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Building Research Note

THE HELIODON

by

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The current practice of using large areas of glass in exterior walls aggravates the problem of coping with solar radiation on buildings. Solar control by outside shades is one of the methods that can be advantageous in some applications. The design of outside shades or the determination of shading by surrounding objects requires knowledge of the geometric relations between the sun, building and shading surface. In the case of a simple shade, such as the vertical or horizontal projection from a vertical wall, the area shaded by the projection can be determined by calculation, utilizing solar charts, slide rules or tables, developed specifically for the purpose.

When the complexity of the building and shades increases, these methods become tedious and time consuming. It is then advantageous to use models to determine the shadow lines. In this case, it is only necessary to position the model relative to a parallel beam of light in the same way as the real object will sit relative to the sun's rays. A heliodon is a simple device for positioning a model with respect to a light beam (Figure 1).

The angle at which the sun strikes the surface of a building depends on:

(1) time of day

(2) date

(3) latitude of the building site

(4) orientation of the building with respect to north.

The heliodon has adjustments for all four parameters and when they have all been set to the prescribed values, the model is in the desired position relative to the beam of light.

A heliodon has been designed at DBR; Figure 1 is a photograph of it and the working drawings are given in Figures 2, 3, 4, and 5.

It should be noted that the graduation marks for latitude and time-of-year scales are not given on the drawings. These marks can be inscribed accurately after the heliodon is assembled. The latitude scale is obtained by setting the angle $90-\varphi$ (where φ is the latitude angle), using a suitable protractor, and marking the φ value opposite the latitude adjustment slider on the latitude scale face. This procedure is repeated until the latitude scale is complete for the range of latitude angles that can be set with the latitude adjustment assembly.

A similar procedure can be used for marking the two time-of-year scales - one for spring and summer, and the other for autumn and winter. The difference is that the angle δ is set and the time of year is noted opposite the time-of-year adjustment sliders. The values of δ versus time of year are given in Table I.

Local solar time is used to set the time of day on the helipdon. To obtain the local solar time corresponding to the local standard time, the following equation can be used:

$$\text{local solar time} = \text{local standard time} - KA + B$$

where

A = Longitudinal difference in degrees between the longitude of the site and the longitude at the centre of the local standard time zone

K = 4 min/degree

B = Equation of Time. The values of Equation of Time as well as the declination angle versus time of year are given in Table I for the year 1964. For shadow angle evaluation, these values can be used for any year.

OPERATION

The building model is placed on the mounting platform and oriented with respect to the compass markings. The latitude angle is set by positioning the latitude adjustment slide at the required latitude angle graduation.

The appropriate time-of-year scale to be used (spring and summer; autumn and winter) depends on the base plate support position:

open position (base plate at 23.5° to horizontal) - spring and summer scale

folded position (base plate horizontal) - autumn and winter scale.

Once the base plate support is positioned, the time of year is set by positioning the declination adjustment sliders at the required date mark.

The time of day is set simply by rotating the mounting platform with respect to the base plate. When the light beam is parallel to the mounting plate surface, this is the time when the sun is just below the horizon.

The light source must be placed so that the centreline of the light beam is parallel to the $\delta = 0°$ plane (i.e. the light beam must be parallel to the surface supporting the heliodon). In addition the heliodon must be oriented so that the light beam is perpendicular to the east-west line when the time of day is set at 12 or 24 hr.

One of the difficulties common to all heliodons is the generation of a beam of parallel light rays large enough to illuminate all the model. Small spotlights (approximately 6-in. diameter) are usually used for convenience but the light beam from these must diverge to cover an area as large as the model. The simplest way to reduce the divergence of the light rays arriving at the model is to place the light source as far as possible from the model, since the resulting error in the shadow angle at any particular point on the model is related to the ratio of the distances from the point to the centre of the light beam (assumed to be the centre of the mounting platform), and the distance from the model to the light source focal point. For example, if the point on the model is 1 ft from the centreline of the light beam and the light source is 18 ft away, and the focal point 2 ft further from the model, the divergence at this point is approximately 3 degrees.

