MEDICAL AND PHARMACEUTICAL CONTRIBUTIONS TO ELECTRICAL SCIENCE.*

BY CHARLES WHITEBREAD.[1]

Pharmacy and medicine have played an important rôle in the development of electrical science because pharmacists and physicians were among the first to make practical use of this agency, and because it was the discoveries, studies and writings of these men which furnished the impetus for the early investigations and researches that have made electricity the agency for good which it is to-day.

Our science, and science generally, does not need champions to proclaim the part taken in human progress, as the accomplishments of the past and of the present speak for themselves. It is a human failing, however, to accept the benefits which come to us as the direct result of the scientific investigations which have made the forces of Nature our servants, and to forget the part taken by mankind to make possible the comforts and conveniences which we now enjoy. Let us, therefore, see how we obtained the fundamentals of our knowledge of electricity, noting particularly the contributions of our own and affiliated professions, and how medicine generally has benefited from a branch of science based in no small degree on the discoveries of medical men.

The earliest mention of electricity is supposed to have been made by the Ionian philosopher, Thales of Miletus, who died about 548 B.C., and who discovered that if a piece of smooth amber is rubbed with a dry cloth it attracts light bodies placed near it. Although Thales was regarded as one of the seven wise men of ancient Greece, it is recorded of him that he thought amber possessed a soul, and that it was nourished by substances which it attracted to itself. Natural magnets were known in Europe more than two thousand years ago, and the Chinese have used them since 600 B.C. They were portions of lodestone, native oxide of iron, and the word magnet came into use because this ore was found in Magnesia, Asia Minor.

The observations of Thales concerning amber, and of others relative to the magnet, remained without development until the 16th century, when Dr. William Gilbert, physician to Queen Elizabeth of England, published a treatise on the magnet in the year 1600, giving the results of the experiments which he had conducted up to that time. This physician was the discoverer of frictional electricity in a large number of substances; of static electricity; the repulsion of similar and the attraction of dissimilar poles of the magnet; the diversion of the magnetic needle by electricity; the strengthening of a magnet by an armature; the fact that iron bars become magnetic along the magnetic meridian; that the earth itself is an enormous magnet, etc. We are also indebted to Dr. Gilbert for the name electricity which was derived from a Greek word meaning amber, and his investigations of a subject which had lain dormant for more than two thousand years, marked the inauguration of the experiments and researches which have since added so greatly to our fund of knowledge.

A German scientist, Otto vonGuericke (1602–1688), made the first electric machine, which consisted of a globe of sulphur on an axis mounted in a frame,

---

* Section on Historical Pharmacy, A. PH. A., Washington meeting, 1934.

[1] Assistant Curator, Division of Medicine, U. S. National Museum.

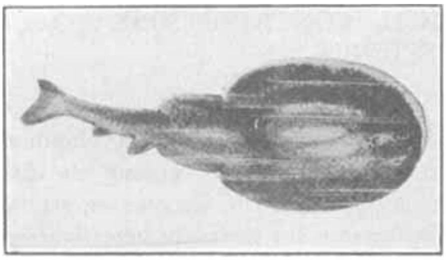

Fig. 1.—The Electric Ray (*Torpedo galvani*). This fish, common in the tropical seas, was the source of the static electricity first employed in the treatment of disease. It was an animal drug at the beginning of the Christian Era.

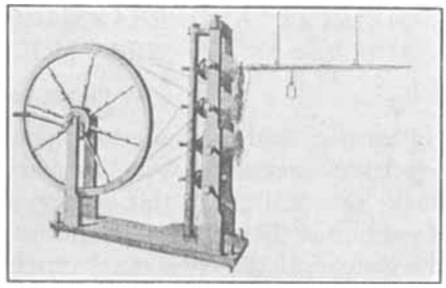

Fig. 3.—Dr. Watson's Electric Machine. The mechanical rubbers are to the left of the globes, and the conductor is suspended by silk cords on the right. (From Priestley's "History of Electricity," 1775.)

