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On death by the electric current.

Edwin J. Houston

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On Death by the Electric Current.

Several cases of death have resulted from incautious or accidental touching or handling of the wires employed in carrying the currents used in electric lighting. It becomes, therefore, a matter of great importance to inquire into some of the peculiarities of such accidents.

There are, as is well known, two distinct characters of current employed for the purpose of electric illumination; viz., the direct current and the alternating current. The direct current, as employed in electric lighting, is fairly steady and uniform. Its electro-motive force, as a rule, is not subject to marked changes in value, and the direction of its flow is always the same. The alternating current, on the contrary, changes both the value of its electro-motive force and its direction, taking its name from the fact that it flows alternately in opposite directions. The changes in the electro-motive force are considerable in amount; they are not, however, as is very generally believed, necessarily sudden, since in most cases the electro-motive force changes gradually from a maximum to a minimum in both directions.

Death has resulted from the incautious handling or accidental contact both with the direct and with the alternating current.

In the case of the direct current, death results sometimes from shock, but generally, it would appear, from an electrolytic effect on the blood or other tissues of the body. The gaseous products arising from the decomposition possibly may, in some cases, be carried by the blood to the heart and thus stop its action, or, as probably occurs in most cases, death may result from electrolytic changes produced in the blood itself, or in other tissues.

Death by the alternating current probably results from shock only. Resuscitation in cases of apparent death are more frequent with the alternating current than with the direct, most probably from the absence of actual electrolytic decomposition of the tissues.

Considerable surprise has often been manifested because certain currents, that, in some instances, have been handled with impunity, in other cases have caused death. A current of a certain number of ampères, and of a certain difference of potential between the points touched, caused death in one case, while in another case with the same current strength in the line, two or three times the difference of potential between the points touched, was received with impunity.

Making due allowance for differences in vitality, or in the condition of the heart-power of the subject, I think the following explanation will throw light on many of these cases. I offer it, however, mainly, though not entirely, from a theoretical standpoint.

The explanation would appear to be found in the portions of the body at which the current enters and passes out, which would of course necessarily be influenced by the position of the person receiving the discharge.

Nearly all fatal or severe shocks occur from the lines being accidentally grounded at some point. The person then either deliberately touches, or is accidentally brought into contact with the line at some other point. Under these conditions, the electricity either passes into or out of the body at the feet. The greater or less probability of serious results will depend on the parts of the body through which the current passes. When any part of the body is placed in the path of an electric discharge, more of the discharge will pass through the better conductors, which perhaps will, generally, be the great nerve trunks and the muscles. Reference must, therefore, be had to the position of such nerve centres, as well as to the heart, the lungs and the viscera and other vital organs. The following contacts are among the commonest.

(1) At the head. This contact is apt to be among the most dangerous, as the discharge in all probability takes place through some of the vital organs, such as the brain, the upper part of the spinal cord, or through some of the organs in the abdominal cavity, or their principal nerves.

(2) At the shoulders. This is probably somewhat less dangerous than the preceding, as the brain is not in the path of the direct discharge. The vicinity of the upper part of the spinal cord is, however, very dangerous.

(3) At one of the hands. If the person is standing on both feet, this may be fatal, since the organs of the abdominal cavity and its nerve centres are in the path of the discharge. If the person is standing on one foot, then if this foot be on the same side of the body as the hand that is touched, the discharge will probably not be fatal, since the discharge does not necessarily pass through the organs of the abdominal cavity. If, however, the foot on which the person is standing be on the other side of the body from the hand that touches the wire, that is if the person be standing on the right foot and touches the wire with his left hand, the discharge, if powerful, is apt to be fatal, since the organs of the abdominal cavity and its nerves are necessarily in the path of the discharge.

(4) On the back, especially in the upper portion. This is apt to be fatal, since the spinal cord is dangerously near the path of the discharge. The muscles of the back are also very large and would thus determine the passage of much of the current in this direction.

(5) Discharges ensuing on touching the wires with each hand are apt to be fatal, since the heart lies in the path of the current.