The intensity of the light source required to give sharp shadow definition depends on the distance between the model and the light source and the divergence of the light rays. Satisfactory results can be obtained using a simple slide projector or photospot light at a distance of 30 ft.

Example Problem

It is required to determine the shaded areas of a building located in Ottawa (latitude = 45.5°, longitude = 75.5°) during the day of June 15. The building façade is facing east. It is assumed that a suitable building model is available.

Procedure:

(1) Place the heliodon on a horizontal surface.

(2) Set the latitude adjustment slider at 45.5° mark.

(3) Set the time-of-year adjustment sliders at June 15 marks.

(4) Set the base plate support in the open position since June 15 occurs in the summer season.

(5) Place the light source as far away as possible from the heliodon and position the centre of the light on a level with the centre of the mounting platform.

(6) Place a straight rod perpendicular to and in the centre of the mounting platform.

(7) Set the time of day at 12 noon and position the heliodon so that the shadow of the rod is parallel to the north-south line.

(8) Place the building model on the mounting platform and orient it with respect to the compass markings.

(9) The shaded areas of the building at a given solar time of day are obtained by setting this time on the heliodon and observing the shaded areas on the model.

TABLE I

THE SUN'S DECLINATION ANGLE AND EQUATION OF TIME VERSUS TIME OF YEAR FOR THE YEAR 1964

Month	Day	Declination		Eq. of Time		Angle δ	
		Deg.	Min.	Min.	Sec.	Deg.	Min.
January	1	-23	6	- 3	00	0	24
	15	-21	20	- 9	01	2	10
February	1	-17	26	-13	28	6	04
	15	-13	05	-14	15	10	25
March	1	- 7	39	-12	28	15	51
	15	- 2	13	- 9	05	21	17
April	1	4	28	- 4	00	4	28
	15	9	41	- 0	08	9	41
May	1	15	01	2	54	15	01
	15	18	49	3	44	18	49
June	1	22	02	2	21	22	02
	15	23	18	- 0	17	23	18
July	1	23	07	- 3	39	23	07
	15	21	34	- 5	50	21	34
August	1	18	04	- 6	15	18	04
	15	14	07	- 4	30	14	07
September	1	8	21	- 0	04	8	21
	15	3	06	4	40	3	06
Odtober	1	- 3	06	10	13	20	24
	15	- 8	27	14	07	15	03
November	1	-14	22	16	22	9	08
	15	-18	26	15	25	5	04
December	1	-21	46	11	03	1	44
	15	-23	15	4	58	0	15

Ref. The American Ephemeris and Nautical Almanac for the year 1964. United States Government Printing Office, Washington, 1962.

