INVESTIGATIONS ON MAGNETIC FIELDS WITH REFERENCE TO ORE-CONCENTRATION

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Investigations on Magnetic Fields with Reference to Ore-concentration by W. R. Crane

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W. R. CRANE

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INVESTIGATIONS

ON

Magnetic Fields with Reference to Ore-Concentration.

BY

W. R. CRANE.

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Investigations of Magnetic Fields, with Reference to Ore-Concentration.*

BY WALTER R. CRANE, LAWRENCE, KANSAS.

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CONTENTS.

THE form and strength of magnetic fields have attracted much attention, especially in connection with the designing of dynamo-electric machinery—an art which has been revolution-

* This paper is a thesis presented by the author for the degree of Ph.D. at Columbia University, New York City.

ized within a comparatively short period by the results of scientific research in this field.

Summarizing the known facts, we may say that the form and strength of magnetic fields are controlled: first, by the form, size and quality of the material composing the magnetic circuit; second, by the ampère-turns of the exciting current; third, by the distance between the poles; and fourth, by the shape of pole-pieces. The present paper has to do with the last two factors, pole-distance and pole-form, only; but in order that the experiments here reported may be clearly understood, the apparatus and methods employed will be first described.

I. Apparatus and Methods.

1. *The Magnetic Circuit.*

The general arrangement of the magnetic circuit and its connections is shown in Fig. 1, in which M is the magnet employed in testing the minerals; R, the resistance in series with the magnet M; W, the four wires connecting with the main switch-board; R-S, the switch that reverses the current in M; T, the test-coil used in determining the amount of magnetization in M; G, the galvanometer used to determine the current in T; and B, a switch to make and break the current in M.

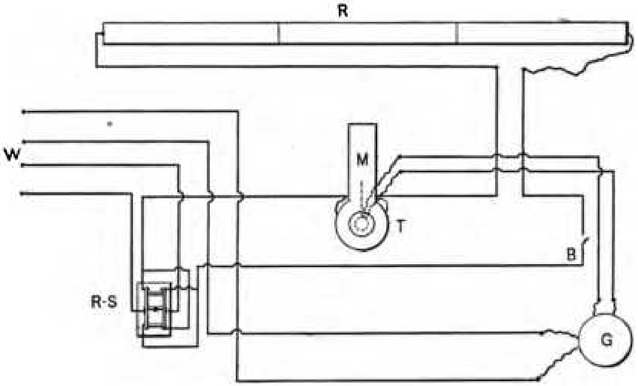
2. *Apparatus Employed in the Traction-Method.*

Fig. 2 shows front- and side-elevations of the apparatus employed in the method (presently to be described) of testing by traction. M is the magnet, with adjustable upper core C; K, the support, attached to the wall above; N, the weighing-device (comprising the spring Z, suspended from K by the wire W, and carrying the support O for the scale-pan O′; and also F, the graduated scale attached to K, and I, the indicator, attached to W); L, L′ and L″, the wires used for adjusting the point of support of the scale-pan O′, or the wire W, into the line of the axis of the core C (L and L′ moving the wire W back and forth respectively in a line perpendicular to the wall X, while L″ moves it parallel to X); M′, the switch-board; R-S, the reversing-switch; G, the galvanometer; T-C, the search-coil; S, the make-and-break switch; Q, the graduated scale, and A, the reel attached, through K, to the scale-pan O′, and serving to measure the pull of the magnet upon the ore.

The magnet, specially made for these experiments, consisted (see M, in the side elevation) of a U-shaped mass of soft-iron, rectangular in section, through the extremities of which were openings, turned to fit large cylinders of similar material, which serve to complete the circuit. The lower cylinder (C′) was set firmly into the U-shaped frame, which was shrunk upon it; the upper cylinder was made to fit closely in the arm which supports it, yet sufficiently loose to allow adjustment, within a range which allows the ends of the cylinders to be brought together or separated ten inches.

