

ESTIMATING HEIGHTS AND DISTANCES.

SOME ROUGH AND READY METHODS.

BY JAMES ASHER.

In the following paragraphs several rough and ready methods of estimating the heights and distances of various objects are shown, and accompanied by practical problems. Many of these methods give surprisingly accurate results.

MEASUREMENT OF HEIGHT.

1. To find the height of a tree, set a stake in the

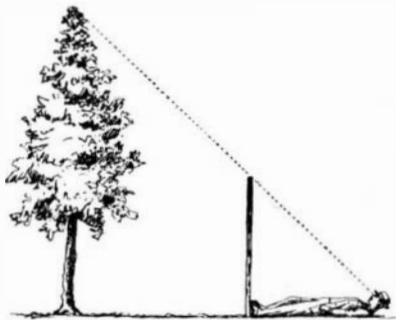


FIG. 1.—HEIGHT OF TREE EQUALS ITS DISTANCE FROM THE EYE.

ground at a distance from the tree which seems nearly equal to the tree's height. The stake must be vertical, and its upper end should be on a level with the eye. The observer should then lie on his back on the ground, with his heels just touching the stake and pointing toward the tree. If he can just see the top of the tree, the distance from his eyes to the foot of the tree is equal to the height which is sought.

2. Heights of objects may be measured by the aid of two parallel upright rods fixed to a wooden base (see Fig. 2). One rod may be 4 and the other 5 feet high, in which case they should be a foot apart. Move this instrument back and forth, keeping the base on level ground, and aim from the top of the shorter rod over the top of the longer one. When the line of sight meets the top of the tree, the eye is as far from the tree as the top of the tree is above the level with the upper end of the shorter rod. Add 4 to the distance from the shorter rod to the tree to find the height. This simple instrument is of use to lumbermen and others.

3. By means of the image of an object reflected in a vessel of water, its height can be readily calculated. For example, in Fig. 3, the height a of the eye above the level of the water is to the distance b between the point on the water where the top of the tower appears and a vertical line drawn from the observer's eye, as the height a' of the tower is to the distance b' of the tower from the point where the reflected image appears ($a : b :: a' : b'$). Example: A man sees the image of the top of a tower in a vessel of water whose

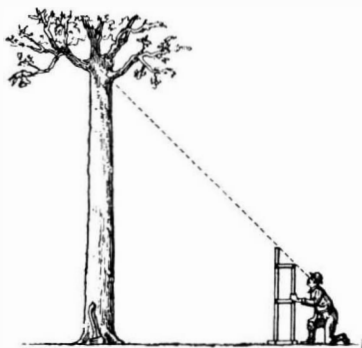


FIG. 2.—MEASURING WITH THE AID OF TWO PARALLEL RODS.

surface is a foot above the ground. The height of the eye above the water is 4 feet. The distance of the point where the image appears from a vertical through the eye is 7 feet, and the distance of the image from the tower is 140 feet. What is the height of the tower? Answer: $4 : 7 :: 80 : 140$. The top of the tower is 80 feet above the water, or 81 feet above the ground.

4. The heights of objects can be found in the following manner from the lengths of their shadows: Set a stake vertically in the ground, and wait until the length of the shadow of the stake is equal to the height. At the same time mark a spot on the ground where the shadow falls of the top of the tree, steeple or other object to be measured. The length of the shadow is then equal to the height of that object. There are parts of the world and seasons of the year wherein this method cannot be used. In all places having a latitude higher than $68\frac{1}{2}$ degrees, either north or south, the shadow of the object is always longer than the height. The foregoing wonderfully simple method was used by Thales, one of the seven

wise men of Greece, 2,500 years ago, in measuring the height of Cheops, the greatest pyramid of Egypt.

5. In a similar way, the height of a steeple or other object may be found by proportion (Fig. 4, $a : b :: a' : b'$). Suppose that the length of the shadow of the steeple is 120 feet, the length of the staff's shadow is 6 feet, while the height of the staff is 5 feet. The height of the staff is to the length of the staff's shadow as the height of the steeple is to the shadow of the steeple, that is, $5 : 6$ as $x : 120$, hence the height of the steeple is 100 feet.

Mr. W. D. Graves, of Brown Valley, Minn., suggests the following method, which is practically the same as the one just described. From the base of the object, stretch a tape line, as nearly level as possible, to the end of the shadow. Now take a square, preferably with one arm a foot long, and with this arm upright lay the other along the tape with the "heel" of the square at the end of the shadow. Note the length measured by the tape line and the length of the shadow of the upright arm on the horizontal arm of the square. As the shadow of the rule is to the length of the rule, so is the shadow of the object to its height. If the shadow of the foot rule is $7\frac{1}{2}$ inches, and the shadow of the object is 38 feet, or 456 inches, then we have $456 \div 7\frac{1}{2} = 60.45$ feet; for $7\frac{1}{2}$ inches of shadow is equal to one foot of substance.

