bewegungen anzuwendende Methode, erläutert am Gelenkmechanismus des Vorderarms beim Menschen. Abhandl. der mat.-physisch. Classe der Königl. Sächs. Gesellschaft der Wissenschaften, vol. iii., 315–336.

ELECAMPANE.—Inula. The root of *Inula Helenium* L. (fam. *Compositæ*).

This is a large, rank, perennial herb, with a thick fleshy rootstock and root, and an upright, branched, hairy or rough stem, from one to two yards high. The lower leaves are half a yard or more long and half as broad. The yellow flower heads are several inches broad, somewhat resembling small sunflowers.

Inula grows, either indigenous or naturalized, in the temperate parts of Europe, Asia, and North America, and is also cultivated in Europe.

The root should be collected either in spring or in autumn, suitably sliced, and dried with gentle heat. It is then "in transverse, concave slices or longitudinal sections, with overlapping bark, externally wrinkled and brown; flexible in damp weather; when dry, breaking with a short fracture; internally grayish, fleshy, slightly radiate, and dotted with numerous shining, yellowish-brown resin cells; free from starch; odor peculiar, aromatic; taste bitter and pungent."

Composition.—*Inulin, helenin, alant camphor, alantol, essential oil, alantoic acid*, waxy, acrid, resinous, and bitter substances, besides ordinary vegetable principles and ash. The first of these, although of no medicinal properties, is the most interesting, and has received its name from this plant. It was discovered in it in 1804 by Valentine Rose, who also pointed out its intermediate position between starch and sugar. Since then it has been observed in the roots of nearly a hundred *Compositæ*, but in the plants of no other family excepting the *Lobeliaceæ*. It has likewise not been found in the aerial portions. The *alant camphor*, or *helenin*, is obtained by boiling the roots with alcohol, filtering, and adding cold water to the filtrate, when the helenin separates, upon standing, in fine needles; or it may be separated by distillation. It is a faintly odorous and nearly tasteless, volatile substance, insoluble in water, but soluble in ether, oils, and hot alcohol. The *oil* is a yellow liquid of mint-like odor, and contains alantol ($C_{10}H_{16}O$). Alantic acid is a crystalline substance associated with the oil.

Action and Use.—Although an old remedy, it can hardly be said that elecampane has any important place in modern therapeutics. It is a stimulant, stomachic tonic, and enjoys a slight reputation in the treatment of amenorrhœa and bronchitis. Dose, from 2 to 4 gm. (gr. xxx. ad ʒ i.) in decoction or infusion. *W. P. Bolles.*

ELECTRICITY: THE DESTRUCTIVE AND LETHAL EFFECTS OF HIGH-PRESSURE* CURRENTS.—There are delivered from the high-pressure line of a big transmission plant, at night glowing blue with the energy that is streaming off into the dielectric, perhaps thousands of kilowatts to distant transformers, which may serve to light a whole city or furnish power to operate a street-railway system. The one result or the other obtains according to the conditions of the conducting circuit; but, in both instances, it is energy which is delivered at the terminals, and which by its expenditure produces the different phenomena instanced.

In the application of an electric current to the human organism, whether administered therapeutically, encountered accidentally in the pursuit of one's avocations, or whether applied with intent to kill (electrocution), energy is expended within the tissues of the body, causing physiological change, pathological lesion, or destruction of life. The phenomena produced, whether for life, disability, or death, depend not alone upon the initial pressure, but upon all the conditions of the conducting circuit, *i.e.*, resistance electrical and vital, as well as position, superficies, and nature of contacts. A recognition of the oneness of this energy, whether of low or of high pressure, whether continuous or alternating in its direction, as well as the precise and definite laws under which it acts, conduces to an intelligent appreciation of the varying phenomena produced by its expenditure. A study of the action of an expenditure of energy from a high-pressure source or from a lower pressure, but capable under suitable conditions of producing injurious or destructive effects, involves an analysis of:

(1) Experiments made upon animals with a view to determine the cause of death;

(2) Of such accidents as occur in the use of industrial currents;

(3) Of the phenomena observed in the electrocution of criminals.

There is a considerable array of experimental work to be drawn from, going back to the time of Nollet, but much of it was conducted in a crude and unscientific manner, and is of little save historical value. The most careful and scientific work has been done within the past eleven years; and the conclusions reached by the different experimenters referred to in the following analysis point in almost every instance to a uniform action and set of conditions, although only interpreted by Prévost and Battelli and Cunningham.

