

on which cows will graze. Should abortion take place on the pasture it should be similarly dealt with, the cow being brought into the house and kept isolated. All cows which have aborted should have the vagina syringed out daily with some disinfectant solution as 1 per thousand mercuric chloride or 2 per cent. of carbolic acid. It is also advocated that the womb itself, the source of the germs, should be washed out three times a week for three weeks after aborting, but this should not be undertaken except under direction of a veterinary surgeon, as alarming straining sometimes follows the injection, though no serious results have come to our knowledge.

It must not be forgotten that attendants may convey the contagium, and that isolation implies the attendance of some one who does not come in contact with non-aborting animals.

Bulls known to have served cows which have aborted should not be used for others. Their parts should be syringed and sponged with some non-irritating disinfectant daily, or at least after each service, and it will not be safe to use the animal for service of healthy cows for some weeks.

The next consideration is, what to do with cows which have aborted. They usually come into œstrus a few days after aborting, and, if then served, almost invariably abort again. Service should not be attempted for at least three months, during which time disinfection should be carried out. Once having aborted, there is usually a tendency to do so again if service occurs soon after, but this tendency diminishes as time goes on, and a certain degree of immunity follows or the germs become less virulent. The method of dealing with such cows will largely depend on the numbers to be dealt with. If only a small number, fattening for the butcher, while being strictly separated from the healthy, is probably the most radical and economical measure.

New purchases should be most carefully kept from chances of contamination, for though there appears a natural tendency for the disease to die out after from two to five years, the introduction of fresh animals appears in some way to maintain its existence.

The adoption of the foregoing measures in their entirety involves an immense amount of trouble and annoyance. In some instances it may not be possible; while success will largely depend on the thoroughness with which they are carried out, it is advisable to apply treatment on the same lines as far as circumstances may permit.

ACCIDENTS CAUSED BY "SURFACE-CONTACT" ELECTRICAL TRAMWAYS.¹

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THE first "surface-contact" electrical tramways laid down in Paris and its environs passed through streets in which electrical energy was distributed by two systems, known by the names of their inventors: the system Diatto and the system Claret-Vuillemier. The latter has not become popular. At the present time almost all the surface-contact lines are equipped with the Diatto system.

¹ Translated from the "Recueil de Méd. Vét.," 15th May 1902.

Considered from the points of view of installation and action, these two systems, despite an apparent analogy, are in reality very different. In both an underground cable extending throughout the system conveys the electric current from the generating station; this cable communicates with metallic plates (surface-contacts, *Transl.*) in the roadway from which the energy is transmitted to the moving vehicle at the moment when the latter passes over the contact, and the surface-contacts are placed at such distances as to allow the current to be continuously supplied to the motors of the vehicle. At this point the resemblance between the two ceases. In the Claret-Vuillemier system automatic distributors are introduced between the cables and the surface-contacts, and each of these automatic distributors is connected to a series of thirty or forty surface-contacts, to each of which in succession it sends a current at the moment when the vehicle is passing over it. In the Diatto system each surface-contact receives the current from the supply cable directly, and is provided with an automatic accumulator apparatus which conducts the current to the metallic cover, whence it passes to the motor apparatus of the vehicle, and which again interrupts the current immediately after the passage of the car.

At the present moment three tramway companies are working the Diatto system on a portion of their lines in Paris, viz. the East-Paris, the West-Paris, and the Vanves-Paris Co. and its extensions. The electrical energy is furnished to the tramways of the latter company by a special generating station. Those of the East-Paris and West-Paris Cos. receive theirs from stations at Vitry and Issy-les-Moulineaux, where triphase high-tension current at 3000 volts is generated, being transformed down in sub-stations to a continuous current at 500 volts for actual use on the line. Throughout the entire extent of these companies' lines the mean daily pressure is 500 volts. In the sections where the cable is underground, the current being distributed to surface-contacts as above indicated, the tension of the current at the surface-contact cannot in any case be higher than 500 volts.

In the Diatto, as in the Claret-Vuillemier system, the mechanism, though appearing relatively simple, is in reality complicated, and is subject to disturbance by many causes. To insure the systems acting well, and to prevent such accidents as might result from a tension of 500 volts, it is essential that the communication established between the live cable and the surface-contact at the moment when the vehicle is passing should be interrupted immediately thereafter.

