LOTS OF TIME

AND HOW TO TELL IT WITH THE SPILHAUS SPACE CLOCK

Booklet # 1300

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DR. ATHELSTAN F. SPILHAUS,
... SCIENTIST, INVENTOR, EDUCATOR AND

Dr. Athelstan Spilhaus, Dean, Institute of Technology, University of Minnesota, is well known to scientists the world over. He is listed in "American Men of Science" as a meteorologist, an oceanographer, and as the inventor of the bathythermograph, an invention which contributed substantially to our submarine warfare success in WW II. Our submarines, equipped with this, were able to find thermoclines and hide there with less chance of detection. It is now used by most navies for rapid measurement and recording of ocean temperatures at various depths.

An estimated 12,000,000 weekly readers know Dr. Spilhaus as the author of the popular educational science strip, "Our New Age", syndicated in 93 Sunday newspapers. Dr. Spilhaus has authored: Workbook of Meteorology, Meteorological Instruments, Weathercraft, Satellite of the Sun, and Turn to the Sea, and is a constant contributor of scientific articles to technical and related journals.

In two atomic tests in Nevada, Dr. Spilhaus served as Scientific Director of "Weapons Effects". Other associations were: Meteorological Adviser to the Union of South Africa Government; Woods Hole Oceanographic Institution; U. S. National Committee for the International Geophysical Year; Advisory Committee on Weather Services, Dept. of Commerce; and more recently, U. S. Commissioner, Seattle World's Fair.

During World War II, Dr. Spilhaus went to Yenan where he taught Chinese guerillas to radio weather data to U. S. forces. His scientific interests have taken him to such diverse areas as Kidal in the Sahara Desert, the Antarctic, and the Gobi Desert.

CREATOR OF THE SPILHAUS SPACE CLOCK SYNDICATED SCIENCE WRITER

Presently, he is Chairman of the Advisory Committee of the U. S. Dept. of Interior for Planning a new National Aquarium to be located in Washington, D. C. He is also a member of more than 20 scientific and other organizations. To maintain his active interests, Dr. Spilhaus flies in excess of 4,000 miles a month.

Through his meteorological work, Dr. Spilhaus has long had a keen interest in astronomical clocks, their history and function. Years ago he conceived the idea of a compact space clock utilizing modern materials not available to the early clockmakers. Over a period of six years he developed the simple, unique gearing for the various discs of the space dial. He built several models, and finally produced a design for a clock that is considered by many to be a breakthrough in the art and science of clockmaking.

When Dr. Spilhaus gave Edmund Scientific Co. the opportunity to manufacture and market the clock, they eagerly accepted the privilege. Edmund Scientific Co. has for over 21 years been a well known source of supply for scientists, teachers, hobbyists and amateur astronomers. In the manufacturing of this unique instrument, everything consistent with good engineering practice has been done.

All who become the proud possessors of a Spilhaus Space Clock, either by purchase or gift, will find they have a renewed interest in time and tide, sun and moon and the starry heavens.

TABLE OF CONTENTS

THE SPILHAUS SPACE CLOCK, A BRIEF DESCRIPTION

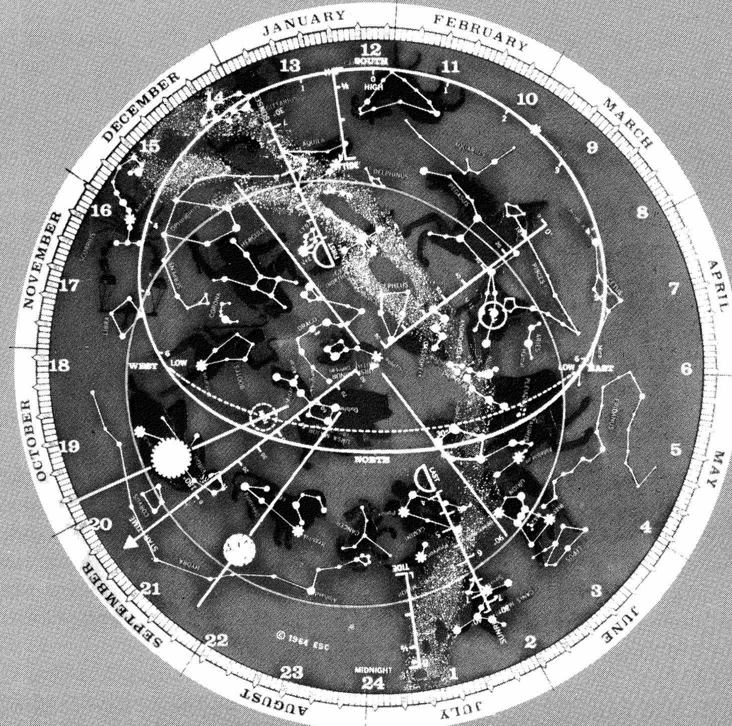
The large Space Dial of the Spilhaus Space Clock presents a variety of important celestial information. The lower left dial shows regular time; the lower right, time around the world.

SPACE DIAL

REGULAR CLOCK DIAL

WORLD TIME DIAL

FROM THE LARGE SPACE DIAL YOU CAN READ



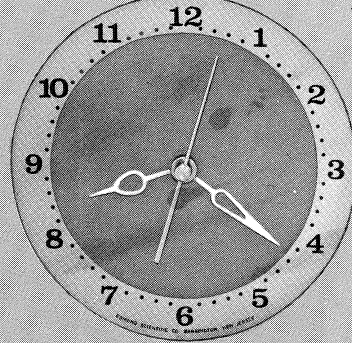
THESE 15 UP-TO-THE-MINUTE FACTS

1. The Horizon and the Visible Heavens
2. Sun's Position in the Sky
3. Moon's Position
4. Position of the Stars
5. Relative Positions of Sun, Moon and Stars
6. Day of Month and Year...a Perpetual Calendar
7. Solar Time of Sun, Moon and Stars at Meridian
8. Sidereal or Star Time...To be Used in Conjunction with Astronomical Tables
9. Current Phase of the Moon
10. Time of Daily Sunrise and Sunset
11. Mean Time of Moon Rise and Moon Set
12. Mean Time of Star Rise and Star Set
13. Current Time High or Low Tide
14. Current Stage of the Tide
15. Mean Solar Time

The large dial, 8-5/8" in diam., has a heavy brass top. A domed crystal protects its 5 separate discs. One is fixed; the other 4 rotate counter-clockwise. Together these five discs correlate all of the fifteen pieces of information.

Quick setting instructions are given on page 32 (back cover).

Full description of setting and reading the large dial is given on pages 7 thru 14.



CLOCK DIAL WITH CENTER SWEEP, SECOND HAND

Large, dark blue numerals on gold make this 4" diameter clock dial extremely easy to read. Radium hour and minute hands stand out distinctly from the blue background. Like the others, this dial is protected by a domed crystal. The power unit which drives the entire clock, is located behind it. In the event of power failure, the resetting of this unit will automatically reset all of the other dials.

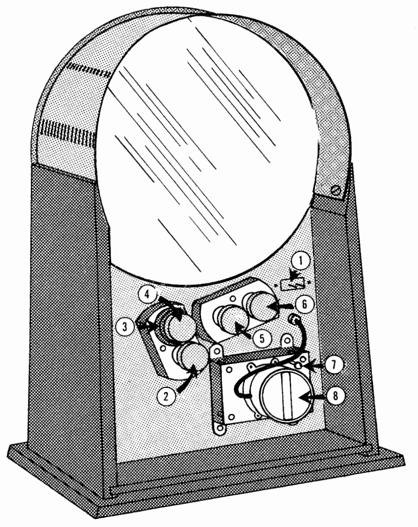
24-HOUR, WORLD TIME DIAL

Under the domed crystal, there is a rotating 4" disc marked with 24-hour time.

Behind it is a fixed circumpolar map of the world. Longitude 0 (Greenwich time) and the International Date Line are marked. A circular dotted line plots the equator. Major cities are pinpointed and identified at the periphery. Time in these cities is conveniently read from the radial lines at the hour marking.

section 1

SETTING INSTRUCTIONS



1. Jack For Electric Cord
2. Ivory Knob For Setting World Time Dial
3. Red Knob For Setting Moon Disc
4. Gray Knob For Setting Tide Disc
5. Blue Knob For Setting Star and Calendar Disc
6. Gold Knob For Setting Sun Disc
7. Brass Thumb Knob For Setting Standard Clock Dial
8. Heavy-duty Electric Clock Motor, 110-volt, 60-cycle AC.

COMPLETE DIRECTIONS FOLLOW

(For condensed instructions, see page 32)

Place your clock upright on a sturdy table. Open protective cover on back of clock. Connect socket of cord to the two terminal projectors on the back plate of the clock and plug power cord into any conventional 110-volt, 60-cycle AC outlet.

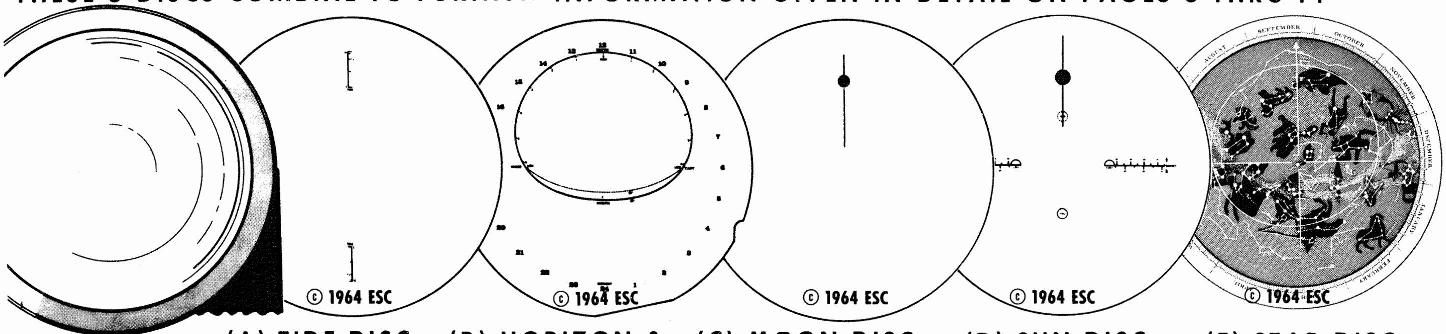
Set your local time on lower left clock dial as you would an ordinary electric clock by rotating brass knob on the clock motor (7). You are now ready to set the individual discs comprising the large Space Dial.

One thing to remember is that in the gear train a small amount of backlash or play has been purposely provided. For proper setting eliminate this backlash by making the last motion a slight counter-clockwise rotation.

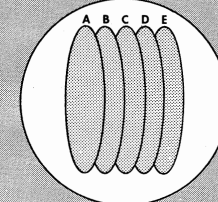
The Star and Calendar Disc (E) is set first. Detailed instructions are given on page 8. Before proceeding, however, look at the five separate discs shown in exploded view on the opposite page, and their relation to one another. Each disc has a letter for identification purposes.

THE FIVE DISCS OF THE SPACE DIAL

THESE 5 DISCS COMBINE TO FURNISH INFORMATION GIVEN IN DETAIL ON PAGES 8 THRU 14



(A) TIDE DISC **(B) HORIZON & HOUR DISC** **(C) MOON DISC** **(D) SUN DISC** **(E) STAR DISC**



THE ABOVE DIAGRAM SHOWS POSITION OF 5 RELATED DISCS WHICH COMPRISE THE SPACE DIAL

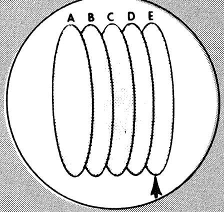
(A) Tide Disc. It carries the reference marks for telling the current time of high or low tide and the stage of the tide.

(B) Horizon and Hour Disc which carries the 30° and 40° latitude horizon lines. The four points of compass are shown also, and 24-hour solar time scale, in gold numerals, is included. This disc does not rotate.

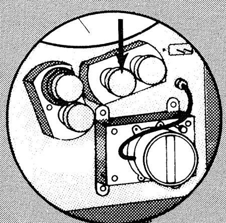
(C) Moon Disc. It carries an image of a white moon with a light blue pointer line running through it.

