and subsequently the stored-up electricity can be employed in heating a platinum wire or knife for cautery purposes, or for illumination.

When this system is fully developed, storage-cells, or accumulators, will be provided from some station and transported to any point desired, and the force given out as required. Furnished with suitable platinum loops, knives, and cautery, the operator can employ the machines anywhere. Obviously, this method will be utilized on a large scale for various operative procedures—for the *removal of the tongue*, of *polypi*, of *hæmorrhoids*, for opening *the trachea*, *deep-seated abscesses*, etc. A beautiful application of the galvano-cautery was made by Thomas, when he opened the sac of a tubal pregnancy by a galvanic knife. The evident advantages of this system are the little pain which attends the operation, and the absence of hæmorrhage. It is necessary to accurately adjust the strength of current, so that the wire or knife will have the requisite temperature to cut the tissues sufficiently and yet not so rapidly as to prevent adequate closure of the vessels. (For full details, see the author's "Treatise on Medical Electricity," second edition, p. 262, *et seq.*)

Static Electricity.—The modified Holtz or Toepler-Holtz electrical machine is now used to procure all of the nerve and muscular effects hitherto obtained by faradic electricity, and also therapeutical results of a very striking kind. It has long been known that chorea and other nervous affections may be readily cured by static electricity, but a remarkable extension has been given to the subject by late discoveries. *Chorea* is now treated by the "electric bath," sparks being drawn from the spine. If the Holtz machine is used, sparks can readily be drawn through the clothing, by presenting the brass knob along the spine. The results, which have been so long obtained at Guy's Hospital by this mode of electrical applications, are now generally conceded. It seems to be the most successful method of treating this disease. *Neuralgia* is now promptly relieved in most instances by insulating the patient and drawing sparks from along the trajectory of the nerve affected. The pains of *progressive locomotor ataxia* are much benefited in the same way, and it is said the disease itself is arrested. *Amenorrhœa*, other conditions favorable, is quickly cured by sparks, or a shock sent through the pelvis. The *general nutrition* is greatly promoted by electrization by sparks.

The Toepler-Holtz machine may, by connecting the interior of one condenser with the exterior of the other, be utilized to procure the muscle and nerve reactions of the faradic current.

Trouvé's Polyscope, referred to above, will probably be largely employed in the future, for the purposes of illumination. Suitable throat and other mirrors, platinum knives, and loops, are furnished with the instrument for illumination of the cavities, and for the various caustic operations. It is very powerful, occupies but little space,

and promises, when certain mechanical defects are overcome, to fulfill more perfectly than any other apparatus the requirements of a surgical galvano-caustic and a medical illuminating apparatus.

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Nux-Vomica.—The seeds of *Strychnos nux-vomica* Linné (Nat. Ord. *Loganiaceæ*). (U. S. P.) *Noix vomique*, Fr. ; *Krähenaugen*, Ger.

Abstractum Nucis Vomicæ.—Abstract of nux-vomica. Dose, gr. ss—gr. ij.

Extractum Nucis Vomicæ.—Extract of nux-vomica. Dose, $\frac{1}{6}$—gr. $\frac{1}{2}$.

Extractum Nucis Vomicæ Fluidum.—Fluid extract of nux-vomica. Dose, ♏ j—♏ v.

Tinctura Nucis Vomicæ.—Tincture of nux-vomica. Dose, ♏ j—♏ xv.

Composition.—Nux-vomica contains two alkaloids and a peculiar acid. The alkaloids are *strychnine* and *brucine*, and the acid *strychnic* or *igasuric acid.* The proportion of strychnine ranges from one fourth to one half of one per cent, and of brucine from one eighth to one per cent. These wide differences are in great part due to the varying skill of the chemists who have made analyses. Besides these, another crys-

tallizable base has been discovered in the mother-liquor from which strychnine and brucine have been precipitated. This has been named *igasurine*. The alkaloids exist in nux-vomica in combination with igasuric acid.

Strychnine is a white or grayish-white powder, of an intensely bitter taste, nearly insoluble in water, slightly soluble in cold alcohol, and readily soluble in boiling alcohol. When heated it melts, and by strong heat is wholly dissipated. It is but slightly or not at all reddened by nitric acid. A small portion dissolved in official sulphuric acid yields, on the addition of a minute quantity of bichromate of potassium, a splendid violet color.

Strychninæ Sulphas.—Sulphate of strychnine. A white salt, in colorless, prismatic crystals, which are without odor, exceedingly bitter, soluble in ten parts of water, sparingly soluble in alcohol, and insoluble in ether. They effloresce on exposure to the air, and melt when heated, losing nearly fourteen per cent of their weight of water of crystallization. By a strong heat they are wholly volatilized. Dose, gr. $\frac{1}{60}$—gr. $\frac{1}{30}$. (U. S. P.)

