THE HALL EFFECT IN A CIRCULAR BISMUTH PLATE[1]

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Volterra (1), from theoretical considerations developed a Principle of Reciprocity, as he called it, for the Hall effect in a circular plate. Alimenti (2, 3) extended Volterra's Principle of Reciprocity and measured the Hall effect in a circular plate when the current entered and left by means of point electrodes situated at the mid-points of perpendicular radii. He found four points on the plate where the potential difference, between these points taken by twos in all combinations, is the same when the magnetic field is excited. As the author was investigating the Hall effect in rectangular plates of bismuth (4) and had the necessary apparatus for making a circular plate, it was decided to verify Alimenti's experiments. Accordingly a bismuth plate 4.7 centimeters in diameter and .088 centimeters thick was made for the experiment.

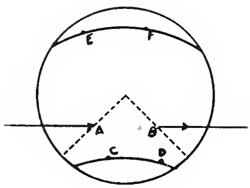

FIG. 1.

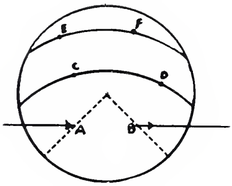

FIG. 2.

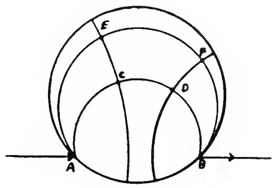

FIG. 3.

The current entered and left the plate by means of the point electrodes A, B, Figure 1, which are situated on the midpoints of perpendicular radii. The points E, F, and C, D, are generic points situated on two curves both belonging to the reciprocal points of A, B. According to Alimenti, the difference of potential between the points E, F, C, D, taken two at a time, should be equal when the plate is acted upon by a magnetic field. Table I gives the difference in potential in micro-volts between the above named points using two amperes through the plate and acted upon by a field intensity of 6100 gauss.

TABLE I

Between Points	H(off)	H(on)	H (reversed)
CD	1276	1578	1510
CE	284	489	149
CF	660	930	628
DF	620	645	880
ED	989	1077	1347
EF	371	436	476

[1]Part of the thesis submitted to the faculty and trustees of Indiana University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

TABLE II

Points	Current Flow A to B			Current Flow B to A		
	H(off)	H(on)	(reversed)	H(off)	H(on)	H(reversed)
ED.....	955	1175	1303	983	1246	1298
CD.....	1155	1465	1520	1113	1454	1442
FD.....	548	688	762	576	743	775
EF.....	423	505	550	404	503	510
EC.....	198	274	217	133	214	162
CF.....	616	774	757	539	724	673

TABLE III

Points	Current Flow A to B			
	H(off)	H(on)	H (reversed)	Average With H(on) and H (reversed)
EF..................	1245	1541	1663	1602
CF..................	1245	1568	1633	1601
CD..................	1245	1565	1623	1594
ED..................	1241	1539	1652	1596
EC..................	0	26	–26	26
FD..................	0	10.5	0	5.25

Points	Current B to A			
	H(off)	H(on)	H (reversed)	Average With H(on) and H (reversed)
EF..................	1287	1698	1560	1629
CF..................	1299	1744	1567	1655
CD..................	1299	1721	1580	1650
ED..................	1285	1677	1571	1624
EC..................	0	–18	17	17.5
FD..................	0	–4	19	11.5

Table I, which is representative of several sets of data taken with the point electrodes situated as shown, indicates that the writer was unable to find any four points on the plate, between which the differences of potentials are the same under the influence of a magnetic field.

The points C, D, were moved to another arc of a circle belonging to the reciprocal points A, B, as shown in Figure 2. The difference of potential in micro-volts was recorded as shown in Table II, when two amperes flowed through the plate and under the influence of a field intensity of 6300 gauss.

The table, which is representative of several sets of data, shows that the writer was unable to find four points on the plate where the difference of potential was equal.

When the current-carrying electrodes are placed on the circumference of the plate, a special case is encounterd, which is calld the theorem of four vertices of Professor Volterra, who says:

"When the point electrodes are on the circumference of the plate, if one considers the quadrilateral formed by the lines of current and corresponding level lines in the case in the magnetic field, and if one determines the value of the electric potential at the four vertices when acted upon by the magnetic field, the difference of the value of two adjacent vertices is equal to the difference between the other two."

With the point electrodes situated as shown in Figure 3, the differences of potential in micro-volts were recorded in Table III, when a current of two amperes flowed and under the influence of a field intensity of 6060 gauss.

In Table III the differences of potential between adjacent points are not exactly equal in all cases, but the differences are so small that they can be attributed to experimental error. Thus the theorem of four vertices is confirmed.

In conclusion, I wish to thank Dr. A. L. Foley, who suggested this problem, and the other members of the faculty of the Department of Physics, for their many helpful suggestions and encouraging attitude during the various phases of this experiment.

References

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