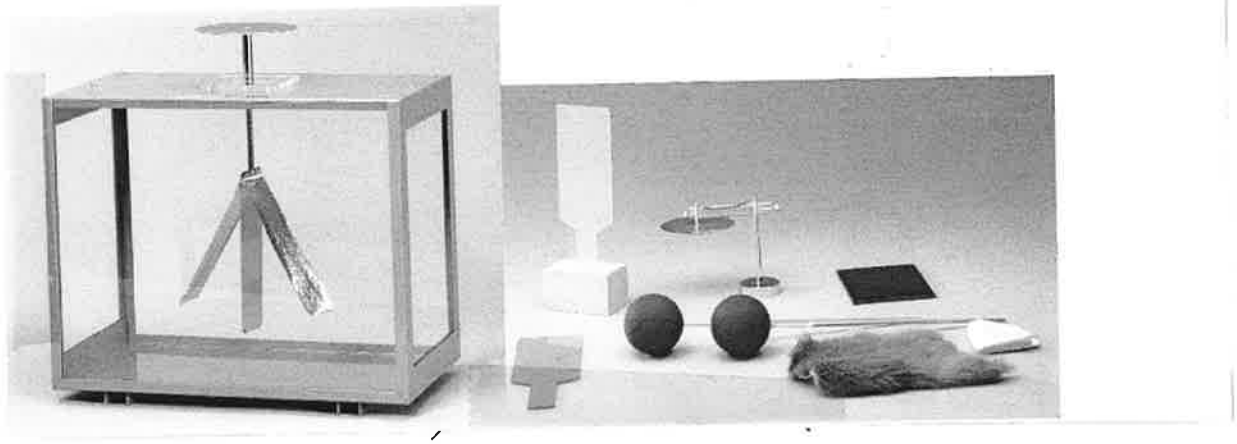
B10-1151

Large Leaf Electrometer



Purpose

The large foil leaves make this an excellent demonstration device for the study of static electricity. The extensive range of experiments includes the applying static electrical charges, identifying the type of charge, examining various conducting and non-conducting materials, electrostatic induction, the principle of condensers, and the photoelectric phenomenon.

Features

1. The movement of the foil leaves is easily observed due to their large size.
2. Theoretical principles are easily studied, since the observed effects are not dependent on the type of metal used.
3. A rich assortment of accessories allow a wide range of experiments to be performed.
4. The metal foil is strong and durable. Damaged foils can be easily repaired or replaced.

Contents of complete set

Large Leaf Electrometer, for demonstration purpose 1

Accessories

1. Friction plates (acrylic resin and vinyl chloride resin) .....1 set
2. Friction plate holder 1
3. Fur 1
4. Silk cloth 1
5. Metal plate with handle.....1
6. Metal plate holder (with ground wire).....1
7. Insulating plate (ebonite).....1
8. Conducting sphere for static electricity experiments (large) ... Set of 2

Additional supplies for studying photoelectric phenomenon

1. Metal plate (aluminum or zinc).....1
2. Sandpaper ..... 1 sheet
3. Fluorescence Detector (ultraviolet lamp)

.....1

Note: Conducting sphere for experiments on static electricity

The conducting sphere consist of hollow plastic ball, the surface of which has been coated with a conductive material. During static electricity experiments, it acts as a solid conductor. Besides its ease of use, the ball has a large surface area, and is able to hold a large capacity charge. Its main purpose is collect a charge for experiments in electrostatic induction.

Experiments

1. Preparing for experiments

(1) Where to place the unit

Since the body and legs of the main unit are constructed of metal, the main unit must be grounded to achieve the desired experimental results. If the location is highly insulated, use the supplied ground wire and clip to ground the unit.

(2) Generating a charge for experimental purposes

The size of the unit requires a charge which is large enough to sufficiently separate the leaves for easy observation. This is easily performed by using the supplied generating plate. Insofar as it is possible, use this plate for each experiment except #2 below.

To generate a static electrical charge, follow these procedures:

Positive charge	Rub the acrylic resin plate with silk cloth.
Negative charge	Rub the vinyl chloride resin plate with fur.

To apply a charge, fold the material once or twice and place it near the edge of a desk or table as shown in Figure 1. Insert the friction plate between the material and the table, and pull the plate out while pressing the material lightly.