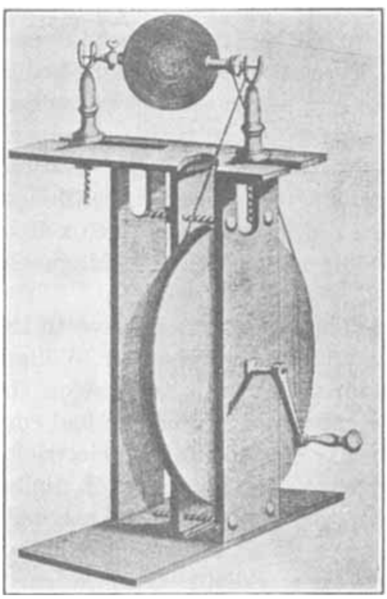

Fig. 2.—Hawksbee's Electric Machine. An early improvement on the first electric machine made by von-Guericke. (From Priestley's "History of Electricity," 1775.)

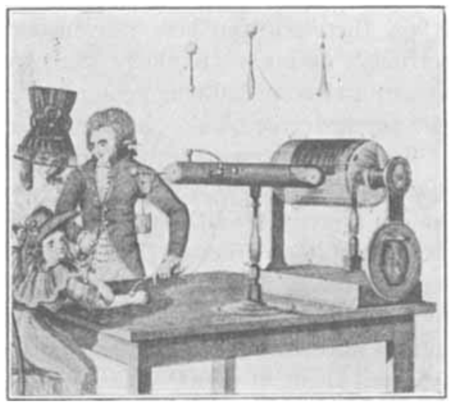

Fig. 4.—Administration of static electricity. (From a print published in 1799.)

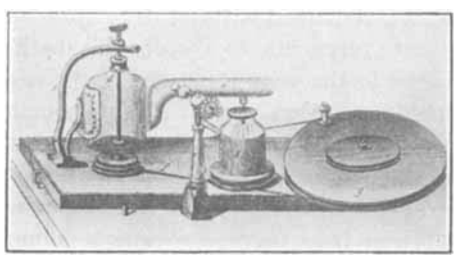

Fig. 5.—Read's Cylinder Machine. One of the early types of electric machines especially constructed for medical purposes. (From Priestley's "History of Electricity," 1775.)

and discovered the electric spark, observing the crackling sound which accompanies it. Francis Hawksbee, in 1709, improved the electric machine, substituting a globe of glass for vonGuericke's sulphur globe. In both of these machines the hand was used to supply the necessary friction, but it was not long before a mechanical rubber and a prime conductor were added to the apparatus. The frictional electric machine was improved by others, and soon a special machine for medical purposes was in use.

In 1729, Stephen Gray, while experimenting with a medicated tube, found that he could convey an electrical charge to a distance by a hemp string. Later he found that when a wire 700 feet long, and hung on loops of silk, was connected at one end with the glass tube, and the tube was rubbed, the other end was electrified and would attract light bodies. This discovery was the first to introduce the distinction between conductors and non-conductors, and was the origin of our knowledge of insulators.

In 1745, the properties of the leyden jar—so-called because many of the early experiments were conducted at the University of Leyden, Holland—were discovered by vonKleist, Cuneus, Allamand and Muschenbroek, and affirmatively answered the question: "Can electricity be stored?" Sir William Watson, M.D., in 1747 and 1748 took part in the experiments by which an electrical discharge from a leyden jar was "extended to four miles in order to prove the velocity of its transmission."

In America, Benjamin Franklin distinguished between positive and negative electricity, in 1747, and demonstrated the identity of the electric spark and lightning in 1752. He also devised the lightning rod, and took such an active part in the study of frictional electricity that it is sometimes called franklinic electricity.

Up to this time researches had been confined to studies of static or frictional electricity, that is, electricity in a condition or state of rest, but in 1791, an Italian physician and professor of anatomy, Luigi Galvani, by his famous frog experiments, laid the basis for the discovery of dynamic electricity, that is, electricity in motion. An Italian physicist, Alessandro Volta, when following up the work of Galvani, in 1799, devised the voltaic pile, the first electric battery. Volta's pile, a vertical column of several pairs of zinc and copper disks separated by moist cloths, supplied the knowledge that electricity is generated by chemical action. This pile was found to be charged with positive electricity at its lower extremity and with negative electricity at the upper extremity. When wires attached to these extremities were brought into communication with each other and then separated, a minute spark was observed which corresponded to the spark obtained from the frictional electric machine. Electricity produced by Volta's pile was called voltaic, galvanic, battery or primary electricity.

