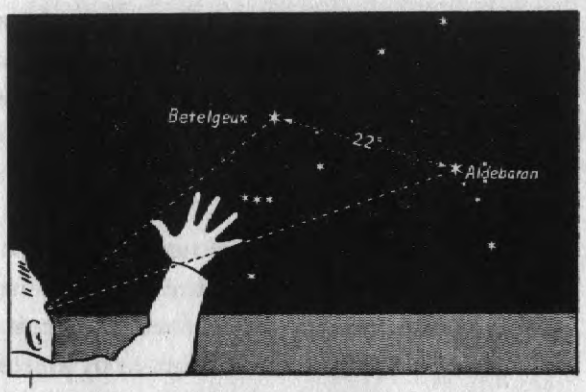
THE RAFT BOOK

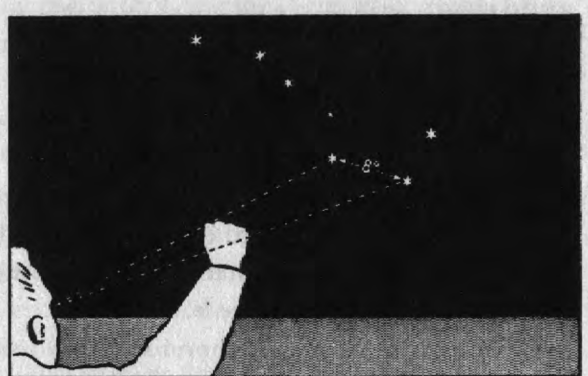
LORE OF THE SEA AND SKY

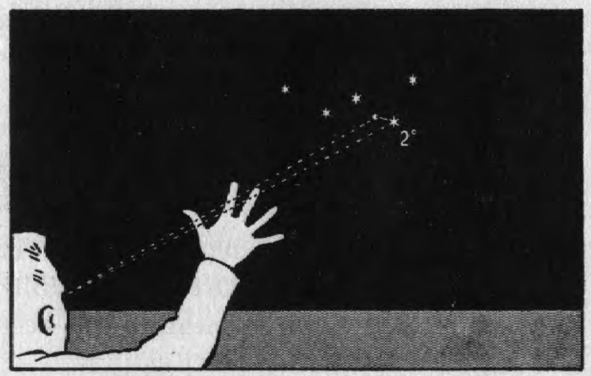
BY HAROLD GATTY

above the horizon, which angle gave them their latitude. A knowledge of rough angle measurement may be very useful.

With the arm outstretched the average person's span between the thumb and middle finger extended just comfortably will measure an angle of about 15° arc. With the arm in the same position, the span between the thumb and middle finger spread as far as possible, will measure about 19° of arc. If you want an angle of 22° extend your arm and hand in the same manner and the distance between the tip of the thumb and the tip of the little finger will approximate 22°.







With the arm outstretched and the palm down, the closed fist will cover an arc of 8°, and with the arm in the same position but with the fingers upright and the back of your hand towards you, the middle finger will cover an angle of 2°.

While these measurements apply for the average person it will be worthwhile for you to check your span with accurate angles. This may be easily done at night after you have learned to recognize some of the principal stars from the star diagrams which follow in the book.

The names of the stars may sound confusing to you and while it is to your advantage to remember them it is not essential as long as you recognize the pattern that they are in.

The angle between Betelgeux and Aldebaran is 22°. The 8° measurement with the fist clenched can be checked between the stars forming the bottom of the bowl of the dipper, Phecda and Merak. The 2° measurement with the middle finger can be compared with the 2° distance between Schedir in the constellation of Cassiopeia, and a much smaller star towards the center of the W.

These angles are accurate to the nearest degree. The actual angles between any stars may be determined from the star chart just as you would measure distance on the world chart.

THE "HARP" FOR MEASURING ANGLES

Hand measurements will be useful for quick and fairly rough determination of angles but can be improved upon even in a simple way where more accuracy is desirable.

All manner of gadgets have been suggested for inclusion as standard equipment in rafts and lifeboats. If all the suggestions were carried out there would be no room for passengers. With this in mind, a means of measuring angles without special equipment has been arranged to suit the particular needs of such craft.