(D) Sun Disc. It carries, in addition to the sun and its pointer, the reference hours for telling sunrise and sunset at both 30° and 40° latitude. The phases of the moon are also included.

(E) Star and Calendar Disc. It carries the perpetual calendar on its circumference and in its center a field of stars and constellations. The light blue pointer is used for reading sidereal or star time, and the gold circle line serves as a reference for reading sunrise and sunset.



DISC (E) IS LAST DISC IN SPACE DIAL



USE BLUE KNOB TO SET DISC (E) (HOLD THE GOLD KNOB)

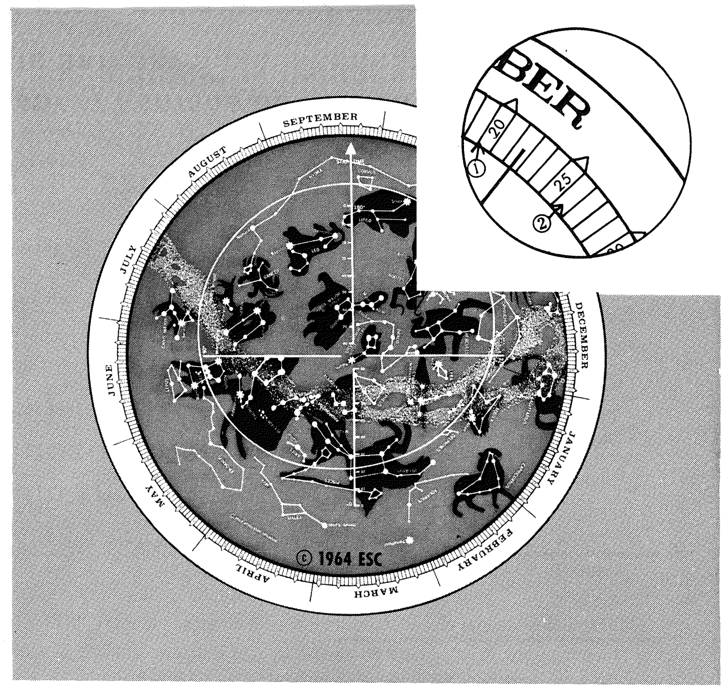
THE STAR AND CALENDAR DISC (E)...HOW TO READ IT

This disc rotates counter-clockwise slightly faster than the Sun Disc (D), and the advance is shown to be one division on the calendar for each full revolution by the sun. The gold line through the sun points to the correct day and month as it appears on the star disc.

The stars and constellations are visible at your location whenever they lie within the light blue ellipse which represents the horizon on Disc (B).

The light blue arrow on Disc (E) points to the correct sidereal or star time. Sidereal time is read from the gold hour numerals on Disc (B).

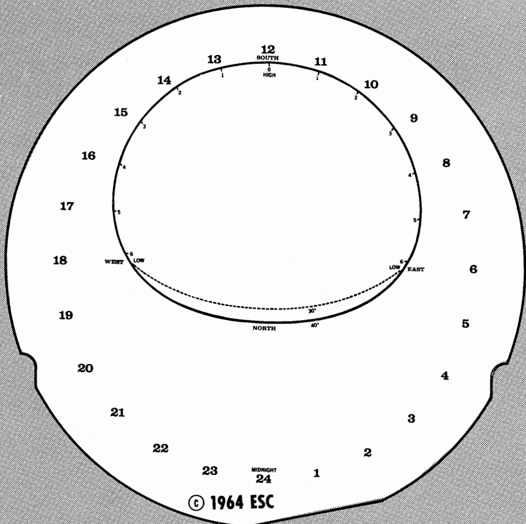
Furthermore, the gold circular shape on Disc (E) is used as the reference for reading time of sunrise and sunset. See page 10.

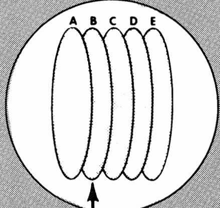


ALL DETAILED SETTING INSTRUCTIONS APPEAR IN RULED BOXES

SETTING STAR AND CALENDAR DISC (E)

Setting this disc is very easy. Hold the gold knob on the back panel and rotate the blue knob until the correct month and date on Star and Calendar Disc E is aligned with the gold line through the Sun on Disc D. See magnified view of calendar in illustration above. Midnight is the blue line (1.) between two day areas. Noon of each day is (2.) the center of the rectangular white area. In the magnified view above, it is noon of the 22nd day of the month.





THE FIXED, HORIZON AND HOUR DISC (B) IS THE SECOND DISC IN THE SPACE DIAL

READING THE FIXED DISC (B) ...THE HORIZON AND HOUR DISC

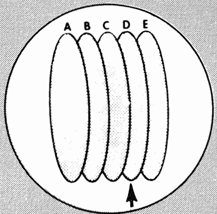
The zenith or south meridian position for any heavenly body (sun, moon or star) is the imaginary fixed radial line from the center of this disc to the position "south" at the top of the clock. The time at which any of these bodies, on its rotating disc, crosses this line is the time at meridian or zenith.

The time indicated by the gold sun line traversing the gold 24-hour scale on this disc registers true solar time. Remember, when relating solar time to standard time, as shown on lower left clock dial, the conversion factor for your particular longitude must always be used.

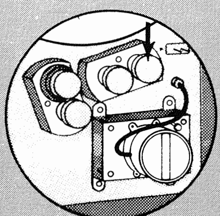
The light blue arrow on Star and Calendar Disc (E) as it traverses the gold hour numerals on this disc, registers sidereal or star time. See page 30 for an explanation of sidereal time.

The light blue ellipse (horizon line) on this disc is important because it encloses the approximate area within which the sun and moon and the stars are visible from the earth. The lower continuous line of the ellipse is marked North 40°, and above it the dotted line is marked 30°. These represent degrees of latitude. North 40° passes through Philadelphia, Pa. and North 30° through New Orleans, La. If you are located near the latitudes mentioned above, any heavenly body within this light blue ellipse will be visible and it will be at the approximate position shown in relation to the zenith or south meridian position.

Whenever one of the graduated scales of the Tide Disc (A) reaches the zenith (marked "HIGH" on the blue horizon ellipse) it is high tide at the location for which you have chosen to set the Tide Disc. Blue numerals on either side of "HIGH" indicate, on the right, the hours before high tide; and on the left, the hours after high tide.



DISC (D) IS FOURTH DISC IN SPACE DIAL



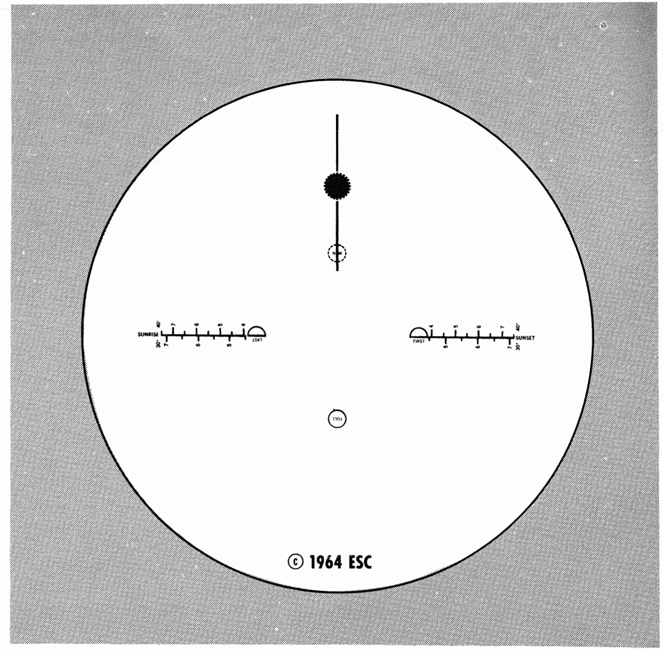
USE GOLD KNOB TO SET DISC (D)

THE SUN DISC (D) AND HOW TO READ IT

The sun's position in the sky is shown continuously by the position of the gold circular sun. It is visible to you when it appears within the light blue horizon ellipse on fixed Horizon and Hour Disc (B). The gold line drawn through it points to "south" (which is at the gold numeral 12) at the top of the fixed Disc (B), when the sun is at "high noon", or at meridian.

The gold line extending through the sun also points to the day and month on Star and Calendar Disc (E), and to the 24-hour solar time dial marked in gold numerals on fixed Horizon and Hour Disc (B). Two gold scales, opposite one another and graduated in half-hours, show time of sunrise and sunset when read against the gold circular shape on Disc (E).

This Sun Disc also carries the phases of the moon (covered in detail on page 12).



SETTING THE SUN DISC (D)

Solar time is generally somewhat different from standard or daylight time. To set the sun disc requires:

STEP 1

You first need to know standard time. If you have set the regular clock dial (lower left) for daylight saving time, deduct 1 hour from this figure.

Continued on page 11.

DISC (D) SETTING INSTRUCTIONS (CONTINUED)

STEP 2

You now need to know local mean time for the exact meridian (longitude) where you live. On pages 28 and 29 are charts to help you find this. In the U.S.A. there are four time meridians which are "standard" occurring at exactly 75°, 90°, 105° and 120° longitude. The sun travels across the U.S.A. from East to West, and it is most important to remember that wherever the sun is at its zenith, at that location it is 12 noon, solar time (see illustration No. 2, page 26). Therefore, for a sun position east of a standard time meridian it is locally high noon while the standard time (for the standard meridian as well as for the whole standard zone) is still before noon. For each 1° of longitude your location is east of a standard time meridian, add 4 minutes (1/4°=1 minute) to the standard time to compute solar (local mean time). For each 1° your location is west of a standard time meridian, deduct 4 minutes from standard time.

STEP 3

Sun Disc D is read against the gold 24-hour scale. If you are setting the Sun Disc for the a.m., use the answer obtained from step 2 directly. In the p.m. hours, add 12 hours to the local solar time as calculated in Step 2. This is the figure you need for setting Disc D.

EXAMPLE

1. Assume your local daylight saving time is 3:00 p.m.
2. Deduct 1 hour to obtain standard time. -1:00
3. This is your local standard time. 2:00
4. Assume you live in New York City which is located on longitude 74°. The nearest time meridian is 75°, so there is a difference of 1° between New York City's longitude and that of the time meridian. 75°-74° = 1°.

   Since the sun time east of a standard time meridian is later than standard time, by approximately 4 minutes for every 1°, 2:00 p.m.

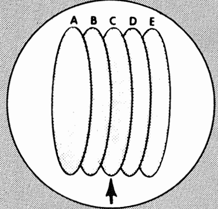
   add 4 minutes to standard time, giving +:04

   our local sun (solar or mean) time in New York City as 2:04 p.m. 2:04
5. Your Sun Disc has a 24-hour dial. To set it for the p.m. add 12 hours +12:00
6. This figure, 14:04 is the exact time at which you should set your Sun Disc D. 14:04

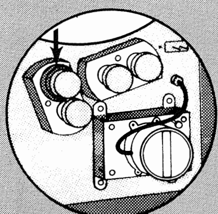
USE SPACE BELOW FOR YOUR CALCULATIONS

1. Your local time .... ________
2. If daylight saving time, subtract one hour .... -1:00
3. Result: standard time.............................. ________
4. Nearest meridian.....________°
5. Your longitude ....________°
6. Difference in degrees________°
7. Difference equivalent in minutes of time (1° = 4 min.)................ ________
8. If east of standard time meridian, add line 7 to line 3 ....SUM ________

   If west of standard time meridian OR subtract line 7 from line 3.............. DIFF. ________
9. If P.M. time, add 12 hours...................... +12:00
10. Time you should set Disc D .... ________ (Solar time for you longitude)



DISC (C)
IS THIRD
DISC OF
SPACE DIAL



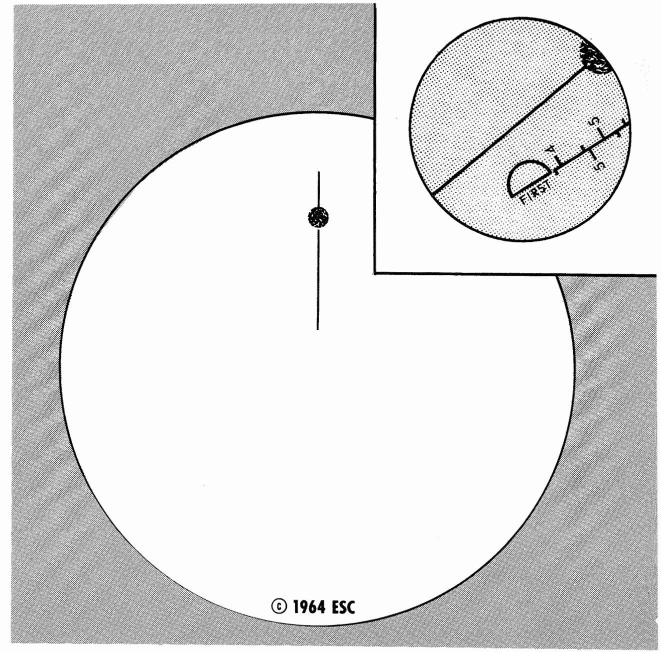
USE RED
KNOB TO
SET MOON
DISC (C)

THE MOON DISC (C) AND HOW TO READ IT

This disc rotates in the same direction as the Sun Disc, but slower by 50 minutes per day. The phases of the moon, which are imprinted on Sun Disc (D) must therefore be read clockwise. If the moon line on the Moon Disc (C) is between the new moon and the first quarter, it is approaching first quarter. See magnified view at right.

