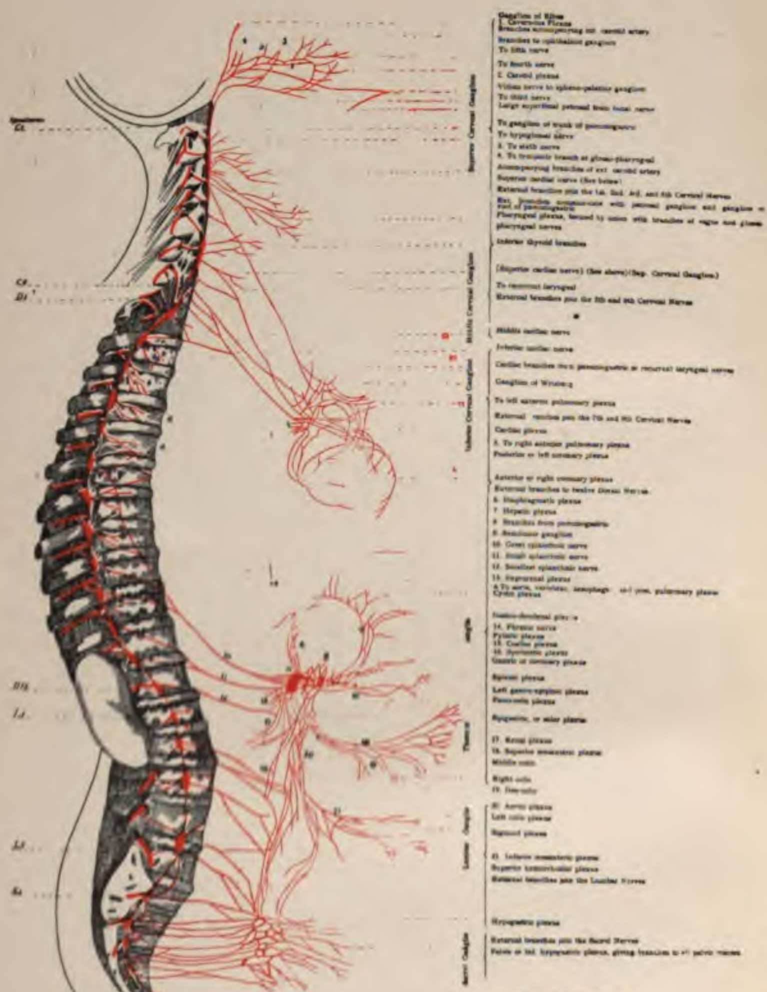
The Gardner Sanitarium



Ganglion of Ribes
1. Cavernous Plexus
To fourth nerve
2. Carotid plexus
Vidian nerve to spheno-palatine ganglion
To third nerve
Large superficial petrosal from facial nerve
To hypoglossal nerve
3. To sixth nerve
Accompanying branches of ext. carotid artery
Superior cardiac nerve (See below)
External branches join the 1st, 2nd, 3rd, and 4th Cervical Nerves
Pharyngeal plexus
Inferior thyroid branches
(Superior cardiac nerve) (See above)(Sup. Cervical Ganglion.)
To recurrent laryngeal
External branches join the 5th and 6th Cervical Nerves
Middle cardiac nerve
Inferior cardiac nerve
Ganglion of Wrisberg
To left anterior pulmonary plexus
External branches join the 7th and 8th Cervical Nerves
Cardiac plexus
5. To right anterior pulmonary plexus
Posterior or left coronary plexus
Anterior or right coronary plexus
External branches to twelve Dorsal Nerves
6. Diaphragmatic plexus
7. Hepatic plexus
8. Branches from pneumogastric
9. Semilunar ganglion
10. Great splanchnic nerve
11. Small splanchnic nerve
12. Smallest splanchnic nerve
13. Suprarenal plexus
Cystic plexus
Gastro-duodenal plexus
14. Phrenic nerve
Pyloric plexus
15. Coeliac plexus
16. Spermatic plexus
Gastric or coronary plexus
Splenic plexus
Left gastro-epiploic plexus
Pancreatic plexus
Epigastric, or solar plexus
17. Renal plexus
18. Superior mesenteric plexus
Middle colic
Right colic
19. Ileo-colic
20. Aortic plexus
Left colic plexus
Sigmoid plexus
21. Inferior mesenteric plexus
Superior haemorrhoidal plexus
External branches join the Lumbar Nerves
Hypogastric plexus
External branches join the Sacral Nerves
Pelvic or inf. hypogastric plexus, giving branches to all pelvic viscera
Coccygeal ganglion, or Ganglion Impar
Superior Cervical Ganglion
Middle Cervical Ganglion
Inferior Cervical Ganglion
Lumbar Ganglia
Sacral Ganglia

MECHANICAL VIBRATION AND ITS THERAPEUTIC APPLICATION

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BY

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PREFACE.

For centuries the basis of mechanical vibratory treatment has been developing. Manner, form, length and localization of treatment have received consideration, and gradually a scientific system of manual massage has been evolved in accord with physiological principles, pathological conditions, and physical laws. Although a laborious method and liable to be performed in a perfunctory way, except by the conscientious masseur, it has attained a high place in therapeutics.

During the past few years machines have been perfected which have made the application of the principles of scientific massage less laborious and more perfect and complete in point of time, intensity, and frequency. The question whether the degree of delicacy associated with the touch is sacrificed, in some cases, is one that the future must determine. There is undoubtedly an extensive field for its therapeutic application, of which spinal stimulation and inhibition constitute but a small part. The subject not having been treated from the broad point of view, this work is written to call attention to the fundamental principles which will enhance the value of mechanical vibration not only in its present therapeutic application but in the important field which will be opened to it in the future.

The author wishes to express appreciation for the inestimable assistance of her husband, Dr. Wm. Benham Snow, and also to Dr. Sigismund Cohn.

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CHAPTER I.

HISTORY AND DEVELOPMENT OF MECHANICAL VIBRATION THERAPY.

Mechanical vibration or vibra-massage has made rapid development during the past few years. It is the outgrowth of a subject which dates back to ancient times,—one which has been maturing for centuries, and which has been practiced by many nationalities in various ways, to wit, *massage*. Until recently, however, massage has not received the recognition it so richly deserves, for in the hands of charlatans and quacks—non-professional masseurs—it has principally become known, and not favorably known. It required such men as Mezger, Zabludowski, Bunge, Graham, Seguin, Weir-Mitchell, Playfair, and Kellogg to give it scientific recognition and establish a technique that could be therapeutically employed.

The history of mechanical vibration is limited, but as much can be learned from its development in its relation to massage it is well to consider it in that connection.

The word massage is from the Greek *μασσόω*, to knead; Sanskrit, Masch, to strike, to press, to condense, and according to the noted authority, Dr. Douglas Graham, author of a "Treatise on Massage," includes "friction, kneading, manipulating, rolling, and percussion of the external tissues of the body in a variety of ways, either with a curative, palliative, or hygienic object in view." Friction, rolling, a form of deep kneading, and percussion, are produced by the action of many of the mechanical vibratodes.

According to the Swedish Movement Cure, massage should be combined with various forms of exercise suited to the case—passive, assistive, resistive, or active movements. Such combination with vibration greatly enhances its field of usefulness, and increases its therapeutic value. It is believed that the Susruta, of the Hindoos, used also by the Brahmins, is the oldest work on the subject. It was probably followed later by the Chinese book, Cong-Fou of the Tao-See which was written hundreds of years before Christ. Some believe that the Greeks probably got their knowledge from the Hindoos and Chinese.

Homer, about 1000 B. C., in his masterpiece, the "Odyssey," notes that rubbing and anointing were used for their invigorating effects. The ancient Greeks and Romans of all classes used massage as a luxury, to hasten recovery from sickness, or to increase their agility and powers of endurance. After gymnastic exercises, it was used in the treatment of pains and as an invigorator marking its early recognition as a therapeutic agent.

Its place, however, today can be far more ably filled by properly applied mechanical vibration, due regard being given to rate, stroke, mode of application, and applied technique. At that time, it was in the hands of priests, trainers (aliptae), and slaves as well as medical men. This is one reason for the slow development of scientific massage. When a subject is taken up by a body of learned men, investigation is thorough, improvements are suggested, and progress results, but when it falls into the hands of charlatans and quacks, the avenue of progress is blocked. For this reason mechanical vibration as a science did not develop until massage had been established on a physiological and well defined basis.

In the 5th century Herodicus advocated exercise for the treatment of disease and compelled his patients to have their bodies rubbed, he being a firm believer in the efficacy of massage.

Joseph Schreiber, M. D., author of "Treatment of Massage and Exercise," translated by Walter Mendelson, M. D., of New York, claims that Herodicus "first laid down principles for rational, mechanical methods of treatment."

Herodotus, 484 B. C., was one of the first to refer to the *manner* of giving massage. He said friction should be gentle and slow at first, then rapid in combination with pressure, which was to be followed by gentle friction. Other advocates were Plato, Socrates, and Hippocrates, who said "rubbing can bind a joint that is too loose, and loosen a joint that is too rigid. Hard rubbing binds, soft rubbing loosens, much rubbing causes parts to waste, moderate rubbing makes them grow," which is the earliest definite information relative to the effect of variations in the application of massage. These maxims should be remembered by those who use mechanical vibration for they well define its general therapeutic application. Hippocrates also suggested the *direction* in which to apply massage, the art of rubbing up, thereby assisting mechanical and physical processes, aiding circulation, relieving stasis and consequently quickening metabolic processes.

Asclepiades, 128-56 B. C., used massage in conjunction with active and passive movements. Cicero and

Julius Cæsar were also advocates, the latter even allowing himself to be pinched daily as a treatment for neuralgia.

Celsus believed most firmly in rubbing, advocating it for chronic pains of the head and for strengthening a paralyzed part. He mentions *general treatment* and also speaks of *localization*, but adds that sometimes treatment is necessary in a part *other than the seat of pain* which is along the same line of thought as vibratory treatment applied to "referred pain." He also mentioned the *length* of treatment, saying that a general treatment if weakness be present should be shorter and gentler than a local treatment—an important consideration in vibratory treatment.

Hadrian, Pliny, and Martialis were also earnest advocates of massage. Galen, A. D. 130-200, recognized friction usually as an adjunct to other measures. He said that if friction be used before exercise for the purpose of rendering the parts supple and less liable to injury, "the *middle quality between hard and soft*" should be used, and this is the keynote to mechanical stimulation. Even at that early date there were advocates of various modes of rubbing. Some taught that tranverse rubbing, known also as "circular rubbing, hardens, and condenses and contracts, and binds the body, but that perpendicular rubbing rarefies and dilates, and softens and unbinds." Galen, however, was eclectic in his views and favored variations in application, advocating nine different ways of employing massage.

Arrian advised *stretching* in connection with massage, which in conjunction with relaxation induced activity of the lymph current. This should be borne in mind when using mechanical vibration, particularly when treating local stasis. Stretching is also useful when applied to affections in which it is desirable to increase the joint nutrition.

Oribasius, a Greek, speaks of the "apotherapeia," a method which included bathing, friction, and inunction. A new feature mentioned by him was that of extension and holding the breath. Extension assists also in the treatment of selected cases when using mechanical vibration; for example, in tendo-synovitis. The patient should not hold his breath during a vibratory treatment, but take deep inhalations followed by slowly forced exhalations. This enables the operator to administer deeper vibratory treatment over deep structures, as the solar plexus, and when used with passive exercise as an adjunct to vibration. Greater tension can be made during the period of forced exhalation.

An ancient method mentioned by Blumenthal was one used by the Greeks, which consisted of wrapping one end of a saw in cotton fabric and applying it to the part to be treated while on the uncovered part of the saw a piece of wood was sawed; thus mechanical vibration was transmitted to the part requiring treatment.

The scourge was also used in cases of impotence. The back was rubbed to cure sterility in ancient times, and "Roman ladies allowed themselves to be whipped with strips of leather" for the cure of the same condition.

Paracelsus, 1492-1541 A. D., Professor of Surgery at Basle, in 1526 wrote "Liber de Vita Longa," in which the effects of friction are extolled, indicating the early recognition of its therapeutic value.

In the sixteenth century, a Japanese book, "Sau-

Tsai-Tou-Hoei," demonstrated the use of *percussion, vibration,* and *pressure,* as well as *passive motion.* These methods were used by the Japs for many years. They were applied for relaxing "rigid muscles" and spasmodic contractions, for the relief of rheumatic pains, and after the union of fractures, conditions amenable to mechanical vibratory treatment.

Ambroise Pare, 1517-1590 A. D., noted for introducing the ligation of arteries, described and advocated that three modifications of friction—gentle, medium, and vigorous—be employed, and demonstrated the effects of each, showing that some attention was then given to technique and its results.

In 1573, Mercurialis published "De Arte Gymnastica," treating of the beneficial effects of movements. Fabricius ab Aquapendente of Padua, author of "De Motu Locali Secundum Totum," Guyon, author of "Miroir de la Beuté," Sydenham, and Hoffman, who wrote "Dissertationes Physico Medical" in 1708, believed in massage. Francis Fuller in 1740 wrote "Medical Gymnastique" in which he treated of the "influence of motion" and its therapeutic value. *Flagellation, percussion,* and *slapping* were prescribed in the seventeenth century by Paullini. Massage rollers and muscle beaters applied in many ways by changing their shapes were primitive vibrators.

Abbe St. Pierre, in the early part of the eighteenth century, invented the trémoussoir.

Three systems relative to motion followed the mediæval period: the Stahl or iatro-mechanical, the Boerhaave or iatro-dynamical, and Hoffman's or the mechanico-dynamical.

An old book of special interest to the mechanotherapist is "A Full Account of the System of Friction as Adopted and Pursued with the Greatest Success in Cases of Contracted Joints and Lameness from Various Causes" by John Grosvenor, the celebrated English surgeon. He did not consider it a cure-all. He said it was not applicable "in all cases of inflammation, in scrofulous cases tending to suppuration, in cases of inflammatory gout and rheumatism" and was "useless in cases of true ankylosis." He found it valuable in "contractions of the joints attended with languid circulation, and thickening of the ligaments," where there was "too great secretion of the synovial fluid in the joints, after wounds in ligamentous, tendinous or muscular parts when the function of the limb is impaired; after violent strains of the joints; in incipient cases of white swelling; after fractures of the articulating extremities of the joints when stiffness remains after union; in cases of dislocation of the joint when the motion is impaired some time after reduction; in case of paralysis; in case of chorea combined with attention to the system; and in weakly people where the circulation is languid." His selection of cases was certainly apt, and the line of division will follow about the same course when mechanical vibration is used, particularly vibratory friction.

In 1808, John Barclay wrote "The Muscular Motion of the Human Body" in which he relates a case of muscular contraction cured by *percussion* alone. M. Blache in a paper on chorea treated by mechanical means, opened the eyes of the profession in France, but Ling and Mezger probably gave the most marked impetus to the subject.

In the early part of the nineteenth century, William Balfour wrote on "Illustrations of the Power of Compression and Percussion in the Cure of Rheumatism, Gout and Debility of the Extremities, and in Promoting Health and Longevity." He says that "Medical practitioners encourage their patients in giving perfect rest to parts affected with rheumatism and gout, till, as often happens, they change their action altogether." He claimed in respect to the treatment of gout by percussion that "percussion, instead of repelling, creates an afflux of nervous energy and sanguineous fluid to the part. Vessels in a state of atony are thereby roused to action and circulation is promoted; and bandages support the vessels and enable them to perform their functions." This was an attempt at an explanation of the physiological action of percussion, so necessary to thoroughly understand that percussion may be more intelligently used therapeutically.

In the nineteenth century impetus was given to the subject by the introduction of the "Swedish Movement Cure" by Peter Henrik Ling in the Royal Central Institution established at Stockholm in 1813. Much controversy has arisen as to the claims of originality, as a like manner of treatment was followed in the early history of the world by the Chinese, Egyptians, and others. But be that as it may, we certainly owe to Ling the introduction of the subject as a whole to civilization on a physiological basis.

In the middle of the nineteenth century, Dr. Zander constructed mechanical motion devices, as his "Headshakes" for neuralgia, etc., and still later Vigoreaux employed a tuning fork in connection with a resounding box for the treatment of contractures, locomotor ataxia, etc.

Taylor of New York and Kellogg of Michigan were also among the pioneer inventors and users of mechanical apparatus for massage. Vibrating, shaking, rolling, percussion, compression, and friction can well be done by such apparatus but due regard to careful technique is necessary in their successful manipulation, as much so as in manual massage. The majority of this apparatus vibrated the subject *en masse*. The next advance step was the introduction of vibration apparatus by means of which treatments could be more localized, the apparatus better controlled, and capable of being applied with a greater nicety of technique.

Peoples of warm countries and cold countries, barbarous and civilized alike, have methods of massage, manual or mechanical. The Toogi-Toogi, Mili or Tota of the people of Oceanica described by Dr. Graham comprises "striking constantly and softly with the fist, rubbing the palm of the hand, and pressing and squeezing the tissues between the fingers and the thumb." It illustrates combination of effects that can be produced with a vibratode. The natives used it for fatigue, pain, etc., and curious enough, if for fatigue, treated only the arms and legs, but if for pain the surrounding area of the particular site was treated, demonstrating that they had an idea of *localization* of treatment. The Sandwich Islanders use a mixture of kneading, squeezing, and rubbing called lomi-lomi.

During the twentieth century the advancement of the status of exercise by such men as Savage, Kellogg and Sargent, has aided also in advancing massage. Dr. Joseph Schreiber considers that the first treatise on mechanical manipulation, physiologically considered, "appeared in 1876 by von Mosengeil in Archiv für Clinische Chirurgie." He put it on a scientific basis. Charcot, Esmarch, Billroth, Trousseau, advocated it, as did also Drs. Weir-Mitchell, Otto Bunge, Brown-Séquard, Edward H. Clark, Samuel G. Webber, Douglas Graham, Professor Playfair and Prof. Zabludowski.

Massage today is of three types—massage as taught scientifically in connection with exercise, hydrotherapy, electricity, and phototherapy; massage in the school of osteopathy, which virtually massages and moves joints for the action on nerve centres; and the unfavorably known massage of the charlatan.

Eventually, massage as a therapeutic measure will be better systematized. Mechanical vibration should profit by past experience and beginning with the present status of scientific manual massage, build up scientifically, physiologically, and therapeutically. This must not be done from the mechanical aspect of the subject alone, for not until exercise was placed on a solid physiological basis did it advance, and not until mechanical vibration is studied from a standpoint other than that of empiricism and the commercialism of the manufacturer will it obtain due recognition from the medical profession.

By recognizing the modes of massage we can more clearly see its relation to mechanical vibration.

"Slow and gentle stroking in a centripetal direction is called effleurage, deep rubbing is massage à friction, deep manipulation without friction is pétrissage," and percussion, one of the main features of mechanical vibration, is tapotement. Dr. Graham makes the subdivisions of "friction, percussion, pressure and movement," and recommends that "all of the single or combined procedures should be begun *moderately, gradually increasing in force and frequency* to their fullest extent desirable, and should end gradually as begun," also that the dose *is "determined by the force and frequency* of the manipulations and the *length of time* during which they are employed considered with regard to their effect upon the patient," which technique is applicable to vibration therapy.

The application of manual vibration to the human body therapeutically has been known for many years. Ling and his advocates had an idea of this mode of treatment of the nerves, and organs, and of its results as noted in "Georgii Traitement des Maladies par le Mouvement," Paris, 1847.—"They observed the effective influences travelling from front to back in the direction of the sinus longitudinalis and of the sinus transversalis, and applied, therefore, vibrations successfully in congestion of the brain. Heinrich Kellgren developed this method about twenty years ago, but used it only in connection with massage, as a system complete in itself, without the accompaniment of drugs, electricity or massage. Its great value was probably first recognized and demonstrated by Dr. Strensch, who introduced his method in this country, in 1891, thus becoming a pioneer in the right sense by calling attention to Nature's foremost law-vibration for medical use."

But little has been written on vibra-massage or mechanical vibration therapy as a separate subject. The late Dr. Maurice Pilgrim's book is the pioneer work in English, and Dr. Barnum has written a manual on the subject lately. Among other contributors have been S. J. Meltzer, W. B. Tomson, C. H. Liedbeck of Stockholm, Boudet de Paris, J. M. Charcot, Gilles de la Tourette, E. J. Godman, E. Morselli, Paul Garnault, Joseph Mortimer Granville, Louis de Lacroix de Lavelette, Reich, George H. Taylor, S. H. Monell, Lucy Hall Brown, Frederick H. Morse, and S. S. Wallian.

It is curious to note that France, the slowest country to adopt massage and yet the one that gave it its name, is the European country that has most extensively employed mechanical devices for vibration-therapy, and as a nation has furnished the most prolific writings on the great sub-division, vibra-massage, except possibly the United States.

The subject of vibration is growing in favor and embraces not only that of manual and mechanical vibration, but chemical, thermal, and electrical.

The word vibration means *"a recurrent change of position." Vibrations are movements where the recurrent changes of position occurring at equal intervals of time called periods of vibration, which may be infinitesimally short, or of sufficient duration to be noted in time, give them the character of waves whose amplitude is very small. Periods of vibration* must not be confused with *duration of vibrating state* relating to the whole. The *amplitude* of the vibration may vary or be fixed in any given apparatus, and the vibratory movement may be *simple* as with the pendulum of a clock, or in the unrestricted movement of an ordinary vibratode, or *complex* as when the vibratode has not a full swing; for example, when it meets the resisting surface of the body of the patient. The hand may be the motor, or the power may be liquid air, carbonic acid gas, electricity or water.

Etheric vibration induced by chemical substances is of greatest intensity, as produced by radium and other radio-active substances, thorium, polonium, uranium, and actinium. These substances give off ether vibrations without stimulation from any known source of energy, setting gases in vibration, producing varied spectra. There are three kinds of rays emanating from radium graduated according to their vibratory activity, as α, β and γ, the α resembling the X-rays, the β rays of higher vibration resembling the cathode rays, which are of still higher vibratory rate, thereby giving "a more powerful chemical action and profounder physiological effects," and the γ rays of still higher vibratory rate.

Etheric vibration induced by electric power is of wide range from the vibrations produced by the continuous and induced current batteries to those of the static machine, or coil; varying also from the convective discharges including static electrification, interrupted or constant, the breeze, spray, brush discharge, and high-frequency discharges from the glass vacuum tubes, to the conductive discharges including the static induced current and the wave-current and also the X-rays, as well as the rays produced by modern photo-therapeutic apparatus.

Selective, harmonic, electric vibration, another form or modification of vibration, has recently been scientifically presented by Morris W. Brinkmann, A. B., M. D., of New York. He considers simple and compound vibrations, but subdivides simple into slow, moderate and high-frequency, and the multiple into combinations of simple rates, harmoniously or discordantly, and "combination of multiple rates from single blows, 16 to 40000 per second or any multiple rates above this to infinity." Pitch, intensity, and timbre are characteristic qualities valuable in therapeutics and are closely associated with the physics of sound. As it is known that hearing depends upon the physiological condition of the organ of Corti, and the optic nerve, and as hearing varies, so do other parts respond differently as their pathological or physiological conditions vary. Dr. Brinkmann says that the body "attunes itself" to rates below 16 per second, which the ear does not hear, and "general sensation is influenced." He believes that the "sensory apparatus and muscle sense can estimate and adapt themselves to 3000 vibrations per minute. Thickness, tension, and length, he says, may regulate "the particular rate or note to which a muscle, nerve or other tissue" may be attuned or respond. The theory is that for example, in a striped muscle composed of fibres which are made up of fibrillae of different lengths and tensions, that "the concurrent use of several rates of oscillation" is required. He therefore believed that harmonics would be more useful than single notes, and devised an apparatus which will be considered later. This subject in a simple form was recognized by Dr. George H. Taylor and Dr. H. C. Houghton, of New York, and Dr. J. Mortimer Granville, of London, a number of years ago. Dr. Granville studied and devised an instrument for musical vibra-massage which is said to give from 1000 to 2000 blows per minute.

The subject of mechano-vibration has been studied by Reich in the Lexikon der Physikalishen Therapie. Diätetic und Krankenflege. He makes a distinction not as yet recognized in this country, the differentiation of concussion and vibration. Vibration is of higher frequency and a milder form of movement while concussion is stronger with less frequency, the maximum being from 120 to 150 per minute. He regards vibration to be high frequency, and concussion low frequency, the body not having time to come to rest before the second tap comes in the first form, results in the summation of stimuli, but in the second form the body has time to come to rest between two single pushes. He cites the Ewer concussor as a type of an instrument giving concussion but not vibration.

Vibration is a subject of wide range and concept, and a brief sketch of it has been given as a whole in order that when we limit ourselves to one small part—mechanical vibration, vibra-massage, or massage, we may bear in mind particularly the import of knowledge gained from experience in other lines of work, the history of massage as it deals with manner, time, frequency, etc., the consideration of all forms of light, heat, and electricity, particularly the static with its most pronounced vibrations, their physiological actions and therapeutic results, and harmonic vibration with its peculiar selectiveness. Time and energy should not be wasted in trying to build up something entirely new when there is so much that has been authoritatively demonstrated, but use all that is applicable and reliable from whatsoever source, building thereon scientifically for the advancement of vibration therapy and in the interest of suffering humanity.

CHAPTER II.

MECHANICAL VIBRATION APPARATUS.

As noted in the previous chapter, mechanical vibration in its application was in the process of development when the Greeks wrapped one end of a saw in cotton and applied it to the part to be treated—while sawing a piece of wood with the uncovered portion for

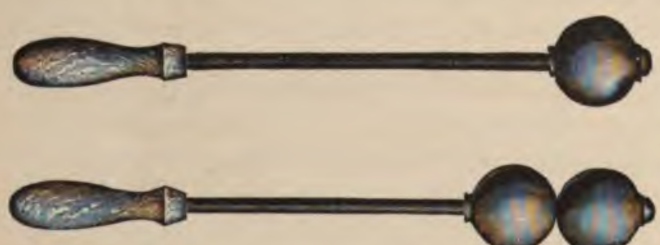

Fig. 1.—Graham's Muscle Beater.

the production of vibration. The improvements on primitive vibrating devices suggested for use with massage were various hand instruments—Klemm's muscle beater, Graham's elastic rods (See Fig. 1) with rubber balls, massage rollers (See Fig 2)—and later the machines of Zander, Taylor (See Fig. 3), Kellogg, Charcot, Phelan, Nebel, Herz, Funke and Krukenberg.

There are two forms of Zander machines (See Figs. 4a and 4b), one for massage and the other for movements. "Their operation depends upon various applications of the lever principle. A manometer is so attached as to show or register the force used, the speed of each machine is governed by the number of teeth in its several cog-wheels, adjustable to obtain differing rates and extents of movements, and a special clutch-wheel or a governing handle is so fitted to each as to make it possible to throw the whole machine out of gear and stop it in an instant."

Necessity is the mother of invention. A demand for

Fig. 2.—Neck Massage Roller.

means of lessening the laborious task of the masseur and various other factors gave an impetus to an old subject. French, Germans and Americans have accordingly invented and improved the wherewithal by means of which the work could be better and more easily accomplished by machinery, thereby saving the time, energy and patience of the operator, and enabling him to give treatment with greater precision as to stroke, and definite measurement as to speed. The employment of the apparatus may or may not equal or excel that of manual massage, according to the touch, knowledge, skill and technique of the operator with each, and the adaptability of the apparatus to the particular work in question.

At the present day there are probably more than 25 kinds of machines in the market and numerous different vibratodes, for making the application. The French have probably contributed more to the literature of the subject of mechanical vibration than any other European nation, and a description of many of their apparatus can be found in the Transactions of the International Congress of Electro-Therapeutics for 1900.

Fig. 3.—Taylor Machine Single Manipulator.

Vibrators may be classified as (1) portable or nonportable; (2) with a rigid arm, flexible shaft or "counterweight type." The hand devices, Aero-Vibrant, Victor, and Wappler machines are examples of a portable apparatus, and the Hanfeld oscillator and Chattanooga vibrator of non-portable. The Chattanooga instrument has a rigid arm, most of the other vibrators have flexible shafts. The device by means of which vibration may be administered is variously designated as applicator, attachment, and vibratode from vibration, vibro, to shake, and σδος, a way.

Fig. 4a.—Zander Vibrator Massage Apparatus Showing Method of Operation.

Vigoreaux used to employ a tuning fork in connection with a sounding box, in the treatment of hemianaesthesia, contractures, pain, etc. Among some of the devices are the vibratory fork of Boudet of Paris, used for anaesthesia and neuralgia, a hand vibrator, Charcot's vibratory helmet, the vibratory cap of Drs. Gilles de la Tourette, Larat and Gautier, the vibratory handle of Dr. Garnault, and the vibrating table of Drs. Charcot and Gilles de la Tourette, from which the patient received a treatment by sitting in a chair on the vibrating table. Two well known vibrators, the "Trem-

Fig. 4b.—Zander Movement Apparatus Showing Method of Administering Leg Adduction with Resistance.

olo" and Bihlmaier, are German inventions. One of the first vibrators from abroad was the Schneider, introduced into this country from Germany by Mr. Henry Tonjes. It resembled the King Harmonic.

Among the small instruments recently noted was a vibrating urethral sound used by Lankowski, Berlin, an account of which was published in the Deutsche Medical Wochenschrift, Leipzig, April 3, 1902, and an abstract of which appeared in the Journal of Advanced Therapeutics for June, 1902. It is "a large metal sound fitted into the rolled end of a wide metal spring, wider and stronger than a watch spring. The

Fig. 5.—Roller Chain.

end of the spring holding the sound is screwed flat between the narrow metal plates, and fastened together with two thumb screws. The sound is inserted in the urethra, and slight blows are struck on the projecting coil of the spring with a padded mallet." The treatment was administered daily or on every second

Cuts of various massage apparatus were kindly loaned by the Kny-Scheerer Co., N. Y.

or third day. The largest sound capable of being introduced without causing pain was found to produce the best results. It was used in cases of relaxation, over-stimulation, sexual neurasthenia, phosphaturia and prostatorrhea.

For the administration of mechanical vibration by hand many devices sold in America are used, a few of which are a roller chain, consisting of a double roll of wooden balls, shown in Fig. 5, that revolve in a flexible, jointed, nickel-plated wire chain, having handles; a roller chain and exerciser combined, many massage rollers, a Preuss' elastic roller (Fig. 6) with 12 interchangeable balls—4 smooth wooden balls, 4 corrugated

Fig. 6.—Preuss Elastic Roller.

Fig. 7.—Boxwood Massage Hammer.

wooden balls and 4 soft rubber balls—a neck roller, made of a piece of solid soft rubber corrugated into five prongs, wheel-shaped (Fig. 2), holding a nickel-plated roller of metal; a massage hammer (Fig. 7), with corrugated soft rubber cushions; muscle beaters; a combined roller, kneader and beater (Fig. 8); Graham's muscle beaters (Fig. 1), consisting of rubber balls attached to flexible rods having a handle at one end; Klemm's muscle beater (Fig. 9), with fingers made of "light steel springs," and Japanese massage rollers.

Concussors for vibratory treatment are of many different shapes and sizes, including probe pointed (Fig. 10) ones, for the pharynx; Ewer's disc, designed for the throat (Fig. 11); round knobbed, concave plate, slightly curved, and saddle shaped (Figs. 12, 13, 14 and 15), etc., and Dapper's abdominal plate and disc Figs. 16 and 17); also concave wheels, cylindrical, corrugated roll and rotation rollers of various designs. There are also many designs of rotary beaters (Figs.

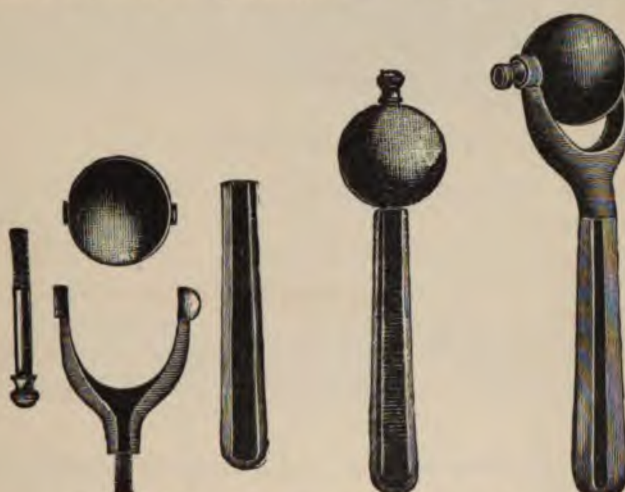

Fig. 8.—Combined Roller, Kneader and Beater.

