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A new graphic map

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the national foe was a heavy one, and one that the self-respect of a more centralised country could not afford to pay. It was not possible for France in 1870 to adopt the policy of the Russians in 1812 or the Boers in 1900. With the increase in material prosperity, therefore, that marked the reigns of the later Jameses, and especially with the recognition of Edinburgh as the capital, came a return to a more active defensive policy. The coast road from Berwick, from Ayton nearly to Dunbar, traversed a stretch of desolate moorland, and at Cockburnspath entered a defile so narrow that there, in Cromwell's phrase, "ten men to hinder are better than forty to make their way." Neither at this point nor at Dunbar, however, nor yet where the Edinburgh road crossed the Tyne at Linton Bridge (East Linton), did the Scots choose to make a stand. The defence of any of these positions would have relieved the invader of half his difficulty as to supplies, while all were liable to be turned by an advance by Lauder over the Lammermuirs, or by a movement by sea such as Hereford's raid in 1544. Exceptional conditions in 1639 which gave to Scotland an unwonted military superiority enabled Alexander Leslie to concentrate south of the Lammermuirs at Duns, where he was so placed that "if the English had moved either towards Haddington or Soutray, he might have been on their backs" (Baillie); the position was reoccupied the following year; and it was understood that, had time permitted, in 1650 also the same course would have been followed. But normal conditions compelled a less ambitious policy and the occupation of a position near the capital. At Musselburgh the main road from Dunbar by Haddington and Tranent, and the coast road by Preston from North Berwick united to cross the Esk by the ancient bridge, while through or near Dalkeith the hill roads from Lauder, the Gala valley, and Innerleithen approached Edinburgh. A force holding the west bank of the Esk thus commanded every line of advance, and it was at Musselburgh that the Scots took post before Pinkie, as Prince Charles Edward proposed to do before Prestonpans. David Leslie's position in 1650, "between Edinburgh and Leith, entrenched by a line flankered from Edinburgh and Leith," retained the advantages of the Esk position, save the actual obstacle the river afforded; while under somewhat altered circumstances the defensive occupation of the river line was recommended in 1803 by Dumouriez, as allowing reinforcement by the hill roads from England in case of a French landing and an advance upon Edinburgh from the east.

A NEW GRAPHIC MAP.

By J. P. STRACHAN.

(*With Maps.*)

THE Parabolic projection of the globe has fully 9 million square miles too many in the map: the Elliptic is 45,733,800 in excess: the Orthographic (Hemisphere) totals 49,341,200 instead of 98,682,400:

and the Quadrant used as a radius contains some 46½ million square miles too many. It thus follows that in none of these is the map equal in area to the surface of the globe.

The sinusoidal curve has been already used for continents, but Mr. Alexander Clark, A.M.Inst.C.E., of Edinburgh, has brought to perfection a system—it is not really a projection—based on the sinusoidal principle, by which we have:—(1) equal-areas all over the sphere, (2) the possibility of accurate measurement between any two points, and (3) the finding of a ship's course.

For the sake of illustration we reproduce here, by the kind permission of Mr. Clark, a map of the sphere (Fig. 1), as also a chart of the North Sea (at end).

The form of the map of the globe is so different from that to which we are accustomed that it is difficult to understand at first that it represents the exact area of the sphere. The main objection to the use of it seems to have been that by this method the portions of the globe which are furthest removed from the major and minor axes are shown in rather high perspective when the whole sphere is in view, but these objectors forget, when they put forward this criticism, that they are generally comparing the complete sphere with the proportions of the hemisphere, to which their eyes are usually accustomed. Now, it is well known that, in any perspective, the parts which are more remote from the line of sight are more altered in figure than those parts which are quite near or within a medium range of angle; hence it is very evident that when a map is drawn of the whole sphere, the change of form is considerably more than double that of the change in a hemisphere. To meet this criticism there is no difficulty in producing a map from different centre lines, so that the parts near the central lines will come in their turn into the best position for square representation. The maps which are so delineated in this series have their centre lines (1) through 0°, the Greenwich Meridian (the British Map); (2) through 90° East, near Calcutta (the Indian Map); (3) through 90° West (the American Map; and (4) through 180° East or West (the New Zealand or Siberian Map).

Besides these forms of the whole sphere, two combinations of hemispheres can be made, and are produced from these maps, namely:—(a) By combining the central 180° of No. 1 with the central 180° of No. 4, and (b) similarly combining the central portions of Nos. 2 and 3.