Every precaution appeared to have been taken to ensure these conditions being realised, and the Diatto system was regarded as uniting all the essentials for successful working. This has been the case, it would appear, in some towns, but in Paris the experience has been less favourable. Scarcely had the vehicles begun to run when a perfect chapter of accidents, involving men and horses, was recorded. In six months nearly 100 occurred; during a single month more than fifty were reported. As regards horses, the greater number of cases resulted only in severe shaking, without serious consequences, though a number of animals were killed on the spot.

The circumstances under which these fatalities to horses occurred necessarily aroused public opinion. The Municipal Council of Paris,

the Prefect of Police, and the Minister of Public Works took up the question. Being consulted by the Ministry, the Governmental Railway Committee enquired into and determined the cause of the accidents. Without doubt these accidents were almost always due to the surface-contacts being permanently electrified, but the Committee indentified five different causes, viz. :—

- (1). Mechanical imperfections in the surface-contacts.
- (2). Insufficient insulation of the surface-contacts.
- (3). Injurious action of the rubbing-contacts at the back of the cars.
- (4). The deposition of soot on the interior of the surface-contacts, and lastly,
- (5). Defective insulation of the cables.

The orders given to the companies by the Prefect of Police regarding changes required in the lines equipped on the Diatto system have been carried out, but, although they have become rarer, accidents have not altogether ceased.

The effects which the current produces on a horse, when one of the animal's feet touches a charged surface-contact, depend principally on the energy of the current, on the dryness or moisture of the roadway, on the more or less intimate apposition between the horse's feet and the surface-contact, and on the length of time during which the two remain touching. When the shock results in the animal falling the effects may vary greatly, depending on whether the animal falls on the surface-contact itself or at some distance from it.

In the great majority of cases the electric shock produced in horses as above described is not of special gravity. Even when the animal falls it seldom shows any serious disturbance afterwards. But sometimes the shock causes instantaneous death or nervous disorders, particularly signs of cerebral depression. In certain cases more or less extensive paresis or paralysis follows. I here recapitulate three cases of the kind reported to me by veterinary surgeons. A horse, previously in perfect health, showed after receiving a shock loss of appetite, depression, and chronic affection of the brain. In another, the shock produced dulness and depression, lasting for more than a month. In still another, symptoms of weakness, loss of appetite, and torpidity continued for a week after the accident. These symptoms disappeared, but were followed by hemiparesis of the left side.

The shock is particularly violent if the ground is moist, if salt has been thrown on the road to melt snow, or if at the moment when one of the feet touches the live surface-contact (in communication with the positive pole of the dynamo) another foot touches one of the rails in communication with the negative pole.

In consequence of the high conductivity of the animal's shoes and of the nails, which penetrate far into the horn, as well as of the rail on which one of these shoes rests, the effects of the shock so produced may be fatal. Nevertheless, experiments, to which I shall return, have proved that the horse is not by any means so sensitive to the action of electric shocks as a number of authors have suggested. These experiments show that the shock produced by a current of 500 volts does not always cause the animal to fall, and does not usually produce any grave disturbance provided it lasts no more than

a few moments, particularly if the feet are not moistened, and if by a sudden forward or sideward movement the animal at once breaks the current. The injurious effects are more serious in proportion to the time during which the current continues to pass through the animal's body. If, therefore, the horse falls on the charged surface-contact and remains touching it, the cardiac and nervous disturbance due to shock usually prove fatal. Horses at liberty or merely led in hand rarely receive fatal shocks, because they can, with a single bound, break contact between themselves and the line. On the other hand, animals in heavy draft—horses pulling heavily-loaded buses or trams uphill, for instance—can only move at a slow pace, and therefore plant the feet more slowly and have less liberty of movement. They are the most seriously affected by shocks. Shaft horses, being confined between two shafts and unable to move sideways, often fall dead on the surface-contact itself.

The following, from a report by M. Rossignol, summarises the experiments made at the Electric Generating Station of Saint-Mandé, by a Commission of the Society of Practical Veterinary Medicine.