When the moon arrives at its zenith or "south" meridian position its solar time is read by the sun line and its gold hour marks.

For other positions, the light blue hours on the horizon curve on Moon Disc (B) show the number of solar hours before or after the moon's meridian position. Moon rise and set will be evenly spaced relative to this meridian position.



SETTING MOON DISC (C)

Find the time of moonrise (or moonset) from your local paper or from other sources listed on page 31. (The Sun Disc should have been set as shown on pages 10 and 11.)

1. Use the Brass Thumb Knob on clock motor (which moves all discs) for the purpose of setting the line through the sun (on Sun Disc (D)) to the time of moonrise (or moonset) given in your newspaper.
2. By turning the red knob only, reset the line through the moon (Disc (C)) to the

Continued on page 13.

DISC (C) SETTING INSTRUCTIONS (CONTINUED)

time of sunrise (or sunset if you used moonset).

3. Return all dials to the original or present standard time settings by turning only the Brass Thumb Knob on clock motor.

By ascertaining the time of sunrise and moonrise (or sunset and moonset) from the newspaper, you set the moon relative to the sun. The 3-step setting procedure given at left is necessary because the space interval between sun's position and moon's position is not constant.

Therefore, you must use the particular time of sunrise and moonrise (or sunset and moonset) given in the newspaper, in order to set the moon correctly relative to the sun. At any other time settings, the positions of the two would be different and incorrect.

EXAMPLE

If your newspaper reports that the sun is to rise at 6:28 a.m., and the moon is to rise at 6:49 p.m., you first set the line through the sun at the time of moonrise, 18:49 hours (=6:49 p.m. + 12). This is done, as previously explained by turning only the Brass Thumb Knob No. 7.

You have previously set the line through the sun, at real sun time (see page 10) and now are changing it only in order to make a correct relative setting of the moon disc.

Now set the moon at the time given for sunrise. This position, corresponding to the hour of sunrise, is the effective horizon for both sun and moon for that day. To continue our example, set the line through the moon at 6: 28 hours.

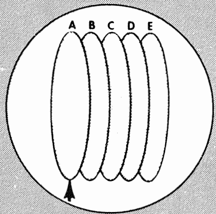
The next step is to reset the clock by turning only the Brass Thumb Knob. This automatically resets all the dials in their proper relationship.

USE THE SPACE PROVIDED BELOW TO NOTE YOUR SETTING FIGURES

DATE:

	RISE	OR SET
Time of Moon ______ (plus 12 hours if it is occuring in the p.m.) is the time at which you will position your sun line.....	______	....
Time of Sun ______ and time at which you will position your moon line..................	______	....

Remember that you will be reading the position of the moon in terms of solar time. If you find it more practical for your purposes to know this in standard time, use your standard-to-solar conversion factor in reverse fashion. This conversion, you will recall, is explained in detail on page 11. A handy chart listing the conversions for the major cities in the United States is also found on page 29.

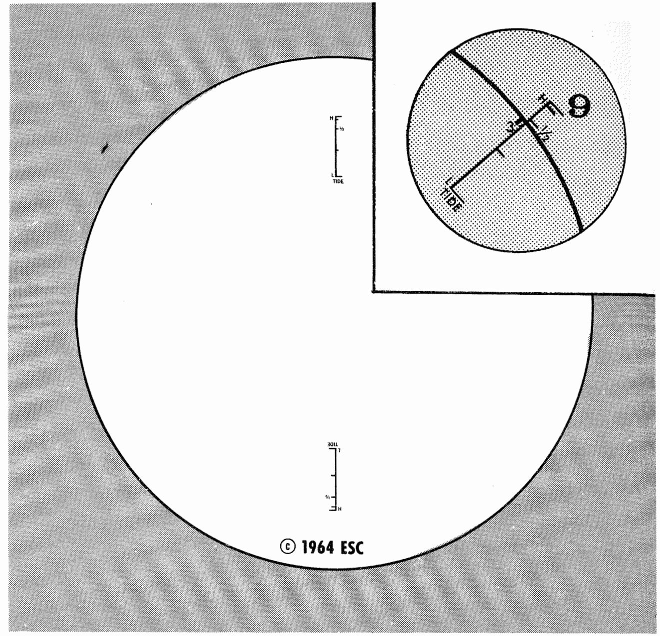


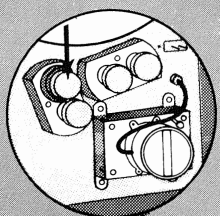
DISC (A) IS FIRST DISC OF SPACE DIAL

THE TIDE DISC (A) AND HOW TO READ IT

The light blue opposing scales on this disc indicate the current stages of the tide. L means low water, the first index 1/4 tide, the second 1/2 tide, the third 3/4 tide and H high tide. These scales are read as they pass over the light blue horizon ellipse on Disc B. The latter carries two sets of numerals, 6 to 1 before HIGH (high tide) and 1 to 6, afterwards. These enable you to read how many hours till high tide and how many hours have gone by since high tide.

Low tide occurs when the letter L on the tide scales meets the words of LOW on the horizon ellipse. Depending on local conditions, low tides may not be equally spaced in time between successive high tides. Set for high tides if these are of major interest.





USE GRAY KNOB TO SET TIDE DISC (A)

SETTING THE TIDE DISC (A)

From your local newspaper, find the standard time of the next high tide at the location of your interest. Set one of the light blue tide scales at the correct number of hours and minutes before the next high tide. These figures appear on the light blue horizon ellipse, Disc (B). If the time on your clock dial is 1:00 p.m., and the next high tide occurs at 4 p.m. (in 3 hours) set the tide scale on the right hand, blue "3". See magnified view in illustration above.

SETTING AND READING WORLD TIME DIAL

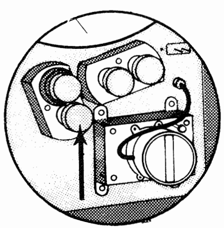
The gold circumpolar map in the background of this dial has lines running from major world cities to the periphery. The 24-hour World Time Disc, which rotates in front of the circumpolar map, is read with reference to any of the above lines.

Note that the numerals representing the hours of daylight are shown in blue on gold. The midday sun (shown encircling the numeral 12) advances around the world at its zenith position indicating High Noon. The hours of darkness appear as gold numerals on a dark background.

The horizontal line, marked Greenwich, on the right side of the circumpolar map, represents meridian 0°. This is an imaginary line of longitude drawn through Greenwich, England and it is used as the prime basis for computing standard time throughout the world. Greenwich Mean Time (G.M.T.) or Universal Time (U.T.) as it is also known, is computed on a 24-hour basis and is the mean solar time at 0° longitude. Persons all over the world use G.M.T. to synchronize their operations.

In the U.S.A., there are four official standards of time, Eastern, Central, Mountain and Pacific, corresponding to the local mean times of the 75th, 90th, 105th and 120th meridians west of Greenwich, England.

Because the earth rotates as it does, the sun appears to travel from East to West. In one hour the sun travels through 15 degrees of longitude. For instance, when it is 12 noon on meridian 0°, one hour later it will be 12 noon on meridian 15°. The four standard times of the United States are respectively 5, 6, 7 and 8 hours "earlier" than the instant time at Greenwich.



THE IVORY KNOB ON THE BACK PLATE IS USED TO SET THE 24-HOUR, WORLD TIME DIAL

> This disc must be set for solar time at your location in order to be correct for Greenwich Mean Time. For this disc only, it is the equivalent of setting it for standard time at your nearest standard time meridian.

section 2

LOTS OF TIME

THE SPILHAUS SPACE CLOCK

AND ITS FUNCTIONS

By DR. ATHELSTAN SPILHAUS

It is most important to understand that all of the time and position measurements of the sun, moon and stars are subject to many and complicated effects, due to the interaction of every astronomical body on every other body. In order to present this eternally moving rhythm of the universe in a relatively simple manner, it is necessary to simplify the presentation and to deal only with the average or mean time and position of each of the heavenly bodies in which we are interested.

The only perfectly regular basis of time is our man-made clock, automatically and synchronously driven by 60-cycle electrical current, or by well adjusted watch movements, etc. These are quite regular since they are almost wholly uninfluenced by external forces.

It is entirely different with the heavenly bodies in the universe around us. The sun, for instance, arrives at its south meridian at high noon within a range of perhaps plus or minus 15 minutes. Most people never know of this, but astronomers do. The same is true of any of the stars.

The moon is so greatly influenced that it shows variations of a much greater amount. The tides are influenced not only by these variations in the moon, but also by the sun and by geographical patterns on the earth.

It is obvious that the best presentation of this kind of variable information must be that of the mean values which can then be more consistently related to the steady routine of our man-made clocks. In this sense, therefore, we will proceed to describe the individual functions of the Spilhaus Space Clock.

1. THE HORIZON AND THE VISIBLE HEAVENS

The complete story of the movement of the sun, moon and stars is continuously displayed on the large Space Dial (see page 4). Whether or not one of these bodies is actually visible to you, in the night sky, depends upon whether it is inside or outside of the horizon, repesented by the fixed, light blue ellipse area (see Horizon and Hour Disc B, page 9) which is in a fixed position at 40^{o} north latitude. The horizon at 30^{o} north latitude is marked in part by a dotted line, and the rest of the curve locates approximately in the position of the hour numbers, 11, 12, 13, etc. This is an area of some inconsistency as to visibility and, therefore, it is not shown as a sharp limitation. For those at say 50^{o}