Under the second head the evidence is not so conclusive as in the first and third. In accidents due to electric currents—by reason of the fact that they are accidents and occur unexpectedly—the precise conditions of the conducting circuit, as well as the phenomena pertaining to the mechanism of injury or death, are rarely observed with scientific accuracy. Still, considerable data have been accumulated, which, with the data of experimental work and those secured from the electrocution of criminals, suffice to further an intelligent analysis of the subject.

Under the third division—the electrocution of criminals—every opportunity is afforded to note exactly all the conditions of the conducting circuit, the pressure, the superficies, position and nature of contacts, the precise measurement of current in amperes, the time, the resistance, the power or watts, and the work or total expenditure of energy in joules. The opportunity also exists, if it could be taken advantage of, for obtaining definite, detailed, and scientific information as to how and when death occurs; as to consciousness and sensation; and also whether resuscitation would be possible by the immediate application of some special method; and it has been suggested that if the law recognized the right of science to have present a trained observer, with the privilege of using the necessary physiological apparatus in order to record graphically the phenomena which take place both during and after the passage of the current, as well as to make a careful study of the post-mortem findings, the result would be of incalculable value in determining the mechanism of death in man.*

The conclusions arrived at as to the manner in which death takes place in man are determined by inference from experimental work, from the accidents which take place in the electrical industries, and from electrocutions; but the data would be more absolute and trustworthy if procured in the way above alluded to, and yet at the same time no harm would be done to the individual suffering the penalty of the law.

Before entering upon a detailed account of experimental work, it would be well to consider the electrical conditions necessary to the production of injurious and lethal effects:

(1) What is to be understood by high-pressure currents in relation to lethal effects—*i.e.*, what voltage is necessary to the production of fatal results?

(2) Is it a matter of pressure—*i.e.*, volts alone, or is it a matter of current—*i.e.*, amperes as well?

(3) What influences the latter, the pressure only, or do high-pressure currents from position and nature of contact act as medium- or low-pressure currents?

An analysis of the experimental work (which will be

* In every instance in which authorities quoted have used the word "tension" in relation to an electric current, the writer has substituted "pressure" in order that the terminology may be exact.

* Cunningham: "The Cause of Death from Industrial Currents."

considered more in detail from the physiological side later on) shows that currents of varying pressure have been used to produce a lethal effect in the same species of animals, while varying pressures are required for different species of animals.

For example: Houston and Kennelly used pressures of from 690 to 1,250 volts alternating (experiments on dogs);* Bleile used from 50 to 100 volts alternating (experiments on dogs);† Kratter used 1,500 volts alternating (experiments on dogs, rabbits, and guinea-pigs);‡ Cunningham employed continuous currents of 115 volts pressure from lighting mains and 124 volts from a battery of accumulators (experiments upon dogs);§ while Prévost and Battelli conducted their experiments with both continuous and alternating currents and pressures varying from a low pressure of 120 volts to a medium pressure of from 240 to 600 volts, and high pressures of from 1,200 to 4,800 volts.‖ They used in their experiments dogs, guinea-pigs, rabbits, and rats. Bokenham and Jones, in their experiments made upon cats, reported the current, viz.: 0.5 ampere, but not the pressure;¶ Tatum used from 0.1 to 1.3 ampere; while Oliver and Bolam give only the physiological results obtained**—to which reference will be made later on,—but neither the pressure nor the current.

Kratter found that rabbits often survived pressures which proved fatal to dogs ten times the size, and Cunningham found it possible instantly to arrest the cardiac function in a very large dog—such as a Newfoundland—with a current of but 0.3 ampere; while the hearts of small, shaggy terriers, although considerably affected, not only withstood repeated shocks of 0.45 ampere, lasting from ten to eighty seconds, but quickly recovered from a shock of 0.7 ampere applied for two seconds and a half. In common with those of Prévost and Battelli, his experiments show that certain species of animals, frogs and turtles, do not succumb to currents of low pressure.

Prévost and Battelli established that with a pressure of 120 volts (alternating currents, contacts good—*i.e.*, one upon the head, the other upon the limbs) death resulted in certain animal species, while others (for example, rats) escaped without harm.

Kratter found that a short exposure to an alternating current of 1,500 volts did not always prove fatal to rabbits and guinea-pigs, while others succumbed presenting typical symptoms.