On the 5th March 1901 this Commission experimented on two horses. In one of the courts of the generating station M. Barry had had constructed an arrangement representing the charged contact plates of the Diatto system. By placing the first horse with one front or one hind foot resting flat on a surface-contact, it was found that a continuous current of 550 to 700 volts only produced more or less violent shock. The animal reared up or its legs collapsed, but as soon as the foot was withdrawn from the plate the symptoms ceased. The second horse showed very similar results.

Each pair of contacts having been covered with a plate of sheet-iron to enlarge their surface, a new trial was made with the first horse, the front feet resting on one of the plates, the hind on the other. A continuous current of 550 volts immediately caused the animal to fall on its side, but it was able to rise again, and after making several plunges rapidly recovered. It was then wetted all over, water being applied to the limbs, belly, and quarters, and having again been placed on the sheets of iron, was submitted to the action of a continuous current of 550 volts. This time the shock was fatal; the horse fell, its limbs extended, its muscles contracted, and with the abdomen, sternum, and lower part of the head in contact with the ground. Then it turned over on the right side and died at the end of a few minutes. The body showed traces of burning at the points which had been in contact with the sheet iron.

The second horse having been placed as above indicated, and subjected to a continuous current of 550 volts, experienced a violent shock and fell down. Nevertheless it was able to rise again, and a fresh application of the current was required to kill it.

On the 23rd March further experiments were made with two horses, the arrangements being slightly different from those in the first series. The first horse was placed so that each of its front feet rested on one of the sheets of iron. A current of 100 volts produced a slight shock and sudden flexion of the knees. Currents of 200 to 400 volts caused the animal to fall on its knees, and produced marked acceleration of the heart's action and of the respiration. At 400 volts

the animal fell on its knees and then on the left side, but rose again in a few moments. A current of 550 volts produced a strong shock and the animal fell, but was able to rise again in a few seconds. When the limbs and belly were moistened the shock was more violent, but not fatal. The hind feet were then placed on the plates of sheet iron, and the animal received a current of 550 volts. It fell on its left side, the croup on the positive plate, the chest on the negative. It made violent and repeated struggles, showed generalised convulsions and grave disturbance of respiration and circulation. It succeeded in altering its position, struggled, and attempted to rise, but the hind limbs were paralysed. The croup having been brought in contact with the positive plate, death rapidly followed.

The second horse, placed in the same position as the first, with one front foot on each of the surface-contacts, received a current of 550 volts. The shock was violent, but the animal did not fall. A second attempt caused the horse to fall on its knees and then on its side; the body muscles were contracted, the breathing and circulation very rapid. Its fall having broken the circuit, the horse was able to rise again. It showed a few superficial burns at the points of contact with the plates. The experiments were then stopped. This horse was kept and placed under observation for several weeks. It showed neither paralysis, lameness, nor any after disturbance.

The principal results of these experiments may be summarised as follows:—

(1). A current of 100 volts produces slight shock and sudden flexion of the knees.

(2). Currents of 200 to 400 volts may cause the animal to fall.

(3). A sudden shock by a current of 550, 600, or even 700 volts, provided it be of very short duration, does not usually cause death or even grave and permanent consequences.

(4). To produce a fatal shock with a current of 500 to 550 volts the action must be prolonged; death does not usually follow until the end of several minutes.

The last number of the *Bulletin* of the Society of Veterinary Science of Lyons contains a report by M. Arloing of similar experiments made there during the month of July 1901, on a section of the electrical line completed for that purpose by M. Roedt, engineer of the Diatto Co. This portion of line consists of a single surface-contact between two rails, the parts being placed at the normal distances. The surface-contact was so arranged as to be constantly charged when the circuit was closed. By means of a voltmeter it was first shown that the current passed freely not only from the surface-contact to the rails but to the different parts of the pavement between the rails and to a certain distance beyond this, especially when the ground was wet. In order that the horse's body may be traversed by the current, it is therefore sufficient that one of its feet should come in contact with the charged surface-contact. Its three other limbs then form negative poles by which the current escapes.

The first animal was a horse weighing 770 lbs., and shod on all four feet. This animal was led on to the line, the pavement being dry. The left front foot was placed on the surface-contact, the right hind on a rail, the two others on the ground; the circuit was then suddenly closed, the tension of the current being 500 volts. The

horse made a slight jump with all four limbs, and fell beyond the contact plate. It was in a state of great excitement. It at once rose, snorted, passed fæces, and took a number of deep breaths, the nostrils being widely dilated. These symptoms completely disappeared in five minutes.