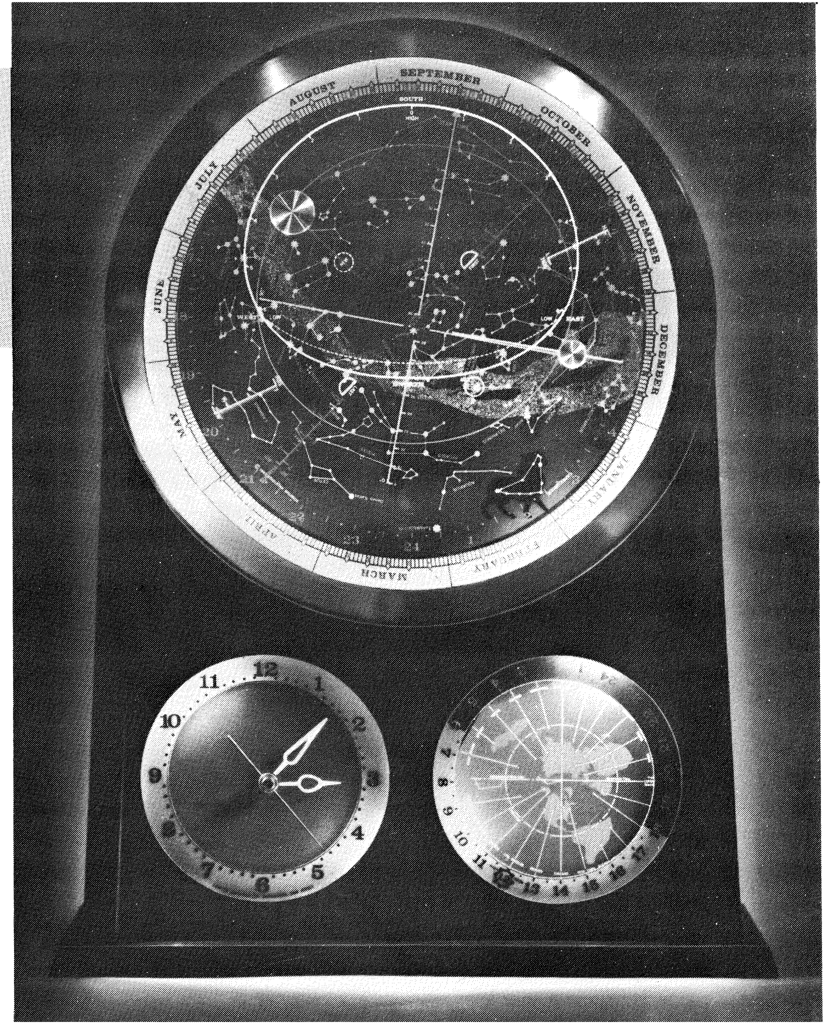
NOW WITH ILLUMINATED DIALS

SPACE CLOCK MODELS 1202 & 1203

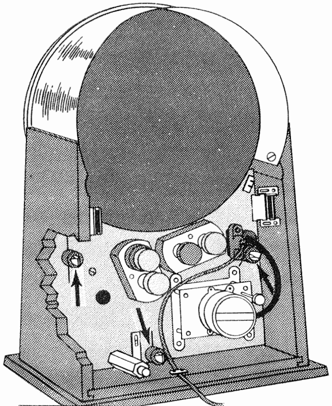
Illumination further emphasizes the beauty of this outstanding showpiece. The large Space Dials take on new depth, and celestial beauty. Cool, soft, balanced lighting gives clear visibility to all three dials, at a comfortable reading level.

A simple pushbutton turns the light on or off and is conveniently accessible through the finger hole in the beautifully finished back cover of the Spilhaus Space Clock. The three long-life, lamps are positioned in the internal aluminum backplate as shown on the following page. Each lamp is designed to burn for over 9,000 continuous hours.

Should your clock fail to light after plugging it in and pressing the switch, remove the cherry wood back cover (this is held in by magnets only) and check to see if lamps are in proper alignment. See following page.

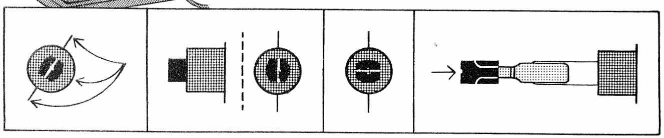


ALIGNING OR REPLACING LAMPS



Three lamps are positioned in the aluminum backplate as shown at left. They are properly aligned when the red edge on the back of each lamp is in line with the black lines printed on the aluminum backplate (Figure A below). If the lamps are not in this position, simply rotate the red base to correct.

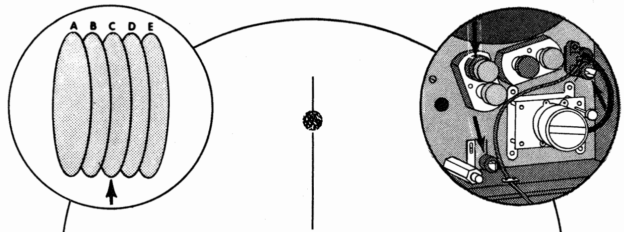
If the red base of the lamp protrudes more than 1/8" from its orange socket, push it in until it stops. If the lamp stops approx. 1/2" from the socket (Figure B), rotate the lamp 1/4 turn (Figure C) and push it in until it stops; then realign as in Figure A.



Replacing lamps is simple. Remove the old lamp from its socket by pulling the red lamp base out from the position shown in Figure A. Insert the new lamp as shown in Figure D. Follow the above procedure for correct alignment.

REPLACEMENT LAMPS FOR MODEL 1202

No. 1301 (Package of 3.) $1.20 Postpaid



AN EASY ALTERNATE METHOD OF SETTING MOON DISC (C) REFER TO PAGES 12-13

1. Consult an almanac and find either the time of moonrise or moonset given for the day at hand.
2. Turn the brass knob on the clock motor and set the regular clock for time of moonrise (or set).
3. Turn the moon disc only (red knob) until the moon is seen just entering the blue horizon circle at the right (for moonrise) or leaving it at the left (for moonset).
4. Now reset the clock to the present time. Reset by turning the brass knob in the opposite direction to that of item 2.

north latitude, an approximately equal shift on the other side of the 40° line can be easily imagined. It is most important to note that all of these curves are close together in the east and west positions where it is of most interest since the rising and setting phenomena occur in these regions. You will see the stars either rising on the eastern horizon, at their zenith on the north-south line and setting on the western horizon or continually visible near the pole star.

2. SUN'S POSITION IN THE SKY

The golden sun moves around in its 24-hour mean time orbit, in a counter-clockwise direction, coming regularly to its South meridian position, which is also marked as 12 o'clock noon. It enters the curve at the right or East, moves across to the left during the daylight hours, and sets in the West at the left. During the night hours, the sun's image on the sun disc travels outside of the horizon circle and, therefore, is not actually visible. It is, however, still in motion and it sweeps down, under and up again to a new dawn.

3. MOON'S POSITION

The moon also sweeps through the visible heavens within the horizon circle and passes down under, and up again much like the sun. The relative positions of the sun and moon are continuously changing, but their patterns of movement are similar.

4. POSITION OF THE STARS

The star field moves in the same general manner in a counter-clockwise direction relative to the visible area within the horizon line, and the individual stars each behave in a manner quite like that of the sun and the moon, but with individual differences as explained later.

5. RELATIVE POSITION OF SUN, MOON AND STARS

These positions are constantly changing, and the Space Clock continuously shows these changes with remarkable accuracy by the relative motions of the sun, moon and star discs which contain these bodies.

6. DAY AND MONTH - PERPETUAL CALENDAR

The gold line through the sun has to be set initially at the proper calendar day, and the clock automatically advances by one calendar day every 24 hours. Thus, it shows you the correct date and month throughout the year. Every fourth year on February 29, you must set the Star Disc back one day (leap year). All of the moving discs rotate together counter-clockwise at an approximate rate of one revolution in 24-hours. Only the Sun Disc rotates at precisely this rate. The other 3 moving discs each have slightly different speeds of rotation. The star disc is slightly faster and this advance is exactly a one day mark on the calendar circle every 24-hours, thus giving us the calendar indicator movement.

7. SOLAR TIME, OF SUN, MOON, STARS AT MERIDIAN

The difference between solar time and our standard zone time, which is displayed by the lower left clock dial, is due to the artificial use of zone time as our ordinary time. (See pages 27 and 28 for an explanation.) The sun actually appears to move quite regularly across the face of the earth and it gives to each position on the earth as it passes directly overhead, an instant of being at its zenith or of crossing the meridian for that particular point on the earth's surface. This is a natural phenomenon and, for the observer of the Space Clock for a given geographical location, there is thus determined the one and only time of the zenith position of the sun at that location. It is this time to which the sun line must be set, and read against the 24-hour numbers on the large dial. Relative to this true sun time, the standard time of an entire geographical zone will be different by an amount as much as plus or minus 45 minutes. This correction must always be kept in mind when any of the information displayed on the large Space Dial or on the World Time Dial, is to be interpreted in terms of either standard or daylight zone time to which we are accustomed.

We have, therefore, to think of the time relations of the sun, moon and stars always in terms of this solar time which is established by the exact longitude of the location of the clock. The sun is the pacemaker and goes around exactly on the hour schedule shown by the gold numerals on the fixed Horizon and Hour Disc, reaching its meridian at 12 hours on this scale.

The moon, and each individual star, likewise arrives at the meridian position of south according to its own time schedule. The south meridian is shown at top center and corresponds in position with the 12 hour mark. These two are coincident only for the sun. When the line of the moon reaches the south meridian point, the time at this instant is read between the sun line and the gold hour numerals. Similarly for each star which, by projection of an imaginary radial line, would reach the south meridian position at an instant of time, this time would be given only by the sun line and the hour markings.

8. SIDEREAL OR STAR TIME

As previously mentioned, this is used principally by astronomers. It is told by the light blue arrow at the September 23rd position, and is read on the gold hour scale. Star time differs from sun time all throughout the year except on one day, September 23rd.

9. CURRENT PHASE OF THE MOON

The phase of the moon is due to the physical position of the sun, the moon, and the viewer on the earth. The sun is always illuminating one-half of the moon, but as the relative positions of the sun and moon on the Space Clock change during the lunar month, the phases of the moon's appearance can be easily explained if one assumes his position to be at the center of the dial and he looks toward the moon and sees that portion of the moon illuminated by the sun. To indicate the 4 quadrant positions in this continuous movement, there are shown the conventional 4 quarters in light blue. For instance, full moon occurs when the moon is diametrically opposite the sun without regard to the direction in which this diameter extends. This means if the sun is visible within the light blue horizon ellipse, then full moon actually occurs when the moon is "down under" and out of sight. An opposite condition would be when the sun is in the night time and the moon is diametrically opposite and visible.

10. TIME OF DAILY SUNRISE AND SUNSET

The variation in this phenomenon is on an annual basis and so it can be shown by markings on both the Sun and the Star and Calendar Discs which, between them, have a once-per-year rotation. Therefore, the gold curve which is almost like a circle, has been carefully drawn to show, in conjunction with the scales for sunrise and sunset, the time at which these occur. Obviously, sunrise and sunset throughout the year depend also upon the latitude of the observer. Two scales have been calibrated, one at 30° and the other at 40° north latitude. Estimates can be made for other latitudes. As a result, the hour of sunrise and the hour of sunset, for the current day, is read from the intersection of the gold circle and the two gold, straight-line, opposing scales, with suitable estimates for north latitude correction. The hours thus obtained are always in terms of solar time, the only true time, and must therefore be further modified to be interpreted as either standard zone time or daylight saving zone time which, again, is an arbitrary matter.

11. MEAN TIME OF MOON RISE AND MOON SET

The complications in this case are too great to show in day-by-day changes, and the mean time is indicated in the following manner. Physically, the moon enters and leaves the visible horizon at times which are so variable that it is impractical to show them without extra-ordinary complications. We are constrained to emphasize the importance of the time at which the moon reaches its "South" zenith position, which is obviously the mid-point in time and position. The zenith position is shown when the moon line reaches the south (12 hour) mark at the top of the dial.

Since the moon travel is 50 minutes a day slower than sun travel, it takes 6 hours and 12 minutes of sun time for the moon to move 90°. The light blue hour markings inside the horizon curve are the hours in sun time against which the moon line can be read. These hour readings tell the time either before or after the hour at which the moon reaches its zenith. This information is shown for only the 6 hours before and after zenith position. Readings, when the moon is below the horizon, are too complicated to display.

12. MEAN TIME OF STAR RISE AND STAR SET

In somewhat similar fashion, the zenith position of a particular star, read against the South point at the top of the dial, is of major interest, and the approximate time of star rise and star set can be read when the star itself comes into or goes out of the horizon curve.

13. CURRENT TIME HIGH OR LOW TIDE

The time of high tide is roughly related to the time of the zenith position of the moon. The vagaries of the behaviors of the tide require that for any particular geographical position, the average difference in time between the zenith passage of the moon and the local high tide be shown as the difference between the moon line and the light blue tide line. This difference is considered constant for the particular place in question, and will be maintained because the moon and tide discs are driven at the same rate, both being slower than the sun rate. Bays, estuaries, shallows and obstructions delay, to a greater or lesser extent, the time that high tide occurs after the moon is directly overhead. So for your particular locality on the seashore, watch and establish the time interval between the moon's being overhead and the next high tide. This is called the establishment of the port for your location.