18 and 19), employed for vibration therapy, some consisting of rubber balls, others of leather straps or hammers; others are for tapping massage, such as an instrument with a cylindrical end for vaginal and uterine use; a long leather covered fork for use in neck and throat treatment (Fig. 20), and a combination rotating and tapping concussor.

A small portable vibratory apparatus, to be operated by hand, is used like forceps (Fig. 21). "By opening and shutting two vibration exciters (hammers) are set in alternating motion." The operator can vary the speed "from 12 to 1500 vibrations per minute."

Another example of a small portable apparatus is one provided with a vibrating fork, known as the "Hutches Vibratile" (Fig. 22), operated by dry cell

Fig. 9.—Klemm's Muscle Beater.

batteries and said to give from 500 to 5000 strokes per minute.

Among electrical vibratory instruments are an electric muscle beater, which consists of a carbon ball covered with chamois, and operated by a battery; an electric massage hammer, a galvanic massage roller, and larger instruments to be combined with the galvanic

Fig. 10.—Small Probe Pointed Concussor.

Fig. 11.—Ewer's Disc Concussor for Throat.

or faradic current, also special ear massage and electrical prostatic massage instruments.

A small apparatus has lately appeared, which is being sold at large, in which the motor power is the hand. It consists of a metal rod about two and one-half feet in length, to one end of which a hard rubber ball about two inches in diameter is attached; at the other end of the rod is a hook-like extremity covered with rubber tubing. On this rod a sliding rod is placed at right angles to the long rod. The sliding rod is shorter than the first one mentioned and has three rubber balls on it, the first being adjacent to the first

Fig. 12. Fig. 13. Fig. 14. Fig. 15.
Ewer's Concussors for Vibration Massage.

rod, the second midway on the second rod, and the third and smallest at its distal end. To operate it the covered end should be placed in contact with the part

Fig. 16. Fig. 17.
Dapper's Concussors.

to be treated; the ball end being held with one hand and with the thumb and index finger of the other hand the sliding rod should be moved to and fro.

Fine, but not powerful, vibrations are thus produced.

Zander of Stockholm, Taylor of New York and Kellogg of Michigan were among the noted pioneers in the induction of mechanical vibration with non-portable apparatus. Among such apparatus was a vibrat-

Fig. 18.

Fig. 19.

Rotary Beaters for Vibration Massage.

ing chair, platform, bar and apparatus for mechanical beating, friction, kneading and trunk rolling. These were the fore-runners of modern vibrators. Many of the movements so produced were similar, but were not so easily applied as the more recent productions. They operated by vibrating the patient en masse, not in part.

The Victor vibrator (Fig. 23) is a well known apparatus of the flexible shaft type. It comprises a "reg-

Fig. 20.—Long Fork for Tapping Massage.

ular massage motor specially wound to give proper speed for the work and is provided with a speed controller in base" for use with the direct current. The pedestal is adjustable and provided with a rotating top. The stroke is obtained by the revolving of an eccentric, which is readily adjusted for the regulation of the stroke. The machine is operated by a 220-volt, or 110-volt, direct current, or by an alternating current. The outfit in the latter case has "an alternating

Fig. 21.—Vibration Apparatus for Hand Use.

current motor so connected that the speed is regulated perfectly by mechanical means, thus obviating the constant destructive sparking that is inevitable when commutators are used on alternating current motors."

Fig. 22.—Hutches Vibratile.

It can be used with a 60, 125 or 133 cycle current. A second form of Victor machine has a peculiar handle which "imparts a lateral rubbing movement to the applicator." Another form (Fig. 24) of the same machine is a combination pneumatic and mechanical vibratory massage outfit, which consists of a special motor that can be operated at any speed from 200 revolutions per minute to 6000 revolutions per minute, two speed controllers, one for the pump and one for

Fig. 23.—Victor Vibrator and Pedestal.

the vibrator handle, a pneumatic pump that gives a stroke from 0 to 1¼ inches, and a vibratory massage handle. The pump gives four air movements, straight exhaust or suction, suction with release, alternate suction and compression, and a succession of forward impulses or compression. An otoscope, which is also necessary in ear massage, and glass cups for eye treatment are provided. In the handle is an air port hole, which is covered by the thumb of the operator during an administration, allowing him to control the escape of air. The cable is provided with six attachments

Fig. 24.—Victor Vibrator with Pneumatic Attachment.

and the handle has a removable cap and a device for regulating the strength of the vibrations. By means of a two-speed countershaft it is possible to use any size motor, water or electric. Twenty-three vibratodes (Fig. 25), are made for the apparatus among which are: a small rubber cone, a medium sized soft rubber cone, an extra large one and two soft rubber cones for special work, a straight probe, a straight rectal applicator for internal use, an internal rectal ap-

Fig. 25.—Victor Vibratodes.

plicator "with spring to lessen severity of vibrations," a rectal for external use, a curved applicator for the throat, one cone of hard rubber, a large and small corrugated rubber disc, a cushioned applicator, a probe with springs, a "probe with twisted silver wire with eyelet to carry medicated ribbon," a large convex hard rubber, a large convex hard rubber muscle roller, a large concave heart applicator and a "spinal applicator, fingers separated sufficiently to span the spine." Special vibratodes, as a 12-inch rectal vibratode, etc., are also provided when desired. The vibratodes may be attached in a straight line with the handle, or at right angles to it. The motion is a rotary one, although seemingly tapping when the vibratode is in the latter site.

In addition to these the Victor Electric Company make a hand power machine (Fig. 26) and an apparatus which is specially wound for high speed, and though not originally intended as a massage machine, is in some respects one of the best for vibra-massage purposes, since it is entirely controlled by a switch which will give the operator any desired speed, varying from 400 to 4000 revolutions per minute, which is an important feature in many cases for massage.

The above machine is known by the Victor Company as the No. 2 Transformer and comprises a transformer motor which, as stated above, is operated by a switch giving perfect control of speed; on one end a massage handle or a nasal drill can be attached, and on the other end a small pump is attached which is used for aural and other forms of pneumo-massage.

This motor also transforms the direct current into the alternating, which is again passed into another transformer, which delivers a cautery current sufficient

Fig. 26.—Victor Foot Power Machine.

to heat any knife, and also a current for lighting diagnostic lights.

The Chattanooga Vibrator (Fig. 27), an example of the rigid arm type of machine, is manufactured by the Vibrator Instrument Company of New York, Chicago and Chattanooga and is an apparatus which has called forth considerable favorable comment. It consists of a perpendicular bar mounted on a metal base at right angles to it. To the perpendicular bar is attached one end of a jointed arm supporting a weight, the other arm being supported by a short perpendicular bar to the base. On the upper part of the long perpendicular bar is a rigid jointed arm supporting a motor, to one side of which is attached the metal handle bar with its perpendicular attachment, on the end of which are screwed the vibratodes. The rigidity of the arm is a particular feature of this apparatus. It can be operated by the direct or alternating electric current.

By means of two adjusting devices the vibratodes as a whole can be swung backwards and forwards, or from side to side. The motor is connected by insulated cords to a plug screwed into an incandescent lamp socket. The holder of the vibratode has a short shaft clamped by a nut on each side, which can be shifted in such a manner as to lengthen or shorten the stroke. The motion of the vibratode itself is to and fro in one plane. The attachments employed with this instrument are a hard rubber rectal, a throat attachment, a hard rubber ball for spinal work, a soft rubber brush, or multiple point vibratode, and a rubber cup. As the designers of this instrument believe that pressure is an important factor in the technique of treatment, they prefer to treat their patients lying down on a specially constructed table, hard cushioned

Fig. 27.—The Chattanooga Vibrator.

and slightly elevated at the head, so as to have a firm resisting surface. It is not absolutely necessary, however, that the patient should lie down, as vibration can be administered while he is sitting or standing, if desired.

Tonjes Aero-Vibrant (Fig. 28) is another mechanical vibration apparatus which employs compressed air or liquid carbonic acid gas as power. The tubes of

Fig. 28.—The Aero-Vibrant.

gas are delivered as ordered, so the apparatus can be conveniently used at the bedside if the house is not provided with electricity. The handle is connected with the atomizer valve by a flexible rubber tube. The Aero-Vibrant consists of a handle which is surmounted by a horizontal tube, the upper part of which is surmounted by a small metal chamber containing four air chambers. The horizontal tube contains the piston, with three air spaces in which three of the four air chambers open, the fourth air chamber opening into the space not occupied by the piston, and the rush of air from which causes the piston to move forwards and backwards in the horizontal tube which imparts an up and down motion to the vibratode, which is introduced into this holder, the opposite end of which makes one end of the horizontal tube. The Aero-Vibrant may be "attached to the atomizer valve or shut-off of any air tank or nebulizer outfit." The motion imparted is an up and down stroke. The following vibratodes (Fig. 29) are provided with the apparatus:

Fig. 29.—Vibratodes for Aero-Vibrant.

one for the uterus, one straight and one curved probe for mucous cavities, a roller vibratode, a multiple knobbed one for applications over the abdominal viscera, a soft-cushioned disc vibratode and a small hard one for body vibration, a small soft cone for the face and arms, a large soft rubber cone for aural massage, a soft rubber rectal-uterine, an extremely long soft rubber rectal probe (Fig. 30). It is claimed that only five pounds of air pressure are necessary to operate it, though oftener 15 to 25 pounds pressure are desired. It will produce over 7000 impulses per minute of a quality ranging from a most delicate touch to energetic vibratory impulse. It is well, but not absolutely necessary, to treat the patient lying on a table. The air pressure should be varied to the requirements of the parts treated. Twelve pounds is sufficient for application to the throat and neck; ten pounds for the liver, and twenty pounds for the treatment of hemorrhoids. The details of treatment will be given in a subsequent chapter.

If liquid carbonic acid (CO_2) is to be employed, the operator must possess a regulator and gauge, and the CO_2 gas drums have to be procured commercially. Each drum contains from 22 to 25 pounds of liquid gas. A woolen cloth, soaked in warm water and

Fig. 30.—Long Rectal Vibratode.

wrapped around the tube, it is claimed, will "increase the life of the tube." Of course, the length of time that a tube will last depends entirely upon the number and length of the administrations and the amount of pressure requisite for the cases.

If a compressed air outfit be employed for power, a power pump is to be preferred to a hand pump. No hydraulic air compressor is satisfactory unless at least "30 pounds faucet water pressure" can be furnished. One compressor manufactured is the Olney Sanitary air compressor, which pumps the air directly as used, no storage tank being necessary. This apparatus is automatic and is regulated by an air regulator. It can be attached to the "main inlet water pipe" and the outlet pipe can be joined to the sewer pipe. From the compressor many rooms can be supplied through one-quarter inch lead pipes. It will be necessary in that event to provide a gauge, regulator and attaching hose in each room. Some types of air compressors require an air tank for storage. An electric, water or gasoline motor can be provided for pumping the air. An electric compressor that will supply the air directly from the pump so that it can be gauged from one pound to thirty-five pounds has been recently perfected by the American Vibrator Company.

The improved form of Aero-Vibrant has a cylinder made of the finest bronze rod instead of tubing, which is reamed out to an exact fit. The piston is made of tool steel and instead of being like the former machine —a solid bar of steel—is hollow in the center. The object of this is to form a greater air cushion in the cylinder, the result being that the force of the vibratory impulse is over one hundred per cent. greater, and the amount of air used is very much less. In fact, for aural work five pounds of air pressure is the greatest ever needed. The hollow piston also overcomes any expansion or contraction in the metal, caused by the various climatic conditions.

The Church vibrator (Fig. 31), made in Syracuse, New York, and invented by Herbert Church, M. D., is a vibrator adapted to either the direct or alternating current or can be successfully used in connection with a water motor and dynamo to generate the current. The principles considered by the inventor as essential in mechanical vibration are first a perfect stroke of uniform and rapid quality, rhythmical in action and tone together with a sustaining power and speed which never varies from the lightest vibration of the eye to the heaviest spinal vibration; second, mechanical perfection with an interchangeable radius of action, and its portability. The vibratodes (Fig. 32) are six in number; one convex for deep spinal work, medium sized vibratode for general work, large sized convex for abdominal and dorsal work, and a vibratode for internal female pelvic trouble, also a rectal vibratode, and vibratode for the prostate. The shaft is made of ten thicknesses of piano wire, and is flexible. The machine has a tapping as well as a lateral motion.

Fig. 31.—Church Vibrator.

The characteristic stroke of this vibrator is obtained by means of a principle of motion never before applied in machinery of any kind (Fig. 33), and which develops more than double the power of any principle hitherto used. It consists of a ball bearing oscillating lever revolving on its own axis, with a ball bearing sliding fulcrum provided with a take-up for perfect adjustment. This construction, with the ball bearings running in a heavy grease, ensures operation with a minimum of friction, no lost motion, noiseless running and a remarkable smoothness of stroke, which remains constant irrespective of the pressure exercised. Experts estimate the machine to run for twenty years.

The motors used are of the Emerson type, 1-8 and

1-10 horse-power respectively. The mechanism is made of the highest grade tool steel, the bearings running in phosphor-bronze in the handle of the vibrator. The wearing parts are of the finest tempered tool steel and are provided with ball bearings throughout. The stroke is instantly adjustable and the vibrator is interchangeable throughout, no moving parts are exposed and vibratodes are easily and quickly adjusted.

The Hanfeld Oscillator (Fig. 34) is a combined type of apparatus; an oscillatory as well as a vibratory treat-

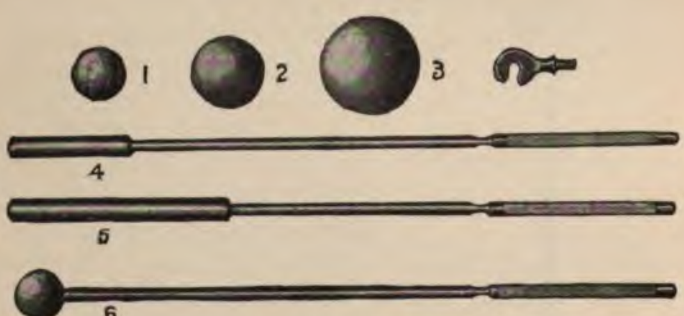

Fig. 32.—Church Vibratodes.

ment can be administered with it. It is operated by an electric motor and consists of a standard, the head of which is a short, horizontal shaft, on each end of which is a wheel, provided on each outer surface with an eccentric. The motor power may be either gas, water or electricity. The motor is connected to the pulleys on the head of the vibrator by a belt. The applicators for oscillation consist of a broad belt, a narrow belt, a hand piece and a foot rest.

A millimeter scale is marked on the side of each eccentric, which, when employing oscillation, should be adjusted the same distance from the center of each axis. After loosening each set screw, shift each eccentric the indicated distance from the center, the distance being regulated to the fineness of oscillatory movement desired, one millimeter or one and one-half millimeters being very fine and suitable to use with the smaller belt for the treatment of headaches or in ear or throat cases: two and one-half millimeters or so for cases where the hand-piece is used. Two to eight or nine miillimeters are usually used with the large

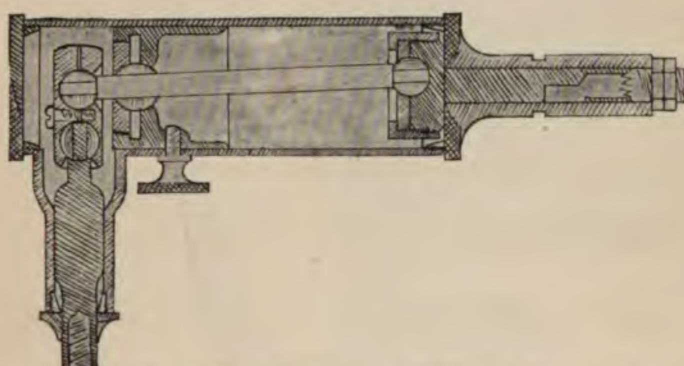

Fig. 33.—Showing Mechanism of Church Vibrator.

belt applied to the body unless very powerful work is required, when ten or eleven millimeters may be used, the limit being sixteen millimeters. After adjustment tighten the set screws. The motor for good work should make at least 2000 revolutions per minute, the speed being regulated by a system of pulleys for use with the alternating current, or pulleys and rheostat when the direct current is employed. When the hand-piece is used, only one eccentric is employed, the other having been put on center, but with the other applications both eccentrics are used. The belts should be non-elastic and firm. The hand applicator

Fig. 34.—Hanfeld Oscillator.

may be used in combination with the faradic or galvanic battery. The belt applicator may also be used with electricity.

The action of the tissue oscillator differs from a percussion stroke—it produces oscillation, having a twofold vibratory effect; the motion being governed by both eccentrics. When the motion is governed by one eccentric, vibration in its limited sense is produced. A revolving stool, and one or two high-backed chairs, one with and one without arms, are useful in giving treatment, but when the hand-applicator is applied administration may be given lying down. Two hand-applicators may be used together in such a manner that they may be applied as in heart massage.

Fig. 35.—King Harmonic Vibrator.

To use the belt, adjust the eccentrics, direct the patient, if a body treatment is desired, to remove the corsets or coat and vest, and facing the machine adjust the belt. He must make a pull of about twenty-five pounds on it in order to keep it taut, at the same time with the hands upon the handles keep them in line.

A late improvement to the above apparatus is the addition of a *flexible shaft* for the administration of forms of vibration other than the oscillatory. The end of the flexible shaft is inserted into the open screw end at the side of the oscillator; a set screw is provided which enables the operator to tighten it down firmly. Both eccentrics must be adjusted on the centre before using the vibrator attachment. It is preferable to insert the vibration shaft on the heavy or pulley side of the oscillator. Any possible speed may be used and regulated by the pulleys or rheostat when the direct current is used. If the greatest speed is desired, place the pulley belt on the inside cone or steps of pulleys. Any flexible shaft can be used although the boring is usually made for a No. 1 Victor flexible shaft.

Fig. 36.—Harmonic Vibrator.

The King Harmonic Vibrator (Fig. 35) is constructed similarly to the preceding. It is claimed to give "long or short vibrations at the rate of 150 to 3000 per minute," the motor power being electric, gas, water or foot. The King Vibrator Co. also make two other styles of vibrators, one of which is shown in Fig. 36.

The Bihlmaier Vibrator (Fig. 37) was invented by Otto Bihlmaier, of Germany, in 1898, but was introduced in America in 1901. It consists of a hand-piece which by means of a cable, is connected to an electric motor. The vibrations are produced by means of a revolving eccentric—a hammer in the hand-piece on which is a sliding adjustment which regulates the height of the stroke of the hammer from zero to one centimeter. No rheostat is said to be necessary. The power used may be a 110-volt street current from either the direct or alternating current, storage battery, dental engine, compressd air, or carbonic acid gas. The motor may be suspended from the wall or

Fig. 37.—The Bihlmaier Vibrator.

ceiling as desired. The vibratodes consist of a small and large hard rubber curved one, a small hard one, and some leather covered and cushioned. Three are made like probes for cervical, aural, and nasal treatment, and two are rubber cups. Special ones are for the chest, stomach, throat, neck, ear, and muscles. The stroke is distinct, even, and instantly regulated. It is demonstrated that the vibrator "can be regulated in the intensity of the vibrations without decreasing

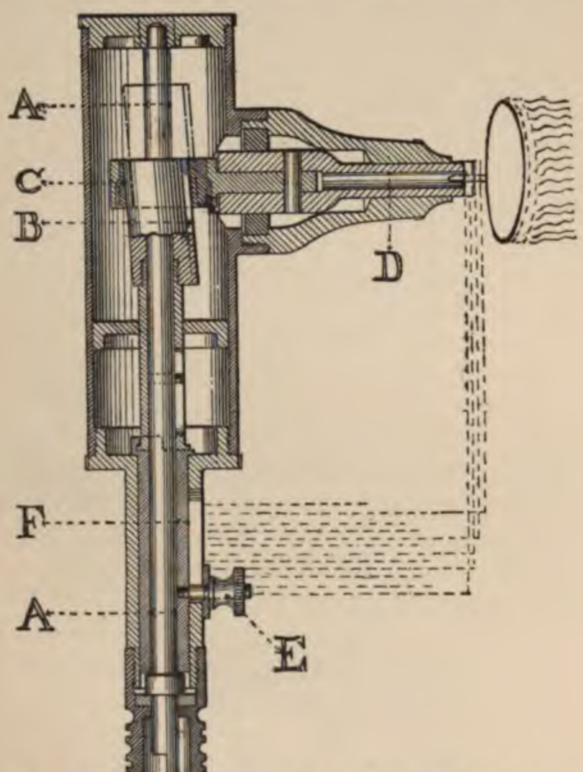

Fig. 38.—The Mechanism of the Bihlmaier Machine.

the number of vibrations, while the apparatus is in operation. There are no loose parts in the mechanism (Fig. 38) producing the stroke; that is to say, there is not the slightest play between the oblique eccentric, the collar holding the same in position, and the piston from which the vibration is delivered." A true even stroke results by means of which a kneading action is secured, which "imparts a penetrative vibratory effect to the tissue without harshness in its delivery."

The Kny-Scheerer machine consists of a cable with "an end piece or tapper (Fig. 39), and is operated by an electric motor employing a 110 or 220 volt direct current, the speed being controlled by a lever." The mechanism of the holder imparts a vibratory piston motion to the tapper.

The Wappler vibrator complete comprises a motor and rheostat combined, a flexible shaft, and a hard rubber handle to the end of which is attached a nickel-plated brass ball about two and one-half inches in diameter. To the latter, the vibratöde is attached. By an additional attachment it is possible to produce a concussion effect. The ordinary motion of the apparatus is designated by the manufacturers to be lateral, i. e., from side to side—from all sides of the vibratode, which is practically a rotary motion. Within the ball is secured a rod, at the end of which is attached at right angles another short rod, having screw threads for attaching two weights, disc-like pieces. One of them adjusts the stroke according to its distance from the first rod, and the second weight serves to lock the first. The power employed with this apparatus is electric, requiring 1-16 to 1-8 horse power motors. A valuable feature of this apparatus is the perfect control of speed and length of stroke, which can be effected either together or independently. It is possible to vary the rate from a very great frequency to one so slow that the strokes may be counted. At one end of the combined motor rheostat is a pneumo-massage attachment which is

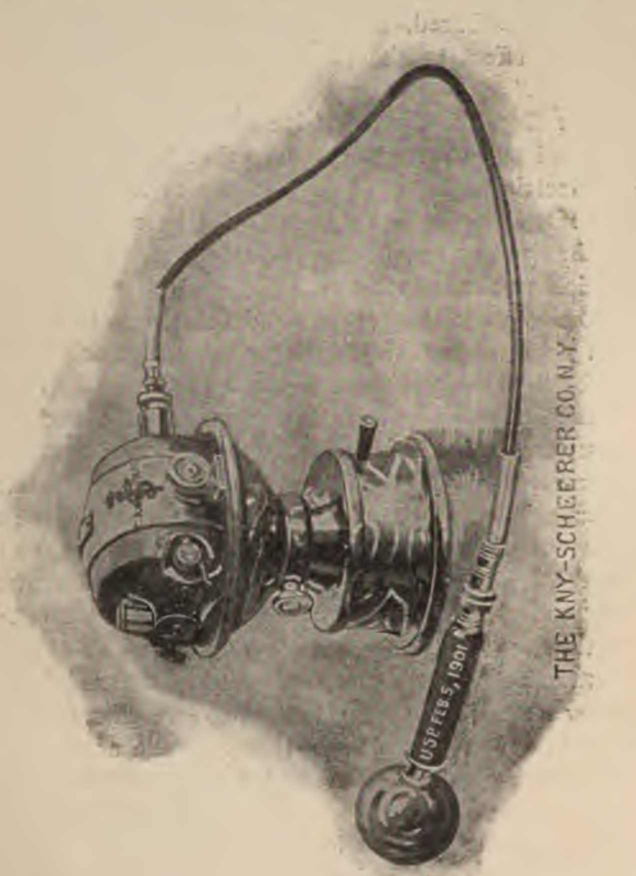

Fig. 39.—Kny-Scheerer Machine.

capable of producing three effects, (1) suction, (2) blowing, and (3) an alternating suction and blowing.

When the pneumo-massage apparatus is used the speed and stroke are regulated together.

Fig. 40.—The Tremolo Vibrator.

A vibrator made by Truax Greene and Company has three forms of strokes—rotation, thrusting, and concussion. It consists of a flexible cable connected with a motor.

The "Tremolo" (Fig. 40) is a German invention. Various motors may be used with it. Two cables are generally used, one of which has a universal left hand fitting so that the shaft on the motor runs in the same direction in which the cable is moved to screw it on to the sleeve so that the cable cannot work off when in use. The handle is surmounted by a metal ball about 2½ inches in diameter to which is transmitted a rotary motion. There are two sockets in this ball into which vibratodes may be inserted. From one insertion a rotary motion may be derived, while from the other a tapping motion is induced. If the cable be attached to a properly controlled and speeded motor, frequencies from 50 to 3000 per minute may be produced. If a multiple knobbed vibratode having five knobs be used the frequency will be increased fivefold. All vibratodes with this apparatus are made of metal. The speed or stroke can be increased or diminished simultaneously or independently—a desirable feature.

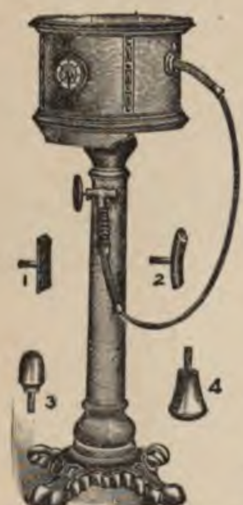

Fig. 41.—Betz Vibrator.

The Betz vibrators include six forms. One consists of a flexible shaft fastened to "an alternating current motor attached to the wall (Fig. 41), the motor being held by an extension rod which slides in and out of the hollow arm of the bracket." A second form is operated by a water motor (Fig. 42). This vibrator may also be attached to any other motor by fastening the bracket on the wall and belting it directly to the pulley of another motor or to a pulley on a line shaft on the ceiling. A third is made for any current. A fourth consists of an enclosed motor and rheostat which turns a flexible shaft to which vibratodes are attached. A fifth form is for hand power (Fig. 43). The gears are all machine cut and perfect. The vibra-

Fig. 42.—Betz Water Motor Vibrator.

Fig. 43.—Betz Hand Power Vibrator.

tor can be run at the rate of 5000 per minute. This machine is mounted on an oak base. The machine is operated with ease and supplies a place in the armamentarium of those who can provide no other power. A sixth form is an oscillator which gives vibrations when the hand piece is used. It is claimed that it will give from 1000 to 5000 vibrations per minute. The manufacturer suggests that those who already have a motor may belt directly or from a line shaft.

The Carpenter Vibrator (Fig. 44) is mounted on a pedestal and has an encased top holding a one-eighth horse power electric motor from which the cable extends. The cable is made of "sixteen piano wires wound in four layers in opposite directions." The ball bearing between the cabinet and post allows the cabinet to turn as the shaft is moved, which is assumed to prevent short curves that tend to break flexible shafts. Two strokes are made "for each turn of the shaft." The machines are made for a 110 or 220 volt direct current, or "110 volt and 60 cycles, or 125 to 140 cycles, alternating current."

Fig. 44.—Carpenter Vibrator.

The Carpenter Vibrator Co. have lately perfected a vibrator to be run with dry cells. It is claimed that the cost of a machine operated in this way giving full power of the other machine is about fifteen cents per hour.

A "counterweight" vibrator (Fig. 44a) is made by the Carpenter Vibrator Co. It is a machine without a rigid arm or a flexible shaft, "the hand piece being


Fig. 44a.—Carpenter Counterweight Vibrator.

attached to the motor in such a way that it can be adapted to any part of the body. The motor is suspended from an arm that is supported by a spring. The hand piece is so attached to the motor that the direction of the stroke can be changed without changing the position of the motor. This is attached to

Fig. 44b.—Hanging Type of Carpenter Vibrator.

the wall." It has a wide range of action. It is claimed that vibrations are not transmitted.

Another machine is the International Vibro-massage apparatus (Fig. 45), which is constructed with an asbestos-lined cabinet and is provided with a stone slab stand for the electric motor, and a rheostat regulated by an outside lever which it is claimed will vary the rate of vibration from 1 to 7000 per minute. The

Fig. 45.—The Birtman Machine.

vibrating mechanism upon the flexible shaft has a sliding movement and three strokes denominated by the manufacturers as a side, an angle, and a pounding stroke. The vibratodes (Fig. 46) are a small facial cup, a medium facial cup, a scalp applicator, an external rectal, a ball vibratode, a plain disc for muscular vibration, a corrugated disc for abdominal use, a curved vibratode, a flexible rectal with hard rubber tip, a spinal vibratode consisting of two fingers, and an ear vibratode.

Another apparatus is the vibrator manufactured by

Fig. 46.—The Birtman Portable Machine and Vibratodes.

the *Western Surgical Instrument House* of Chicago, consisting of an electric motor, supplied with a current "from incandescent electric light wires through an extension plug which is screwed into a socket whence an incandescent lamp has been removed," and connected by the wires to a switch connected with a faradic coil of high tension. The motor and coil are in a cabinet. A pliable shaft connects the vibrator to the motor. The outfit is so arranged that the faradic treatment can be given as well.

As early as 1808 Dr. Thomas S. Dowse, Fellow of the College of Physicians of Edinburgh, used the faradic

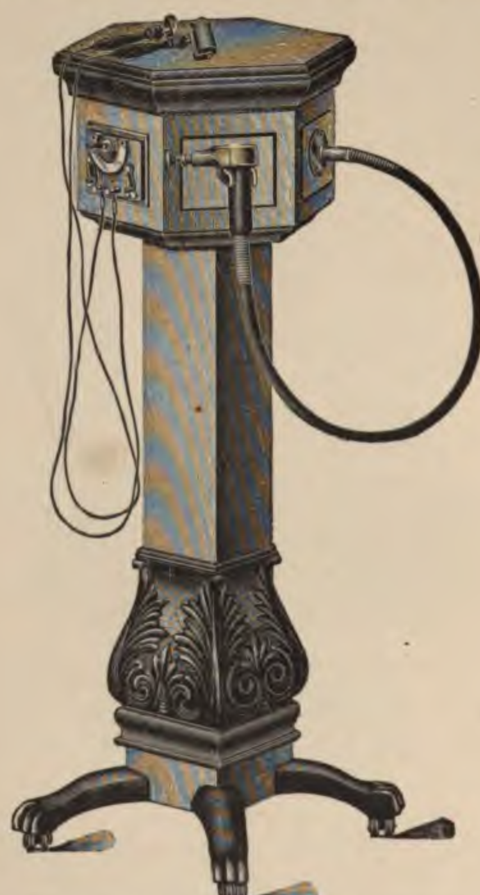

Fig. 47.—The Western Surgical Vibrator.

current with two damp chamois-covered metal electrodes, or sponge electrodes, and the galvanic with sponge electrodes as well as a unipolar current from the static machine for administering vibra-massage.

Dr. Morris W. Brinkmann, of New York, for the application of selective, harmonic, electric vibration uses "an apparatus having three ribbon vibrators of different thicknesses, each being adjustable for tension by its own lever and thumbscrew; each also having its own contact point and individual adjustment. The primary current, instead of passing through the ordinary spring or ribbon vibrator, was split into two or three divisions according to the number of ribbons in use. We therefore get induced currents in the secondary of desired speeds, as determined by the tension or attunement adjustments. The current tension is regulated by the amount of current allowed to pass through the primary, the amount of secondary embracing the primary, and the particular winding of the secondary used."

Considerable discussion has arisen from time to time as to whether this or that machine was properly a mechanical vibrator. Some claim that a "vibrator must have a to-and-fro motion," and others that one apparatus rotates, another percusses, another pounds, and still another shakes. The subject of vibration must be considered in a broader sense. As correctly considered, a vibration is "a recurrent change of position."

Some have endeavored to classify the machines. Monell gives the following classification:

1. "Those which cover the field of slow Swedish movements and mechanical gymnastics.