Those exposed to electric discharges would be protected from the effects of accidental grounding of the conductors, by wearing plates or discs of any high insulating material on the soles of the shoes, or inside the same.

Death by lightning probably results from the effects of shock, combined with those of electrolysis. In discharges of such enormous difference of potential as exist in lightning, disruptive effects may also be produced.

The almost instantaneous and consequently painless nature of death by the electric shock has, as is well known, led to the suggestion that it be employed in public executions in place of hanging or decapitation. Should such suggestion be adopted, the character of the apparatus employed should be such as to cause death by shock, followed, to avoid the possibility of resuscitation, in case of apparent death, by the passage of an electrolyzing current.

On the Paillard Palladium Alloys in Watches.

I have concluded my experiments on the Paillard watches. The following results were reached; viz.,

I am satisfied that a watch whose balance-wheel, hair spring, and escapement are made of the Paillard palladium alloys can not have its rate sensibly affected by the influence of any magnetic field into which it is possible to bring it while on the person of its wearer.

In order to test this, such watches were carried into exceedingly powerful magnetic fields, and although carefully rated, both before and after exposure, no sensible change in their rate could be detected.

Experiments showed that the palladium alloys are entirely destitute of any paramagnetic properties. As far as the amount of the alloys at my disposal permitted, experiments failed to show that they possessed any diamagnetic properties.

A number of these alloys are made by Mr. Paillard. The composition of four described by him in his U. S. patents, and numbered for convenience Nos. 1, 2, 3, 4, is as follows, viz:

Palladium Alloy No. 1.

Palladium	60 to 75	parts.
Copper	15 to 25	"
Iron	1 to 5	"

Palladium Alloy No. 2.

Palladium	50 to 75	parts.
Copper	20 to 30	"
Iron	5 to 20	"

Palladium Alloy No. 3.

Palladium	65 to 75	parts.
Copper	15 to 25	"
Nickel	1 to 5	"
Gold	1 to $2\frac{1}{2}$	"
Platinum	$\frac{1}{2}$ to 2	"
Silver	3 to 10	"
Steel	1 to 5	"

Palladium Alloy No. 4.

Palladium	45 to 50	parts.
Silver	20 to 25	"
Copper	15 to 25	"
Gold	2 to 5	"
Platinum	2 to 5	"
Nickel	2 to 5	"
Steel	2 to 5	"

The complete masking of the paramagnetic properties of some of the ingredients of these alloys is of considerable interest, and would seem to indicate a true chemical union of their constituents. The most interesting results of my experiments, however, were those in which it was established that no matter of what materials the balance wheel or hair spring may be made, provided they are conductors of electricity, their movements through a magnetic field, when the moving masses properly cut the lines of force, must result in a change in their rate of movement, and consequently in a change in the rate of the watch ; or, briefly, it was established that *a watch placed in a magnetic field acts like a dynamo-electric machine.*

The amount of this action is exceedingly small. In order to detect it, a very powerful magnetic field must be employed, and the watch subjected to its influence for an hour or more.

In order to obtain this field, and to properly concentrate it on the rim of the balance wheel (thus placing said rim in a position analogous to the copper disc in the well-known experiment between the poles of an electro-magnet), I mounted massive conical pole pieces, of soft iron, inside the pole pieces of the armature field of an Excelsior arc-light machine, whose armature had been removed. The space left between the opposing ends of these pole pieces was just sufficient to permit the introduction of the watch.

The watch was then securely fixed in place, with its face upwards, so that the lines of magnetic force, concentrated on that part of the edge of the balance wheel nearest the edge of the watch, passed through it at right angles to the plane of its movements. After an exposure of one hour to the influence of this extraordinary field, *the watch was found to have gained fifteen seconds.*

I believe that the cause of the gain is to be ascribed to a decrease in the arc of oscillation of the balance wheel, which would thus result in an increase in the rapidity of its movements.

The fact that the watch, after its removal from this powerful field, did not manifest any sensible change in its rate, shows the extent of the protection the palladium alloys give it against the effects of external magnetism.