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and SCHENCK (W.E.)

*Reprinted from the Cincinnati Lancet-Clinic,
May 30, 1896.*

THE "SINUSOIDAL" CURRENT IN ELECTRO-
THERAPY.

BY

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CLINICAL PROFESSOR OF NERVOUS DISEASES AT MIAMI MEDICAL COLLEGE; NEUROLOGIST TO THE
CINCINNATI HOSPITAL AND TO THE OPHTHALMIC HOSPITAL OF CINCINNATI

presented by the author

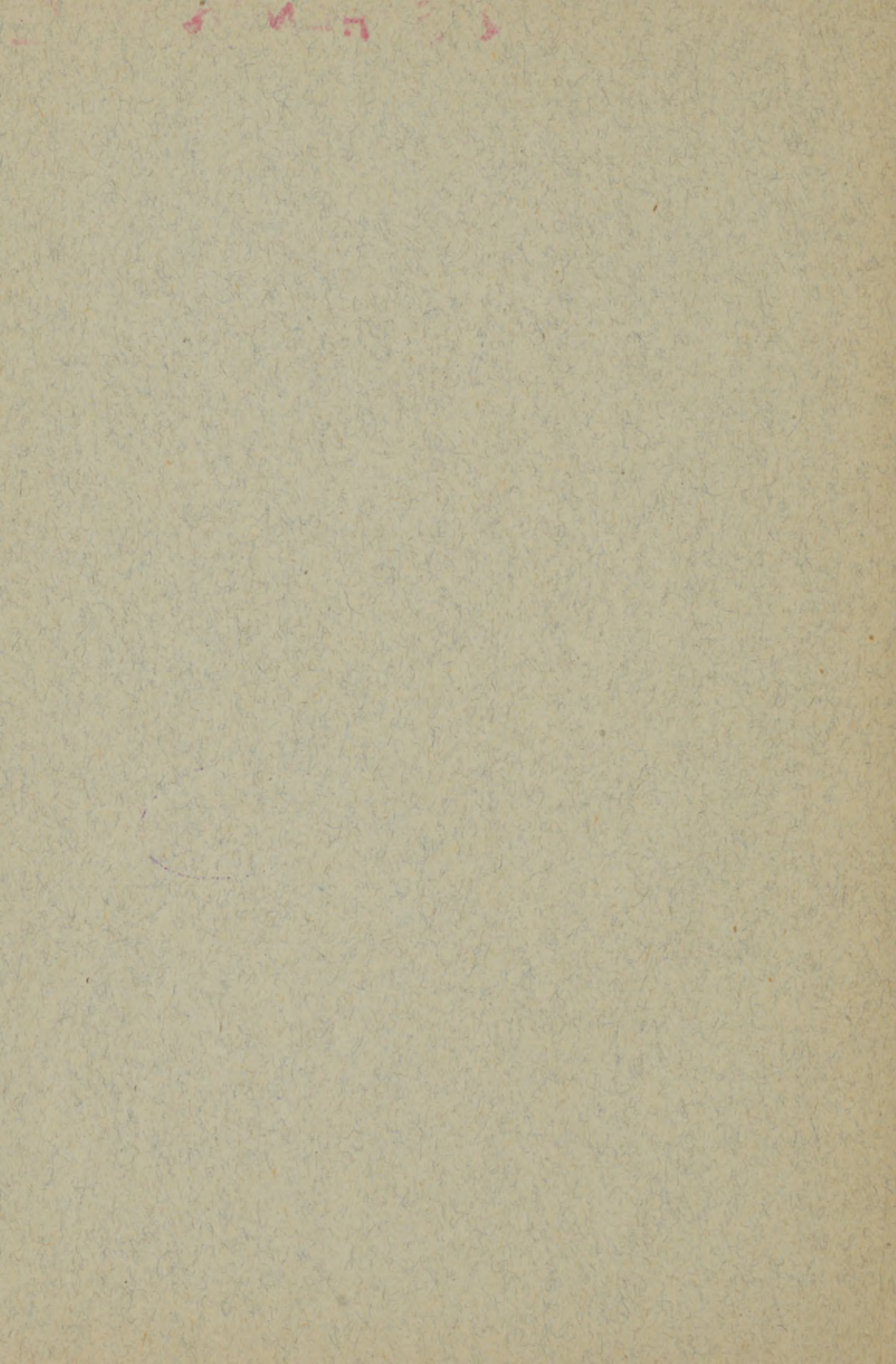
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While all forms of electricity are identical in their ultimate nature, so far as we know, they may differ widely in their physiological and therapeutic effects, as is evident from the familiar differences in results obtained with the galvanic and faradic "currents," both as diagnostic and therapeutic agents. That the view once held, that the results observed from electrical treatment were altogether due to a "psychic" or "suggestive" influence, is now no longer tenable in many cases, is evident when we consider that the *form of current* influences materially the result, and this in patients who do not know one current from another. Hence it is evident that the differences noted in these cases at least are *positive differences*, due to the *form* in which the electricity is administered.

We see an analogy, physiologically, in the differing effects of the two forms of phosphorus, and in the varying action of the various alkaloids which have the opium plant for their common source. Electrically, the now famous Roentgen rays afford another instance of the varying effects derivable from one agent by changing its conditions of production and the relations of its application.

The term "current," while a misnomer, is so firmly ingrained into our nomenclature as to be not easily dislodged, even if we possessed a more satisfactory name, which we do not. It is used here, therefore, in the conven-

tional sense, as a general term for the varying phenomena due to the action of electro-motive force ("E. M. F.").

The "wave symbol" is used as a convenient means of expressing graphically one of the differences between "currents." The instrument known as the electrograph is used to register these "waves," in the same manner as similar instruments register for the physiologist the heart and respiratory movements, the pulse waves, etc.