The device suggested is very simply made. In order that we may refer to it in one word rather than describe it each time, it will be referred to hereafter as the "Harp."

It is assumed that you have no precision instruments with you and it is also assumed that you have no experience in the use of them. If you follow the instructions carefully, you should be able to measure the height of the sun or stars with reasonable accuracy.

Take a stick, paddle or other object 3 feet or more in length, mark a distance of exactly 3 feet along its edge. On the back of the world base chart, along the bottom edge below the tables will be found an accurate 3 foot measurement on the Harp scale.

There is no need to mark the scale divisions on the stick, but merely the 3 foot mark from one end of the stick.

Knot a length of string or fishing line so that you have on each side of the knot a length of over 26 inches; tie the ends of these strings, one to the extreme end of the stick and the other at the 3 foot mark, but tie them so that each length is as exactly as possible 25.45 inches from the edge of the stick to the knot. This length of 25.45 inches is shown on a scale above the 3 foot Harp scale on the back of the chart.

When pulled out from the position of the knot, a triangle is formed which is 3 feet on one side and 25.45 inches on each of the other sides. If, as with the average person, your right eye is your sighting eye, hold the stick in your left hand, the knot between the thumb and first finger of the right hand. Now pull the strings taut holding the knot at the corner of your eye as closely as possible and in against the base of the nose, with the stick in a vertical position. Turn your body towards the sun or star whose height you wish to measure and turn the head to the left so that the right eye faces squarely to the sun.

Keeping the stick in an up and down position, raise the bottom of it to a point just touching the horizon. With the bottom of the stick just flush with the horizon, get the sun or star along the vertical edge. Move the hand along the stick so that the top of the sun just clears the tip of your thumb. With a sideways twist of the hand, see that the bottom of the stick describes a small arc just *skimming* the horizon and then note the exact position of the sun or star along the stick.

Actually the thumb may be held in the position where the sun appears on the stick. Now mark this point on the stick and then lay it along the degree scale (marked Harp Scale) on the back of the base

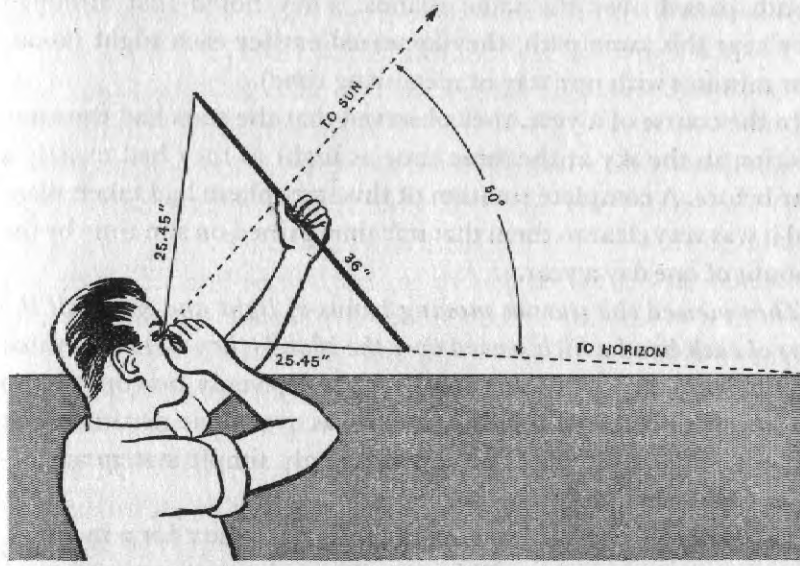


chart. Read off the angle for the distance from the bottom of the stick to the point where the sun or star is marked. This will be the angular height of the sun or star, from which you will be able to determine your latitude north or south of the Equator. How you obtain your latitude from this measurement will be described on page 94.