Until the year 1820 electricity and magnetism were regarded as distinctly separate sciences, but in this year Hans Christian Oersted,[1] a professor of physics at Copenhagen, proved the intimate relationship between the two, when he observed that a wire in which a voltaic current was passing deflected a magnetic needle suspended near it. Oersted's experiments and those which followed by Ampere, Weber, Arago and Sturgeon marked the discovery of electro-magnetism, and introduced an important era of electrical research which was participated in by many eminent authorities. Michael Faraday, in England, and Joseph Henry, in the United States, almost simultaneously made the discoveries that gave us

[1] Son of a pharmacist—see JOUR. A. PH. A., April 1931, page 370.

our knowledge of induced currents, and furnished the fundamental information which made possible the modern era in the history of electricity.

Among the earliest applications of electricity to human welfare was its use in the treatment of disease. The compass was of great service in navigation, and Franklin's rods had provided a safe method of protecting buildings from lightning. The real advances in the way of putting electricity to practical use, however, only date from the time of Faraday and Henry, the great men who, by their experiments and researches, made possible many of the conveniences which we enjoy to-day. One of the first of these modern applications was telegraphy; the telephone was another; and magneto-electric and dynamo-electric generators and motors are now so common that we are inclined to forget that their introduction has taken just about a century.

The practical applications of electricity have come with such rapidity since the days of Faraday and Henry that they cannot be considered in this brief article. With the fundamental discoveries in mind, and a recollection that materia medica specimens were the chief source of electricity in the early days; that search for a means of curing disease stimulated investigation; and that medical men were leaders in electric experimentation, we can now turn our attention to a consideration of electrotherapy.

The treatment of disease by electricity is called electrotherapy, and if the earliest employment of remedial substances whose real or supposed efficacy depended on electrical phenomena are included under this term, electrotherapy can claim an antiquity as great as some of the oldest branches of medical science. The fish known as the "electric ray," common in the tropical seas, was the source of the static electricity first employed in the treatment of disease. A Roman compiler of materia medica, Scribonius Largus (14–54 A.D.), was the first to recommend the use of electric shock as communicated by this fish in the treatment of severe headaches. Galen, "The Father of Pharmacy," and the most famous of the Græco-Roman physicians at the beginning of the Christian era, also prescribed shocks from the "electric ray" for the cure of headache, and classical writers of this time spoke of this form of medication in cases of cramp, paralysis, gout, diseases of the joints and disorders of nervous origin. In his "Natural History" Pliny refers to the electric ray as if its use as a therapeutic agent was quite general. He says: "From a considerable distance, even, and if only touched with the end of a spear or staff, this fish has the property of benumbing the most vigorous arm, and of riveting the feet of the runner, however swift he may be in the race. If, upon considering this fresh illustration, we find ourselves compelled to admit that there is in existence a certain power, which by the very exhalations, and, as it were, emanations therefrom, is enabled to affect the members of the human body, what are we not to hope for from the remedial influences which Nature has centered in all animated beings?" Later on, the *Gymnotus electricus*, or electric eel of South America, was of interest as the subject of much experimentation because it was able to administer a much more powerful shock than the electric ray.

The natural magnet, or lodestone, was a form of primitive electrotherapy, which comes under the heading of magic medicine, as whatever effect was produced by holding it in the hand or wearing it suspended from the neck must have been a psychological one which arose from the superstitious belief that the characteristic properties of the magnet gave it the power to attract or repel the causes of disease. The oldest account of the use of the magnet in medicine is ascribed to Aetius, physician to Justinian I (A.D. 527–565), who said: "We are assured that those who are troubled with the gout in their hands or feet, or with convulsions, find relief when they hold a magnet in their hand." Johannes Arculanus, a professor at Bologna and Padua during the 15th century, is said to have endeavored to remove splinters of iron from the eye by means of the attraction of amber electrified by friction. Paracelsus, one of the most famous of the 16th century European physicians, made use of the magnet in the treatment of toothache and other disorders. Later it was used in the treatment of headache, and magnetic toothpicks and earpicks were extolled as remedies for disorders of the teeth and ears, and Kircher (1598–1680) speaks of the magnet being worn about the neck to prevent convulsions and nervous diseases. While most of these early attempts to utilize a force concerning which little was known were based on "the influence of imagination in the cure of disease," still they served the very good purpose of keeping alive the interest in electrical science and electrotherapeutics.