2. Those which exercise the tissues of a local part en masse in a series of oscillations of a regulated stroke and speed, for a prescribed time.

3. Those which do not move the part as a whole but which transmit coarse or fine rapid vibrations (as prescribed) through the softer tissues and vessels by means of motor-driven hammer strokes upon the surface."

Modern mechanical vibrators classified according to the manner of stroke are:

1. Those which have a to and fro motion in one direction or plane.

2. Those characterized by an up and down motion.

3. Those which have distinct oscillations.

4. Those which have a lateral motion in all planes or a rotary motion.

The essential elements of a good machine are as follows, when considered not therapeutically but with reference to mechanism. It should be constructed so as not to injure, by soiling or tearing, the patient's clothing; the vibrations should be capable of a range from weak to strong, and the force of impulse and rate, or speed, should be under control (the rate ranging as high as 6500 per minute), and the stroke should be adjustable. It should be easily moved about, easily operated, and readily adapted to the part to be treated. It should have the least possible frictional wear, and the vibratodes should be easily adjusted. The apparatus should be so constructed as not to be easily broken or put out of repair. Weight and transmitted vibrations to the operator are objectionable features.

From the foregoing it is noticeable that vibrators differ in size, in form, in the supporting arm—flexible or rigid, in the motor power—electric, gas, water, etc., in the form of vibratodes, as well as direction and kind of stroke, number of impulses as well as in the method of applying them. Some are much more meritorious than others. The selection of a machine should depend upon the work to be done. None of them are perfect, but all have merit. As Dr. George H. Taylor so aptly states, "Mechanical impulse may be so applied as to oppose the end sought, and actually to operate in the direction of morbid activity, it may obstruct physiological endeavor." There must be such an "adaptation of mechanical processes as will successfully blend with the various physiological processes."

CHAPTER III.

SYSTEMS OF VIBRATION THERAPY, AND THE USE OF A FEW VIBRATORS.

There are various methods of applying mechanical vibration, but up to the present too little attention has been given to the determination of scientific modes of application.

The application of mechanical vibration is subject to great latitude, varying from the employment of a portable machine operated by hand power to an elaborate apparatus whose motor power is electricity. The average physician has little time for manual massage, which naturally falls to a trained masseuse; and as this is written for physicians and not for masseurs, the application of the various hand devices for administering mechanical vibration by percussion, concussion or tapping will not be considered. In order to familiarize the reader with what has thus far been accomplished, a few methods will be included.

The basis for treatment for the application of mechanical vibration as treated by Pilgrim is as follows:

The spinal cord is

(1) "The principal seat of reflex nerve action.

(2) It is the center of the vaso-motor system.

(3) It exercises an automatic action over the arterial tone and various viscera.

(4) It is the index of abnormal action in many parts of the body."

From this standpoint, vibratory treatment for the relief of pain may be applied in three ways, as summarized by the author of the "Course on Mechanical Vibratory Stimulation," published by the Chattanooga Vibrator Company.

(1) "Application of the inhibitory stroke to the spinal nerve *centers*, supplying *sensory fibres* to the affected part.

(2) Stimulation of the *vaso-motor centers*.

(3) Inhibition of the *peripheral termination* of the *sensory fibres*."

"Affected nerve centers are evidenced by the presence of muscles in a state of contraction, atrophy of muscle or muscles overlying the posterior primary divisions of the spinal nerves, and vertebral spreading or deviation."

Although the patient may be treated in a sitting posture those who use machines generally prefer to have him lie on a narrow hard-cushioned table. The table should be about six feet long and twenty inches wide in order that the operator may easily reach across during the administration. For spinal treatment the prone position is assumed with the face down and the arms hanging loosely over each side of the table. When the thorax is to be treated a pillow should be placed beneath the posterior portion of the chest.

When mechanical vibration is to be applied to the region of the neck, the patient's head should be turned on the pillow so as to provide a resisting surface, and in some cases no pillow need be used. It is a recognized fact that an opposing resistance increases the value and efficacy of vibratory treatment.

It is best that ladies remove their corsets, in fact all clothing about the waist but the undervest, and that a man should remove his vest, coat, suspenders, and stiff-bosomed shirt.

When the Chattanooga machine is employed, the length of stroke should be varied to a nicety, bearing in mind that as the arm of the lever nearest the attachment becomes longer the vibratory arc of the to and fro movement becomes greater.

If application is to be made to the spine, the ball vibratode is generally used, except possibly in hypersensitive cases, when the brush (multiple point vibratode) is preferable. A medium stroke is generally indicated, which with the Chattanooga instrument is obtained by shifting the short horizontal bar half way down the grooved slot of the vibrator. When treating the abdomen a similar length of stroke is generally used, employing the brush (multiple point vibratode).

The shorter the stroke, the nearer the fulcrum or the horizontal bar must be moved towards the attachment.

The rectal attachment of the above machine can be more easily tolerated when the attachment (having been lubricated) is set in motion before introduction, and removed while still in vibration, as the greatest vibrating arc then comes in contact with the external parts and gradually makes a way for itself as it is introduced; whereas, otherwise the maximum vibrating arc for a given speed acts more in the nature of a shock to that part of the bowel reached by the free or distal end of the attachment.

The following refers to views of the authorities mentioned above. The duration of treatment is usually from two to four or five minutes and each individual part should not be treated for a longer time than five or eight seconds for stimulation, or ten to twenty seconds for inhibition—

bearing in mind that stimulation, vibratory stimulation, or inhibition depend relatively upon pressure and length of stroke as well as time. If what is termed stimulation be desired, the brush (multiple point vibratode) should be applied for a few seconds, using light pressure and medium stroke; if vibratory stimulation is sought for, a slightly longer application, according to Pilgrim, "eight to twelve seconds," with tolerably deep pressure is necessary, and actual inhibition is brought about in from a quarter of a minute to a minute or more, employing deep pressure with the ball. The writer believes that the condition under treatment, the immediate response of the patient to treatment during previous administrations and the after effects must be the guide as to length of time requisite to obtain the effect desired. Great care must be taken not to make the treatment too long, or, what is a matter of the utmost importance in the writer's judgment, to exert too great pressure, as inhibition may occur or the patient be overcome and the treatment be followed by a sense of great weariness or lassitude.

In the treatment of pathological conditions affecting the organs of special sense the following general plan is adopted. First, consider the nervous supply of the organ and its general relationship. If it is indicated to treat the superior cervical ganglion, apply vibration to "the upper part of the anterior border of the sterno-cleido-mastoid muscle," or if lower in the neck it may be treated indirectly through the other cervical ganglia, applying the vibratode "in front of the transverse processes."

In venereal diseases, according to instructions issued by the Clinical Dept. of the Vibrator Instrument Company, the treatment should be as follows:

(1) "Stimulate with the rubber ball the proper vasomotor area for the purpose of inducing a more efficient blood flow, and the nerve area in the spine, which controls the nutrition of the genital or other affected organs which, under such conditions, are quite sensitive to deep pressure.

(2) Stimulate with the brush the lymphatics generally, but especially those along the sides of the penis and in the inguinal region, in order to secure the best drainage possible, relaxing at the same time all contiguous muscular tissue.

(3) Stimulate at their nerve connections at the spine (with the ball), and also directly over the organs, with the brush, the liver, kidneys, spleen and bowels, with a view of accelerating their eliminative action.

(4) Place the patient in the "Sim's" position, with knees well elevated, shorten the stroke of the vibrator arm and apply a mild treatment to the prostate gland per rectum, using for this purpose the special rectal attachment.

When treating the affected spinal centres treatment should be applied just inside of the tuberosities of the ischium, deeply, immediately behind the attachments of the perinaeum, using the ball and medium stroke."

If the stimulation be spinal, the ball attachment is applied between the transverse processes. Great care must be exercised to avoid the spinous processes. This treatment is based on the idea that pain is of nervous origin and by treating the centers of such nerves we can act upon the affected part.

Other special conditions are treated in accordance with the theories on which the above line of treatment is based. One very unique method was recommended by Pilgrim for flushing the mesenteric glands in cases of alcoholism or morphinism as follows: "The patient should drink a pint at least of water (hot if for the former condition, and hot or cold for the latter) and then lie on his right side with the knees well elevated. Vibratory stimulation with the ball should then be applied to the spine between the fourth and fifth dorsal vertebræ, using firm and tolerably deep pressure." This should be continued for one minute and is done to relax the pylorus. "Next place the hand over the abdomen, just below the stomach, and exert heavy upward pressure with a view to elevating the stomach. When this is accomplished, the contents of the stomach will rapidly discharge into the abdomen without much absorption taking place through the gastric glands." After this stimulate the splanchnic nerves to hasten absorption by means of the mesenteric glands.

The above is only a brief outline of the method employed by many advocates of vibration.

The action of the Hanfeld tissue oscillator is radically different from that of the apparatus above considered. One of its advocates prescribes the following particular line of treatment, based not upon theory but the results of practice, which affords a consideration of the subject from another point of view. Its action by some is regarded as closely resembling that of a mechanical exerciser, such as some of the apparatus of Zander and Taylor.

In using this apparatus the patient sits or stands, or he may recline when the hand piece is applied to the back or when the new additional vibratory attachment is used. Monell considers three kinds of chairs necessary: (1) a revolving stool, (2) a chair with arms, and (3) a chair without arms to be used in association with the different attachments employed. If the patient applies the hand piece, a chair with arms is desirable, otherwise the chair without arms is to be preferred. Chairs should be firmly fastened to the floor, or have, as Monell suggests, "rubber tips on the front legs." The patient may under certain conditions remove nothing but the hat, in others, as for throat applications, the collar, or for foot applications the shoes must be removed. If a woman is to be treated, corsets or tight clothing should be discarded. In the case of a man, suspenders and stiff-bosomed shirt should be removed. Of course an application to the exposed skin is oftentimes desirable in order to secure the full effects, in which the clothing to be removed will be determined by the judgment of the operator.

If a body treatment is indicated the wide belt should be used and the administration made with the patient standing. Usually abdominal or spinal treatments are best given with the patient standing, as he can more easily hold the belt taut. In almost all other cases sitting is advised. An application as a whole may last from a few to seven or eight minutes, although some employ it for a longer period when treating exceptionally vigorous patients. Sometimes the effect produced instead of the time will best serve as a guide, but it is well under no conditions to make the treatment exceptionally long. The same rule obtains as with all cases under mechanical vibratory treatment, viz., the first administration should be made shorter and milder than those following.

The frequency of treatment is left mostly to the judgment of the operator. Daily treatments at first followed by treatments three times a week is the general rule, but the rule of electro-therapeutics is applicable to oscillation; a daily treatment unless otherwise indicated is best at first, to be followed later by one on alternate days, every third day, or two or three times weekly, according as the relief can be "bridged over"—that is, the effect produced should last until or almost until the following treatment—until the conditions are finally relieved. Another plan, advocated by the manufacturer, is to give an administration every other day until the patient becomes used to it, after which lengthen the stroke, increase the speed, and give daily treatments.

This machine affords a vigorous means of massaging the abdomen, holding good the law of exercise—do not exercise on a full stomach or immediately following other exercise or exertion. The dosage should be regulated according to the effect sought, based upon its use according to Monell as follows, to "(1) Accelerate the general or local circulation. (2) Determine an increased supply of blood to a part. (3) Increase under-nutrition. (4) Excite over-oxidation. (5) Relieve pain or muscular stiffness. (6) Stimulate internal organs to improved functions. (7) Tone up atonic muscle fibres. (8) Increase secretion, especially of the liver and digestive apparatus. (9) Increase peristaltic action of the intestinal tract. (10) Secure the effects of fine rapid vibration."

To regulate the length of stroke an eccentric provided for the purpose should be adjusted to one or one and one-half millimeters for a fine stroke. A stroke of one and one-half millimeters is best adapted for work about the neck when the smaller belt is used.

The use of over two and one-half milimeters is not advisable when the hand piece is employed. With the large belt a stroke of from three to eight or nine millimeters may be used according to the size and tolerance of the patient, as well as the condition of the part treated. Beyond this limit the strokes become actual muscle and body exercisers.

The employment of special applicators will be considered in connection with the treatment of particular parts. The use of the hand applicator with this apparatus is illustrated in the treatment of the ear. Remove the distal end portion of one handle and lock the eccentric on the same side at zero, then unscrew the set screw of the other eccentric and adjust it so as to secure a stroke of about one millimeter and in place of the lower part of the other handle attach the hand applicator. One eccentric being locked, vibrations instead of oscillations occur. The operator should strap his hand to the applicator and use his finger tips or thumb tip in making the applications, the vibrations being transmitted through the hand of the operator to the patient. The handle bar should always be rigid during administrations as a deviation affects the vibrations. It is desirable in the writer's opinion to start the vibrations before applying the hand to the region to be treated and thereby avoid shock and discomfort. With one finger tip, using well regulated pressure, treatment may be given over an area where administration is indicated, as the Eustachian tube, larynx, or pharynx.

The treatment of myalgia of the neck has been followed by good results by the use of the narrow belt in the writer's experience, employing the apparatus as follows: Adjust each eccentric so the stroke will be

PLATE II. TREATMENT OF MYALGIA WITH THE OSCILLATOR.

about one and one-half millimeters and tighten the set screw. To the lower part of each handle hook on the narrow belt. Have the patient remove her hat and collar and adjust the belt. She should sit in the chair at such a distance as to bring the belt taut, and the handles must be in line. Start the motor at a rapid rate of speed. At the end of five minutes the patient under such treatment was able to move her neck freely. When the large belt is used the patient should stand in such a position as to throw a weight of about twenty-five pounds upon the belt in order to keep it taut.

In respect to the treatment of the extremities, taking the foot as an example, as it will also demonstrate the method of using the foot rest, the method is as follows: Seat the patient facing the apparatus with legs extended. It is best, although not absolutely necessary, that the shoes be removed. Hook the foot rest to each handle bar. The patient should then place her feet in the foot rest and hold the belt in her hands, or have it fastened around her body, or around the chair, as it must be held taut. Three or four millimeters as indicated on the eccentric of this apparatus will usually give a stroke of sufficient length for this administration. The treatment should be continued for about five minutes, unless existing conditions indicate otherwise, and a short rest should follow before the patient leaves the office. This treatment is adapted to patients suffering from poor circulation and cold feet.

As mentioned in the preceding chapter electricity can be administered during the treatment with the applicators, but is not considered a valuable combination. With a new improved vibratory attachment which has been added to this machine, mechanical vibration treatment may be administered in accordance with the directions given in the chapters that follow for the employment of local applications.

The Aero-Vibrant (see Fig. 28) is a type of apparatus having an up and down or tapping motion, and is operated by compressed air or liquid carbonic acid gas. When using this apparatus, the patient may sit, stand, or lie upon the operating table. The best effects, however, are obtained when all parts are relaxed, as when the body is in a state of repose. It is therefore preferable to treat the patient lying down, varying the position to the application of the vibratode. The manufacturers of the Aero-Vibrant advise its use for from one to five minutes, but from the writer's experience it is found that it can be used to advantage for much longer periods. It is best that a short rest be given after the treatment of each part of the body, if several parts are treated, in order not to counteract some of the beneficial effects produced by the first portion of the treatment.

With this apparatus an increase of air pressure will produce an increase of frequency, the length of stroke remaining always the same.

For the treatment of the ear adjust the vibratode giving it a slight turn of pressure to keep it in position. Then slowly move the key on the top of the gas tank allowing the gas to flow. Open the gas cock on the side of the gauge towards the instrument, then regulate with the screw the pressure sought, which should stand at zero at the beginning and end of the treatment. If the apparatus does not produce vibrations at once a slight tap or two upon the end opposite that to which the vibratode is attached will arouse it to activity.

The following method is advocated by Dr. Robert T. Howe of New York City, who has employed this instrument for massaging the typanum. "The large soft rubber cone was used over the meatus, and the small or leather covered pad was firmly pressed over the tragus creating aerial vibrations by rapidly alternating pressure on the external auditory canal which is thus transformed into an air chamber. The rubber covered pad applied to the under surface of the lower jaw just beneath the chin gradually carried to either angle of the jaw up to the articulation and then slowly over the temporal bone above the back of the ear, will thoroughly vibrate the middle ear and produce the deep vibratory massage necessary to stimulate the circulation, generally sluggish in these parts." No manual pressure need be exerted. The writer prefers to vibrate from below the ear posterior to the angle of the jaw downward instead of upward.

Whenever the operator changes vibratodes he should shut off his supply of gas by turning the gas cock upward. In using this apparatus in cases of narrowing of the Eustachian tube good results may be obtained by applying the ball vibratode to the nutritional nerve centers corresponding with the ear, employing an air pressure of about twenty pounds, followed by a direct application with an air pressure of ten pounds over the Eustachian tube in order to effect a local vibration.

For the rectal treatment of constipation an air pressure of fifteen to twenty pounds as indicated by the gauge should be employed. The flexible rubber vibratodes (See Figs. 29 and 30) furnished with this apparatus are especially well adapted to the treatment of constipation.

For the internal rectal treatment, employ fifteen pounds gas pressure, increasing to twenty or a little more. Towards the last of the treatment, which should be continued for about five minutes, gradually diminish the air pressure as indicated. The vibratode should be kept in motion until it is withdrawn from the rectum. If the long rectal vibratode is used the treatment should not last longer than three minutes.

The methods that have been followed by some advocates of the **Victor vibrator** more closely follow the line of manual massage. As an example the following is noted in respect to neuralgia. This writer states that the best way "of treating neuralgia with vibratory massage, is to 'coup' the pain by immediate application of very powerful vibrations for a short period, one-quarter to one-half minute, and then continue with milder, but increasing vibrations over the pain points and along the course of the nerve, up and down and then finish with vibrations of the initial strength and duration. There is however one obstacle to the successful carrying out of the above treatment, viz., the inability of most patients to withstand the shock of the 'couping.' Therefore, one must mostly resort at the beginning to moderately strong vibrations and then increase until the limit, to be determined by the patient. Milder vibrations will cure but not so rapidly. The element of time varies" from two to twenty minutes, and two treatments per day have been necessary in some cases.

The Victor is an example of a machine from which two distinct motions may be produced as with the Wappler and "Tremolo," the variance in motion depending on whether the vibratode is screwed in the end or to one side of the nickel-plated shield cap. If the vibratode is in the centre of the end a sedative rotary motion results, if at the site to one side a tapping motion results.

In the adaptation of all machines to therapeutics, the operator must consider many features other than the directions generally given, viz., the relative strokes, speed, and pressure of and with different machines vary. He should always test the application of each particular vibratode with varying degrees of speed and fluctuating pressure on himself at the same spot he is to treat the patient; for without so doing he cannot rightly appreciate the effects or make intelligent application until definite standards are adopted by the manufacturers.

CHAPTER IV.

METHODS OF APPLICATION OF MECHANICAL VIBRATION.

Mechanical-vibration or vibra-massage in the modern sense produces *vibration* as understood by physicists, whether that motion be to and fro in one plane, up and down, percussory, oscillatory, mixed recurrent or rotary. When a vibration is induced through connected particles of matter a succession of waves are set in motion which form a line known as the *wave line.* From a fixed point on one wave to a corresponding point on the next is one *wave length.* When several wave lengths send impulses throughout a given area, motion from each follows resulting in interference. *Interference* may increase, decrease, or inhibit motion. It may cause areas of different degrees of vibration, and in membranes, etc., it may result in vibration in segments or stationary vibrations, the points of least vibration being called *nodes,* the points of greatest motion, *antinodes,* and the portion between two nodes, a *ventral segment* or *loop.* The resultant wave will be longitudinal if the particles in vibration and the wave path be in the same direction, or transverse when they are in opposite directions. The rapidity of the wave transmission is increased with the increase of the elasticity of the medium as it more easily transmits "waves made up of condensations and rarefactions," hence the elasticity of the region treated will influence the effect. Therefore with a given rate of vibration one tissue or organ may have few waves transmitted in a given time, whereas another may have many consisting of nodes, antinodes, and loops produced with marked rapidity under which conditions physiological inhibition may be induced instead of stimulation. It is also possible in an organization so intricate and complex as the human body that *sympathetic* vibrations may be elicited in certain parts in harmony, i. e., having the same periods of vibration. When the vibration period peculiar to a particular part is not recognized, mechanical vibration may cause *forced vibrations.* Gage states that "When a vibratile body is compelled to surrender its own vibration period and to vibrate in an arbitrary manner imposed upon it by another, the phenomenon is known as forced vibrations," which may occur when mechanical vibration is applied to a part.

The study of harmonic vibration is a field yet requiring much investigation, but in connection with it, it must be remembered that an increase in the number of vibrations shortens the wave length and increases the pitch and that "the vibration frequency of strings of the same material varies inversely as their lengths and the square roots of their weights and directly as the square roots of their tensions." All of which are important factors to be considered.

Vibration may be administered in the following forms, irrespective of the type of vibrator—although some vibrators may be found to be more suitable for some modes of application than others.

1. **Interrupted vibration** is an interrupted vibratory impulse communicated to the body without pressure, or with varying degrees of pressure.

A. *Superficial* without pressure.

B. *Deep* with light, moderate, or heavy pressure. Heavy pressure may be *compressing* in character.

2. **Stroking**—a superficial vibratory impulse applied with motion over a part, no pressure being exerted.

3. **Friction**—a deep vibratory impulse applied with motion, and varying degrees of pressure over a part. The subdivisions according to directions are:

A. *Centripetal* vibratory friction.

B. *Centrifugal* vibratory friction.

C. *Circular* vibratory friction.

4. **Rolling**—a forward and backward movement of a part over underlying structures. It is a form of kneading.

The operating room should be well ventilated and warm (about 75° F.), because the chilling of a patient causes unnecessary discomfort and induces a state of muscular contraction whereas all parts should be relaxed or in a state of repose when being treated.

The furniture necessary will depend somewhat on the type of machine used. In general, a long, hard table, the height of an operating table, which can be elevated at either end is desirable. Two adjustable arm rests are a convenience for treating the arms if the operator has no assistant, as the best work can only be accomplished when all parts are in a state of relaxation, and are properly supported. Two hard pillows of different sizes will be of service. The table should not be so wide that the operator cannot easily reach across, because some machines cannot be conveniently operated from either side. If provided with rollers it can be readily moved about by the operator

PLATE III. OPERATING ROOM.

which is often an advantage. A hard-cushioned Morris chair is also useful in some cases, supporting the body in a relaxed and comfortable position when it is not necessary to have more than an indirect resisting surface as when treating the eye, ear or nose. The furniture essential for use with an oscillator is mentioned in the chapter describing its therapeutic application.

Thoroughly examine each patient before treatment for obvious reasons. If a woman and she is to lie down for treatment, she should remove waist, corsets, and all other clothing about the upper part of the body except her undervest, which, in certain cases, as when vibratory friction is applied to the arm, should have loose, short sleeves. In some cases it is preferable to make the application to the bare skin. It is always best to cover parts not being treated. If the upper part of the body is to be treated, let the patient wear a kimona, which can easily be pushed aside as indications require. All waistbands of the underwear should be loosened, so as not to interfere with circulatory activity and to permit the tissues to be generally relaxed.

If a man is to be treated he should remove coat, vest, suspenders, collar and outer shirt, and in all cases whatever other clothing necessary so that the vibration may not be interfered with.

Interrupted vibration may be administered directly over an intervening medium, but *mechanical vibratory stroking, friction,* or *rolling* is best applied to the bare skin. The work should be done in a most thorough and systematic manner, with due regard to technique; and no part should be left until the treatment is finished, opposite portions of the body being best treated successively, because it is thought by some to "intensify the effect upon the nerve centers." All treatment should be mild at first, then gradually increased in pressure and speed and finally finished with diminishing motion. Painful parts should be treated with caution.

It is advisable that the patient should *rest* on the table for a short time after treatment and then arise slowly in order to maintain a state of absolute repose and composure so as to avoid the disturbing factors which follow sudden change from a horizontal to an upright position. It should not be inferred that vibration cannot be applied without the removal of corsets and other garments, but it is best to follow the suggestions given to obtain the best results from mechanical vibratory treatment.

The patient's posture during the treatment should depend upon the indications of the individual case. The elevation of the head should be regulated by the end sought and the comfort of the patient. In cases of œdema of the neck the lowering of the head induces a violent headache, therefore elevate the neck and shoulders with a hard pillow or pad, and if the patient is lying face downward, allow the arms to rest in a half flexed or otherwise suitable position on the arm rests if such are provided on the table. In case the operator has no assistant and is using a table without arm or foot supporters, hard-cushioned pads will serve to elevate the arms or feet, as desired, otherwise an assistant must hold the part elevated, the patient allowing it to rest in a relaxed state. During a spinal treatment the patient should lie in the prone position, arms loosely hanging over the sides of the table, unless contra-indications exist, in order to secure relaxation of certain muscles of the back.

Joints are best treated in a position midway between flexion and extension. If the patient lies on his back, his arms should rest extended upwards on the arm rest, if one is provided on the table, toward his head, unless contra-indicated.

When treating the chest place a hard pillow beneath the thorax to elevate it and throw the ribs outward.

For internal rectal treatment the patient should lie on the right or left side, preferably the right, with the knees drawn up, his back being towards the machine. Other positions will be considered in connection with the treatment of various conditions when taken up in subsequent chapters. In all cases the position of the patient should always be such that the part treated will be relaxed and the patient comfortable. The posture should be such that the vibratode can be easily applied, thereby assisting in securing the end desired.

The first treatment should be short in order to accommodate gradually the tissues and the patient. Although there are many who advocate treatment upon alternate days, it is better practice, the author believes, in most cases to follow the rule applied to static methods by Dr. Wm. Benham Snow in his work on "Static Electricity and the Use of the Roentgen Ray," which is to "bridge the condition of relief from treatment to treatment, lessening the frequency as the requirements permit." Usually best progress is made when daily treatments are given for four to ten days, and in some cases for longer time.

Many of the failures leading to such remarks as "Vibration gives temporary relief, but I have seen no cures, and will not give it much consideration until

I do" are caused by lack of attention to technique as regards the mode of application, duration of application and a non-observance of "bridging" in the management of cases. No set rule can be made as to methods which will be applicable to all cases, irrespective of cause, condition, effect to be sought or to the frequency of treatments. Such absurdity can only equal the administration of a particular dose of a drug indicated in a disease irrespective of sex, age, or idiosyncrasy, for a fixed length of time, expecting in all cases to obtain the same result.

The intervals of rest during administration should be four to six times as long as the treatment of different parts of the body, and the periods of intermission, when interrupted vibration is applied, should be three or four times as long as the periods of contact. A rest of at least half an hour following the treatment will assist the "fixation and perpetuity" of the vibratory effects.

Vibration should not be administered irrespective of the duration of time elapsing after eating. It is advisable never to apply it sooner than half an hour after eating and when abdominal mechanical vibration is to be applied at least one and one-half hours should elapse.

The daily administration should be at a particular time, not in the morning one day and in the evening another. The *duration* of each treatment and the *frequency* of the interruptions during the treatment will also depend on the speed of the machine, stroke, and on the modes of application of interrupted vibration, stroking, friction, or rolling. It should vary from five minutes to fifteen, or even longer. For instance, deep or compressing interrupted vibration is usually short, but stroking, friction and rolling may be of much longer duration. Sometimes twenty minutes or more will be required to treat a case where varied modes are indicated and results show that such prolonged administrations are not contra-indicated. The patient's physique and the conditions to be treated should always be considered. The most careful application with large experience, judgment and close observation will greatly assist the operator in making correct discrimination.

Too much stress cannot be placed on the three important factors of administration—speed, stroke, and pressure—as employed in mechanical vibration therapy.

If a moderate rate of speed be applied with a medium stroke without pressure, and the same rate of speed and same stroke be supplemented by pressure, deeper penetration and diffusion result.

The employment of a given speed and medium stroke without exerted pressure will induce the same depth of penetration as another slower rate of speed and medium stroke with some pressure; and if the speed be much accelerated the penetration *without exerted pressure* will be relatively increased.

If a *given speed* and *shortened stroke* be employed without exerted pressure, the effect is more superficial than with an increased speed and same stroke with pressure. In other words, increasing the speed intensifies the effect. Effects produced by light, moderate, or heavy pressure are modified by the length of stroke, and rate of speed relative to the part to which it is applied; *what causes stimulation of one part of the body may induce inhibition in another,* other things being equal.

(1). *Pressure under all conditions* increases penetration and diffusion of vibration.

(2). *To increase or lessen speed* with a *given stroke* will increase or lessen penetration and affect the quality of the vibration, producing fine or coarse vibrations.

(3). *An increase or lessening of stroke* with a *given speed* increases or lessens penetration and affects diffusion.

In the use of these modes of application due regard must be paid to stroke and speed. As a rule a low rate of speed with a sufficiently long stroke has a sedative effect on pain, whereas a high rate of frequency with a medium or short stroke has a benumbing effect. Directions as to stroke in chapters following should be considered in a relative sense, for the medium stroke of one machine corresponds to a stroke much shorter than the medium of another—stroke being an arbitrary factor.

When applying interrupted vibration to the spine, a medium stroke with a moderately rapid rate of speed is desirable.

If applied to the ear, however, the shortest possible stroke is necessary.

For abdominal work the multiple point vibratode with a medium stroke is generally preferable.

For the administration of friction generally a medium stroke is to be preferred, but for vibratory stroking the shortest stroke.

The stroke, it will be observed, should always be *adapted to the part* treated and the *speed* to the *indications* of the case. For example, the shortest stroke would be applicable with vibration of short duration and moderate speed for anæsthesia, but vibration of long duration with a rapid or high rate of speed should be applied for the relief of *spasm* of the same part.

Too much attention cannot be given to technique, as failure or success so often depend on the method in which vibration is administered. A good apparatus will permit the operator to use it as the trained masseur would use his hand—according to its particular adaptability in all its forms from the lightest touch to the greatest force.

When a vibratode is applied to the surface of a patient it should not come suddenly in contact, as a blow or shock, but should be at first applied with a light touch or pressure. A light touch has a soothing effect. A cold metal vibratode is disagreeable when applied to the bare skin of the patient. It is desirable therefore that the vibratode be warmed to about the temperature of the body before it is used.

Asepsis is also important with the promiscuous use of vibratodes. They should be thoroughly cleansed by boiling or by placing them in solutions of carbolic acid or bichloride.

Pressure as applied to vibratory therapy may be designated as light, moderate, or heavy pressure exerted by the hand of the operator when applying the vibratode. Dr. Thomas Stretch Dowse says that "pressure is transmitted variably, according to the resisting power of the tissue to which it is applied—to its vitality—and to its mass. Pressure of *given quantity* deranges molecular integrity, alters equilibrium, and so engenders irritability and instability. Pressure of *given intensity* produces molecular inertia and death. According to the nature of the pressure applied and the resisting power of the tissue operated upon, so do we get changes in such tissues of molecular activity and irritability, or molecular derangement and death." Light pressure on the trunk of a nerve acts as a stimulus and is transmitted to the nerve. Continued deep pressure applied to a nerve induces sedation, as it benumbs and may essentially paralyze the nerve, and probably at the same time lessens the blood supply of the part.

In the employment of vibration, moderate pressure is recommended to the nerves over points or between the transverse processes on each side of the spine alternately in most cases, but of course many factors should be considered before the operator decides upon the degree of pressure to apply. Tolerance to pressure increases during an administration, and during the progress of a course of treatment.

If too great pressure be used nausea, weariness, or pain may result. Pressure over a nerve trunk should be applied with caution. Sometimes the pressure should be applied directly over the seat of pain as well as over the seat of its origin, as in neuritis.

Pressure should be light at first during an administration and gradually increased as the pain lessens to as great a degree as constantly increasing deeper pressure can be borne. If the case under treatment be a stubborn one, do not attempt to fully relieve all of the pain at one administration. Be satisfied with a short treatment and its results, or the patient will be the sufferer.

A *moderate pressure*, but firm, is advisable when it is sought to produce spinal stimulation. The application over the spinal region should be made between the transverse processes, care being taken not to place the vibratode too close to the spine.

