MAC DONALD (C. F.)

THE INFLICTION OF THE DEATH PENALTY BY MEANS OF ELECTRICITY

BEING A REPORT OF SEVEN CASES

With Remarks on the Methods of Application and the Gross and Microscopical Effects of Electrical Currents of Lethal Energy on the Human Subject

BY

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DR. MacDONALD'S ARTICLE ON THE INFLICTION OF THE DEATH PENALTY BY MEANS OF ELECTRICITY.

FIG. 1.

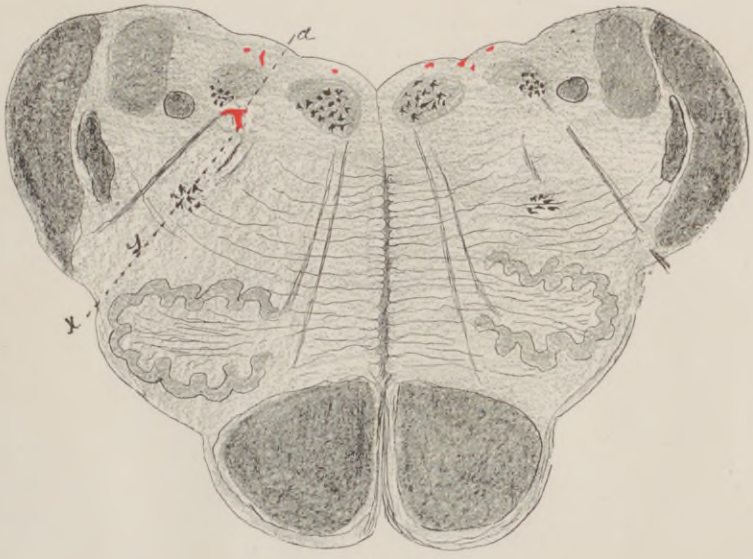

FIG. 3.

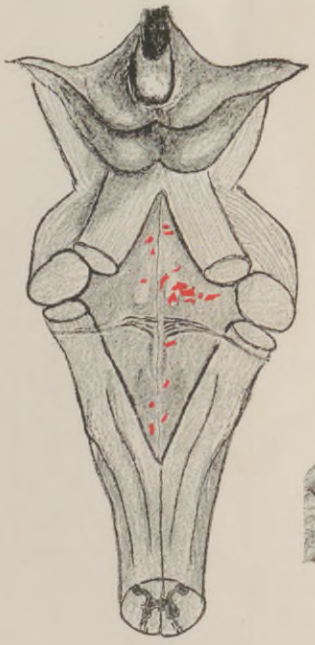

FIG. 2.

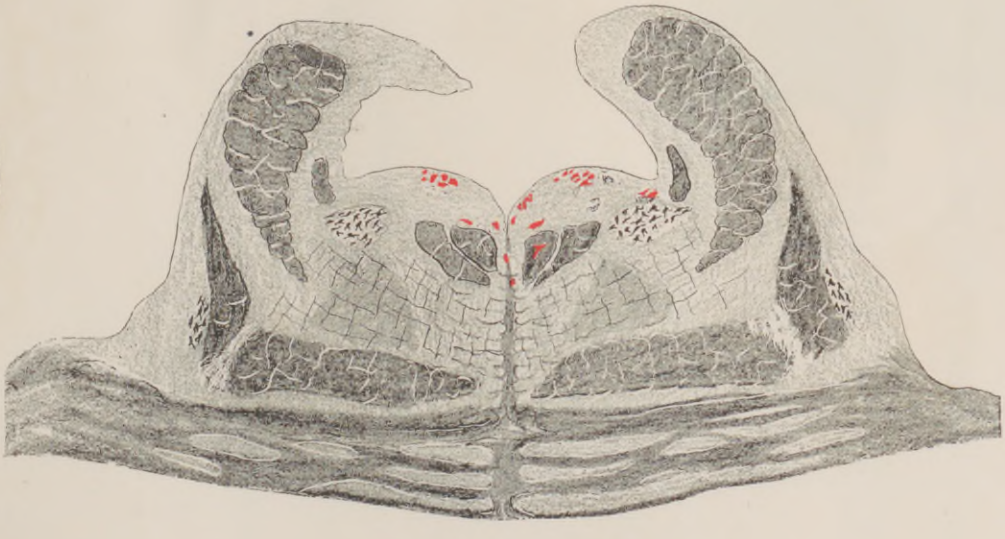

FIG. 4.

FIG. 1 shows the construction of the "death chair," the method of applying the current through the hands in the case of McElvaine, and the attitude of the subject before receiving the contact.

FIGS. 2, 3, and 4 show the character and distribution of the petechial spots in the floor of the fourth ventricle in the case of Schichiok Jugigo.

With the Compliments of

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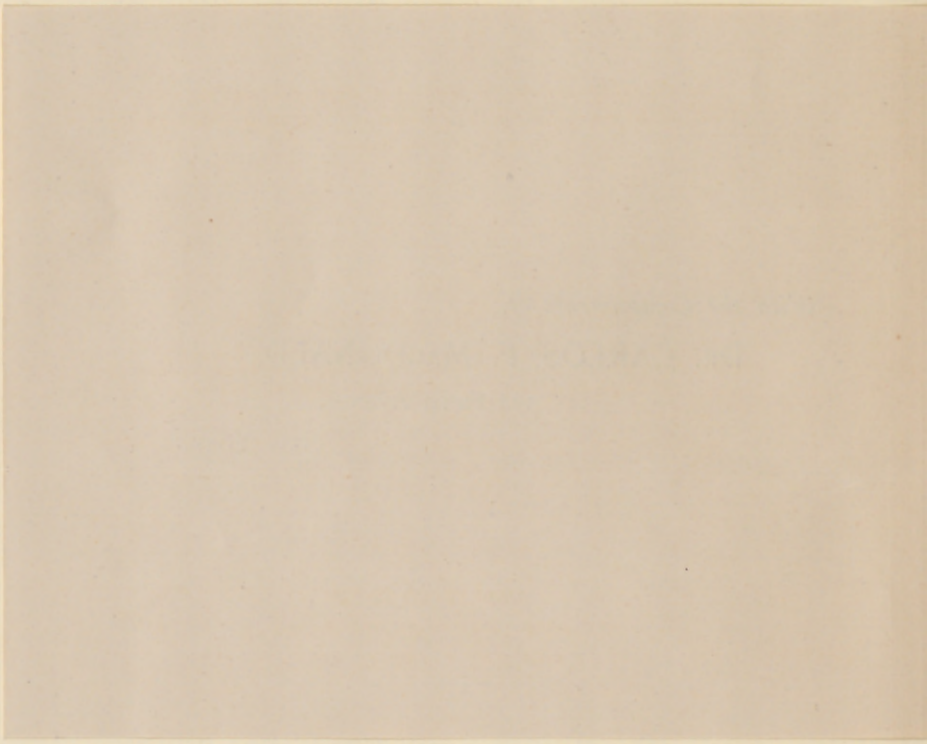

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THE INFLICTION OF THE DEATH PENALTY BY MEANS OF ELECTRICITY.*

The widespread interest manifested by the general public in the new method of inflicting the death penalty by means of electricity, and the interest which medical science would naturally be expected to feel in the humane and scientific aspects of the subject, especially with reference to the absence of conscious suffering, and the changes, if any, in the tissues and organs of the human body resulting from the passage through it of electrical currents of lethal energy, together with the fact that this method of executing criminals may now be said to have practically passed beyond the experimental stage, would seem to justify, if not indeed to demand, the presentation of an authentic summary of the practical results thus far obtained by some one whose data and conclusions would be derived from actual observation and experience in the application of the statute. The fact that the writer happens to be the only physician who has participated in all of the official preliminary experimental tests of apparatus, and witnessed all of the executions thus far had under the new law—not, however, from any zealous interest in the subject, nor even inclination to be present, but in obedience to the expressed desire of the chief executive of the State and other official superiors—furnishes the only excuse he would offer for undertaking what otherwise might well be regarded as an undesirable task.

* Read before the Section in Public Health of the New York Academy of Medicine, March 16, 1892; also read by title before the Medical Society of the State of New York, February, 1892.

In view of the wide publication of distorted and sensational accounts of the Kemmler execution, and the amount of adverse criticism and even condemnation based thereon of those who were called to act in an advisory capacity in the administration of the law, the writer, at the request of the Governor, prepared an official report of that event, some portions of which are necessarily here reproduced.

The execution of William Kemmler, alias John Hart, at Auburn Prison, on August 6, 1890, pursuant to the statute in such case made and provided, marked the first case in the world's history of the infliction of the death penalty by electricity. Since then six other condemned murderers have been legally killed by this method at Sing Sing Prison—namely, James J. Slocum, Harris A. Smiler, Joseph Wood, and Schichiok Jugigo, on July 7, 1891; Martin D. Loppy, on December 7, 1891; and Charles McElvaine, on February 8, 1892; making in all seven cases of successful infliction of the death penalty by electricity in the State of New York.