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HOW THE POLYNESIANS USED THE STARS

Polynesians viewed the heavens as the inside of a shell or pit which revolved around them. The Stars in this dome were seen to rise over the eastern horizon and to descend and finally disappear over the of the transparent star chart towards you the stars will appear in a similar position to the way you see them in the heavens. After you have found the position of this star on your star chart, make sure that this star is actually overhead. You will find this quite easy in any small craft by remaining stationary and picking out the star you think is directly overhead and then either turning yourself or, what will be much easier, *paddling the raft or boat in circles.* You will usually be surprised when you turn 180 degrees and find that the star you thought was overhead you will almost break your neck to see. The height of a star is invariably underestimated. By turning yourself in this manner, you should actually be able to determine the point directly overhead to half a degree. Even if the sea is rough, by taking longer over the operation and judging it each time you think you are temporarily level, your results will be reasonably close.

After you have found your overhead star or the star nearest overhead, by sliding the transparent star chart horizontally over the world chart, you will see at what latitude you are.

This method can be used on the darkest night when there is no horizon and will require neither instruments, watch nor even the Harp.

Should you observe at a time when there is no star overhead which you can see marked on the transparent chart, wait a while for another star.

One considerable advantage of the overhead star method is that you do not have to identify the star by name.

BY THE DURATION OF DAY

For this method of getting latitude, you do not need to measure angles, but all you need is the table which you will find on the back of the world chart, and a watch. What you are going to do is to determine latitude by the length of the day.

It does not matter to what particular time your watch is set, but it is necessary to see the sun rise in the morning and set at night.

The idea of getting latitude in this manner is very old, but this is the first time that it has been able to be put into practice, as tables suitable for its practical use have not previously been published. It is a method not suitable for steamships or aircraft, but it is most valuable for rafts or life-boats whose distance run in about 12 hours of daylight is not very great and where a limit of error of six miles or so is of little consequence.

Have your watch wound and running before sunrise and wait until the top of the sun is just showing in line with the horizon. Write down the time showing on your watch at this instant. When the sun is setting, wait until the top of the sun is again in line with the horizon and note again the time showing on your watch. Subtract the time at sunrise from 12 hours and add the time showing on your watch at sunset and this will give you the duration of the day.

Knowing only the date and the duration of the day it is possible to determine the latitude. Look at the table for the particular hemisphere you are in, on the back of the world chart, and find the date on the left-hand side. If the exact day is not shown, take the nearest *previous* date shown.

LATITUDE BY THE DURATION OF THE DAY

EXAMPLE 1

On April 4, 1943 the sun peeped above the horizon at 05 hr. 44 min. A.M., and dropped behind the horizon at 07 hr. 44 min. P.M., giving the day's duration an even 14 hours. Our watch was set to Greenwich time, although that is NOT necessary to compute our latitude, but is VITAL for longitude.

Table A gives durations, and the nearest printed dates to April 4 are April 1 and April 6. Looking for the nearest durations to our measured value for these two dates, we find the values shown as follows in columns headed 66 N. and 68 N.

	66°	68°
	Duration	*Duration*
Apr. 1	13 hr. 34 min.	13 hr. 43 min.
Apr. 6	14 hr. 10 min.	14 hr. 24 min.

Our time of 14 hours is somewhere between Apr. 1 and Apr. 6 and latitude between 66° N. and 68° N. We might expand the table thus, to accommodate our date of April 4.

	66° N.		68° N.
	Duration		*Duration*
Apr. 1	13 hr. 34 min.		13 hr. 43 min.
2			
3			
4	- - - - -	14 hr. 00 min.	- - - -
5			
6	14 hr. 10 min.		14 hr. 24 min.

Immediately we KNOW we are between 66 and 68 degrees North.

To find it more accurately, we proceed as follows:

In the column 66° N. where the duration for

April 1 is - - - - - - - - -	13 hr. 34 min.
and April 6 is - - - - - - - - -	14 hr. 10 min.
the difference is - - - - - - - -	00 hr. 36 min.

Our next job is to find the *computed* duration for latitude 66 for April 4, which we can get from Table B. Entering the SIDE of the table at 36 minutes (the difference) to the right under the 3rd day (after April 1) we find 21.6 minutes. The tabulated duration for April 1 latitude 66° N. is 13 hr. 34 min. to which we add the 21.6 minutes, and we now have 13 hr. 55.6 min. duration for latitude 66° N. on April 4, our day. But our measured duration was 14 hours for April 4, so we must be farther north (as previously shown), so let us find the computed duration for latitude 66° N.