Antagonists and Incompatibles.—The paralyzers, such as woorara, conium, tobacco, opium, belladonna, and physostigma, antagonize the actions of strychnine in a part of the sphere of its influence. They do not antagonize its toxic action. Chloral, tobacco, bromide of potassium, ether, and chloroform (inhaled), are its true physiological antagonists.

In cases of poisoning, tannin and the vegetables containing it should be freely administered, for the tannate of strychnine is very insoluble. Emetics, or the stomach-pump, must be used promptly. The tetanic spasms are best controlled by chloral and the inhalation of ether, or by tobacco, or by the bromide of potassium in very large doses (℥ ij—℥ ss). The maintenance of artificial respiration has a decided effect in postponing in animals as in man the lethal action of strychnine.

Strychnine should not be combined with bromides, chlorides, and iodides, in the same solution. Accidents have happened by taking the last portion, which will contain all of the strychnine, precipitated as hydrobromate, hydriodate, etc.

Synergists.—Brucine, picrotoxine, thebaine, ergot, and, according to my own experimental investigations, belladonna, electricity, cold, etc., promote the activity of nux-vomica and its alkaloids.

Physiological Effects.—The preparations of nux-vomica are extremely and persistently bitter. Like all bitters, they promote the flow of the stomach and intestinal juices, increase the digestive power, and thus favorably affect the appetite. They also hasten the intestinal movements, and the stools voided are somewhat relaxed.

The alkaloids of nux-vomica are very diffusible substances, and

enter the blood very quickly. They lessen somewhat the oxidizing power of the blood, but this effect is quite insufficient to account for the physiological reactions produced in the nervous system. Small medicinal doses of nux-vomica and its alkaloid accomplish no more than other bitters, as respects the circulation. More or less plethora, slightly increased action of the heart, and, as a consequence of this condition of the vascular system, a greater energy in the performance of the various functions, result from their administration.

When a lethal dose of nux-vomica, or of its alkaloid, has been taken, characteristic symptoms follow in a few minutes. The state of the stomach as to food, the presence of tannic acid in the food, and of fat, probably ; also the condition of the blood-vessels, influence the rate of absorption, and symptoms may begin in a few minutes or be delayed an hour or even longer. When a full medicinal dose has been taken, some slight shuddering, a sense of constriction of the fauces and jaws, sudden pains like electric shocks passing through the limbs, startings of some of the voluntary muscles, dilated pupils, "a meaningless smile," paleness of the face, followed by flushing and increased warmth of the surface and perspiration, are symptoms which may be produced without further development of a toxic action. If the dose be large enough to cause death, the above-described symptoms are quickly followed by tetanic convulsions, in which nearly all the voluntary muscles are engaged. When the paroxysm occurs, a shudder passes through the whole frame ; the head and extremities jerk and twitch, and then suddenly a general tonic convulsion takes place —the limbs are extended, the hands clinched, the toes and feet incurvated, the head bent backward, the body arched and rigid, the abdominal muscles hard and tense, the respiratory muscles fixed so that the body, curved in the form of a bow, rests on the occiput and heels. The countenance assumes a ghastly grin—the *risus sardonicus ;* the arrest of the respiratory movements suspends oxidation of the blood, and the skin becomes cyanosed ; strong erections of the penis occur, and frequently involuntary evacuations of semen, urine, and fæces take place. Rarely does death ensue in the first paroxysm ; the spasm relaxes, and nothing remains of the attack but the muscular soreness and fatigue, and the sense of impending dissolution. Absolute quiet retards the paroxysms. At first the senses are preternaturally acute, and, as the reflex function is abnormally excitable, the slightest peripheral irritation suffices to bring on the spasms. Generally patients experience comfort when the limbs are strongly held, or even rubbed, during the paroxysms ; but, in the interval, absolute quiet is most grateful. The mind remains unaffected until the close, or, at least, until carbonic-acid poisoning sets in. The paroxysms rapidly succeed each other, and increase in duration and severity, death occurring usually by fixation of the muscles of respiration, or

by exhaustion, and within two hours, as a rule, from the beginning of symptoms.

The remarkable similarity in the symptomatology of traumatic tetanus and strychnine tetanus requires that the points of difference between them be clearly set forth. In strychnine tetanus the jaw-muscles are not first thrown into spasm, and are not always rigid during the paroxysm ; in traumatic tetanus, trismus is one of the first symptoms. In strychnine tetanus, after the convulsion, lasting from a half to one or two minutes, there is usually complete relaxation ; in traumatic tetanus rigidity of the affected muscles continues. A case of strychnine tetanus goes on rapidly increasing in severity, and lasts from a few minutes to two hours ; a case of traumatic tetanus proceeds more slowly, and lasts always a number of hours, and may extend over days and even weeks. And, lastly, in traumatic tetanus, the capital symptom of a wound or injury exists.

