THE DESCRIPTION AND USE OF DONN'S IMPROVED NAVIGATION SCALE.

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As in all Books of Navigation, the Use of the common Gunter's Scales are described, and also known to the generality of Teachers, it is presumed, that a Description and Use, merely of the particular Additions and Alterations, will be fully competent to the perfect Comprehension of the superior Usefulness of Mr. Donn's Scales.

To distinguish this Scale from others, the Book will not be sold separate.
THE DESCRIPTION & USE OF THE IMPROVED NAVIGATION SCALE.

THE defects of the common Gunter's scale, induced Mr. Benjamin Donn to contrive the one described in the following pages; which, to any person ever so little acquainted with navigation, will appear to possess both valuable and essential improvements; their uses, also, will be to them very evident: but for the sake of the young nautical student, a concise description will be indispensably necessary; part of which is in Mr. Donn's own words—On that side of the scale which has the bevel edge, are the following scales:

1. A scale of 24 inches divided into tenths of an inch. Over the beginning of the inches are several small brass pins with figures annexed, shewing weight of the ball to any diameter of the gun. Example. If the diameter of the bore of a gun
be 5 inches 3 tenths, it shews, by inspection only, that such a bore will carry 18 pound shot. It is known to sailors, that the weight of powder for service is generally half the weight of the shot.

2. Under the above line of inches, a foot is divided into 100 equal parts; so again, by inspection, inches may readily be turned into the decimal parts of a foot; or, on the contrary, the decimals of a foot turned into inches. In mensuration, this scale is very useful, as divisions may be taken in feet, and the decimal parts instead of feet and inches. Hence the content of any piece of timber, &c. may be found by common multiplication. Example. If a plank is 20 feet long, and 1 foot 50 hundredths broad, the 1.50 multiplied by 20, gives 30 feet, the content required. This line is not on the common scales.

3. As in many schemes which are to be plotted, scales of equal parts, containing different numbers of parts to an inch, are frequently wanted; so, to retain these, the diagonal scale has been rejected, to the no small inconvenience of the mensurator, to give room for these plotting scales: but, in this improved scale, the diagonal, which is sometimes preferable on account of its accuracy, is still preserved on the scale, and different scales of equal parts are added at the bottom, marked 25, 30, 35, 40, 45, 50, and 60, signifying 25, &c. parts to an inch, making, with the diagonal, a compleat set, as
Improved Navigation Scale.

as that contains, from its principle, 10 and 20 to an inch.

4. This side of the scale contains, likewise, the line of rhumbs, chords, sines, tangents, &c., as on the common scales; also two corresponding lines; one marked M. LONG, the other CHORD; by which, is shewn, by inspection, how many miles in any latitude make a degree of longitude. Example. Against 70 degrees of longitude on the Chord, you will find on M. Long that 21 miles make a degree of longitude, in that latitude.

As Mr. Donn observes—"Nothing farther need be said to explain this side of the scale, to those who are acquainted with the use of the common scales;" and in respect to the other side, known by the name of Gunter's, (from the logarithms of numbers, sines, and tangents being first laid thereon by Mr. Edward Gunter) the extensive usefulness of these lines are too well known, to need a particular description here; but as this description is intended to explain those things, in which this scale differs from others, a word or two will be necessary—First, hinting to the young nautical student, that To work a cannon, or proportion on Gunter's scale, who have only to extend the compasses from the first term to the second on the proper line, then will the same extent, laid the same way from the third term, viz. from the left to the right, or from the right to the left, according as the second term lay from the first, give on its proper line the fourth number required.
As in the common rule of three it is no matter which of the two middle terms are placed first, since the product is the same; so, in working on the Gunter's scale, if at any time it is found more convenient, we may extend the compasses from the first term, in the proportion, to the third term; then will that distance extend from the second term to the fourth, or required term.

In counting on the line of numbers, it may be proper to remark, that the numbers 1, 2, 3, 4, &c. represent not only 1, 2, 3, 4, &c. but 10, 20, 30, &c. Thus if the cannon, a proportion you are working, requires you to call the 1 in the middle of the line of number 100, then must the 2, 3, 4, 5, 6, 7, 8, 9, 10, on the right hand be called 200, 300, 400, 500, 600, 700, 800, 900, 1000; the 9, 8, 7, 6, 5, 4, 3, 2, 1, on the left, be called 90, 80, 70, 60, 50, 40, 30, 20, 10.

If the 1, in the middle of the line, be called 1000, the figures 2, 3, 4, &c. on the right, will be 2000, 3000, 4000, &c. and 9, 8, 7, 6, &c. on the left, 900, 800, 700, 600, &c.

Again, if the 1 in the middle be called 10, the figures 2, 3, 4, &c. on the right hand, must be 20, 30, 40, &c. and on the left, 9, 8, 7, &c. will be only 9, 8, 7, &c.

Also, if the 1 in the middle be called 1, then 2, 3, 4, &c. on the right hand, will stand for 2, 3, 4, &c. but 9, 8, 7, 6, &c. on the left, will be only 9, 8, 7, &c.
To refresh the memory of the young learner, the cannons, in common use for working a day's work, are stamped on the scale. The R: Dist.: SC: Dep: SCC: D LAT. signifies, that as radius is to the distance, so is sine of the course to the departure; and so is sine complement of the course to the difference of latitude.

Again. D. LAT: Dep: tangent 45: T. course, is as difference of latitude is to the departure, so is tangent of 45 degrees to the tangent of the course.

Also, SC Mid LAT: Dep: R: D Long, is to be read as sine complement of the middle latitude is to the departure; so is radius 90 degrees to the difference of longitude. Or to find the difference of longitude by meridional parts; D LAT: Dep: MD LAT: D Long, which is to be read, as difference of latitude is to the departure, so is the meridional difference of latitude to the difference of longitude.