Thus differences in the "wave type" of E. M. F. give rise to the following forms of currents recognized by electricians.¹

E. M. F. {	Continuous {	Pulsating {	Intermittent.
		Steady.	Non-intermittent.
	Alternating {	Symmetrical {	SINUSOIDAL.
		Dissymmetrical.	Non-sinusoidal.

The "galvanic" current, as commonly used in medicine, is a "continuous steady" (*i.e.*, direct) current (Fig. 1). This is its form when produced by a battery; when derived from a dynamo it presents a finely undulating non-intermittent wave. The "primary faradic" current presents an alternating dissymmetrical intermittent wave (Fig. 2), with abrupt lines of ascent and descent; the "secondary faradic" an alternating dissymmetrical intermittent wave, with

¹ Houston and Kennelly: "Electricity in Electro-Therapeutics." New York: W. J. Johnston Co., 1896.

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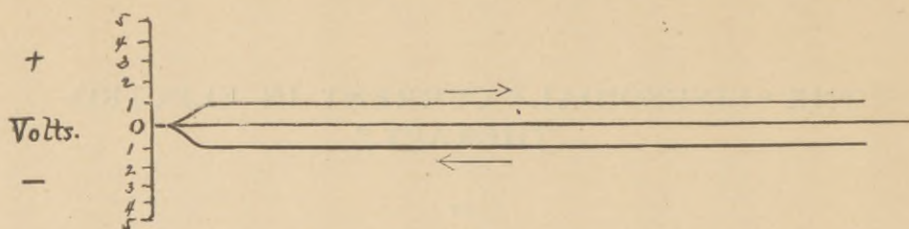


FIG. 1.—“Continuous steady” line of flow of “direct” galvanic current.

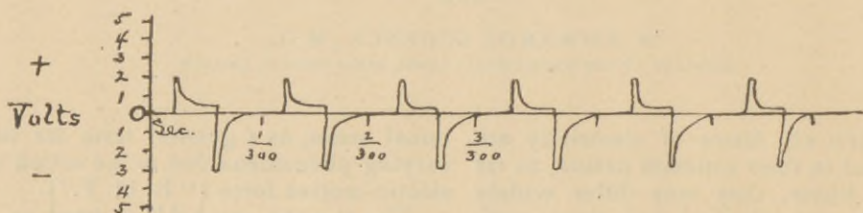


FIG. 2.—“Alternating dissymmetrical intermittent” wave of primary faradic current.

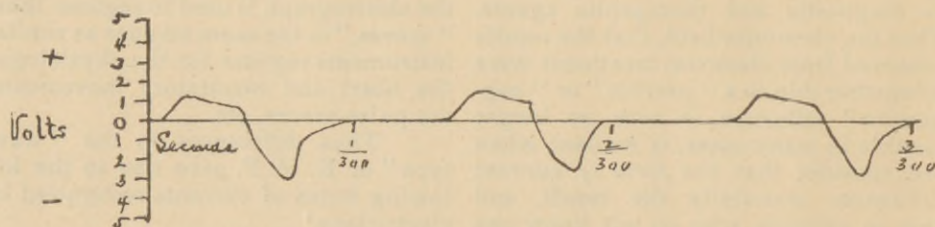


FIG. 3.—Alternating dissymmetrical intermittent wave of secondary faradic current.

less abrupt lines of ascent and descent (Fig. 3).

The “combined” galvanic and faradic current (of DeWatteville) is the wave of the primary faradic to which is added “magnitude” (quantity—ampereage) by the addition of the “continuous steady” (direct galvanic) current, which also eliminates the alternations and dissymmetry. Hence it is described as a “pulsating intermittent” wave (Fig. 4).

The “static breeze,” “static spark” and other forms of frictional electricity in common medical use are pulsating non-intermittent currents of high intensity and extremely rapid pulsation, but possess the disadvantage of variability in wave form (dissymmetry) (Fig. 5), and are not controllable as to frequency

in a certain and convenient manner. Their uncertainty of action in damp weather is another drawback in practice.

The above mentioned are the currents heretofore at the disposal of the profession for diagnostic and therapeutic purposes.

The “sinusoidal” current, the subject of the present paper, presents an “alternating symmetrical” wave of the form shown in Fig. 6. It is said to have been discovered by d’Arsonval, of Paris, about the year 1892.

The accessible literature of the sinusoidal current is as yet very meagre. D’Arsonval’s communications were published in the *Archives de Physiologie*, 1888 to 1893. Kellogg makes some reference to the subject in the “Inter-

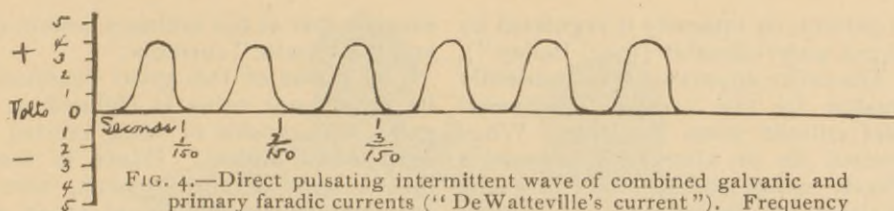


FIG. 4.—Direct pulsating intermittent wave of combined galvanic and primary faradic currents ("DeWatteville's current"). Frequency attainable with ordinary spring vibrator = 150 to 300 per second.