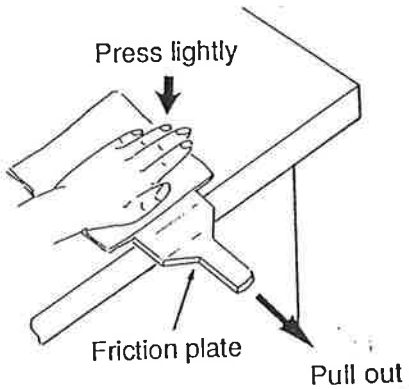


Figure 1

This will produce a large enough charge to cause the foils to open.

Note: A friction bar may be used for typical static electricity experiments. Several bars may be used to generate a sufficiently large charge.

2. Experiment for determining the presence of a static electric charge

Bring a charged object near the metal plate of the electrometer (which has not been previously charged) will cause the foils to separate according to the strength of the charge.

When the object is removed, the foils will gradually close to their previous state.

Reference

① When the charged body is brought near the metal plate, an electrostatic charge is induced in the conducting part of the electrometer (Figure 2).

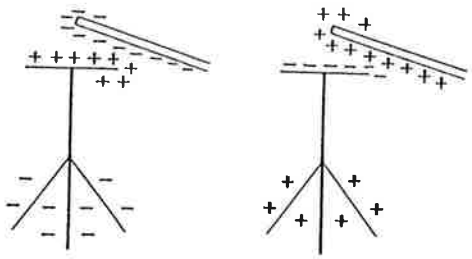


Figure 2

② The foils are mutually repelled since they acquire like charges.

③ The foils continue to separate until the strength of the charge is balanced with the weight of the foils.

3. Applying a charge to the electrometer

(1) Applying a like charge to the electrometer

(A) Directly applying a charge

Directly touch the charged body to the metal plate of the electrometer (Figure 3A). Once the electrometer is charged, the foils remain separated even after the charged body has been removed.

Note 1. Occasionally the electrometer will not receive a charge from a charged body which is constructed from nonconductive materials, even if the charged body is brought into direct contact with metal plate. In this

case, it is necessary to slowly rub the charged body against the metal plate to transfer the charge (Figure 3B).

An alternative method is to bring the charged body near the plate and blow between them (Figure 3C).

Note 2. If the charge applied from the charged body is too large, the like charge is discharged from the foil, leaving the opposite charge on the foil.

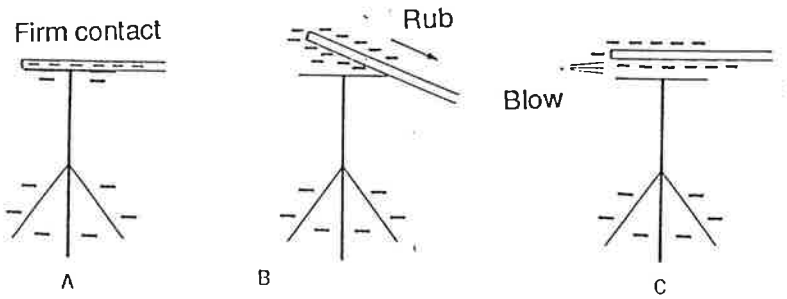


Figure 3

(B) Using electrostatic induction

By using the supplied conducting sphere, a charge can be applied to the electrometer via electrostatic induction. This will yield better results than those obtained by using a nonconductive charged body as described in (A).

① Remove any charge from the conducting sphere and the metal plate of the electrometer by bringing the sphere into contact with the plate and touching them with your finger.

② Bring a charged body near the electrometer above the conducting sphere. An electrostatic charge is induced in both the conducting sphere and the metal plate, and the foil leaves separate (Figure 4A).

③ Move the original source of the charge and the conducting sphere completely away from the electrometer (Figure 4B). The distance

between the foils will decrease slightly, and the electrometer will have a like charge to that as the charged body (Figure 4C).

④ Alternatively, the charged body may be brought into contact with the conducting sphere at some distance from the electrometer (Figure 4D). An opposite charge will be induced in the conducting sphere which can then be brought into direct contact with the metal plate, causing the foil leaves to separate (Figure 4E). The charge in the electrometer will be like that of the charged body (Figure 4F).

