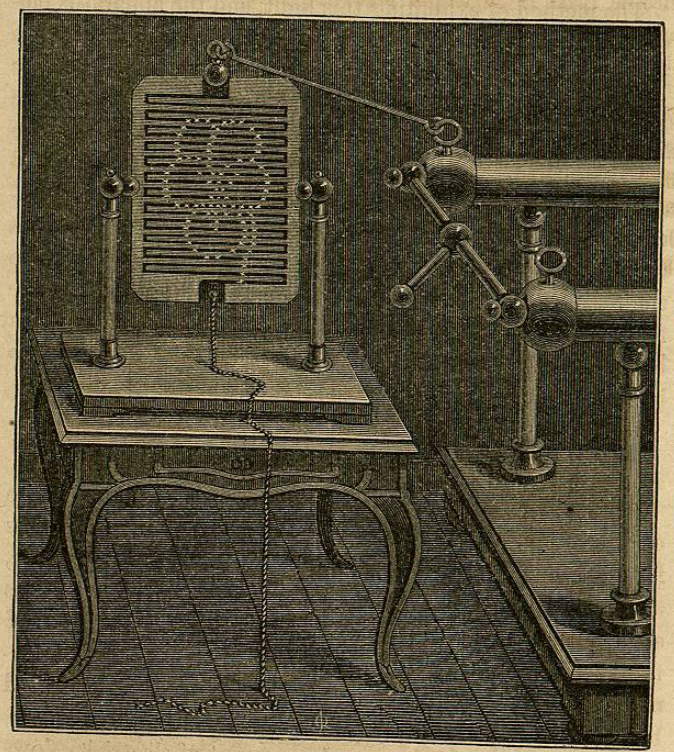

Fig. 266.

or words may be written on the glass. The experiment is more striking in a darkened room.

The Electrical Cannon.

384. The ELECTRICAL CANNON is a small cannon which is discharged by means of the electrical spark.

This cannon is used not only as an electrical recreation, but it serves also to demonstrate an important scientific fact, viz.: that the

(384.) What is the Electrical Cannon? *What is its use?*

electric spark is capable of producing chemical reactions. For example, water is formed of oxygen and hydrogen gases in the proportion of two volumes of the former to one volume of the latter. Now if these two gases be mixed in this proportion, and an electrical spark be passed through the mixture, the gases instantly unite and form water. Moreover, the combination takes place with a brilliant flash of light and a loud report, the report being due to the expansive force of the vapor which is produced at the moment of combination. It is upon these principles that the electrical cannon represented in Fig. 267 is constructed.

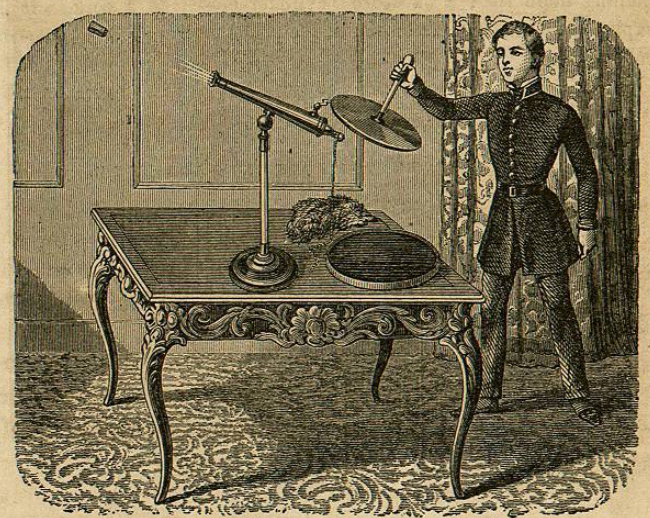

Fig. 267.

It consists of a small copper cannon mounted on a stem of glass. In the vent of the cannon is a tube of glass, through which passes a copper wire. This wire terminates externally in a ball, and internally it terminates near the metal of the cannon without touching it. The whole communicates with the earth by a chain.

