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A NEW PARALLEL PLATE COMPARATOR

By Jesse W. M. DuMond

The "Parallel Plate Comparator" is best adapted for measuring the separation of two parallel lines (eg. spectral lines) whose structures are practically identical and which are on the same negative and only a few millimeters apart. It consists of two[1] plane parallel plates of glass attached to a mechanism such that they can be set at equal and opposite angles with the plane of the negative. The two equal and opposite angles between the plates and the negative must lie in a plane normal to the lines whose separation is to be measured. The lines are viewed through the inclined glass plates with a long focus microscope having a sufficiently large field to include both plates and both lines. The lines are brought into apparent coincidence in the field of the microscope by varying the obliquity of the glass plates to the line of sight. This obliquity is then a measure of the separation of the lines. If the lines are of identical structure and intensity, even though they are not symmetrical in structure, much greater precision is possible by bringing them into apparent coincidence than by attempting to set a crosshair first on one line and and then on the other. (The lines should be photographed or blocked off so that the upper half of one and the lower half of the other only is visible. The slightest fault in the apparent coincidence of the ends of the two half lines is then glaringly evident through the microscope. When coincidence is obtained, the two half lines give a good photometric match across their juncture and appear as one. In a properly designed instrument, the crack separating the two plane parallel glass plates is invisible because it is not in the focal plan of the objective.)

Many parallel plate micrometers have been designed in the past. The author's only excuse for describing the one which forms the subject of this paper lies in the great simplicity of its construction. As illustrated in the photographs and drawings, the present instrument was built in sixty hours in a student shop very inadequately supplied with tools. Only a few hours more were required for calibration. The construction and calibration were done entirely by Dr. Norris Johnston The author takes this opportunity to express with the keenest pleasure his appre-

[1] Essentially the parallel plate micrometer need have only two plates. The one built at this laboratory is provided with three plates, however, as this slightly facilitates the special work for which it was designed. The two outside plates rotate together while the middle plate rotates in the opposite sense.

ciation of Dr. Johnston's ingenuity and skill which more than compensated for the inadequate equipment. Dr. Johnston's knowledge of machine shop practice is merely an incident among his many qualifications as an experiment physicist.

The accompanying photograph is almost self-explanatory. Two vertical square brass posts screwed to the base contain the main bearings. Between these posts, two brass discs turn with only a very slight clearance between them. The back disc turns on a steel shaft to which it is solidly fixed and which passes through both front and back bearings while the front disc is attached to and turns on a sleeve fitting smoothly

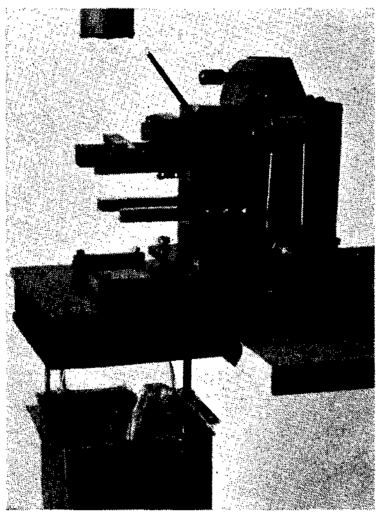

FIG. 1. *Parallel plate comparator.*

over the first shaft and passing through the front bearing only. Crank arms are attached to the projecting ends of the shaft and sleeve and the other end of each of these arms carries a flat bar to which the plane parallel glass plate is cemented. Five machine screws hold the flat bar to the crank arm. They are arranged on the corners of a square with one in the center. The central screw holds the two parts together while the four peripheral screws oppose it. This gives at least three degrees of freedom in adjusting the plane parallel plate. This adjustment is due to Dr. Johnston.