One of the light blue, opposed line scales of the tides is always intersecting the upper half of the horizon curve. In the vertical position, "H" on the tide scale will coincide with the

"HIGH" position at the top center of the curve at the instant of high tide. The time at which this occurs is in true sun time and is read between the sun line and the divisions of the gold 24-hour scale. Six hours and 12 minutes later, the tide scales will be horizontal, approximating low tides, one scale leaving the horizon curve and the other taking up intersection with it. The hours before the next high tide are now correctly shown as 6 hours and 12 minutes on the light blue figures.

14. CURRENT STAGE OF THE TIDES

The scale on the Tide Disc is marked in light blue and indicates approximately the stage or the height of the tide at any given instant. This is shown continuously, providing for the two high and two low tides which usually occur each day. The non-uniform divisions on the tide scales are required because of the shape of blue ellipse of the horizon curve which, to avoid confusion, has been taken as the other coordinating curve. The individual markings on the Tide Disc are for 1/4, 1/2 and 3/4 to indicate the stage of the tide. The stage of the tide, as well as the hours before high or low tide can be read.

15. ORDINARY OR ZONE TIME

The conventional clock dial at the lower left displays the arbitrary time which is the same over approximately 1/24 of the earth's surface. If the time is standard time for that zone and not daylight saving time, then, for the positions precisely on the central meridian, as the 75th, 90th, etc., the standard time would correspond with the sun time of the other dials. For all other positions, and therefore for most positions in the United States, the zone time dials would be set arbitrarily and would be out of synchronism with the mean solar time, basis of astronomical displays. Changes made each year between standard and daylight saving time affect only the time shown on the ordinary clock dial, time on the other 2 dials remaining unchanged. Resetting twice a year to use daylight saving time is made by usual changing of ordinary time dial and then resetting all other dials to their previous positions, since they are on unchanging solar time.

16. MEAN SOLAR TIME

This is time as referred to the precise 24-hour period which is the mean solar day period through the year.

It is the basis for the time of all displays of natural phenomena and is used throughout the space dial and the world time dial.

17. 24-HOUR WORLD TIME

The lower right dial with 24-hour division shows how the sequence of hours sweeps across any given position on the earth's surface. At any instant, therefore, this moving dial shows the solar time at any and all positions on the earth's surface on a 24-hour basis.

The hours representing daylight 6 (6 a.m.) through 12 (high noon surrounded by the sun) to 18 (6 p.m.) appear in dark blue on a bright gold background.

The hours of darkness 18 (6 p.m.) through 24 (midnight) to 6 (6 a.m.) are shown in gold on a dark blue background. This, of course, is solar time and must be corrected for the artificial time zoning which applies in the various world areas. See pages 26 through 29 for an explanation of this.

18. UNIVERSAL OR GREENWICH MEAN TIME

The sun is shown at its zenith position of high noon (the hour of 12) on both the World Time Dial and the Horizon and Hour Disc.

On the World Time Dial we see the figure 12 surrounded by an image of the sun. This represents 12 noon with the sun at its zenith. Draw an imaginary line from the figure 12 to the North Pole. As this imaginary line travels around the world it indicates that the time of high noon has arrived at the places directly below it.

As the World Time Dial rotates in a clockwise direction it changes the hour reading for the Greenwich longitude line on the map. This will be Greenwich mean time (G. M. T.) or Universal Time. Greenwich, England is located on longitude 0°. When people in other countries want to speak in a universal language about a particular instant of time, by common agreement, they refer to the instant time at Greenwich.

For example, it could be high noon or 12 hours at Sydney, Australia, but a person talking with someone in South America would say it is 2 hours Greenwich mean time.

19. TIME IN THE MAJOR CITIES OF U.S.A. AND WORLD

For any city anywhere, the instant sun time is indicated on the World Time Dial by an imaginary radial line through the city to the hour scale.

For all named cities shown, zone corrections have been made and these show standard time readings at the outer end of the lead line. All locations require further corrections, such as for daylight saving and local variations.

FOR THOSE WHO HAVE AN INTEREST IN ASTROLOGY

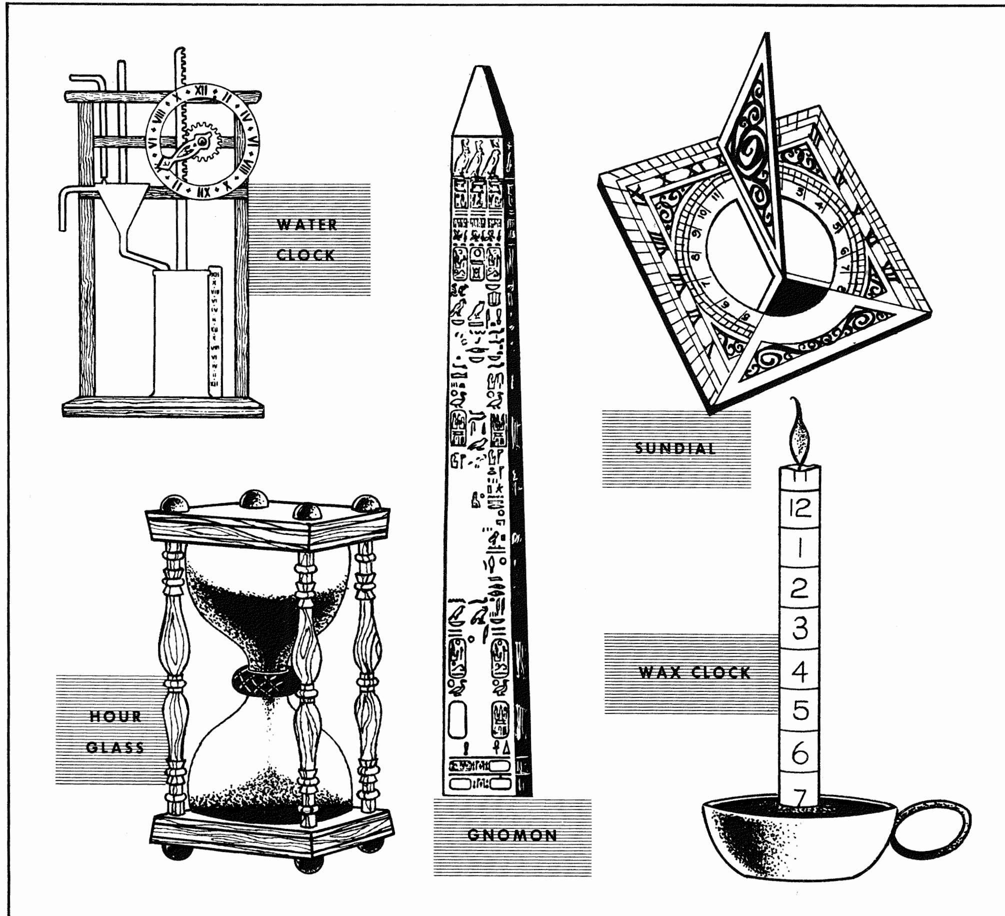
If you like to cast your horoscope, which depends on the position of the sun and moon in the constellations of the stars, the Space Clock will be found helpful. It should be pointed out, however, that information read from the Space Dial represents the current picture of the heavens rather than that expressed by the signs of the zodiac.

The latter, some 2,000 years ago, coincided with the constellations from which the signs took their names. The retrograde motion of the equinoxes along the ecliptic, during the course of 2,000 years has moved each backward into the constellation west of it, some 30°

Therefore, the signs of the zodiac are not now associated with the same days of the year as they were 2,000 years ago.

section 3

CLOCKS, TIME AND ASTRONOMY



THE BEGINNING OF TIME

There is little wonder that the sun proved to be a challenging mystery to primitive man. It provided him with light and warmth. Sunrise marked the beginning of his day and sunset the end of his labors.

The Chinese, Babylonians, Egyptians and Greeks are all believed to have systematically observed shadows cast by gnomons, or indicators. In sunshine the gnomon casts a shadow that varies in trend as well as length as the hours pass by. It is also affected by the time of year. Whenever the sun is at its highest point (noon on a midsummer's day) the shadow has its least length. Historical evidence has been found indicating as early as 1500 B. C., the Egyptians used a type of gnomon for measuring sun time.

The sundial, an improved form of timepiece, was eventually developed. Its major improvement was the positioning of its gnomon due north and its long length parallel to the earth's axis. Additional refinements to the dial face were added through the centuries thus increasing its accuracy.

In Europe wax clocks were known to be in use towards the end of the ninth century. These employed a candle long enough to be consumed within a given period of time. Usually the candle was placed inside of a protective housing to exclude drafts and air currents liable to change the rate of consumption. King Alfred the Great of England used one to regulate his working hours.

The Arabian, al-Jazari, made some ingenious improvements to the "light-clock". A treatise written in 1206 describes his invention which consisted of a length of candle designed to burn for 13 hours. In the candle body of wax, 13 marbles were imbedded at equal intervals. At the end of the first hour one of the marbles, released by the melting wax, landed on a device which cut the candle wick and so put out the light indicating the passing of one more hour of time.

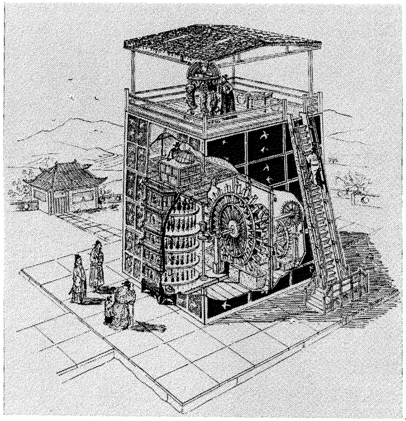
Hydraulic or water clocks, in many forms, have been used for centuries. One of the earliest examples, was built by Amenophis III about 1400 B. C.

The American Indian, centuries ago, told his time by boring a hole in the bottom of a boat. His reckoning was made between the time the water started to come through the hole and the time the boat sank below the surface.

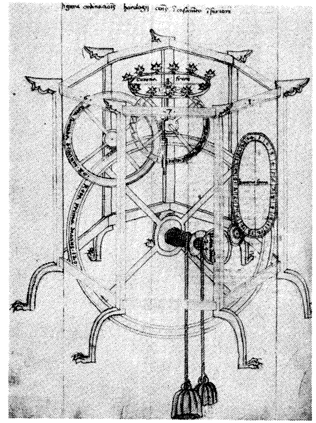
A similar type of hydraulic clock consisted of a truncated cone marked with equidistant horizontal lines. Water entered through a small hole in the bottom. As the liquid level reached a horizontal line another period of time was measured.

Sandglasses or hourglasses were known and used about the fourteenth century for recording the passage of short periods of time. Inexpensive to make, reliable and unusually accurate, they played their part in man's continual search for a more convenient type of clock, one independent of the sun.

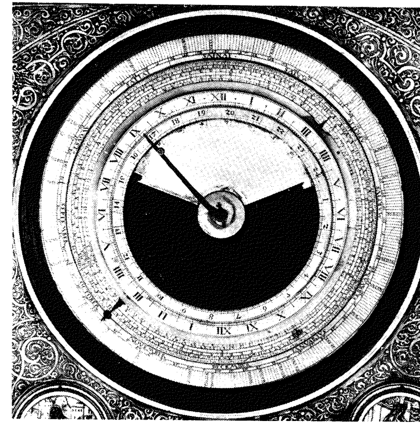
As the science of mechanics began to be applied to horology we find the development of weight and spring driven clocks. Balances, adjustable escapements, gear trains and other refinements were also designed to go along with them. Some of the earliest mechanical clocks were astronomical models. In reality, these were ingenious mechanical orreries showing the correct relative motions of the sun, moon, stars, planets as well as the time of day, fixed feast of the church, signs of the zodiac, etc.



Su Sung's Clocktower. From "Heavenly Clockwork" by Needham, Ling and Price. Reprinted by permission of Cambridge University Press.



Dondi's Clock, Motion Work.