6. The heights of mountains can be found by allowing 600 feet for each degree of difference between the boiling points of water at the base and the summit of

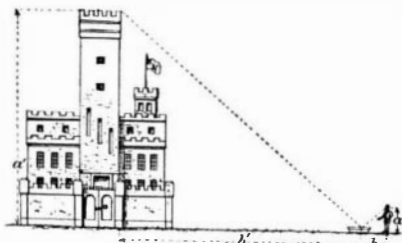


FIG. 3.—MEASUREMENT BY REFLECTION.

the mountain. Thus, suppose that water boils at 212 degrees at the base. The difference between the two temperatures is 26. Hence the height of that mountain is 26×600 , or 15,600 feet.

7. Heights of moderate elevations can be found by means of a barometer. One-tenth of an inch corresponds to 90 feet of ascent. Example: The height of a barometer at the ground is 29.34 inches, while it is 29.14 at the top of the tower at the same time. What is the height of the tower? Solution: The difference between 29.34 and 29.14 is 0.20, or $2-10$ of an inch. Now, since $1-10$ of an inch corresponds to 90 feet, $2-10$ will correspond to 180 feet, which is the height of the tower.

MEASUREMENT OF DISTANCES.

1. The distance of an object can be found by observing the time in seconds required by sound to traverse the space intervening between the object and the observer. The velocity of sound at 32 deg. F. is 1,090 feet a second. It is one foot a second more than this for each degree above and one foot a second less for each degree below 32 deg. For example, a person sees steam rise from the whistle of a distant locomotive; he hears the sound 15 seconds later. The temperature of the air is 67 deg. What is the distance of the locomotive from the observer? Solution: The temperature is 35 deg. above the freezing point, consequently the velocity of sound is 1,125 feet a second. The time required by the sound wave in passing from the locomotive to the observer is 15 seconds, therefore the distance is 15



FIG. 4.—THE LENGTH OF SHADOW AS A GAGE OF HEIGHT.

times 1,125 feet, or 3 miles and 1,035 feet. The distance of a cannon or a flash of lightning can be calculated in the same manner.

2. The breadth of a river can be roughly measured without instruments in the manner illustrated in Fig. 5. Stand at the edge of the river, and pull down the visor or peak of your cap until the lowest part just in-

tercepts your view of the water's edge on the opposite side of the river. Next turn slowly about, keeping the head steady, until you face either upstream or downstream on your own side of the river. Observe the spot where the line of sight past the lower edge of the cap peak meets the shore. The distance from the spot on which you stand to this point is equal to the river's



FIG. 5.—SIMPLE METHOD OF ESTIMATING DISTANCE.

width. The writer once measured the width of the Niagara River between Fort Erie and Buffalo in this manner. The breadth of the river is 700 yards.

3. We can also measure the distance of an object in the following manner, as illustrated in Fig. 6: Measure a base line of convenient length, then stretch a string from each end of this line directly toward the distant object. From the farther end of one of these strings measure the distance between the two, being careful to measure parallel to the base line. Multiply the length of the measured string by the length of the base line, then divide the product by the difference between the length of the base line and the distance between the strings at the farther end of the measured string. The result will be the distance of the object from the point of intersection of the base line and the measured string. Example: The base line is 217 feet long, the length of one string is 197 feet, the distance between the two strings at the end of the measured string is 184 feet. What is the distance of the object from the base line where it intersects the measured string? Solution: $33 : 197 :: 217 : x$. Multiplying 217 by 197, and dividing the product by 33, which is the difference between 217 and 184, we obtain for our answer 1,295 feet as the measure of the distance sought.

AUDIBILITY OF THE AURORA.

By W. F. KING.

DOUBT has been cast upon the reality of the aurora's audibility from the fact that apparently the sound has never been heard by any of the scientific Arctic explorers, though they have listened for it. The evi-

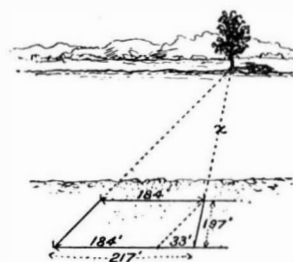


FIG. 6.—A WELL-KNOWN METHOD OF MEASURING DISTANCE.

dence of those who claim to have heard it is commonly, in scientific writings, turned by the supposition that the sounds are due, not to the auroral movement, but to the cracking of ice, the driving of snow before the wind, etc.

In this connection may be cited a piece of evidence which, though in print for nearly twenty years, has not yet found its way into the literature of the subject.

Mr. William Ogilvie, the well-known surveyor and explorer of Yukon Territory, in a report forming Part 8 of the Report of the Department of the Interior for the year 1889, says:

"As to the aurora making an audible sound, although I often listened when there was a very brilliant display, and despite the profound stillness which is favorable to hearing the sound, if any sound occurs, I cannot say that I ever even fancied I heard anything. I have often met people who said they could hear a slight rustling sound whenever the aurora made a sudden rush. One man, a member of my party in