It should be remembered that a *heavy pressure*, especially when prolonged, produces an inhibitory effect which is exhausting. For this reason heavy pressure is applied in the form of deep interrupted vibration, as for the relief of a painful motor point. Sudden heavy pressure is valuable in the treatment of some painful conditions, as neuralgia, but it should be administered with care. Zederbaum has demonstrated that sudden heavy pressure on a *nerve decreases its irritability*, but if the same pressure is gradually increased, the decrease was slower and not so "marked." A principle to be remembered was aptly stated when Dr. Geo. H. Taylor, the noted pioneer investigator in vibratory work, said, "The *degree of force* of processes applied must be apportioned to the *degree of irritability* of the different parts of the body and must be the *greatest* to the *least* irritable parts. *Sensitiveness to impression is an approximate measure of irritability*. Luderitz found that *motor nerve fibres are paralyzed sooner than sensory by continuous pressure*. These are reasons why we should refuse the patient's request for a longer treatment, as is sometimes the case.

Interrupted vibration may be defined as an interrupted vibratory impulse communicated to the body without pressure or with varying degrees of pressure. It may be sub-divided into two classes, superficial and deep. The deep may be compressing in character.

(1). *Superficial interrupted vibration* may be considered a very short, light interrupted touching of the part with the vibratode.

(2). *Deep interrupted vibration*, on the other hand, may indicate a very short interrupted application of a vibratode to a part of the body with pressure—light, moderate, or heavy. *Compressing interrupted vibration* is a term which indicates very slowly interrupted vibratory compression of a part, exerted with heavy pressure. Vibrations applied with any exerted pressure, light or heavy, penetrate deeply, relative to the stroke, speed, and the structure of the part treated.

Superficial interrupted vibration is accomplished by lightly touching the part, the periods of rest being three or four times as long as the time of contact, which should be but for a few seconds. It imparts a varied light movement, the vibration varying in rate, force, form, and rhythm, according to the speed used, and the relative power of a machine, as some machines, running at a given rate of speed and having a known power, but of a certain type of construction, impart much more force than others using the same power and running at the same rate of speed on account of the particular movement or stroke of the vibratode—to and fro, rotary, up and down, or oscillatory.

This method of vibration is applicable when an effect soothing in character is desired, as it acts as a sedative to the nervous system, lessening nervous irritability. It is desirable, when using superficial interrupted vibrations, that quiet prevail, as it thereby intensifies the effect. This type of vibration can be employed with all machines including an oscillator provided with a hand applicator. The application can be made with the vibratode held in a sidewise or perpendicular position, the position altering somewhat the form of movement imparted, i. e., a vibratode that gives a to and fro motion in a horizontal plane if held perpendicularly, will give a percussion stroke when held oblique or parallel to the surface plane.

Deep interrupted vibration is administered by applying the vibratode with a light, moderate, or heavy pressure to the surface of the patient for a few seconds, and then removing it. The applications should always be followed by intervals of rest three or four times as long as the period of application. As a rule, such applications should be made three, four, or five times to a given site and should be light or moderate, according to indications. This form of vibration differs from superficial interrupted vibration in that some pressure is used. An administration should always be begun with light pressure, gradually increasing as pain diminishes. According to Taylor, imparted motion "contributes to and participates in chemical activity" and it is necessary that there be a certain degree of motion with pressure in order that motor energy may restore the chemical change which is present in health. He thought also that physical results were proportional to the different rates of transmitted motion, i. e., a deep interrupted vibration with light pressure, a given speed and stroke being used, gives a different degree of penetration than a moderate pressure with the same speed and stroke. The same authority believed that there are two periods for waves of motion that have been transmitted; one when "fibres, membranes and molecules glide upon each other with some degree of adhesion, promoted by pressure," this period being quite "similar in quality and rate of motion, whether the waves are long or short." The second period is at the end of the stroke when "the direction of the motion is reversed," when reinforced energy is set free into other forms of energy, principally chemical energy. One of the principal uses of this phase of vibratory work is stimulation of the spinal nerves through the internal branch of the posterior division of spinal nerves, and the sympathetic nerves through the rami communicantes. If the pressure applied be too great, the patient will complain of pain over the back in some cases for several days after the treatment. This has led some already to condemn and abandon vibratory treatment. Treatment should therefore be begun with light pressure, the operator bearing in mind Zederbaum's demonstration that sudden heavy pressure on a nerve decreases its irritability and that the degree of pressure should be governed by the irritability of the several parts, and must be greatest to those which are least irritable.

Deep interrupted vibration is applicable to œdema, swelling, pain, and congestion, and is especially useful in the treatment of joint affections. Always bear in mind that *light pressure stimulates,* and *heavy pressure exhausts.*

By compressing interrupted vibration is designated firm pressure applied to a part interruptedly. Contacts with such interruptions should in most instances be made for a number of times less than when applying deep interrupted vibration. It is particularly indicated for application to the "motor points," and at painful sites for the purpose of benumbing the nerves and lessening the blood supply. Hyperæsthesia is also favorably affected by its employment. In the treatment of hyperæsthetic cases vibration of long duration is indicated.

When applying compressing interrupted vibration to the abdomen, during each forced expiration carry the vibratode more and more deeply and allow for intervals of rest four to seven times as long as the periods of contact. Jacoby of New York found that rapidly repeated percussion on the nerve of a muscle increased the muscular contractility, but if too long continued, exhausted it.

PLATE IV. SPINAL APPLICATION.

By vibratory stroking is designated lightly touching a part of the body with a vibratode and at the same time moving it over the surface in indicated directions.

When about to apply vibratory stroking the operator should test the speed, rate, and stroke by placing the vibratode on the side of his own cheek or forehead and lightly stroke the parts. When it produces a soothing, agreeable sensation the conditions will be right for making an administration. The stroke should be as short as possible, the speed fairly rapid, but not so rapid as to produce stimulation. For this form of administration a soft rubber vibratode, particularly one made in the form of a small ball or disc, is preferable. The writer has applied it very successfully in the treatment of headache, and has noted that in this condition the stroke should be made rather slowly and with a very careful touch. It may be applied many times over the same place, the effects sought determining the duration. The touch should be very light in order that a sense of friction is not produced—a soothing effect being desired. It may also be applied for reflex effects to areas of the skin, stimulation of which, by massage, was first advocated by Kellogg for the purpose of reflexly stimulating the spinal centers with the object of affecting not only the muscles, but the internal organs as well, and also to increase secretory, excretory and vascular activity.

The superficial cutaneous reflexes, according to Gowers, are as follows:

"Cervical	6	Interscapular.
"	7	
"	8	
Dorsal	1	

Dorsal	5		
"	6	Epigastric.	
"	7		
Dorsal	8		
"	9		
"	10	Abdominal.	
"	11		
"	12		
Lumbar	1	Cremasteric	
"	2		
"	3	Knee-jerk.	
"	4	Gluteal.	
"	5		
Sacral	1	Ankle	Plantar.
"	2	Clonus	Vesical.
"	3		Rectal.
"	4		Sexual."
"	5		

Kellogg also adds the thoracic at the sides of the thorax "between the fourth and fifth ribs."

It must be remembered when the chain, consisting of the centripetal nerve carrying the message, the anterior horn of the spinal cord and the motor nerve is broken, the reflexes are accordingly affected, being absent or lessened in degree. The *stimulus to produce a reflex* action must be *stronger* than one required for *stimulation of the motor nerve* directly, and the stimulation of "the *specific end-organ of the afferent nerve*" *produces more easily a more complex reflex movement* than stimulation of its trunk (Hall) (Landois and Stirling).

Plantar stroking is indicated in cases characterized

PLATE V. ADMINISTRATION OF VIBRATORY STROKING.

by loss of tone of the legs; *cremasteric and gluteal* stroking in rectal or vesical atony; abdominal stroking for relaxed walls of constipation, and lack of tone; and *interscapular* stroking in certain cases of anæmia. In general, vibratory stroking is used where there is a lack of muscular tone in the area, to which stimulation of the reflexes induces contraction and increases the tone.

Vibratory stroking can be most effectively applied in respect to direction by observing the rules of stroking as used for massage which are as follows:

"Head—from before backward, starting at the center of the forehead and from above downward, starting at the vertex.

Back—from above downward, from the median line outward.

Chest—from the sides toward the median line.

Abdomen—upper part, from the sides inward and upward; middle part, toward the median line; lower part, from below upward and inward.

Arms—from the shoulders toward the hands.

Legs—from the hips downward.

Feet—from the toes toward the heel."

Stroking is generally directed against the venous flow, but may be applied in any direction indicated in the case.

Vibratory friction applied with moderate pressure has probably been but little used by operators in mechanical vibratory therapeutics. It is, however, of more value than is generally recognized. It is applied by moving the vibratode over a part of the body with varying degrees of pressure suited to the particular part or condition under treatment. Winternitz demonstrated that friction by hand power increased the excretion of moisture 60 per cent., and dissipated heat more than 95 per cent. and in some cases increased heat elimination 95 per cent.

When applying vibratory friction the vibratode should be moved rapidly over the surface, and since superficial effects only are sought, such as its effects on the circulatory system and lymphatics, a light, or between a light and a moderate pressure, will be required. A fairly short stroke (one suited to the part treated) and a fairly rapid rate of speed are also essential features of this method of application. If the skin is delicate or moist a little talcum powder dusted over the surface to be treated before applying the vibratory friction will assist in diminishing the friction irritation, but it is seldom necessary. A multiple point vibratode is preferable for the administration of this method, but if the treatment be prolonged a rubber covered disc one may be used, as it is not so irritating to the skin. The treatment may be given over waxed paper.

Vibratory friction may be applied to meet different indications, *centripetally,* toward the heart, *centrifugally,* away from the heart, and in a *circular* direction. If the direction be centripetal, follow the course of the large veins particularly, i. e., the course of the median on the median line of the anterior surface of the forearm, and the ulnar along the inner border of the forearms both anteriorly and posteriorly, the basilic on the inner and the cephalic on the outer side of the arms.

Centripetal vibratory friction increases the flow of lymph, blood and chyle, and assists absorption, whereas centrifugal vibratory friction tends to lessen such activity, and is used to produce soothing and derivative effects on organs as relieving œdema. If the chest be treated, let the direction be from the sternum on either side toward the axillary space; and in case of the abdomen from the median line down and out, and in some cases circular, the umbilicus being taken as the center. Vibratory friction centripetally over the parts between the affected portion and the heart is indicated in swelling, dropsy, gout, rheumatism, sprains, sciatica, etc., but should follow in many cases the massage of the part. If the inflammation be local, vibra-massage should be applied particularly between the site and the heart.

Headache may sometimes be relieved by the application of vibratory friction of the spine, thus affecting the vaso-motors. Pelvic pain may often be relieved by applying vibratory friction over the lumbar and sacral regions.

Centripetal vibratory friction may be applied to the *head* from the median line backward, downward, and outward to the line of the middle, or inferior cervical region. When applying it to the *neck* anteriorly follow the line of the vessels from above downward. When applying it to the *hand* and the *arm* for producing other than the lightest superficial penetration, a little less than medium stroke is to be preferred with moderate pressure, and a medium rate of speed. The patient should lie upon the table, at first face downward, resting his hand and arm on the arm-rest, or lightly on the palmar surface of an assistant's hand, while with the other the assistant should support the patient's elbow, the hand being held higher than the elbow. This should be applied with the patient's arm perfectly relaxed, else the muscular tension will oppose the effect sought. Apply the vibratode five or six times, beginning at the finger tips, particularly in the intermetacarpal spaces and extending it to the wrist. To the wrist, in most cases, also apply deep interrupted vibration with moderate pressure in the usual manner. Then, with the patient lying on his back with the arm supported on an arm-rest or an assistant holding the hand elevated as before, make the application to the palmar surface of the hand and arm, applying deep interrupted vibration with moderate pressure in the palm, and about the wrist for the purpose of reflexly inducing greater circulatory activity. The *forearm* should be treated from the wrist to the elbow, posteriorly and anteriorly, particular attention being paid to the ulnar, median, and the radial veins, and the blood and lymph supply at the joint. Then apply deep interrupted vibration to the elbow joint. This should be followed by vibratory friction of the arm from the elbow to the shoulder, and interrupted vibratory treatment of the axillary glands. The treatment should not be continued longer than for seven or eight minutes to an arm. In applying it to the *lower extremities* proceed from the toes to the heel, then from the toes to the ankle, using deep interrupted vibration with moderate or heavy pressure, according to the thickness of the foot, under the arch of the foot and about the ankle. In applying it to the *leg*, the patient should lie face downward with leg flexed on the thigh and supported by an assistant. Apply then vibratory friction posteriorly, first from the ankle to the popliteal space four or five times, moving over the surface following the course of the veins: then anteriorly applying deep interrupted vibration with a varying degree of pressure suited to the case at the ankle, if it has not been previously vibrated. Then use interrupted vibration at the knee joints two or

PLATE VI. ADMINISTRATION OF VIBRATORY FRICTION.

three times in the depressions about the joints. The thigh should be similarly treated, and deep interrupted vibration applied to the groin. When used to lessen œdema of the arm, apply deep interrupted vibration to the axillary glands, then vibratory friction from the elbow toward the axilla. Deep interrupted vibration of the elbow joint should follow. Vibratory friction centripetally should then be applied to the forearm, followed by deep interrupted vibration to the wrist joint. The hand should then be treated with vibratory friction. A similar plan should be followed for œdema of the legs and thigh.

Vibratory friction to the neck should be applied from the space between the angle of the jaw and the mastoid process downward and inward to the lower border of the neck, and then outward to the shoulders after which apply extremely superficial interrupted vibration on each side of the larynx. Posteriorly employ vibratory friction from the occipital protuberance over the neck downward and outward. It is desirable to have the patient lie face downward at first and then on her back and allow a few minutes' interval of rest between these applications.

When applying *vibratory friction* to the *chest* the patient should lie with the arms upon the arm rests of the table the inclination of which will depend upon indications. Apply the vibratode from the insertion of the pectorals toward the sternum three or four times and then below the pectoral muscles, vibrating from the sternum out and around to the axilla following the course of the ribs.

Vibratory friction in the circular and centripetal directions should be applied with fairly deep pressure when application is made to the hip. *Circular friction* is first employed and then centripetal, forward along the iliac muscle from the great trochanter.

When applied to the *back* begin at the occiput and follow each side of the spinal column to the pelvis, then apply friction from above downward, the vibratory circular friction to be employed with moderate pressure above the scapulæ. *Below the scapulæ* follow the ribs from without inward toward the spine. Then use deep interrupted vibration with moderate pressure from above downward alternately on each side of the spinal column making the applications between the transverse processes three or four times to each. Great care must be exercised that the pressure is not too heavily applied lest pain and tenderness follow. As demonstrated by Professor Maggiora the duration of an application is an important consideration requiring an exercise of care lest it be too long. *Vibratory friction* is applicable to inflammatory conditions and œdemas. In such cases begin the friction at the part nearest the trunk and gradually approach the distal part affected *always working toward the trunk.*

The application of friction is best based upon methods in use for years by scientific masseurs.

"(1) Head—from before backward and above downward.

(2) Neck—downward.

(3) Back—above shoulder blades circular; from shoulder blades to sacrum down; in the region of the loins, from the sides toward the spine.

(4) Hips—circular.

(5) Chest—from the sternum toward the axilla.

(6) Abdomen—upper part, from above downward,

and outward; lower part, from the median line downward and outward.

(7) Arms and legs—from below upward."

In cases of œdema of the arms vibrate the axilla then start at the inside of arm and proceed up, at the same time gradually approaching the hand. Apply interrupted vibration at each joint as it is reached.

"(8) Hands—from the finger tips to the wrist, dorsum first.

(9) Feet—from toes to the heel on dorsum first then from toes to the heel and instep alternately."

In cases of œdema, apply interrupted vibration to the inguinal glands. Then commence at inner side of thigh and proceed up, at the same time gradually approaching the foot. Apply interrupted vibration to each joint as it is reached.

"(10) Face—from the median line of the forehead outward to the temples, then downward toward the chin."

For general vibratory treatment the patient should be clad in a loose robe and all parts except that to be treated should be covered. The order preferred is that used in general massage,—"(1) Arms, (2) chest, (3) legs, (4) abdomen, (5) hips, (6) back, (7) head, (8) neck." General treatment is very rarely indicated and when used should be exceedingly short, the vibratory frictonal treatment being the one best suited for the purpose.

Professor Zabludowski of the University of Berlin who looked askance at instruments now employs them for applying percussion at a rapid rate for heart and nerve affections.

Vibratory rolling, the last modality, is applied by using the ball or roller vibratode to roll backward and forward over a part with varying degrees of pressure, moderate particularly, to stimulate functional activity especially of the skin. If the arm is to be treated roll the parts on the underlying structures to and fro from the shoulders gradually approaching the elbow and in like manner from the elbow toward the hand. The stroke should be in accordance with the indications, and the rolling should be rapid but the speed medium. When manual massage is used centripetal friction followed by the rolling has been found useful. It favors the production of heat and stimulates cellular activities.

The above includes forms of application to which modern vibrators of different types of independent motion may be adapted. A growing demand will eventually bring forth more perfect machines as new features are suggested by skillful clinicians. It seems probable however that the skill and technique of the hand united with the never tiring power employed with modern appliances under the absolute control and guidance of the skilled operator, is certain to accomplish more easily and with better results the otherwise laborious task of the masseur, the degree of touch as a factor sacrificed in mechanical vibratory work being dependent on the operator's individuality of touch transmission.

A good rule to follow is that of scientific massage. "All of the single or combined procedures should be begun moderately, gradually increased in force and frequency to the fullest extent desirable, and should end gradually as begun." Vibration can be used to advantage oftentimes in connection with electricity, hydrotherapy, phototherapy, and exercise,—passive or active, assistive or resistive. If the part treated be motionless and exercise is indicated, prescribe passive motion. If there be slight but not complete motion use assistive movements, if a superfluity of motion resistive movements are indicated, but care must be taken not to strain the part. The motions should be slowly and regularly executed, and each movement should be followed by a short interval of rest. It is also necessary that the exercises be taken daily. When dizziness, palpitation of the heart, pain in the chest, very rapid breathing or any other difficulty follows the exercises, they should be modified, possibly changed, or even omitted for a time until the powers of the patient warrant a continuance. There should always be an interval between the time of exercise and the meal preceding as well as the meal following it.

CHAPTER V.

GENERAL PHYSIOLOGICAL EFFECTS OF MECHANICAL VIBRATION.

Massage and mechano-exercise have been investigated for many years, and during the past fifty years have been recognized as scientific, therapeutic measures. As certain facts and principles have been scientifically demonstrated by such pioneers as Ling of Sweden, Profs. Maggiora, Colombo, Mezger, Sargent, Savage, and Drs. Taylor, Graham, Kellogg, and a host of other reputable scientific men, it is fitting to apply the results of their labor to mechano-vibration therapy. For it would be delaying progress to cover a similar field ignoring present developments ultimately to arrive at the same conclusion. Beginning with the work heretofore accomplished it will be possible to perfect a more complete system. In order to do so, certain physiological and anatomical data must be recalled to bring out the full sense of realization of the work.

Mechanical vibration in accordance with the rapidity of speed used, the length of stroke, and the degree of pressure, light, moderate, or heavy, may affect every tissue and organ in the body in various ways included under the following natural processes.

1. **Mechanical**—It induces the removal of extravasations, lymph, exudations, and transudations, breaks up adhesions, and stimulates the circulatory and lymphatic systems. It improves respiration, stimulates

excretion and secretion, relaxes over contracted parts, and contracts relaxed parts.

2. **Chemical**—It assists in the interchange of oxygen and CO_2 and in the increase of certain waste products as sarcolactic acid.

3. **Thermal**—It causes the generation of heat—vibratory friction increases heat elimination, and deep interrupted vibration with moderate or heavy pressure by acting on muscles increases heat production. Cutaneous and vaso-motor stimulation affect the storage of heat, for "When the skin and its blood-vessels contract, the heat evolved is diminished. When they dilate it is increased." If stimulation of sensory nerves causes the circulation to be accelerated, the respiration to be increased, the skeletal muscles to be relaxed, "the temperature of the interior of the body and rectum is increased." If the circulation is retarded, respiration decreased, and the skeletal muscles contracted reflexly, "the temperature of the interior of the body and rectum is diminished." (Landois and Stirling) "External parts give off more heat than they produce, so that they become cooler the more slowly new blood flows into them." Internal parts give up heat "to the blood which flows through them," so acceleration of blood flow decreases their temperature. (Liebermeister) (Landois and Stirling). An increased temperature means an increase in the number of heart beats, according to Liebermeister.

"Pulse beats per minute.......	78.6	91.2	99.8	108.5	110	137.5
Temperature in C.........	37°	38°	39°	40°	41°	42°"

(Landois and Stirling)

4. **Physical**—It assists endosmosis of the lymphatics, and the physical action of respiration.

5. **Metabolic**—It induces anabolic or katabolic changes affecting the functional activity of a part as in the removal of stasis and an increase in the nutrition of a poorly nourished muscle.

6. **Reflex**—It induces activities and changes in related parts through the nerve stimulation of the central and peripheral parts of the cerebro-spinal and sympathetic systems, as in its action as a sedative.

The following, by Taylor, is of interest: "The analysis of transmitted motion into its factors, and the discrimination of the separate, distinct effects of these, is of direct consequence for estimating the influence of different rates of rhythm or length of motion-waves transmitted.

"We may presume that the heat evolved must pretty closely correspond with the rectilinear extent of the motion and the accompanying pressure whatsoever the length of the waves. On the other hand, the chemical products are in proportion to the number of changes of direction into which this imaginary direct line of motion is broken up, for every concussion which accompanies change of direction throws off energy in the chemical form, doubtless increasing the oxidation and other chemical changes to which all constituents of the organism are by nature destined, and the promotion of which all curative processes must include.

"But the evidences derived from chemical analogies and chemical facts are by no means the conclusion of the array available. Those ordinarily satisfactory are abundant. These are clinical tests. The peculiarity of this class of evidence of chemical effects consists in removing obstinate local and general manifestations of disease, for which the most potent chemical remedies are commonly employed with far less conclusive success. This effect of rapid wave or vibratory motion shows that profound chemical changes are superinduced by the means used, which in this case can only be liberation of chemical energy in contact with material having unstable equilibrium—the non-vital suboxides."

The effect of vibration has been appreciated for a long time, as noted by Snow in his work, "Static Electricity and the Uses of the Roentgen Ray," as follows:

"The action upon metabolism of vibratory influences has long been recognized by physiologists such as that attributed to the heart's impulse. Dubois-Reymond taught 'That the nutritional effects depend not on the quantity of the electricity, but upon the *variations* in the quantity, and the *suddenness* of these variations," which is true as applied to vibration, but requires qualification in various features of administration.

1. The vibration should possess the necessary rapidity and length of stroke, and exerted pressure must be such as to be painless.

2. The rapidity, stroke, pressure, or non-pressure, should be governed by the indications and the patient's reactionary resistance.

3. The interruptions when using interrupted vibration should be limited in number to avoid exhaustion in nerve power.

4. The intervals of rest should be three or even four times as long as the period of impulse contact to assist in the perpetuity and fixedness of the effect.

5. The periods of contact and rest should be rhythmical in the administration of interrupted vibration.

6. Vibratory effects should be applied to aid or promote functional activity of a part without altering the integrity or unfavorably affecting the normal activity of the part.

Vibration has a marked effect on respiration, digestion, absorption, heat, secretion, excretion, the nervous system, the muscular system, and all physiological processes which are affected by active change as has been said. This being the case it is necessary that the anatomical relations, the physiological function, the blood, nerve and lymph supply of each organ or part of the human body be thoroughly understood in order to more fully appreciate faulty technique, for too often vibratory work is misdirected, energy is misspent, and mechano-vibration or the particular vibrator used, is condemned.

According to Monell, "The researches of Hasebroek established the following results of vibrations:

'Lowering of the pulse rate.

Improved tone of the cardiac muscles.

Vasomotor increase of arterial tension.

Increase of blood-pressure.

Increased excretion of carbonic acid.'

'Vibrations facilitate the peripheral circulation and improve the nutrition of the muscles by stimulating the heart to a greater activity and by promoting (in valvular diseases) the compensatory hypertrophy so beneficial in these cases. They constitute an indispensable auxiliary to other physical methods of treatment. The essence of the treatment of heart diseases by mechano-therapy is:

1. The acceleration of the peripheral circulation caused by the mechanical actions on veins and capillaries.

2. The aid to the action of the heart rendered by lowering the arterial tension, either by reflex dilatation of the capillaries or by diverting a greater quantity of blood to the muscles exercised. The diminution of resistance acts in a measure as a cardiac sedative.

3. The acceleration of the pulmonic circulation by the increased respiratory action which accompanies the exercise and which reacts beneficially upon the general system of the patient.' "

The physiological effect of vibration, according to Reich, is to increase "the excitability as well in the motor as in the sensory nerves if the excitation continues for a short period, but lessens the excitability if the time given for the vibration or concussion is prolonged. Therefore we have reason to believe that small excitations of long duration have the same effect upon the nerves as strong applications which only work once, according to Pflüger-Arndt's law. The skin will be pale after a short application of vibration (high frequency), but will redden after a longer application. Therefore a contraction will be at the beginning sometimes even contraction of muscles of the skin, while vaso-dilatation will ensue in the further application." He believes that general vibration increases the blood pressure, accelerates the circulation, increases absorption and the secretory power of glands. Mechanically it can favor the expulsion of gall and kidney stones. Reflexly when vibration is applied "in the region of the roots of the spinal cord, especially of the neck a general sense of cold results." If applied to the spinal cord in the interscapular region a decrease in heart rhythm ensues. "Manipulations of short duration will have a stimulating and tonic effect, while prolonged vibration will have a quieting, analgesic, sedative effect, therefore use short but often repeated vibrations in cases of paresis, cutaneous anæsthesia, and when used as an analgesic.

In relaxations of contractile tissue, in weakness of the heart, and atonic, hypertonic conditions of the intestinal tract as appear singly or as a symptom of neurasthenia, or enteroptosis, in floating kidney, in relaxations of the uterus, in hemorrhoids and prostatic hypertrophy, for the sensations of lassitude of neurasthenic patients—in all these conditions use short but often repeated vibration.

The prolonged vibration should be used in neuralgia. hyperæsthesia, spasms, tremor, paralysis agitans, insomnia, and all conditions of general excitability. Also use prolonged vibration for the mechanical effect, for instance for the expulsion of kidney and gall stones. Sometimes the treatment may be given for as long a period as one-half hour." (Reich.)

CHAPTER VI.

THE RELATION OF MECHANICAL VIBRATION TO THE CIRCULATORY SYSTEM.

The Circulation in relation to mechanical vibration includes the effects upon the heart, arteries, blood, veins and capillaries.

Anatomically the heart extends as low as "three-fourths of an inch to the inner side and one-half inch below the left nipple," between the fifth and sixth costal cartilages, and as high anteriorly as a line on the chest in front of the fifth dorsal vertebra.

Von Ziemssen found that when mechanical stimuli were applied to the heart from without, "*slight pressure* on the auriculo-ventricular groove caused a second short contraction of both ventricles after the heart-beat," and *strong pressure* made the cardiac muscle act very irregularly, which fact should be considered when exerting pressure with the vibratode over the heart muscles.

The heart is supplied with three ganglia—two excitors and one inhibitory—and branches from the pneumogastric and also motor fibres from centers in the brain from the spinal accessory. The latter assists in inhibition (doubted by some authorities). The accelerator nerves also supply the heart, increasing the activity. Stimulation applied to these nerves will affect the heart's action accordingly. The accelerator fibres arise from the medulla, passing by the cord to the *last cervical and first dorsal* of the *sympathetic* and thence to the heart. It is also claimed that "the cervical sympathetic and the splanchnic contain fibres which when their central ends are stimulated excite the cardio-inhibitory system in the medulla oblongata (Bernstein)."

Kirke claims that stimulation "through the fibres of the vagi" causes slowing or inhibits the heart beats, while stimulation of the sympathetic fibres accelerates or augments the beats, also that "the restraining influence of the center in the medulla may be *reflexly increased* by stimulation of almost any afferent nerve, particularly of the abdominal sympathetic, so as to produce slowing or stoppage of the heart, through impulses from it passing down the vagi. The circulation of venous blood appears to stimulate the inhibitory center and of highly oxygenated the augmentor center." It is also claimed that stimulation of the vagus relaxes the heart muscle. Vibration by stimulating the abdominal sympathetic affects the heart-beat, which is also indirectly affected by the action of vibration on the circulation.

The nervous system is a most important field for the application of vibratory stimulation, but its exact indications are difficult to determine. It is true that the physician who is a trained masseur, such as Oertel, or Graham, has for years obtained good results from local treatment. Yet some who consider vibratory stimulation of the nerves of prime importance vibrate other parts as well. The branches of the spinal nerves sometimes govern more than one function, as in the vagus of the frog, the stimulation of which may cause *inhibition* or *increased activity*, "according to the *position where* the stimulus is applied, the *intensity* of the stimulus and the *condition* of the heart." (Kirke). It seems, therefore, more rational to vibrate nerve centers and nerve distributions as well. Since the limitations of central stimulation are not demonstrated it will take time and experience with vibration to discover their relative value. The nerves in their various relations will be more fully considered in a following chapter, but the subject of local or central stimulation must be left, until more definite knowledge is acquired, largely to the judgment and experience of the operator as he studies his results.

The pneumogastric nerve may be reached by the operator at the anterior border of the sterno-cleido-mastoid muscle just above where the sterno-cleido-mastoid crosses the omo-hyoid or on either side of the larynx above the top of the sternum. The vibratode in making the application should be carried back and a little below the top of the sternum. The application should be made with care, as grave symptoms may be induced by too great inhibition of the heart and respiratory functions—too violent stimulation in some cases might prove fatal.

The superior cervical ganglion may be reached with the round ball vibratode at the anterior border of the sterno-cleido-mastoid muscle in its upper part on either side in front of the transverse processes of the second and third cervical vertebræ, or stimulation may be applied to the communicantes rami adjoining the ganglion with the upper spinal cervical nerves. The *middle cervical ganglion* will be reached between the trachea and the sterno-cleido-mastoid muscle anterior to the transverse process of the sixth cervical vertebra between the transverse processes, between the fifth and sixth and sixth and seventh vertebræ.

The inferior cervical ganglion may be vibrated by applying the vibratode on the head of the first rib on each side of the spine. The *automatic rhythm of the heart,* the force of its contraction, and the power of conduction ("the capacity for conducting muscular contractions") are influenced by stimulation of the vagus. If the stimulation be *moderate* the heart's *action diminishes,* but if *strong it will stop in diastole.*

The cardio-inhibitory center can be stimulated reflexly by stimulating sensory nerves; as the central end of the infra-orbital nerves, or by stimulating the sensory nerves of the intestines, which "arrests the heart's action," as proven by the tapping experiment of Goltz.* Stimulation of the cervical sympathetic, the abdominal sympathetic, or the splanchnic nerves produces the same effect. "Very strong stimulation of the sensory nerves, however, arrests the above named reflex effect upon the vagus. The action of the heart may be arrested by stimulation of the vagus, not only by means of electrical stimuli but also by chemical (common salt, glycerin), or by mechanical stimuli. As a rule, the right vagus is more powerful than the left."

The same is true also of vibratory stimulation. The arrest, however, is not lasting. It has been found that a *rhythmical interrupted stimulus of a frequency of eighteen to thirty per second is necessary to produce cardiac inhibition.* According to some observers stimulation of certain accelerating fibres in the cervical sympathetic will accelerate the heart-beat or strengthen the contractions of the heart (Heidenhain and Löwit), or the latter effect only may be induced (Pawlow). These facts then should decidedly influence the

*See page 849, Landois and Stirling's Handbook of Physiology.

amount of pressure and the number of impulses when employing vibratory applications.

Vibration of the heart according to Oertel's or Kellogg's method of manual massage may be followed with a nicety of precision and control of force hardly obtainable by hand. With the patient standing, use vibratory friction according to Oertel's method as given by Graham. Make "gliding pressure upon the chest walls downward and inward from the axillary line." A rubber-covered disc or multiple point vibratode is preferable. When applied by the hand it perfects expiration and influences nutrition. It is used:

"1. When the heart muscle is weak from deficient nutrition, anæmia or corpulence.

2. When the arterial system is imperfectly filled and there is passive congestion as a result of insufficiency of the myocardium.

3. When there are valvular lesions or obstruction to the circulation, the pressure of tumors, or contraction of the pulmonary orifice. Emphysema and curvature of the spine increase the demands of the heart.