The execution of Kemmler was under the immediate direction and control of the prison warden, the Hon. C. F. Durston, and took place in a room set apart for the purpose, in the basement of the administration building of the Auburn Prison, to which the electric current was conducted by means of an ordinary electric-light wire. The apparatus consisted of a stationary engine, an alternating-current dynamo and exciter, a Cardew volt meter, with extra resistance coil, calibrated for a range of from 30 to 2,000 volts; an ammeter for alternating currents from 0·10 to 3 ampères, a Wheatstone bridge, rheostat, bell signals, and necessary switches; a "death chair," with adjustable head-rest, binding straps, and two adjustable electrodes. The dynamo was an alternating-current dynamo intended to supply 750 incandescent lamps of sixteen-candle power each, and capable of generating, as shown by careful tests made several months prior to the execution, a maximum electro-motive pressure of 2,376 volts, the commercial and mean voltage being 1,680 and 1,512, respectively, the speed of the dynamo being 1,900 revolutions, and of the exciter 2,700. The chair, a square-framed heavy oaken one, with a high, slightly sloping back and broad arms, was fastened to the floor, the feet of the chair being properly insulated.

Attached to the back of the chair, above the head-rest, was a sliding arrangement shaped like a figure four (4), the base or horizontal arm of which projected forward, and from which was suspended the head electrode, so as to rest on the vertex, or top of the head, against which it was firmly held by means of a spiral spring. The spinal or body electrode was attached to the lower part of the back of the chair and projected forward horizontally on a level with the hollow of the sacrum. The electrodes each consisted of a bell-shapped rubber cup about four inches in diameter, the part corresponding to the handle of the bell being of wood, through the long axis of which the wire passed into the bell, terminating in a metallic disc about three inches in diameter, and faced with a layer of sponge. The lower electrode was also provided with a sliding arrangement and spiral spring to hold it in place, while a broad strap fastened to the back of the chair and passed around the lower part of the prisoner's abdomen rendered the contact secure. The head was firmly secured by means of conjoined broad leather bands, which encircled the forehead and chin, concealing the eyes and upper portion of the face, and were fastened to the back of the almost perpendicular head rest, while the chest, arms, and legs were secured by broad straps attached to corresponding portions of the chair. The wire attached to the head electrode descended from the ceiling, and that of the lower one passed along the floor to the chair, being protected by a strip of wood.

The dynamo and engine were located in one of the prison shops several hundred feet distant from the execution room; the voltmeter, ammeter, switch-board, etc., were located in a room adjoining the execution room, which contained the death chair, electrodes, and connecting wires. Communication between the meter room and dynamo room was by means of electric signals.

The apparatus used in the subsequent executions at Sing Sing was substantially a duplicate of that above described, except as regards the location of the measuring instruments, switch-board, etc., and the form and points of application of the electrodes to be hereafter referred to.

Of the twenty-five official witnesses present, fourteen were physicians; two of whom—Dr. E. C. Spitzka and the

writer — were officially designated as physicians by the warden, in pursuance of the statute.

Before Kemmler was brought into the room the warden asked the physicians how long the contact should be maintained; the writer replied, Twenty seconds, but subsequently assented to ten seconds, in deference to the opinion of another that a considerably less period of time would suffice —an opinion which doubtless would have been sustained had the electro-motive pressure been sufficiently great.

Unfortunately, in this instance, the voltmeter, ammeter, switch-board, etc., were not located in the execution room; hence none of the official witnesses could know precisely how much the electro-motive pressure and current strength were at the time of making and during the continuance of the first contact. Nor has the voltage or ampèrage in this instance, to the writer's knowledge, ever been officially determined. But reasoning from the known lethal effect of an electro-motive pressure of 1,600 volts and upward, as shown by subsequent executions and by deaths which have occurred from accidental contact with live electric wires, as well as by numerous experiments on animals whose weight exceeded that of man, affords solid ground for the conclusion that no human being could survive the passage through his body of an alternating current of more than 1,500 volts for a period of even twenty seconds, the contact being perfect.

The preliminary arrangements having been completed, Kemmler was brought into the execution room by the warden and introduced to the witnesses, who were seated in a semicircle facing the death chair. On entering the room, the prisoner appeared strikingly calm and collected. In fact, his manner and appearance indicated a state of subdued elation, as if gratified at being the central figure of the occasion, his somewhat limited intellect evidently rendering him unable to fully appreciate the gravity of his situation. He was given a chair near the death chair, and, on being seated, in response to the warden's introduction, said: "Well, I wish every one good luck in this world, and I think I am going to a good place, and the papers has been saying a lot of stuff about me that wasn't true. That's all I have to say." At the warden's bidding, he then arose,

removed his coat, and, without the least display of emotion or nervousness, took his seat in the execution chair, calmly submitting to the adjustment of the electrodes and binding straps, himself aiding the proceedings by suggestions and fixing his body and limbs in proper position. Observing the nervousness of the prison officers who were adjusting the straps, he admonished them not to hurry, and to "be sure that everything is all right." He pressed his bared back firmly against the spinal electrode and requested that the head electrode be pressed down more firmly on the top of his head, from which the hair had been imperfectly clipped before he entered the room, remarking, at the same time, that he desired to perform his part to the best of his ability. The preparations terminated with a final moistening of the electrodes, the whole occupying, at most, between three and four minutes. Everything being seemingly ready, the warden signaled to his assistants in charge of the switches in the adjoining room to turn the lever which closed the circuit and instantly sent the deadly current through the prisoner's body. The instant the contact was made the body was thrown into a state of extreme rigidity, every fiber of the entire muscular system being apparently in a marked condition of tonic spasm. Synchronously with the onset of rigidity, bodily sensation, motion, and consciousness were apparently absolutely suspended, and remained so while electrical contact was maintained. At the end of seventeen seconds Kemmler was pronounced dead, none of the witnesses dissenting, and the warden signaled to have the contact broken, which was immediately done.

For obvious reasons, the only means of determining the question of death while the body was in circuit was by ocular demonstration; so that it can not be positively asserted that the heart's action entirely ceased with the onset of unconsciousness, though most of the medical witnesses present thought that it did.

When the electrical contact was broken the condition of rigidity noted above was instantly succeeded by one of complete muscular relaxation. At the same time superficial discolorations resembling commencing capillary post-mortem changes were observed on the exposed portions of the face. The body remained limp and motionless for approxi-

mately half a minute, when there occurred a series of slight spasmodic movements of the chest, accompanied by the expulsion of a small amount of mucus from the mouth. There were no evidences of a return of consciousness or of sensory function; but, in view of the possibility that life was not wholly extinct, beyond resuscitation, and in order to take no risk of such a contingency, the current was ordered to be reapplied, which was done within about two minutes from the time the first contact was broken. The sudden muscular rigidity noted on the first closure of the circuit was again observed and continued until the contact was again broken, when the opposite state of complete muscular relaxation re-occurred. The second closure of the circuit was inadvertently maintained for about seventy seconds, when a small volume of vapor, and subsequently of smoke, was seen to issue from the point of application of the spinal electrode, due, as was subsequently found, to scorching of the edge of the sponge with which the electrode was faced, and from which the moisture had been evaporated by prolonged electrical contact. The odor of the burning sponge was faintly perceptible in the room. There was also some desiccation of the already dead body, immediately underneath the electrodes, especially under the lower one, which will be described in connection with the autopsy.

A careful examination of the body was now made, in which the medical witnesses participated to a greater or less extent. The radial pulse and heart's action had ceased, the pupils were dilated, and the corneæ were depressed and flaccid on pressure. In other words, William Kemmler was dead, and the intent and purpose of the law to effect sudden and painless death in the execution of criminals had been successfully carried out.

In the excitement and confusion of the moment, occasioned by the belief on the part of some that death was not complete, the second application of the current in Kemmler's case was maintained too long—nearly a minute and a half. If there was a spark of unconscious vitality remaining in the prisoner's body after the first contact was broken—there certainly was no conscious life—it was absolutely extinguished the instant the second and last contact was made. That the man was dead, however, com-

paratively long before the burning of the sponge and desiccation of tissue occurred, there is no reason to doubt.

The movements referred to were regarded by most of the medical witnesses present, including the writer, as similar in character to those which have occasionally been observed for a short time in animals experimentally killed by electricity, when the contact was too brief or the current strength insufficient, the animal dying, however, in a short time without regaining consciousness—movements which may properly be regarded as involuntary or reflex in character, following the too early interruption of the current, and in no sense a resumption of respiratory function, however much they may appear to be so to superficial observers or to those not familiar with the phenomena referred to, as observed in experiments on lower animals. These movements are very slight in comparison with those usually exhibited by animals suddenly decapitated, and which usually continue a considerable period of time.

