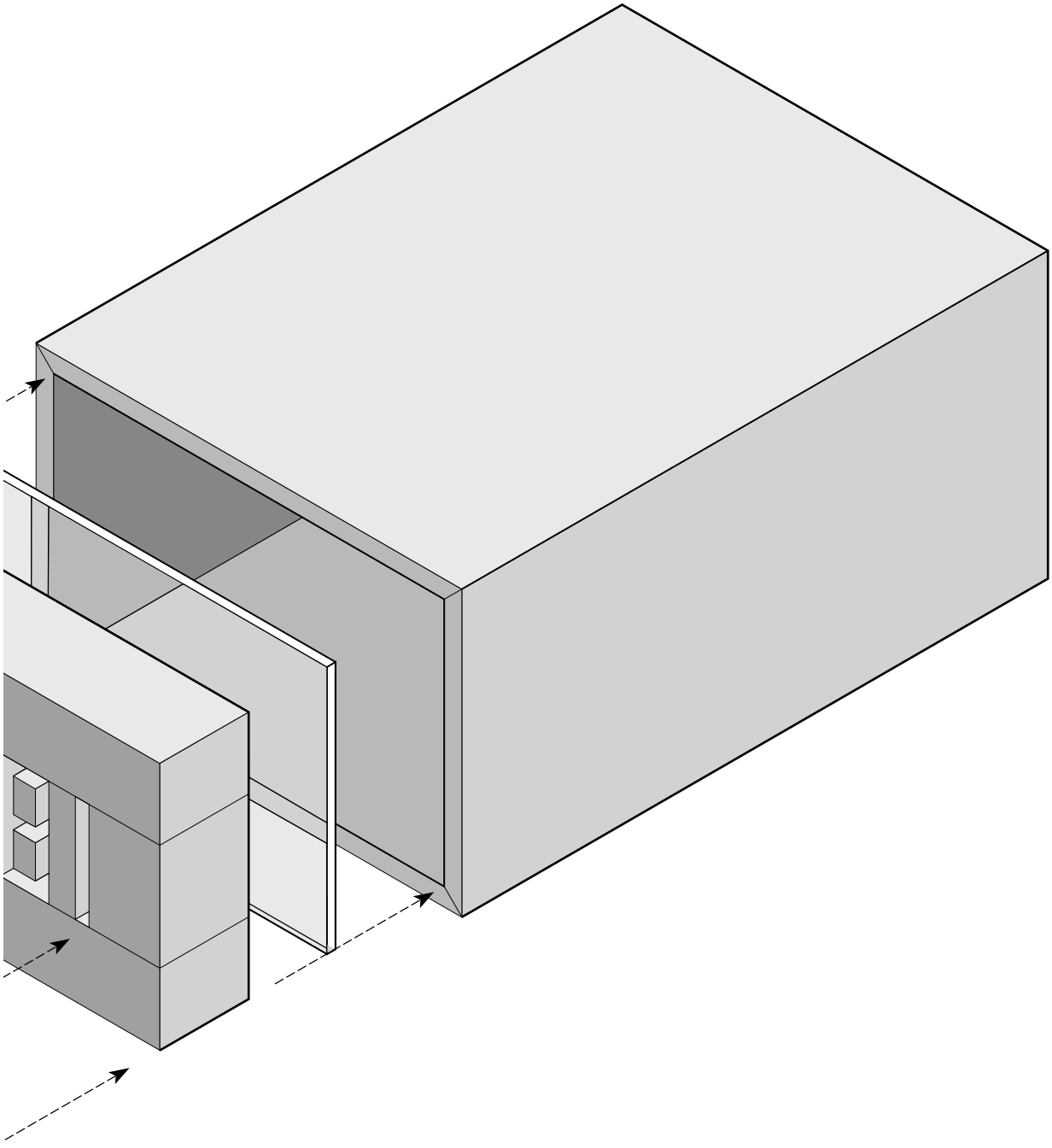


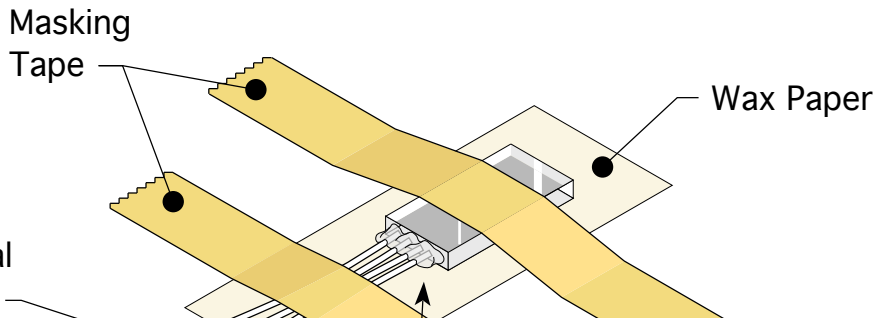
EW ONLY,
GLUE

THK. HARD WOOD

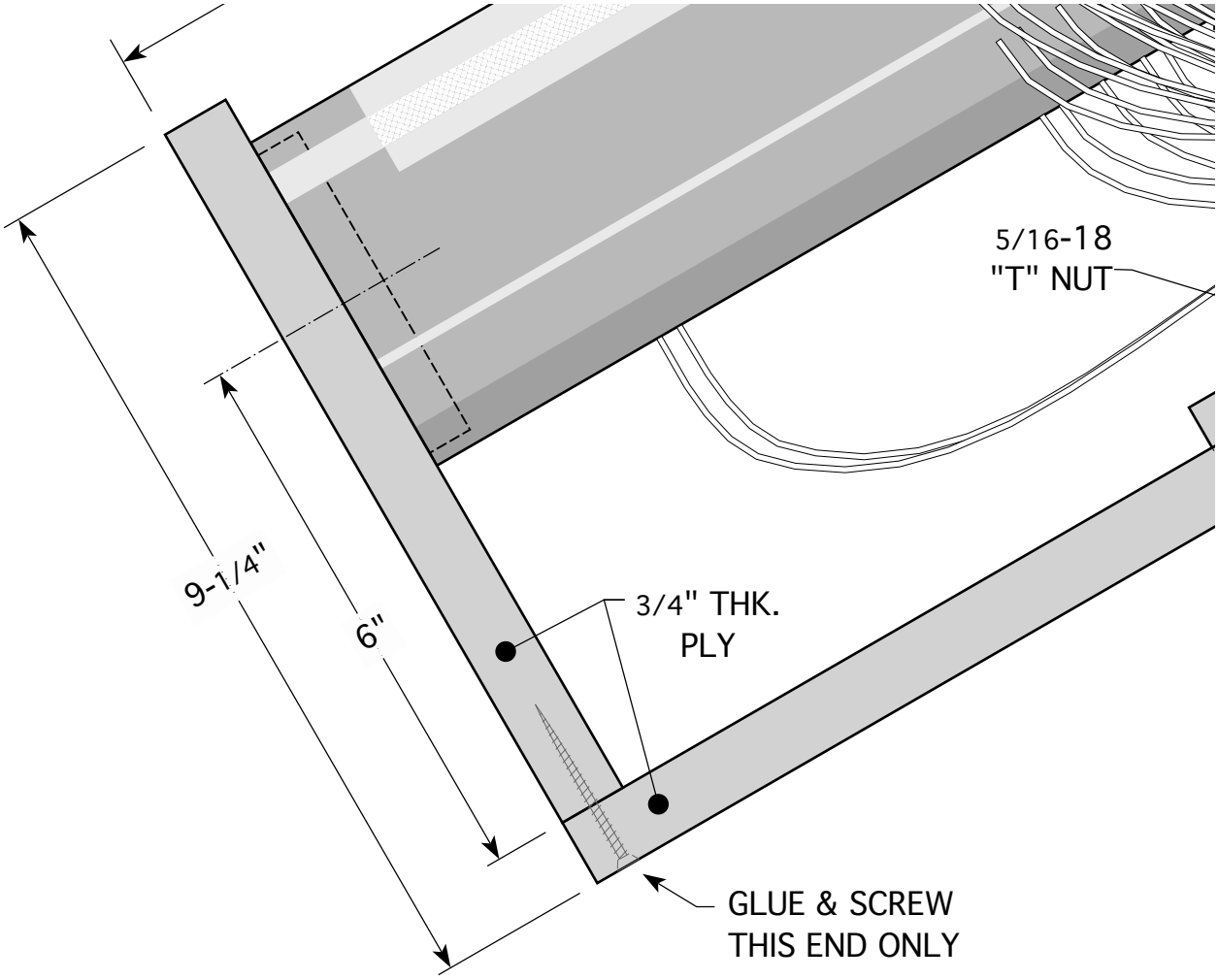
DISPLAY


Balsa wood or Styrofoam, etc.
Plexiglas display segments must be held "dry", with no adhesive, paint or wet contact that would bleed off the light.
single-weight clear or anti-reflection glass, or 1/8” clear Plexiglas
Plexiglas display segments. Sides, tops and bottoms must be polished clear. Leave front rough sanded to act as a diffuser. Back end can be rough cut because clear epoxy will fill in surface and make transparent contact between fiber and Plex
Drill and file holes behind segments to act as guides for fibers.
Optical fibers po
to back of Plexig
display segment