4. As an accompaniment of treatment of the heart by mountain climbing."

The contra-indications are:

"1. Acute or recurring endocarditis or pericarditis.
2. Acute or sub-acute myocarditis.
3. The result of sclerosis of the coronary arteries.
4. General arterio-sclerosis."

Kellogg believes that during expiration is the time best adapted for massage of the heart. He causes the patient to recline and manual massage is directed from each axilla "toward the sternum," at the same time applying the greatest force "between the fifth and eighth ribs, the maximum of pressure falling over the latter."

Vibra-massage may be employed for lessening extreme *hyper-activity* of the heart, as in hypertrophy, and certain lung diseases, as manifested by increased action and strong pulse. This treatment should be given at the bedside, for rest in bed is compulsory in these cases. Light abdominal vibration daily, and in some cases a few breathing exercises for a few minutes preceding and following each meal, and when the patient first wakens in the morning, are valuable as auxiliaries. For general treatment, vibratory stroking centrifugally and *very light* vibratory friction centrifugally, using the multiple point or the rubber-covered disc vibratode for retarding the blood flow, are the forms of administration preferred. Interscapular spinal treatment will lower the pulse rate.

When spinal stimulation of the heart is indicated, make the application in the upper half of the dorsal region. So far as can be ascertained, no experimental demonstrations have been made to show the exact localization for stimulation, except on the dog, in which it was shown to be from the third to the fifth dorsal.

In treating certain functional disturbances, as *palpitation* of the heart, caused by a stimulation of the sympathetic nerves by affected *viscera* of the abdomen, it is necessary that the cause should receive first attention. If dilatation of the stomach be present, vibration or lavage of the organ should be employed before applying it to the heart.

If there be heat flushes, tachychardia, or *irregular heart action*, a general mechanical vibration, combined with other appropriate physical measures, as light, static electricity, or hydrotherapy, is indicated. The *frequency of tachycardia* may be lessened by spinal stimulation with the ball in the interscapular region. If there be flushings at the menopause employ deep vibratory friction with the multiple point vibratode as a general massage. It accelerates the blood flow and lessens the heat to the interior of the body. In certain cases the Schott treatment by baths and resistive movements, graded according to the strength or weakness of the heart, may be useful adjuncts either with or after the vibratory treatment. Interrupted vibration with a moderate pressure applied to the solar plexus and the lumbar ganglia (two inches on each side of the umbilicus) in succession, making the application three, four or five times at a sitting; the treatment being given at first daily, has a marked effect on the sensations of "internal heat," the effect depending on the strength of the stimulus. If the stimulus be too strong or too prolonged, it will not control the condition. External parts are cooled by lessening the flow of blood or the heart's frequency.

Many cases of organic heart disease can be improved by the general application of mechanical vibration. Only the extremities should be treated at first if the case is severe, but after two or three applications abdominal vibration should follow. Treatment should be administered at least twice daily, carefully observing the pulse rate. A tendency to shortness of breath is an indication that treatment should be stopped. When applications are made to the back in severe cases, it is best that the patient lie on his right side. If great œdema is present, especially in cases associated with Bright's disease, mechanical vibration is contra-indicated, as it is liable to overtax the kidneys or do harm internally.

If the patient has a *weak heart* he should rest in a reclining or horizontal position. During treatment he should breathe slowly and deeply. When desirable employ exercises to assist expiration—very light abdominal vibration, and joint movements. At first make gentle passive flexion and extension, which will assist in emptying and filling the vessels. These movements should be made a few times alternately, first to one extremity and then to the other, moving the arms and legs consecutively. The slightest indications of dyspnoea should be taken as a signal to stop. These movements should not be performed more than four or five times at first. The movements of the extremities in order should be followed by vibratory friction centripetally. Oertel's method of massaging the heart, employing the rubber-covered multiple point or rubber-covered disc vibratode, should follow. When indicated, an abdominal supporter should be worn by these patients in the intervals between treatments. With increase of the patient's powers, resistive motion may be added. A safe method of employing this maneuver is to have the patient flex the joint to be treated and endeavor to keep it in a flexed position while the operator extends it. This procedure is followed by the patient extending the limb and holding it rigid as the operator overcomes the rigidity in flexing it, little force at first being employed. Great care must be taken in the opposition force, as it is liable to be too strong. Still later when the patient can walk he may make movements of flexion and extension without the aid of the operator. Do not allow the exercises to be so energetic as to induce rapid breathing to a marked degree. The patient lying in a horizontal position, passive, active-passive and voluntary exercise of the joints should be employed for twenty minutes or so after each effort of the patient to become accustomed to exercises in a vertical position in order to quiet the heart's activity, or interscapular spinal vibratory treatment or abdominal vibratory treatment is indicated.

Vibratory friction so applied decreases the heart's action, diminishes the blood pressure, and has a general quieting, soporific effect. It must be remembered, however, that the magnitude of the heart's beat depends not on the *amount* of stimuli, but on the condition of the muscles of the ventricles, which is contrary to the rule for skeletal muscles as noted by Sir Michael Foster.

The effect of vibration on the lumen of the arteries is influenced by their elasticity and contraction, which affects the blood pressure, thereby equalizing the blood current and determining the amount sent to each part, their lumen being under the control of the vaso-constrictor and vaso-dilator fibres.

From Landois and Stirling we learn that the effects of mechanical stimuli "on blood vessels may be due to their action on peripheral nervous mechanisms (supposed ganglia along the course of the vessels). The arteries may contract so much as almost to disappear, but sometimes dilatation follows the primary stimulus."

The physical and physiological effects of vibratory stimulation on the circulation will vary with the methods of administration and other physical conditions. Quickened circulation induced by vibratory stimulation increases the heart's action, raising the arterial tension. Lessened frequency is associated with lowered tension with dilatation of the blood vessels and increased production of heat. Reflexly an alteration in the exchange of oxygen and CO_2 in the lungs as produced by increased tissue combustion affects the respiration. Vibration can be so applied as to restore the equilibrium of the blood stream and raise the temperature of the body.

When constriction of an artery is produced the following effect results according to Foster: (1) Diminished flow through the artery itself. (2) Increased general arterial pressure leading to increased flow through the veins. It should be remembered that the contraction of an artery is slow and of long duration. There is also a latent period. Mechanical stimuli must not, therefore, be too continuous or too heavy unless dilatation is sought, because strong percussion induces dilatation of the blood vessel and light percussion if too prolonged has the same effect. The effect of dilatation is (1) to increase the blood flow through the artery, (2) to lessen general pressure, and (3) to lessen the flow through the other arteries. Dilatation then is especially indicated in the treatment of diseased conditions associated with impaired nutrition.

Two powerful factors concerning vibration relative to blood pressure in the veins are, (1) the induction of contraction of voluntary muscles producing pressure on the veins, and (2) the vibratory influence on respiration. If the vibratode be applied from below upward on the legs both *pulmonary and portal congestion* may be relieved, and if upwards on the arms *pulmonary congestion* is also favorably influenced.

Vibration may be so applied as to increase or diminish nutrition and the elimination of waste products. This is accomplished by its influence upon the distribution of the constituents of the blood, and the increased elimination of effete matter from the tissues. The interchange may be varied in ratio, consistency, quality, and quantity, thereby favorably affecting the function of the tissue.

If vibratory friction be centripetally applied to the extremities it assists lymphatic and venous circulation in joint affections, œdema, dropsy, and similar conditions. For this administration a multiple point vibratode is best employed, but if the frictional treatment be frequent or long continued, the rubber-covered disc vibratode is to be preferred. In cases of œdema begin the frictional treatment near the trunk and gradually approach the extremities. (See Chapter IV.)

Vibratory friction applied centrifugally to the extremities is indicated in *compensatory hypertrophy* of the heart, due to valvular lesions or pulmonary circulatory obstructions, as well as in *insomnia* due to congestion of the blood vessels of the head, and all other conditions where acceleration of the arterial flow is indicated. If the bowels be vibrated for the purpose of stimulating the flow of blood to the liver it induces a slowing of the pulse. In an experimental case the pulse was 84 before abdominal vibration and but 74 following the treatment. Vibratory stimulation also affects the circulation by increasing or diminishing the action of the diaphragm, thereby indirectly increasing or diminishing the blood flow.

Anaemia is characterized by "a diminution in the number of red corpuscles, also of albumin (the serum containing a disproportionate amount of water), the chief symptoms being debility, palpitation, sometimes a functional systolic murmur, and pallor of the skin and mucous membranes." In this condition, a general tonic treatment is indicated. Apply the ball vibratode alternately on each side of the spine between the transverse processes, applying deep interrupted vibration with moderate pressure about three times at each interspace. Each contact should be but for a few seconds. Follow this application with abdominal treatment according to directions in Chapter X. Constipation must also be treated in these cases and pelvic or gastric disturbances, if present, be rectified as well.

Convalescence from exhausting disease is greatly assisted by proper vibratory spinal treatment with the ball vibratode. Apply superficial interrupted vibration at first, gradually increasing the pressure from day to day, but *never using very deep pressure.* Passive extension and flexion of the extremities may be followed by assistive movements and later by the gradual introduction of active movements.

From the effects of vibration applied as a tissue exerciser, it may be inferred that it increases the number of red corpuscles and the hæmoglobin. Winternitz has demonstrated that exercise increased the number of red blood corpuscles. It is probable also that it influences phagocytosis as does manual massage by causing more leucocytes to become phagocytes and by breaking up minute adhesions and consequently permitting a freer circulation and drainage, thereby increasing the natural body resistance.

Vibration is also of benefit in **phlebitis.** Morris reports the cure of a case, "complicated with lymphangitis and adenitis." He sought to accomplish two objects, viz., "(1) improvement of the systemic condition with a possible reduction of obesity; and (2) the abatement, if not the actual cure, of the local inflammatory trouble. For the accomplishment of the first indication, deep vibration was applied to the spinal nerve centers of the liver and spleen (Vide Pilgrim's 'Vibratory Stimulation,' 4, 5, 6, 7, 8 dorsal), and also to the organs direct, as well as over the abdominal muscles. It was hoped that this might favorably affect the local conditions."

He "sought to accomplish the second indication through stimulation with the brush (multiple point vibratode) of the lymphatics in the inguinal region and mild brush applications directly to the affected area, following the venous current throughout, supplemented by the application of the ball with medium stroke, to the lumbar and dorsal spine."

The lymphatics, which finally discharge their contents into the blood stream at the junction of the subclavian and internal jugular veins by means of the thoracic duct on the left, and the right lymphatic duct on the right, play an important part when influenced by vibratory stimulation, particularly so in respect to drainage and metabolism. The same is true of all lymphatic glands—those of the neck, the mesenteric, mediastinal, axillary, inguinal, popliteal, and the coeliac glands. To the glands, especially, deep interrupted vibration with moderate or deep pressure with the rubber-covered disc or multiple point vibratode is applicable. Horvath of Keiff has discovered that bacteria reside mostly in the lymphatics; and Meltzer seems recently to have demonstrated that bacteria cannot withstand continued vibrations, which suggests the importance of vibration of the lymphatic glands. The lymphatic vessels, most numerous in muscle fascia between and around the muscle in subcutaneous tissue, are readily acted upon by vibratory friction.

When the stroke is percussive much of "the energy conveyed by the process (percussion) is expended on the skin and its reflex and sensory powers are highly stimulated by the application." The lacteals are also susceptible to vibratory therapeutics, and their meta-

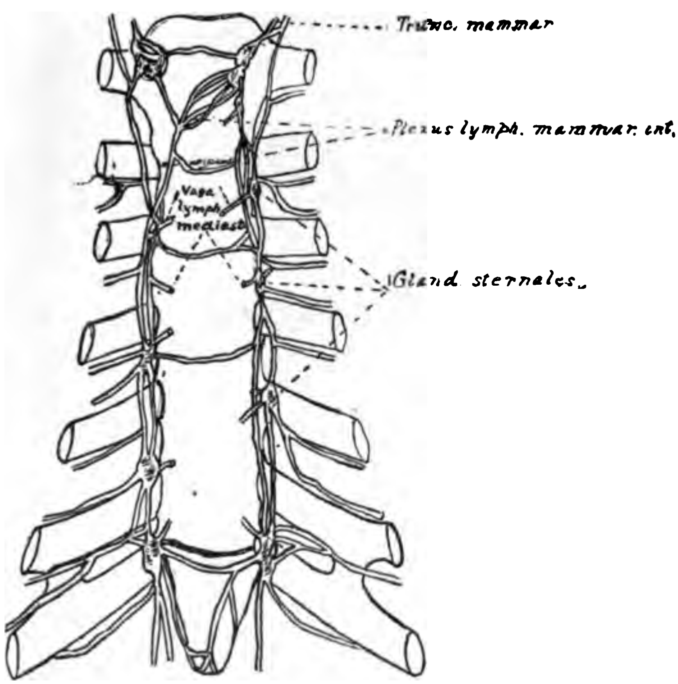

Fig. 48.—Sternal Lymphatics (after Heitzmann).

bolic processes are thereby affected. Water, peptones, glucose and soluble salts pass into the general circulation, being emptied from the hepatic vein into the inferior vena cava. Their course is through the lymph-spaces of the villi, passing by endosmosis through the walls of the capillaries to the blood stream going through the portal vein and thence to the

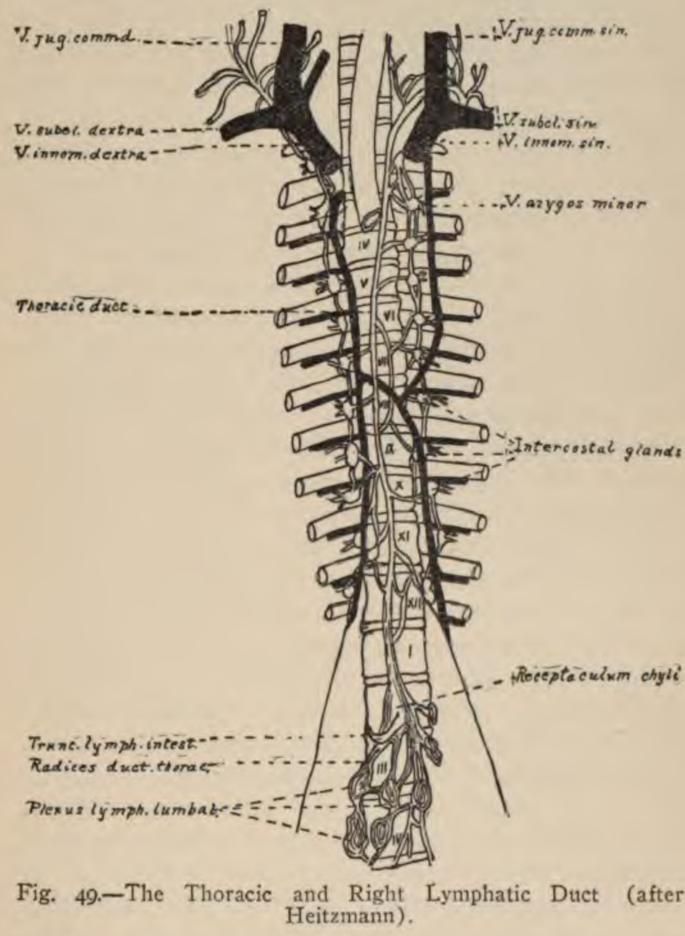

Fig. 49.—The Thoracic and Right Lymphatic Duct (after Heitzmann).

hepatic. The emulsified fat is forced from the villus by the contraction of the muscles around it on into the lacteal, and is thence carried into the general circulation through the thoracic duct. Through vibratory influences affecting the circulatory system absorption is affected, as "absorption is less rapid the fuller and more tense the blood vessels are"—and "is the quicker the more rapid the circulation of the blood." The lymphatic circulation can be increased by interrupted vibration or vibratory friction according to the part treated for both produce tissue massage and exercise. This is of importance in treating inflammatory conditions, and enlarged glands, and in promoting absorption in cases of local œdema, dropsy and similar conditions, and also in reopening obstructed lymph channels. The main force promoting the chyle and lymph flow depends (1) on difference in pressure in the thoracic duct and in the commencement of the lymphatic vessels, which is due to muscular contractions of the villus as before stated, aided by muscular contraction of the fibres of the vessels and by intermittent pressure arising from muscular contractions in different parts of the body. (2) Respiratory movements are important factors—inspiration increasing the flow in the veins and expiration diminishing it as well. (3) The nervous system as shown by Goltz and Hoffman also influences the flow. Vibratory action, therefore, either impulse or friction, affecting contraction, accelerates the lymphatic circulation. While the body is at rest Reibmayr observed that the flow of lymph nearly ceased. These glands are safeguards in infectious processes and their activity is necessary in order to effect good drainage. The necessary activity may be induced by interrupted vibration or vibratory friction, varying with the part treated, each being especially applicable to different structures. To stimulate the glands of the neck employ interrupted vibration with the rubber covered disc or multiple point vibratode and over the vessels apply vibratory friction. If the glands at the elbow are affected apply deep interrupted vibration to the axillary glands and around the shoulder joint, then apply vibratory friction to the arm. Follow this with deep interrupted vibration with moderate or deep pressure around the elbow joint. Then apply vibratory friction to the forearm, followed by deep interrupted vibration with moderate or deep pressure with the multiple point vibratode around the wrist joint and employ vibratory friction from the tips of the fingers, on the dorsal surface, to the wrist, and from the tips of the fingers, on the palmar surface, to the wrist.

In metastatic processes vibration is of great value either alone or in connection with other methods of treatment, for by its appropriate use the stimulation induced will carry off the toxic products with sufficient rapidity, so that the natural resistance of the body will be increased, materially assisting in the improvement of health.

In cases of abcess vibrate the vaso-motor area of the part affected, and also vibrate the glands, using deep interrupted vibration with moderate or fairly deep pressure. Then apply vibratory friction to the extremities with the multiple point vibratode and use deep interrupted vibration with moderate or fairly deep pressure about the joints between the abscess and the heart.

Adenitis of a non-suppurative character, is treated by prolonged interrupted vibration over the nearest lymphatic glands, the multiple point or rubber covered disc vibratode with a stroke suited to the part and a fairly rapid rate of speed being used. Interrupted vibration over the affected glands and vibratory friction of the lymphatics should follow. Treatment should be every day at first.

Vibration affects respiration by increasing tissue combustion, and metabolism, by promoting the absorption of O and the removal of CO_2, which is induced principally by stimulation of the muscles affecting the oxidation of muscle glycogen. This also causes increased activity of the lungs, diaphragm, and all parts affected by respiratory changes, the depth of respiratory movements being increased.

When applying vibration to the lungs, the arms should be extended parallel to the sides of the head, thus elevating the ribs and favoring chest expansion.

Nerve stimulation is also affected, as the muscles are under the control of nerves or nerve centers. If a particular intercostal nerve be cut the action of the muscle which it supplies stops absolutely, and if the spinal cord is divided below the level of the fifth cervical nerve, that is, below the origin of the roots of the phrenic nerves, costal respiration will cease but the diaphragm will still move. When the cord is divided below the medulla all thoracic movements cease, but the respiratory action of the nostrils and glottis does not cease. Vibration of the vagus and trigeminus also modifies respiration slightly. According to Landois and Stirling "the degree of excitability and the stimulation of the center depends upon the state of the blood, and chiefly upon the amount of the blood gases, the O and CO_2 (J. Rosenthal)." Great care must be exercised in the application of vibration, remembering that a mild irritation stimulates and a stronger or longer exhausts. It has been demonstrated that

"Weak tetanizing (electrical) currents applied to the central end of the vagus cause acceleration of the respirations, while at the same time the effort of the respiratory muscles may be increased, or diminished, or remain unchanged (Gad). They may be increased in number and diminished in extent (Stirling). Strong tetanizing currents applied to the central end of the vagus may cause standstill of the respiration in the inspiratory phase (Traube) [i. e., there is a true tetanus of the diaphragm], or especially in fatigue of the nerves, in the expiratory phase. Single induction shocks have no effect (Marckwald and Kronecker)." From the above facts it will be noted how important speed and tehcnique are as factors in vibratory application, for vibration will accomplish much that electrical currents do mechanically, less their electrical effects. Both inspiratory and expiratory fibres are found in the vagus in the neck. Stimulation of the expiratory fibres reflexly arrests respiration during expiration. The inhibition nerves affecting the respiratory centre are in the superior and inferior laryngeal nerves. If they be stimulated, respiration is slowed and even arrested in expiration (Rosenthal). "According to Langendorff, direct electrical, *mechanical*, or chemical stimulation of the center may arrest respiration, perhaps in consequence of the stimulus affecting the central ends of these inhibitory nerves where they enter the ganglion of the respiratory center. During the reflex inhibition of the respiration in the expiratory phase there is a suppression of the motor impulse in the inspiratory center (Wegele). Stimulation of the nasal and ophthalmic branches of the trigeminus, glosso-pharyngeal, and of the olfactory stops respiration in expiration (Landois and Stirling). "Stimulation of sensory cutaneous nerves, especially of the chest and abdomen (as occurs on taking a cold douche), and stimulation of the splanchnics, cause a standstill in expiration; the first cause often giving rise to temporary clonic contractions of the respiratory muscles." These facts should be considered in treating respiratory affections. "Stimulation of the central end of the sciatic nerve usually accelerates the respiration, more rarely reflex expiratory arrest."

Special reference has been made to these various actions relative to stimuli, as such knowledge has a direct bearing on the application of vibration and in explanation of some of the various apparent phenomena that sometimes arise from treatment.

The vaso-motors (constrictors) of the blood vessels of the lungs come from the dorsal region of the spinal cord (2nd to 7th dorsal) through the first thoracic ganglion (Brown-Séquard, Fick and Badoud, Lichtheim), which is of prime importance when spinal stimulation for such control may be necessary.

"The nervous Circle of Respiration is as follows, according to Brubaker:

Entirely reflex.

Excitor or centripetal nerves.	Pulmonary branches of the pneumogastric. Superior laryngeal. Trifacial or fifth pair. Nerves of general sensibility. Sympathetic nerve.

Motor or centrifugal nerves.	Phrenic. Intercostals. Facial. External branch of spinal accessory."

The following is a general review of the muscles of respiration from Landois and Stirling's "Text book of Human Physiology":

"A. Inspiration.

I. During Ordinary Inspiration.

(1) Diaphragm supplied by the phrenic nerve from the 3rd, 4th, and 5th cervical and phrenic plexus of the sympathetic, which can be reached near the right supra-renal capsule or the solar plexus. (2) "Mm. Levatores costarum longi et breves (Rami-posteriores Nn. dorsalium). (3) Mm. intercostales externi et intercartilaginei. (Nn. intercostales)."

II. During Forced Inspiration.

(a) Muscles of the Trunk.

1. The three Mm. scaleni (Rami musculares of the plexus cervicalis et brachialis).
2. M. sternocleido mastoideus (Ram. externus N. accessorii).
3. M. trapezius (R. externus N. accessorii et Ram. musculares plexus cervicalis).
4. M. pectoralis minor (Nn. Thoracici anteriores) (5th, 6th, and 7th cervical).
5. M. serratus posticus superior (N. dorsalis scapulæ).
6. Mm. rhomboidei (N. dorsalis scapulæ).
7. Mm. extensores columnæ vertebralis (Ram. posteriores nervorum dorsalium).

[8. Mm. serratus anticus major (N. thoracicus longus) (??)].

(b) Muscles of the Larynx.

1. M. sternohyoideus (Ram. descendens hypoglossi).
2. M. sternothyreoideus (Ram. descendens hypoglossi).
3. M. crico-arytænoideus posticus (N. laryngeus inferior vagi).
4. M. thyreo-arytænoideus (N. laryngeus inferior vagi).

(c) Muscles of the Face.

1. M. dilatator narium anterior et posterior (N. facialis).
2. M. levator alæ nasi (N. facialis).
3. The dilators of the mouth and nares, during forced respiration ["gasping for breath"] (N. facialis).

(d) Muscles of the Pharynx.

1. M. Levator veli palatini (N. facialis).
2. M. azygos uvulæ (N. facialis).
3. According to Garland the pharynx is always narrowed.

Or, classified according to their action, the *auxiliary muscles of forced inspiration*, are those that elevate the ribs directly or indirectly, or fix the lower jaw, so that muscles attached to the hyoid bone can act (Rutherford).

The hyoid bone is raised by:	Mylo-hyoid. Genio-hyoid. Stylo-hyoid. Digastric.
The sternum is raised by:	Sterno-mastoid. Sterno-hyoid. Sterno-hyoid. Thyro-hyoid.

The upper ribs are raised by:	Scaleni. Cervicalis ascendens. Serratus posticus superior
The shoulder girdle is raised and drawn backwards by:	Trapezius. Levator anguli scapulæ. Rhomboideus major. Rhomboideus minor.
The following muscles pull on the ribs and tend to approach them to the raised shoulder girdle.	Pectoralis major. Pectoralis minor. Subclavius. Serratus magnus.]

B. Expiration.

I. During Ordinary Respiration.

The thoracic cavity is diminished by the *weight* of the chest-wall, the *elasticity* of the lungs, costal cartilages, and abdominal wall and abdominal contents.

Ordinary expiration, therefore, is non-muscular, and the act is a purely passive one.

II. During Forced Respiration.

The Abdominal Muscles.

1. The abdominal muscles [including the obliquus externus and internus, and the transversalis abdominis] (Nn. abdominis internis anteriores e nervis intercostalibus, 8-12).

2. Mm. intercostales interni, so far as they lie between the osseous parts of the ribs, and the Mm. infracostales (Nn. intercostales).

3. M. triangularis sterni (Nn. intercostales).

4. M. serratus posticus inferior (Ram. externi nerv. dorsalium).

5. M. quadratus lumborum (Ram. muscular e plexu

lumbali)," or branches of last dorsal and 1st lumbar.

"6. Rectus abdominis (Nn. intercostales, 7-12).

7. Levator ani (Nn. sacrales, 3-4).

[The abdominal contents are compressed and forced against the diaphragm by:	Obliquus externus. Obliquus internus. Transversus abdominis. Levator ani. Rectus abdominis.
The ribs are depressed by:	Rectus abdominis. Quadratus lumborum. Serratus posticus inferior. Triangularis sterni.]"

The above is given in order that respiratory activity may be more easily controlled through appropriate nerve or muscle stimulation.

By applying interrupted vibration with moderate or fairly deep pressure with the ball between the transverse processes on each side of the spine from the 1st cervical to the 7th dorsal and over the solar plexus, the nutritional activity of all muscles in ordinary inspiration and most of the muscles in forced inspiration is accelerated.

In treating pulmonary affections, a general vibratory massage of the chest is indicated with special directions as to specific indications.

With the patient lying down breathing deeply and slowly through the nose, and holding his arms outward and upward to straighten the pectorals, apply very light centripetal friction, going over each region about three times, from the insertion at the humerus of the pectoral muscles and from the clavicle toward the upper part of the sternum. Below the pectoral muscles work from the sternum toward the axilla following the direction of the ribs and cartilages. Avoid the breasts in women. It is more satisfactory if the chest is inflated when interrupted vibration with the rubber covered disc is used over it. If there are painful spots, as are frequently found in **asthma,** use deep interrupted vibration very lightly, gradually increasing the pressure until the pain lessens or disappears when it is applied. If the patient breathes through his mouth, it being opened as though he were about to whistle, it will assist in resisting expiration.

Movements may be used in connection with the vibratory treatment for assisting inspiration or expiration. If it is desirable to assist expiration during the act, make pressure on the sides of the thorax or draw the arms upward and outward.

To help resist inspiration "Place one hand upon the abdomen, causing the patient to lift it upward by the inspiratory movement, making at the same time a degree of pressure variously adapted to the patient's condition."

Stimulating the nose and larynx causes the bronchi to contract reflexly (Landois and Stirling).

Asthma, spasmodic or bronchial, is characterized by cough, difficulty of expectoration, and dyspnœa, the expiration being prolonged and wheezy. According to Osler, "All writers agree that there is in a majority of cases of bronchial asthma a strong neurotic element," which has been the case with all cases under the writer's care. The theories as to cause are (1) spasm of the bronchial muscles, (2) "swelling of the bronchial mucous membrane, fluctionary hyperæmia (Traube), vaso-motor turgescence (Weber), diffuse hyperæmic swelling" (Clark), (3) "a special form of inflammation of the smaller bronchioles," (4) "spasm of the diaphragm or a reflex spasm of all the inspiratory muscles."

Salter and Bergson believe that bronchial asthma is due to "stimulation of the pulmonary plexus, causing spasmodic contraction of the bronchial muscle. If this condition is really spasmodic in its nature (? of the vessels), it must be usually of a reflex character; the afferent nerves may be those of the lung, skin, or genitals (in hysteria). Perhaps, however, it is due to a temporary paralysis of the pulmonary nerves (afferent), which excite the respiratory center (excito-respiratory)." Hennoch's asthma dyspepticum is due to the vagus acting reflexly on the respiration.

The patient's general condition must be considered. If the asthma is the only indication for treatment, mechanical vibration is all that is necessary; but if the patient's constitutional condition is markedly affected, the static wave-current administered with a spinal electrode is a useful adjunct. Have the patient remove all clothing about the waist except the undervest, and use the ball vibratode, employing a medium stroke, the rate of speed being left to the judgment of the operator. Apply deep interrupted vibration with the ball on each side alternately between the transverse processes or reach the ganglia from the anterior portion of the neck to stimulate the cervical sympathetic supplying "the great majority of the blood vessels of the head" (Landois and Stirling) and from the second to the seventh dorsal nerves to affect the vaso-motor area controlling the blood supply of the lungs. This application should be made for about three times unless sensitive spots are found, as they will be in most cases, when interrupted vibration should be applied about six or seven times, depending upon the effect produced. The vaso-motors of the bronchi are said to be governed by the third and fourth dorsal nerves. Apply the vibratode lightly at first, gradually increasing the pressure with each application as the pain diminishes. Allow the patient to rest for a short time, after which he should lie upon his back with a pillow beneath the thorax to elevate it. His arms should lie along the sides of his head while the multiple point or rubber covered disc vibratode is being used. Apply interrupted vibration with the rubber covered disc or multiple point vibratode with a very short stroke to the vagus in the neck, as it, together with the sympathetic, forms the pulmonary plexuses, anterior and posterior, from which the nerves to the lung are derived.

After a few moments' rest apply light vibratory friction from the insertion at the humerus of the pectoral muscles toward the sternum. Below the pectorals vibrate from the sternum toward the axilla. If there are any particularly painful spots use interrupted vibration very lightly at first, gradually increasing the pressure at each impulse until the pain lessens or disappears. Also use interrupted vibration with the rubber covered disc or multiple point vibratode over the solar plexus to affect the phrenic nerves and thus affect the action of the diaphragm. The writer sometimes applies frictional vibra-massage in addition to the above over the region of soreness, which may be as a girdle around the waist line in men, or in the abdominal region in women, probably due to their manner of breathing and mode of dress. Treatments should be given daily at first, the intervals being lengthened as the case progresses. If possible, give them early in the day for the comfort of the patient.

Sometimes forced breathing exercises are useful while the patient lies in a prone position, the head and chest being below the level of the pelvis, to assist in getting rid of the secretion.

Absorption is assisted by paying particular attention to the lymphatics emptying into the axillary glands. Use vibratory friction from the sternum below the pectorals outward, toward the axilla following the line of the ribs. "Poliakow reports most excellent results in the treatment of cases of **pleurisy** with exudation," thoracic massage being employed. The manipulations were made in the direction of the lymphatics of the affected region. The treatment was begun with light stroking, and soon brisk, deep massage was used, and this was followed by percussion, all occupying from ten to twenty minutes daily. Vibratory friction should be supplemented by interrupted vibration. Vibration applied to produce the vibratory effect of "hacking" is useful in **unresolved pneumonia, chronic pleurisy,** and where there is an effusion of a serous character or of pus into the pleural cavity. According to Graham, Dr. Emil Schliegel accelerated absorption in some cases of **pleuritic effusion** by manual massage "in the form of percussion only with the ulnar border of the hand striking at a rate of two blows a second, or six hundred in five minutes, which made a sitting and two of these were given daily." Properly applied vibration will accomplish all that that form of manual massage will, and in less time. The number of percussions per second given by Schliegel will suggest to the operator an idea of the importance for a definite control of speed.