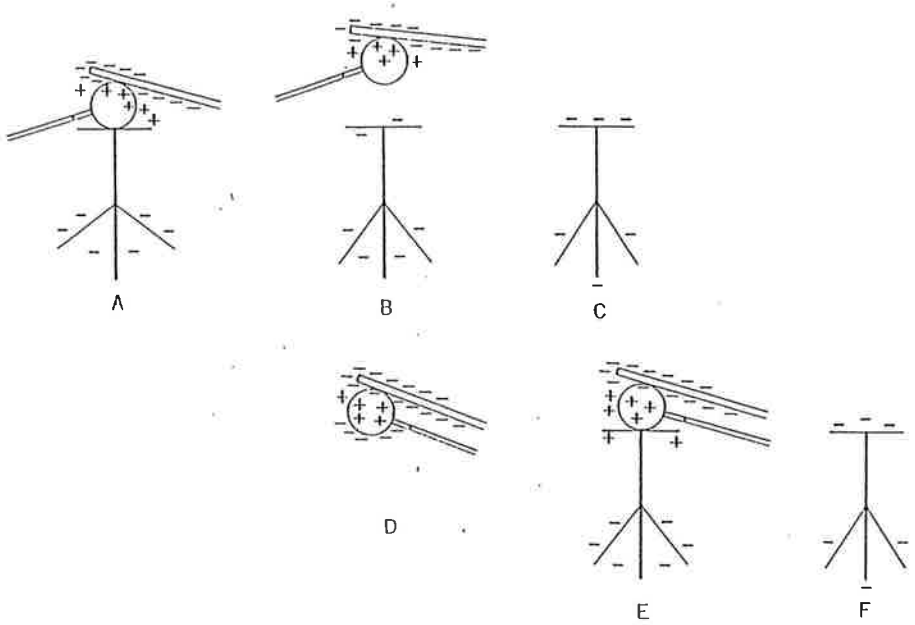


Figure 4

(2) Applying an opposite charge to the electrometer

① Bring a charged body close to the metal plate of the electrometer. An electrostatic charge is induced in the conducting part of the electrometer, and the foil leaves separate (Figure 5A).

② Touch your finger to one edge of the plate. A like charge to that of the charged body and of the foil is discharged through your finger and the foil leaves close (Figure 5B).

③ After taking your finger off the plate, remove the charged body. The charge remaining in the electrometer will be opposite from that of the charged body and the leaves will open (Figure 5C).

Note 1. In step ①, when the charged body is a nonconductor, the results will not be affected even if the body directly touches the plate.

Note 2. The amount of charge required to open the leaves to approximately 45° is 0.07μC and a potential of about 6kV. Electrical capacity is about 12pF.

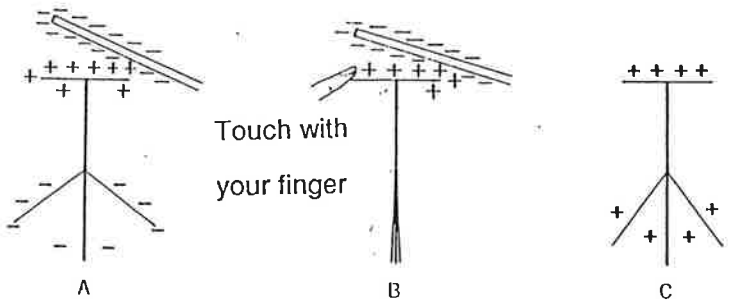


Figure 5

4. Investigating the type of charge held by a charged body

Prepare the electrometer by charging it with either a positive or negative charge. Then bring a charged specimen near the metal plate of the electrometer.

(1) When the charge of the specimen is like that of the electrometer, the charge of the electrometer is increased, causing the leaves to open wider (Figure 6B).

If the amount of charge of the specimen is very large, the charge of the metal plate is quickly lost, leaving an opposite charge on the plate. The nearer the specimen is brought to the plate, the stronger the opposite charge is induced on the plate. The charge on the leaves also increases, causing them to separate even wider (Figure 6C).

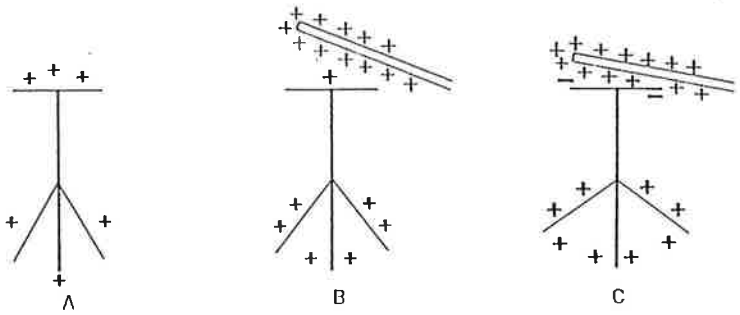


Figure 6

(2) When the charge of the specimen is opposite to that of the electrometer, and the specimen is brought near the metal plate, the charge applied to the leaves decreases and the opening between them decreases (Figure 7B). If the charge applied to the specimen is large, the charge at the leaves is gradually lost, causing the leaves to progressively close, until the same charge of the specimen is induced on the leaves, causing them to reopen (Figure 7C).