Those portions of the cylindrical circuit enclosed between

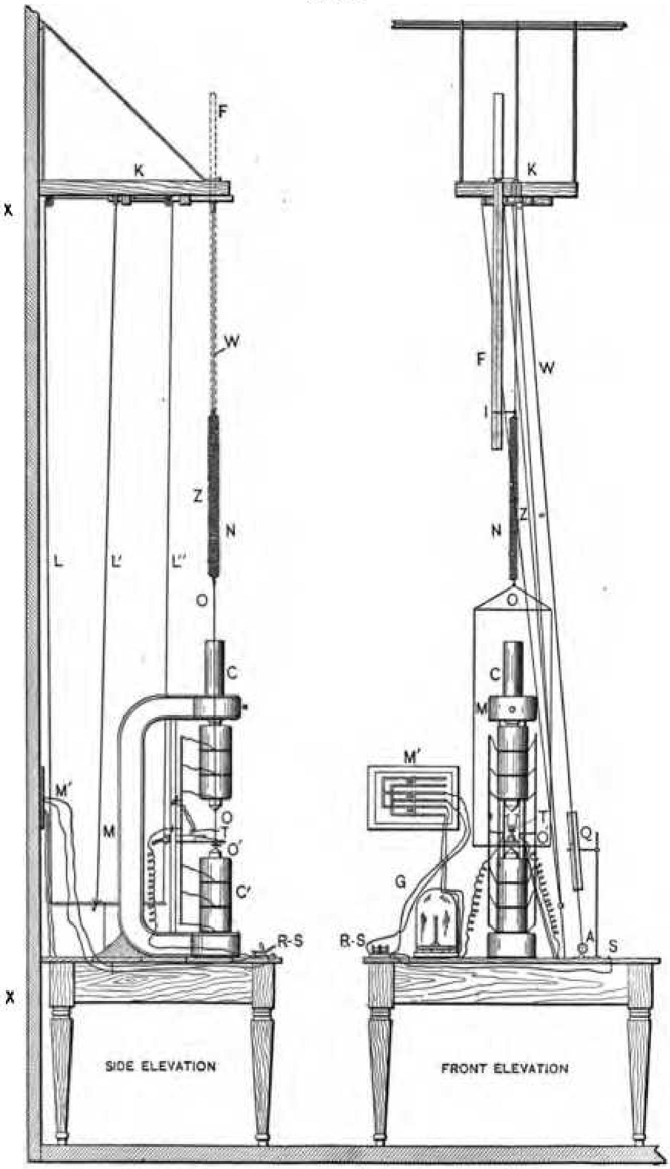
FIG. 1.



General Arrangement of the Magnetic Circuit.

the arms of the U-shaped frame were nearly as large in cross-section as the frame. The extremities of the arms were enlarged to receive the cylindrical circuit, the object being to maintain the same size of circuit throughout its entire length, and so not materially reduce the flux. Twelve inches of the cylindrical circuits of each arm were cut down to receive the exciting coils, thus forming the cores of the circuit. The coils were wedged fast to the cores, thus maintaining their relative position to the magnet, regardless of *its* position. The coils thus faced one another, enclosing the same axis, and, with the cores, could be brought together as the pole-pieces, giving a maximum concentration and a minimum leakage.

Fig. 2.



Apparatus Employed in the Traction-Method.

In the design of the magnet proper, the rules of the latest dynamo-construction were followed, except that the length of the circuit, which was necessitated by the required adjustment, is a radical departure from the latest design. The nature of the work required an adjustment of from 0.5 to 10 in.

a. The Coils.—As shown in Fig. 2, six coils were arranged in two groups—three on either pole. The coils were connected in multiple—primarily, to give maximum flux; secondarily, to facilitate the control of excitation by introducing or throwing out coils, as found desirable. The coils were of high resistance, allowing a current of only 3.5 ampères to pass on a 118-volt circuit. They were, however, wound to resist high temperatures, and would run continuously for several hours without overheating. Each coil was wound with 6500 turns of No. 24 B. & S. wire, giving, for the six coils, 39,000 turns, which, at 3.5 ampères, gives 136,500 ampère-turns of excitation.

b. The Pole-Pieces.—Tests were made with a large number of combinations of pole-pieces of different forms. Four sets of twos, with three odd ones, give twenty-odd possible combinations. The forms used were as follows: (1) Cones with rounded points, with semi-angle of 45°; (2) the same, with semi-angle of 52.5°; (3) cones with circular chisel-edges, the inner side being perpendicular and the outer side forming an angle of 60° with the base; (4) poles with a flat surface tangent to the outer curved edge; (5) poles with a spherical surface of 1.5 in. radius; (6) cones with a semi-angle of 60°, tipped with an inch-cylinder, which in turn is finished off with a spherical surface of 0.5 in. radius; (7) a concave, spherical surface of 4 in. radius, the inner surface being tangent to the outer curved edge.

3. *Methods of Testing Fields Produced by Different Pole-Pieces.*

The fields produced by differently formed pole-pieces of different forms were tested in two ways: first, by means of a search-coil; second, by a new application (as we believe) of an old principle, namely, the use of iron filings in a glass tube. By this method, both vertical and horizontal fields can be tested with equal facility, and both the arrangement and intensity of the lines of force in the field can be determined with great accuracy.