The equal but opposite rotatory movement of the two brass discs and their attached glass plates is accomplished by means of a 14 mil steel piano wire acting as a belt. This wire passes through a groove around both discs. The wire is in contact with the upper 180° of each disc and passes vertically down on each side around two idler pulleys rotating on short studs at right angles to the main shaft of the instrument. The idler pulleys are provided with a V groove having an angle of 15°. These idler pulleys are provided with knurling, so that they serve as adjusting wheels to be held one in each hand by the operator while he looks through the microcsope. By applying the operating force at these two points, there is no danger of the wire slipping in the grooves in the large discs and thus throwing the instrument out of adjustment. This clever scheme is also one of Dr. Johnston's contributions as well as the means for taking up any slack which might appear in the wire belt. This latter consists in a small screw passing through the base of the instrument. and one end of the brass block which holds the idler pulley bearing studs. A saw cut in the brass block renders it slightly elastic in flexure, so that when the screw is tightened the idler pulley descends slightly and tightens the belt. The instrument has been in constant use for nearly a year and it has not yet been found necessary to take up on this screw. The two ends of the wire belt terminate under clamping screws at a point in the V groove in the front disc. This point of attachment does not interfere with the rotation of the disc since the total swing of the parallel plates is obviously less than 90°. The instrument proper as above described stands on a sub-base designed to project over the edge of a table. A box hanging under the projecting end of this sub-base contains an electric bulb which serves to illuminate the negative to be measured through an opal glass window.

The microscope used is an adaptation of an old microscope tube with its eyepiece. A low power large field objective was obtained by removing the objective proper and attaching a single lens in the end of the tube. Probably some improvement could be made here.

With the instrument in its zero position, two holes are bored in the brass discs at the top in accurate mutual alignment, the hole in the rear disc having a slight taper. A plug with tapered end is inserted through these two holes thus clamping the discs together. The plane parallel glass plates clamped mutually parallel by means of two other plates are then adjusted so that their plane is parallel to the axis of the shaft by rotating the two discs and plates together through 180° and observing the reflections of the crosshairs in a Gauss Eyepiece following the well-known method of adjusting a prism in a spectrometer. When this adjustment is satisfactorily accomplished, the plates are permanently cemented to their holders with sealing wax.

The calibration of the scale on the brass discs is accomplished after the instrument is completed and the wire belt is in place by observing an accurately divided metric scale through the microscope and rotating plates. The scale is so placed that its smallest divisions are visible through both glass plates. The entire system of divisions on the reference scale then appears double. The discs are then slightly rotated and the two halves of this double system of divisions appear to move in opposite directions through the microscope field until a new coincidence between all the lines is established. The scale divisions on the brass discs are scribed at each coincidence point by means of a sharp steel tool and a straight edge clamped for the purpose just above the discs. Finally, a small celluloid window across which a reference line has been scribed is mounted just over the scale on the discs. Obviously, the scale on the discs is not a scale of equal parts. Its divisions are much larger near the zero position than near the extremities. This is a convenient feature of the instrument since it is frequently desirable to measure small displacements with greater absolute accuracy than large displacements. It tends to make the relative error of the instrument more nearly constant in all parts of the scale. On the instrument here described, the smallest scale division corresponds to a displacement of the films of 0.25 mm. This gives a separation of 3 mm at the beginning of the scale on the brass discs and a separation of 1 mm at the extreme end. Small displacements can therefore be read to about .02 mm. It is possible to magnify the sensitivity of the instrument by placing a lens between the rotating plane parallel plates and the negative. A correction factor must then be applied to the scale readings. In general, this scheme is not to be recommended as the correction factor may differ slightly in different regions of the field of view. Such a lens below the plates also reduces the range of displacements that can be measured of course.

The plane parallel plates used in this instrument here described were cut out of a selected piece of plate glass. This has been found sufficiently accurate for the purpose intended. The thickness of the plates is about 6.2 mm and the refractive index about 1.8. Thus when the plates stand at 45° with the line of sight, two lines having a separation of 5 mm can be brought into apparent coincidence. The total range of the instrument is 9 mm.

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