Illustrate. Describe it.

To use the instrument, it is filled with a mixture of oxygen and hydrogen in the proportions to form water, and the muzzle is then closed by a cork. If a charged electrophorus is brought in contact with the ball, a spark passes between them, and another between the internal extremity of the wire and the metal of the cannon. This spark causes an explosion and drives out the cork.

A similar apparatus, called VOLTA'S pistol, is used for exploding a mixture of oxygen and hydrogen, or of air and hydrogen. It is nothing more than a sheet-iron cylinder closed by a cork. It is exploded by touching its button to the prime conductor of an electrical machine.

IV.—ACCUMULATION OF ELECTRICITY.

Electrical Condenser.

385. An ELECTRICAL CONDENSER is an apparatus employed for the accumulation of electricity.

They are of various forms, but are all essentially composed of two conductors separated by an insulator. The condenser of EPINUS may serve as a type of this class of apparatus.

Condenser of Epinus.

386. The CONDENSER OF EPINUS is composed of two metallic plates, *A* and *B*, Fig. 268, standing upon supports of glass, with an intervening plate of glass, *C*, somewhat larger than either of the metallic plates. These several plates are so mounted that the plates *A* and *B* may be made to approach to, or recede from the plate *C*.

How is it used? *Describe* VOLTA'S *pistol.* (**385.**) What is an Electrical Condenser? (**386.**) Describe the Condenser of EPINUS.

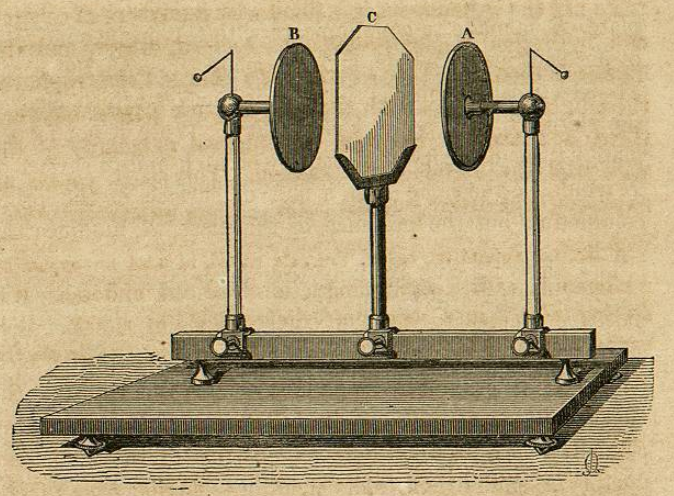

Fig. 268.

Method of using the Condenser.

387. To use the condenser, the plates, *A* and *B*, are moved up to touch the plate, *C*, as shown in Fig. 269. The

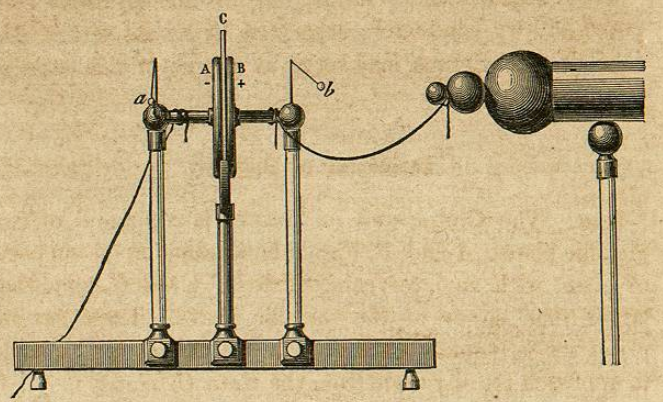

Fig. 269.

(**387.**) Describe the method of using it, in detail.

plate, B, is made to communicate with the prime conductor of an electrical machine, and the plate, A, with the earth. The electrical machine is then put in motion, which charges the plate, B, with positive electricity. Were it not for the plate, A, the quantity of electricity on each unit of surface of B would be the same as on a unit of surface of the prime conductor; but the presence of the plate, A, modifies this result.