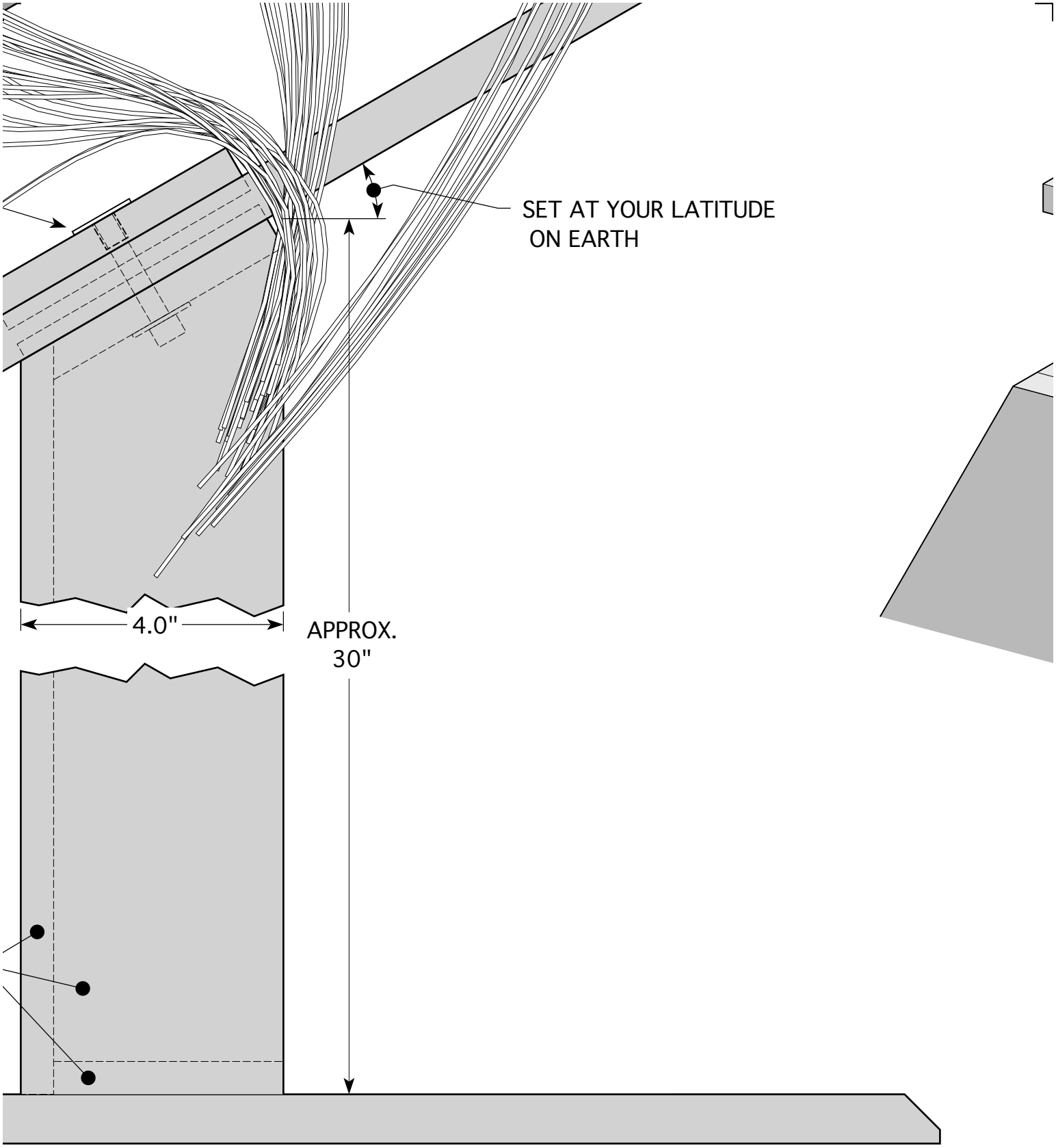


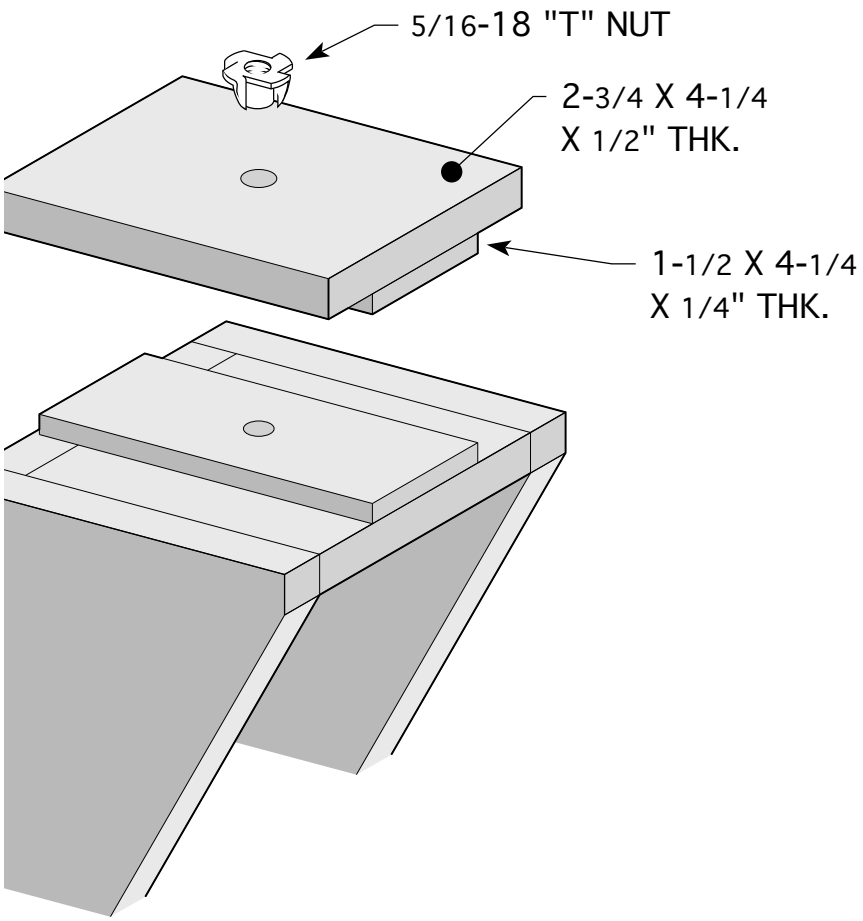
tted
las
s.