From Table A for latitude 68° duration

on April 1 is - - - - -	13 hr. 43 min.
and on April 6 is - - - - -	14 hr. 24 min.
and the difference is - - - - -	00 hr. 41 min.

From Table B, entering at 41 minutes on the side under the column for 3rd day, appears 24.6 minutes. The tabulated duration for April 1 latitude 68° N. is 13 hours 43 minutes, to which we add the 24.6 minutes, and we now have 14 hours 07.6 minutes duration for Latitude 68° North on April 4.

	Lat. 66°		*Lat. 68°*
	Duration		*Duration*
Apr. 1	13 hr. 34 min.		13 hr. 43 min.
2	↑ Table B–21.6 min.		Table B–24.6 min.
3	↓		
Apr. 4	13 hr. 55.6	←(12 min. diff.)→	14 hr. 07.6 min.
5			
6	14 hr. 10 min.		14 hr. 24 min.

Our day of 14 hr. 00 min. is between Latitude 66° N. and 68° N. and is nearer 66° N. than 68° N.

The duration in Table A on April 4 for Latitude 66° N. is 13 hr. 55.6 min., and on April 4 for Latitude 68° N. is 14 hr. 07.6 min. The difference is 00 hr. 12.0 min.

Our measured duration was 14 hours, our computed duration for April 4, Latitude 66° N. was 13 hours 55.6 minutes, and these two have a difference of 4.4 minutes.

Enter top of Table D with the nearest whole number to the 4.4, or 4.0 minutes, travel down until on a line with the 12.0 minutes difference (between the durations for April 4 on Latitudes 66 N.–68 N.). The value is .7°, which we add to Latitude 66° N., giving our latitude of 66.7° N. or 66° 42′ N.

By established navigational calculations the latitude in this instance is 66° 53.5′ N., showing an error of only 12 miles by the duration method. Random calculations show the average accuracy of these tables to be in the neighborhood of 6 to 10 miles.

Table C is included for adjustments when the measured duration appears to be under 30° latitude, where adjacent columns are 5° apart instead of Table D for columns 2° apart. The procedure for both tables is the same.

Determination of latitude by duration of the day is not restricted to the duration between sunrise and sunset on the same day. If the sun is observed when rising on the morning of one day, the time of sunset should be noted and the time of sunrise the next morning taken. Subtract the sunrise time from 12, add to the sunset time of the night before, and this will give sufficiently closely the duration of your day.

LATITUDE BY THE DURATION OF THE DAY CAN NOT BE USED WITHIN ABOUT A WEEK BEFORE AND A WEEK AFTER MARCH 21 AND SEPTEMBER 23 BECAUSE AT THESE TIMES WHEN THE SUN IS CROSSING THE EQUATOR THE DIFFERENCE IN DURATION AT VARIOUS LATITUDES IS NOT SUFFICIENT TO GIVE ANY PRACTICAL RESULTS.

It is recommended that around these dates noon heights of the sun, the Pole Star or overhead star methods, should be used to obtain latitude.

FINDING YOUR DESTINATION WITHOUT A WATCH

As we have described, there are quite a number of ways of finding your latitude and which do not require a watch set to Greenwich Time.

If you have no watch you are in a position similar to the European and American navigators who up until about 1800, when chronometers became more common, were forced to navigate without

a time-piece. They sailed the Seven Seas and most of them had no way of obtaining their longitude.

What they did was to sail on a course well to one side of their destination and when they reached the latitude of their destination they sailed due East or West along this latitude until they reached the place to which they were going.

By setting a course to one side more than they could possibly be drifted, they knew very definitely which way to turn on reaching the desired parallel of latitude.

Should you have no watch set to Greenwich Time you can do the same thing.

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HOW FAR YOU ARE EAST OR WEST

Longitude is a division of the earth in an east and west direction and is measured in degrees—180 degrees to the east and 180 degrees to the west—of a base line which is taken to be a line running from the North Pole to the South Pole through Greenwich in England. While a degree of latitude represents the same distance at any place on the earth, the actual number of miles included in a degree of longitude varies from 60 miles east or west on the Equator to zero at either the North or South Pole.