The plate, B, acts by induction upon A, and drives its *positive* electricity to the earth, retaining its negative electricity by the force of attraction. The *negative* electricity of A now reacts upon B, partially neutralizing the effect of its *positive* electricity. The electricity of B being partially neutralized, no longer holds that of the prime conductor in equilibrium, and an additional quantity of the positive fluid flows into it, which, acting as before, draws into A, from the earth, an additional quantity of the negative fluid, and so on. In this way there is gradually accumulated upon B and A, large quantities of the positive and negative fluids.

When the apparatus is fully charged, we cut off the communication between A and the earth, then that between B and the machine, by taking away the chains. In this condition the two electricities on A and B show no effects, but simply hold each other in equilibrium. There is, however, in consequence of the intervening glass plate, an excess of electricity in B, as is shown by the electrical pendulum, b, placed in connection with it. A similar pendulum placed in connection with A, gives no such indication.

If, now, the plates be separated, as shown in Fig. 268, both electrical pendulums will diverge, as they should do, because the two electricities no longer hold each other in equilibrium. In this condition the electricities of the two plates may be

Explain its theory. How may it be shown that the two plates are differently charged?

tested and shown to be opposite. If a rod of glass be rubbed with silk and brought near the pendulum upon B, it will be repelled, indicating positive electricity; if it be brought near the pendulum upon A, it will be attracted, indicating negative electricity.

Slow discharge of the Condenser.—Instantaneous discharge.—Discharger.

388. The condenser being charged and placed as in Fig. 269, may be discharged, that is, brought back to its neutral state, in two ways. *First*, by successive contacts, in which case the discharge takes place slowly; or *secondly*, by connecting the plates A and B by a conductor, in which case the discharge is instantaneous.

If the plate, A, is touched, no electricity is drawn off, because all that it contains is held in equilibrium by that in the plate, B. If, however, the plate, B, is touched, all of its free electricity, that is, all which is not neutralized by that in the plate, A, is drawn off. After this, a certain unneutralized portion of electricity will exist upon A, which will be indicated by the pendulum. By continuing to touch the plates *alternately*, the whole charge may be drawn off in small quantities.

To obtain an instantaneous discharge, we might touch one plate with one hand and the other plate with the other hand, when the two fluids would flow through the body and neutralize each other; this method produces a shock much more powerful than that produced by the simple spark from the prime conductor.

To avoid this shock we make use of a *discharger*. A discharger consists of a heavy wire bent into an arc, terminated at its two ends by balls, and having a hinge joint in the

(388.) In how many ways may a condenser be discharged? Describe the first method. The second method. Describe the method by successive contacts. How may it be instantaneously discharged? What is a discharger, and what is its use?

middle, so that it can be folded upon itself, as shown in Fig. 271. It is usually provided with a glass handle, by which it is held.

To discharge the condenser, one ball is brought in contact with one plate, and being held there, the discharger is folded so that the other ball will touch the second plate. At the instant of contact a spark is emitted, arising from the combination of the two fluids, which takes place through the discharger. No shock is felt, because the electricity does not pass through the body as in the previous case.

Limit of the Charge in a Condenser.

389. Two circumstances limit the amount of electricity that may be accumulated in a condenser. *First*, the unbalanced electricity in the plate, *B*, goes on augmenting with the charge, until at last its tension becomes equal to that on the prime conductor, after which no more can flow into the condenser from the machine. *Secondly*, the two electricities on the plates, *A* and *B*, tend to unite with an energy which goes on augmenting with the accumulation of electricity on the plates, and may ultimately become so great as to break through the glass and thus cause a union of the two fluids.

The Leyden Jar.

390. The LEYDEN JAR, named from the city where it was invented, is a condenser, differing only in form from that which has been described.

