of variation of latitude, at fixed stations, under the auspices of the International Geodetic Bureau, and for the astronomical deter­mination of the constant of aberration. The instrument is shown in its most recent form in fig. 24. A is a sleeve that revolves very freely and without shake on a vertical steel cone. This cone is mounted on a circular base *b* which rests on three levelling screws, two of which are visible in the figure. The sleeve carries a cross­piece on its upper extremity to which the bearings of the horizontal axis *c* are attached. A reversible level *d* rests on the accurately turned pivots of this axis. The telescope is attached to one end of this axis and a counterpoise *e* to the other. The long arm *f* serves to clamp the telescope in zenith distance and to communi­cate slow motion in zenith distance when so clamped. On the side of the telescope opposite to the horizontal axis is attached a graduated circle g, and, turning concentrically with this circle, is a framework *h,* to which the readers and verniers of the circle arc fixed. This frame carries two very sensitive levels, *k* and *l,* and the whole frame can be clamped to the circle *g* by means of the clamping screw *m.*

The object-glass of the telescope is, of course, attached by its cell to the upper end of the telescope tube. Within the focus of the

object-glass is a right-angled prism of total reflection, which diverts the converging rays from the object-glass at right angles to the axis of the telescope, and permits the observing micrometer *n* to be mounted in the very convenient position shown in the figure. A small graduated circle *p* concentric with A is attached to the circular base *b* and read by the microscopes *q r,* attached to *a.* The instrument is thus a theodolite, although, compared with its other dimensions, feeble as an apparatus for the measurement of absolute altitudes and azimuths, although capable of determining these co-ordinates with considerable precision.

In practice the vertical circle is adjusted once for all, so that when the levels *k* and *l* are in the centre of their run, the verniers read true zenith distances. When the instrument has been set up and levelled (either with aid of the cross level *d,* or the levels *k* and Z), the reading of the circle *p* for the meridional position of the telescope is determined either by the method of transits in the meridian (see Transit Circle), or by the observation of the azimuth of a known star at a known hour angle. This done, the stops *s* and *t* are clamped and adjusted so that when arm *r* comes in contact with the screw of stop *t* the telescope will point due north, and when in contact with *s,* it will point due south, or vice versa. A pair of stars of known declination arc selected such that their zenith distances, when on the meridian, are nearly equal and opposite, and whose right ascensions differ by five or ten minutes

of time. Assuming, for example, that the northern star has the smaller right ascension, the instrument is first, with the aid of the stop, placed in the meridian towards the north; the verniers of the graduated circle g are set to read to the reading -½(δn+δn) where 0 is the approximate latitude of the place and. δn, δ, the declinations of the northern and southern star respectively; then the level frame *h* is turned till the levels *k* and *l* are in the middle of their run, and there clamped by the screw *m*, aided in the final adjustment by the adjoining slow motion screw shown in the figure. The telescope is now turned on the horizontal axis till the levels read near the centres of these scales and the telescope is clamped to the arm *f*. When the star enters the field of view its image is approximately bisected by the spider web of the micrometer *n,* the exact bisection being completed in the immediate neighbour­hood of the meridian. The readings of the levels *k* and *l* and the reading of the micrometer-drum arc then entered, and the observa­tion of the northern star is complete. Now the instrument is slowly turned towards, the south, till the azimuth arm is gently brought into contact with the corresponding stop *s*, care being taken not to touch any part of the instrument except the azimuth arm itself. When the southern star enters the field the same process is repeated.

Suppose now, for the moment, that the readings of the levels *k* and *l* are identical in both observations, we have then, in the differ­ence between the micrometer readings north and south, a measure of the difference of the two. zenith distances expressed in terms of the micrometer screw ; and, if the "value of one revolution of the micrometer screw” is known in seconds of arc we have for the resulting latitude

*Φ = i* í ‰ f í) + (δn + δl)),

where fn -f\* is the difference of the micrometer readings converted into arc—it being assumed that increased micrometer readings correspond with increased zenith distance of the star.

If between the north and south observation there is a change in the level readings of the levels *k* and *l*, this indicates a change in the zenith distance of the axis of the telescope.. By directing the telescope to a distant object, or to the intersection of the webs of a fixed collimating telescope (see Transit Circle), it is easy to measure the effect of a small change of zenith distance of the axis of the telescope in terms both of the level and of the micrometer screw, and thus, *if the levels are perfectly sensitive and uniform in curvature and graduation,* to determine the value of one division of each level in terms of the micrometer screw. The value of "one revolution of the. screw in seconds of arc" can be determined either by observing at transit the difference of zenith distance of two stars of known declination in terms of the micrometer screw, the instru­ment remaining at rest between their transits; or by measuring at known instants in terms of the screw, the change of zenith distance of a standard star of small polar distance near the time of its greatest elongation.

The reason why two levels are employed is that sometimes crystals are formed by the decomposition of the glass which cause the bubble to stick at different points and so give false readings. Two levels are hardly likely to have such causes of error arise at exactly corresponding points in their run, and thus two levels furnish an independent control the one on the other. Also it is impossible to make levels that are in every respect perfect, nor even to deter­mine these errors for different lengths of bubble and at different readings with the highest precision. The mean of two levels there­fore adds to the accuracy of the result.

Attempts have been made to overcome the difficulties connected with levels by adopting the principle of Kater’s floating collimator *(Phil. Trans.,* 1825 and 1828). On this principle the use of the level is abolished, the telescope is mounted on a metallic float, and it is assumed that, in course of the rotation of this float, the zenith distance of the axis of the telescope will remain undisturbed, that is, of course, after the undulations, induced by the disturbance of the mercury, have ceased.

S. C. Chandler in 1884 constructed an equal altitude instrument on this principle, which he called the almucantar, and he found that after disturbance the telescope recovered its original zenith distance within 1/20 of a second of arc. R. A. Sampson at Durham *(Monthly Notices R.A.S.* lx. 572) and H. A. Howe *(Ast. Jahrb,* xxi. 57) have had instruments constructed on the same general principle. It is, however, obviously impossible to apply a micrometer with advantage to such instruments, because to touch such an instru­ment, in order to turn a micrometer screw, would obviously set it into motion. The almucantar was therefore used only to observe the vertical transits of stars in different azimuths over fixed hori­zontal webs, without touching the telescope.

By the use of photography, however, it is possible to photograph the trail of a star as it transits the meridian when the telescope is directed towards the north, and another trail be similarly photo­graphed when the telescope is directed towards the south. The interval between the true trails, measured at right angles to the direction of the trails, obviously corresponds to the difference of zenith distance of the two stars. This principle has been applied with great completeness and ingenuity of detail by Bryan Cookson to the construction of a “ photographic floating zenith telescope,”