The animal, having been brought back to the road and placed as before, received a shock of 500 volts. It fell to the left; it was placed on and kept lying across the line, the left side of the chest being on the surface-contact plate, the hind limbs resting on the left rail, the front limbs and the head on the right rail. The principal symptoms noted were convulsions, sometimes tonic, sometimes clonic, of the different groups of muscles, a smell of burnt hair, emanating from the portion of the body in contact with the surface-contact, retraction of the eyes into the orbits, dilation of the nostrils; finally, muscular relaxation, opening of the mouth, and evacuation of urine. Death followed at the end of three and a half minutes, during which the tension of the current varied between 400 and 500 volts.

For the second experiment the ground was covered with planks, above which the rails and surface-contact plate projected slightly, the conditions being similar to those in roads paved with wood blocks. During the four experiments the current varied between 500 and 525 volts.

The horse weighed about 740 lbs. Its temperature was 37.4°C . It was placed obliquely across the line, the left front foot on the contact plate, the left hind on the corresponding rail, the others on the wooden plank between the rails. Under the action of the current the animal made a leap and fell on the right side. On rising it was excited, but the symptoms rapidly disappeared.

In two succeeding experiments, with currents of 500 and 525 volts (the animal being placed as on the previous occasion) the shock was less violent and the horse did not fall; it seemed, in fact, as though it had to some extent become accustomed to the electrical discharge.

The planks having been removed and the ground moistened with water in order to increase its conductivity, a fourth attempt was made, and it was agreed that if the horse fell it should be kept over the surface-contact. It was placed between the rails, the left front foot on the surface-contact, the others on the ground, and the circuit of 500 volts was suddenly closed. The animal flexed its legs, fell on the left side, and was drawn by assistants into contact with the charged plate. It immediately showed symptoms like those of the first subject: tonic convulsions of the muscles of the limbs, trunk, and neck, retraction of the eyes into the orbits, dilatation of the nostrils, and very pronounced contraction of the facial muscles. In sixty to eighty seconds the tonic convulsions were replaced by clonic convulsions; a smell of burnt hair was noticeable, the head and trunk became covered with sweat, and death occurred in a little less than two minutes. The rectal temperature was then 38.2°C .

The other experiment consisted in exposing a mule to the action of a current of 500 volts, and keeping it alive in order to study the delayed effects of the electric shock. The animal was placed between the rails, the left front foot on the contact plate, the others resting on the wet soil. Under the action of the shock produced by the closure of the circuit, the animal flexed its limbs and fell across the rails, the

right side of the chest resting on the surface-contact. It was kept there for twenty seconds, during which time it showed great excitement and perspired freely. The current was then cut off. The mule remained lying on the ground for five minutes ; then with a little assistance it rose. The respiration and circulation, though still rather rapid, gradually returned to normal. Although towards the end of the experiment a slight odour of singed hair had been noted, no trace of burning could be seen.

The mule walked the four kilometres between the place where the experiments were made and the Veterinary College without showing anything unusual. It was kept under observation for four days. At first it had little appetite, but it soon returned to its normal condition and showed no disturbance of the principal functions.

The chief conclusions deduced from these experiments were as follows :—

Currents of high voltage only seem to produce death when passed through the animal's body for a period of sixty to eighty seconds. It is necessary that during this time some part of the animal's body should remain in contact with the electrified plate.

A horse killed by the current seems always to show a skin-burn extending to a greater or less depth into the subjacent tissues.

Horses recover easily and rapidly from the effects of a current of 500 volts continued for twenty seconds.

The dangers inherent to the presence of a charged surface-contact plate are reduced to a minimum when the street is paved with wood and is dry.

In Paris horses have often received fatal shocks from tram lines using a current of 500 volts simply by stepping on a charged contact plate, without having fallen on the plate and without showing any trace of burning on *post-mortem* examination. Those of our confrères who have been consulted in connection with fatalities of this kind explain them by the wet condition of the road and by the general state of health of the subjects ; that is to say, by the fatigue, great excitement, over-exertion, etc., of the animals at the moment when they have been subjected to the action of the current.