If you are at a latitude of 40 degrees North of the Equator and want to fix your position east or west of the base meridian of Greenwich, you say that you are so many degrees east or west, and unless you plot your position at this latitude on your chart, at the number of degrees east or west, it will have no meaning to you as far as the number of miles is concerned.

Instead of streets the coordinates used in navigation are latitude north or south of the Equator and longitude east or west of the base meridian of Greenwich.

To find your longitude (how many degrees you are east or west of

Greenwich) you must carry a watch which has been set to Greenwich time.

The angle east or west of Greenwich is the same as the difference in time between yourself and Greenwich. The earth revolves on its axis once in 24 hours, which is equal to 15 degrees in each hour or one degree in 4 minutes. If you know what time it is in Greenwich at any instant and you know your local time for your position, the difference will be a certain number of hours, which, if changed into degrees by the above amount, will give you how many degrees of longitude you are east or west of Greenwich.

By tables that are given on the back of the base chart showing local times of sunrise and sunset, you are able to find longitude in a very simple manner. If you are able to see the top part of the sun just in line with the horizon as it is rising, write down the Greenwich time in hours, minutes and parts of a minute that are showing on your watch at this instant. Then by knowing what is the local day you look in the tables for your latitude, which we assume you have obtained by one of the methods given in an earlier chapter, and find the local time of sunrise or sunset.

If you take the difference between this local time of sunrise or sunset given in the table for your latitude, and your local date and the Greenwich time shown on your watch, you will obtain your longitude. You may step this time difference from Greenwich along the top of the world chart to the East or West depending upon whether your time is ahead of Greenwich or behind.

If the Greenwich time is greater than your local time, your longitude is west of Greenwich. If your Greenwich time is less than your local time, your longitude is east of Greenwich. A simple way of remembering this is by the jingle:

Longitude west,
Greenwich time best;
Longitude east,
Greenwich time least.

There is no practicable way of finding out how far you are east or west on the surface of the earth by the sun, moon or stars without the use of a watch showing Greenwich time.

From this you will see that it is well worth anybody's while who is either sailing or flying across the seas in these times to obtain from the navigator of his ship or aircraft the time at Greenwich and keep this time as closely as his watch permits.

Even if you do not wish to make a habit of this, there may be sufficient time in an emergency to set your watch to Greenwich time. It is certainly not advisable to assume that there will be a navigator present in every raft or lifeboat, and this precaution is very worthwhile as a measure of safety.

Take good care of your watch. Keep it dry and preferably in a rubber sack. Wind it at the same time every day and give it a chance to settle down to a steady rate. Check its rate, know how many seconds it is running fast or slow each day. Keep your watch in the same position as nearly as possible at all times, either vertical or horizontal, and do not set it down on a hard surface if you wish to keep it running with a steady rate.

A 23-jewel watch is the best you can get, but a watch having 17 or more jewels will give good results.

An unwaterproofed watch kept in a thin, transparent rubber sack will be preferable to a waterproof watch with less jewels. Don't expect to keep very accurate time on a wrist watch for the motions of the arm will not permit of a steady rate.

TO FIND YOUR LONGITUDE

For this purpose we can use either time of sunrise or sunset. For our solution we will use the time of sunrise which we obtain from Table A.

In the example showing how we obtain latitude by the duration of the day on page 101 we found our latitude to be 66.7° North for which latitude we will now find the local time of sunrise on April 4.

At sunrise on the morning of April 4 we found the time on our watch, which was set to Greenwich time, to be 05 hours 44 minutes A. M.

Entering Table A

At Latitude 66°, April 1, sunrise is	05 hr. 18 min.
Latitude 66°, April 6, sunrise is	04 hr. 59 min.
The difference is	00 hr. 19 min.

Entering Date Adjustment Table B on the side with 19 minutes and under the 3rd day, we find 11.4 minutes. We *subtract* this from the sunrise time of April 1 (because on April 6 the sunrise time is earlier) and find the sunrise time of April 4 at Latitude 66° North to be (05 hours 18 minutes minus 11.4 minutes) 05 hours 06.6 minutes.