Dalton, in his work on Human Physiology,* refers to observations made by Robin on the reflex action of the spinal cord in the case of a criminal who was executed by decapitation, the head having been severed near the fourth cervical vertebra. Muscular contractions were produced about an hour after execution by scratching with a pointed instrument the skin of the chest at the areola of the nipple while the right arm was lying extended by the side. On irritating the skin at the point and in the manner mentioned there immediately occurred a series of contractions of the pectoralis major, the biceps, probably the brachialis anticus, and lastly the muscles covering the internal condyle, causing the whole arm to approach the trunk, with inward rotation and half flexion of the forearm upon the arm, and bringing the hand toward the chest as far as the epigastrium. On replacing the arm and repeating the irritation as before, a similar defensive movement occurred. This experiment was repeated four times with similar results, except that each time the movement was less extensive; and finally scratching the skin over the chest "produced only contractions in the great pectoral muscles which hardly stirred the limb."

* *A Treatise on Human Physiology*, seventh edition, p. 404.

Observations made at executions subsequent to Kemmler's tend to show that reflex excitability of the voluntary muscles disappears much more rapidly after death by electricity than by any other method of sudden dissolution. In the case of McElvaine, executed at Sing Sing on February 8, 1892, Dr. Van Gieson found that reflex action of the voluntary muscles was absolutely unresponsive—to ordinary mechanical stimuli (see report of autopsy in case of McElvaine)—within two or three minutes after the last contact was broken.

That there were certain defects of a minor character in the arrangement and operation of the apparatus at the first execution by this method will be questioned by no one who witnessed it; but when it is recalled that, notwithstanding these defects, unconsciousness was instantly effected and death was painless—also that less than four minutes elapsed between the making of the first contact and the breaking of the last one, when Kemmler was absolutely dead—it will be conceded by unprejudiced minds that the object to be attained in the infliction of the death penalty, at least so far as relates to the individual—namely, sudden and painless death—was fully realized in Kemmler's case; and had the first contact been maintained for a sufficient length of time, in all probability there would have been no involuntary movement of the body after it was broken, and no unfavorable criticism of the result could then have truthfully been made.

Among other criticisms which appeared in the public press anent the execution of Kemmler was a reported declaration of the most illustrious electrical expert of the age, in which he was made to say that a serious mistake had been committed in not making contact through the hands instead of the head, the skull and hairy scalp being poor conducting media.

However logical this criticism may be from the standpoint of an electrician, it is not sustained by our knowledge of electro-therapeutics and of the physical properties of live bone. In what was intended to be an impersonal reply to this criticism, the writer, in his report to the Governor, took occasion to call attention to certain facts which are well known to physiologists and medical electricians—

namely, that the arrest of the heart's action can be as readily effected by destroying or paralyzing the brain center which controls such action as by attacking the heart itself; hence, by including the brain directly in the circuit, the action of the heart would probably be quickly arrested, while at the same time all the vital centers, including that of consciousness, would be paralyzed; also that the brain itself is very susceptible to the influence of electricity, and can be readily affected, sometimes to an alarming extent, by the passage into it through the skull of mild currents, such as are obtained from medical batteries; that the nerve tissues contain an excess of saline moisture, and hence are among the best of conductors, while the amount of organic matter contained in *live* bone is sufficient to render that substance a fairly good conductor. Further, it is not difficult to penetrate the hairy scalp by electricity if the hair be properly moistened, the conductivity of all the tissues of the body being largely dependent on the amount of moisture and salinity contained in them.

In each of the five cases following the Kemmler case * —namely, Slocum, Smiler, Wood, and Jugigo, executed at Sing Sing Prison, July 7, 1891, and Loppy at the same place, December 7, 1891—one electrode was so applied as to cover the forehead and temples, and the other, a larger one, the calf of the right leg, except in the case of Joseph Wood, in which it was applied to the left leg in consequence of the existence of an ulcer on the right one. The calf of the leg was selected because it furnished a broad area of thin skin. The point of contact of the body electrode is not of material importance. It may be applied to the hand, the foot, the calf of the leg, or to any other indifferent part of the body.

The electrodes were thoroughly wet with a solution of salt water before the current was turned on, and were moistened at intervals, when the current was interrupted, with the same solution thrown on them from a syringe.

The following summary of these executions, except as

* The head electrode originally suggested in Kemmler's case, but which, for some reason unknown to the writer, was not used, was designed to include the forehead, down to the eyebrows, in the zone of contact.

relates to Kemmler, is taken from the official reports made to the warden of the prison, the Hon. W. R. Brown, by Dr. S. B. Ward, of Albany, N. Y., and the writer, who appeared as medical advisers for the State:

The electromotive pressure, as shown by the readings of the voltmeter, taken by Professor L. A. Laudy, of Columbia College, varied from 1,458 to 1,716 volts, while the ammeter showed a variation in current of from 2 to 7 ampères.

The preliminary preparations—that is, from the time the prisoner entered the execution room to the closure of the circuit which rendered him unconscious—occupied, in Kemmler's case, approximately, four minutes; in Slocum's case, three minutes and forty seconds; in Smiler's case, two minutes; in Wood's case, two minutes and forty seconds; in Jugigo's case, two minutes and fifteen seconds; in Loppy's case, two minutes and thirteen seconds; and in McElvaine's case, one minute and forty-nine seconds.

In each instance the prisoner walked deliberately to the chair and quietly submitted to the application of the restraining straps and electrodes without the slightest opposition or show of resistance, and also, save in the cases of Kemmler and McElvaine, without uttering a word in relation to the proceedings. With the single exception referred to (Kemmler's case), there was no exhibition of confusion or excitement on the part of witnesses, nor was there anything unduly repulsive in the executions themselves; on the contrary, everything was done in a quiet, orderly, and dignified manner, in keeping with the solemnity of the occasion. The most striking and constant objective phenomena observed were instantaneous and complete tonic rigidity of the muscular system on closure of the circuit and marked muscular relaxation immediately the contact was broken.

In Kemmler's case there were two contacts, through vertex and lower end of spine, lasting seventeen and seventy seconds, respectively, the last one being unnecessarily prolonged; in Slocum's case, two contacts—twenty-seven and twenty-six seconds; in Smiler's case, four contacts, three of ten seconds each and the fourth nineteen seconds; in Wood's, three contacts of twenty seconds each; in Jugigo's, three contacts of fifteen seconds each; in Loppy's case, four

contacts of fifteen, eleven, fifteen and a half, and ten and a half seconds, respectively. (In all of these five cases contact was through the head and leg.) And in McElvaine's case, two contacts, the first one through the hands * (immersed to the wrists in liquid electrodes), lasting fifty seconds, and the last one through the head and leg, lasting thirty-six seconds.

In Kemmler's case there were chest movements, and possibly heart-beat, after the first contact (seventeen seconds); in Slocum's, chest movements and radial pulsation after first contact (twenty-seven seconds); in Smiler's, no movement of chest, but radial pulsation after three contacts (ten seconds each); in Wood's, no movement or pulse-beat whatever; in Jugigo's, a slight fluttering of radial pulse when final contact was broken, which rapidly ceased.

In all the cases except Kemmler's and McElvaine's contact was broken for the purpose of wetting the electrodes.

From the foregoing it appears that the time consumed in the preliminary preparations—strapping, adjusting electrodes, etc.—varied from four minutes in the first to less than a minute and a half in the last instance; that the number of contacts varied from two to four, and that the aggregate length of the contacts in each case varied from forty-five to eighty-seven seconds, at the end of which, if not before, in most instances, both conscious and organic life were absolutely extinct.

In other words, the length of time which elapsed from the moment the prisoner entered the execution room until he was absolutely dead was, in Kemmler's case, eight minutes; in Slocum's, six minutes; in Smiler's, four minutes; in Wood's, four minutes and ten seconds; in Jugigo's, three minutes and thirty seconds; in Loppy's, three min-

* In view of the opinions expressed by electrical experts of the highest standing, it had been previously agreed that contact should first be made by immersing the hands in two cells, containing tepid salt water, connected respectively with the opposite poles of the dynamo, and, in the event of this not causing cessation of the heart-beat, that recourse should be had to the mode of application through the head and leg employed in the previous executions at Sing Sing Prison. The apparatus was so arranged that either mode of application could be instantly employed at will.

utes fifty-three seconds and a half; and in McElvaine's, three minutes and fifty-eight seconds.

It appears, therefore, that the time actually consumed in each of these seven executions, from the moment the prisoner entered the room until he was absolutely dead, varied from eight minutes in the longest to three and a half in the shortest, whereas executions by hanging usually require from fifteen to thirty minutes. In fact, in hanging, it not infrequently happens that the heart continues to beat for that length of time after the fall of the fatal drop. Then, too, far more time is consumed in placing the prisoner on the gallows, pinioning his limbs, putting on the black cap, placing the noose about his neck, and carefully adjusting the knot under his left ear (from whence it sometimes slips at the critical moment, resulting in strangulation instead of a broken neck), than would be required for arranging the preliminary details of an electrical execution. During the preparation of this report the Associated Press dispatches contained an account of a hanging in which the criminal's head was almost completely torn from the body.

