PHYSICS

The Edison Effect

"A Classic of Science"

Filament and Plate of the Electron Tube Trace to Edison While English Physicists Studied its Strange Properties And de Forest Added the Grid which Allows it to Speak

ON A PECULIAR BEHAVIOUR OF GLOW-LAMPS WHEN RAISED TO HIGH INCANDESCENCE. By William Henry Preece, in Proceedings of the Royal Society of London, Vol. XXXVIII. March 18, 1885. London, MDCCCLXXXV.

DURING my recent visit to America (October, 1884) Mr. Edison showed me a very striking experiment with glow-lamps, the principle of which he had not threshed out, although he had attempted to apply it practically to the regulation of the current flowing in electric light circuits.

If *abc* be the incandescent filament of a glow-lamp, *de* a thin narrow platinum plate fixed between the limbs of the filament with an independent wire connection *ee,* sealed in the glass globe, then, if a galvanometer G be connected between *a,* the positive electrode, and *e,* a derived current will be observed to pass through G, and through the rarefied space *ec* when the main current is increased to a certain strength, and the filament reaches a certain degree of incandescence. The strength of this derived current will increase with the increased brilliancy of the glowing filament. Mr. Edison made for me several lamps of different forms and character to enable me to investigate the phenomenon more carefully in England, and I have the pleasure of submitting the results of those experiments to the Society. . . .

Experiment 1.—The connexions were made as shown in the figure. The lamp (No. 4) was a short (75 mm.) filament lamp, with a platinum plate 30 mm. long and 5 mm. broad.

The variation of the current and the increase in the resistance of the filament towards the end of the experiment, together with the behaviour of the shunt, are very noticeable. It is quite clear that when the electromotive force attained 82 volts, a critical point was reached. From that point the current in the filament remained very steady, but the resistance gradually increased. The shunt increased in resistance enormously, and the current through it diminished, although the electromotive force increased very largely. It is remarkable how steady the electromotive force in the shunt remained until the critical point was reached, when it suddenly increased and only reached that of the main current at the point of rupture of the filament. Again the current, which steadily increased until the critical point was reached, then diminished, indicating a considerable increase in the resistance of the rarefied space *ec.* In one subsequent experiment, after the critical point was reached, no current could be obtained through the shunt.

Bright Arc Observed

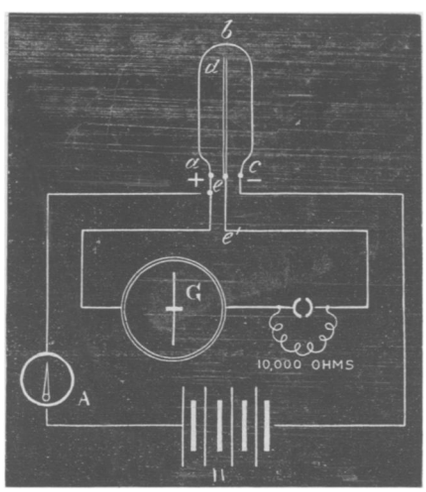
The direction of the current is shown in the figure.

Towards the end of the experiment, when the characteristic diffused blue effect in the globe was very marked, a bright arc was observed to be playing about the bottom of the limb at *c,* and it was quite clear that a bridge of conducting material was formed between *e* and *c,* which, together with the galvanometer, made a shunt to the filament. . . .

Although the maximum effect was produced by Mr. Edison when the plate was fixed between the limbs, he obtained a current when it was fixed in any part of the rarefied space. If the effect was due primarily to the Crookes effect, or to the projection of molecules from the carbon filament on to the metal plate, since this bombardment takes place in right lines, we ought to have obtained effects when these lines were projected on the plate, but no effects when they could not strike the plate. . . .

Professors Liveing and Dewar ("Proc. Roy. Soc.," March 9, 1882) observed a "sort of flame" during high incandescence, showing by its spectrum the presence of carbonic oxide. It was strongest about the junction of the carbon thread and the positive electrode. It was, according to them, the glow of the positive pole attending a discharge in rarefied gas.