In its improved form it consists of a bottle or jar of thin glass, as shown in Fig. 270, nearly covered on its outside with tin foil, and nearly filled within by loose tin foil, or some other metallic substance in a loose state. A wire passing through the cork extends to the metallic filling within, and terminates externally in a sphere of metal called the *button*.

How is it employed? (**389.**) What circumstances limit the charge in a condenser? (**390.**) What is the Leyden Jar? Describe it.

This is a condenser in which the glass of the bottle serves as an insulator, whilst the metallic substances within and without correspond to the metallic plates in the instrument already described. The interior metal corresponds with the plate, *B*, and may be called the collector, whilst the external metal corresponds with the plate, *A*. What has been said of the condenser holds good for the Leyden jar.

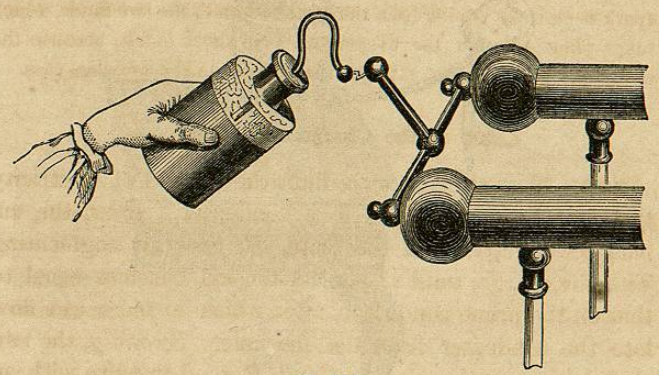

Fig. 270.

The Leyden jar is charged by holding the outer tinned part in the hand, and bringing the button in contact with the prime conductor of an electrical machine, as shown in Fig. 270. The positive fluid is accumulated in the interior, and acts by induction upon the outer coating, which becomes negative, the positive fluid in that coating being conveyed away by the hand through the body. As in the condenser, the two fluids react so as to accumulate a large quantity of positive electricity on the inside of the jar, and of negative electricity on the outside.

After the jar has been charged, if it be held in one hand whilst the other is brought in contact with the button, a shock will be felt through the arms and body, and the jar will return to its neutral state. When it is desirable to discharge the jar without the shock,

How does it resemble a condenser? How is the jar charged? Explain the theory. *How is it discharged?*

the discharger is used, as shown in Fig. 271. One ball of the discharger is made to touch the outer coating, and the other is then

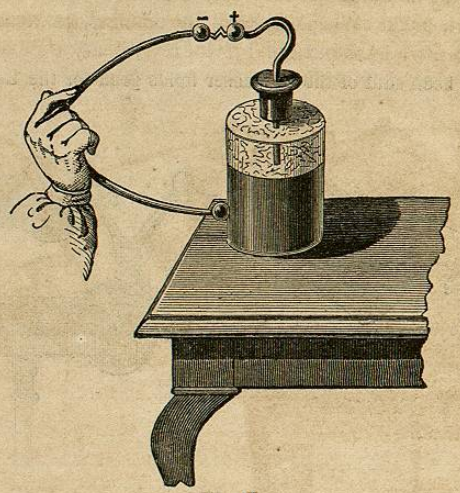

Fig. 271.

brought in contact with the button. In this case there is a spark emitted, and the jar returns to its neutral condition.

Electrical Battery.

391. An ELECTRICAL BATTERY consists of an assemblage of Leyden jars so connected as to act like a single condenser, as shown in Fig. 272.

The jars are placed in a box whose bottom is lined with metal, which serves to connect their outside surfaces. Their inside surfaces are brought into communication by connecting the several buttons with metallic rods.

In batteries the jars are made large, and are covered within and without with tin foil, the interior lining being brought into communication with the button of each jar by a metallic chain. Upon one

(**391.**) What is an Electrical Battery? Describe it. *What kind of jars are used in batteries?*

of the buttons is placed an electrical pendulum, which indicates the excess of the fluid on the inner over that on the outer surface.