Emphysema, the most marked form of which is hypertrophic emphysema, is "characterized by enlargement of the lungs, due to distension of the air-cells and atrophy of their walls, and clinically by imperfect aeration of the blood and more or less marked dyspnœa." The effort is greatest in expiration. For the treatment of this disease vibratory friction centripetally of the legs and arms, combined with interrupted vibration with moderate or deep pressure with the multiple point vibratode at the joints should be used with caution, and the administration should end with centrifugal friction for assisting the circulation in congested conditions of the lungs. Assist expiration at the close as follows: "compress the sides of the chest during expiration, or raise the arms outward and upward with inspiration." A spinal treatment to assist in controlling the blood supply is indicated. An oscillatory treatment administered by applying the narrow belt across the chest and running the oscillator at a medium rate of speed, the eccentrics having been set at one and a half millimeters, gives great relief.

In some cases of pulmonary tuberculosis, before the daily increase of temperature, apply *very light* centrifugal vibratory friction with the multiple point vibratode to the extremities, followed by a rest for an hour or so. Give a light vibratory treatment of the chest. Whether spinal treatment using deep interrupted vibration with the ball should be used in addition to the above must be left to the judgment of the operator, as the symptoms and conditions of the individual patient determine the indications. "Full, held breathing," the breath being held 3 or 4 seconds, can be used as an exercise a number of times daily. A most careful line of experiments relative to the effect of vibration on bacteria will increase our knowledge so as to treat tuberculosis in the most effective and scientific manner.

In certain chronic affections of the larynx and underdeveloped muscles use the shortest stroke and a small multiple point vibratode. Begin at the upper portion of the neck and make downward strokes anteriorly and from the occiput downward and outward towards the shoulders to assist in influencing the cervical sympathetic which may be directly stimulated if preferred. Follow this by superficial interrupted vibration with the multiple point or disc vibratode to the larynx.

Slow and gentle vibratory stroking centripetally when applied to the neck is serviceable in *catarrhal inflammations* of the nose, pharynx and larynx as well as in *œdema* of the neck affecting respiration.

Nasal catarrh may be favorably affected by vibramassage applied to the muscles about the nose, eyes and mouth, using vibratory stroking in an outward direction. A vibratory treatment of the neck will also assist the process. An internal nasal treatment is seldom necessary.

In chronic follicular pharyngitis vibration has already been demonstrated to be of value. Morse treated a case successfully by vibrating "deeply over the cervical spinal nerves, and externally over the glands of the neck," presumably to control the vaso-motor area of the head (Landois and Stirling) to lessen congestion, and to unload the lymphatics, particularly the cervical glands. To this treatment may be added vibratory stroking of the neck anteriorly and posteriorly from the occiput down, and a general vibratory treatment if the case warranted it.

Curtis reports success in the treatment of three cases of **tonsilitis.** Application was made to the spinal nerves throughout the cervical region, using ball attachment and medium stroke. The patient was then placed on his back and treatment applied to the cervical sympathetics, using the throat attachment with firm pressure to thoroughly relax the muscles and allow the venous blood to more rapidly escape. In addition the lymphatics in the axilla were stimulated with the brush attachment (multiple point vibratode). Treatment was then applied to both the liver and spleen to increase the elimination of waste products.

CHAPTER VII.

VIBRATION IN RELATION TO THE MUSCULAR SYSTEM.

The muscular system occupies a most important position in relation to vibration, being vitally concerned in metabolism—the metabolism depending on muscle energy.

In the subject under discussion the voluntary, or skeletal, muscles most directly concern us. The muscle fibres, 30 to 45 or even 120 mm. in length by 10 to 50 mm. in width, are liberally supplied with blood vessels, which are in close relation by means of capillary net works around each fibre. These are extended when the muscle is at rest, but curved when the muscle is contracted. According to Piersol, dilatations occur in the course of the blood vessels, which possibly give relief "to sudden temporary interference with the circulation during contractions." Distinct lymphatic vessels in striated muscles are limited "to the larger or looser masses of tissue of the perimysium" and are not found in many small muscles (Kölliker).

Vibration has a marked effect on the circulation as noted in the preceding chapter, and when we recall that it is estimated that the muscles contain about 25 per cent. of the blood in the body we can understand their importance as factors in metabolism. In many cases exercise, particularly passive exercise, has been found a useful adjunct to vibratory treatment, the two acting by regulating functional cellular activity. They also assist in the elimination of toxic substances, consume reserve materials as fat, and increase nutritional activity.

Vibration increases the blood supply to the muscle, renders it firmer, more healthy and more elastic. In cases following injury it rapidly diminishes the tense hardness due to local stasis so characteristic of the affected part. After the first treatment properly administered, the part treated usually has a feeling of warmth and comfort. The nerves supplying the striated muscle consist of both sensory and motor fibres, the sensory ending as a "loose network, the fibrillæ of which apparently terminate between the individual muscle fibres" and the motor ending in the end-plates. There are also sensory end-plates in the tendon as studied by Golgi (Piersol). The trunk of a nerve generally enters the muscle at its "geometric center." According to Landois and Stirling in triangular muscles, however, this point of entrance is more towards the apex of the triangle, and in all muscles it is generally where the muscle substance is the *least* misplaced during contraction. The motor nerves supplying non-striated muscles end in a ground plexus, which forms the intermediate plexus, which in turn forms the intermuscular plexus" in the cement substance between the muscle cells," which ends in the vicinity of the nucleus (Lustig) or "nucleoli of the nucleus" (Fränkenhauser).

A muscular contraction consists of:

1—A period of or stage of latent stimulation lasting from .004 to .01 second.

2—A period of increasing energy or contraction (from .03 to .04), in non-striated muscles for a few seconds.

3—A period of decreasing energy or more rapid relaxation (elongation) of a shorter duration than (2).

4—**A period of slow relaxation** or the elastic after vibration.

The latent period is lessened if the *strength of the stimulus is increased* or if heated. Cooling or fatigue will increase it. The latent period is lengthened in "secondary degeneration of the cord after apoplexy, atrophic muscular anchylosis of the limbs, muscular atrophy, progressive ataxia, and paralysis agitans of long standing, and is shortened in the contracture of senile chorea and spastic tabes (Mendelssohn)." "In chorea the curve is short." In Thomsen's disease the contraction is lengthened. The contraction varies as the stimulus, muscle excitability being shorter for a mild stimulus or if the muscle be not fatigued. The latent period may be even from .0033 to .0025 sec. "if the muscle be still attached to the body, protected as much as possible from external influences and properly supplied with blood" (Landois and Stirling). According to the same authorities "the latency of the individual muscular elements is shorter than that of the entire muscle (Gad, Tigerstedt)."

The elongation stage varies with the stimulus, it being lengthened as the *strength of the stimulus* is increased. The fourth stage is dependent upon muscular elasticity and its time is in proportion to the force of the contraction, being longest when the contraction is more powerful. It is worthy of notice also in this connection that *"if the stimulus be applied to the motor nerve instead of to the muscle itself, the contraction is greater (Pflüger), and lasts longer (Wundt), the nearer to the spinal cord the stimulus is applied to the nerve."* It has been found by Cash and Kronecker that "individual muscles have a special form of muscle curve" which may shed some light on the value of the use of harmonic vibrations.

"The pale muscles are more excitable, have a longer latent period, are more readily fatigued, and their contraction is of shorter duration than the red." They also "produce more acid" during contraction (Geiss) and "execute more rapid movements."—"Muscles which are composed chiefly of pale fibres have a greater 'lift' and a considerably greater absolute force during a single contraction, but during tetanus they are second to the red" (Grutzner). Non-striated muscles have a longer period of contraction. When a muscle contracts and also as it relaxes heat is evolved, the amount being in proportion to the muscular tension. Fatigue diminishes heat production. The above physiological data are of importance in vibratory selection for the production of certain effects.

The points to which the administration of mechanical stimulation causes most energetic muscular contraction are those that best respond to the faradic current. In speaking of electrical stimuli Kirke says: "Weaker electrical stimuli will excite nerve than will excite muscle; the nerve stimulus appears to gain strength as it descends; a weaker stimulus applied far from the muscle will have the same effect as a stronger one applied to the nerve near the muscle," which is in accordance to the observations noted above relative to nerve stimulation. Within natural limits the contraction of a muscle is increased by tension or extension.

Muscular excitability, normally is best maintained when the temperature of the body is normal, as it may vary above or below that temperature. This excitability is best induced by stimuli, although it has been demonstrated that muscles also possess "independent excitability," not depending on the excitability of nerves (Landois and Stirling). It is important in using vibratory stimulation that there be no interference with the blood supply as by bands, or strained positions, as it diminishes the energizing power of the muscles. Another important point concerning the regulation of the strength of interrupted vibration as applied is to remember that although a feeble stimulus will not cause a contraction, a second one may, as "the first one has increased the muscular excitability" (Fick). Vibratory stimuli inducing muscular contraction cause dilatation of the blood-vessels of the muscles.

Vibratory stimuli may be direct or indirect. Contractions are generally best induced by the use of a ball vibratode. The application, however, of a multiple point vibratode over very sensitive regions will induce contractions, or interrupted vibration repeated with a requisite amount of intensity, and rapidity may be made to induce tetanus. If a violent stimulus be applied to a fatigued muscle a local contraction of considerable duration will result, Schiff's "idio-muscular contraction," which may also be caused "when the blunt edge of an instrument is drawn transversely over the direction of muscular fibres." The muscle during contraction becomes not only shorter and thicker, but the volume is slightly lessened. The degree of contraction varies according to the *strength* of the stimulus, the *fatigue* of the muscle and the *temperature*. According to Landois and Stirling, Schmulewitsch found by experimenting on a frog that with a "given strength of stimulus" and degree of fatigue, the contraction in the muscle of a frog was increased when heat was applied to 35°C, but above this temperature the contraction diminished.

Vibration as a stimulus, by inducing muscular contraction, causes increased heat production, diminished elasticity, increased extensibility, and a muscle sound. It increases the amount of CO_2 given off, promotes the absorption of more oxygen, increases the production of sarcolactic acid, and during tetanus decreases the "extractives soluble in water" and increases "those soluble in alcohol."

If two successive stimuli be applied the effect varies. If each is capable of causing a maximal contraction, when the second follows the relaxation two maximal contractions result. If the second is applied during muscular contraction or relaxation a new contraction follows. If "both occur in the latent period, we obtain only one maximal contraction" (v. Helmholtz). If the stimuli are not maximal a summation of contractions result. Sewall believes that *the best time for the second stimulus to be applied is 1-20 of a second after the first.* This is important in vibratory therapeutics, for we are apt to employ too high a frequency and make too frequent repetitions. In accordance with these views the number of movements of the vibratode should not exceed 1200 per minute for muscle stimulation. The number of stimuli to produce tetanus varies for different muscles. Kronecker believes that very feeble stimuli, "more than 20 per second, cause tetanus." (Landois and Stirling). Strong vibrations at a high rate of speed will cause tetanus. Landois wrote the letters n, n, and every contraction was "equal to about 3.5 vibrations (of a tuning fork) (vibration= .01613 second)=.0564 second. When the right arm was tetanized 2 to 2.5 vibrations occur=.0323 to .0403 second."

According to Landois and Stirling a simple muscular twitch caused by a single induction shock, is shorter than a momentary voluntary single movement (v. Kries), a point to be remembered in the treatment of disease characterized by *involuntary twitchings.* Kellogg employs vibratory apparatus, having a movement of 30 per second, for inducing muscular contractions. He claims, in speaking of mechanical vibration relative to the large and old machines, that "vibratory movements forcibly communicated to the body at the rate of six per minute, have been shown to produce at first a distinct muscular contraction with each oscillation; but if the vibration is long continued, the individual contractions become generally less distinct, and after a time merge one into another, so that the contractions become continuous or tetanic." Schäfer finds that prolonged voluntary contraction in man is an incomplete tetanus produced by eight to thirteen successive nervous impulses per second. About ten per second may be taken as the average." (Landois and Stirling.) Barbaker says that 2.5 to 4 stimulations per second cause a "most rapid voluntary contraction."

If "induction shocks 224 to 360 per second be applied to a muscle, the tetanus after a so-called "initial contraction" (Bernstein) may cease to contract (Harless, Heidenhain). This occurs most readily when the nerves are cooled. Kronecker and Stirling, however, found that "stimuli following each other at greater rapidity than 24000 per second produced tetanus;" which demonstrates that *rate of speed is an im-*

portant factor to be considered in the treatment of certain conditions.

Herrman believes that "the velocity of the contraction-wave, in the voluntary muscles (not exercised) of a living man" is "10 to 13 metres" per second, which is diminished by conditions such as fatigue and cold; but strength of stimulus has no effect on the velocity of the wave. Kirke believes that the stimuli must be very rapid or the tetanus will be "in a condition of vibratory contraction and not of unvarying contraction."

If the stimulus be applied to the muscle about its middle the wave is propagated in both directions, but if the motor nerve can be stimulated the wave begins at the motorial end-plate, and although the contraction is apparently simultaneous still it varies as the motorial end-plates are at different distances from the nerve trunk.

Voluntary muscles respond more quickly to stimuli than the involuntary, "but when any part supplied with unstriped muscular fibres, e. g., the intestine or bladder, is irritated, the subsequent contraction ensues more slowly, extends beyond the part irritated, and with alternate relaxation continues for some time after the withdrawal of the irritation." After a rectal treatment patients have said they felt the vibratory sensasation for five minutes after the withdrawal of the instrument.

"The ureters and gall bladder are the parts *least excited* by stimuli; they do not act at all till the stimulus has been long applied, and then contract feebly, and to a small extent.

The contractions of the caecum and stomach are quicker and wider spread; still quicker those of the *iris*, and of the *urinary bladder* if it be not full.

The actions of the small and large intestines, of the *vas deferens* and *pregnant uterus*, are yet more vivid, more regular and more sustained; and they also require no more stimulus than that of varying temperatures of the air to excite them. *The heart*, on account, doubtless, of its striated muscle, is the quickest and most vigorous of all the muscles of organic life in contracting upon irritation." (Kirke).

The above will act as a guide to length and to the regulation of vibratory treatment when particular effects are sought.

A number of years ago, Professor Maggiora, of the University of Turin, through experimental work demonstrated many valuable points. He made the right and left middle fingers voluntarily raise six pounds every two seconds, twice in the morning and twice in the afternoon, the fingers having first been massaged for three minutes. The left and middle finger without massage raised 4252 kilos, whereas after massage 8019 kilos could be raised before "extreme fatigue prevented further contractions." Fatigue curves were also taken with Mosso's ergograph. The results show that massage rightly applied will increase the working energy of a muscle or group of muscles. Another experiment made was to test the effects of friction, kneading, and percussion to determine if the results had any fixed ratio of effect in respect to length of time. He demonstrated that after employing massage for varying periods of two, five, ten and fifteen minutes, that five-minute administrations produced the best result. Longer applications produced a slight difference above and below that of five minutes. The third experiment to determine the relative effects of friction, percussion and kneading demonstrated but slight difference in the work done following five minutes of friction or five minutes of percussion. The contractions representing work done were greatest in "force and duration" after kneading, but the best results were produced when the three movements alternated. The fourth experiment showed that massage temporarily restored the working power of the muscles after fasting.

From another experiment relative to the effects of massage after fatigue from an indirect cause, Dr. Douglas Graham claims that five minutes of massage would equal two hours of rest.

Yet another experiment demonstrated that ten minutes of massage could restore the muscles to such an extent that they would give a normal fatigue curve after a night's loss of sleep. He also showed that ten minutes' massage following great intellectual effort after one-half hour, left the working energy "little less than natural;" that after ten hours of fever massage recuperated weak muscles, and that it had a favorable effect where the blood supply was cut off.

Vibration may be employed to increase muscular electro-excitability. It has been demonstrated by the writer that after vibration a contraction may be caused by a smaller number of milliamperes of the continuous electrical current than before. In the case tried, a pad was held in the writer's left hand, which had not been vibrated, while make and break shocks were applied to the right thenar eminence which elicited contractions in the left wrist when nearly five milliamperes were indicated. After a vibratory treatment nearly four milliamperes caused such contractions.

Fatigue is a condition variously affected by vibration. La Grange divides fatigue into local and general, immediate and consecutive fatigue, caused by "(1) Traumatic effects of work on the motor organs, (2) Auto-intoxication by the products of dissimilation, (3) Organic exhaustion through autophagy. (4) Dynamic exhaustion through expenditure of all the force at the disposal of the muscular and nervous elements." Vibratory friction employing the multiple point vibratode, as well as interrupted vibration, greatly assists in lessening fatigue.

A muscle that is fatigued has slower latent contractions, its latent period is longer, and its extensibility increases. Vibration also lessens stiffness, probably by removing products of dissimilation, which La Grange thinks act as an auto-intoxicant, causing the "stiffness of fatigue," and which, according to the same authority, "are found among the substances which go to form deposits of urates and that among these uric acid and the urates play an important part in the phenomena of general consecutive fatigue." If resistive movements be used as an adjunct, the contracted muscle not being allowed to shorten, there is an increase of acid formation and metabolism. *Muscle fatigue* is relieved by promoting absorption and stimulating peripheral circulation, but *mental fatigue* by increasing the peripheral circulation of the body, thereby relieving cerebral congestion.

According to Starr, "The muscles represented in groups of cells in the various segments of the spinal cord" are as follows:

II, III. Cervical—Diaphragm, Sterno-mastoid, Trapezius, Scalenus.

IV. Cervical—Diaphragm, Lev. ang. Scap., Rhomboid, Supra- and infra-spin., Deltoid, Supin. long., Biceps.

V. **Cervical**—Rhomboid, Supra- and infra-spin., Deltoid, Supin. long., Biceps, Supin. brev., Serratus mag., Pect. (clav.), Teres minor.

VI. **Cervical**—Biceps, Serratus mag., Pect. (clav.), Pronators, Triceps, Brach. ant., Long extensors of wrist.

VII. **Cervical**—Pronators, Triceps, Brach. ant., Long extensors of wrist and fingers, Pect. (costal), Latis. dorsi., Teres major, Long flexors of wrist and fingers.

VIII. **Cervical**—Long flexors of wrist and fingers, Extensor of thumb, Intrinsic muscles of hands.

I. **Dorsal**—Extensor of thumb, instrinsic muscles of hands.

I. **Lumbar**—Quadr. lumb., Obliqui, Transversalis, Psoas, Iliacus.

II. **Lumbar**—Psoas, Iliacus, Sartorius, Quad. ext. cruris.

III. **Lumbar**—Quad. ext. cruris, Obturator, Adductores.

IV. **Lumbar**—Obturator, Adductores, Glutei.

V. **Lumbar**—Glutei, Biceps femoris, Semi-tend. Popliteus.

I. **Sacral**—Biceps femor., Semimemb., Ext. long. dig., Gastroc., Tibialis post.

II. **Sacral**—Gastroc., Tibialis post., Tibialis antic., Peronei, Instrinsic muscles of foot.

III. Sacral—Peronei, Intrinsic muscles of foot.

IV, V. Sacral—Sphincter ani et vesicæ, Perinael muscles."

Many spasmodic affections, as chorea, blepharospasm, and wry neck, some of which are of nervous origin and are considered in the chapter devoted to the nervous system, are greatly relieved by vibration alone, or vibration in combination with corrected diet, hygiene, exercise, or electricity, particularly static electricity.

In joint affections, certain muscles are usually involved, as Kellogg so aptly states in knee involvement "the quadriceps atrophies, in hip joint cases the glutei muscles are chiefly affected, in cases of the elbow the biceps and brachialis anticus, in cases of the shoulder the deltoid and supra- and infra-spinatus."

Progressive muscular atrophy may be greatly benefited by vibration, but it must be begun early and great patience is necessary. Static electricity as a general tonic is also indicated in these cases.

Atrophy of the muscles is treated by vibratory friction applied directly to the muscles, or vibratory rolling, for both methods improve nutrition without using up the reserve force of the muscle. If atrophy is due to nerve disturbance, the nerve centre or trunk of the nerve should be stimulated. In the treatment of muscular atrophy apply vibratory friction centripetally over the muscle to increase its blood supply and improve its nutrition; manual petrissage may or may not be used as an adjunct. Later, appropriate exercises may follow.

Vibratory rolling and friction may be also employed for the treatment of **paralysis,** and also for **paresis.** Vibration has a soothing effect upon the paretic patient, but will not cure the disease. A mild spinal treatment is indicated.

In myositis, whether traumatic or spontaneous, vibratory treatment is applicable. In chronic myositis, or muscular rheumatism, "where proliferation and induration of the connective tissue have taken place with secondary atrophy of muscular fibres and consequent interference with motion, circulation, and innervation," mechanical vibration may be successfully used, observing the principles governing the relief of inflammatory conditions. Its effects are to relieve local stasis, promote absorption, induce a freer circulation, and relieve pain.

In pseudo-hypertrophy of the muscles, "a chronic myositis accompanied by interstitial hyperplasia of the connective tissue," the early use of vibration and hydrotherapy is indicated.

Œdema following fractures may be promptly relieved by vibratory friction centripetally applied over the muscles and interrupted vibration with moderate or heavy pressure about the joint and over the glands. In such cases elevate the limb, the hand or foot being the highest. The multiple point vibratode or the rubber-covered disc vibratode are the best for such cases, the rubber-covered disc being preferable in cases requiring much treatment, as the multiple point vibratode sometimes irritates. Vibratory friction will also relieve other œdemas temporarily or permanently, depending on their cause. In œdemas resulting from kidney, heart, liver affections, or thrombosis, the relief will be but temporary. Care must be taken in relieving œdema that the removal of the local œdema does not overtax the heart, kidneys or lungs.

Muscular relaxation, due to atony, is effectively treated by vibration and exercise. In such cases vibratory friction is best applied below and above the origin and insertion of the muscle as well as over it.

The application of interrupted vibration with light or moderate pressure with the rubber-covered disc or multiple point vibratode will also do much towards improving the general tone. In these cases vibratory applications with moderate pressure should be applied to the nerve center as well.

To relieve contractions, mechanical vibration applied with heavy pressure, associated with applications of deep vibratory compression over the contracture in combination with appropriate exercises, is serviceable.

In the treatment of some spinal deformities, vibratory friction with the multiple point vibratode, combined with vibratory compression employed alone or in combination with indicated exercise, or when necessary the employment of properly constructed braces, will be of great service in recent cases and those caused by weak or underdeveloped muscles. These cases require a devotion of considerable time and patience, both to the treatment and exercises; for such exercises must be very carefully directed and suited to the requirements of each case.

In treating scoliosis employ interrupted vibratory pressure with the ball on opposite sides of the spine, using deeper pressure on the side where the contractions are. *Inhibit* the contractures and *stimulate* the relaxed muscles by interrupted vibration or vibratory friction. Carefully graded suitable exercises should follow.

In treating diseases of the nervous system where the muscular system is affected vibration oftentimes will be most effectively applied in combination with auxiliary forms of treatment. If the affection be such that the part under treatment has no power of motion, use passive motion as an adjunct. If there be slight but not complete motion use assistive movements. If there be a superfluity of muscular force, as in spasmodic conditions, employ resistive movements, but not forcibly. If stimulation of sensation, motion or circulation is necessary, employ interrupted vibration.

Muscular spasms are greatly relieved by vibration. Wry neck caused by a "tonic contraction of the flexors of the head" may be greatly benefited by application of interrupted vibration. If the head moves "with each clonic spasm," the branch of the spinal accessory nerve which supplies the sterno-mastoid muscle is affected. "In spasms of the trapezius the head is drawn backward and to the side. Stimulation of the outer branch of the spinal accessory (which communicates with the first and sometimes with the second cervical nerves) causes tonic or clonic spasms of the above named muscles (sterno-mastoid and trapezius) usually on one side." Apply interrupted vibration on each side of the upper portion of the spine with the ball, making about three applications from the occiput as low as the insertion of the trapezius. When such spasms occur apply interrupted vibration with the ball, employing a high rate of speed and a stroke a little more than the shortest and often a medium stroke in order to produce a decided vibrating effect over the painful sites and use interrupted vibration over the motor points of the affected muscles of the neck. In these cases painful spots are often found in the vicinity of the sixth and seventh cervical and first few upper dorsal vertebræ, as well as in the region of the first and second cervical. Apply the impulse with *deep* pressure five or six times to the painful sites. With the patient lying on her back apply interrupted vibration with compression over the sterno-mastoid opposite the affected side and interrupted vibration and friction over the muscles on the affected side. Movements are often a useful adjunct to vibration. Mitchell's movements as follows are recommended: "The ordinary movements of rotation, forward bending, and extension of the head are the needed procedures. These are opposed by the attendant, who stands in front or behind the seated patient and places his hands on the sides of the head or clasps them over the frontal region, according to the action to be resisted, whether rotation or forward bending. In attempting extension of the neck, which perhaps would be better described as simple elongation of the neck, the patient's effort is, while keeping the chin level or a little drawn in, to elevate the head as if he were trying to make himself taller. Lateral bending of the head without rotation may be needed in certain cases (which the writer has found to be extremely useful as a passive and later an active exercise). The face must be kept directed forward, while the effort is made to bring the cheek down to the shoulder; and the attendant opposes either the depression or the return of the head according to the effect sought for." Each movement should be repeated three to seven or ten times, morning and evening, the number of repeated movements depending on the indications of the case, muscular irritability and fatigue. Oftentimes passive followed by active movements may be used instead of the resistive movements.

Hiccoughs, singultus, are "due to a spasmodic contraction of the diaphragm, causing an inspiration, which is arrested by the sudden closure of the glottis so that a characteristic sound is emitted. Not unfrequently it is due to irritation of the gastric membrane, and sometimes it is a very troublesome symptom in uræmic poisoning." Vibratory treatment is oftentimes of great value in cases of hiccoughs. A case worthy of special mention is that of a patient who had had hiccoughs for a year. It was successfully treated by Dr. House. In this case there was "pain in the epigastrium along the costal arch, especially over the right side." Drugs and other treatment had proved of no value. An examination of the patient previous to vibratory treatment showed "marked irritation at the right sacro-iliac synchondrosis, causing great contraction of the quadratus lumborum muscle (a muscle of inspiration). Following up the course of the muscle to its attachment to the last rib, it was found that irritation of the diaphragm was conveyed reflexly through this means. The other points of reflex irritation were at the twelfth dorsal and fifth lumbar spinal nerves." The brush (multiple point vibratode) was used "over the affected areas, and also over the diaphragm" with the above result.

Vibration is also indicated in the treatment of **relaxed ligaments** and **relaxed and atrophied muscles**, such as are often present in rheumatoid arthritis and kindred affections. Vibration should be applied both above and below the affected joint in the form of light vibratory friction centripetally with a multiple point or rubber-covered disc vibratode. Around the joint, however, interrupted vibration with varying degrees of pressure should be applied at first lightly and later with moderate pressure. This treatment should be followed by passive, active, assistive or resistive movements according to the indications of each particular case. Time, patience and perseverance are requisites to be considered.

Vibration applied locally, particularly as vibratory friction, with the multiple point vibratode and deep interrupted vibration with pressure suited to the case, will relieve the pain of **uncomplicated contusions,** and in those affecting a joint it relieves contractures and prevents muscular atrophy by giving firmness and tone to the muscles. The earlier it is applied in such cases the better. In the treatment of luxations it is best to combine vibration applications with well adapted and regulated movements. The result is relief of pain, diminution of swelling, the rendering of the tissues soft which were tense, the gradual removal of ecchymoses, the prevention of stiffness and the consequent atrophy of disuse. The combined treatment is very satisfactory. Applied to a joint, mechanical vibration increases circulatory activity in the structures and lessens local stasis. If vibratory friction be also applied centripetally above the joint the circulatory flow will be assisted. If vibratory friction be applied above and below the joint the flow of blood will be lessened in the joint, but increased in the other parts vibrated. The shoulder and hip joints, owing to their inaccessible relations, are the most intractable. Dr. John Hilton has aptly summarized the adaptability of massage to joint structures. "The same trunks of nerves whose branches supply the groups of muscles moving a joint furnish also a distribution of nerves to the skin over the insertion of the same muscles, and the interior of the joint receives its nerves from the same source. This implies an accurate and consentaneous physiological harmony in these various co-operating structures." (Graham.)

In applying vibration to a swollen and painful joint, employ vibratory stroking centripetally above the joint, gradually beginning the strokes nearer and nearer the joint. Also stroke the tissues beyond centrifugally, gradually increasing the pressure, the stroking in each case becoming deep vibratory friction. After vibratory friction with the multiple point vibratode or the rubber-covered disc vibratode has been thus applied above and below the joint, superficial interrupted vibration at first but later deep may be applied directly to the joint. In this manner local stasis and compression of vessels due to exudates may be relieved, and the elimination of the exudate will be promoted.

The following movements successfully used by Graham in manual massage are suggested: "After time for repair has elapsed, in order to gradually increase the strength of the muscles, as well as the confidence of the patient to use them, there is nothing better than resistive motion, alternately resisting, flexion and extension or other natural movements of the affected joint, *while keeping the resistance less than the strength of the contracting muscles,* so that the patient may not recognize any weakness."

When there is flabbiness of the muscles and a relaxed joint with no marked symptoms, apply deep interrupted vibration with varying degrees of pressure around the joint and vibratory friction with multiple point or rubber-covered flat disc vibratode *centripetally* above and below the joint. Then use active movements, followed by proper bandaging of the joint. Resistive movements may also be found valuable, but care must be exercised that resistive motion is not carried so far as to cause fatigue.

In cases of periarticular and capsular induration and

thickening use deep interrupted vibration with a multiple point or rubber-covered flat disc vibratode on the joint and vibratory stroking followed by superficial vibratory friction above the joint, particularly in conjunction with passive movements.

"Massage," and better still mechanical vibration, "*disintegrates newly-formed granulation-tissue,* removes the stasis which it has occasioned and forces the white corpuscles and transuded plasma into the lymph-current; at the same time the newly-formed capillaries that feed this granulation-tissue are ruptured and undergo retrograde metamorphosis, as well as the crushed mass, and thus the formation of connective tissue, which often causes pernicious retraction, is prevented or limited."

Hyperplastic tissue, firmly organized and solid, like india rubber, and not sensitive to pressure, is probably non-vascular, owing to its pressure upon and obliteration of the capillaries which previously nourished it. Dr. Graham regards the treatment of hyperplastic tissues unfavorably, but Billroth, Gottlieb and others claim that by "Vigorous perseverance in manipulation, impervious blood- and lymph-vessels may be reopened and absorption of the adventitious tissue promoted." Mechanical vibration, like massage, is contra-indicated when solutions of continuity or anchylosis are present, or where there is danger of inducing auto-infection.

Peri-arthritis, particularly of the shoulder-joint, "a subacute or chronic inflammation of the subacrominal bursa and of the loose areolar tissue under the deltoid, with thickening and the formation of adhesions" resulting in or associated with neuritis and limited motion, and also often complicated with myositis, may be successfully treated by mechanical vibration in conjunction with electricity and properly applied movements. Hydrotherapy may also prove useful in expert hands in addition to the other measures.

A vibratory treatment of the shoulder joint, as indicated under the head of friction in the chapter on technique, combined at first with superficial and later deep interrupted vibrations, should be applied in conjunction with passive motion in early cases to be soon followed by active movements. In old cases first break up the adhesions under an anæsthetic and then treat the same as a sprain or fracture. In using passive motion care should be taken that it is done very slowly and cautiously and is best performed during deep exhalations.

In the treatment of rheumatoid arthritis after the acute stage, apply a spinal vibratory treatment. Above and below the affected joints of the extremities apply vibratory friction centripetally as directed in chapter IV, and employ superficial and later deep interrupted vibration about the joint and above and below the affected joint, as well as particularly *on* the affected joint, with stimulation of the next set of lymphatic glands nearest the trunk. Follow this with passive and later resistive and active movements. If the pain resulting from motion gradually disappears within half an hour, such exercise is not contra-indicated. If the pain lasts, the movements should be diminished in number and extent or even stopped for a time. Passive and active exercise, consisting of opening and closing the mouth, following the application of vibration in the form of interrupted vibration with a multiple point or rubber-covered disc vibratode to the temporomaxillary articulation are valuable for overcoming contractions of the temporal, pterygoid and masseter muscles. In rheumatoid arthritis vibration is best employed in connection with the static treatment of the disease. A hot air treatment of affected joints preceding the vibratory treatment is often beneficial.