It is a common thing with glow-lamps which have the heels of the filament close together to have an arc forming across when the electromotive force at the terminals is too high. Hence in recent lamps requiring 100 volts, Mr. Swan has considerably increased the distance between the electrodes. Moreover, whenever the incandescence of the filament is raised beyond a certain limit the interior of the glass envelope is blackened by a layer of carbon, which has been deposited by a Crookes bombardment effect. When the carbon filament is fixed on copper electrodes, the interior of the glass sometimes becomes coated with copper as well as with carbon, and the line between the two is perfectly marked, showing that the bombardment takes place in right lines. Experiment I. shows how very high the electromotive force can be carried, if it be steadily and rapidly increased, before the filament is broken; but practice shows that when once the blue effect appears, destruction is only a question of time. Hence the blue effect is an



PREECE'S APPARATUS

For measuring potential difference between filament and insulated grid in the tubes Edison made for him.

indication of the advent of disintegration, and a very useful warning of danger ahead.

Now it is clear that we have a combination of the phenomena above described in the Edison effect. A continuous bridge of molecules is formed between the junction of the carbon filament and the metal plates inserted between its heels. They are found deposited on the metal plate. A shunt is thus formed whose resistance is measurable, and a definite current passes. This shunt is formed just where the negative metallic connexion joins the heel of the carbon filament, as we should expect from the investigations of Mr. Crookes. The current is, however, weak and variable, and it is scarcely reliable enough to be useful for practical purposes as was hoped by its discoverer. . . .

"Among the Breakers"

It is very evident that this Edison effect is due to the formation of an arc between the carbon filament and the metal plate fixed in the vacuous bulb; that this arc is due to the projection of the carbon particles in right lines across the vacuous space; and that it makes its appearance earlier, and is more strongly marked, when the connexions are as shown in Fig. 1 than when they are reversed, because, as Mr. Crookes has pointed out, the projection proceeds from the negative to the positive pole, and it would commence at the point of least resistance. Its presence is detrimental to the life of the lamp, and as its appearance is contemporaneous with the blue effect, the latter is a warning of the approach of the critical point, and a sure indication that the electromotive force is dangerously high. It is also clear that as the Edison effect is only evident when we are "among the breakers," it is not available for practically regulating the conditions of electric light currents as its ingenious discoverer originally proposed.

ON ELECTRIC DISCHARGE BETWEEN ELECTRODES AT DIFFERENT TEMPERATURES IN AIR AND IN HIGH VACUA. By J. A. Fleming, in Proceedings of the Royal Society of London, Vol. XLVII. December 16, 1889. London, MDCCCXC.

IT has been known for some time that if a platinum plate or wire is sealed through the glass bulb of an ordinary carbon filament incandescent lamp, this metallic plate being quite out of contact with the carbon conductor, a sensitive galvanometer connected between this insulated metal plate enclosed in the vacuum and the external *positive* electrode of the lamp indicates a current of some milliamperes passing through it when the lamp is set in action, but the same instrument when connected between the *negative* electrode of the lamp and the insulated metal plate indicates no sensible current. This phenomenon in carbon incandescence lamps was first observed by Mr. Edison, in 1884, and further examined by Mr. W. H. Preece, in 1885. The primary object of the experiments described in this paper was the further examination of this effect, but the inquiry has extended itself beyond this range and embraced some general phenomena of electric discharge between electrodes at unequal temperatures, and in particular has revealed some curious effects in the behaviour of an electric arc taken between carbon poles towards a third insulated carbon of metal poles.

The first series of experiments had reference to the nature of the effect observed in the incandescence lamps having an insulated wire or plate placed in the vacuum.