The battery is charged in the same manner as the condenser of EPINUS (Art. 391). When charged, the chains are removed by a hook with a glass handle.

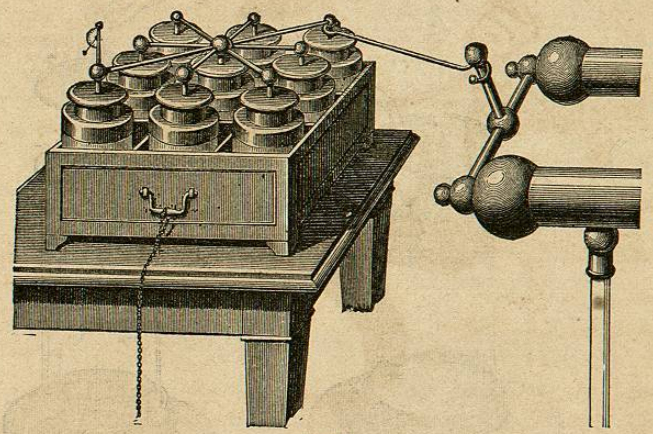

Fig. 272.

In discharging an electrical battery, a discharger is used with two glass handles, as shown in Fig. 276. Care should be taken to touch the external covering before touching the common button with the discharger.

Condensing Electrometer.

392. The gold-leaf electrometer, shown in Fig. 259, is very sensitive, but it may be rendered still more so by the addition of two disks or condensing plates, as shown in Figs. 273 and 274. The inferior disk is attached permanently to the stem, *t*, which supports the strips of gold-leaf. The superior disk has a glass handle by which it can be removed at pleasure. The two disks are of brass, coated

How connected? How charged? How discharged? (**392.**) What is a Condensing Electrometer?

with varnish, which serves as an insulator, taking the place of the glass plates in the condensers already described,

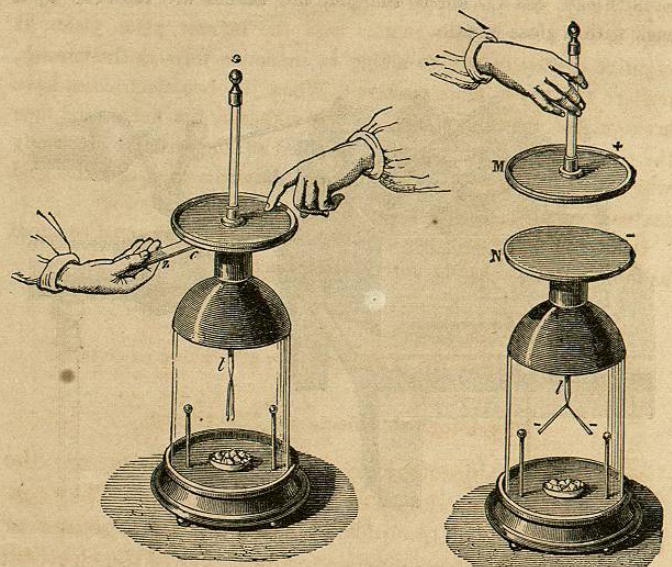

Fig. 273.

Fig. 274.

but being very thin, the condensing power is much augmented.

Use of the Condensing Electrometer.

393. To use the condensing electrometer for detecting small quantities of electricity, we place the upper disk upon the lower one, as shown in Fig. 273, then using the lower disk as a collector we bring it into contact with the body to be experimented upon. At the same time we establish a connection between the upper disk and the earth, by touching it with the finger.

(**393.**) How is the condensing electrometer used?