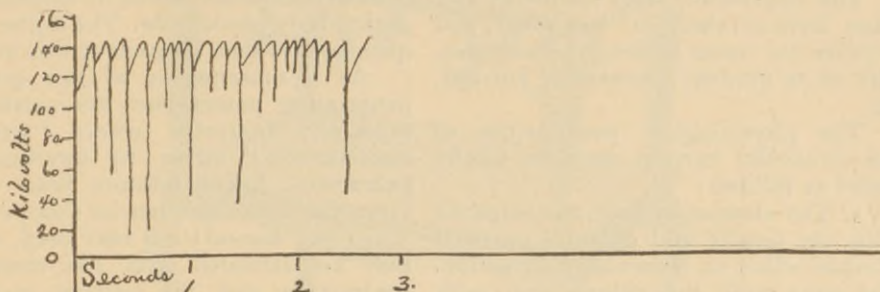


FIG. 5.—Direct pulsating non-intermittent wave of "static" current.

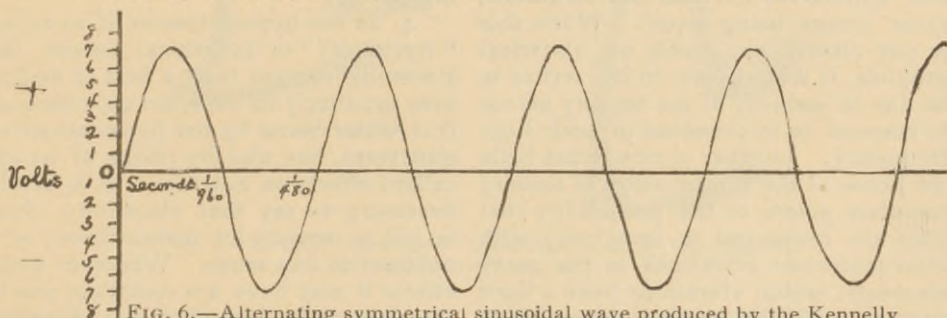


FIG. 6.—Alternating symmetrical sinusoidal wave produced by the Kennelly apparatus running at frequency of 480 alternations per second. Rate may be increased to 1920 per second.

national System of Electro-Therapeutics."

The so-called "Tesla" current, with which such surprising effects are obtained, seems to be a sinusoidal current of unusually high frequency.

Various firms have placed on the market apparatuses devised for the purpose of producing the sinusoidal current. The only one of these with which I am familiar is the one here shown, which was constructed for me by the Edison Company, of Orange, N. J. It consists (as shown in Fig. 7) of an alternator, composed of twelve primary and secondary coils, mounted in circular form so as to surround the dentated revolving armature, which is so proportioned as to produce the symmetrical sinusoidal waves required. Twenty-

four alternations are produced at each revolution of the armature.

These revolutions are produced by an electric motor of one-twelfth horse power, the speed of which is controllable within given limits, by means of lamp rheostats. By varying the speed of the motor the frequency of alternations, and consequently of the sinusoidal "waves," may be varied from 480 *per second*, the lowest, increasing by multiples of this amount to 1,920 *per second*, the highest. The current admitted to the primary coils is controlled also by four lamp rheostats, so as to be capable of variation between 27½ volts and multiples thereof, up to 110 volts. As the "sinusoidal secondary current" so produced passes from the alternator to the binding posts, to be there transferred to

the patient, its intensity is regulated by a shunt water-rheostat (the "Bailey").

The entire apparatus is conveniently operated by the 110-volt *continuous* street current when available. When mounted for an alternating current a different motor and a battery to excite the alternator are required.

The application is as simple as any other form of electrical treatment, and requires the same variety of electrodes, care as to gradual increase of current, etc.

The physiological peculiarities of the sinusoidal current may be briefly stated as follows:

1. The absence of pain, as compared with the faradic and galvanic currents of equal effect on muscular contraction. The more rapid the alternations (with this apparatus) the less the sensation, other things being equal. While this is not clearly explicable on electrical grounds, it would seem to the writer to be due to inability of the sensory nerves to respond to impressions of such high frequency. In other words, what little we know of the transmission of sensory impulses points to the probability that they are connected in some way with inter-molecular vibrations in the nerve elements, which vibrations have a limit varying with the previous education of the nerve substance. The rapidity of the alternations probably exceeds this limit, hence the failure of the sensory nerves to transmit and register as pain the alternating waves of such enormous frequency.

A similar failure of appreciation is seen in the "Galton whistle" test, the highest pitched notes of which are inaudible to the human ear while heard readily by some animals.

2. The production of muscular contractions when faradism fails, *i.e.*, in nerve degenerations following poliomyelitis, etc. The lower frequencies (480 per second) are better adapted to produce muscular contractions. In this feature it resembles the galvanic or direct current, with the advantage of absence of pain.

3. The penetrating power of the current, which is probably superior to that of any other alternating current, and far

exceeds that of the ordinary faradic coil and the "static" currents.

By reason of this great penetration its nutritional value is claimed to be great, and capable of being exerted on deep-seated organs. Hence in motor insufficiency of the stomach, chronic constipation due to bowel atony and relaxed abdominal walls its influence is particularly serviceable. The higher frequencies are best adapted to this end.

As a consequence of this greater penetrating power also, this current is especially indicated where "general electrization," either by faradism or galvanism, has heretofore been used. Here the higher frequencies (960, 1,440, 1,920 per second) are best used, since they are attended with less muscular contraction and the voltage may be higher.

4. In the hyperesthesias of so-called "hysterical" or functional nature, the sinusoidal current finds a field of usefulness peculiarly its own, not only because it is better borne by the hyper-sensitive structures, but also by reason of its excellent effects on nutrition. It is hardly necessary to say that electricity alone is not a remedy for malnutrition, or a nutrient in any sense. Whatever good effects it may have are doubtless due to the promotion of metabolism and assimilation. He who attempts to build up a patient on tonics of any kind, without a correct dietary and hygiene, will find electricity as great a disappointment as any other treatment.

The following brief abstracts are selected from a large number of cases treated by us with the sinusoidal current here referred to, in order to illustrate its range of action. No attempt is made to select especially favorable results, but failures are recorded in rather greater proportion than they actually bore to the total number of cases treated.