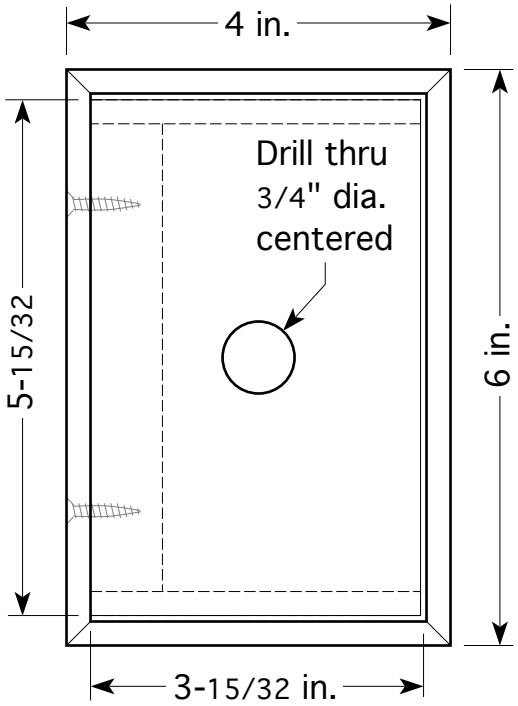


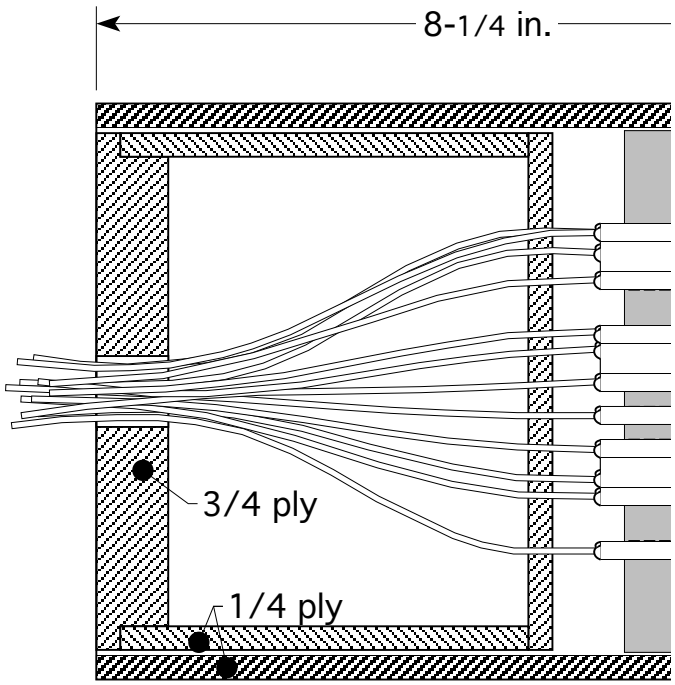
1/2" PLY
TYP.