There are abundant reasons for believing that conscious life is destroyed so rapidly by electricity that the application of the current could be repeated several times within the interval that is known to elapse between the receipt of an injury or a peripheral sensory impression, and its conscious perception by the brain through the medium of the sensory nerves. In other words, the electrical current would travel from the point of contact to the brain many times faster than sensory impressions or nerve currents would, the rate of velocity of the latter being, roughly speaking, only about one hundred and fifty-five feet per second—a rate which is quite slow in comparison with the lightning-like velocity of electricity, which travels at the rate of millions of feet per second.

Thus it will readily be seen that an electrical current of lethal energy coming in contact with the body so as to include the brain in the circuit would reach the latter and produce unconsciousness long, comparatively, before any sensory impression, at the point of contact or elsewhere, could be conveyed to and appreciated by that organ, through the process of nerve-conduction, which, as has been

shown, requires a distinctly appreciable period of time, the rate of transmission of painful sensations being even slower than that of ordinary tactile impressions.

A striking illustration of the relative slowness of nerve conduction as compared with electricity was shown in a series of experiments in instantaneous photography recently conducted by Professor Muybridge, in the following manner:

The lantern was used to make a series of instantaneous photographs, and in order to make the intervals between the exposures, as well as the periods of exposure, exceedingly short, the plates were exposed and stopped by means of an electric current. One very interesting series of pictures made was intended to illustrate the slowness of the brain in receiving impressions. Two women were employed; one stood in a bath-tub and the other sat on a raised chair and poured a bucket of water over the standing woman's head and shoulders. In order to make the shock more intense, Professor Muybridge had filled the bucket with ice-water, unknown to the victim, who would not have awaited the douche so patiently had she known what its temperature was going to be. One view showed the water tipped over and falling, yet not quite touching the girl's head. The next view showed the water splashing from her head and shoulders, and yet there were no signs of sensation. In the third picture she was just beginning to respond to the shock, and the subsequent pictures illustrated the further phases of the response. The point of special interest, however, is in connection with the second view. The electric current had in that case first exposed the plate, and then after a very short interval had shut it off again; that is to say, had acted twice with an interval of time between the two sufficiently long for the sensitive plate to take an impression of the view, and this after the ice-water had touched the woman's shoulders, and before she was conscious of it.

Respecting the resistance offered to the current by the human body, Mr. A. E. Kennelly, of the Edison Laboratory, at Orange, N. J., and who witnessed the execution of McElvaine, in a contribution to the *Electrical Engineer* for February 17, 1892, says:

The electrical pressure at the electrodes was determined from a Cardew voltmeter in circuit with a non-inductive resistance. The current passing through the electrodes was observed from a direct-reading dead-beat ammeter, and the indications of these carefully calibrated instruments afford reliable

inferences as to the resistance of a human body, under definite conditions of surface contact, to an alternating current making some 150 periods per second.

From the official records as already published it would appear that in the first application the pressure at electrodes was maintained at approximately 1,600 volts, and the current, which commenced at 2·0 ampères, steadily increased during the fifty seconds of contact up to 3·1, indicating a resistance between electrodes diminishing from the initial value of 800 ohms to a final value of 516, a reduction during the interval of more than thirty-five per cent. The electrodes were metal plates in large wooden receptacles nearly filled with tepid salt water, and in which the hands of the criminal were immersed. Judging from the fact that, although the skin of the hands was blistered over the areas above the water level that had been wetted by first immersion and then withdrawn, yet the skin that remained immersed was entirely uninjured, it seems reasonable to suppose that no very large proportion of the whole resistance of the body would reside in the integuments at the electrodes.

In the second application, forty-three seconds later, the pressure was observed to be maintained at approximately 1,500 volts, and the current which passed between the forehead and the calf of the right leg continued at 7·0 ampères during the thirty-six seconds of contact, indicating a resistance practically steady at 214 ohms during that time. The electrodes were of sponge, kept thoroughly wetted with cool salt water and backed by metallic plates, the area covered by each being about 100 square centimetres. Since no blistering took place immediately below the head electrode, although some blistering occurred at the other, it would appear that no large proportion of the total resistance existed in the contact areas.

The mean activity developed in heat during the first application was thus 4,080 watts, and in the second 10,500 watts, or about 14 E. H. P., this large expenditure of energy accounting for the considerable post-mortem temperatures that are stated to have been observed.

The average resistance of the human body between the hands, immersed to the wrists in dilute solutions of salt or soda, is often overstated in measurement, owing to the vitiating influence of polarization on observations taken with feeble currents in the Wheatstone bridge. Correct readings can, however, be obtained either by bridge measurement to "immediate false zero," or by the use of large resistances inserted directly in the electrode circuit through a galvanometer, so as to employ a higher pressure without pain to the subject, and so reduce the in-

fluence of the possible 2·5 volts of polarization counter E. M. F. In either case the mean resistance under these conditions is about 1,000 ohms.

The inference appears to be drawn that the resistance of the body between hands to an alternating pressure of 1,500 volts is only about one half what it is to continuous pressures of 5 volts, or to alternating pressures of 2 or 3 volts, and, from the observations above mentioned, it would seem that the resistance between forehead and calf is very much lower than between immersed hands. While, in conclusion, the general belief is further substantiated that the quantity of current which may pass through the body from a contact with high pressures will entirely depend upon the area and moisture of the contact surfaces, being large with extended and wet surfaces, but, perhaps, comparatively small for brief contacts on dry and limited surfaces of touch.

Autopsies.

William Kemmler.—The autopsy, held about three hours post mortem, was by verbal direction of the warden officially in charge of the writer, and was performed by Dr. E. C. Spitzka, Dr. George F. Shrady, and Dr. W. T. Jenkins, of New York, and Dr. C. M. Daniels and Dr. George E. Fell, of Buffalo, N. Y. Notes were taken by Dr. Shrady, from which the following is compiled:

Body fairly well nourished. Rigor mortis marked, particularly in the muscles of the jaw, neck, and thorax, and gradually extending from above downward, involving the feet and legs last. Post-mortem discoloration existed over lower portion (posterior and lateral aspects of trunk) of body, and extended up as far as the anterior axillary line, also on the pendent surfaces of the upper and lower extremities. The upper extremities were partly flexed and rotated outward, the nails showing post-mortem lividity. There was a seminal discharge, which, on microscopic examination, was found to contain a large quantity of dead spermatozoa. There was marked post-mortem discoloration of the forehead, about an inch in width, corresponding with the position of the strap, beginning at the hair on the left side and extending to the hair line on the right side. A corresponding discoloration from the pressure of the chin strap was also noted. There was an oval depression of the scalp upon the vertex, due to the pressure of the electrode, beginning at the anterior hair line and measuring four inches in its long and three inches and a half in its short diameter. Anterior to the posterior portion of the depression and in the immediate line there was a vesication

an inch and a half in length, very superficial in character, crescentic in shape, and upon which the hair appeared to be slightly scorched. On the small of the back, corresponding to the level of the fourth sacral vertebra below and second above, four inches and a half in vertical diameter and four inches and a half in transverse diameter, was a burn, presenting four concentric zones, of which the outermost had a pale area, corresponding to that of the rubber cap of the electrode, and one fourth of an inch in diameter.

Succeeding this was a vesication, partial below and complete above, about an inch in diameter above and one third of an inch below.

Then followed another zone, which was in its upper third a complete eschar, black in appearance, and in its lower part showed desiccation of a greenish-brown color. The last or inner zone showed a number of vesicles, chiefly peripheral, and below the center was a black eschar, half an inch in its vertical and five eighths of an inch in its transverse diameter. Above was a tongue-shaped, pale area, with a lateral projection to the left of the median line, extending about two inches, and an upper projection in the dorsal furrow, which was more sharply pointed, and which on its periphery showed a reddened portion, with here and there vesication. In addition, the back showed a number of depressions produced by the folds of the shirt and suspenders, such as are commonly found in dead bodies lying on the back.

On incising the skin over the sternum, the blood which escaped was unusually dark and fluid, and remained so on exposure. The muscles of the thorax were of the usual color. "Tardieu spots" were noticed on the posterior border of the lower lobe of the left lung. When placed in water, more than half of the lung floated above the surface, showing a marked emphysematous condition. The bronchi were normal in appearance, and contained mucus and air bubbles. The right lung was adherent throughout to the diaphragm. In the middle lobe of this lung there were numerous well-marked "*Tardieu spots.*" The heart weighed five ounces and three quarters; its valves and substance were normal in appearance, and its ventricles were empty. The stomach contained a pint of undigested food. The blood from the cut surface of the liver was of a dark-crimson hue. The gall-bladder was distended with bile. The spleen was normal in size and appearance. The left kidney weighed three ounces and a half, and the right three ounces; both were markedly congested. There was no vermicular action of the intestines on exposure to the air or on irritation. The bladder was contracted.