ORGANIC DISEASES.

Locomotor Ataxia.—This disease has always been considered peculiarly hopeless as regards cure or the material mitigation of its chief processes, and is consequently the favorite example held up by the pessimistic therapist to illus-

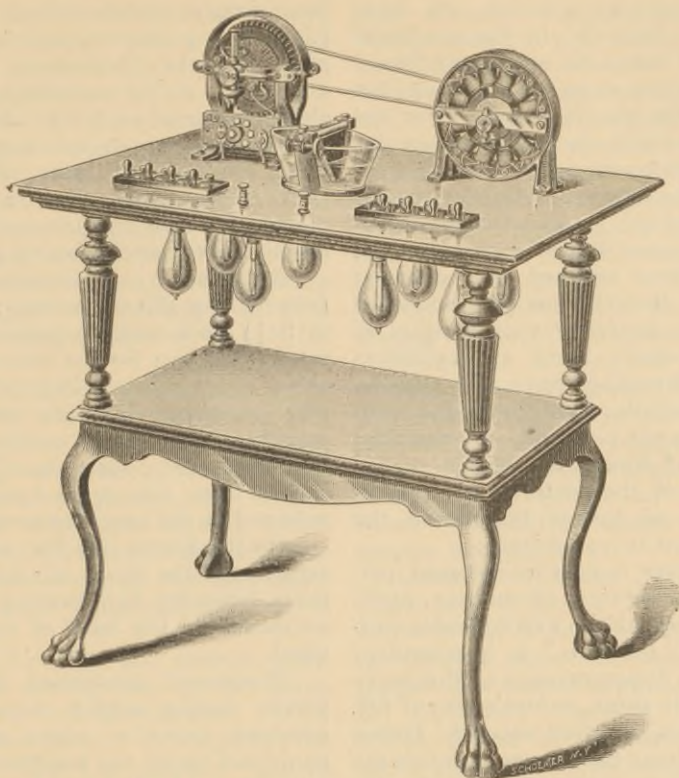


FIG. 7.—Kennelly Sinusoidal Apparatus, made by the Edison Manufacturing Company.

trate the powerlessness of remedies to favorably influence an organic nervous disease. Amongst the chief symptoms which annoy the patient and make his very existence miserable are (1) the "lightning pains;" (2) the ataxic gait; both of which are the expression of degenerative changes in the peripheral intra-muscular nerve fibres. For the shooting pains the continuous administration of opiates and coal-tar analgesics is, to say the least, objectionable; and, even though the pains are thus made more bearable, the ataxia is unaffected.

The sinusoidal current is the one satisfactory means known to the writer which is capable of absolutely removing the "lightning pains" and at the same time materially benefiting the ataxia. To do the latter it should, of course, be used early, while some fibres are yet undegenerated. If the results heretofore obtained are verified by a larger and wider experience, it would appear prob-

able that we have in this current a most desirable agent in the treatment of tabes. Whether the improved function is due to permanent better nutrition in the peripheral neuron or not, the cases observed are too few and the time too short to state positively. It appears to the writer probable that if treated at an early stage the progress of the disease may be materially slowed and the comfort of the patient vastly increased.

In this connection attention may be called to the chloride of aluminium as a remedy for the pains where, for any reason, the patient cannot have the benefit of electrical treatment. This remedy, to which attention was first called by Dr. Gowers, who introduced it to the profession for this purpose rather more than a year ago, we have found extremely serviceable in many cases. It is administered in doses of from two to four grains, dissolved in distilled water, three times a day.

On theoretical grounds we have thought it advisable, in the electrical treatment of tabes, to apply one broad electrode at the nape of the neck, the other over the painful areas. For the ataxia, a foot-plate is the best form for the lower pole and a broad neck electrode for the upper. The anatomical and pathological reasons for the selection of the above localities are obvious, as the neurons affected in locomotor ataxia have their bodies (the so called cells) in the posterior root ganglia of the cord, while their axis-cylinders (axons), bifurcating, have one extremity in the medulla, the other at the periphery. The old idea that the essential pathology of locomotor ataxia was a "sclerosis" of the posterior columns of the cord is no longer tenable in the light of recent investigations.

The disease is now considered primarily a degeneration of neurons, probably beginning at the axis-cylinder *endings*. The "sclerosis" is a secondary result of the disappearance of the nerve structures—in short, nature's way of filling that much-abhorred vacuum. Hence the time to treat the disease is *before* the degeneration is complete. To do this early diagnosis is essential.

The well-established pathological law that the portion of the neuron which first suffers in degenerative disease is that farthest from the (trophic) neuron-body, would furnish a rational indication for the selection of the localities noted, since it is the degenerative process we hope to retard or arrest by improvement in circulation and functional activity. Another good reason for the selection of these localities is the fact that in the early stages of the disease some neurons are probably unaffected, and we may hope, by improving the powers of assimilation and nutrition, to influence favorably their function, a "training" process which may be aided by the well-known one of having the patient practice co-ordination by walking a chalk line, practicing manual movements, etc.

CASE I.—Mr. A., forty-one, manufacturer. Referred by Dr. F. B. Cross. Married, two healthy children. Heredity good. Chancre twenty years ago.

No history of secondary symptoms. Lightning pains very severe for a year past; Argyle-Robertson pupil; lost knee-jerks, girdle anesthesia, seventh to eleventh dorsal vertebra. Ataxia slight.

Has been given iodide of potassium freely during past year without good effect of any kind. For six months has taken morphine hypodermically and by mouth for the excruciating pains.

Application of sinusoidal current (alternating 480 per second; voltage 55 to 82½) from neck to painful points in thighs and legs for ten minutes. Relief of pains complete. Patient slept without morphine for the first time in months. The pains returned on the following day, same locality, in less severe form, and were again promptly relieved in the same manner.

