VI. On a theorem relating to curved diffraction-gratings

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magnets thus formed were placed on a block between springs which held their ends firmly in contact, thus giving a closed iron circuit. A magnetizing current being passed through the primary, the induction through the secondary coils on reversing the primary current was measured, and found to be the same for both coils. Then a piece of copper 0.5 millim. thick was interposed between each of the opposed pairs of faces of iron; and the induction near the end was found to be only 0.73 of the mean induction.

The effect produced with a long iron rod would naturally be of the same kind as with the ring described above, except that the leakage of induction would take place to a greater extent.

Another point is, that in experiments with a closed iron ring the lines of induction lie entirely within the iron, and hence the magnetic permeability μ ($=1+4\pi k$) is determined directly; but when a rod is employed, the lines of induction pass for the greatest part of their course through air, and what is measured is the *average* permeability of an air-iron circuit. Now air having always a smaller permeability than iron, the result is to bring out the magnetization-coefficient again too low.

Hence it would hardly seem necessary to adopt M. Mascart's suggestion that "a special phenomenon is produced in the case of closed rings which exaggerates the effect of induction."

VI. On a Theorem relating to Curved Diffraction-gratings.

By WALTER BAILY, M.A.*

IN a paper read before this Society in January 1883 †, I showed that if a plane be taken perpendicular to the lines of a curved diffraction-grating, and the normal to the centre of the grating be taken as the initial line, then the equation

$$\frac{\cos^2 \theta}{r} = \frac{\cos \theta}{c} + \frac{1}{d}, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

in which c is the radius of curvature of the grating and d is an arbitrary constant, gives a curve having the property that if a source of light is placed at any point of the curve, the curve is the locus of the foci of all diffracted rays whether reflected or transmitted.

When d is greater than c , r may be infinite. Let ϕ be the

* Communicated by the Physical Society: read May 8, 1886.

† Phil. Mag. March 1883, p. 183.

value of θ for which r is infinite. Then

$$0 = \frac{\cos \phi}{c} + \frac{1}{d},$$

and the equation to the curve may be written

$$\frac{c}{r} \cdot \cos^2 \theta = \cos \theta - \cos \phi. \quad \dots \quad (2)$$

In fig. 1, G is the diffraction-grating and GN its normal ;

Fig. 1.

and the angle NGS is equal to ϕ . The curves marked L_1, L_2 are traced from equation (2). GS is parallel to one asymptote to the curve, so that if a source of light (say a star) is at an infinite distance on the corresponding branch of the curve it lies in the direction GS ; and the foci of its diffracted light lie on the curves L_1, L_2 . The foci of reflected light will lie on the oval marked L_1 , and the foci of transmitted light will lie on the branches marked L_2 .

Let F_1, F_2 be the points at which these curves cut the normal to the grating, and let $GF_1 = \rho_1$ and $GF_2 = \rho_2$. The points F_1, F_2 I will call the normal foci; F_1 is the normal focus for reflected light, and F_2 for transmitted light.

Putting $r=\rho_1$ and $\theta=0$ in (2), we have

$$c/\rho_1=1-\cos\phi; \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and, again, putting $-r=\rho_2$ and $\theta=\pi$, we have

$$c/\rho_2=1+\cos\phi. \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Now suppose GS the direction of the star to be kept fixed, and the grating turned so as to vary the value of ϕ ; then equations (3) and (4) will give the loci of F_1 and F_2 respectively. The loci are the parabolas marked P_1 and P_2 . They have a common focus G , and common axis GS , and a common latus rectum $=2c$.

F_1 is the real focus of reflected light, having a wave-length $=\frac{\sigma}{n}\sin\phi$, where σ is the distance between the lines of the grating, and n is an integer.

F_2 is the virtual focus of transmitted light having the same wave-length.

In fig. 2, PP is part of the parabola (on a larger scale)

Fig. 2.

which is the locus of the normal focus of reflected light; GN , GN' , GN'' are difference positions of the normal to the grating; and LL , $L'L'$, $L''L''$ are respective positions of the spectra, and F , F' , F'' are respective positions of the normal foci.

The theorem is, When the sources of light are at an infinite distance the normal foci lie on two parabolas whose common focus is the centre of the grating and common latus rectum is equal to the diameter of curvature of the grating; the parabolas for reflected light being convex to the source of light, and those for transmitted light being concave.

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