24" DIA. OR SQUARE X 3/4"
THK. PLYWOOD BASE


SET AT YOUR LATITUDE
ON EARTH
4.0"
APPROX.
30"

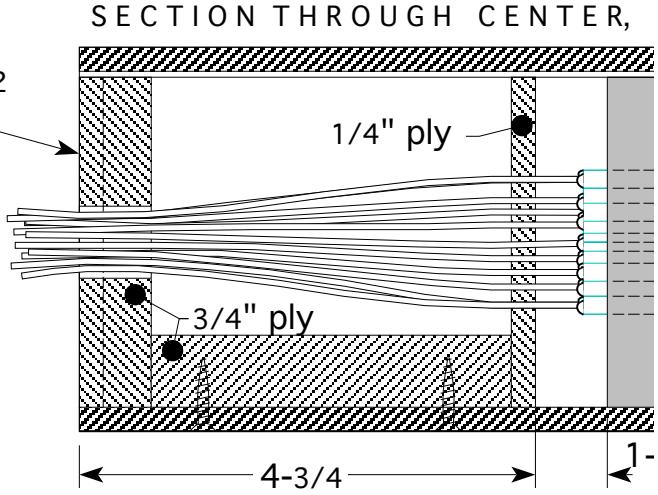

5/16-18 "T" NUT
2-3/4 X 4-1/4
X 1/2" THK.
1-1/2 X 4-1/4
X 1/4" THK.



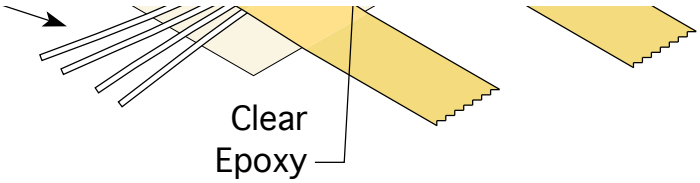


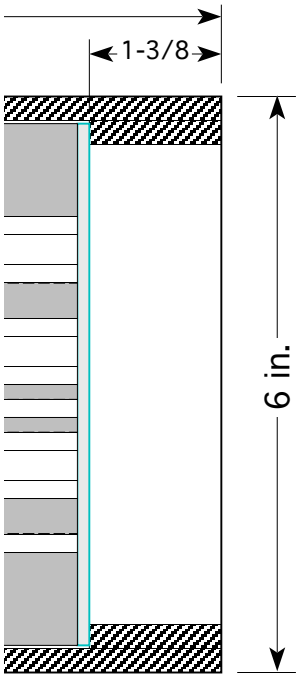
SECTION, TOP V

Back Panel
3-15/32 x 5-15/32
x 3/4 in. thk.



Drwg. Scale: 1/2

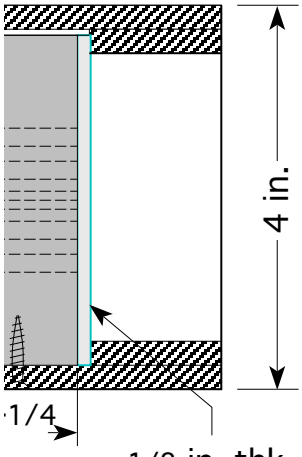




I E W

Clear Plexiglas required for display.	Quantity
3/4 W. x 1-1/2 L. x 3/16 in. thk.	8
9/16 W. x 1-1/2 L. x 3/16 in. thk.	6
1/2 W. x 1-1/2 L. x 3/16 in. thk.	6
5/16 W. x 1-1/2 L. x 3/16 in. thk.	2
3/16 dia. rod x 1-1/2 in. L.	2

SIDE VIEW



1/8 in. thk. Plexiglas
3-7/16 x 5-7/16"
light gray tint, or clear