No very characteristic *post-mortem* appearances result from strychnine-poisoning. The muscles, at first relaxed, become rigid, the feet turned in, the fingers clinched, or the body may maintain the position of opisthotonos, in which it was at the moment of death. Congestion of the cerebral and spinal meninges is usually observed, and Schroeder Van der Kolk first ascertained that dilatation of the vessels and sanguineous extravasations are found in the gray matter of the cord (medulla oblongata), and this observation has since been repeatedly confirmed.

The smallest quantity of strychnine which has produced a fatal result in an adult was a half-grain. Rarely can one twelfth of a grain be given without causing muscular twitchings, and one sixteenth of a grain has caused death in a child of between two and three years.

The effects of strychnine are exerted on the spinal cord, on the seat of the motor functions. It does not affect the functions of the motor nerves directly—the irritability of the motor nerves is not destroyed by strychnine, it is exhausted by over-stimulation. The sensory nerves are either unaffected, or their irritability is exhausted. The reflex functions of the spinal cord are exalted. The afferent nerves, while preserving their irritability, communicate impressions to the reflex centers, motor impulses are quickly originated, and the muscles through the motor nerves are fixed in a state of tonic contraction. The over-stimulation of the cord and the motor nerves exhausts the irritability of the latter. The muscles preserve their contractility.

The effects of strychnine are not limited to the nervous system of animal life : the organic nervous system participates in the perturbation. The dilatation of the pupil, the erection of the hair-follicles, the *tinnitus*, the increased heat in the limbs, and the perspiration which are produced when strychnine is injected subcutaneously, indicate an influence on the sympathetic system similar in kind to that exerted

on the voluntary. Experimental investigations have confirmed these clinical observations. A very considerable rise in the arterial pressure, contraction of the vessels in the frog's web, and increased action of the heart, have been experimentally demonstrated to be caused by strychnine (Sigmund Mayer).

Magendie, who made the first study of the actions of strychnine, found that, by previously destroying the spinal cord, no convulsions followed the administration of a poisonous dose. The precise agency of the cord is disputed, but it is in a high degree probable that the condition is one of exaggerated reflex excitability, so that the smallest possible peripheric irritation induces a response in the reflex motor center. When Setschenow's inhibiting center of reflex movements is withdrawn as in the decapitated frog, the spasms are induced as before. The passage over the face of the faintest current of air, even the mental conception of such an impression, will excite the spasms. Absolute repose, as by placing the poisoned frog under a bell-glass, the table firm so that no jar can reach the animal, and light excluded, has a decided effect in preventing attacks. If a poisoned human subject is similarly protected, the convulsions are diminished in violence. Again, if, when the convulsions are impending, the limbs are firmly grasped and held, the force of the spasm is lessened thereby. The medicines most effective in affording relief are those which lower the activity of the reflex function—notably chloral, bromide of potassium, etc. These facts indicate that an exaltation of the reflex function of the spinal cord is caused by strychnine. But this is probably not alone sufficient : irritation of the motor cells is also a factor (Spitzka). In opposition to the commonly accepted view, Falck maintains that strychnine acts primarily on the brain, or rather on the vaso-motor center of the brain, then on the inhibitory center for the heart, and the respiratory center, and lastly on the reflex apparatus of the cord. The spasms are the combined results of these actions.

Bernard held that the sensibility of the sensory nerves is destroyed by strychnine, but after the motor functions have ceased. Martin-Magron, and subsequently Vulpian, ascertained that the sensibility persists after motility has ceased. This contradiction of supposed facts has been examined more recently by Busch, whose observations, if entitled to belief, support the statement of Bernard. Busch has found that the toe of the poisoned frog may be crushed, and the central portion of the divided sciatic may be burned, without inducing spasms or reflex movements, when the slightest jar of the animal will cause strong convulsions. Kölliker and Vulpian, with many others, hold that the excitability of the motor nerves is so far impaired by strychnine that irritation of the nerve-trunk produces very feeble or no muscular contractions. The American observers Klapp and Spitzka both maintain that the peripheral nerves are unaffected in strychnine-

poisoning. Martin-Magron et Buisson and Vulpian find that the action of strychnine is local on the nerves, and is therefore greatly influenced by the quantity of the poison reaching them. If the dose of strychnine is small, the motor and sensory nerves remain unimpaired; but if the dose be large, their irritability is destroyed. The influence of the quantity administered is consequently very great, and is exhibited in other respects. Thus, while a merely lethal dose causes strong convulsions, a very large toxic dose will kill at once without any reflex disturbances. It is impossible, then, to make the distinction between motor and sensory nerves as respects the action of strychnine: it either destroys or spares the excitability of both.