Experiments recently made on the action of electric currents on small animals have thrown light on the mode by which death is brought about. Whatever the form of death, such currents kill either by direct action, at the same time producing electrolytic effects, or by reflex action, in consequence of inhibitory impulses resulting from irritation of nervous centres. When death is about to occur the animal shows violent and generalised convulsions ; respiration and circulation, usually accelerated at first, are soon suspended ; the mucous membranes become pale, the pupils dilate, urine may be passed ; one or more deep inspirations are made, and death follows. Arrest of respiration is not usually the immediate cause. Currents of medium intensity (500 to 600 volts) seldom produce such severe effects on the respiratory centre as finally to stop respiration. They act specially on the heart, the ventricular walls of which show fibrillar trembling and cease to contract ; the heart-chambers become dilated with blood, and death follows from cardiac paralysis.

When death follows immediately on the shock it is due to simultaneous paralysis of the heart and respiratory centre. Paralysis of

the heart, however, like that of respiration, is not necessarily final. The heart may resume its rhythmic contractions and the animal recover; but more or less severe disturbance of the central nervous system is produced, which accounts for the subsequent symptoms noted in animals affected by shock.

The *post-mortem* examination of the three horses killed at Saint-Mandé was very carefully carried out at Alfort by M. Basset some hours after death. It showed that fatal electric shocks do not produce characteristic lesions:—the blood is black, viscous, and becomes red on exposure to air; there is slight congestion of the intestinal mucous membrane and of certain of the viscera; ecchymoses exist under the pleura, pericardium, and endocardium. Nothing of special significance is found in the nervous centres. More or less deep burns may be noted in different regions.

One can always detect more or less pronounced congestive and hemorrhagic changes, depending on the case. Although little marked in the animals destroyed at Saint-Mandé, these changes were more distinct in animals killed on the working electric tramways, but it should be noted that in the latter the *post-mortem* examination was made late, a fact which might account for errors in interpreting the appearances seen.

MM. Blanchard and Mouquet in making the *post-mortem* examination of a horse which the evening before had fallen on a surface-contact, and had died in five or six minutes, found the skin burnt at the point which had touched the surface-contact; the blood was black, fluid, and did not redden on exposure to the air; the intestine was greatly congested and marked with large branching hæmorrhages, and its mucous membrane was more or less reddened. The mucous membrane of the stomach was marked with large and numerous hæmorrhagic spots, the myocardium was dotted through with infarcts, and the endocardium was of so deep a red that it appeared almost black.

MM. Arloing and Peuch describe the following lesions as having been noted at the *post-mortem* examination of a horse killed the previous evening whilst crossing an electric tramway equipped on the Claret-Vuillemier system. The *post-mortem* examination was made eighteen hours after death. There were numerous extravasations of blood in the connective tissue around the left front and hind limbs, extravasations which were repeated in the subcutaneous connective tissue of the neck and head, in the connective tissue separating the layers of muscle in these regions, and in the left front and hind limbs. In all these parts the connective tissue was of a rosy tint which contrasted with the white colour of the similar tissue in the right hind leg.

The subcutaneous and deep veins of the above-mentioned regions were very strongly injected. The veins of the stomach and intestines were injected and the spleen congested. The respiratory apparatus was very markedly congested throughout its entire extent. The mucous membrane was of a deep red, in places almost violet, and showed numerous submucous hæmorrhages. The lungs were of a violet colour, marked with numerous reddish-brown patches, the majority isolated and of very small extent, some, however, confluent, forming patches of $\frac{3}{4}$ to $1\frac{1}{4}$ in. in diameter. These patches had

resulted from sub-pleural and intrapulmonary hæmorrhage. The heart showed nothing abnormal. In the nervous centres there was no hæmorrhage; only a little injection of the vessels of the brain.

The *post-mortem* examination of the two horses killed in the Lyons experiments revealed the following lesions:—In the first horse, examined ten minutes after death, the skin of the left hypochondriac region was burned; the subcutaneous connective tissue below it was injected and showed hæmorrhagic points. The pleura was yellowish and very hot to the touch; the lung burning hot and dry on the surface; section of the sucutaneous veins led to the escape of reddish laky blood, which coagulated slowly or not at all; there was congestion of both lungs, with hæmorrhagic subpleural effusions, the largest the size of a sixpence; the right cavities of the heart were distended with blood; the right ventricle was soft and flabby, the left ventricle hard and resistant to the touch. No change in the endocardium. In the abdomen the intestinal branches of the portal vein were distended; certain points in the walls of the small intestine and a part of the double colon were congested. There were traces of burning on the anterior surface of the left lobe of the liver, the tissue being yellowish and showing hæmorrhagic spots. The anterior part of the left kidney showed similar changes. The surface of the brain and the floor of the fourth ventricle were slightly congested.