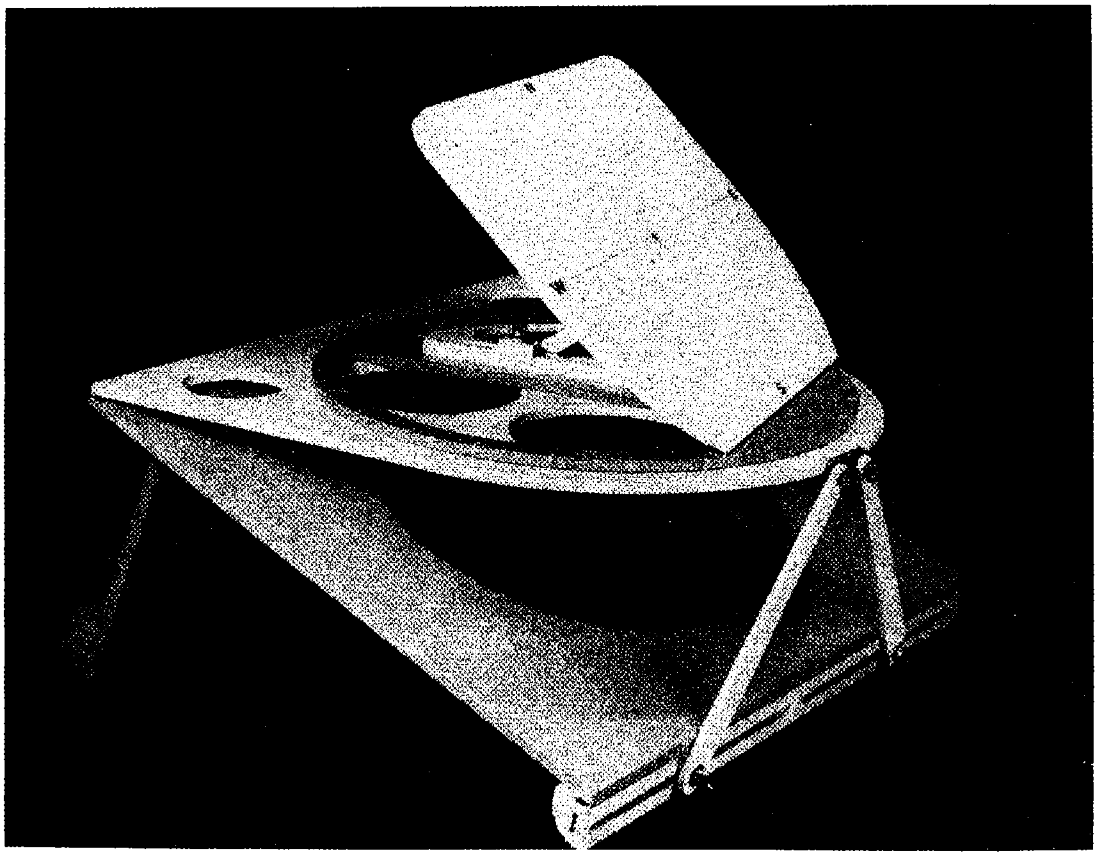


Figure 1   The Heliodon