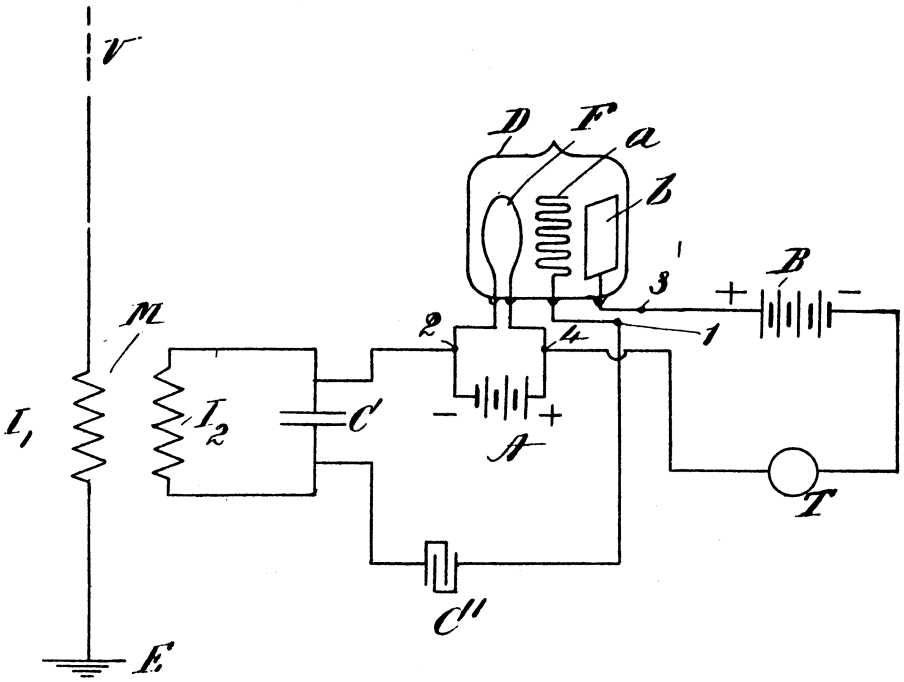
If a platinum wire is sealed through the glass bulb of an ordinary carbon filament lamp and carries at its extremity a metal plate, so placed as to stand up between the legs of the carbon horseshoe without touching either of them, then when the lamp is actuated by a continuous current it is found that. . . .

(6.) When the lamp is actuated by an *alternating* current a *continuous* current is found flowing through a galvanometer, connected between the insulated plate and *either* terminal of the lamp. The direction of the current through the galvanometer is such as to show that negative electricity is flowing from the plate through the galvanometer to the lamp terminal. This is also the case in (4.); but, if the lamp has a bad vacuum, then negative electricity flows *from* the plate through the galvanometer *to* the positive terminal of the lamp, and negative electricity flows *to* the plate through the galvanometer from the negative terminal of the lamp. . . .

Seeking an Hypothesis

In seeking for an hypothesis to connect together these observed facts, the one which suggests itself as most in accordance with the facts is as follows:

In the case of a carbon incandescence lamp when at vivid incandescence, carbon particles are being projected from all parts of the filament, but chiefly from the negative half of the loop. These carbon molecules carry *negative* charges of electricity, and when they impinge upon a metal plate placed in the vacuum they can dis-



DE FOREST'S PATENT DRAWING

Showing the grid which he added to the electron tube, increasing its sensitivity so that it can be used in telephone circuits.

The Courage to Predict

properties of unknown elements from the general Periodic Law was characteristic of

MENDELEEFF

(or Mendeleyev)

whose specifications for elements and their compounds then undiscovered forms the next

CLASSIC OF SCIENCE

charge themselves if this plate is positively electrified, either by being in metallic connexion with the positive electrode of the lamp or with a separate positively charged body. When the plate is simply insulated the stream of negatively charged carbon molecules brings down this insulated plate to the potential of the base of the negative leg, or to the potential of that part of the carbon conductor from which it is receiving projected molecules. These carbon molecules projected from an incandescent conductor can carry negative charges, but either cannot be positively charged, or else lose a positive charge almost instantly when projected off from the conductor. . . .

SPACE TELEGRAPHY, Lee de Forest, U. S. Patent No. 879,532, Patented Feb. 18, 1908.