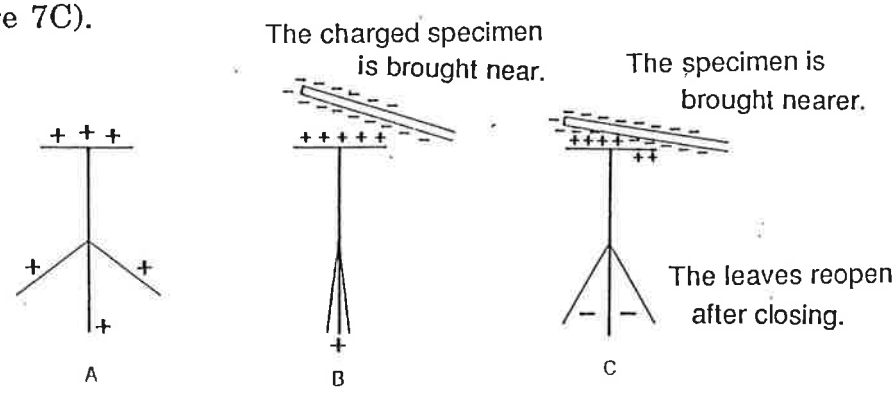


Figure 7

5. Examining electrical conductors and nonconductors

While applying a charge to the electrometer by one of the methods described in Experiment 3, ground the specimen by touching it with your hand. If the specimen is a conductor, the charge will be lost and the foil leaves will close. If the specimen is a nonconductor, there will little change in the separation between the leaves.

Note 1. Static electricity is generally characterized by small capacity and high potential. Thus a nonconductor functions as an effective insulator. For example, Bakelite is a widely used insulator, but some varieties of Bakelite appear to lose a charge during this experiment.

Note 2. Using an charged object which is a strong insulator in Experiment 4 will exhibit similar results in the determination of positive or negative charge.

6. Electrostatic induction

(1) Using a single conducting sphere

When a conductor is brought near a charged body, the opposite charge is induced in the portion of the conductor nearest the charged body, and a like charge in the portion which is farthest from the charged body.

① Apply a charge to a friction plate and insert it in the supplied holder.

② When the conducting sphere is brought near the plate, an electrostatic charge is induced (Figure 8A).

③ Touch the sphere with your finger. The charge induced at the side which is farthest from the plate will be discharged through your finger (Figure 8B).

④ After you have taken your finger off the sphere, move it away from the charged plate. The entire conducting sphere will hold an opposite charge to that on the charged plate (Figure 8C).

⑤ The type of charge on the conducting sphere can be confirmed by bringing it near the electrometer.

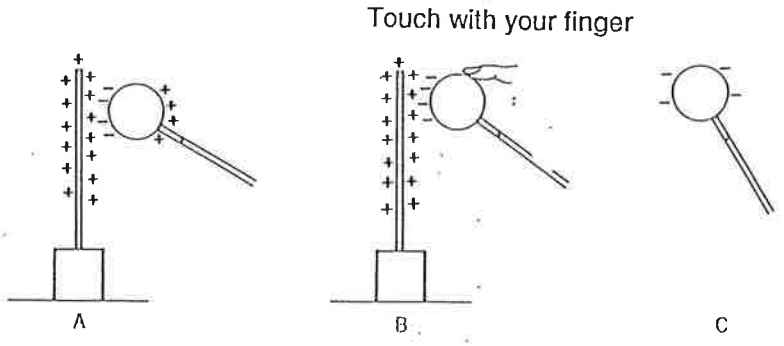


Figure 8

(2) Using two conducting spheres

This experiment investigates the type of charge induced on a second conductor.

① Apply a charge to a friction plate and place it in the supplied holder.

② After removing any residual charge from two conducting spheres, touch the spheres together and bring them near the charged plate (Figure 9A).