Lastly, SCL: S © Dec: R: S © AMP. is to be read as sine compliment of the latitude is to the sine of the sun, or stars, &c. 's declination, so is radius, or sine of 90 degrees, to the sine of the sun's, &c. true amplitude.

The first line on the Gunter's side is marked S. RUMB, that is, sines of rumbs, or courses.

The second line is marked NUMB Sqr. and is the common line of numbers intended to be used with the sines, or tangents, &c. In working the usual
usual cannons in trigonometry or navigation, it is marked \textit{NUMB Sqr.}, because, with the line marked \textit{NUMB Root}, it will serve for squaring numbers, \\&c. of which farther notice will be taken presently.

The third line, marked S. (CS) Sec. is the common line of \textit{sines}, with the addition of being numbered backwards, by smaller figures; by which addition it now serves the several purposes of a line of \textit{sines}, \textit{co-sines}, and \textit{secants}. A notion has very much prevailed among some teachers of trigonometry and navigation, that if a \textit{secant} was in the proportion, it could not be solved by the scale. Nay, two writers on navigation have positively affirmed, that if in the cannon, or proportion, there is a \textit{secant}, the operation cannot be performed by the scale; but that they are mistaken, may be readily shewn by only working one example. Let us suppose the angle A, or the angle at the base of a right angled triangle, to be given equal to 50 degrees, and the base 86 yards, to find the hypotenuse. If the base be made radius, the cannon is, as radius is to the base 86, so is \textit{secant} of the angle A 50 degrees, to the hypotenuse. This may be worked on the scale thus: Extend the compasses from radius, or 90 degrees to 50 degrees on the same line, (of \textit{sines}) counted backwards from radius, by the small figures, for the \textit{secant}; then, one leg of the compasses being set at 86 on the line
line of numbers, that extent will, turned the contrary way, (because the secants are supposed to run beyond the scale) reach to 134, the distance which was required.

The fourth and fifth lines are the versed lines, and tangents, as on the common scales.

The sixth is the meridian line, which, on the common scales, is too short to be of much service; but by making on two lines, as done here, we are enabled to go from 30 to 80 degrees of latitude, and yet have the degrees sufficiently large to divide the meridian of Wright's chart into every 19 minutes, or less parts. The length of the degrees of the equator, corresponding to those of the meridian, are annexed on the left hand, and marked Eq. Deg.

The meridian lines being constructed by the diagonal scale of 20; if at any time, in the absence of tables, we are inclined to know nearly the meridional difference of latitude between any two places, we have only to take the distance between the two latitudes, from the meridian line on the scale, then measuring the distance on the diagonal scale of 20, we shall have nearly the meridional miles required. Thus, for example. If it was required to find the meridional difference of latitude, between the latitudes of 20 and 30 degrees, the distance between these degrees taken from the meridian line, will, on the lesser diagonal
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at scale, measure 663, reckoning each primary division, or half inch, 100 miles, for the meridional difference of latitude.

The seventh and eighth, or two remaining lines of the scale, are a single and triple line of numbers, marked Numb Root, Numb Cube, which, together with the second line, or double line of numbers, marked Numb Sqr. are for squaring or cubing numbers, or for working proportions wherein squares and cubes are concerned, of great use in various parts of the mathematics. We shall here work a few examples. What is the square root of 144? or, which is the same thing, what is the side of a square whose area is 144 feet?—Solution—Call the 1, at the beginning of the line of numbers, marked Numb Root, 100, and extend the compasses from that point to 144, the calling the 1, at the beginning of the line of numbers, marked Numb Root, 10, and placing one point of the compasses at the 10, the other point will extend to 12, the required root.

Example 2nd. The areas of circle being as the squares of their circumferences, let us suppose the weight of cables of unequal circumferences, but of equal lengths, to be in the same proportion. On this supposition, let it be required to find the weight of a cable, whose circumference is 8 inches, the weight of one of equal length of 10 inches circumference being 25 hundred. Here, by the supposition, the proportion is, as the square of
10 is to the square of 8, so is 25 to the required weight.

To solve this by the scale, extend the compasses on the line Numb Root from 10 to 8, then on the Numb Sqr. will that extent reach from 25 to 16 hundred, the weight of a cable of 8 inches.

Example 3. What is the cube root of 1728? or, which is the same thing, if a cube or die contains 1728 solid inches, what is the side of the cube?

This may be solved by a bare inspection; for calling the 1, at the beginning of the line Numb Cube, 1000, and the 1 corresponding to it, on the Numb Root, 10, then against 1728 on the Numb Cube, you will see 12 on the Numb Root, the required root.

Example 4th. Suppose a ship of 300 tons to be 75 feet by the keel, it is required to find the length of a keel of a similar ship of 500 tons burden.

Solution. Similae solids being in proportion, as the cubes of their like sides, we have as 300 is to 100, so is the cube of 75 to the cube of the required keel. Therefore, extend the compasses from 300 to 500, or from 3 to 5, on the line Numb Cube, then will that same extent on the Numb Root reach from 75 to 891 feet, nearly the length of the keel required.

This instance of a useful, but troublesome question, if solved by arithmetick, being so expeditiously solved by the scale, by means of the addition
tion of these lines, is a sufficient recommendation of their use.

As the greater part of a sailor's day's work may be worked by the Gunter's scale, to a sufficient degree of accuracy, and in an expedition manner, (and it is the wish of many to be possessed of a good scale, the common fort, usually vended, being too erroneous, even for a carpenter) it may, therefore, now be considered as their own fault, if they are not provided with a good and accurate scale.

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