With currents of high pressure, Prévost and Battelli found that 1,200 volts (the contacts being good—*i.e.*, the one upon the head and the other upon the limbs) could kill all animals by inhibition of the respiratory centre; but that the pressure of the current and the duration of the contact should increase with the size of the animal in order to inhibit the respiratory centre. A rat, for example, succumbed to a pressure of 600 volts for one second, while a rabbit required 1,200 volts for two seconds. A dog of smallest size required 2,400 volts for three seconds, while a dog weighing 8 kgm. resisted a shock produced by the passage of a current of 1,200 volts prolonged for five seconds.†† Nor is the pressure fatal to animals, when acting as a high pressure, necessarily fatal to man.

Of equal importance with the pressure is the position, superficies, and nature of contacts. The latter may be of a material which is a good conductor, but by reason of imperfect contact they may act as a poor conductor, thereby increasing the resistance and diminishing the amperes; the same will be true if the contacts are dry instead of moist. With the skin well wetted with salt solution the resistance is lessened; and with diminution of resistance there is an increase in the amperes. In such a condition of the skin a greater amount of current is delivered to the tissues, producing a fatal result; whereas, if the skin had been dry and able to perform its function as an insulator, the resistance would have been so great as to have limited the flow in current below the lethal dose. A well-insulated contact also serves to increase the resistance and to minimize the current.

The superficies governs the distribution of current on the one hand, or its current density on the other. With large square-inch area of contact, the greater the current diffusion; with small superficies the greater the current density, within a localized area. These are factors of great importance and must never be lost sight of when considering physiological effect.

The position of contacts is of the greatest importance and largely influences the result. All experimental work, as well as what is observed at electrocutions, proves that fatal results ensue much more quickly when the contacts are so placed as to bring the heart, which is the vulnerable organ, on a line which unites the two electrodes—*i.e.*, directly in the conducting path; as, for example, on the head and calf of the leg. When they are placed on the head and fore legs, or in the case of man (electrocuted criminals) on the hands, a much greater pressure is necessary to destroy life. This is because the heart is not in the direct pathway of the current. When both contacts are placed upon the head, higher pressures are required to produce fatal results. Here, by reason of the skull, there is increased resistance; and, as the evidence shows that stronger currents, *i.e.*, greater amperage (see Houston and Kennelly, pressure 690 volts, R. 1,200 ohms, current 6 amperes, dog not killed), are withstood, the pressure must of necessity be proportional. As will be seen further on, the action of the current is different in a head contact than when the heart is included in the circuit. These facts all point to the chest directly over the heart, and to the dorsal region, as the better places for the contacts in electrocutions; but, as it is desirable that consciousness should be annulled at once, the posterior contact could be made to include the cervical spine, medulla oblongata, and the head.

Duration of contact, or time, is another important element. An instantaneous contact with a high-pressure current may be encountered with impunity, but a fatal result will ensue if an application of several seconds—five, ten, or more—be made; or, if a high-pressure current be applied for an instant of time and repeated, fatal results may ensue.

As to the amperage of a lethal current, it is not definitely known, but all the evidence obtained from experiments on animals and accidents with industrial currents show that it is very small—probably much under one ampere. In the application of the death penalty as practised in the State of New York, the strength of the alternating current passed through the body of the criminal is usually seven or eight amperes. In experimental work, the species, weight, and age of the animal have influenced the result, and the age of man, as well as the vital resistance in both man and animals, is a factor that must be considered in determining the lethal dose. In his experiments Cunningham found that young, well-nourished, and hardy dogs bore a stronger current than those older and ill-nourished, but that the size and weight seemed to bear no relation to the minimum current.

The nature of the pressure, whether continuous or alternating, is not without its influence. Cunningham found that alternating currents of moderate frequency, intermittent and coarsely pulsatory currents, were able to produce fibrillary contractions of the heart much more readily than a non-alternating or a continuous current. Tatum found alternating twice as fatal as continuous currents, but when the animal experimented upon was under ether the difference was much less marked. This would point to the influence of the powerful muscular contractions in the production of lethal effects; as, under the influence of anæsthesia, there would be a condition of general muscular relaxation which would tend to

* Houston and Kennelly: "Death by the Alternating Currents."
† Bleile, A. M.: "The Cause of Death by Electrical Shock."
‡ Kratter: "Lesions of Fatal Electrical Currents."
§ Cunningham: "The Cause of Death from Industrial Currents."
‖ Prévost and Battelli: "The Mechanism of Death by Electric Currents in Man."
¶ Tatum, Edward: "Death from Electrical Currents."
** Oliver and Bolam: "The Cause of Death by Electric Shock."
†† Battelli, Frederic C.: "The Mechanism of Death by Electric Currents in Man."