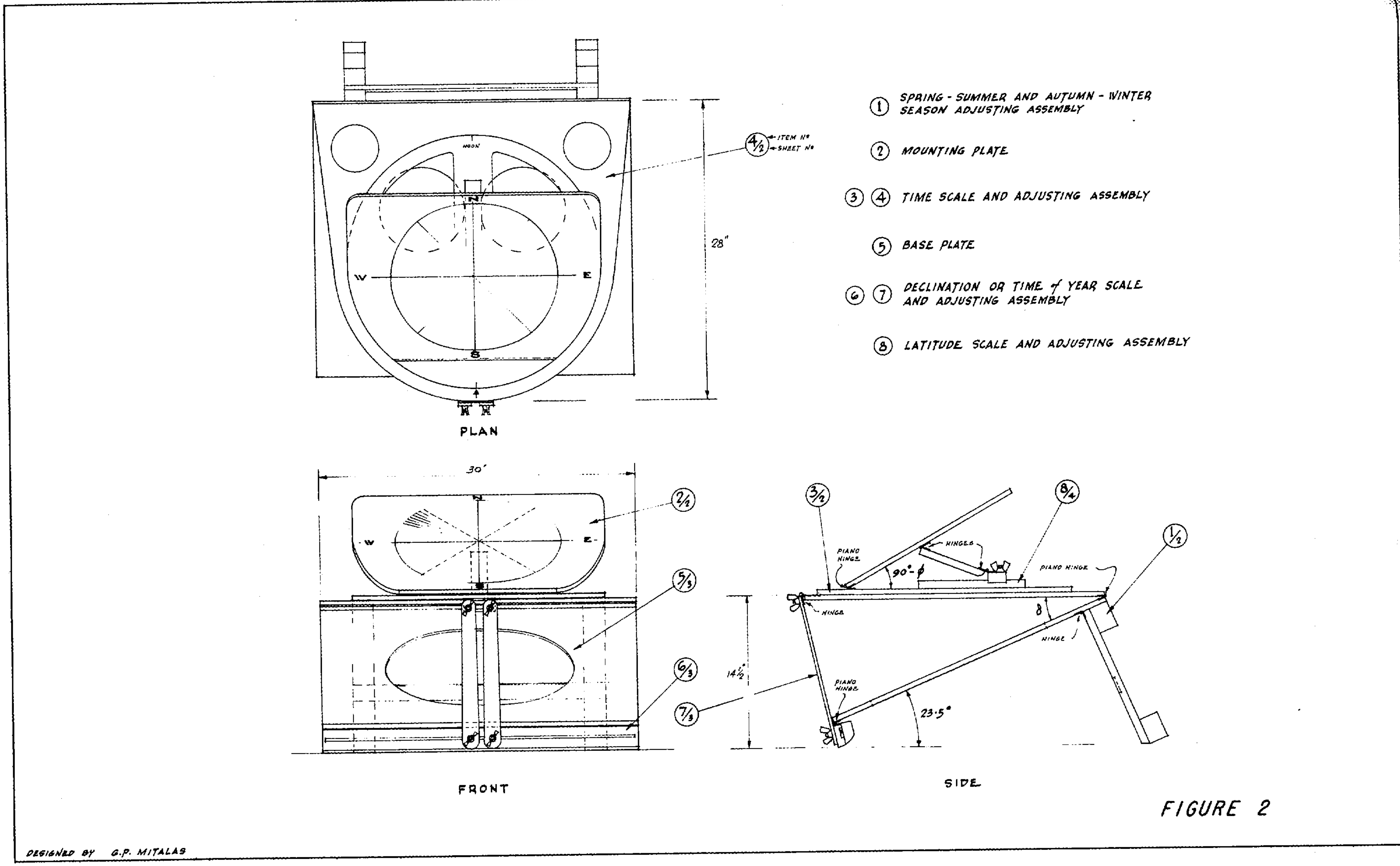