③ Separate the conducting spheres and move them away from the charged plate. The two spheres will hold opposite charges with the same capacity ((Figure 9B).

④ When one of the spheres is brought into contact with the metal plate of the electrometer, the leaves open; but when the second sphere contacts the metal plate, the leaves close. This confirms that the two spheres hold opposite charges of the same capacity (Figure 9C).

Note: In step ④, touch the second sphere to the first sphere after the first sphere has been moved away from the electrometer. Now when the second sphere touches the electrometer, the leaves will not close completely as part of the charge has been removed.

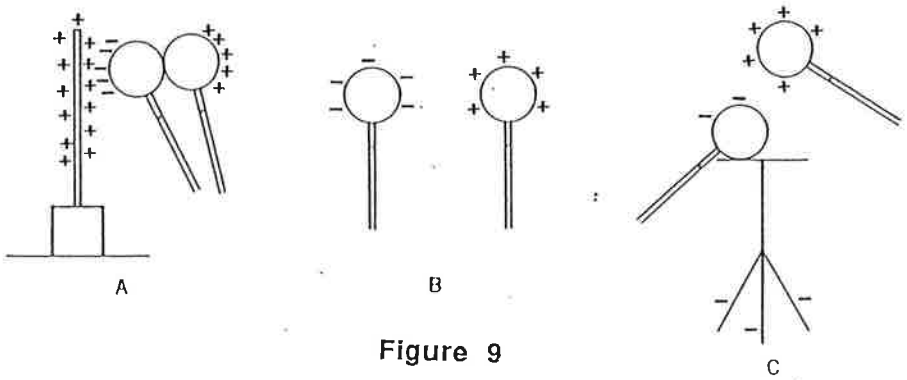


Figure 9

7. Principle of the condenser

Demonstrating that a condenser consists of two parallel metal plates which store a charge. Note that the capacity of the condenser is related to the distance between the plates, the overlapped facing areas, and the insulator inserted between the plates.

(1) Principle of the parallel plate condenser

① Mount the metal plate with handle on the metal plate holder and adjust it on the electrometer so that there is approximately 5mm between the two metal plates. (In this experiment, the ground wire attached to the holder should not be used to ground the first plate.)

② Move the metal plate with handle to one side and apply a charge to the metal plate of the electrometer.

③ When the metal plate with a handle is returned to its position near the metal plate of the electrometer, the leaves will slightly close (Figure 10A).

④ Touch the metal plate with handle with your finger. The two metal plates function as a condenser. The distance between the leaves will noticeably decrease (Figure 10B).

Note 1. This experiment can also be performed without the metal plate holder by holding the insulated handle of the metal plate.

Note 2. The charges placed on the two plates will be the same capacity when the metal plate with handle is grounded as described in step ④.

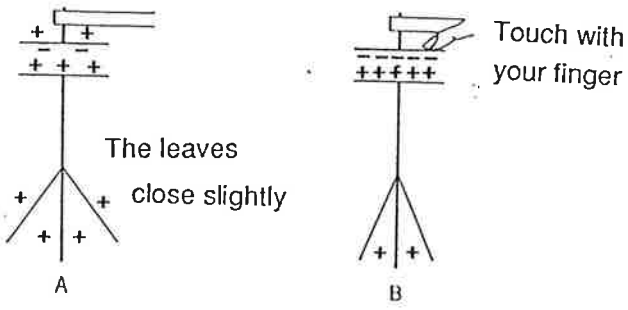


Figure 10

(2) Capacity of a condenser

① Mount the metal plate with handle on the metal plate holder and connect the ground wire of the plate to the upright rod of the holder. Place the holder on the electrometer and adjust the height of the metal plate to about 5mm above the plate of the electrometer.

② Move the metal plate with handle to one side and apply a charge to the electrometer plate.

③ When the metal plate with handle is returned to its position over the electrometer plate, the leaves will slightly close. This confirms that a portion of the charge applied to the leaves has moved toward the plate. The relation between the distance between the plates and the capacity of a condenser can be demonstrated and explained (Figure 11A).

④ Laterally slide the metal plate with holder to vary the facing area between the two plates. The distance between the leaves will vary according to the facing area. This demonstrates the relationship between the facing area between the plates and the capacity of a condenser (Figure 11B).

⑤ Now insert the supplied insulator plate between the two metal plates. The opening between the leaves will vary according to the extent to which the insulator is inserted (Figure 11C).