Such treatment increases nutrition and the activity of the metabolic processes and removes pathological obstructions which are the local indications in rheumatoid arthritis. "The soft structures may be made to adapt themselves to nodosities and deformities which cannot be removed." The writer has followed this line of treatment in connection with static treatment and has seen marked improvement result. In beginning cases mild interrupted vibrations with a rubber-covered disc applied over affected joints of the hand afford considerable relief.

In the treatment of juxta-articular fractures, vibration with appropriate passive exercise, to be followed later by active exercise, used immediately after the removal of the plaster cast, will remove œdema, relieve stiffness and lessen sensory disturbances. What it may do when applied without the removal of the plaster remains to be demonstrated.

Sprains and fractures are satisfactorily treated with vibration. The earlier the treatment, the quicker and better the result. The relief of pain or cause of discomfort should govern the length of each treatment. Following fractures, particularly, exercise is used as an adjunct, both passive and active, but should not be brought into service *until a good union has taken place.* Vibratory treatment diminishes the swelling, increases the nutrition of the muscles, prevents the adhesion of inactive tendons in their sheaths, and shortens the period of repair. The aim as in massage should be *"to move the neighboring parts but to keep the broken bone still"* while enhancing its nutrition. We should base our employment on what has lately been done by noted surgeons, such as Mm. Championniere, Tripier, Rafin, Marevery, Landerer, Franks, Tilanus and Wagner. Manual massage was used in intra- and para-articular fractures. "Fracture of the lower end of the fibula, the inferior extremity of the radius, transverse fracture of the patella," fracture of one of the bones of the leg or forearm where the other bone acts as a natural splint and prevents displacement, and transverse fracture of the humerus and forearm or leg and in fractures of the patella. The vibratory method followed is that recommended for joints.

An acute sprain should be treated at first twice daily and later once. How soon movements may be introduced should rest with the judgment of the operator who will be guided by the character of the sprain and by the patient's feelings. Mechanical vibration when applied hastens the recovery by favorably affecting absorption, circulation, and stiffness, but care must be exercised that it be employed without causing pain during the treatment of swollen and painful parts, and careful selection and gradation must also mark the auxiliary exercises.

In certain injuries to the head as fracture of the skull, concussion, etc., vibratory stroking from the mastoid processes downward and outward on the neck and shoulders, and posteriorly downward stroking from the occiput to the scapulæ, and interrupted vibration with the ball to the cervical sympathetic controlling the blood supply to the head will lessen the hyperæmia. The patient should breathe deeply during the administration.

Joints affected by increased tension involuntary in character associated with pain and limitation of motion may often be benefited by interrupted vibration and passive motion of a mild degree. In applying vibration to a joint Kellogg's excellent rule for massage is appropriate. "When a joint is very sensitive, derivative massage only should be employed for a week or ten days at the beginning, the manipulations being gradually brought nearer the joint from day to day." In all cases it is best to employ carefully selected joint movements as early as possible. Centripetal friction above and movement of the joint above with centrifugal stroking below are useful when first treating a painful joint. If the case be an old one, and the results of chronic inflammation are present, as when a crepitus is discernible in a joint on movement, vibrate the joint directly. It is well also to apply static electricity, hydrotherapy, or thermotherapy in all inflammatory joint cases. Vibration may be so applied as to prevent or increase a flow of blood to the joint and also to promote absorption and elimination.

After breaking up adhesions the indications are vibratory treatment, at first associated with passive movements, later to be followed by active exercise.

In strumous synovitis use deep interrupted vibration with deep pressure, vibratory friction, a multiple point or flat disc vibratode being used. Passive motion should be begun at the cessation of inflammation, but should be used with care. "An active condition of the swelling, evidenced by pain and tenderness, any considerable amount of degeneration, or suppuration, darting pains and tenderness of the joint surfaces" contra-indicate passive motion. More rapid progress can be made in using passive motion, when the joint has a certain fixedness, if the movement be made gradually and tentatively, directing the patient to take deep breaths and making the increased movement when he exhales.

Mechanical vibration is indicated over the site of fractures and over the centres controlling the blood supply in cases of incomplete union. Apply mechanical vibration to induce hyperæmia in cases of fibrous union where "absorption and attenuation of the ends of the fragments, or eburnation has not occurred, and where there is no constitutional dyscrasia." It is also applicable to certain cases of Dupuytren's finger contraction and even in elephantiasis where tight bandaging and elevation should be employed as adjuncts.

CHAPTER VIII.

RELATION OF MECHANICAL VIBRATION TO THE NERVOUS SYSTEM.

There are certain indications for the vibratory treatment of spinal nerves and there are conditions and times where and when there is a question as to the advisability of inducing additional stimulation. Another point to be considered is how to affect the vaso-constrictors or the vaso-dilators as desired.

The two great systems are the *cerebro-spinal* consisting of the brain, spinal cord, and cranial and spinal nerves,—and the *sympathetic*, consisting of a connected chain of ganglia on each side of the spinal column, three plexuses,—cardiac, solar, and hypogastric, which consist of nerves and ganglia "in front of the spine in the thoracic, abdominal and pelvic cavities respectively," and of smaller ganglia in relation with certain viscera, and two kinds of nerve-fibres,—communicating and distributory.

The *situation of the ganglia* varies in their relation to the vertebræ in the different regions—the cervical lying "in front of the transverse processes of the vertebræ, in the dorsal region; in front of the heads of the ribs, except the last two, in the lumbar region; on the sides of the bodies of the vertebræ, and in front of the sacrum" in the sacral region.

The unit of nerve tissue as now recognized is the neuron or neurone, consisting of "the nerve cell, neurocyte or corpus, the axon, or axone, or nerve process, and the end tufts or terminal branches." A neurone of the first class developed "in the central nervous system" consists of a "cell body and its projecting branches." Sometimes from the nerve cells protoplasm extends which portions are called dendrites or dendrones. "The surface of the dendrite is rough and often nodular, and appears to be covered with small granules called buds or gemmules" (Starr). The cell is composed of unstained protoplasm, "a nucleus, a nucleolus and a large number of granular bodies" called "Nissl bodies, chromophile bodies, stainable substance or tigroid." The second class of neurones belongs "to the sensory part of the nervous system."

The axon "is supposed to transmit nervous impulses from the cell." The axon, an axis cylinder process, may be invested in a myelin sheath and an outer covering, the neurilemma, or may have no myelin sheath and be a non-medullated nerve fibre as of the sympathetic system.

Some authorities divide the *neurones into two classes,* the *central* class, or a neurone of the first class, and the *peripheral* or second class, the latter belonging "to the sensory part of the nervous system." "It develops originally in the posterior spinal ganglia that lie outside of the spinal cord and in homologous ganglia that are in connection with the sensory cranial nerves and also the ganglia of the sympathetic. The *sensory axone* never terminates in a cell in the spinal cord or brain axis. It ends in brush-like terminations or tassels" (Starr). The *sensory neurone* gives off two branches, one going to the periphery and terminating "in a fine brush-like expansion of filaments in the skin or in the tactile corpuscles." The other branch enters the spinal cord, bifurcating, one part passing up, the other down, giving off collaterals at right angles which end "within the gray matter of the posterior horn, either near their entrance, or as far from their entrance as the posterior nuclei of the medulla oblongata, or at various levels in the brain axis. In this form of neurone the cell body is situated about one-half way between the terminal extremities of its two great branches, and this fact of the interposition of the body in the course of a nerve tract, which, from the nature of the case, must be a continuous tract, suggests that the function of the cell is a trophic one."

"In the adult the *sensory neurone* is pear-shaped and appears to send out a single axone which divides into two branches passing in opposite directions. One of these branches finds its way outward to the periphery of the body, forming *a sensory nerve,* and terminates in a fine brush-like expansion of the filaments in the skin or in the tactile corpuscles. The other branch finds its way inward through the posterior nerve root into the spinal cord or brain axis, where it bifurcates, one portion passing downward and the other portion upward in the posterior columns of the spinal cord, or in the formatio reticularis of the brain axis" (Starr).

Neurones classified according to functions are

"(1) Centrifugal: (a) motor, (b) secretory, (c) trophic.

"(2) Centripetal or sensory.

"(3) Intrinsic or association."

Another classification is as follows:

(1) Primary neurones, whose axone goes to the periphery, namely to a gland, the skin, a muscle, or a sensory organ.

(2) Secondary neurones, whose axones end "about

a primary neurone or about another secondary neurone."

The primary neurones are concerned in reflex acts, but both primary and secondary neurones govern voluntary movements and conscious sensation.

A very good illustration of this is given by Dr. M. Allen Starr, when in analyzing "a simple sensation like the impact of a particle of dust in the eye, which causes a wink, a flow of tears, a conscious pain, and a voluntary effort to remove the particle. The sensation comes in from the eye along the primary sensory neurone, is transmitted (a) to the brain axis, where it reaches the primary motor neurone, setting up the centrifugal reflex acts of a wink and of secretion of tears, and (b) to the secondary sensory neurone, which transmits it upward to the brain. This secondary neurone may terminate about another secondary or association neurone, which then sends the impulse on to a secondary motor neurone, and this in turn sends its impulse down to the primary neurone, which transmits it to the muscle causing the removal by the hand of the particle."

What concerns us particularly is the *nutrition* of the nerve as it is affected by various pathological conditions and the direct bearing of the nerve to stimulation or inhibition. It was first noted by Hodge that the cell and nucleus changed if active. Vas noted that a mild stimulation caused the cell to swell and clear up in the center, and "Mann showed that functional activity of the cell is accompanied by an increase in the size due to inhibition of the lymph lying in the cavity about the cell, the cell at work filling up the cavity in which it lies. When activity goes on to the point of fatigue then a shrivelling of the cell begins, first in the nucleus then in the body." These changes were induced by various stimuli both electrical and *mechanical*, as running." If a cell that has been stimulated be given sufficient rest, it will revive and resume its functional activity but it is necessary that the blood supply be perfect and that the blood contain the requisite nutrition. There may be an injury to the neurone of a character which cannot be repaired, which will lead to organic nervous disease. According to Dr. Starr bacteria as well as leucocytes may be found in the neurone body and its branches.

The spinal cord is supplied with *blood vessels* which are non-anastomosing terminal arteries. If an embolus occurs in such an artery "an area of softening" results. Some of the veins empty their contents eventually into the vena cava, and others into branches of the jugular. Starr believes that too little attention has been given to diseases of the spinal blood vessels and "to the results of end-arteritis" and cases of supposed myelitis have been found to be "softening of the cord due to thrombosis in diseased blood vessels" (Starr from R. J. Williamson, Manchester Medical Chronicle, 1895). These facts must be taken into account when using vibratory stimulation, for dire results otherwise may follow.

The spinal cord controls various voluntary and involuntary actions of the human body. Nerve centers for many of these functions have been discovered, but others are as yet unknown or are in doubt, some authorities claiming one and some another region to be the centre for a certain act or impulse, and yet again in some instances experiments have been made on the lower animals resulting in the discovery of certain centers which have not as yet been verified in respect to man.

"While the *vaso-constrictors* arise from a limited but extensive area of the cord, the *vaso-dilators,* at least so far as they have been investigated, are said to arise from a wide area, which unlike that of the vaso-constrictors, is not limited chiefly to the thoracic region of the cord, but on the contrary, there is a copious outflow of these nerve-fibres from the cranial and sacral regions of the central nervous system. In fact, it would seem that vaso-dilator fibres arise from all parts of the spinal cord. Stimuli which are applied *at long intervals* to the nerve act especially on the *vaso-dilator* fibres; while *tetanizing stimuli* act on the vaso-motors. (Bowditch and Warren)."

Stimulation of *pressor* and *depressor* fibres of "different afferent nerves" excites or inhibits the action of the vaso-motors. Loven believes that "the first effect of stimulating every sensory nerve is a pressor action" and "S. Mayer and Pribram found that mechanical stimulation of the stomach, especially of its serosa, caused pressor effects."

The *centrifugal neurones* end by the axone, axis cylinder, dividing into tufts or branches which are directly connected with the tissue elements. In skeletal muscles they form a "motorial end-plate and each fibre has an individual end-plate (Brubaker). Sometimes a plexus is found around the muscle fibres as in visceral muscles, and in glands, the fibres going to the secreting cells. The endings of the centripetal nerves which have been referred to before are as follows:

(1) Free endings in the epithelium of the skin, mucous membrane, and cornea.

(2) Tactile cells of Merkel in the epidermis.

(3) Tactile corpuscles in the papillæ of the true skin.

(4) Pacinian corpuscles found attached to the nerves of the hands and feet, to the intercostal nerves, and to nerves in other situations.

(5) End bulbs of Krause in the conjunctiva, penis, clitoris, etc.

The spinal nerves have two roots, an anterior and posterior, the anterior being supposedly efferent, and the posterior afferent, for according to Brubaker **stimulation of the anterior roots** causes:

1. Convulsive movements of muscles.
2. The formation of a secretion in glands.
3. Changes in the caliber of blood vessels.
4. Inhibition of the rhythmic activity of certain organs.

Division of these roots is followed by:

1. Loss of muscular movement (paralysis of motion).
2. Cessation of secretion.
3. Cessation of vascular changes.

Stimulation of posterior roots causes

1. Reflex activities.
2. Conscious sensations.
3. Inhibition of the rhythmic activity of certain organs.

Division of the posterior roots is followed by:

1. Loss of reflex activities.
2. Loss of sensation in all parts to which they are distributed.

The reflex activity is what some authorities consider to be of the greatest importance as it is believed that in chronic visceral diseases "the spinal muscles lying over the reflexly affected spinal nerve center will generally be found contracted, and if long continued more or less atrophied," and that stimuli "applied directly over the affected center," acts as a *vis a tergo* to restore normal functionating power, and therefore interrupted vibration with the ball is used on each side of the spine between the transverse processes.

"The efferent nerve fibres of the sympathetic system supply (a) the *muscles of the vascular system,* to which they send vaso-motor fibres, i. e., vaso-constrictor and cardiac augmentor or accelerator, and vaso-inhibitory fibres, i. e., vaso-dilator and cardiac inhibitory; (b) the *visceral muscles,* to which they send both viscero-motor and viscero-inhibitory fibres; (c) the *secretory gland-cells."*

The motor nerves "of the non-striped muscles of the arterial system" otherwise known as vaso-hypertonic or vaso-constrictor or vaso-motor of the blood vessels (Ludwig and Thiry-Landois and Stirling page 854) cause a lessening of the caliber of the blood vessels when stimulated. If the central end of a sensory nerve be stimulated as of the sciatic, it causes a rise in the blood pressure. Strong mechanical stimuli lessen the action of the vaso-constrictors and cause a dilatation of the arteries with sometimes a preliminary contraction (Landois and Stirling). "Tetanizing stimuli act on the vaso-motors." Stimulation of the vaso-motor nerves supplying the blood vessels may be based on the following. (See Fig. 50.)

The blood-vessels of the head are supplied by the cervical sympathetic, of the upper extremities "through the anterior roots of the middle dorsal nerves, into the thoracic sympathetic, and upwards to the last thoracic ganglion, and from thence to the rami communicantes to the brachial plexus (Schiff, Cyon)," of the lower extremities "through the nerves of the lumbar and sacral plexuses into the sympathetic, and from thence to the lower limbs (Pflüger, Schiff, Cl. Bernard)," of the skin of the trunk through the dorsal and

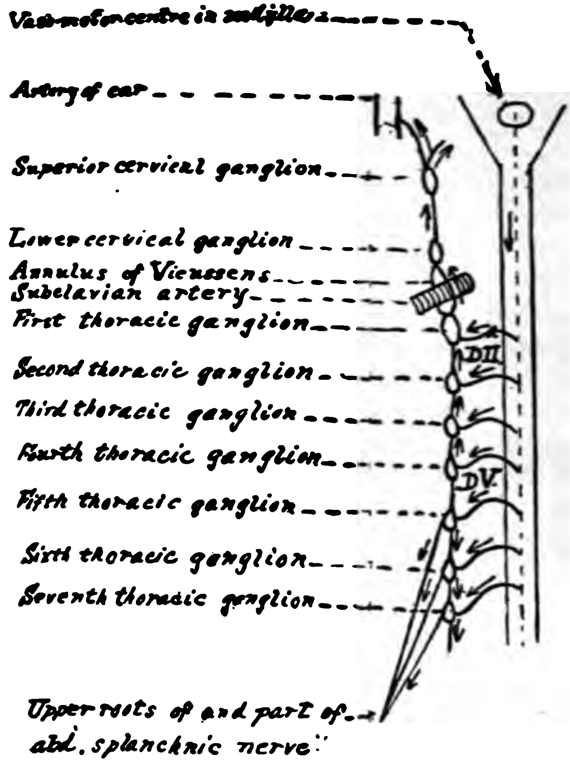

Fig. 50.—Diagram of the paths of vaso-constrictor fibres along the cervical sympathetic and part of the abd. splanchnic. Constrictor impulses pass down the cord from the vaso-motor center of the medulla. *a. ramus communicans.* (After Foster.)

lumbar nerves, of the lungs "from the dorsal spinal cord through the first thoracic ganglion (Brown-Séquard, Fick and Badoud, Lichtheim) of the abdominal viscera from the splanchnics" (v. Bezold, Ludwig and Cyon) (Landois & Stirling). Loven thinks that the first effect of stimulating a sensory nerve causes a pressor action, and S. Mayer and Pribram discovered that if the stomach, especially its serosa, was stimulater mechanically pressor effects resulted. If a stimulus be very slight, it lowers the cutaneous temperature, and lessens "the volume of the corresponding limb, sometimes increase of the general blood pressure and change of heart-beat."

The body temperature and even the body weight are through *stimulation of particular vascular areas* acted upon by the vaso-motor nerves. Stimulation of a motor nerve or the spinal cord causes not only the *contraction of the corresponding muscles,* but also *dilatation* of their blood-vessels. (C. Ludwig and Sczelkow, Hafix and Gaskell)—the dilatation of the vessels taking place even when the muscle is prevented from shortening. Gaskell observed under the microscope the dilatation produced by stimulation of the nerve to the mylo-hyoid muscle of the frog. It is thought that vaso-dilator fibres arise from all parts of the spinal cord, the ear receiving its supply from the lowest cervical ganglion and first dorsal; and the nervi erigentes from the sacral plexus when stimulated cause the arteries of the penis to dilate. (Eckhardt, Loven). Vaso-dilator nerves are also known as vaso-inhibitory and vaso-hypotonic nerves. (Landois and Stirling page 863.) In applying vibration take as a guide the rule, "Stimuli, which are applied at long intervals to the nerve, act especially on the vaso-dilator fibres, while tetanizing stimuli act on the vaso-motors (constrictors). The latent period of the vaso-dilators is longer and they are more easily exhausted than the vaso-motors (Bowditch and Warren)."

Abrams has lately called attention in "The American Journal of the Medical Sciences" to the Cardiosplanchnic Phenomenon, (a change from "resonant or even hyperresonant" tone to a "dull or flat" tone when "the sternum contiguous to the heart is first percussed in the standing and then again in the recumbent posture"), which is important in connection with the application of pneumo-massage and interrupted vibration—compressing in character. "There is a tendency of the blood to accumulate in the splanchnic area, with consequent syncope. Like the generality of veins, the great splanchnic veins are very susceptible to pressure, and the amount of blood within them is greatly influenced by pressure on the abdominal walls. Mere pressure of the latter suffices to squeeze out of them a large quantity of blood. Three factors enter into consideration in the mechanism of the blood supply to the splanchnic vessels, viz. (1) contraction of the abdominal muscles, (2) respiration, and (3) the regulating vaso-motor action of the splanchnic vessels."

The phenomenon exaggerated in diseased conditions is not only valuable diagnostically as in differentiating "a dilated heart from a pericardial exudate," but is of value therapeutically. "A large number of respiratory affections owe their dyspnœa to an overtaxed right heart, and this is notably the case in asthma." "While I (Abrams) do not agree with Kingscote, that a dilated heart is the invariable concomitant of asthma, yet I do contend that an enlargement of the viscus is operative in predisposing to a paroxysm and augmenting its severity. In a severe asthmatic attack which resisted the conventional remedies, a vacuum cup to the abdomen arrested the attack." "The predominance of dyspnœic attacks at night in cardio-respiratory affections can be explained by the augmented blood supply to the right ventricle, the mere result of recumbency. *In syncope* it appears to me that the object achieved is not so much the determination of blood to the anemic brain as it is to the determination of blood to the heart. To affect compression of the abdomen in acute conditions demanding cardiac stimulation, paroxysmal abdominal compression will suffice."

Relative to spinal stimulation, the following observavations in respect to the communication between the sympathetic system and the ganglia of the posterior roots of the spinal nerves are of importance. According to Kirke "The connection between these parts is as follows: the visceral branch or ramus communicans of each spinal nerve, which is one of the divisions of a typical spinal nerve—the others being the dorsal and ventral—passes first of all into the lateral chain; from this chain branches, *rami* efferentes, pass into the collateral ganglia, and from these again other branches pass off into the organs to end in the terminal ganglia. In the thoracic region, the rami communicantes are composed of two parts, white and gray. The former can be traced backward into *both spinal nerve-roots* of their corresponding spinal nerve; and in the other direction partly into the lateral sympathetic chain, and partly into the great splanchnic nerves and so on into collateral ganglia without entering the collateral chain at all. The upper *white* rami (from the 2nd to the 5th), however, proceed upward and join the superior cervical ganglion instead of passing downward into the splanchnics. Other branches go downward into the lumbar and sacral plexuses. The *gray* rami of all the spinal nerves are the only apparent representatives of the visceral branches in the regions above the 2nd thoracic nerve-root, and below the 2nd lumbar nerve-root, with the exception of the roots of the 2nd and 3rd sacral nerves, which have also white rami, and consist of non-medullated fibres, and pass from the ganglia to be distributed chiefly to the spinal column, to the spinal membranes and to the spinal nerve-roots themselves. We must look upon the white rami then as the visceral branches proper."

It has been demonstrated "that there is an exchange of materials within the nerves which is proved by the fact that after compression of the blood vessels of the nerves the excitability of the nerves falls and is restored again when the circulation is re-established." Mechanical stimuli act when sufficiently rapid to cause a change in the nerve particles. Their effects vary; if the *pressure on a mixed nerve be continuous the motor fibres are paralyzed sooner than the sensory.* If the pressure be increased gradually an increase of excitability follows to be later followed by a decrease. According to Kronecker and Zederbaum *pressure* applied to a mixed nerve abolishes reflex conduction before motor conduction. Fontana, 1758, found that a stimulus increased very gradually caused the nerve to be inexcitable without showing stimulation signs. A mechanical stimuli does not cause the nerve to become acid. "Tigerstedt ascertained that the minimal mechanical stimulus is represented by 900 milli-gram millimeters, and the maximum by 7000 to 8000. Strong stimuli cause fatigue, but the fatigue does not extend beyond the part stimulated. *Slight pressure* without tension increases the excitability, which again diminishes after a short time. The mechanical work produced by an excited muscle in consequence of a stimulus was 100 times greater than the mechanical energy of the mechanical nerve stimulus."

It is also well to recall Pflüger's "avalanche theory," which, although incorrect, makes us remember that the nearer the nerve center the greater the excitability, that is a muscle that contracts with a given stimulus at a given point will answer with a greater contraction if the same stimulus be applied nearer the spinal cord. Yet another point to be noted is that in the same nerve a stronger stimulus is required for it to act on some muscles as of extensors than on others as flexors, as has been demonstrated on the sciatic nerve of a frog. This has not yet been fully investigated and determined, but furnishes a field for study, the results of which may ultimately aid in estimating the degree of stimulation indicated for various groups of muscles which it may be advisable to affect.

If stimulation be continuous and excessive, fatigue followed by exhaustion results. Bernstein demonstrated that "a nerve trunk is more slowly fatigued than a muscle, but it recovers more slowly" (Landois and Stirling, page 683), which suggests a judicious employment of vibratory stimulation according to the case treated, that over stimulation be avoided.

Nerves are capable of carrying impulses even after there is loss of excitability. We should not, therefore, stimulate a nerve *too rapidly* in order that the nervous impulse may be allowed to travel without interruption. The impulse travels in a motor nerve at from "100 to 120 feet per second as found by v. Helmholtz and Baxt" and from 90 to 280 in sensory nerves, as shown by v. Helmholtz. It is less in the visceral nerves, being but 26 feet in some branches of the vagus (Chauveau).

The following is of importance as regards **reflexes:**

"1. Reflexes are more easily and more completely discharged when the specific end-organ of the afferent nerve is stimulated, than when the trunk of the nerve is stimulated in its course" (Marshall Hall).

2. A stronger stimulus is required to discharge a reflex movement than for the direct stimulation of the motor nerves.

3. A movement produced reflexly is of shorter duration than the corresponding movement executed voluntarily. Further the occurrence of the movement after the moment of stimulation is distinctly delayed.

"Strong stimulation of a sensory nerve inhibits reflex movements. The reflex does not take place if an afferent be stimulated very powerfully (Goltz, Lewisson)."

Setschenow distinguished *tactile* reflexes, which are discharged by stimulation of the nerves of touch; and *pathic* which are due to stimulation of sensory (pain conducting) fibres. He and Paschutin suppose that tactile reflexes are suppresed by voluntary impulses, and the pathic by the center in the optic lobes."

In connection with the subject of reflexes the question arises whether the spinal cord is or is not stimulated when we stimulate the posterior root. "As the spinal cord conduces to the brain impulses communicated to it from the stimulated posterior roots, but does not itself respond to stimuli which produce sensations, Schiff has applied to it the term 'æsthesodic.'" Further as the cord can conduct both voluntary and reflex motor impulses, without, however, itself being affected by motor impulses applied to it directly, he calls it *"kinesodic."* Many others believe that direct stimulation will excite the spinal cord.

Reflex time or the time for carrying impulses by means of the afferent nerves through the cord to the efferent varies, in the frog being .0008 to .015 second, but is increased by "almost 1-3 if the impulses pass to the other side of the cord." It lessens as the strength of the stimulus is increased "and may even become of minimal duration." (J. Rosenthal.)

What investigation has demonstrated of the relation that stimuli bear to effect has been aptly summarized by Kirke acording to Pflüger as follows:

"1. *Law of unilateral reflection*:—A slight irritation of the surface supplied by certain sensory nerves is reflected along the motor nerves of the same region. Thus if the skin of a frog's foot be tickled on the *right* side, the right leg is drawn up.

2. *Law of symmetrical reflection*:—A stronger irritation is reflected, not only on one side, but also along the corresponding motor nerve of the opposite side.

3. *Law of intensity*:—In the above case, the contractions will be more violent on the side irritated, but it must not be assumed that the effect is always in proportion to the strength of the stimulus.

4. *Law of radiation*:—If the irritation (afferent impulses) increases it is reflected along other motor nerves till at length all the muscles of the body are thrown into action.

The vagus nerve is particularly worthy of notice as it has such a wide range of control. "It supplies (1) motor influence to the pharynx and œsophagus, stomach and intestines, to the larynx, trachea, bronchi and lung; (2) sensory and in part (3) vaso-motor influences, to the same regions; (4) inhibitory influence to the heart; (5) inhibitory afferent impulses to the vaso-motor centre; (6) excito-secretory in the salivary glands; (7) excito-motor in coughing, vomiting, etc."

Weber first studied the relation "between the intensity of the stimuli and the changes in the quantity of the resulting sensations. He used the method of "least observable differences" as applied to sensations of pressure and the measurements of lines by the eye." Fechner carried it further, and it is now known as "Fechner's Law." "The result depends on (1) the *strength* of the stimulus, and (2) the *degree* of excitability. Supposing the latter to be constant while the former is varied, it is found that if the stimulus be doubled, tripled, or quadrupled, the *sensation increases only* as the *logarithm* of the stimulus," that is a *stimulus increased 10* will increase the *sensation 1*, or a stimulus increased 100 will increase the sensation 2. It must be remembered, however, that there is a minimum and a maximum limit of excitation between which is a range of sensibility according to Wundt. According to Landois and Stirling the "necessary increment is proportional to the intensity of the stimulus, and it varies for each sense organ. If a weight of 10 grams be placed in the hand, it is found that 3.3 grams must be added or removed before a difference in the sensation is perceptible; if 100 grams are held, 33.3 grams must be added or removed to obtain a perceptible difference in the sensation. The magnitude of the fraction indicating the increment of stimulus necessary to obtain a perceptible difference of sensation, is spoken of as the *constant proportion* or the discriminating sensibility. In the above case it is 1:3. The following table gives approximately the constant proportion for each sense:

Tactile sensation 1:3
Thermal sensation 1:3

Auditory sensation 1:3
Muscular sensation 6:100
Visual sensation 1:100

Ladd claims that at best it is only an approximately correct statement of what holds true of the relative intensity of certain sensations of light and hearing, and less exactly of pressure and the muscular sense, when these sensations are of moderate strength."

Fechner's "psycho-physical law" refers to *homologous* stimuli—stimuli for whose action the sense organs are specially adapted and, according to Landois and Stirling, "holds good only with regard to stimuli of medium strength." "Heterologous stimuli (mechanical, electrical, etc.) act upon the nervous elements of the sensory apparatus along the entire course, from the end-organ to the cortex cerebri. The homologous stimuli, on the other hand, act only on the end-organ."

Scientific investigation is of importance to all employing vibratory stimulation of whatever form—static wave-current, high-frequency current, or mechanical vibration. It demonstrates the existence of factors that are too often overlooked. The response of the different parts to varying strengths of stimuli and the reaction of sensation gives a clue to the magnitude of over-work when altering the strength of an homologous stimulus by some multiple thereof.

Vibratory friction acts on nerve endings of both systems and *interrupted vibration* acts upon the nerve trunks and centers. Lightly applied, interrupted vibration stimulates while stronger or longer fatigues or exhausts the nerves, according to the degree, and may affect the blood flow, causing a numbness from diminished nutrition. *Percussion* excites "languid nerves, but if *long* and *vigorous* may over stimulate them and exhaust their ability of perceiving impressions and allay morbid irritability, a point of therapeutic interest.

Light percussion at first increases pain, but later diminishes it, often causing it to finally disappear. The greater the sensitiveness of the nerve, the less pressure should be at first employed.

Vibratory stroking has a soothing effect and vibratory friction by acting on the nerve of the blood vessels and lymphatics has a marked effect on inflammation. It also helps to give the tired nerves their necessary blood supply.

When **deep interrupted vibration, even compressing** in character, is used pressure on the trunk is best made over the "motor points." Douglas Graham says "it is often surprising how much better contraction can be obtained from percussion than from a faradic current." When made on the solar plexus below the xiphoid cartilage and the lumbar ganglia, situated about two inches on each side of the umbilicus, the patient should exhale slowly and forcibly, breathing deeply. All abdominal viscera will be affected, persistalsis being markedly excited.

If deep interrupted vibration is applied to the aortic lumbar plexus the vibratode should be placed about two inches below the umbilicus. During applications to these regions the patient should lie on his back, the head and shoulders being elevated, the legs being flexed, and feet supported. The patient should breathe deeply and during forced exhalation the pressure should be increased, the vibratode being carried more deeply at the sites of application. Each impulse should be but for a few seconds at each site, the period of rest being about four or six times as long as the time of contact. The vibratodes should be applied but for three or four times and great care must be exercised that the pressure is not applied too suddenly or too heavily, as unpleasant effects, such as nausea and depression may result.

Deep interrupted vibration with moderate or deep pressure is stimulating if the application is short, but is exhausting if too strong or if it be applied too long.

In applying interrupted vibration to the spine place the ball vibratode over the site of the ganglion and make the pressure "close to the spinous processes and opposite the spaces between the spines, or between the ribs near the spine."

Below are the "chief actions of the sympathetic nerves on the one hand, and of the cranial and sacral autonomic nerves on the other, in the regions of double supply."

Tissue.	*Effect of stimulating the Cranial and Sacral Fibres.*	*Effect of stimulating the sympathetic fibres.*
"Heart	Inhibition	Increase in rate and strength.
Bl. ves. of salivary glands and most of buccal mucous membrane.	Dilatation	Dilatation and in certain cases contracture.
Salivary glands	Secretion	Secretion.
Muscular coats of alimentary canal.	Chiefly contraction, sometimes apparent inhibition.	Chiefly inhibition, sometimes contraction.
Bladder	Strong contraction	Feeble contraction.
Ext. generative organs	Inhibition	Contraction.
Bl. ves. of anal mucous-membrane and of ext. generative organs.	Dilatation	Contraction."