The scalp, on being removed, showed the outer aspect of the vertex of the skull to be in a desiccated condition, corresponding with the site of the electrode as previously noted, but of a larger area, being four by four inches, the zone of the scalp being only two and a half by three inches, the long diameter being antero-posterior. On removal of the skull-cap, the dura was normal in texture, somewhat dull in color, particularly over the area corresponding with the zone of contact. In the pre-Rolandic region the meningeal vessels, measuring along the convexity antero-posteriorly four inches on the left side and three on the right, were filled with carbonized blood. On the internal aspect of the calvarium the meningeal vessels in the dura and in their contents appeared to be black and carbonized. The carbonized vessels were so brittle that their ends were torn off with the calvarium and presented a broken, crummy appearance. This carbonization was limited in an abrupt manner. The other meningeal vessels in the region corresponding to the outer burn, previously described, contained blood of a dark-crimson hue. In the narrowest portion of this region was seen, a little posteriorly, in the median line, a dark discoloration sending out a right lateral prolongation three fourths of an inch in the direction of the longitudinal sinus, and in width seven eighths of an inch. Over the left cerebral hemisphere, one third of an inch to the left of the median line, there was a deep carbonized spot corresponding with the desiccated portion of the calvaria. The pia and gyri were of a pale-buff color; the rest of the cerebral cortex was normal in appearance. While observing this anæmic area it was noticed that its blood-vessels began to fill. The pia and arachnoid on the convexity of the brain were perfectly normal. An interesting fact was observed on handling the pons and medulla, in that they were found to be warm. By a thermometer inserted in the fourth ventricle, the temperature was noted at 97° F. The area of this temperature corresponded with an area of temperature on the back of the neck which was noted at 99° F., three hours post mortem, the temperature of the room being 83° F. The smaller vessels of the pia were ectatic. *Capillary hæmorrhages were noted on the floor of the fourth ventricle, also in the third ventricle and the anterior portion of the lateral ventricle. The circumvascular spaces appeared to be distended with serum and blood.* The brain cortex in the area of contact was sensibly hardened to one sixth of its depth, where there was a broken line of vascularity. The vessels over the corpus striatum showed enlargements in different parts of their ramifications. The pons was slightly softened. The spinal cord was removed entire, but showed no gross appearances of pathological condition. Portions of the brain and

spinal cord were preserved for purposes of hardening and microscopical examination. The blood taken immediately after death showed, under the microscope, a markedly granular condition, almost suggesting an electrolytic dissolution of the red corpuscles.

A preliminary microscopical examination of portions of the brain and spinal cord, including specimens from all the cerebral lobes of both sides, segments of the cervical, dorsal, and lumbar regions of the spinal cord, with the connected nerve groups, was subsequently made by Dr. Spitzka, who states as follows:

The brain, spinal cord, and peripheral nerves appeared structurally healthy in every portion examined, except in the area corresponding to the discolored (anæmic through extreme contraction of vascular channels) area of the Rolandic and pre-Rolandic regions, the ventricular surfaces, and the pons and medulla oblongata. The latter, which had been the seat of a remarkable post-mortem preservation of a temperature approaching that of the normal human body, were distinctly softer than the observer has been accustomed to find these parts in autopsies on persons of Kemmler's age, and performed so soon after death. The hæmorrhagic spots in the fourth ventricle, which were strongly marked, were not accompanied by signs of parenchymatous rupture of larger vessels. Hence they may be regarded as having the same significance as the "*taches de Tardieu*" found on the surfaces of other organs—notably, the heart and lungs.

The peculiar softened vesicular zone of tissue underlying the outermost layer of the cerebral cortex being very fragile, will require extreme care in hardening and manipulation to enable me to obtain reliable specimens. It is noteworthy that this "destruction line" runs parallel to the free surface of the brain and does not "dip" with the sulci.

Examination of the fresh specimen revealed the existence of vacuoles (probably gas bubbles) in the ganglion cells and in the parenchyma of the "destruction line." From the fact that no hæmorrhages had occurred in this softened area, it is a just inference that it was produced after life had become entirely extinct, for the continuance of a blood circulation in a softened brain area is incompatible with the bloodless appearance already noted and the absence of capillary hæmorrhages in this very district while they were present in those remote from the site of the electrode.

A more minute analysis will be completed, but can not be reported until some future time.

That the "cooked" appearance of the muscular tissue of the back beneath the site of the electrode, and the desiccation of the skull and so-called "carbonized" state of the blood-vessels on the internal aspect of the calvaria over the area corresponding to the zone of contact, were due to the unduly prolonged second contact, together with failure to properly moisten the electrodes, there can be no question, no such results having been observed in any of the subsequent cases, the surface lesion in these latter being limited to superficial vesication of the skin at the points of application of the electrodes, as will presently appear.

All of the subsequent autopsies, including the microscopical examinations, were made by Dr. Ira Van Gieson, of the Pathological Laboratory of the College of Physicians and Surgeons, and are here described substantially in Dr. Van Gieson's language.

Schichiok Jugigo.—The post-mortem examination in this case was held four hours after death. The pupils were alike and moderately contracted. The body was well nourished and unusually well developed. The anterior epithelial cells of the cornea had desquamated from the central portion by the action of heat. There was a bulging forward of the sclera of the left eye at the left sclero-corneal junction. Conjunctiva anæmic. The scalp and skin covering the neck had a dull, purplish hue. The skin of the anterior surface of the body was not discolored or ecchymosed. At the flexure of both elbows were a number of symmetrical linear ecchymoses, which were more marked on the right side. Also a curved, narrow ecchymotic line just below the outside of the right nipple. These probably were caused by the straps. At the posterior surface of the right knee-joint, and on the posterior and inner and upper surface of the calf, the epidermis was raised, wrinkled, and folded. At the flexure of the knee joint the epidermis had been torn away to the extent of about an inch in diameter. The right lower extremity was flexed and bent more to the median line than its fellow. There is a slight discharge of thin, milky fluid from the urethra and some still remaining in the canal. A sample of this fluid was taken for microscopical examination. Post-mortem rigidity well marked except in the arms, where it was only slight. The whole posterior surface of neck, trunk, arms, and lower extremities was of a dull, purplish hue. There

were a few slight blisters on both temples, and both cheeks and eyelids. There were raised whitish streaks on both sides of the neck, just below the angle of the jaw.

The trunk was opened by a straight incision from the top of the sternum to the pubes. The fat was an inch thick over the abdomen. Muscles red and firm. Diaphragm at left side was found at the level of the sixth intercostal space, and on the right side at the fifth intercostal space. Portions of small intestine were taken for microscopical examination.

Examination of heart: Auricles and ventricles flaccid and in diastole and filled with fluid blood. The larger vessels were tied and the heart removed. The left ventricle was well filled with fluid blood but no clots. The auricles were the same. The blood was of the same color in the left ventricle as in the right. Valves normal. On opening the vessels, a large quantity of dark-colored liquid blood escaped, half filling the pleural cavity. There were no pleural adhesions. Lungs perfectly healthy, but slightly congested.

The spleen was found to be of normal size, the capsule smooth, pulp firm, and uniformly filled with blood, and the arrangement of the Malpighian bodies and splenic connective tissue entirely normal.

The pancreas was perfectly normal and a portion removed for microscopical examination.

Liver entirely normal, and a portion was also removed for microscopical examination.

The gall-bladder was filled with bile.

Left kidney: The capsule was non-adherent. It was rather large and the cortex of normal thickness. The kidney was uniformly injected and the markings in the cortex were normal as to number and arrangement. The right kidney was in the same condition.

The stomach was empty, the mucous membrane pale; the rugæ were well marked and perfectly healthy.

The intestines were healthy. The small intestines were filled with semi-fluid fæces. The large intestines showed the same condition.

The urinary bladder was normal and half full.

Examination of brain: The brain was exposed by a straight incision of scalp over the vertex from ear to ear, and saw cuts through the skull at a slight angle and at the level of the eyebrows. The scalp showed several old scars, and was slightly less adherent under those portions where the electrode was attached. The skull was symmetrical. The dura mater was normal and the vessels moderately dilated. The longitudinal sinus was found to be normal and contained some fluid blood.

The brain was removed in the usual way. The pia mater was uniformly thin and transparent; the vessels in a medium state of congestion; subpial fluid small in amount. The blood was everywhere fluid in the meshes of the pia mater. There was no apparent difference in that portion which the electrode covered. The vessels at the base were perfectly normal. The ventricles contained a small amount of clear fluid. The roof and floor of the lateral ventricles were normal. The ependyma was smooth and transparent. White substance firm. Gray matter normal in every respect. Floor of the fourth ventricle at the upper half contained some dilated vessels, and on the left side there were a number of minute, radiating petechial spots from one to two millimetres in diameter. (See Fig. 1.)

The spinal cord was exposed in the usual manner. The external appearance of both cord and membranes was entirely normal, and the vessels containing, if anything, even less blood than usual, due, probably, to the short time that had elapsed between the occurrence of death and the holding of the autopsy. Sections half an inch apart showed nothing abnormal. A portion of both sciatic nerves was taken for microscopical examination.

Owing to the great length of time necessary to make this autopsy as completely and minutely as was done, and the subsequent careful microscopical examinations, it was not considered necessary to examine the brain and spinal cord in the other cases, especially as nothing of any importance had been observed in these organs in this case.

Harris A. Smiler.—Posterior surface of the body was of the same color, and also showed the same blisters as in the case of Jugigo. The left leg showed the same state of contraction.