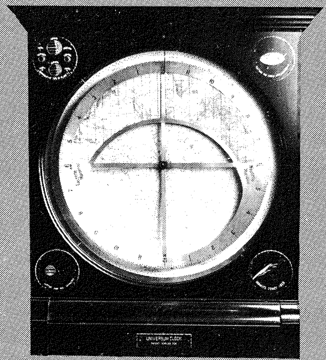
Baldewin's Planetary Clock, The Calendar Dial

From "Some Outstanding Clocks Over Seven Hundred Years, 1250-1950." Copyright, 1958, by H. Alan Lloyd. Reprinted by permission of Arco Publishing Company, Inc.

ASTRONOMICAL CLOCKS

Clockmakers, even the very early ones, have always been interested in the construction of mechanisms to register not only the hours and minutes, but also the movements of the sun and other celestial bodies.

As early as 1090 Su Sung, a Chinese, built an astronomical clock tower. It stood some thirty feet high with another ten foot section above it for observing instruments mounted on a platform. Operated by water power, the observing instruments on top of the observation platform were mechanically rotated and constantly pointed at the moving heavenly bodies. In a chamber below, a marked star-globe rotated automatically to provide the astronomer with a microcosm of the movements of the stars and planets



Astronomical clock showing time all over the globe and stars at all times. Manufactured by Universal Clock Co. Reprinted by permission of Essex Institute, Salem, Mass.

without going outside to observe them, an ideal arrangement when weather conditions prevented direct observations.

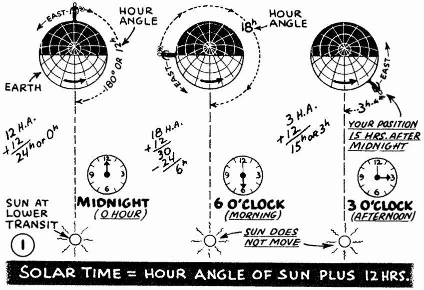
In those early times few had the knowledge and ability to build clocks. Still fewer could compute, design and construct the intricate gear trains necessary for an astronomical model. Costs were comparatively high so we find that early clocks were individually built for a specific purpose. Many functioned as public timepieces and were placed in a church or public building for that purpose.

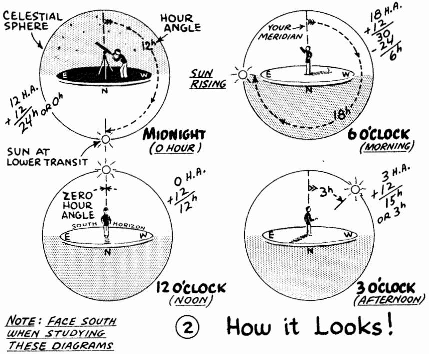
A very famous weight driven astronomical clock was built by Giovanni de Dondi in Padua, Italy between the years of 1348 and 1362. Its size was such that it required a large room to accomodate it. Heptagonal in design, one planet appeared on each of its seven sides with the planetarium on top. In 1440 a mention of this clock appeared in the writings of Michele Savronarola. During the years of 1556 and 1557 it was removed to the Convent of San Yste in Spain and eventually destroyed by fire in 1809.

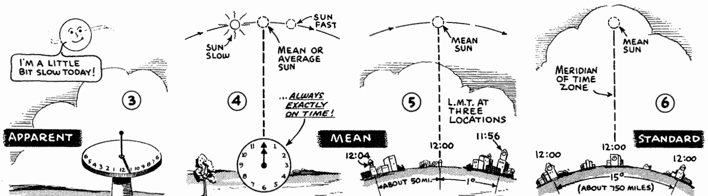
Another very famous astronomical clock was built by Eberhart Baldewin in 1561 for Landgraf William IV of Hesse. In this instance the calculations for the clock were made by the Landgraf and his Astronomer, Andreas Schoener. Dials were provided for Mars, Venus, Mercury, Saturn, Jupiter, Moon, an Astrolabe and one for the calendar dial. On the top of the clock a celestial globe was mounted.

The fictional writings of Jules Verne are rapidly becoming realities of today. Successful flights orbiting the earth, active preparations for journeys to other planets, the considerable area of new knowledge we have acquired about outer space, all have created an upsurge of interest in the universe around us. So we, in the space age, are vitally interested in the various kinds of time which the astronomical clocks of old foretold.

As of today the astronomical clock is no longer a rare museum piece. The scientific background and skills of Dr. Spilhaus, combined with the use of modern materials and manufacturing methods by Edmund Scientific Co., have converted the complex arrangement of heavy mechanical parts into a concise mantle clock of pleasing design and decor. Entirely functional, reliable and esthetically pleasing, the Spilhaus Space Clock is well within the reach of many. It is a possession to be proud of (we believe it will become a collector's item) and as a conversation piece it has no equal.







APPARENT TIME IS TIME BY THE REAL SUN. SUN'S MOVEMENT IS NOT UNIFORM–SOME DAYS ARE AS MUCH AS 50 SECONDS LONGER THAN OTHERS

MEAN TIME MAKES USE OF AN IMAGINARY SUN TRAVELING AT A UNIFORM SPEED EQUAL TO THE MEAN OR AVERAGE SPEED OF THE REAL SUN

LOCAL MEAN TIME IS THE SPECIFIC USE OF MEAN TIME AT ANY PARTICULAR PLACE. IT VARIES FOUR MINUTES PER DEGREE OF LONGITUDE

STANDARD TIME IS THE MEAN TIME OF A SPECIFIC LOCATION USED AS THE STANDARD CLOCK TIME OVER AN AREA OF ABOUT 15°

OUR EARTH IS A CLOCK

The yardstick used to measure time is the period it takes the earth to make one complete rotation. This period is very uniform...it will not vary by as much as a fraction of a second in your lifetime. To mark one rotation requires some kind of index mark. When the index mark is the sun, the resulting time is SOLAR TIME (or sun time); when the index is a star, the time is SIDEREAL TIME (or star time).

SOLAR TIME

Our common day, like that of prehistoric man, is still timed to the sun because its presence lightens and warms our days, and its absence darkens and cools our nights. To tell time we consider the sun to be like the hand of a huge earth clock as it seems to go around us once each 24 hours. Of course, we know that it is the earth that goes around the sun.

The solar day begins when the sun is at the lower transit, Figure 1. There are 24 hours in one solar day which, in everyday life, we divide for convenience into two sets of 12 hours each, a.m. for the morning hours and p.m. for the afternoon and evening hours.

Time in astronomy is straight 24-hour time, starting at the zero hour, midnight. The actual keeping of time is based on the hour angle of the sun from the observer's meridian.

Hour angle is always measured to the west, and examples of how this works are shown in Figure 1. The "plus 12 hours" is needed to have the day start at midnight.

It is definitely not easy to visualize the rotation of the earth. Hence, astronomy texts adopt the system of showing things as they appear to be rather than what they are. This makes a diagram like Figure 2. It represents an observer standing on a fairly flat piece of non-moving ground, while the sun, moon and stars turn around him. Although an entirely different concept than the true situation, the base rules work just as before. The day starts with the sun at the lower transit, and solar time is the hour angle of the sun plus 12 hours.

KINDS OF SOLAR TIME

Your Spilhaus Space Clock will be much more meaningful to you if you have a better understanding of the different kinds of Solar Time.

APPARENT SOLAR TIME

This is true sun time, governed by the passage of the sun across the sky. It is the time which you can read from a sundial. Although true sun time, it is not uniform time because the earth travels in an ellipse around the sun, making some days longer than others. See Figure 3.

MEAN SOLAR TIME

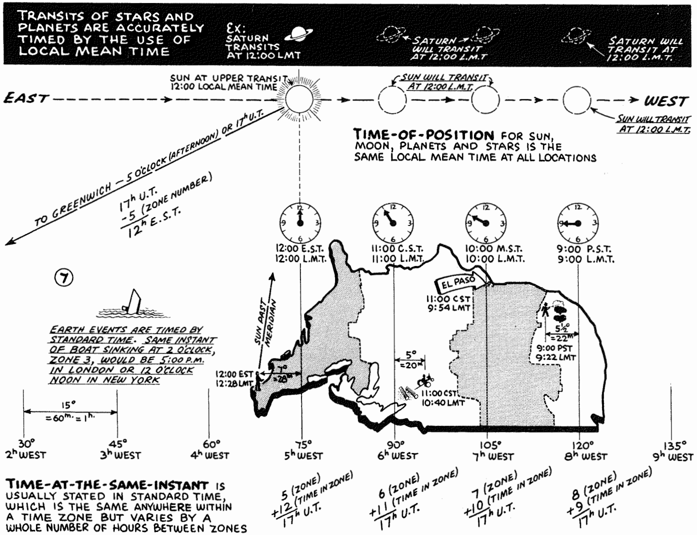
To obtain uniform time, the total time in a solar year is divided into 365 days of equal length. This average type of time is paced by an imaginary sun known as the mean sun. The difference between the real sun and the mean sun ranges from zero to about 15 minutes fast or slow, the difference being calculated by the equation of time. The equation of time is used to convert apparent time to mean time, a time problem seldom encountered by the amateur star gazer. See Figure 4.

STANDARD TIME

Both apparent and mean solar time give a different time for every different location, **(Figure 5)** It was not until 1884 that the people of the world got together and agreed on a world-wide standard of time. This system divides the world into 24 standard time zones, each comprising an area of some 15 degrees of longitude. All of the area in a zone uses the same standard time as determined by the mean solar time of its central meridian, Figure 6. The Zero zone is centered at Greenwich, England. Zones to the west are numbered Plus 1 to Plus 12; the number of the zone added to the standard time of the zone equals Greenwich mean time, as shown at bottom of Figure 7. The United States has four zones, Plus 5, 6, 7 and 8, better known as Eastern, Central, Mountain and Pacific standard time, as shown in Figure 8. Standard time does not vary more than about an hour from mean solar time at any location. At the central meridian of each zone, standard time coincides exactly with mean solar time.

LOCAL MEAN TIME (L.M.T.)

This is also known as Local Civil Time. It is generally referred to as mean time or local time. In all cases, exact positions for celestial objects can only be given in local mean time. This means you must convert mean time to the standard time shown by your clock. If you are lucky enough to live on or near a time zone meridian,

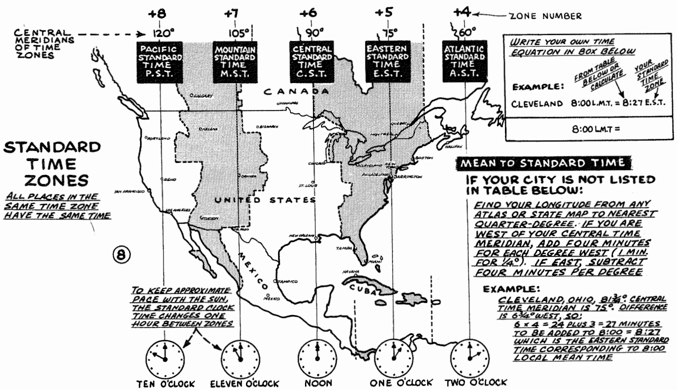


you have no problem because mean time there is the same as standard time. Elsewhere in the zone, L.M.T. is calculated by applying a correction equal to four minutes (4') for each degree (°) you are away from the zone meridian. If your location is in the list of cities, shown in Figure 8, you can determine your time correction by inspection. It is simply the amount by which the time given differs from 8:00 L.M.T. Whether this correction is plus or minus depends on your location east or west of the time zone meridian and also whether you are converting mean to standard time or standard time to mean time.

UNIVERSAL TIME (U.T.)

This is the mean solar time at O degrees longitude, passing through Greenwich, England. It is also the standard time of Zone O, usually known as G.M.T. (Greenwich Mean Time) or G.C.T. (Greenwich Civil Time). Both of these terms meaning exactly the same time as U.T. For astronomical use, Universal time is computed on a 24-hour basis, from midnight at O hours through 24 hours to O hours (midnight).