⑥ Removing the insulator plate and moving the metal plate with handle away from the plate of the electrometer will result in the leaves opening wider. It can therefore be observed that the potential difference increases as capacity decreases.

Note 1. If the metal plates are positioned too closely, the static electric potential may be discharged; and if the plates are to distant, the effect on the leaves may be too slight to observe.

Note 2. The holder will be grounded through the case of the main unit when it is placed on the electrometer. For safety, connect the clip cord to the

legs of the case. (the coating on the surface of the case is not an effective insulator.)

Note 3. The charge applied to a nonconductor (as in Experiment ⑤ above) is more difficult to control. Conduct the experiment after sandwiching the insulator plate between the palms your hands so as not to inadvertently rub the plate and discharge it.

The experiment can also be conducted using a sewing needle. Hold the needle in your hand, thereby grounding it, and point the eye of the needle toward the insulator plate. Move it across the face of the plate in a rubbing motion without touching the plate, but far enough away to prevent discharging the plate.

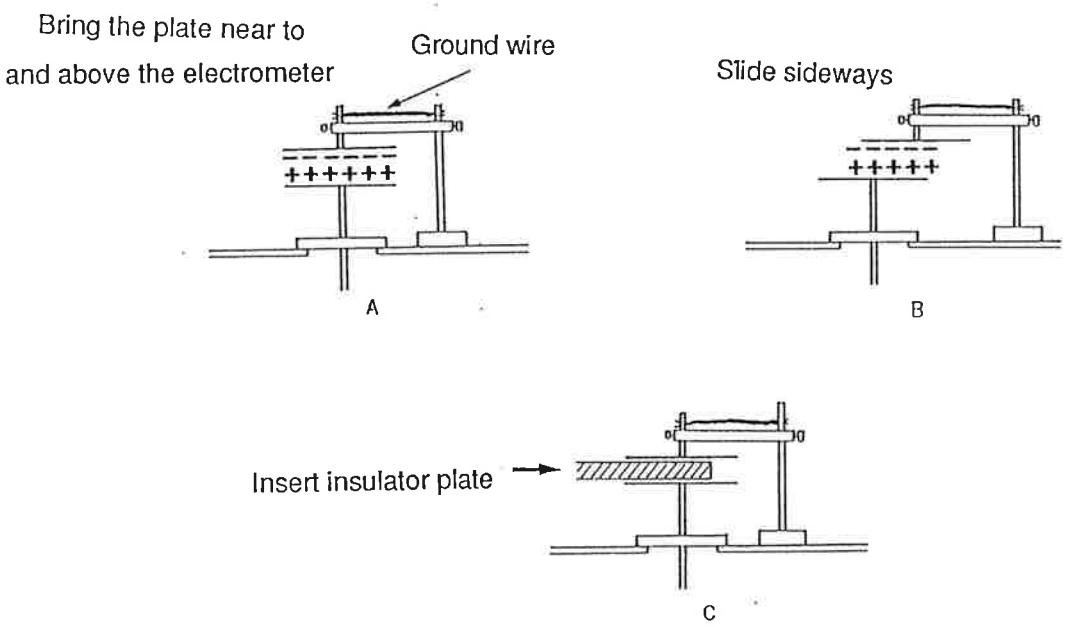


Figure 11

8. Photoelectric effect

In this experiment, the metal plate produces a photoelectric effect on the electrometer, imparting a positive charge. The leaves are closed by the photoelectric effect after being exposed to ultraviolet rays. A fluorescence detector is used as the light source and either an aluminum or zinc plate is used as the metal plate.

The following are required in addition to the electrometer and accessories:

1. Metal plate (aluminum or zinc) 1
2. Sandpaper.....1 sheet
3. Fluorescence Detector (ultraviolet lamp)
.....1

Note: An electrode plate (aluminum or zinc) used in battery experiments can also be used.

① Polish the metal plate to remove oxide deposits on the surface.

② Place the metal plate on the metal plate of the electrometer and apply a negative charge to the electrometer, causing the leaves to open.

③ When the metal plate is exposed to ultraviolet rays, the leaves promptly close.

Note 1. If for comparison a positive charge has been applied to the micrometer, the leaves will not close, confirming that the photoelectric effect emits negatively charged particles.

Note 2. To demonstrate that the leaves are not closed simply because the ultraviolet rays are brought close to the unit, turn on a room light after the leaves have closed.

Note 3. Set the wavelength of the ultraviolet rays to 250nm.