While strychnine exalts the irritability of the reflex motor center, it stimulates the vaso-motor center or centers in the cord, with the result of greatly increasing the blood-pressure. This rise in blood-pressure is prevented by dividing the cord, according to Mayer, Klapp, and others, but, according to Schlesinger, not. Now, as it has been found by Richter, who has studied the circulation in transparent parts, by Mayer, and by Spitzka, that the arterioles strongly contract under the influence of strychnine, the blood-pressure must rise from this cause; hence, the observation of Schlesinger is probably correct, that the blood-pressure rises in strychnine-poisoning, notwithstanding division of the cord. As has been tersely expressed by Spitzka, "its vaso-motor effect is to increase the blood-pressure and the rapidity of the blood-current by contracting the arterioles. This effect is independent of the central nervous system." The effects of strychnine on the heart differ in cold- and warm-blooded animals, according to most authorities, and decidedly, also, according to the size of the dose. On frogs, the diastolic pause is prolonged, and the force of the systole augmented, so that arrest of the heart's action may take place in tetanic rigidity. These results, Spitzka holds, are due to an action on the cardiac ganglia and on the pneumogastric. The previous observations of Heinemann, however, do not correspond, for he finds that these phenomena are produced after the vagi are divided. In warm-blooded animals the heart's action is accelerated, while the tension is raised. Klapp, however, finds that strychnine slows the pulse in the cat and rabbit, and that the retardation is due to an impression on the cardiac motor ganglia, and not to stimulation of the inhibition. He finds that the action is the same on both classes of animals. These contradictions are probably due to the difference in the dose employed. A large toxic dose of strychnine will paralyze, instead of stimulate, the vaso-motor center in the medulla, and thus prevent any rise of blood-pressure. A small, merely lethal dose will stimulate the cardiac ganglia, the pneumogastric, and the vaso-motor ganglia; but a large toxic dose will slow the heart, paralyze the vagi and the accelerator apparatus, and depress the vaso-motor functions generally. In the

course of annual experiments for class instruction, the author has constantly observed the difference in results due to the quantity administered.

From clinical observation, in the absence of any experimental evidence, strychnine has been ascertained to have a stimulating effect on the respiration. If the dose is less than sufficient to tetanize, the function of respiration is increased in energy and in depth. Hence, this agent antagonizes the respiratory poisons, as well as those morbid states which depress the respiratory function.

On the blood, the experiments of Harley show, strychnine has some action. Agitation of blood with the air, in the presence of strychnine, is followed by a less production of carbonic acid than if strychnine be not present, but such experiments are entitled to small consideration. Strychnine, as Hippel and Cohn have shown, stimulates the retina and increases the sharpness of definition and the area of the visual field. These facts explain the curative effects of strychnine in certain diseases of the retina.

Very peculiar phenomena have been observed by Spitzka as a result of chronic poisoning—an entirely new subject. It appears to be exceedingly difficult to keep animals alive, but Spitzka succeeded in maintaining five frogs in tetanus for over forty days. Symptoms occur under these circumstances quite distinct from those produced in acute poisoning by strychnine. Disease in the cord is set up, "partly as an insular sclerosis, partly as an hæmorrhagic or non-hæmorrhagic myelitis." These experiments demonstrate that, to maintain a constant effect by strychnine in the beginning, the dose must be increased, but later the quantity given may be decreased and administered at longer intervals. The importance of these observations from the therapeutical point of view is, indeed, great. The symptoms occurring from chronic poisoning are, as respects the spasms, a diminution of their energy, the development of an ataxic state, with tremors and pupillary myosis. These phenomena approach those produced by picrotoxin, and are intermediate between the effects of strychnine proper and of curara or methyl strychnium.

THERAPY.—The tincture of nux-vomica is one of the numerous remedies proposed for the *vomiting of pregnancy*. It is best adapted, according to the author's observation, to those women who have a sea-sick feeling and who do not vomit much. Half a drop to a drop, in cherry-laurel water, or in simple water, every hour or two, is a suitable dose. Like all other remedies, nux-vomica often fails in this malady. Owing partly to its intense bitterness, and partly to its influence on the nervous system, the tincture of nux-vomica is an excellent stomachic tonic, adapted more especially to the treatment of those cases in which there is a neurotic element, as, for example, *atonic dyspepsia* and *gastralgia*. From five to ten drops three times a day be-