The electrotherapy of the 18th century was confined to the electrification of patients and the administration of shocks by means of electric machines and leyden jars. Professor Jallabert, of Geneva, in 1748, noticed the phenomenon of muscular contraction resulting from electric stimulation, and Professor Kratzenstein (1723–1795), was among the first to employ electricity produced by these methods successfully, it being recorded that after fifteen minutes of electrification he cured a woman suffering with a contraction of the little finger. Rossler introduced the electric bath as a remedial agent in 1768; Manduyt, in 1777, employed electricity in the treatment of amblyopia; Charles Darwin used it as a remedy for jaundice; and Hufeland recommended electricity for the relief of asphyxia.

Exaggerated accounts of great cures effected in Europe reached America and prompted Benjamin Franklin to experiment with electricity as a therapeutic measure, and he related his experiences to a friend in this manner: "People were brought to me from Pennsylvania and the neighboring provinces to be electrified; which I did for them at their request. My method was to place the patient in a chair and draw a large number of sparks from all parts of the affected limb or limbs. Then I fully charged six two-gallon jars, each of which had about three square feet of surface coated; and I sent the united shock through the affected limb or limbs; repeating the shock commonly three times each day." Franklin noted temporary improvements, but the general result of his attempt to utilize electricity for curative purposes seems to have coincided with the experience in Europe of the Abbé Nollet, who said he did not know of a permanent cure by electrification.

Galvani's observation that the limbs of a freshly killed frog were thrown into violent convulsions when placed close to the prime conductor of a frictional electric machine led to much physiological experimentation, first upon invertebrates and later on warm-blooded animals. These experiments supplied much valuable information with reference to the various forms of response to electric stimulation, and proved that both the voluntary and involuntary muscles were affected.

At the beginning of the 19th century galvanic electricity was in use by physicians as a therapeutic measure particularly for the treatment of those diseases which had been found to receive benefit from frictional electricity. Amateur investigators were proclaiming galvanic electricity as a specific for all kinds of nervous disorders and paralytic affections, deafness, blindness, suffocation, etc. These unwarranted and unauthorized claims soon brought electrotherapy into such disrepute that the use of electricity as a therapeutic agent was temporarily discontinued.

Modern electrotherapy dates only from 1847 when a French physician, Dr. G. B. A. Duchenne, discovered that individual muscles could be stimulated by the application of electrodes to the overlying skin. Before this the general twitchings produced by an electric shock had been observed, but, as at that time all impairments of movements were included under the term "paralysis" the pathology of which was unknown, very little progress had been made in the way of specific electrotherapy. Duchenne now devoted his attention to specific treatment, choosing as his subjects the class of incurable paralytic patients in the large hospitals of Paris. He employed induced currents, and his success in restoring health to these sufferers was so great that it gave the special impulse which resulted in the formation of a practical specialty of electrotherapeutics. Other men such as Remak, vonZiemssen, Erb, Addison, Crusell, Gull, Bird and Benedikt assisted in the modernization of electrotherapy, and widely extended the usefulness of electricity as a diagnostic and therapeutic agent.

The general benefits which are derived from electricity are well known. The benefits which have come to medicine are not so familiar, but these, too, are so numerous that we can only skim the surface with the statement that the development of a method of measuring dosage, the discovery of X-rays, and the standardization of electrical apparatus for the purpose of diagnosis and treatment have brought about a true appreciation of electrotherapeutics. All forms of electric current are now used in the treatment of disease, the kind of current and the way in which it is applied depending on the result to be effected, and the usefulness of electricity seems all the more wonderful when we consider that most of the cases successfully treated are those for whom there seems no further hope by other methods.