STANDARD TIME ZONES...All places in the same time zone have the same Standard time



PLACE	8:00 L.M.T.	LAT.	LONG.	PLACE	8:00 L.M.T.	LAT.	LONG.	PLACE	8:00 L.M.T.	LAT.	LONG.	PLACE	8:00 L.M.T.	LAT.	LONG.
AKRON, OHIO	8 26 E	41° 05'	81° 31'	DAYTON, OHIO	8 37 E	39° 46'	84° 12'	LONG BEACH, CAL.	7 53 P	33° 46'	118° 11'	SAGINAW, MICH.	8 36 E	43° 26'	83° 56'
ALBANY, N.Y.	7 55 E	42 39	73 45	DAYTONA BEACH	8 24 E	29 13	81 01	LORAIN, OHIO	8 29 E	41 28	82 10	SCHENECTADY	7 56 E	42 49	73 56
ALBUQUERQUE	8 07 M	35 05	106 39	DECATUR, ILL.	7 56 C	39 51	88 57	LOS ANGELES, CAL.	7 53 P	34 03	118 14	ST. JOSEPH, MO.	8 19 C	39 46	94 51
ALLENTOWN, PA.	8 02 E	40 36	75 28	DENVER, COL.	8 00 M	39 45	104 59	LOUISVILLE, KY.	7 43 C	38 15	85 46	ST. LOUIS, MO.	8 01 C	38 38	90 12
ALTOONA, PA.	8 14 E	40 31	78 24	DES MOINES, IOWA	8 14 C	41 35	93 37	LOWELL MASS.	7 45 E	42 38	71 19	ST. PAUL, MINN.	8 12 C	44 57	93 06
AMARILLO, TEX.	8 47 C	35 12	101 50	DETROIT, MICH.	8 32 E	42 20	83 03	LUBBOCK, TEX.	8 47 C	33 35	101 51	ST. PETERSBURG	8 31 E	27 46	82 38
ANN ARBOR, MICH	8 35 E	42 17	83 45	DODGE CITY, KAN.	7 40 M	37 45	100 01	MACON, GA.	8 35 E	32 50	83 38	SALT LAKE CITY	8 28 M	40 45	111 53
ASHEVILLE, N.C.	8 30 E	35 36	82 33	DULUTH, MINN.	8 08 C	46 47	92 06	MADISON, WIS.	7 58 C	43 04	89 23	SAN ANTONIO, TEX.	8 34 C	29 26	98 29
ASHLAND, KY.	7 31 C	38 29	82 38	DURHAM, N.C.	8 16 E	36 01	78 54	MANCHESTER, N.H.	7 46 E	42 59	71 28	SAN BERNARDINO	7 49 P	34 07	117 17
ATLANTA, GA.	8 38 E	33 45	82 24	EL PASO, TEX.	9 06 C	31 46	106 29	MARION, OHIO	8 33 E	40 35	83 10	SAN DIEGO, CAL.	7 49 P	32 43	117 09
ATLANTIC CITY, N.J.	7 58 E	39 22	74 26	ELIZABETH, N.J.	7 57 E	40 40	74 13	MEMPHIS, TENN.	8 00 C	35 09	90 03	SAN FRANCISCO	8 10 P	37 47	122 25
AUGUSTA, GA.	8 28 E	33 28	81 58	ERIE, PA.	8 20 E	42 07	80 05	MIAMI, FLA.	8 21 E	25 47	80 12	SAN JOSE, CAL.	8 08 P	37 20	121 53
AUGUSTA, ME.	7 39 E	44 19	69 46	EUGENE, ORE.	8 12 P	44 03	123 06	MILWAUKEE, WIS.	7 52 C	43 02	87 54	SANTA BARBARA	7 59 P	34 25	119 42
AUSTIN, TEX.	8 31 C	30 16	97 45	EVANSVILLE, IND.	7 50 C	37 58	87 34	MINNEAPOLIS	8 13 C	44 59	93 16	SANTA FE, N.M.	8 04 M	35 41	105 56
BALTIMORE, MD.	8 06 E	39 17	76 37	FALL RIVER, MASS.	7 45 E	41 42	71 09	MOBILE, ALA.	7 52 C	30 42	88 03	SAVANNAH, GA.	8 24 E	32 05	81 06
BANGOR, ME.	7 35 E	44 48	68 46	FARGO, N.D.	8 27 C	46 53	96 47	MOLINE, ILL.	8 02 C	41 31	90 31	SCRANTON, PA.	8 03 E	41 25	75 40
BARRINGTON, N.J.	8 00 E	39 52	75 02	FLINT, MICH.	8 35 E	43 01	83 42	MONTGOMERY, ALA.	7 45 C	32 23	86 19	SEATTLE, WASH.	8 09 P	47 37	122 20
BATON ROUGE, LA.	8 07 C	30 27	91 11	FORT WAYNE, IND.	7 41 C	41 04	85 08	MONTPELIER, VT.	7 50 E	44 16	72 35	SHREVEPORT, LA.	8 15 C	32 31	93 45
BATTLE CREEK, MICH	8 41 E	42 19	85 11	FORT WORTH, TEX.	8 29 C	32 45	97 20	MUNCIE, IND.	7 42 C	40 11	85 23	SIOUX CITY, IOWA	8 26 C	42 30	96 25
BAY CITY, MICH.	8 36 E	43 36	83 53	FRESNO, CAL.	7 59 P	36 44	119 47	NASHVILLE, TENN.	7 47 C	36 10	86 47	SIOUX FALLS, S.D.	8 27 C	43 33	96 44
BEAUMONT, TEX.	8 16 C	30 05	94 06	GADSDEN, ALA.	7 44 C	34 01	86 01	NEWARK, N.J.	7 57 E	40 44	74 10	SOMERVILLE, MASS.	7 44 E	42 23	71 06
BELLINGHAM, WSH	8 10 P	48 45	122 29	GALVESTON, TEX.	8 15 C	29 18	94 48	NEW BEDFORD, MASS.	7 44 E	41 38	70 56	SOUTH BEND, IND.	7 45 C	41 41	86 15
BERKELEY, CAL.	8 09 P	37 52	122 16	GARY, IND.	7 49 C	41 36	87 21	NEW BRITAIN, CONN.	7 51 E	41 40	72 47	SPARTANBURG, S.C.	8 28 E	34 57	81 56
BETHLEHEM, PA.	8 02 E	40 37	75 23	GRAND RAPIDS, MICH.	8 43 E	42 58	85 40	NEW HAVEN, CONN.	7 52 E	41 18	72 56	SPOKANE, WASH.	7 50 P	47 40	117 26
BILLINGS, MONT.	8 14 M	45 47	108 30	GREEN BAY, WIS.	7 52 C	44 31	88 01	NEW ORLEANS, LA.	8 00 C	29 57	90 04	SPRINGFIELD, ILL.	7 59 C	39 48	89 39
BINGHAMPTON, N.Y.	8 04 E	42 06	75 55	GREENSBORO, N.C.	8 19 E	36 04	79 47	NEW YORK, N.Y.	7 56 E	40 45	74 00	SPRINGFIELD, MASS	7 50 E	42 06	72 36
BIRMINGHAM, ALA.	7 47 C	33 21	86 49	GREENVILLE, S.C.	8 30 E	34 51	82 24	NIAGARA FALLS	8 16 E	43 06	79 03	SPRINGFIELD, MO.	8 13 C	37 13	93 18
BISMARCK, N.D.	8 43 C	46 48	100 47	GULFPORT, MISS.	7 56 C	30 22	89 06	NORFOLK, VA.	8 05 E	36 51	76 17	SPRINGFIELD, OHIO	8 35 E	39 56	83 48
BOISE, IDAHO	8 45 M	43 37	116 12	HAMILTON, OHIO	8 38 E	39 24	84 33	OAKLAND, CAL.	8 09 P	37 48	122 16	STAMFORD, CONN.	7 54 E	41 03	73 32
BOSTON, MASS.	7 44 E	42 21	71 03	HARRISBURG, PA.	8 08 E	40 16	76 53	OGDEN, UTAH	8 28 M	41 14	111 58	STEUBENVILLE, O.	8 22 E	40 22	80 37
BRIDGEPORT, CONN.	7 53 E	41 11	73 11	HARTFORD, CONN.	7 51 E	41 46	72 41	OKLAHOMA CITY	8 30 C	35 28	97 31	STOCKTON, CAL.	8 06 P	37 58	121 17
BROCKTOWN, MASS.	7 44 E	42 05	71 01	HELENA, MONT.	8 28 M	46 36	112 02	OMAHA, NEB.	8 24 C	41 16	95 56	SUPERIOR, WIS.	8 08 C	46 43	92 06
BROWNSVILLE, TEX.	8 30 C	25 54	97 30	HOLYOKE, MASS.	7 50 E	42 12	72 37	ORLANDO, FLA.	8 26 E	28 33	81 23	SYRACUSE, N.Y.	8 05 E	43 03	76 09
BUFFALO, N.Y.	8 15 E	42 53	78 52	HOUSTON, TEX.	8 21 C	29 45	95 22	PADUCAH, KY.	7 54 C	37 05	88 36	TACOMA, WASH.	8 10 P	47 15	122 26
BURLINGTON, VT.	7 53 E	44 29	73 13	HUNTINGTON, W.VA.	8 30 E	38 25	82 27	PASADENA, CAL.	7 53 P	34 09	118 09	TAMPA, FLA.	8 30 E	27 57	82 27
BUTTE, MONT.	8 30 M	46 01	112 32	INDIANAPOLIS	7 45 C	39 46	86 10	PATERSON, N.J.	7 57 E	40 55	74 09	TERRE HAUTE, IND.	7 50 C	39 28	87 24
CAMBRIDGE, MASS.	7 44 E	42 22	71 06	IOWA CITY, IOWA	8 06 C	41 40	91 32	PENSACOLA, FLA.	7 49 C	30 25	87 13	TOLEDO, OHIO	8 34 E	41 39	83 33
CAMDEN, N.J.	8 00 E	39 57	75 07	JACKSON, MICH.	8 38 E	42 15	84 24	PEORIA, ILL.	7 58 C	40 42	89 36	TOPEKA, KAN.	8 23 C	39 03	95 40
CANTON, OHIO	8 26 E	40 48	81 23	JACKSON, MISS.	8 01 C	32 18	90 11	PHILADELPHIA	8 01 E	39 57	75 09	TRENTON, N.J.	7 59 E	40 13	74 46
CEDAR RAPIDS, IOWA	8 07 C	41 58	91 40	JACKSONVILLE, FLA.	8 27 E	30 20	81 40	PHOENIX, ARIZ.	8 28 M	33 27	112 04	TROY, N.Y.	7 55 E	42 44	73 41
CHAMPAIGN, ILL.	7 53 C	40 07	88 15	JERSEY CITY	7 56 E	40 44	74 04	PITTSBURG, PA.	8 20 E	40 26	80 00	TUCSON, ARIZ.	8 24 M	32 13	110 58
CHARLESTON, S.C.	8 20 E	32 47	79 56	JOHNSTOWN, PA.	8 16 E	40 20	78 55	PITTSFIELD, MASS.	7 53 E	42 27	73 15	TULSA, OKLA.	8 24 C	36 09	96 00
CHARLESTON, W.VA.	8 27 E	38 21	81 38	KALAMAZOO, MICH.	8 42 E	42 17	85 35	PORT ARTHUR, TEX.	8 16 C	29 53	93 56	UTICA, N.Y.	8 01 E	43 06	75 14
CHARLOTTE, N.C.	8 23 E	35 14	80 51	KANSAS CITY, KAN.	8 18 C	39 07	94 36	PORTLAND, ME.	7 41 E	43 40	70 15	WACO, TEX.	8 29 C	31 33	97 08
CHATTANOOGA	7 41 C	35 03	85 19	KANSAS CITY, MO.	8 18 C	39 05	94 35	PORTLAND, ORE.	8 11 P	45 31	122 41	WALLA WALLA	7 53 P	46 04	118 20
CHEYENNE, WYO.	7 59 M	41 08	104 49	KENOSHA, WIS.	7 52 C	42 36	87 50	PORTSMOUTH, VA.	8 05 E	36 50	76 18	WASHINGTON, D.C.	8 08 E	38 54	77 01
CHICAGO, ILL.	7 51 C	41 52	87 38	KEY WEST, FLA.	8 27 E	24 34	81 48	PROVIDENCE, R.I.	7 46 E	41 50	71 25	WATERBURY, CONN.	7 52 E	41 33	73 03
CINCINNATI, OHIO	8 38 E	39 06	84 31	KNOXVILLE, TENN.	8 36 E	35 58	83 55	PUEBLO, COL.	7 58 M	38 16	104 37	WATERLOO, IOWA	8 09 C	42 30	92 20
CLEVELAND, OHIO	8 27 E	41 30	81 42	LAFAYETTE, IND.	7 48 C	40 25	86 54	RACINE, WIS.	7 51 C	42 44	87 47	WHEELING, W.VA.	8 23 E	40 04	80 43
COLORADO SPRINGS	7 59 M	38 50	104 49	LANCASTER, PA.	8 05 E	40 02	76 18	RALEIGH, N.C.	8 15 E	35 47	78 38	WICHITA, KAN.	8 29 C	37 42	97 20
COLUMBIA, MO.	8 09 C	38 57	92 20	LANSING, MICH.	8 38 E	42 44	84 33	READING, PA.	8 04 E	40 20	75 56	WICHITA FALLS, TEX.	8 33 C	33 55	98 29
COLUMBIA, S.C.	8 24 E	34 00	81 02	LAREDO, TEX.	8 38 C	27 30	99 31	RENO, NEV.	7 59 P	39 31	119 49	WILKES-BARRE, PA.	8 04 E	41 15	75 53
COLUMBUS, GA.	8 40 E	32 28	84 59	LAS VEGAS, NEV.	7 41 P	36 10	115 09	RICHMOND, VA.	8 10 E	37 32	77 26	WILMINGTON, DEL.	8 02 E	39 45	75 33
COLUMBUS, OHIO	8 32 E	39 58	83 00	LAWRENCE, MASS.	7 45 E	42 42	71 10	ROANOKE, VA.	8 20 E	37 16	79 57	WINSTON-SALEM	8 21 E	36 06	80 15
CONCORD, N.H.	7 46 E	43 12	71 32	LEXINGTON, KY.	7 38 C	38 03	84 30	ROCHESTER, MINN.	8 10 C	44 01	92 28	WORCESTER, MASS.	7 47 E	42 16	71 48
CORPUS CHRISTI	8 30 C	27 48	97 24	LIMA, OHIO	8 36 E	40 45	84 06	ROCHESTER, N.Y.	8 10 E	43 10	77 36	YONKERS, N.Y.	7 56 E	40 56	73 54
DALLAS, TEX.	8 27 C	32 47	96 48	LINCOLN, NEB.	8 27 C	40 49	96 42	ROCKFORD, ILL.	7 56 C	42 16	89 06	YORK, PA.	8 07 E	39 58	76 44
DAVENPORT, IOWA	8 02 C	41 31	90 35	LITTLE ROCK, ARK.	8 09 C	34 45	92 17	SACRAMENTO	8 06 P	38 35	121 30	YOUNGSTOWN, OHIO	8 23 E	41 06	80 39