Because our latitude is BETWEEN 66° North and 68° North, we will now find sunrise time for Latitude 68° on April 4.

Entering Table A again April 1 at Latitude 68°,

April 1 at Latitude 68°, sunrise is - - - -	05 hr. 14 min.
and for April 6 at Latitude 68°, sunrise is - - - -	04 hr. 52 min.
The difference is - - - -	22 min.

Entering Date Adjustment Table B again on the side with 22 minutes and under the 3rd day, we find 13.2 minutes. We subtract this from sunrise time of April 1 (because on April 6 the sunrise is earlier) and find the sunrise time of April 4 at Latitude 66° North to be (05 hours 14 minutes minus 13.2 minutes) 05 hours 00.8 minutes.

We have found:

Sunrise April 4 Latitude 66° to be	05 hr. 06.6 min.
" " " 68° " "	05 hr. 00.8 min.
Difference	00 hr. 05.8 min.

Entering side of Table D at the nearest number to 5.8 minutes, or at 6 minutes, and proceeding to the right until we come to the nearest number corresponding to our latitude ABOVE 66° North (our latitude is 66.7° North) or .7, we find ourselves in the column labeled 2 minutes at the TOP.

Since the sunrise at 68° North is *earlier* than at 66° North, we subtract these 2.0 minutes found in Table D from the sunrise time we have just computed for 66° North on April 4.

Sunrise April 4, Latitude 66° North	05 hr. 06.6 min.
Table D, difference - - - - - -	00 hr. 02.0 min.
Local time sunrise April 4, Latitude 66.7° North - - - - - -	05 hr. 04.6 min.
Greenwich time, sunrise April 4, Latitude 66.7° North (you took the time by your watch) - - - - -	05 hr. 44.0 min.
Difference in time between Greenwich and ourselves (which is our longitude) is - - - - - - - - -	00 hr. 39.4 min.

If you know whether you are in East or West Longitude, you also know whether the sun rose at Greenwich before or after it rose with you. You know then in this case, the sun rose at Greenwich BEFORE it did with you, and you will read off the time difference of 39.4 minutes on the top scale of the World Chart to the *left* or West of Greenwich or 0 hours time.

Reading along the top of the base chart until we find 39½ minutes (nearest 39.4) and dropping to the bottom scale at this point, we find our longitude to be 09° 51′ West. A more practical way is to drop down from the time scale to our computed latitude and plot the intersection of this line with our latitude, thus giving us our geographical position on the world chart.

The previous example shows the method of obtaining your position in an East or West direction (your longitude) by noting the Greenwich Time at sunrise.

Exactly the same method may be used at sunset when you will take the difference between sunset time for your date and the Greenwich Time from your watch at sunset.

LONGITUDE BY THE OVERHEAD STAR METHOD

The use of the transparent star chart for determining latitude has been described in the chapter on "How Far You Are North or South." For this determination of latitude a watch was not necessary.

The procedure for obtaining longitude requires the use of a watch accurately set to Greenwich Time. The date at Greenwich must also be known. The watch is required in order to adjust the transparent star chart over the world chart so that the stars are over their correct position on the earth for that instant.

Below the longitude scale along the bottom of the world chart is a scale of months and days of the year. The date scale on this edition of the chart is for 1943.*

Place the transparent star chart directly over the world chart with the plotting side uppermost. See that the latitude lines coincide very precisely. The best reference line for alignment will be the 40th parallel of South latitude.

Place the setting line in the extreme lower right corner of the star chart so that the arrow rests exactly on the mark representing your Greenwich day on the date scale running along the extreme bottom of the world chart.

This setting gives the position of the stars at midnight on the beginning of your Greenwich day. The stars at that time are exactly overhead at the points beneath them on the world chart. Your watch at this time, we will assume, is showing 10 hours Greenwich Time, which means that the stars have moved 10 hours past the position of the setting you have just made.

In other words, the stars are 10 hours to the left, or West, of the midnight or 0 hour setting.

Star time is faster than sun time by about four minutes a day. However, this has been taken into account on the hour scale along the bottom of the star chart, so that you can use the Greenwich Time showing on your watch.

