using a formula which permits of a ready check. This only takes about five minutes for each sight, and is, no doubt, the best way; in fact, it is the only safe way where a very considerable degree of precision is aimed at. But most navigators prefer to avoid computation so far as possible by the use of tables, and in ordinary circumstances the altitude tables used in the Royal Navy will give sufficiently accurate results. The great defect of the tabular method is that one has to round off the dead-reckoning latitude to the nearest degree for the assumed position in order to enter the tables, and consequently the position-lines may extend over so great a distance on the chart that their curvature cannot properly be neglected. With logarithmic calculation, on the other hand, the actual dead-reckoning position can be taken as the assumed position, and the position-lines will then be so short that their curvature can be neglected without any perceptible loss of accuracy.

It may not be out of place to remark in conclusion that the utility of the Sumner line or position-line principle is not confined to position-fixing with a sextant at sea. I have shown in two recently published papers ("Notes on the Working of the New Navigation," Cairo, 1918, and "The Prismatic Astrolabe," *Geographical Journal*, July, 1919, p. 37) that the "new navigation" is capable of useful application on land in conjunction with theodolite observations and wireless time-signals, and that determinations of geographical position of very considerable accuracy may be made in this way. The method has since been put into practice by Dr. Hamilton Rice on exploratory land surveys in South America (see the *Geographical Journal* for July, p. 59) with satisfactory results.

JOHN BALL.

Survey of Egypt, Cairo, July 24.

Relativity and Hyperbolic Space.

OBSERVATION tells us that while gravitation dominates the history of a lump of matter moving in the vast ocean of free æther, it has practically no effect on the history of a pulse of light in similar circumstances. Since last mail I have investigated the bearings of space being hyperbolic on light-rays.

The central-projection map of the space, used before, in which $r=\tanh\Theta$, where r is the radius vector of the map and $R\Theta$ the radius vector in the space, will be called a gnomonic map; planes are mapped as planes. If the projection used be given by $r=2\tanh\frac{1}{2}\Theta$, the map will be called stereographic; small regions are mapped in correct shape, spheres and planes as spheres, and the two sheets of a pseudo sphere as two spheres intersecting and making equal angles with the sphere representing the median plane, in a circle lying on the absolute, $r=2$. (A pseudo-sphere is the locus of a point at a given distance from a given plane, called its median plane. The characteristic of the map-sphere which represents a plane is that it cuts the absolute $r=2$ orthogonally.) A point (x, y, z) on the gnomonic map becomes $[x/(1+\frac{1}{4}r^2), \quad y/(1+\frac{1}{4}r^2), z/(1+\frac{1}{4}r^2)]$ on the stereographic map.

The behaviour of a ray of light is fully described by saying that its path on the gnomonic map may be put in the form $x^2/a^2+y^2=1$, where a is less than 1, and that the eccentric angle is t/R, where t is co-ordinate time. This ellipse really represents the two branches of a pseudo-circle; the ray goes out to infinity (in the space) along one branch and returns along the other, the complete circuit having the period $2\pi R$. The median line of the pseudo-circle passes through the origin—that is, through the observer.

If from a given point rays start in all directions there will be a definite wave-front. For a finite time before t attains the value of a quarter-period, $\frac{1}{2}\pi R$, this front will form the single sheet of a true sphere the centre of which recedes to infinity, whereupon the front develops the two sheets of a pseudo-sphere, the one proceeding in the same direction as before, and the other, together with the median plane, returning from infinity, having been reflected back by the absolute. By the time $t=\frac{1}{2}\pi R$ the median plane has just reached the origin, and the reflected sheet is chasing both the other sheet and the median plane back on the way to infinity. In the next quarter-period these motions are reversed in order of time, in direction of motion, and in position relative to the origin. At the time $t=\pi R$ the front has contracted down to a point focus situated on the opposite side of the origin from the radiant point at a distance equal to that of the point. At the time $t=2\pi R$ the original circumstances recur, and everything is about to be repeated. A ray always moves normal to the front, although the centre of the true sphere and the median plane of the pseudo-sphere themselves move from and to infinity in a finite time.

All these motions can be exactly imitated in Euclidean space. Let, at a given point in such a space, the velocity of light be $1+r^2/4R^2$, the same in all directions, and let the sphere $r=2R$ be a perfect reflector. Then light will in this medium behave exactly as does the light in the stereographic map (when the scale of that map is increased in the ratio of R to 1). Indeed, this seems the easiest method to get the differential equation of the path of a point in the hyperbolic space, for which $\int dt$ is stationary. I may remark, however, that when the equation is obtained, later work is much simplified by changing the dependent to a form corresponding to the gnomonic map.

In the stereographic map the rays after an even number of reflections, by the absolute form a system of coaxial circles through the radiant point and that point on the *opposite* side of the origin which is inverse to the sphere $r=2$. (For radiant point let $0=x-a=y=z$. Then for the second point mentioned it is meant that $0=x+4/a=y=z$. Ordinary inverse point would be $0=x-4/a=y=z$.) After an odd number of reflections they are similarly related to the focus mentioned above. The fronts are the spheres cutting these coaxial circles orthogonally.

ALEX. MCAULAY.

University of Tasmania, June 10.

The Antarctic Anticyclone.

IN NATURE for August 5 Mr. R. F. T. Granger remarks: "The same conditions, *i.e.* the surface outflow and the central descent of air, exist in Prof. Hobbs's polar ice-cap anticyclone; the only difference is the physical origin."

In the case of the ice-cap there are other differences as well; the temperature is lower in the case of an ice-cap than in an anticyclone. The ice-cap conditions which resemble those of an anticyclone are, as Mr. Granger says, "surface outflow and the central descent of air." The differences are low temperature, low pressure, and different physical origin. My suggestion was that these differences made it inadvisable to call them both anticyclones.

R. M. DEELEY.

Tintagel, Kew Gardens Road, Surrey,
August 18.