DREPRESENTS an evacuated vessel, preferably of glass, having sealed therein three conducting members, F, *a* and *b*, in the figure. The conducting member or electrode F is shown as consisting of a filament, preferably of metal, which is connected in series with the battery A or other source of electrical current of sufficient strength to heat said filament, preferably to incandescence. The conducting member *b*, which may be a plate of platinum, has one end brought out to the terminal 3. Interposed between the members F and *b* is a grid-shaped member *a*, which may be formed of platinum wire, and which has one end brought out to the terminal 1. The local receiving circuit, which includes the battery B, or other suitable source of electromotive force, and the signal indicating device T, which may be a telephone receiver, has its terminals connected to the plate *b* and filament F at the points 3 and 4 respectively. The means for conveying the oscillations to be detected to the oscillation-detector, are the conductors which connect the filament F and grid *a* to the tuned receiving circuit and, as shown, said conductors pass from the terminals 2 and 1 to the armatures of the condenser C.

I have determined experimentally that the presence of the conducting member *a*, which as before stated may be grid-shaped, increases the sensitiveness of the oscillation detector and, inasmuch as the explanation of this phenomenon is exceedingly complex and at best would be merely tentative, I do not deem it necessary herein to enter into a detailed statement of what I believe to be the probable explanation.

Science News Letter, October 24, 1931

MEDICINE

Digestive Ferments Used in Treating Abdominal Adhesions

SUCCESSFUL experiments in the use of digestive ferments to treat troublesome adhesions which may form after abdominal operations were reported to the American College of Surgeons by Dr. Alton Ochsner and Dr. Earl Garside of Tulane University of Louisiana School of Medicine, New Orleans.

Drs. Ochsner and Garside studied 280 animals and found that in every animal adhesions reformed after operation to divide the pre-existing ones. They then tried introducing various solutions into the abdominal cavity after operating on the adhesions. With a solution of the digestive ferment, papain, few or no adhesions reformed in over nine-tenths of the cases. Papain is obtained from the juice of the fruit of the papaya. Another ferment, trypsin, prevented the reformation of adhesions in nearly half the cases. The theory is that after the adhesions have been divided, the ferments act to assist in removing the excessive amounts of fibrinous adhesions before the organization of the fibrous tissue into new adhesions has occurred.

Science News Letter, October 24, 1931

Geological Moving Days

From Page 263

Alps, there was no glaciation in Asia. All of Manchuria, Mongolia, eastern Siberia, were ice-free. That does not mean that they were not cold. They probably had very severe winters, but in summer the ground thawed out and raised its usual crop of plants, and herds of animals grazed and browsed and wandered where they would.

Interior Alaska was also unglaciated, and probably there was a land bridge to Asia, so that during that time there was free migration of such creatures as the great hairy mammoth and the musk-ox between the two continents. Only they could not get southward, for advance along the west coast of North America was blocked by the Cordilleran glacier front coming down to the sea.

The southward migration of the animals did not take place as a single, gradual, coordinated movement, in Prof. Matthew's opinion. Instead there were a number of separate dispersals, or waves of migration; perhaps one to each slow convulsion of the earth.

Man No Exception

The most advanced of animals, Prof. Matthew pointed out, came down out of the cold lands latest and are still found predominantly in north temperate and subtropical regions: dogs and wolves, bears and raccoons, weasels and otters, deer and horses, and cats of all degrees.

Man himself is no exception. Australia, which gives asylum to the largest remnant of the primitive first dispersal wave of animals, also has the most primitive of living human races. Other dark races, less primitive but still unadvanced, occupy the forest lands of the southern continental projections—sharing them, by the way, with man's lesser cousins, the apes and monkeys. In the North, nearest the roots of the old glaciers, the most intelligent and progressive races have built their civilizations in Europe and Asia, and have transplanted their culture to that other glacier-scoured continent, North America.

Science News Letter, October 24, 1931

The windiest spot on earth so far found by explorers is on the coast of Antarctica, at Commonwealth Bay.

In the eleven far western states, motor vehicles average about 500 miles a year of travel more than cars in the other states.