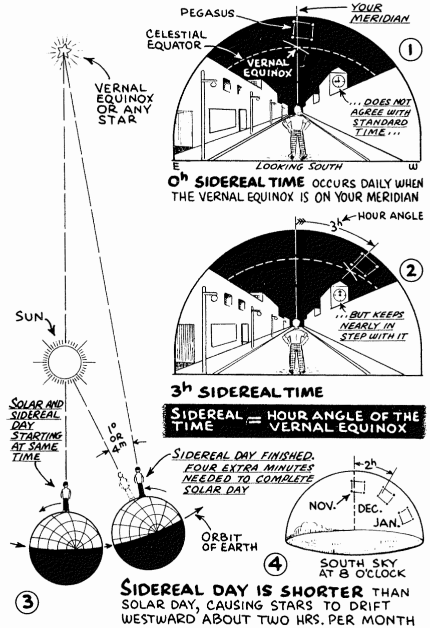
TABLE COMPILED FROM THE WORLD ALMANAC

CONVERSION TABLE

For your convenience in setting Sun Disc (D) ...pages 10-11.

This table determines the time difference to be used in setting the Sun Disc (D). Table refers in each case to 8:00 L. M. T. (which is solar time) and gives the corresponding standard time for each city listed. The difference in minutes between these values is to be used in your calculations as illustrated by the examples on pages 10 and 11.

SIDEREAL TIME



The main use of Sidereal Time is in astronomy where it provides an exact timetable of the stars. The sidereal day is divided into 24 sidereal hours with the hours marked continuously from O hours to 24 hours (or O hours). To a sky observer sidereal time is the hour angle of the vernal equinox measured westward from your meridian, Figure 2. Because the earth rotates around the sun once a year, while it turns on its axis 365 times, the star day is 1/365th of a day shorter than 24 hours...about 4 minutes shorter. The star or sidereal day is 23 hours, 56 minutes and 4.09 seconds long...so a star will rise about 4 minutes earlier clocktime each night. One rotation of the earth, in reference to any star, rather than in reference to the sun, equals 24 hours of sidereal or star time. The zero hour (O hour) at which the sidereal and the solar times are the same occurs when the vernal equinox is on your meridian.

The one feature which makes sidereal time somewhat of a puzzle is that the hours are 10 seconds shorter than similar hours of solar time. While this doesn't sound like much, it amounts to 240 seconds or 4 minutes in one day, 2 hours in one month and 24 hours or one whole day in a year. Why the sidereal day is shorter than the solar day can be seen in Figure 3. Because the earth revolves around the sun, it takes four minutes extra per day between two successive upper transits of the sun. The true period of the earth's rotation is actually the transit to transit time of a star on the vernal equinox. The four minute difference per day allows the stars to advance westward by this amount before the solar day is completed, and this small time difference repeated night after night, gives us a constantly changing parade of stars.

The big advantage of sidereal time is that, since it is governed by the apparent motion of the stars, it also keeps exact pace with them.

THE LUNAR DAY

In similar manner, the moon orbits around the earth as the earth, in turn, orbits around the sun. The new moon appears when sun, moon and earth are in a straight line with the moon in between. There are 29 days, 12 hours, 44 minutes and 3 seconds from one new moon to the next new moon. This is the lunar month, the very word month comes from the word moon. The moon rises and sets about 50 minutes later each day. On your Spilhaus Space Clock the times of the positions of the moon are given in terms of sun or standard time, and not in terms of the lunar days, etc.

GUARANTEE

Your Spilhaus Space Clock when properly registered is guaranteed to be free from defects in materials and workmanship for a period of one year.

In the event of damage, accidental or otherwise, write Edmund Scientific Co., Barrington, New Jersey 08007 about the trouble. Please be sure to indicate from whom the clock was purchased, the serial number (engraved on the aluminum back plate located behind the dust cover) and a brief description of the trouble. On receipt of your letter, we will gladly outline the procedure to be followed.

NEW DEVELOPMENTS

More detailed information or additional accessory items are likely to be available from time to time. Please be sure to register your clock on the form provided and mail it so you can be advised of new developments.

SPECIAL PURPOSE DISCS

Because of varied individual interests, you may wish to remove certain of the discs in the Space Dial and replace them with specialized ones of your own making. Prices on blank discs complete with gear teeth can be supplied on request. If your interests are shared by others, we may be able to prepare special discs for you.

HELPFUL BOOKS ON CLOCKS, TIME AND ASTRONOMY

"Some Outstanding Clocks Over Seven Hundred Years" by H. Alan Lloyd. Published 1958, Leonard Hill (Books) Limited, Nine Edan Street, London N.W.I., England. Available from Edmund Scientific Co., Barrington, N. J. Clothbound, 160 pages (7-1/2 x 11"), 173 illustrations. No. 9357 $15.00 Postpaid.

"Britten's Old Clocks and Watches and Their Makers" by G. H. Baillie, C. Clutton, C. A. Ilbert. Published 1956, E. P. Dutton & Co., Inc., New York, New York.

"The Clock Book" by Wallace Nutting. Published 1924, Garden City Publishing Co., Inc. Garden City, N. Y.

"Time in Astronomy" No. 9054...60¢. Edmund Scientific Co., Barrington, New Jersey 08007.

"Time and Its Measurement" by J. Cowan. Published by World Publishing Co., Cleveland, Ohio.

"Heavenly Clockwork" by Needham, Ling and Price. Cambridge University Press, New York, N. Y.

"The World Almanac". Annually by New York World Telegram & Sun, 125 Barclay St., New York 15, N.Y.

"The American Ephemeris and Nautical Almanac". Published annually and available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. At most libraries.

MUSEUMS WITH HOROLOGICAL ITEMS OF INTEREST

Los Angeles County Museum, 900 Exposition Boulevard, Los Angeles 7, California

Griffith Observatory and Planetarium, Griffith Park, Los Angeles 27, California

California Academy of Science, Golden Gate Park, San Francisco 18, California

Hagans Clock Manor Museum, Bergen Park, Evergreen, Colorado

U. S. National Museum (Smithsonian Institute) Jefferson Drive at 9 St., N. W., Washington 25, D. C.

Essex Institute, 132 Essex Street, Salem, Massachusetts

Henry Ford Museum and Greenfield Village, Dearborn, Michigan

The Clock Museum, Newport, New Hampshire

New York University of Clocks and Watches, University Avenue at 181 St., Bronx 53, New York

Metropolitan Museum of Art, 5th Avenue at 82nd Street, New York 28, New York

Hoffman Foundation, Newark Public Library, Newark, New York

Old Salem, Inc. 614 Main Street, Winston Salem, North Carolina

Western Reserve Historical Society, 10825 East Boulevard, Cleveland 6, Ohio

Columbia Museum of Horological Antiquities, 333 N. Third St., Columbia , Pa.

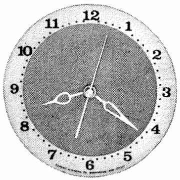
Franklin Institute Museum, Ben Franklin Parkway, Philadelphia 3, Pennsylvania

Harthill's Clock Museum, Whitman Street, Rosalia, Washington

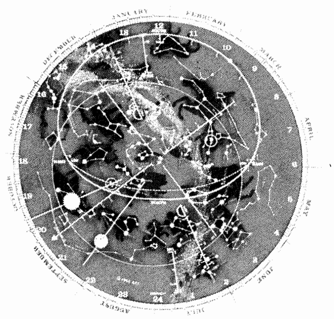
CLOCK COLLECTORS ASSOCIATION

National Association of Watch and Clock Collectors, Inc., 333 N. Third Street, Columbia, Pennsylvania

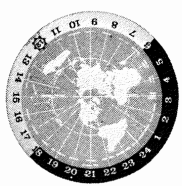
CONDENSED SETTING INSTRUCTIONS



REGULAR TIME DIAL



LARGE SPACE DIAL WITH 4 ROTATING DISCS



WORLD TIME DIAL

Printed in U.S.A.

REGULAR TIME DIAL

Set as you would an ordinary electric clock by rotating the brass knob on clock motor.

LARGE SPACE DIAL

1. To Set the Correct Date on the Star Disc: Hold the gold knob on the back panel and rotate the blue knob until the correct month and day on the Star Disc are aligned with the gold line through the Sun on Sun Disc.
2. To Set the Sun Disc: Turn the gold knob to the correct solar time (24-hour dial) for your geographical location. This is computed by correcting for local mean time, and if necessary, for daylight saving time.
3. To Set the Moon Disc: Find the time of moonrise (or moonset) from your local newspaper, World Almanac, or from an ephermeris.
   (a) Rotate the brass knob on the clock motor (which moves all discs) to reset the line through the sun (on Sun Disc) to the time of moonrise (or moonset).
   (b) Turn the red knob only, and reset the line through the moon (on the Moon Disc) to the time of sunrise (or sunset if you used moonset).
   (c) Turn only the brass knob and reset the lower left dial to the present regular time. This moves all discs to their correct settings.
4. To Set the Tide Disc: Find the standard time of high tide at the location of your choice. Turn the gray knob, and set one of the light blue tide scales at the correct number of hours before or after the nearest high tide. These hour figures appear inside the blue horizon ellipse on the Horizon and Hour Disc. The blue hours to the right of "O" hours are "before high tide"

WORLD TIME DIAL

Turn the ivory knob and set the World Time Dial for solar time already found in (2) above. Dial will then show Greenwich Mean Time and standard time for cities named.