On the fourth day the pains did not return on the front of thighs, where their intensity had been greatest, but appeared on the back of thighs, lower third.

Treatment continued daily for a week, during which time the pains returned twice at night, and patient could not resist the temptation to take morphine, which he had in the house. After ten days' treatment (from the beginning) the pains ceased to return, patient took no more morphine, and expressed himself as comfortable in every respect, and in better health than for a year or more past.

Treatment was continued every other day for a month, by passing current from nape of neck to foot-plate, and patient went to his home in another city in excellent health and spirits. This has continued for the past five months, during which I have seen him about once a month. Very slight pains appeared on one occasion before his visit, which one treatment promptly relieved. During his five months' treatment he has taken the chloride of aluminium in four-grain doses, for a month at a time, and alternating with it phosphorus, strychnia and iron at intervals. His weight has increased eighteen pounds, and he appears in vigorous health. The knee-jerks are still absent, and the Argyle-Robertson pupil present. Ataxia not noticeable, even with eyes closed.

No mercury or iodides have been administered at any time while under my care. I do not consider them indicated in this disease (L.).

CASE II.—Mr. B., actor, aged fifty, looks younger. Good physique, spare build, active habits. No history of or visible indications of syphilis. Has Argyle-Robertson pupils, lost knee-jerks, marked static and locomotor ataxia. Gastric crises, no lightning pains. Staggers noticeably even with eyes open; cannot stand or walk with eyes closed.

Sinusoidal current passed from nape of neck to foot-plate. Alternations 480, voltage (apparent) 55, time ten minutes. Immediately afterwards was able to walk without staggering, and walked across room with eyes closed, which he could not do before treatment. Improvement continued for five days under daily treatment. Case still in progress (S.).

CASE III.—Mr. C., farmer, fifty. Referred to me by Dr. J. B. King. Spare build, well developed. Father died of consumption. Had syphilis ten years ago. Has had grippe. Habits generally good. Has Argyle-Robertson pupil, lost knee-jerks, marked static and locomotor ataxia with eyes open; cannot stand or walk with eyes closed. High-action gait, cannot walk without cane. Girdle anesthesia below nipple line. No lightning pains.

Treatment: Phosphorus, gr. $\frac{1}{50}$ t. d.; aluminium chloride, gr. iii, three times a day.

Sinusoidal current, neck to foot plate. Alternations 480, voltage 25 to 50. Improvement in ataxia so as to be able to walk without cane and without the "high-action" gait. Can be treated but once a week, owing to distance at which he lives. A most unpromising case, but showing marked improvement after three treatments a week apart. Still under treatment (L.).

CASE IV.—*Poliomyelitis Anterior Acuta*.—Referred by Dr. A. I. Carson. (Child) D., five and three-quarter years. Onset rapid six weeks ago. Helpless for three weeks, then some power in hands and arms. Can extend and flex thighs, but not legs and feet. Knee-

jerks absent. Plantar reflex present. Tactile sensibility present.

Electrical examination: No response to faradism of leg and foot muscles. R. D. to galvanism, which causes pain and complaints from child.

Sinusoidal current applied to paralyzed muscles produces contraction, and child does not complain of pain with this current. Continuous treatment advised, but mother would not take trouble to fetch child for treatment, though it was offered gratis.

This case is reported in order to emphasize the observation that the sinusoidal current acts like the galvanic in producing muscular contraction where the nerves are degenerated. It has the additional advantage of being well borne by children because of its slight sensory effects (L.).

CASE V.—*Nuclear Palsy, with Anosmia and Olfactory Paresthesia, apparently due to peripheral degeneration of olfactory nerves. Nasal disease excluded by a competent rhinologist*.—Mr. E., forty-five. Specific history, for which course of treatment has been taken recently. Smell absent on right side entirely. On left side complains of a constant, very disagreeable odor of something burning. Has ophthalmoplegia, external and internal. No ataxia. Knee-jerks present normal. His chief complaint is the disagreeable odor above mentioned, which is so persistent and annoying as to cause nausea and loss of appetite.

Sinusoidal current applied daily, from nose to nape of neck, at first with partial, later with complete, relief to the peculiar odor; relief would last a day, rarely two days. Immediately after treatment would recognize test odors with both nostrils (peppermint, etc.).

After one month's treatment, with marked improvement in the chief complaint, patient ceased his visits. This patient thought he knew so well how to treat his constitutional condition that he looked with contempt on medical advice for that purpose (L.).

CASE VI.—*Sciatic Peri-Neuritis (Syphilis or La Grippe?)*.—Mr. F., twenty-eight. Dissipated habits. Has secondary syphilis, and recently had an

attack of la grippe. Complains of extreme pain in loins and over course of sciatic nerve. Walks with great difficulty, and with a rolling movement from side to side. Prescribed K. I. Applied sinusoidal current to painful areas. Effect almost magical. Pains relieved and gait improved at once. Returned in two days with similar pains less severe. A second application gave complete relief. K. I. continued (S.).

CASE VII.—*Brachial Neuritis (diphtheritic?)*—Referred by Dr. G. M. Allen.

Mrs. G., thirty-five. Slender build. General health good. Complains of pain and inability to raise right arm, to put on dress, etc. Examination reveals marked weakness of deltoid. Pain on deep pressure and on slight voluntary movements. Cannot abduct right arm to a right angle, muscle somewhat atrophied; also the supra-spinatus and infra-spinatus on same side. Partial R. D. in right deltoid (sluggish galvanic contraction, poles not reversed). No response to faradism. Palate reflex absent. History of sore throat and difficulty in swallowing a few weeks ago. Upper arm muscles generally weak and flabby as compared with left arm. Sensations of numbness present.