The body was opened by the long, straight incision, as in the case of Jugigo. The diaphragm was found at the left side at the sixth intercostal space and on the right side at the fifth intercostal space. The left lung was slightly adherent at the apex. The heart was rather small. The left ventricle was somewhat firmer than the right, which latter was a little flabby. The auricles were distended with fluid blood. The right ventricle was empty and collapsed. The apex of the left lung was small and shrunken and retracted, and contained a few small, scattered, dense, tubercular nodules, some of which were calcified. Otherwise the lung was normal and resembled the preceding case. Right lung shows the same set of changes, but not so marked. Small ecchymotic spots (Tardieu's spots) were observed under the pericardium on surface of left ventricle. The walls of the ventricles were of normal thickness. There were

signs of an old endocarditis below the aortic valves. All the valves were healthy.

The spleen was small and the pulp soft and normal.

The pancreas was normal.

The liver was normal both in size and texture.

The left kidney was greatly hypertrophied and the capsule non-adherent. The cortex was somewhat thickened and the markings distinct and regular; moderately congested. The right kidney was small, two and a half by three quarters of an inch in size, and weighed forty-eight grammes—less than an ounce and three quarters. The tissue was normal, but the kidney was apparently congenitally small.

Intestines.—Descending colon was filled with gas; ascending colon and small intestine pallid and contained semi-fluid material.

Stomach contained undigested food, potatoes, etc. Mucous membrane pale and coated with a thin layer of slimy mucus. Bladder distended with urine. Walls and mucous membrane normal.

Examination of brain and cord deemed unnecessary. The blood was fluid everywhere and darker than normal.

Joseph Wood.—Autopsy held at 1.25 P. M.

Body presented same appearance as in preceding cases. There was the same contraction of the legs and the same general appearance as in the others. Same condition of epithelium of cornea.

Median incision made as in other cases. Diaphragm attached to fifth intercostal space on both sides. There were half a dozen scattered petechial points found under the pericardium, half a millimetre in diameter. On the anterior surface of both ventricles and on the posterior surface of the left ventricle were five scattered similar points. On the posterior surface of the right ventricle were three similar small points and one larger, three millimetres and a half in diameter.

Heart normal in size and condition of ventricles the same as in the case of Smiler. Both lungs were free from adhesions. The right lung, bronchi, pulmonary vessels, and lung tissue were normal, but somewhat more pigmented than usual. The substance of the lung was dry and dark pink in color. Heart muscles pale and firm and of normal thickness. All the valves were normal.

Spleen was normal in size and dark red in color, and showed two thickened white patches on capsule. The pulp was firm.

The pancreas was normal.

The liver was normal in every respect.

Both kidneys normal in every respect.

Nothing abnormal was found in the intestines.

The gall-bladder was distended with normal bile.

The urinary bladder was of normal thickness, but the mucous membrane was considerably congested.

The brain and cord were not examined.

James J. Slocum.—Autopsy held at 1.45 P. M. There were the same blisters and external appearances as in the others. There was also the same appearance of cornea. Median incision was made as in the other cases.

Heart.—Petechial spots scattered about as in the other cases, and were also observed under the pulmonary pleura. The left ventricle was firmly contracted, while the right was flabby. Both auricles, especially the right one, were filled with fluid blood. The left lung was free from adhesions. The upper lobe of right lung was slightly adherent. The left lung was in the same condition as the others, but slightly œdematous. The right lung was in the same condition. There was a well-marked large group of petechial spots at the center of anterior surface of left ventricle.

The spleen was of normal size, with the pulp soft, of dark-red color and somewhat congested.

Pancreas was normal both on the surface and on section.

The gall-bladder was half full of bile and the common duct patulous.

The liver was normal in every respect.

The left kidney was very much congested, but normal in all other respects.

The right kidney was in a similar condition.

A careful examination of the intestines showed nothing abnormal.

The bladder was collapsed and normal.

The trachea was normal.

Microscopical Examination.

The practical results of the microscopical examination are, that the passage of the electric current through the body is attended with no recognizable changes in its tissues or organs, excepting the local thermic changes in the skin at the points of application of the electrodes and some minute petechial spots on several of the organs.

Such a summary of the examination, however, seems insufficient without adding that it was determined by most exhaustive and modern investigation, and as there are apparently no recorded examinations of similar cases in medical literature, it seems not inappropriate to give the detailed report subjoined,

showing in what way and to what extent the tissues were examined.

Specimens were taken from all four of the subjects, but the material from the Japanese criminal was especially selected for minute study, as it could be obtained the soonest after death.

Notes about the technical preparation of tissues are added at the conclusion of the report.

The Examination of the Cells in General.—For this purpose the ciliated cells of the trachea, the liver cells, and the ganglion cells were studied especially with the oil-immersion lens. The physical properties of the protoplasm are in no way changed. The arrangement of the protoplasm, its volume, consistency, its behavior with light and staining reagents, are not at all different from the ordinary cell body. The same may be said of the constituent elements of the nucleus. None of the cells in any of the tissues examined show any signs of mechanical violence, such as tearing, fracture, or disintegration of the protoplasm. Neither does there appear to be any chemical change in the nucleus or cell body, as far as can be determined with micro-chemical methods. (The cells thus studied were prepared with solutions of corrosive sublimate, and also osmic acid.)

The Blood.—The blood cells are not damaged in any way by the current. The red cells have their normal size and shape. The white cells are uniformly spherical and have the usual arrangement of the nuclei. The blood was very perfectly preserved, even the blood plaques being unchanged.

The stomach, small intestine, and kidney are unchanged, with the exception of a slight amount of post-mortem degeneration in the parenchyma cells. The stomach shows the appearances of functional activity.

The liver and pancreas and spleen show no changes.

The Muscular System.—The smooth muscles, studied from the gastro-intestinal tracts and the heart muscle fibers, are unchanged.

In sections of the eyelid lying directly beneath the electrode the voluntary muscle fibers are normal.

The blood-vessels are not altered. *The lungs* and *genital* organs were not examined microscopically. The fluid ejaculated from the urethra in the case of the Japanese criminal does not show spermatozoa.

The central nervous system was examined with especial care. It has recently been determined that, during periods of muscular fatigue or prolonged muscular exertion, certain of the motor-ganglion cells are diminished in volume, which is recovered again during periods of muscular repose. Speaking roughly, this shrinkage of the ganglion cells during muscular fatigue

represents a sort of mechanical equivalent of the work done by the muscles. Hodge (*Am. Jour. of Psychology*, May, 1888, 1889, and 1891), in inducing experimentally the effects of fatigue in ganglion cells by the prolonged action of weak electrical currents, found that the ganglion cells suffered a vacuolation, shrinkage in the volume of the cell body, and a still greater reduction in the size of the nucleus. This diminution of the ganglion cell was tangible enough and could be measured, and in some cases in Hodge's experiments with the current on cats the nucleus shrank to 43·9 per cent. of its original bulk.

Although it could hardly be expected that there would be time enough for the ganglion cells of these criminals to show traces of the intense muscular contractions, yet the ganglion cells of the central convolutions and the anterior spinal cornua were very carefully examined to see if there would be any shrinkage coincident with the expenditure of so great an amount of muscular energy as was manifested during the contacts.

The ganglion cells in these regions, however, as far as can be determined by careful comparison with sections from the same regions in other ordinary healthy subjects, seem to be normal in size, or at least do not show any striking reduction in volume. A slight shrinkage may be present, but it would be almost impossible to determine it from the lack of a normal standard to make measurements with. Concerning this suspected change in the ganglion cells, then, it may be said that if there is any shrinkage at all, it is of very limited extent.

At the autopsy some minute petechial spots were found on the floor of the fourth ventricle (Fig. 1).* Microscopically, these spots are small masses of extravasated red blood-cells, situated, for the most part, in the perivascular spaces just beneath the ependyma.

The diagrams show the distribution and character of those hæmorrhages well enough, so that we may omit detailed description of them. A few of the extravasations are more deeply situated and have a more significant position with regard to the important nuclear groups in the medulla. Fig. 2*a* shows one of the hæmorrhages just on the outskirts of the sensory vagus, and other smaller ones close to the hypoglossal nuclei. The extravasation near the vagus is confined by the perivascular space of the median lateral artery of the medulla, which takes the course of the dotted line *x*, *y*, in Fig. 2.

These hæmorrhages look as if due to the passage of blood along the perivascular spaces, and out into the tissues after rupture of a small vein or capillary, but whether any especial

* The plates are from drawings by Dr. Van Gieson.

significance should be attached to these hæmorrhages, or whether they are caused directly by the current, or by intense muscular tension, or by manipulation in removing the brain, are questions extremely difficult to decide about.

The Peripheral Nerves.—The sciatic nerves from both sides were examined without finding any change or difference between the sciatic of the electrode side and its fellow.

The delicate structures of the *retina* lying so close to the electrode are not altered.