In the first method, with the four-sphere maps, the change of form only affects 45° on each side of the centre line on each map, so that the whole world is brought within this limit of perspective. It must also be remembered that over the whole globe, in all these maps, equal areas are maintained, and distances between any two places on the surface of the globe can be accurately measured.

If any of the ordinary maps or projections now in use be examined, it will be found that none of them are true drawings, but merely approximations made up of averages over comparatively narrow spaces, with continually changing scales, so that no particular space or distance

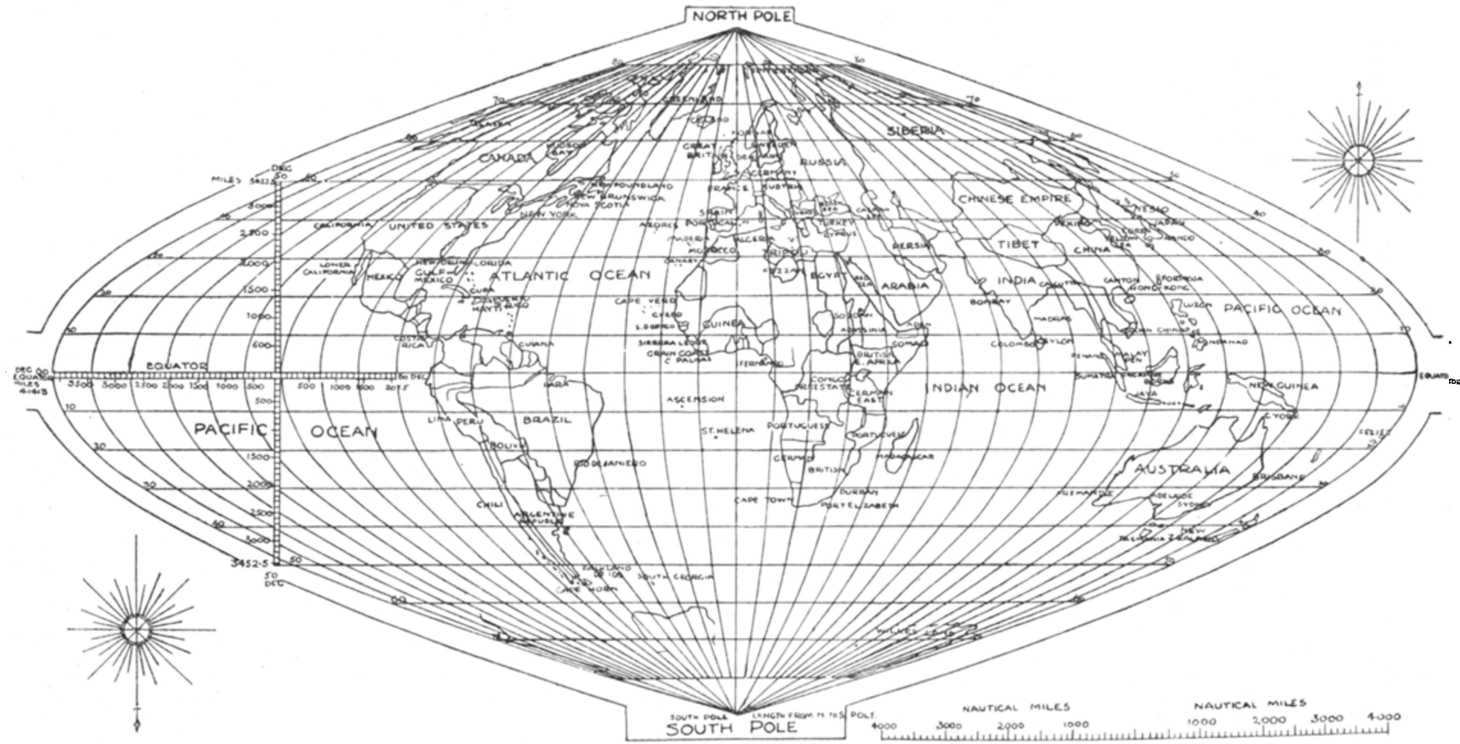

Fig. 1.—Graphic Map of the Sphere.

can be considered correct by itself, but only as an average correct within certain limits.