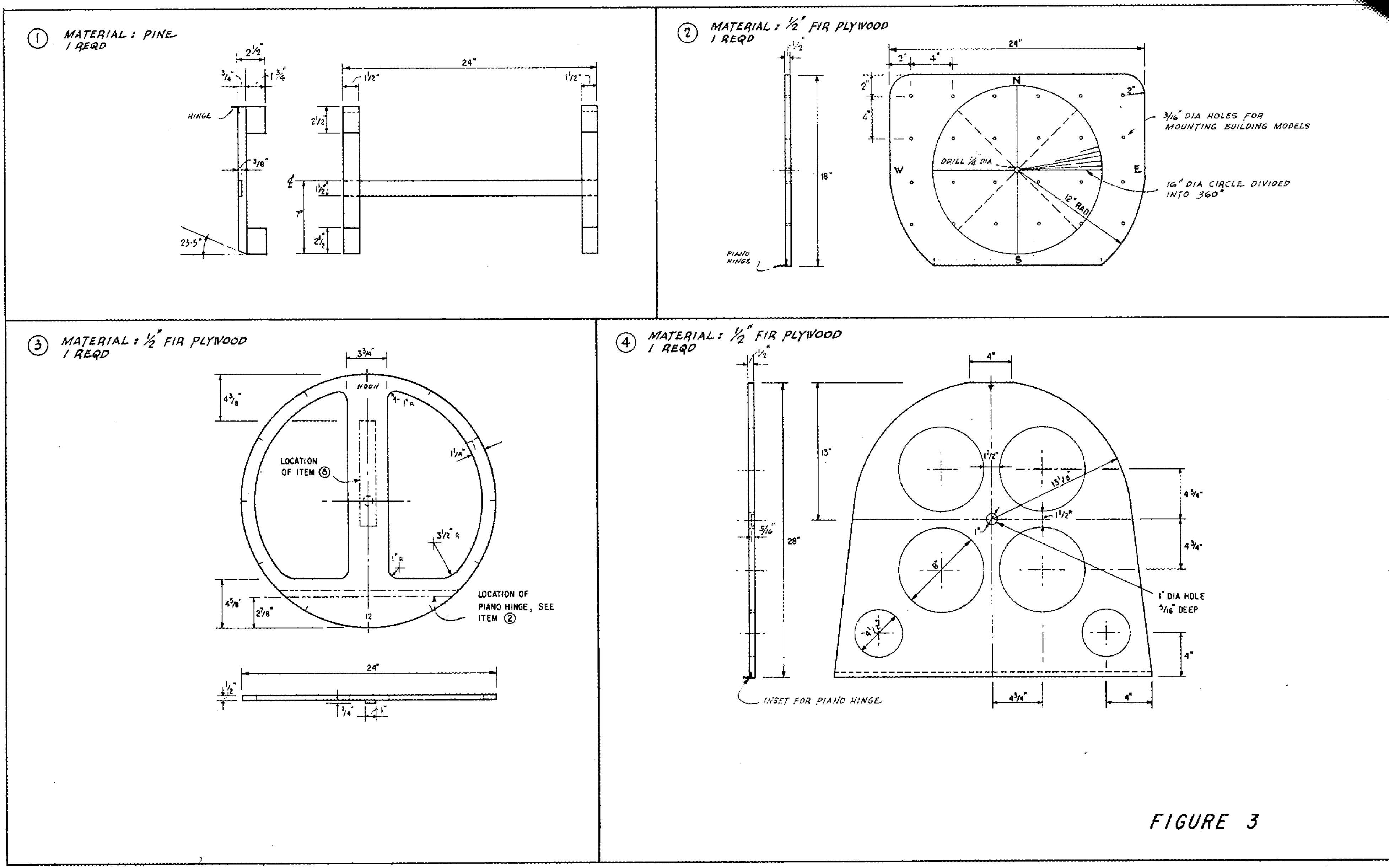
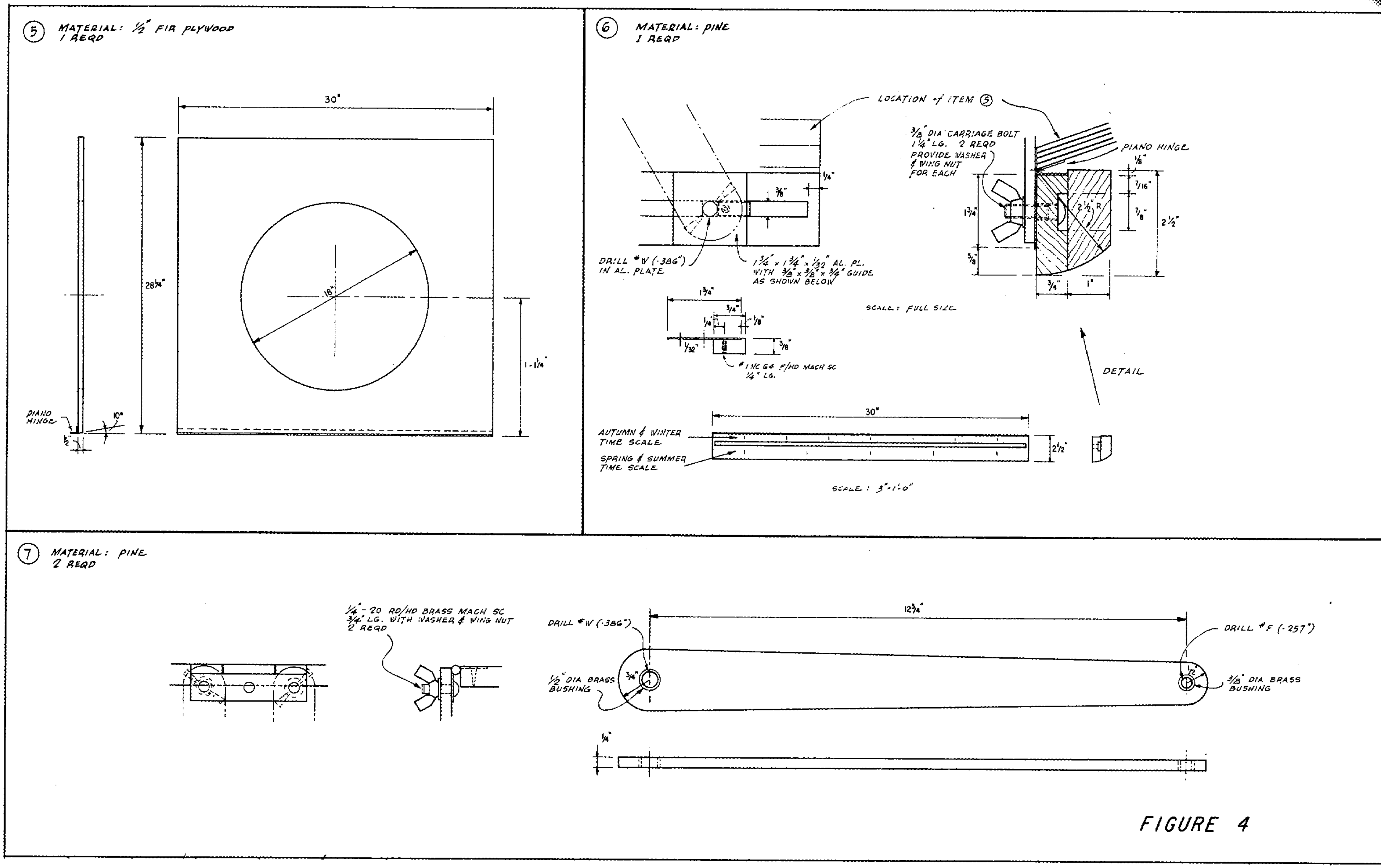