The skin beneath the electrode is but slightly changed. The epidermis is absent or raised up from the corium and has a dried-up appearance. The corium, structurally, is nearly normal; the connective-tissue nuclei are not shrunken and stain well, but the connective-tissue bundles and fibers seemed changed chemically and behave abnormally with certain staining reagents. The sweat glands are degenerated to a considerable extent; they have a desiccated appearance.

It would then appear from this examination that, beyond the scalding effects of the electrodes, electric currents passed through the body in this way produce no change in the body except minute petechiæ, and it is doubtful if these are not some indirect or secondary consequence of the current. The results of the microscopical examination of the two remaining subjects —Loppy and McElvaine—are corroborative in every way of this examination.

It seems proper to add that the central nervous system of only one of these four cases was removed, because nothing was found in it which would receive any further elucidation from the examination of the other three cases.

METHODS OF THE PREPARATION OF THE SPECIMENS.

The Blood.—Two drops from a glass rod dipped in the freshly cut right ventricle were received in a one-per-cent. aqueous osmic-acid solution.

The sciatic nerves were prepared in the same medium by gently pulling short fasciculi out of their lamellar sheaths, allowing the acid to penetrate.

The Central Nervous System.—Thin shavings of the convolutions and of the cervical spinal cord were placed in alcoholic and aqueous solutions of corrosive sublimate of different strength for periods of time varying from an hour to several days. Exceedingly small portions of the gray matter were also hardened in Fleming's osmic-acid mixture and in one-per-cent. osmic-acid solution for half an hour. All of the specimens were subsequently hardened in eighty per cent., and then in strong alcohol.

Still other portions of the convolutions were scraped gently with a sharp razor, so that the gray matter was reduced to a thick pulpy broth on the edge of the razor. This pulp was then shaken into exceedingly fine fragments in osmic acid and sublimate solutions, so that the fixation of the ganglion cells would be as nearly as possible uniform and instantaneous. (Incidentally, attention may be called to this method as giving very good results for ganglion cells, and being much better than the ordinary methods of hardening the cortex in blocks, no matter how small.)

The medulla and portions of the cord were also hardened in Müller's fluid in the usual way. The *trachea*, *thoracic* and *abdominal* viscera were prepared in sublimate solution, and also with strong alcohol in the ordinary way. Portions of the *spleen*, *pancreas*, and *liver* were also injected interstitially with osmic-acid solution. The eyeball, *eyelid*, and *singed portions* of the *integument* beneath the electrodes, were prepared with Müller's fluid.

All of these variously hardened portions of the tissues were imbedded in celloidin and sections stained appropriately with several different methods, such as Weigert's method, double staining with hæmatoxylon and eosin, and also with the picro-acid fuchsin method.

Martin D. Loppy.—Autopsy held as soon as practicable after breaking of the last current. Subject somewhat below the medium stature. Body well nourished. Muscular system well developed. Rigor mortis almost completely, if not entirely, absent, except in the right leg, where there is sufficient muscular rigidity to hold the leg slightly adducted and flexed at the knee joint. The mouth and nostrils are perfectly natural, and show no traces of the extrusion of fluids or frothy material. About a drachm of viscid fluid, wetting the skin of the pubic region, has escaped from the urethra.

There are no discolorations, contusions, or other marks on the skin, except in two places—viz., (1) at the flexure of the right knee, where the lower electrode was applied, and (2) upon the cheeks, corresponding to the position of one of the restraining straps. The unexposed surfaces of the skin are everywhere else smooth, white, rather thin, and delicate in structure, and show no settling of blood in the dependent portions of the body.

At the flexure (or back part of the knee joint), where the *lower electrode* was applied, there is a diffuse reddish discoloration of the skin about three inches and a half by five inches in

diameter. This region of the skin shows a very moderate, superficial, irregular separation of the thin outer scarf skin or epidermis from the true and thicker skin beneath. The epidermis or scarf skin in this region is raised up and corrugated, and it can be easily rubbed off with slight force. When the whole thickness of the skin is cut through with a knife, it can be seen that this change is quite superficial, affecting the outer scarf skin only, and does not damage the corium or true skin beneath to any appreciable extent.

The corium or true thicker skin underlying the electrode region is soft, pliable, not desiccated, and seems to be normal in every way, except that it is somewhat congested, which produces the reddish discoloration in this region.

The layer of fat beneath the skin in the electrode region is in no way changed or damaged.

The *head electrode* has left no traces upon the skin. The forehead and scalp beneath the electrode are perfectly white and natural, and there are absolutely none of the superficial alterations referred to above at the knee joint.

There is redness and swelling of both cheeks just beneath the eyes, which is very moderate in extent and not enough to make any distortion of the face. This was occasioned by pressure against one of the leather restraining straps during the periods of muscular activity when the current was applied.

The right eye had been lost some time previously during life. The eyelids are closed; skin of eyelids intact. Anterior corneal epithelium of the left eye cloudy, but not detached. The eyeball is perfectly natural; it has the proper tension and contour.

The interior of the mouth is normal. The tongue and the teeth show no signs whatsoever of injury.

The body was opened in the usual way. The abdominal organs were critically examined first, then the thoracic viscera, and finally the brain and upper portion of the spinal cord.

The *stomach* is normal; it is much contracted, rather small; mucosa pallid; fundus smooth; pyloric extremity folded.

The *small intestine* is normal, contracted, upper portion nearly empty, lower portion partially filled with semi-fluid fæcal matter.

The *spleen* contains, just beneath the normal capsule, several larger and smaller hæmorrhagic spots, from one millimetre to three millimetres in diameter, such as are not infrequently found after death from a variety of causes. The substance of the spleen is normal.

The *pancreas* is normal in size and texture.

The *liver* is normal in size, and uniformly filled with blood;

cut surface smooth, stroma and parenchyma unchanged. *Gall-bladder* normal; partially filled with bile.

The *kidneys* are of medium size; capsules non-adherent; vessels well filled; the cortex is normal in thickness, and has its constituent elements properly arranged.

The *suprarenal capsules* are unchanged.

The *urinary bladder* shows no abnormities; it is much contracted and its mucosa pallid.

Heart.—The left ventricle is firmly contracted and empty; both auricles and the left ventricle are flaccid. The right ventricle contains a little fluid blood. Two small thickened patches of old endocarditis are at the base of the aortic valve. The heart muscle is firm and normal.

The *diaphragm* stands at the level of the sixth intercostal space on the left side, and at the sixth rib on the right side.

The *lungs* are non-adherent, pale, normal in size, texture, and consistence.

The *trachea*, *œsophagus*, and *aorta* are normal.

The *vocal cords* are in cadaveric position.

Brain and Spinal Cord.—The brain was removed in the ordinarily practiced method, and the scalp, pericranium, and skull show no effects of the head electrode. Skull brachycephalic. Dura mater of convexity normal. Longitudinal sinus normal; contains a little fluid blood. Pia mater not thickened, but contains a number of nebulous striæ and opacities uniformly scattered over the whole convexity. There was considerable subpial fluid. Both this change in the pia mater and the increased subpial fluid are referable to some pre-existing condition, and are such as are not infrequently found in persons having the age and intemperate habits of this subject.

Convolutions of the brain have the normal topographical distribution; substance of brain normal, both as to the conditions of the blood-vessels and the character of both the gray and white matter. Vessels at base normal. Lateral ventricles contain a slight amount of clear fluid. Ependyma of all ventricles unchanged. Floor of fourth ventricle normal.

The right optic nerve—corresponding to the lost eye—is atrophied, having about half of its ordinary thickness. The medulla, pons, and basal ganglia show no abnormities. (These were referred to Dr. Brill for microscopical examination.)

There is an old healed fracture extending across the right orbital process of the frontal bone, one centimetre from the median line, which extends backward and outward nearly to the apex of the petrous portion of the temporal bone for a distance of about five centimetres. The dura mater along the track

of this old fracture is slightly thickened (to the extent of three millimetres) and adherent to the bone.

The superior portion of the *spinal cord* shows no changes in its coverings, vessels, or substance.

The muscles were critically examined to determine if there were any signs of violence induced by the current or the contraction it caused, and with a negative result. The muscles of the chest, abdomen, and calf were normal, bright red, firm, and show not the slightest tearing or rupture.

Remarks.—In looking carefully over the details of this autopsy and comparing this report with that of the four previous cases of infliction of the death penalty by electricity, the following points may be noted:

1. The passage of an electrical current of the pressure employed in these cases (of approximately from 1,400 to 1,700 volts) and in this manner does not do any damage to any of the internal organs, tissues, or muscles. None of these parts are lacerated or changed in volume; neither are there any gross chemical or morphological changes or alteration of their finer structural features.

2. The local thermic effects of the electrodes are limited to the outer scarf skin. The true skin beneath is not damaged to any appreciable extent. The epidermis or scarf skin may be separated from the deeper skin, and resembles in this way an ordinary blister from which the fluid has escaped. The blisters about the knee in this case are like the ordinary familiar water blisters on the hands from friction, or the blisters which physicians often have occasion to produce in their treatment of disease. Where the skin has been exposed to the weather, and is tougher and more resistant, as on the forehead and scalp, the blistering does not take place, whereas in the more sensitive delicate skin of unexposed surfaces, as at the fold of the knee joint or the calf, the superficial blistering is more readily induced. Compared with the four previous executions, the changes in the skin induced by the local thermic action of the electrode are even still less in degree in this case, and may be pronounced altogether trivial.