The second horse, examined seven and a half hours after death, which occurred on a very warm day, showed a degree of putrefaction such as would have been expected. There were slight traces of burning of the skin and of the more superficial of the subjacent tissues; congestion of both lungs, especially of the right; subpleural ecchymoses, most marked opposite the anterior lobes; slight congestion of the mucous membrane of the trachea and larynx; subperitoneal hæmorrhagic effusions along the colic and cæcal veins and on the floating colon; the small intestine was of a bluish-red colour, and showed numerous branching hæmorrhages. There was slight congestion of the floor of the fourth ventricle.

M. Arloing concludes that the above *post-mortem* examinations have not revealed any lesions characteristic of death by electric shock, but that the congestive changes found here and there in the intestine, lung, and connective tissue, and the colour of the blood, assume special importance when found in a horse which has died whilst passing over an electric tramway line, particularly if they are accompanied by traces of burning.

Viewed collectively, the lesions shown are those of asphyxia; and if, apart from the burning, there is nothing of an absolutely unequivocal character to point to, yet the *post-mortem* appearances acquire a special significance when the horse has died within a few minutes of its fall. To state the case otherwise, when death follows suddenly, apart from the action of the electric current, one expects to find the lesions which have determined it—injury of the brain, rupture of the heart or of one of the large thoracic or abdominal vessels.

To sum up, horses which have received an electric shock seldom show other injuries than those produced by the fall; but continued contact with charged surfaces may produce grave and more or less permanent lesions of varying characters. Those most commonly

seen hitherto have been burns due to the horse lying on the charged surface-contact on which it originally fell. As stated above, when the horse is moving rapidly or is comparatively free at the moment of touching the charged surface-contact, it seldom suffers more than a somewhat intense shock. On the other hand, slowly moving horses and these confined in the shafts of heavy vehicles often fall, and may thus bring some portion of the body over the charged surface-contact. It has been shown above that such a fall on a charged surface-contact is generally fatal. It is not invariably so, however, provided the horse is removed in time, but in such case the region which has touched the contact-plate is the seat of a burn proportionate in size and depth to the time during which the skin and plate have been in contact. If the horse whilst down struggles violently, parts of its body may successively come in touch with the charged surface-contact, in which case they show burns of varying severity. Several horses burned in this way showed lesions of so grave a character as to necessitate slaughter.

After falls following on violent electric shocks, nervous disorders like coma, stupor, and nervous twitchings indicating profound cerebral disturbance, have been noted, but these disappeared in time. In others, lameness, localised paralysis, paralysis of both hind limbs or of the hind and front limbs of one side, have been noted. These nervous symptoms are without doubt due, in some cases at least, to hæmorrhages in the nervous centres resulting from the action of the electric current.

The only constant lesions found on *post-mortem* examination of horses killed by electricity—the lesions truly produced by the current—resemble those of asphyxia, being of a congestive and hæmorrhagic character, but usually somewhat discrete and localised in the intestine, pleura, and lung, or, in a less degree, in the serous membrane of the heart and in the nervous centres. The gross changes described after certain *post-mortem* examinations were the result of physiological congestion of certain organs at the moment when the horse received the shock, or were the result of *post-mortem* decomposition.

It is quite true, as has been remarked, that on the surface-contact electric tramlines horses are particularly liable to accidents which are usually ascribed to the electric shock, but in the production of which shock has played no part. In consequence of the gradual wearing of the road the surface-contacts project more or less above the common level, forming a series of mechanical obstacles which are a continual menace to horses. Horses stumble on these and fall, and thus arise claims which in the absence of precise information are very difficult to assess. For whether the horse has fallen in consequence of electric shock, of slipping, or of its foot striking against an obstacle like the projecting surface-contact, the injuries which follow show precisely similar physical characters. The existence of burns is the only evidence on which we are absolutely justified in ascribing the accident to electricity.