4/2 ← ITEM No ← SHEET No
28"
PLAN
30'
FRONT
14½"
PIANO HINGE
HINGES
90°-ϕ
PIANO HINGE
HINGE
δ
HINGE
PIANO HINGE
23·5°
SIDE
① SPRING - SUMMER AND AUTUMN - WINTER SEASON ADJUSTING ASSEMBLY
② MOUNTING PLATE
③ ④ TIME SCALE AND ADJUSTING ASSEMBLY
⑤ BASE PLATE
⑥ ⑦ DECLINATION OR TIME of YEAR SCALE AND ADJUSTING ASSEMBLY
⑧ LATITUDE SCALE AND ADJUSTING ASSEMBLY
DESIGNED BY G.P. MITALAS

FIGURE 2



① MATERIAL : PINE
1 REQD
HINGE
23.5°
② MATERIAL : ½" FIR PLYWOOD
1 REQD
PIANO HINGE
3/16" DIA HOLES FOR MOUNTING BUILDING MODELS
16" DIA CIRCLE DIVIDED INTO 360°
DRILL ¼ DIA
12" RAD
N
S
E
W
③ MATERIAL : ½" FIR PLYWOOD
1 REQD
NOON
LOCATION OF ITEM ⑥
LOCATION OF PIANO HINGE, SEE ITEM ②
④ MATERIAL : ½" FIR PLYWOOD
1 REQD
1" DIA HOLE 5/16" DEEP
INSET FOR PIANO HINGE

FIGURE 3



(5) MATERIAL: 1/2" FIR PLYWOOD
1 REQD
30"
28 1/4"
18"
1-1/4"
PIANO HINGE
10°
1/2"
(6) MATERIAL: PINE
1 REQD
LOCATION of ITEM (5)
3/8" DIA CARRIAGE BOLT
1 1/4" LG. 2 REQD
PROVIDE WASHER
& WING NUT
FOR EACH
PIANO HINGE
DRILL #W (.386")
IN AL. PLATE
1 3/4" x 1 3/4" x 1/32" AL. PL.
WITH 3/8" x 3/8" x 3/4" GUIDE
AS SHOWN BELOW
#1 NC 64 F/HD MACH SC
1/4" LG.
SCALE: FULL SIZE
DETAIL
2 1/2" R
2 1/2"
AUTUMN & WINTER
TIME SCALE
SPRING & SUMMER
TIME SCALE
SCALE: 3"=1'-0"
(7) MATERIAL: PINE
2 REQD
1/4"-20 RD/HD BRASS MACH SC
3/4" LG. WITH WASHER & WING NUT
2 REQD
DRILL #W (.386")
1/2" DIA BRASS
BUSHING
12 3/4"
DRILL #F (.257")
3/8" DIA BRASS
BUSHING