Treatment: Sinusoidal current, three times a week, to produce mild muscular contractions. Voltage 25 to 35; alternations 480; time five minutes. Result immediate relief of pains; progressive increase in nutrition and power of muscles. Duration of treatment about three weeks, regularly; after that occasional treatments once a week (L.).

CASE VIII.—*Lead Neuritis.*—Mr. H., thirty-five, printer. January 21, 1896. Complains of weakness in right arm. Says he has had three attacks of paresis in that arm in three successive years. This one is the worst. Muscles of right arm, forearm and hand wasted, soft and flabby. Measurements: Middle of forearm, right $9\frac{1}{2}$ inches, left $10\frac{1}{4}$ inches; wrist, R. $6\frac{1}{2}$ inches, L. $6\frac{3}{8}$ inches. Power much diminished as compared with left arm. Dynamometer, R. 80, L. 200 (lower scale).

Treatment: K. I. and sinusoidal current. After three treatments the dyna-

meter showed R. 180, L. 220. Three days later R. 195, L. 220. Measurements: Middle of forearm, R. $9\frac{1}{8}$ inches. Continued to improve in use of arm for a month, but measurements and dynamometer register unchanged.

The gain in this case is quite satisfactory in every way. The failure of the weak arm to fully recover and become as strong as the left is probably due to two causes: (1) The previous attacks of paralysis; (2) the lack of sufficient time for complete nerve regeneration (S.).

CASE IX.—*Left Facial Paralysis, complete, due to destruction of nerve by mastoid disease.*—Miss I., domestic. Inability to close left eye; mouth drawn to right. Left face smooth. This was evidently a most unpromising case for any treatment, but the sinusoidal current was applied for experimental purposes. The most annoying symptom to the patient was the lagophthalmus. After a few treatments it was observed that the patient could close the eye while the current was passing.

Treatment for two months, rather irregularly on account of the patient's indifference, was attended with marked improvement in voluntary power over the paralyzed eyelid and more plump appearance of the paralyzed side of face. Patient then passed from view and returned four months later with the lagophthalmus almost as bad as ever. She is at present under irregular treatment, and improving again.

The improved power over the orbicularis when the nerve was supposed to be completely severed in the Fallopiian canal is, of course, susceptible of two explanations: (1) That some nerve fibres escaped damage and treatment improved their function; (2) more probably, however, it was the "associated" action of fibres reaching the muscle by other routes than the *portio dura* (by the third nucleus, for instance, as has been suggested by Mendel and others) (S.).

CASE X.—*Left Hemiplegia from Cerebral Hemorrhage.*—Referred by Dr. G. M. Allen.

Mr. J., sixty-two, merchant, married, excellent habits. Patient has been hemi-

plegic for two years, with marked contracture of flexors of left forearm and fingers, so that the hand is useless. Exaggerated knee-jerks, left face weak. Grasp, R. 120, L. 60. The long duration of the condition, and the fact that he had had intelligent treatment from the start, with later, prolonged faradic treatment, rendered the case a most unpromising one for any treatment. Voluntary power over extension of fingers of left hand almost *nil*. Cannot pick up pencil, button clothes, etc. Is very desirous of improving use of hand.

Treatment.—Sinusoidal current from nape of neck to weak muscles (extensors). Later from right parietal region to muscles. After a few weeks better control of hand movements resulted, so that he could pick up pencil, open and close hand fairly well.

A feature of especial interest was the quickening of response and better control of voluntary power in the paralyzed hand during the application of the current to the opposite parietal region. The long duration of the symptoms would render any improvement remarkable in such a case, and it was gratifying to have the patient's assurance that the hand was really more useful after two months' treatment.

The result in this case probably emphasizes the fact that in every cerebral paralysis there exists a "functional" element of greater or less degree, treatment of which may be followed by improvement even in apparently hopeless cases. This is not to be attributed, of course, to removal of any organic lesion, but simply to better functional activity of neighboring slightly damaged or undamaged nerve elements (L.).

FUNCTIONAL AFFECTIONS (MOTOR).

CASE XI.—*Spasmodic Torticollis.*—Referred by Dr. Wade Thrasher.

Mr. K., twenty-four. Street-car conductor. Single. Onset sudden, with gradual increase of symptoms, viz., inability to keep head from turning strongly to right. The spasm yielded at once to the sinusoidal current, but returned repeatedly in even a worse form, the posterior rotators of the skull being affected. The patient's surround-

ings being undesirable, I thought best to advise him to go to the hospital, where he could have rest in bed and constant care. This was all the more important as I suspected an organic cause for the torticollis. Under the care of my colleague, Dr. Hoppe, however, he has improved materially, so that hopes are entertained that the affection is functional in nature (L.).

CASE XII.—*Blepharospasm (tonic).*—Referred by Dr. R. Sattler.

Mr. L., forty-nine. Plumber, married. Has had double blepharospasm for seven months, at times so severe as to disable him for work. Habits good. No eye cause discovered by oculist.

Treatment by sinusoidal current three times a week for two weeks, with entire relief of symptom. During the first treatment patient could hold eyes open all the time current was passing. Relapse occurred, however, some hours later. After three or four treatments the spasm failed to return, and he disappeared from observation (L.).

CASE XII.—*Blepharospasm (tonic and clonic with much tremor).*—Referred by Dr. R. Sattler.

Miss M., twenty-two, domestic. Hysterical stigmata. Has been disabled for her work for several months by persistent blepharospasm, varying in severity, at times.

Treatment by weak sinusoidal current, alternations 480 per second, during passage of which she can keep both eyes wide open. Treatment repeated twice a week, with considerable improvement in two weeks. Still under treatment (L.).

CASE XIV.—*Hysterical Aphonia.*—Referred by Dr. C. R. Holmes.