3. The occurrence and distribution of the minute hæmorrhagic spots (described more completely in the previous cases) are not a uniform or constant feature in these cases, and as they are found after death from the greatest variety of causes, they can not properly be regarded as positively characteristic of death by this method.

4. The attitude of the body on the autopsy table is peculiar and very uniform. When the electrodes are applied at the knee

flexure, the leg is invariably slightly flexed at the knee and a trifle adducted.

Charles McElvaine.—Approximately two to three minutes after the breaking of the last current the reflex action of the voluntary muscles was tested as follows:

1. The patellar reflex was tried in the usual way without any response from the muscles either in the knee of the electrode side, which was rigid, or the knee of the other side, which was relaxed.

2. The cornea was touched with the finger without eliciting any exertion from the muscles of the eyelids.

3. The nipples were pinched with a forceps, and the surrounding skin was scratched and lightly scarified with fine scissors; but this did not induce any motion of the muscle groups, or even any fine fibrillary twitching of the individual fibers of the subjacent muscles.

4. One of the muscles of the abdomen (the rectus) was exposed, but showed no activity when cut or irritated with the knife. Voluntary muscle reflexes to ordinary stimuli were absent. The activity of smooth or involuntary muscle was *not* interfered with; thus peristalsis of the intestines and the cremasteric reflex could be excited.

After these tests the autopsy was made immediately.

I. *External Appearances of the Body.*—The subject is a trifle below the medium stature, well nourished, has no deformities, and has well-developed muscular system. The lips are pallid, but the nostrils and interior of the mouth are perfectly natural. The left eyelid is quite firmly closed, while the other lid is partly open. The delicate membrane coating the front of the cornea has not been disturbed by the head electrode. The pupils are about midway open, nearly uniform, and measure about two millimetres and a half in diameter. The eyeballs are natural. There is no distortion of the face, such as muscular contractions or marks of violence, to mar the countenance.

Rigor mortis is marked only where the current was applied; the electrode leg is flexed at the knee joint at an angle of about 90°, and is a trifle adducted. The arms, which received the first contact, are less flexed than the knee joint, and the fingers are almost completely closed in the palm of the hand.

There are no evidences of a seminal emission.

The skin is everywhere perfectly natural, except at the points of application of the electrodes, and here there are some superficial changes in the outer layers of the skin. In these places, at the back part of the right knee joint and on the upper surface of the wrists (where the first contact was made), the

thin outer scarf skin is wrinkled and raised up or partially detached from the true or deeper skin beneath.

These superficial patches on the skin in the electrode regions are not extensive and do not measure more than two to two inches and a half in diameter. In order to see if these patches involved the skin beyond the outer layers, the whole skin was cut through with the knife and looked at critically. It was then seen that the deeper layers of the skin were but very little involved. The deeper or true skin is in places in these patches a little drier than it ought to be, and this is all. The layer of fat beneath the slightly superficially damaged patches on the skin is perfectly normal in every way.

II. *Examination of the Thoracic and Abdominal Organs.*—There is very little to be said about the examination of these organs other than that they were subjected to a thoroughly detailed systematic scrutiny, and nothing abnormal was found either about their shape, consistency, or texture, except the left ventricle of the heart was firmly contracted, while the right ventricle was flaccid. Valves and heart muscle normal.

The left kidney (measuring 6 × 13 centimetres in diameter) contained a number of larger and smaller cavities (the largest one centimetre and a half in diameter) near the region of the pelvis, some of which contain calculi. Such a condition of the kidney is due to an old chronic previous process, and is to be expected in persons who develop calculi in the kidney.

All of the viscera and organs of the thorax and abdomen were examined.

III. *The Central Nervous System.*—The brain is brachycephalic and is perfectly normal as to its coverings, in the disposition and structure of its blood-vessels, in the arrangement of the convolutions, fissures, and sulci, and in the texture and relative distribution of the gray and white matter. The fourth ventricle and its floor are normal. The superior portion of the spinal cord is normal. (The brain was not completely dissected, in order that it might be transported to Professor Donaldson, of Clarke University.) The brain with the pia weighed, on scales weighing to half a gramme, 1,442 grammes. The dura mater weighed 52 grammes.

IV. *The Muscular System.*—The muscles are red and firm and show no signs of tearing, rupture, or hæmorrhage.

Conclusion.—As might naturally have been expected, the adoption and successful inauguration of this new method of capital punishment has not been accomplished without encountering vigorous opposition, amounting in some instances to violent and apparently malicious denun-

ciation of the acts and motives of those who were called upon to act as principals in carrying out a law the establishment of which must eventually be regarded as an important advance in criminal jurisprudence in the direction of a higher civilization. But even to-day, despite the wide publication of unofficial reports, proclaiming the method a failure and apparently designed to invest it with an air of repulsion, brutality, and horror, it is conceded by substantially all unprejudiced individuals who have witnessed these executions, or who are reliably informed as to the facts relating thereto, as well as by a large and increasing proportion of the daily press, that the intent of the law to effect sudden and painless death has been fully attained in each instance. That a method of judicially inflicting the penalty of death in punishment of the crime of murder will ever be devised which in its operation shall be divested of that sense of awe and dread usually experienced, especially by laymen, when in the presence of death, is not to be expected; and even were it possible, the wisdom of such a method might well be questioned, so long as the welfare and protection of society require the infliction of such a penalty to deter men from committing murder.

It should be borne in mind that up to the time of Kemmler's execution there was no recorded instance of death having been deliberately effected on the human subject by this method, the only knowledge on the subject being derived from experiments on lower animals and from observations in cases of death from accidental contact with live electric wires and from such deductions as could logically be made from technical knowledge of electro-motive force; hence the first execution by electricity was necessarily to some extent experimental and attended with possible elements of uncertainty, owing in part to crudeness in the law and in part to certain minor defects in the arrangement and operation of the apparatus and to the inexperience of those in charge. In spite of these defects, however, the important fact remains that the prisoner was instantly rendered unconscious and death was painless.

Of the nearly one hundred physicians, many of whom are eminent members of their profession, who have witnessed one or more of these executions, only two have dis-

sented in any essential particular from the conclusion that this mode of inflicting the death penalty destroys conscious and organic life, both aggregate and segregate, with a suddenness and thoroughness that is not attained by any other known method. One of these gentlemen, a distinguished surgeon and an ardent opponent of capital punishment in any form, witnessed the Kemmler execution, and while concurring in the general opinion that unconsciousness was instantly produced by the first contact, still thought there was a possibility that resuscitation might have been accomplished by means of hypodermic injections of brandy—that is, after the first contact. The other dissenting physician, who is an advocate of the execution of criminals by means of suffocation with toxic gases, witnessed the execution of McElvaine. He also agreed that unconsciousness was instantly produced by the first contact, but thought that the second shock was required to effect absolute death. There is no reason to doubt the sincerity of either of these gentlemen.

Dr. Van Gieson, in his official report of the McElvaine autopsy, in speaking of the rapid abolition of reflex action of the voluntary muscles, says:

> This tends to show how superlatively complete and far-reaching the effects of the currents are in abolishing life, not only in the concrete form, but also in the integral activities of the body which in other forms of sudden and violent death is liable to persist for a time after life is extinct. From observations at this execution, as well as at the subsequent examination of the body, the current appears at first not only to extinguish life in the ordinary sense of the word, so far as consciousness, feeling, and volition are concerned, with overwhelming suddenness, but reaches beyond this and destroys the energies of the individual component parts of the body so that they can not be raised into activity by artificial mechanical stimulation, as is usually the case in sudden violent death.

The experience thus far had has demonstrated that the only reasonable objection to so-called "electrocution"—at least so far as the individual is concerned—as compared with other modes of inflicting the death penalty, lies in the fact that the application of a current of lethal energy results in the generation of heat at the point of contact, and, if sufficiently prolonged, is attended with vesication of the

skin at that point, owing to the temperature of the moisture on the electrodes becoming elevated to the boiling point, while if the sponges are allowed to dry out, local burning may occur. This occurs, however, if at all, toward the end of the contact and long, comparatively, after conscious life is extinct; hence the objection is, after all, merely a sentimental one. Furthermore, it may reasonably be assumed that a method of avoiding this local thermal effect will soon be determined.

Finally, as compared with hanging, in which death is frequently produced by strangulation, with every indication of conscious suffering for an appreciable time on the part of the victim, execution by electricity is infinitely preferable, both as regards the suddenness with which death is effected and the expedition with which all the immediate preliminary details may be arranged. By the latter method the fatal stroke renders the subject unconscious in an infinitesimal fraction of a second—so small as to be beyond the power of the human mind to estimate it—while, at the same time, it destroys both conscious and organic life in a shorter space of time than is possible by any other known method. In other words, it is the surest, quickest, most efficient, and least painful method of inflicting the death penalty that has yet been devised.

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