A METHOD OF MAGNIFYING SMALL ANGULAR DISPLACEMENTS

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OUTLINE AND SUMMARY

1. Basic principle is multiple reflection
II. Limits of range
    (a) Theoretical
    (b) Practical
III. Experimental data and conclusions.

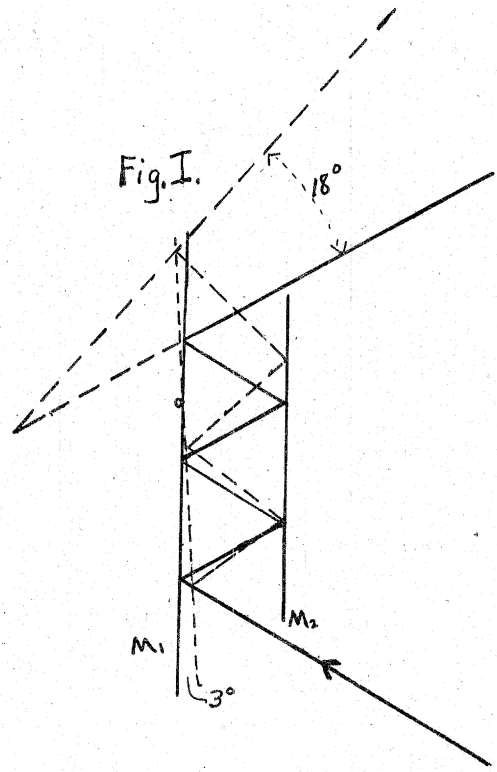
SUMMARY

By multiple reflection between two parallel mirrors, an incident ray is turned through a magnified angle upon emerging provided one or both of the mirrors are turned slightly. The amount of magnification depends on the number of reflections. Theoretically the limits of operation are much greater than are possible from a practical standpoint, for on account of absorption, the incident ray after many reflections becomes a very weak emergent ray. However, with mirrors of high reflective power, and by taking advantage of moving both mirrors, a magnification of one hundred is easily obtainable.

I. BASIC PRINCIPLE IS MULTIPLE REFLECTION

The author was confronted with the problem of measuring some very small angular displacements, and devised an optical method which he chose to call "The angleometer". A beam of light is reflected back and forth between two parallel mirrors as in Figure I. If either or both of the mirrors are turned through a small angle, the emergent ray will be turned through an increased angle depending upon the number of reflections of the turning mirror.

In Figure I, the illustration shows the short mirror stationary, and the long mirror turning through a small angle. The number of reflections on the movable mirror multiplied by two gives the magnification number. A reflected ray from a mirror is turned through twice the



angle that the mirror is turned. The magnification is increased by increasing the number of reflections and by turning both mirrors in opposite sense. It is evident that in Figure I if the short mirror had turned an equal amount in the opposite sense to the long mirror, we would have increased our magnification.

II. LIMITS OF THE RANGE OF "THE ANGLEOMETER"

The nearer to the perpendicular the incident ray is brought, the greater the number of reflections, and the greater the magnification. But on account of the absorption of the mirror with each reflection, we are limited in the number of reflections. With a mirror of 95% reflective power, and allowing 50 reflections, there would about 10% of the light get through as the emergent ray. This is not an impossibility, for with a very intense source and an emerging ray one-tenth the intensity as the incident ray, it is readable to a good degree of accuracy.

EXPERIMENTAL DATA AND CONCLUSIONS.

Number of moving reflections N	Angle mirror moved A	Angle emergent ray moved B	$\frac{B}{A}$	N x 2
7	0.06°	0.86°	14.3	14
9	0.05°	0.95°	19.0	18
11	0.042°	0.93°	22.1	22

By utilizing the optical lever, the emergent ray is converted into a measurable quantity even with .0001° angular displacement of the moveable mirror, using eleven reflections.

By using the two mirrors on moveable systems, an angular displacement of .00005° can be measured.

CONCLUSIONS

One-fifth of a second of arc is measurable with high precision by this method, and it seems not an improbability to refine it to measure much smaller displacements.