Mrs. N., forty-five, wife of a physician. Has been in poor general health but is now better. Lost voice some weeks ago, and cannot speak above a whisper. No local lesion. Has had extra diet, hygienic exercise, rest, change of scene, attention to eyes, and "suggestion" treatment, all with no effect.

Three applications of sinusoidal current to larynx and nape of neck; no pain; no wire brush. Complete return of voice (L.).

FUNCTIONAL AFFECTIONS
(VISCERAL).

CASE XV.—*Gastric Spasms (periodical)*.—Referred by Dr. G. M. Allen.

Mrs. O., forty-five, married. Active, neurotic, emotional. Has had for two years or more spasmodic contractions, which she locates in the stomach. Usual time of onset, 5 o'clock A.M., waking her out of a sound sleep. These occur almost daily. Were cured on one occasion by change of climate. She has been given quinine in various ways and in full doses, with little or no effect on the spasms. No motor or sensory symptoms elsewhere. No fever at any time.

Treatment with sinusoidal current from nape of neck to epigastrium, repeated three times a week. Gradual improvement, the spasms, after six treatments, ceasing. Patient felt much encouraged, but upon ceasing treatment for a few weeks had a relapse, which also yielded readily to the same treatment (L.).

CASE XVI.—*Senile Neurasthenia, with gastric and intestinal indigestion*.—Referred by Dr. G. M. Allen.

Mr. P., sixty-five, married. Has had influenza recently. Much depressed mentally; lacks appetite and power to digest food. Has had tonics and digestants without benefit. Tells a characteristic "neurasthenic" story. Loss of weight. Pulse 80, feeble. Visual fields contracted. Hard arteries. Power and sensation fair. Knee-jerks increased. Urine negative.

Treatment: Sinusoidal current three times weekly, from neck to epigastrium and abdomen. Result, in two weeks return of appetite, eats "sausages and buckwheat cakes" with a relish. Disappearance of flatulence. Mental state cheerful, making plans for the future again. Advised to go South for the winter, which he finally decided to do, though he considered it entirely unnecessary so far as his health and feelings were concerned. At last accounts his improvement continues permanent (L.).

CASE XVII.—*Intestinal Atony*.—Mrs. Q., wife of a physician. Referred by Dr. E. W. Mitchell. Has complained of chronic constipation and flatulence

for some years. Dietetic, medicinal and galvanic treatment, in skillful hands, have failed to give material relief.

After a few weeks' treatment with the sinusoidal current she expresses herself as much improved. Bowels moving regularly and digestion improved. Still under treatment (L.).

SENSORY AFFECTIONS.

CASE XVIII.—"*Hysterical*" (?) *Neuralgia*.—Referred by Dr. W. H. McGrew, of Pleasant Ridge, O.

Miss R., age twenty-three, farmer's daughter, a large, well-developed handsome woman. No contraction of visual fields or other hysterical stigmata. Complains of severe pains, with "cramps," at times located chiefly in the back of the neck, shoulders, calves of the legs and tendo-achilles. Pains are constant, with exacerbations. Duration seven months. Onset sudden, following a severe emotional shock (death of a favorite brother). Intelligent medicinal care, change of scene, etc., had failed to benefit the patient.

Treatment: Sinusoidal current 55 (?) volts, alternations 960, completely relieved the pains in ten minutes. Treatment repeated every other day. Occasional return of pains for a month. Patient then ceased her visits for a month, as they were inconvenient on account of distance from the city. The pains returning, however, she resumed treatment, with complete relief from two applications. Has remained well for four months (L.).

CASE XIX.—*Neurasthenia, with functional hyperesthesia and "shooting pains" in limbs*.—This patient was a physician, age forty-seven, of good habits and a hard worker. The pains in the limbs and back were severe enough to make him apprehensive of a beginning locomotor ataxia. Examination revealed that they were decidedly worse in the vicinity of an old scar of many years' duration. No symptoms of tabes were found.

Care in diet and the sinusoidal current relieved him in a few weeks, without the rest from practice which was advised and needed. So satisfactory was the relief afforded that it was difficult

to convince him that rest and careful nutrition were essential to a permanent cure (L.).

CASE XX.—*Hyperesthesia of Abdomen*.—Miss T., twenty-five. Complains of extreme sensitiveness of abdomen, so that the necessary manipulations of a dress-maker caused severe pain.

A strong current (60 to 80 volts)(?), with the highest attainable frequency of alternations (1,920 per second), was used locally. Improvement progressed steadily up to the eighth application, when the trouble was completely relieved. There has been no return to date (S.).

CASE XXI.—*Hyperesthesia (dorsal)*.—Referred by Dr. S. C. Ayres.

Mrs. U., thirty-five, married, three children. Good heredity, robust physique. Pulse 84. Heart, lungs and urine normal. Nineteen years ago was in an out-house during a thunder storm, when the building was struck by lightning. Is positive that the boards were charred and burned. Her clothing and skin were not burned. Was found unconscious, and since then has had five or six "fits" at long intervals, with rigidity and unconsciousness. For more than two years past has had extreme hyperesthesia of right side of back (dorsal and lumbar regions), with weakness of left arm.

Examination reveals a normal mental "tone," not emotional," but somewhat depressed. No speech disturbances. Right visual field much contracted. Taste absent to salt, sugar, and bitter on right side of tongue anteriorly. No muscular rigidity, spasm or wasting. Grasp, right 40, left 20 (lower scale of dynamometer). Some weakness on flexion of left thigh. Uncertainty of heat and cold sense over left shoulder, arm and hand. Marked hyperesthesia over an area extending six inches to right of spine from third dorsal to first sacral vertebrae. Sensation normal on opposite side corresponding. Touch of a wisp of cotton, without her knowledge, causes excessive pain over the hyperesthetic area noted. No bladder or rectal symptoms. Knee-jerks absent.