Still holding your star chart with the setting line over the Greenwich date on the world chart, count along from the lower right hand corner of your transparent star chart 10 hours to the left or westward. Mark this position with a pencil on the bottom of the star chart, and underneath on the world chart, exactly in this same spot. This may be done most easily by making a heavily rubbed area with a soft pencil, on a small piece of paper, which may be inserted between the two charts and used as carbon paper.

Now move the transparent star chart horizontally to the left until the setting line is exactly on the mark that you have made on the world chart. If your chart is aligned with the setting line as described, and the latitude lines on the star chart exactly coincide with the latitude lines on the world chart, the stars will be in their exact positions for that date and hour.

If moving the star chart to the left puts your overhead star be-

* If these 1943 editions of the star chart and the world chart are used for determining longitude by the overhead star method after December 31, 1943, there will be an error to the eastward of about one quarter of a degree of longitude, unless a correction is applied. Charts for 1944 will be printed in the latter part of 1943 and may then be obtained from the publishers.

If the 1943 edition of the charts must for any reason be used after December 31, 1943, the following correction is necessary: Subtract one minute from the Greenwich Time showing on your watch. This must be done throughout 1944.

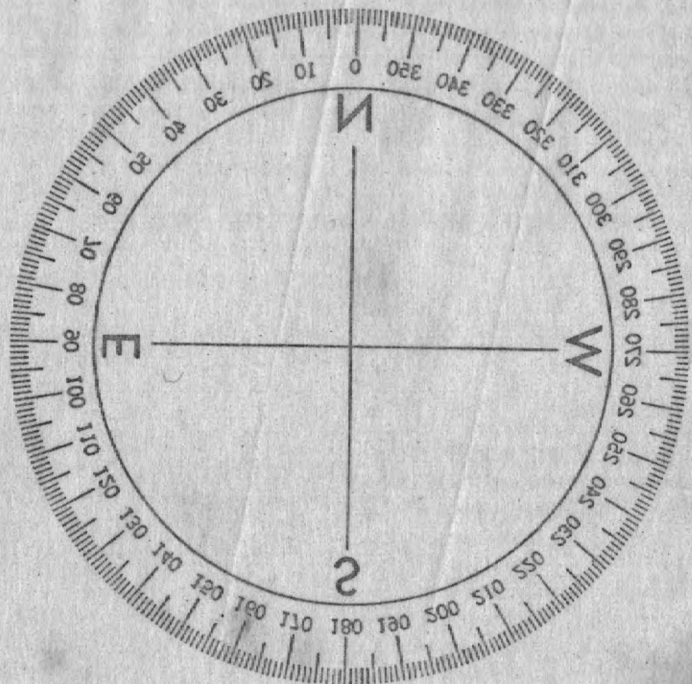
As 1944 is a Leap Year, for February 29 use March 1 as your plotting date, continuing to add one day to your plotting date thereafter throughout 1944, but only after February 29.

For example, on March 31 Greenwich date, 1944, you will use April 1 as your plotting date for setting the star chart.

This addition of a day after February 29 must be done as well as subtracting one minute from your Greenwich Time throughout the year 1944.

PLATE 29

Removable Transparent Protractor For Emergency Use



ERRATA

TABLES ON BACK OF THE WORLD CHART

Table A

Latitude 72° N., November 17, time of sunset given 11–53, should be 12–53.
Latitude 5° S., December 27, time of sunrise " 6 48 " " 5 48.

Adjustment Table C

13 min. horizontally to	7 min. vertically,	2.6 given,	should be	2.7.
14 " " "	9 " "	3.3 "	" "	3.2.
14 " " "	10 " "	3.7 "	" "	3.6.
15 " " "	8 " "	2.6 "	" "	2.7.
21 " " "	14 " "	3.4 "	" "	3.3.
22 " " "	15 " "	3.3 "	" "	3.4.

FRONT OF WORLD CHART

On inset chart, Variation of the Compass, in upper left area of World Chart, the variation line south of India shown as 10 E, should be 10 W. In N. W. Africa the variation line shown as 10 E, should be 10 W.