FIGURE 4

(8) MATERIAL: PINE
1 REQD

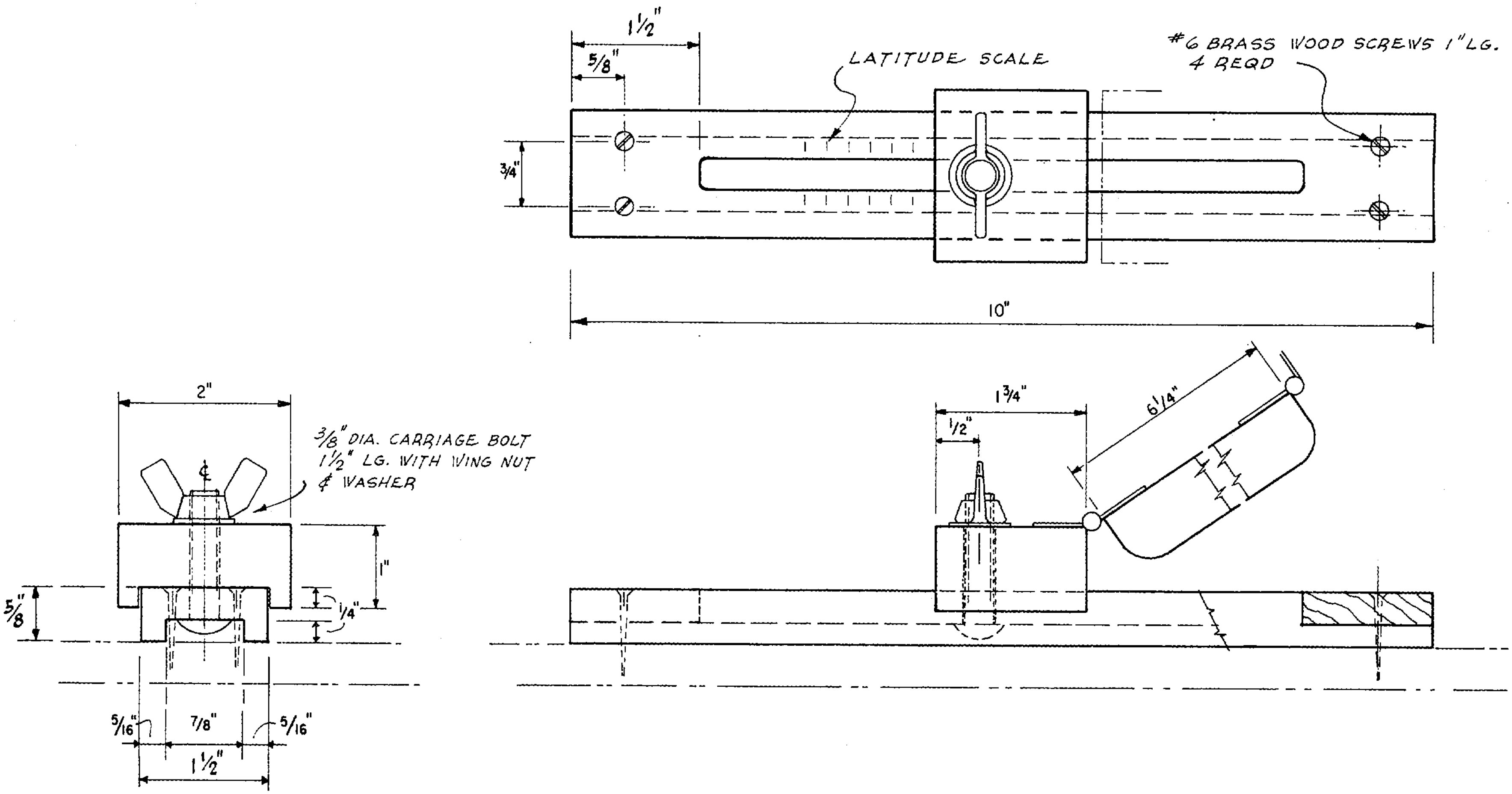


FIGURE 5