The peculiar complex of symptoms rendered the diagnosis in this case

somewhat uncertain for a time, but I was finally led to consider the hyperesthesia, as well as the other symptoms, entirely functional, and probably of cortical origin, chiefly by reason of their peculiar distribution. This opinion was further strengthened by the marked relief afforded by the sinusoidal current, which, however, had to be applied at the margins of the affected area, and the electrodes gradually shifted as the sedative effect was obtained. It was impossible for the patient to bear for a moment the weight, or even the mere contact, of the electrode without any current. By means of the procedure adopted, however, the current was applied to the entire hyperesthetic area.

The patient declined to remain for treatment, however, and went home to a distant city, where she applied to a physician for "electrical treatment." The slightest current used, which I suppose was an ordinary secondary faradic from her description, caused such excessive pain that she ceased treatment at once and returned in a few days to Cincinnati.

A course of one month's treatment, during which time the current was increased from $27\frac{1}{2}$ to 50 or more volts and the alternations reduced from 960 per second to 480, was attended with complete relief, which has continued for three months.

Before returning home the dynamometer test registered R. 90, L. 95. The hyperesthesia had disappeared. The knee-jerks were still absent, even to reinforcement. The right visual field remained contracted. Her general health was excellent in every respect (L.).

Respecting the precise mode of action of the sinusoidal current, we are perhaps as much in the dark as we are with the similar problem pertaining to most remedies. Our limited knowledge of the ultimate nature of nerve-conduction points to the probability that it is a "mode of inter-molecular motion" in the ultimate nerve elements.

One explanation, therefore, of the mechanism of action of the sinusoidal current in hyperesthesias is that it modifies favorably and in a regular

manner this inter-molecular motion. The facility with which the rate of alternation may be varied from 480 to 1,920 per second, and the "potential" (voltage)¹ within equally wide limits, renders this form of current peculiarly adapted to the modification of neuro-activity. The more rapid alternations appear to produce a sedative effect, the slower alternations a stimulant action. The improved circulation locally and generally observed to follow its use in

most cases is probably another potent factor in the results, by its good effect on tissue metabolism.

Aside from these, the current appears to possess in an unusually satisfactory degree the common action of all electric currents on living tissues—catalysis.

For assistance and information respecting the sinusoidal current and its relations, acknowledgements are due to Mr. A. L. Duwelius, of Cincinnati, and to Mr. J. H. Gladstone, of the Edison Manufacturing Company, of New York. The very satisfactory little book of Houston and Kennelly, before referred to, has also been freely used in the preparation of this paper.

¹ Where the term volts occurs in this paper it refers to the voltage per lamp ($27\frac{1}{2}$ volts) admitted to the primary coils. The voltage to the patient can only be approximately stated on account of the impracticability of exactly measuring an alternating current of such high frequency.

DISCUSSION.

The President, DR. JOSEPH EICHBURG: The Academy is indebted to Drs. Langdon and Schenck for their excellent paper, and for their kindness in demonstrating a new apparatus. It is unfortunate that the paper is of such character that the knowledge of the subject is mainly confined to the essayists, but we will be glad to hear from any member who may have had any experience in this direction. It certainly appears to be an important contribution to our knowledge of the treatment of some organic diseases of the nervous system.

DR. A. D. BIRCHARD: I can testify to the efficacy of the sinusoidal current as an analgesic on my own person. I was afflicted with a radial neuritis, causing severe pains at the wrist, with anesthesia over the dorsum of thumb, probably due to exposure to cold in driving. After the first application the pain was relieved, and this relief remained permanent after a few applications. The anesthesia continued for some months, but it did not annoy me sufficiently to require continued treatment.

DR. M. A. TATE: I would like to ask the essayist if he considers the sinu-

soidal current a substitute or equivalent for all other electric currents for medical purposes?

DR. S. P. KRAMER: The especially valuable feature of the sinusoidal current appears to me to be its power of producing muscular contractions of a tetanic character where faradism fails, and this without the cutaneous pain of the faradic current. It is superior to the galvanic current as a nutritional agent if, in nerve degenerations, we can produce a more continuous contraction of the muscles. The sensory effects are of less importance, since we may obtain them in some degree from other forms of current.

DR. JOSEPH E. BROWN: I understand from the remarks of the essayist that this is an induced current, the poles of which change rapidly. Why would we not have the same effect with a rapidly interrupted galvanic current? With the ordinary rheotome we do not have interruptions of sufficient rapidity.

DR. KENNON DUNHAM: I desire to ask the essayist what the value of the sinusoidal current is as a diagnostic agent?

DR. LANGDON: With reference to Dr. Birchard's experience, his case is

not amongst those reported. I regarded the lesion as a radial peri-neuritis, probably due to exposure to cold in driving. The analgesic effects of the current were all that could be desired.

In reply to Dr. Tate's query, I would state that the sinusoidal current cannot, in my opinion, be looked upon as a substitute or equivalent for any other current. Its wave form, as shown in the diagrams, indicates that it is a distinct thing in itself, not a modification of any other current. Its therapeutic effects also point to this conclusion.

I entirely concur in Dr. Kramer's remarks as to the value of this current in nerve degenerations, and the case of

polio-myelitis recorded shows its desirability in these forms of paralysis.

Dr. Dunham's question respecting the diagnostic value of the sinusoidal current cannot be properly answered at present, for the reason that all recorded observations bearing on diagnosis have been made with the galvanic and faradic currents.

To Dr. Brown's question I would reply that any rapidly interrupted *galvanic* (direct) current has nothing in common with the sinusoidal wave. Such a current as the doctor refers to would be a pulsating (De Watteville) current, *not* an alternating current of any kind.

