Electricity

Electromagnetic induction
Eddy currents

Waltenhofen's pendulum: demonstration of an eddy-current brake

Objects of the experiments

- Studying the eddy-current damping on a Waltenhofen pendulum oscillating in a magnetic field.
- Evidencing the suppression of eddy currents in a slotted metal plate.

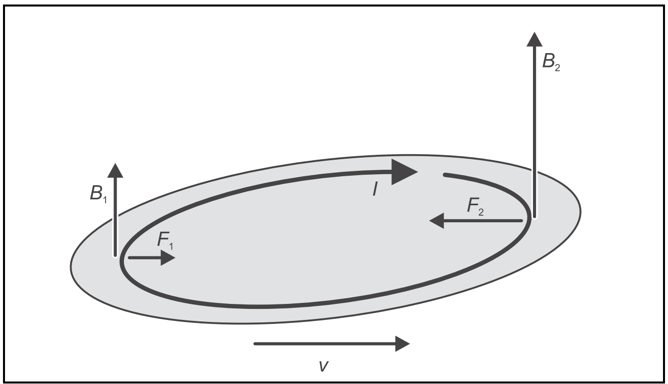

Fig. 1 Eddy current *I* induced in a moving metal plate and Lorentz forces F_1 and F_2 acting on the two branches of the eddy current (B_1, B_2: inhomogeneous magnetic field, v: velocity). The force acting in the opposite direction of the motion is greater than the force acting in the direction of motion.

Principles

If a metal plate moves in an inhomogeneous magnetic field, the magnetic flux in any section of the plate changes continuously leading to a circulation voltage, which is induced in the circumference of the respective section. Therefore eddy currents flow at any location of the metal plate. In the magnetic field, *Lorentz* forces act on the eddy currents, whereby the movement of the disc is restrained (see Fig. 1). The eddy currents are reduced drastically if the metal plate is provided with slots so that the current has to take a roundabout way from one bar to the other.

The formation and suppression of eddy currents can be demonstrated in an impressive manner by means of a Waltenhofen pendulum. This is a metal plate which oscillates between the pole pieces of a strong electromagnet. As soon as a sufficiently strong magnetic field has been switched on, the pendulum is stopped on entering the field. However, the pendular oscillations of a slotted metal plate are only weakly damped.

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Apparatus

1 Waltenhofen pendulum 560 34
1 clamp with knife-edge bearings 342 07

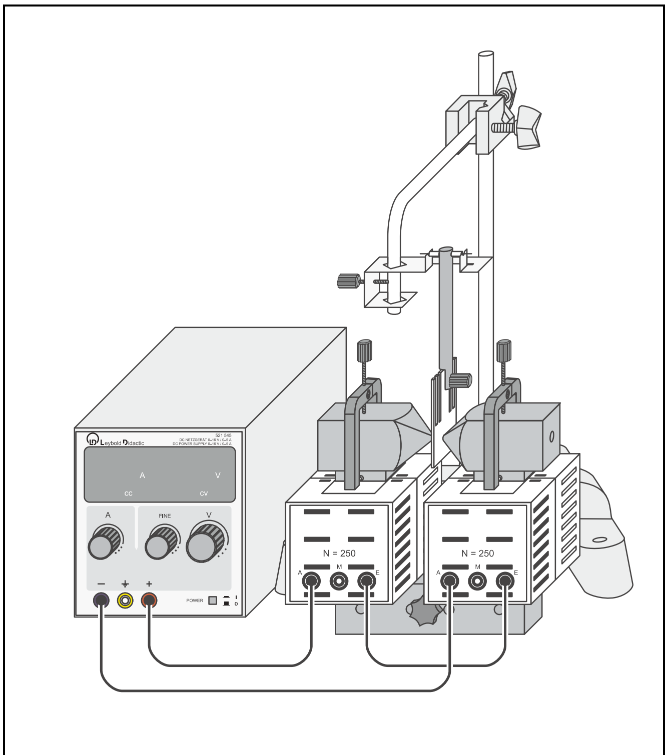
1 U-core with yoke 562 11
2 coils with 250 turns 562 13
1 pair of bored pole pieces 560 31

1 DC power supply 0–16 V / 0–5 A 521 545

1 stand base, V-shape, 20 cm 300 02
1 stand rod, 47 cm 300 42
1 stand rod, right angled 300 51
1 Leybold multiclamp 301 01

Connecting leads

Fig. 2 Experimental setup with Waltenhofen's pendulum



Setup

The experimental setup is illustrated in Fig. 2.

Electromagnet:

– Assemble an electromagnet from the U-core, two coils with 250 turns and two pole pieces.
– Connect the coils in series to the DC power supply.

Waltenhofen's pendulum:

– First clamp the slotted side of the aluminium plate in the pendulum rod.
– Set up the stand material with the clamp with knife-edge bearings and suspend the Waltenhofen pendulum.
– Align the setup so that the unslotted part of the aluminium plate can oscillate freely between the tips of the pole pieces the pendulum's position of rest being located between the pole pieces.
– Choose the distance between the pole pieces as small as possible, but so that the movement of the pendulum is not impeded. Fix the pole pieces.

Carrying out the experiment

– Increase the current through the electromagnet step by step (the load should exceed 5 A only for short periods).
– Give the pendulum a push while it is in its position of rest, and observe the oscillations.
– Clamp the unslotted side of the aluminium plate in the pendulum rod, and repeat the experiments.

Measuring example

Table 1: Number of oscillations of the aluminium plate in the magnetic field after it has been given a push from its position of rest

$\frac{I}{A}$	Number of oscillations	
	unslotted area	slotted area
0	>20	>20
2,5	8	>20
5	3	>20
7,5	2	>20
10	1	>20

Evaluation

If the unslotted area oscillates in the magnetic field, the oscillations are damped. The damping becomes stronger with increasing strength of the magnetic field. In the case of the unslotted area, there is only weak damping.

Results

In the metal plate, which moves in an inhomogeneous magnetic field, eddy currents are induced. The inhomogeneous magnetic field exerts an overall force in the opposite direction of the movement (compare *Lenz* rule).

In the slotted aluminium plate, eddy currents can only form very weakly.