The construction of the graphic map itself is easily described. The major axis of the figure is the length of the Equator, and the minor axis is the semi-circumference from Pole to Pole. The parallels are 10° apart, and are all truly parallel with the Equator, so that each represents the exact circumference of the sphere at its relative distance from the Equator. As the meridians are divided equally on all these circumferences, they must of necessity give the true distances between the meridians all round the world, and they must also agree with the varying distances all round the sphere from the Equator to the Poles. After constructing the map in this way it requires no effort of imagination to see that all the measurements north and south must be true perpendicularly, and those taken east and west must be true horizontally. The only difference is thus with the diagonal lines, and these are combinations of the perpendicular and horizontal lines, which is the natural course. It would not be possible to measure exact diagonals unless the surface represented were perfectly flat; so that with a globular surface, or in anything of the nature of a perspective, we are fortunate if we can find areas correctly by taking two measurements. These naturally fall into groups of (a) latitudes and (b) longitudes. In the case of the latitudes the lengths of the degrees are practically the same from Pole to Pole. The longitudes, however, vary from the full-sized degree at the Equator to a point at the Pole, so that in ascertaining the difference of longitude the mean length of the degree must be found between the points where the distance is required. These distances are generally got by direct measurement on *this* map, but there are tables to be found of all the latitudes and longitudes of the principal places on the globe, and by resorting to these a simple subtraction or addition is all that is required. There are also tables published giving the length of every degree or half degree between the Equator and the Poles, from which the distances may easily be found by simple multiplication. When these distances are known and applied, that is (a) the difference of latitude to the vertical scale, and (b) the difference of longitude to the horizontal scale, the length of the diagonal between the two points will give the true direct distance on the globe.

As to the question of finding the true course of a ship, if the length of the diagonal be found as before described, a parallel line drawn from this to the figure of the compass gives the true direction. It is to be noted that the difference of longitude is marked on the horizontal scale in the *opposite* direction from that to which the vessel is to proceed. In any case the true angle will be found, but if this point of position be not attended to, it may be that the complement or supplement of the angle will be noted instead of the true angle.

This method may be used for any portion of land or water, up to the size of the sphere, with perfect results, in any quarter of the globe. The map is thus very suitable for a nautical chart, and directions or sailing courses may be found on it much more readily than on any existing chart. Mercator's chart cannot be compared with it, as it can only be used for finding approximate courses in low latitudes, the scales of which are only averages over certain areas, and is useless within the Polar regions.

As illustrative of these new and ingenious features we now give a few examples :—

To measure distance, let us take the two points of 70° S. and 20° W. and 10° S. and 80° W. :—(1) For longitude, from 70° S. 20° W. follow the 20° meridian until it comes to the parallel 10° S.; measure from this joining point to 10° S. 80° W., and we get . . 4085 miles.

Then from 10° S. 80° W. follow the 80° meridian down until it crosses the 70th S. parallel; measure from this joining point to 70° S. 20° W. and we get . . 1415 „

This gives a total of . . . . . 5500 „

the mean of which is one half = . . . 2750 „

(2) For latitude, measure, say, the central meridian between 10° S. and 70° S., and we get . . 4145 „

We fix these two totals on the scale and cross scale, and the diagonal, measured, gives 4974 statute miles, or 4320 knots, which is the *distance*.

To find the *angle of sailing* from Fremantle to Colombo :—We place the mean longitude, 2335 miles, on the scale, starting from 0° eastwards (being the direction *opposite* to the line of sailing), and the difference in latitude, 2695, we place on the cross scale. The diagonal of these—3565 statute miles, or 3095 knots, the length of the course, taken parallel to the compass, gives 49° 5′ north of true west, or 40° 55′ off the true north, which is the *angle of sailing*.

Equal Area : Place the net over, say, Australia or New Guinea on each of the maps of this series, and the measurements are all the same. This cannot be done with any other map, sphere or hemisphere. Take Mollweide's as a standard projection; it is something like twenty-three per cent. over the actual area of the globe; *ergo*, if we have, say, Australia at the central meridian in one map, and 50° off the central meridian in the other map, it is an absolute impossibility to measure and find the two totals the same. Yet, Mollweide's is "called" an "equal-area" map. Taking any other projection, we have practically the same discrepancy. In other words, Clark's new graphic maps are the only equal area-maps which stand the test of taking any one area of land or sea, placing it in any position with regard to the central meridian, and finding the area always equal.

PROCEEDINGS OF THE ROYAL SCOTTISH GEOGRAPHICAL SOCIETY.

Lectures in January.

Mr. J. Y. Buchanan, F.R.S., will address the Society in Edinburgh and Glasgow on the 24th and 26th of January respectively. The