If the placing in the hands of physicians of a curative agent for the relief of conditions which could not be helped by other remedial measures were the only benefit which had come to medical science, it would be amply repaid for the part it has taken in the development of electrical science. It has received, however, an equal benefit in a diagnostic way, for what could be more wonderful than the X-ray machine which makes it possible to examine the "inside" of a patient; the electrocardiograph which graphically records the action of the heart muscle; the bronchoscope for inspecting the interior of the bronchial tubes; and the electrostethoscope by which the heart sounds can be intensified and heard for a considerable distance, not to mention the numberless other practical uses in medicine.

When Franklin was asked what use there was in his electrical experiments he replied by asking: "What is the use of a baby?" When Faraday was similarly questioned he responded that he was endeavoring to make electricity useful. Franklin realized that electrical science was a very promising infant, and Faraday knew that the child must be put to work to overcome complaints such as the following made in the year 1840: "It must be allowed, that the case has not been the same with electricity as with magnetism. The latter, by the invention of the magnetic needle, has served to render navigation more secure, and to discover the new world, a source of new riches, new wants and of new evils to the old one. But electricity has not yet produced anything of so much importance, to mankind, and to the arts, if we except the analogy now proved between the electric fire and lightning; an analogy which has given rise to a pretty sure preservative from the effects of that dreadful meteor; for in regard to the cures effected by electricity, it must be acknowledged that they are either rare, or not well ascertained."

Only a century has elapsed since the discoveries of Faraday and Henry introduced the modern era of electricity, and since Duchenne laid the foundation for present-day electrotherapy, but this short period of time has been sufficient to overcome all complaints concerning the uselessness of electricity. The electrical inventions have come with such clock-like regularity that it would seem that they have been timed to keep interest in the subject alive, for as soon as the novelty of one invention waned another of even greater significance would be made to encourage the workers on to further effort.

This review, which has purposely been made brief and consequently incomplete, including only a few of the items of great importance in the early stages of electrical development most likely to be overlooked by the present generation, calls to mind what great good can come from seemingly trivial experiments in the field of pure science.

With the thought of the times focused on the matter of devising new methods of utilizing the universal servant, electricity, undoubtedly what we now regard as modern phases will before long be classed among the early ideas and undertakings of electrical science. So while lauding, as we should, each new advance, let us occasionally call to mind that pharmacists and physicians, by fundamental contributions, helped to make electrical accomplishments and achievements possible.

BARBITURATES: ALLEGED DANGERS.*

Gillespie (Guy's Hosp.) contributes an exhaustive and reasoned article in defense of the barbiturates. The article does not lend itself to abstraction, but a few points may be mentioned. A review of the published records to the end of 1932 fails to show a case in which these drugs, in single or repeated therapeutic doses, have caused death in the absence of complicating factors. In complicated cases (with one possible exception) the drug has never been the essential cause of death. The margin of safety (the ratio of customary maximum dose to minimum recorded lethal dose) is with barbitone 1:5, and with phenobarbitone 1:3; with the newer barbiturates data are not sufficient to permit such a calculation. Idiosyncrasy has to be reckoned with in a proportion of cases—about 3 per cent or less, but this is chiefly a matter of skin conditions or neurological disturbances: there is no case on record of a single therapeutic dose, even in an idiosyncratic patient, having a lethal effect. Contraindications, or indications for caution, are: (1) old age (smaller dose); (*a*) kidney disease, absolute except in pernocton or nembutal, which are contraindicated in (3) liver diseases; (4) advanced heart or lung disease (smaller doses and not continued); (5) toxæmia (sepsis or possibly hypothyroidism); (6) idiosyncrasy, to be borne in mind on first administration. Addiction may occur, but is unlikely, as the barbiturates do not afford the same euphoria as alcohol or morphine, while their withdrawal is not accompanied by the same distressing results.

---

* R. D. Gillespie, "On the Alleged Dangers of the Barbiturates," *Lancet* (February 17, 1934), 337–345.