In Fig. 273, the body experimented upon consists of two plates, one of zinc, and the other of copper, fastened together. We shall see hereafter, that by a simple contact of two such plates, the zinc is positively, and the copper negatively electrified. This last metal then being brought into contact with the inferior plate, yields its negative electricity, which acting by induction through the varnish, renders the upper plate positive. When the two electricities have accumulated upon the plates, we first withdraw the finger, and then the plate *cz*. If the upper plate be lifted off, the negative electricity which was before held in equilibrium, becomes free, and the gold leaves diverge, as shown in Fig. 274.

In this manner quantities of electricity may be discovered so small as to be unnoticed by the simple electrometer.

V.—EFFECTS OF ACCUMULATED ELECTRICITY.

Physiological Effects of Electricity.

394. The physiological effects of electricity are the effects which it produces on men and animals. They consist of muscular contractions, accompanied by a greater or less amount of pain, according to the power of the electrical apparatus.

When we receive a simple spark from the prime conductor, we experience only a slight stinging sensation; with a small Leyden jar, the pain is felt extending up the arms to the elbows or shoulders; with a more powerful jar or a battery the shock is felt through the arms and chest, and may be sufficient to produce death.

An electric shock may be given to a great number of persons at the same time. To that end they form a chain by taking each other by the hand, as shown in Fig. 275; then the person at one end takes a Leyden jar in his hand: the circuit is completed by the person at the other end of the chain touching the button of the jar, when the shock is felt simultaneously throughout the ring. NOLLET

Explain Fig. 273. What are the advantages of this instrument? (**394.**) What are the physiological effects of electricity? *Describe the shock. How may the shock be given to a number of persons?*

administered in this manner, in the presence of Louis XV., an electrical shock to an entire regiment of soldiers.

Fig. 275.

With a battery, the shock becomes so powerful as to render it dangerous to attempt receiving it. With a battery of only six jars of mean size, it would be hazardous to receive the shock. With more powerful batteries, cats, dogs, and even stronger animals may be killed by a single shock. Fig. 276 represents a dog killed by a shock from a battery of nine jars. The metallic collar of the dog is connected with the exterior coating of the battery, then one ball of the discharger is placed near the posterior part of the dog's spinal column, after which the circuit is completed by touching the button

Examples. What is the effect of a shock from a powerful battery? Explain the experiment.

of the battery with the other ball of the discharger. The animal is killed instantly.

In the Museum at Harlem, in Holland, is a battery whose discharge is capable of killing an ox. There is also a very powerful

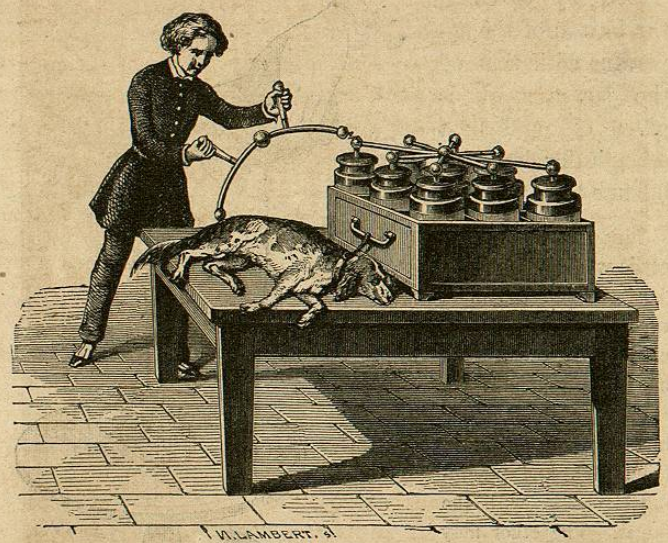

Fig. 276.

battery in the Conservatory at Paris, which was given to it by the Physicist Charles.

Heating Power of Electricity.

395. The heat developed by electricity is sufficient not only to inflame ether, gunpowder, and the like, but also to melt and volatilize the metals.

Fig. 277 represents the manner of inflaming ether. The ether is poured into a glass vase, through the bottom of

The Harlem battery. (**395.**) Is there much heat developed by electricity? Explain the experiment shown in Fig. 277.