CHAPTER IX.

THE THERAPEUTIC APPLICATION OF MECHANICAL VIBRATION TO THE NERVOUS SYSTEM.

The blood vessels of the head are supplied with vasomotor nerves, principally from the cervical sympathetic. For stimulation of the nerve and blood supply, therefore, employ the ball vibratode, applying interrupted vibration with moderate pressure. For affecting the nasal supply directly, vibratory friction with very light pressure should be used from the root of the nose downward and at the same time outward. Vibration should also be applied to the face for relief of any inflammatory condition as *nasal catarrh* in order to stimulate the activity of the lymphatics in that region.

The *nasal mucous membrane* may also be directly affected by vibration, for which apply vibratory stroking, employing the shortest stroke and fairly rapid speed with a soft rubber vibratode.

According to Foster "the dominating effect on the blood-vessels of stimulating the *cervical sympathetic is a vaso-constrictor effect.*" In some cases, however, a vaso-dilator effect is induced. To meet these indications vibrate with the ball, applying deep interrupted vibration with moderate pressure at the upper portion of the anterior border of the sterno-cleido-mastoid muscle, between the trachea and the sterno-cleido-mastoid muscle—in front of the transverse processes of the 6th cervical vertebra, and over the head of the first rib. The vaso-dilators of the face and mouth are the 2nd, 3rd, and 4th dorsal. The vaso-constrictors for the corresponding side of the face, eye, ear, salivary glands and possibly the brain are 1st, 2nd, 3rd 4th, 5th, 6th, 7th, and 8th cervical—the cervical sympathetic.

Motor fibres of the eye enter the cervical sympathetic through the anterior roots of the two lower cervical and first and second dorsal nerves. In order therefore, to stimulate them, apply interrupted vibration on each side of the spinal column opposite the transverse processes of the corresponding vertebræ with the ball vibratode. Deep interrupted vibration with light pressure will cause the pupil to dilate as does also stimulation of the fifth cranial nerve. Constriction of retinal vessels is governed by the cervical sympathetic and their dilatation by the thoracic sympathetic.

Vibration is applicable to eye diseases, for the treatment of which it should be employed as a vibra-massage. Pagenstecher's method of massage, as given by Graham, consists of "moving the lid as quickly as possible under slight pressure in a radial direction, starting from the center of the cornea, and after this by making circular friction by means of pressure upon the upper lid around and upon the sclero-corneal region." Make the treatment for but a short time, 30 seconds to a minute or so, and only once daily, although twice if necessary, using a soft rubber vibratode. Vibratory stroking of the head and face is also advisable so as to more directly affect the nerves and blood-vessels.

It is applicable to the treatment of superficial opacities, the result of keratitis after the subsidence of the inflammation of the cornea; to the chronic pustular form of conjunctivitis, and to congestion of the ciliary region, local in character. In all cases, indicated constitutional treatment with due consideration to diet and hygiene must be observed.

Vibration of the eye is indicated in twitching of the lids, blepharitis, blepharospasm, trachoma, superficial corneal opacity, sub-acute and chronic conjunctivitis, sub-conjunctival extravasations, supra-orbital neuralgia, and asthenopia. *The greatest gentleness and skill must be employed in the treatment of the eye, avoiding irreparable injury, such as retinal detachment.* Sometimes vibratory treatment alone is sufficient, in other cases a combination with manual massage, or proper exercises is indicated. As with other affections treatments should vary from twice a day to once a week, according to the indications of the case. The restrictions of massage as given by Mitchell are very appropriate, applying as well to vibration. "It is contra-indicated in the acute inflammations of the conjunctiva, cornea, sclera, iris, and ciliary body, and after accidents or purposive surgical wounds."

In general, vibratory stroking of the face and neck should be used in most cases. In massage of the eye, a small shallow vibratode or Maklakow's electric vibrator giving, it is claimed, 9000 taps per minute, or pneumo-massage cups, as those of the Aero-Vibrant, Victor or Wappler machines may be used. Very light pressure if any should be employed in a degree adapted to the case. In cases of paralysis of the muscles of the eye, according to Mitchell (See Cohen's System of Physiologic Therapeutics,) "passive exercise by massage and forcible stretching and contraction of the paralyzed muscles is sometimes employed."

A shallow cup vibratode placed over the eyeball is adapted to ocular massage. Vibratory stroking with the shortest stroke should be employed and should be applied as in manual massage "in centripetal, centrifugal, and circulatory directions."

Mechanical vibration relieves congestion, assists elimination, and absorption, and stimulates the functions of the various structures of the eye.

The lids and face may be successfully treated by mechanical vibration. Vibratory stroking is indicated for the relief of *paralysis, œdema, and ecchymoses.* Twitchings are best treated by direct application over the motor points of the affected muscles.

Subacute and chronic conjunctivitis may be treated by vibratory massage in connection with other applications. For *trachoma* use the shortest stroke and a high frequency of speed with a soft eye fitting vibratode, applying friction with slight pressure.

Very light interrupted vibration with a soft shallow rubber cup applied with well regulated pressure over the lids is indicated in *glaucoma* for relief of the tension, the lids being massaged while the eyeball is rolled in all directions similar to Gould's method. The administration must be made with the *greatest* gentleness and but for a few seconds, to be followed by facial massage.

Retinal anæmia was successfully treated by the late Dr. Maurice F. Pilgrim by the application of mechanical vibration "over the vaso-motor area in the spinal cord, which influences the blood supply of the eye—at the junction of the fourth and fifth dorsal. It was also applied to the third and fourth cervical, and over the sub-occipitals, for its derivative effect through relaxation of muscular contractures." Vibration was not used over the eyeball more than six times and then but "for a few seconds." Treatment was administered daily. Constriction of retinal vessels is controlled by the cervical sympathetic and their dilatation by the thoracic sympathetic.

Secretion of tears may be reflexly induced by stimulating the mucous membrane of the nose. If vibration be applied directly to the eye a very soft rubber vibratode should be applied with the shortest stroke of the vibratode and the lightest possible pressure. The application should be made but for a few seconds. Begin the application at the inner corner of the eye and stroke outward above and below. Such administration is indicated in *muscular asthenopia*, or when drainage or vascularity should be increased.

The muscles of the eye are supplied by the 3rd cranial, the motor oculi, which also supplies the levator palpebræ superioris, rectus superior, inferior and internal, and the obliquus oculi inferior. The 4th nerve supplies the obliquus oculi superior, and the 6th the external rectus. These nerves are best affected by vibrating through their connection with a division of the superior cervical ganglion. The superior cervical ganglion gives off a branch to the middle cervical opposite the 6th cervical vertebra which, although generally opposite the second and third cervical, may be as low as the fifth. Interrupted vibration should therefore be applied with moderate pressure with the ball on each side of the spine from the occiput to the sixth cervical. Stimulation of this region has been found applicable in *hyperphoria, exophoria, and esophoria.*

The auditory nerve may be stimulated by "mechanical vibration of the end-organ of the auditory nerve, due to the wave-motion of the lymph of the labyrinth." The nerves of the auditory canal come from the auricular branch of the pneumo-gastric and the inferior maxillary of the fifth and these with a branch of the glosso-pharyngeal supply the membrani-tympani. The muscles of the ear are supplied by the facial nerve.

The nerves of the middle ear constitute the branches of the otic ganglion. They comprise a branch of the facial chorda tympani nerve, a branch of the glosso-pharyngeal, one from the carotid plexus of the sympathetic and a branch of the great superficial petrosal. Those of the Eustachian tube are derived from branches of the sympathetic through the pharyngeal plexus, which comprise also a branch from the superior cervical ganglion, some nasal branches from Meckel's ganglion, and some branches from the pneumo-gastric and glosso-pharyngeal. The blood-vessels of the ear are derived directly or indirectly from the external and internal carotid. The vaso-dilator nerves of the blood-vessels of the ear are branches "from the 1st dorsal to the lowest cervical ganglion" and the vaso-constrictors are from the cervical sympathetic which may be stimulated when desirable by employment of the methods previously described.

The external ear is supplied by the auricularis magnus, which is made up of a branch of the 2nd and 3rd cervical nerve, a branch from the facial, pneumogastric, inferior maxillary, occipitalis minor, one from the 2nd cervical nerve, and another branch from the posterior division of the 2nd cervical nerve. When treating the external ear apply vibratory stroking, followed by vibratory friction with the disc shaped vibratode anteriorly, posteriorly and inferiorly in respect to the external ear.

Acute inflammatory conditions should be treated by first stimulating the cervical sympathetic and then applying deep interrupted vibration with the small rubber disc or cup over the tragus. The shortest stroke should be employed and a moderate rate of speed. Apply the vibration in such a manner as to open and close the external meatus. In treating the ear locally always make use of a soft rubber vibratode.

The above method is employed for the purpose of exercising the structures of the middle ear, and should be followed by treatment directed to the Eustachian tube. This is best accomplished by applying vibratory friction with light pressure to the neck in the groove behind the ear following downward in the space between the angle of the jaw and the mastoid process along the anterior border of the sterno-cleido-mastoid muscle in its upper part, thereby stimulating the superior cervical ganglion. The latter treatment is instrumental in relieving *inflammation and obstruction of the Eustachian tube,* and also *itching of the throat* caused by obstruction of the tube. To affect the vaso-motor area of the head vibrate the cervical sympathetic. For exercising the tympanum a pneumo-massage apparatus has been found useful.

Mechanical vibration may be successfully applied for the treatment of *chronic diseases of the middle ear* when suppuration is not present. In catarrh of the tube it may be employed, and it is sometimes of value for relief of *tinnitus aurium.* Tinnitus aurium may be due to either central or peripheral lesions. Abrams classified them as follows: "To the former (central) belong those noises produced exclusively by pathological changes of the structures of the labyrinth; and peripheral, to those due to causes external to the labyrinthal structures. Noises originating in the labyrinth may be caused by exudation, increased pressure,

PLATE VII. APPLICATION OF PNEUMO-MASSAGE TO THE EAR.

anæmic and hyperæmic conditions, and from the action of drugs. These noises are always associated with a disturbance of hearing. Catarrh of the middle ear frequently gives rise to entotic or subjective noises. Sometimes the noises come from the vessels, particularly the carotid, which passes in close proximity to the ear. Other noises emanate from the jugular fossa, and others are produced by muscular contraction, particularly of the masseter" muscles. If an acute inflammation exists only the parts around the ear should be treated by vibration, not the ear itself. The pain occurring with *otitis externa* may sometimes be relieved by the application of interrupted vibration and centripetal vibratory stroking, employing a small rubber disc over the mastoid anterior to the external ear and over the neck, usually with compression as an adjunct. In ear troubles as in other conditions, the removal of causes, and the building up of tissue resistance is indicated. Compressing interrupted vibration is indicated in cases of *auricular induration* after healing of the incision after operative procedures.

Vibratory stroking has a marked sedative effect upon cutaneous nerves, it is therefore of value in the treatment of *nervous headache*.

Neurasthenia is a neuropathic condition which, according to Snow, "partakes in every case of some functional or organic derangement which either may have been primarily the cause of the nervous exhaustion or has resulted from it." The common symptoms are pain, insomnia, indigestion, an alteration of secretory and excretory functions, false angina, anæmia and associated conditions—tending to hysteria or hypochondriasis. If the patient complains of symptoms referable to cerebral exhaustion, apply vibratory stroking to the head daily or upon alternate days, the frequency to be determined by the individual conditions and effects. In the treatment of this condition apply interrupted vibration to the spine with the ball vibratode, and also treat according to indications any local condition associated with the trouble. In all cases stimulate the liver, spleen and solar plexus to awaken sluggish activities. In some cases a more general treatment may be indicated.

Vibration induces functional activity without the expenditure of active energy on the part of the patient. *Constitutional vibratory treatment,* however, will be of little value unless the cause for the condition be treated and relieved. Hygiene and diet should always be corrected and the environments as far as possible made congenial.

Pelvic disorders, amenorrhea and dysmenorrhea in the female are probably more often associated with neurasthenia than any other condition. The treatment of pelvic derangements, constipation and other associated conditions will be considered under their respective heads. The length of time necessary to treat an individual case, and the prognosis will depend upon the chronicity, whether organic disease be present, and on how amenable the cause is to treatment.

Neurasthenia may also be caused by gastric disturbances as chronic gastritis, and gastroptosis, or by derangements and displacements of other abdominal viscera.

Sexual neurasthenia, impotency and prostatitis may also be treated by vibration either alone or in connection with static electricity. For the treatment of which employ the rectal vibratode for five minutes or so, using the minimum stroke and a fairly rapid speed, taking care that the treatment be not too prolonged. The best vibratode, in the writer's opinion, is a flexible one of soft rubber about six inches long. The application has a soothing effect and is not disagreeable to the patient. As yet little has been published in this line of treatment, but it offers a splendid field for rational investigation.

Occupation neuroses are due to overuse of muscles and consequent nervous strain in (1) movements requiring co-ordination in the performance of skilled technique requisite in writing, piano playing, telegraphing and similar occupations, (2) movements requiring work of more weight, as shoemaking and painting, characterized by chronic or tonic spasms of flexors or extensors, accompanied with marked fatigue, tremor, pain, and sensory disturbances. The condition is generally found in neurasthenic individuals, or those of neurasthenic tendencies.

Vibration in these sufferers when properly applied acts as a tonic and sedative; it promotes absorption and improves nutrition. A local treatment is always advisable, but many cases also require a constitutional treatment, either spinal static or vibratory tonic, as will be indicated to improve the general condition and raise the individual's resistance to normal.

Employ centripetal vibratory friction with at first light and later moderate pressure, with medium stroke, beginning the application at the ends of the fingers, first on the dorsal side, moving the vibratode along the intermetacarpal spaces to the wrist joint where it is desirable to apply deep interrupted vibration. Anteriorly apply vibratory friction from the finger tips to the wrist, traversing the surface six or seven times. Particular attention should be given as well to the muscles of the inner part of the hand. Also apply deep interrupted vibration three or four times successively to the center of the palm to induce acceleration of the venous circulation. Then apply vibratory friction to the forearm, posteriorly and anteriorly as far as the elbow joint and about the elbow apply interrupted vibration with deep pressure as at the wrist. Continue the application of vibratory friction to the arm and apply interrupted vibration to the axillary region with the multiple point vibratode or rubber-covered disc, also use prolonged interrupted vibration over the site of contraction. Stretching of the arm and shoulder joint is accomplished (1) by the operator and patient grasping each other's "thumbs with the corresponding hands" and "making a series of vigorous elastic pulls" and twitches, the applied force being gradual, but the withdrawal should be rather sudden, or (2) by the operator placing one hand on the shoulder and grasping the patient's hand and pulling carefully and steadily with the other hand. The patient should lie upon his back during the application with the arm raised upward.

After the treatment of the arm has been persisted in for a time, associated with rest from occupation, and when all spasms at least of the extensors have ceased, employ active or resistive movements, or both, as indicated to exercise the extensors. Wolff cured 157 cases of occupation neuroses, improved 22, and failed in 98 of 277 cases treated. He employed massage twice daily in combination with "exercises of bending and stretching, spreading and contracting of the hand and arms for hours until the hand was fatigued, and these were repeated until the patient was able to move each finger voluntarily in all directions." "Elementary exercises in writing, prescribed and adapted to each case, also formed part of the treatment. Fixation of muscles by elastic bands, so as to give special exercises, was resorted to in some cases." These results were attested to by Billroth, Charcot, Esmarch and others (Graham). The successes were obtained in the cases which were characterized by tremor and spasm. The writer has pursued this plan of treatment associated with mechanical vibration instead of massage with marked success. Exercises were prescribed to be taken late in the evening and early in the morning, as well as at the time of treatment. Writing exercises should not be introduced too early, and then a faulty position of holding the pen or pencil must be corrected. Treatments twice daily are desirable at first.

Insomnia is often favorably affected by vibratory treatment applied to the neck, thereby relieving cerebral congestion or by centrifugal friction toward the extremities for the purpose of inducing the blood from the head, thereby relieving the brain. Relaxation, lessened nerve irritability and diminished arterial tension are the indications met by vibration. Local causes which influence the conditions must also be treated according to indications. *In cerebral anæmia,* centripetal friction should be applied. The best time of the day for the treatment of insomnia is in the evening or before supper. Attention should be given to a proper application of spinal stimulation in conformity with the indications of the case.

Migraine or hemicrania is characterized by unilateral headaches, which occur periodically. It is associated in most cases with gastric and visceral derangements. These attacks are probably due to a disturbance of parts of the sympathetic nervous system, particularly the abdominal. The treatment should be directed according to Snow, to "(1) improving the general nutrition, (2) to lessening the nervous irritability by restoring or establishing a proper stability of the nervous system, (3) to correcting or removing exciting causes as far as possible which induce attacks, and (4) to relieving the attacks when they do occur."

The third indication calls for particular attention to the correction of physical derangements or environments. The others may be successfully managed by local or general vibratory treatment. Spinal treatment should be administered daily, or every second day, depending upon indications. The stroke, speed and pressure exerted should be adapted in every case to the condition of the patient. Above all *no pain* must be caused by the treatment. A soothing effect is to be sought. Vibratory stroking from before backward and from the occiput down and outward and over the neck anteriorly with a rubber-covered disc, and interrupted vibration with moderate or deep pressure over the painful areas, is indicated. Kellogg believes that sometimes there are "points of induration or thickening in the trapezius and scaleni muscle" which seem to have some relation to some attacks of migraine. Such cases should receive indicated local treatment. Vibratory treatment of the liver and abdomen, which will improve digestion, associated with a restricted diet, are often indicated, as well as applications of proper spinal stimulation with the ball.

Disorders of sensation, as paraesthesia or numbness and hyperaesthesia of functional character, may be improved by vibratory treatment. For cutaneous anaesthesia use interrupted vibration with moderate pressure. Hyperæsthesia, however, is most effectively treated with interrupted vibration of a compressing character, and of longer duration.

Neuralgia is a sensory nerve disease characterized by pain or present as a symptom. There are various localized pains so designated—intercostal, facial, podalgia, plantar neuralgia, gastralgia, cardialgia. nephralgia, and neuralgia of the liver, rectum, testicles and ovaries. By some it is thought to be a peripheral disease, but most authorities regard it as not necessarily so, but a symptom due to central lesions or neuritis referred to the periphery. A nutritional disturbance of the central sensory regions is supposed to be the most frequent cause. A diagnosis as to the cause should be made, and if it be an advanced organic disease, treatment with vibration is of little avail, for it will not relieve the symptom when it is impossible to remove the cause.

The symptom may be pain together with numbness, tingling, burning, and sensitiveness, and may be also associated with automatic or reflex spasms, sweating, eruptions or flushing. The pain may or may not be intermittent.

Starr states in respect to facial neuralgia, that "vibrations maintained by a tuning-fork electrically vibrated, the end of the fork being in contact with the affected branch of the nerve and vibration with the end of the fingers of an expert masseur, have given relief in some cases."

In treating neuralgia as a rule apply the vibratode over the painful site or where the nerve is nearest the surface, and in the intercostal form apply it to the inferior border of the rib, i. e., of the uppermost rib at the site of the pain.

The size of the plexus as well as the nerve trunk should receive treatment in these cases. In employing mechanical vibration with a fairly slow rate of speed the rubber cone, apply it lightly at first but as soon as it will be borne gradually increase the pressure, the diminution of pain being a guide as to the increase of pressure. If deep pressure be first used the pain will cease sooner but the treatment is not so satisfactory to the patient owing to the extreme sensitiveness of the part. The pain may gradually diminish and may cease entirely during the first treatment, but if it does not, do not persist after a reasonable length of time. As a rule treat the case daily. It may be best to treat some very obstinate or acute cases twice daily for several days until the pain is gradually subdued and then "taper" accordingly.

Vibration improves the nutrition of the nerve, overcomes local stasis, and improves circulatory conditions. It may be a derivative measure or may be used directly over the nerve. Interrupted vibration with the multiple point vibratode or rubber-covered disc, superficial, deep or compressing in character may be used, the degree of pressure being regulated by the pain produced, i.e., as pain diminishes, increase the pressure. [illegible] has written very wisely on the subject of massage and the principles outlined by him are applicable to all operators of mechanical vibration. He says: "Massage to be useful should be painless. I have seen severe injuries of nerves follow the painful manipulation of unintelligent masseurs and osteopaths, and the statement which such individuals often make, that if their manipulations cause pain they are thereby doing good, is absolutely false."

Longer treatments are advisable for acute than for chronic cases. Sufferers from neuralgia habitually have used firm pressure over points of tenderness or pain, which are generally in the vicinity of a joint or bony surface. Compressing interrupted vibration may likewise be applied to such points. It has been demonstrated that "light and rapid percussion temporarily aggravates pain, but *slow* and *heavy* blows set in an obtunding effect at once."

Kellogg has made use of the nerve percuter of Dr. Mortimer Granville of London in the treatment of nerves, to induce vibration, but objects to the apparatus because it gets so easily out of order. He has, however, had good results from another percuter. Granville believes "that pain is due to disharmony or morbid vibration in a nerve, and has found in his experience that acute, sharp pain is best relieved by musical vibration of a low tone (to interrupt speedy vibrations of pain), while dull heavy pain is best relieved by high-keyed vibrations (to interrupt slow vibrations of pain). He thinks that relief is obtained by interruption of the discordant nerve vibration which he considers the cause of the pain." He considers the rate of speed employed to be an important factor.

On the other hand, Dr. Pilgrim believed that "the essential factor both in the mechanical stroke and in the electric current as regards their effect on nerve tissue, is, it would seem, *intensified* natural vibration," which is a still different theory relative to vibratory effects. He says that with certain vibration rates, amplitudes, timbres and associated rates, general sensation is influenced, and he theorizes in respect to muscles that as the primary elements of striped muscle are of unequal lengths and varying degrees of tension, to induce a general contraction "several rates of oscillation" are necessary.

Time and experience will solve these problems and determine the various rates and methods of treatment and their respective status in vibratory therapeutics.

While treating of neuralgia a consideration of the subject of "referred pain," of which Head, Dana and others have made a scientific study, is properly in order. Starr says, "they are referred by consciousness not to their actual point of origin, but to the part of the body from which sensations usually come when received at the particular segment irritated." As given by Starr:

"The pain produced by decayed teeth may be felt in the *temple* or *behind the ear*, instead of in the jaw. Severe pain *in the back* of the head is a common symptom of uterine disease or of inflammation of the bladder.

Pain *down the left arm* is a common symptom of ear disease, and may be attended by hyperæsthesia in the region of the fourth and fifth dorsal nerves on the chest. Pain *in the wrist* on the flexor surface is frequently felt in disease of the uterus, ovaries or bladder. Pain *under the right shoulder blade* is common in enlargement of the spleen.

Pain *between the shoulder blades* is a very common symptom of gastric affections of any kind. It may be attended by hyperæsthesia in the epigastric region, and the nearer the disease to the cardiac end of the stomach, e. g., ulcer, the higher the pain is felt. In severe vomiting pain may be felt *on the back of the arms* or even down the back of the forearms.

Pain *across the small of the back* is common in colitis or in impaction of the fæces within the colon.

Pain *across the upper sacral region* is very common in uterine disease.

Pain *over the outer side of the hips* is usually due to ovarian congestion.

Pain *down the inner side of the legs* is also due to the same cause.

Pain *down the inner side of the knee* is an early symptom of hip-joint disease.

Pain *in the heel* is a frequent symptom in lithæmia, and may also be felt in ovarian diseases."

According to the same authority the regions after Dana are:

"*Cerebro-Spinal Nerves*	*Distribution*	*Associated ganglia of sympathetic*	*Distribution*
I. Trigeminus facial.	Face and anterior scalp.	4th cerebral.	Head.
II. Upper 4 cervical.	Occiput, neck.	1st cervical.	Head, ear.
III. Lower 4 cervical and first dorsal.	Upper extremity.	2d and 3d cervical, 1st dorsal.	Heart.
IV. Upper 6 dorsal.	Thorax.	1st to 6th dorsal.	Lungs.
V. Lower 6 dorsal.	Abdomen, upper lumbar.	6th to 12th dorsal.	Viscera of abdomen and testes.
VI. 12th dorsal and 4th lumbar.	Lumbar region, upper gluteal, anterior and inner thigh and knee.	1st to 5th lumbar.	Pelvic organs.
VII. 5th lumbar and 5 sacral.	Lower gluteal, posterior thigh and leg.	1st to 5th sacral.	Pelvic organs and legs."

The general principle for treating these conditions is to vibrate the spinal centers; Starr, however, believes that treatment of the functional or organic disorder present is desirable, although sharp counter-irritation where the pain is will frequently improve the condition of the viscus as well as relieve the pain. This agrees with the results obtained from the administration of other modalities.

James Ross suggested that the pain is in such cases referred to parts supplied by sensory cutaneous nerve fibres, ending in the same segments of the cord as do the afferent fibres of the viscus diseased. "Referred pain will occur in the skin areas of those roots which have white rami, of those from which the pelvic nerves arise, and of those nerves, if any, with which the vagus afferent fibres are intimately connected. And there should not be primary referred pain in any other skin areas."

According to Schäfer the "earliest attempt to determine which spinal nerves innervate a given abdominal viscus was made by Bulgak in 1877." Other investigators were Bradford, Bechterew, Mislawsky, Bayliss, Starling, Schäfer and Moore.

Probable distribution of visceral afferent fibres of the spinal ganglia in man (Head):

"Heart	1, 2, 3 thoracic.
Lungs	1, 2, 3, 4, 5 thoracic.
Stomach	6, 7, 8, 9 thoracic.
Intestines	9, 10, 11, 12 thoracic.
Liver and gall bladder	7, 8, 9, 10 thoracic.
Kidney and ureter	10, 11, 12 thoracic and 1 lumbar.
Bladder	2, 3, 4 sacral, 11, 12 thoracic and 1 lumbar.
Prostate	10, 11, 12 thoracic, and 1, 2, 3 sacral.
Testis and epididymis	10, 11, 12 thoracic and 1 lumbar.
Ovary	10 thoracic, ovarian appendages 11 and 12 thoracic and 1st lumbar.
Uterus	10, 11, 12 thoracic, 1st lumbar, 2, 3, 4 sacral.
Rectum	2, 3, 4 sacral."

The application of interrupted vibration accomplishes much in the treatment of neuralgia. It acts not only directly but indirectly upon the nervous system as upon a special nerve as when it relaxes muscular contracture, thus relieving tension and removing pressure. Thereby the food supply of the nerve is increased, the blood pressure lowered and elimination increased. This fact has long been recognized, as noted by Snow in respect to "Physiological Action of the Various Static Modalities." "The action upon metabolism of vibratory influence has long been recognized by physiologists, such as that attributed to the heart's impulse."

Sciatica is a pathological condition of the sciatic nerve, manifested by pain, and is in many cases, or as believed by some authorities in all cases, associated with a local neuritis, either involving the nerve itself or the plexus. Starr, who treats of it as a neuralgia of the nerve, states that "in all cases in which an autopsy has been obtained an interstitial neuritis with congestion of the vessels, hemorrhages in the sheath and secondary degenerations of the nerve fibres have been found." Pain may occur in the whole or any part of the distribution of the nerve, but is generally most intense over the sacro-sciatic notch. Points of tenderness may also be found in some cases above the hip-joint, near the posterior iliac spine, middle of the thigh posteriorly, the back of the knee, and posterior to the external condyle of the ankle. When a neuritis has become chronic, perverted sensations as heat, cold, and numbness are noticeable. Starr believes that where there is pelvic pressure the pain is more likely to be peripheral in character.

It is absolutely necessary that a careful diagnosis be made from coxalgia in which pain usually first appears on the inner side of the knee and there is "a rigid position of adduction with slight rotation," lesions in the cauda equina where the trouble is almost always bilateral, and there is incontinence of fæces and urine; and sacral caries characterized by sacral tenderness, and pain on motion involving the pelvis.

Vibratory treatment of sciatica, applied directly to the nerve trunk, is efficacious, the pressure employed, however, should be light at first. Best results are obtained if interrupted vibration is applied superficially at first, to be followed later as the pain lessens by heavy vibration administered at the sacro-sciatic notch with the ball vibratode for the purpose of producing an inhibitory effect, i. e., in cases in which the lesion is at the notch, the most common site. Sometimes fæcal impaction causes pain in the sciatic nerve, in which case a rectal vibratory treatment and spinal treatment will afford complete relief.

Double sciatica, "with chronic muscular contractures," has been reported as successfully treated by Rochelle. He employed heavy vibration "over the 6th to the 12th dorsal and 5th lumbar nerves."

A case of recurrent sciatic neuritis has been reported cured by Jurin by heavy vibration over "the 7th, 8th and 12th dorsal and 5th lumbar nerves, with vibration of liver and spleen anteriorly."

The static wave-current and sparks are valuable in the treatment of sciatica, neuritis, and neuralgia, and may be advantageously combined with vibratory treatment.

Neuritis, local, disseminated, or general, is an inflammation of one nerve or several nerves. In some cases it is occasioned by the constitutional condition of the patient, when it often occurs as a peripheral neuritis. The pathology of neuritis may be divided into (1) parenchymatous, and (2) interstitial, in which the blood vessels and lymphatics are more extensively involved; (3) another form known as "segmental periaxillary neuritis," in which type the normal and degenerated segments alternate. This form occurs in senility, after diphtheria and the use of toxic agents as lead.

The time necessary to effect a cure will vary from a few days to twelve months, or even longer in some chronic cases.

In treating neuritis due to an injury it should be remembered that when a sensory nerve is affected, anæsthesia, thermo-anæsthesia or analgesia may be present, but the muscular sense is seldom lost. In cases in which septic infection is present the lightest touch of the sensitive area will elicit pain.

Some consider neuritis as a vaso-motor nerve disease, and believe that the relief and cure depend upon the correction of the blood supply to the affected part, which is probably only true in so far as any other inflammatory process might be so considered.

For the treatment of neuritis employ interrupted vibration, at first superficially, to be followed later by deeper pressure four or five times to each area which is the seat of pain, i. e., wherever the nerve is easily accessible. The interrupted impulse should be prolonged sufficiently to relieve the pain. The spinal region corresponding to the origin of the affected nerves should also be vibrated in the usual manner. In some cases an application of light vibratory friction to the affected area in addition to the above will be found desirable. The *modus operandi* of mechanical vibration scientifically applied in inflammatory processes is that it relieves local stasis and promotes absorption.

Hemiplegia is a paralysis of one-half of the body laterally and is classified with reference to the localization of the lesions and symptoms by Abrams as follows:

Symptoms.	*Seat of Lesion.*
"Hemiplegia with motor aphasia.	3rd left frontal convolution.
Hemiplegia with paralysis of lower facial branches.	Posterior limb of internal capsule.
Hemiplegia with hemianæsthesia.	Posterior third of internal capsule.
Hemiplegia with crossed paralysis of third cranial nerve.	Crus cerebri on same side as paralyzed nerve.
Hemiplegia with crossed facial paralysis.	Pons paralyzed."

From a therapeutic point of view we are most interested in the causative conditions, which are: (1) *Embolism;* occurring principally in young people, in which case the onset of the paralysis is usually sudden, without loss of consciousness, and usually associated with motor aphasia, and most often occurs in patients in whom a cardiac lesion is present. (2) *Apoplexy;* occurring usually after middle age, of sudden invasion "with loss of consciousness and usually associated with lower facial paralysis," and atheromatous arteries. White reports excellent results from the treatment of "a case of hemiplegia complicated with persistent insomnia." He applied the ball vibratode "in the interspaces between the transverse processes of the spinal column from the occiput to the last sacral vertebra" and a multiple point vibratode to the fingers and affected arm. Insomnia in this case was also relieved. The writer has noted improvement following a vibratory frictional treatment of the arm in a case where the arm had been affected.

Melancholia may be classified as (1) simple, (2) attonita associated with nutritional and circulatory disturbances with stupidity, and (3) agitated. The cause should if possible be removed and food, hygiene and environments be regulated. Vibratory treatment may also be advantageously applied,—spinal, local, or both, according to indication, sensitiveness, contractures, or other symptoms.

Locomotor ataxia, a disease of the spinal cord, is characterized by "lightning pains, absence of knee jerk, Argyl-Robertson pupil, marked inco-ordination with no loss of muscular power, diplopia, optic atrophy, impotency and unsteadiness on the feet when the eyes are closed." For treatment apply interrupted vibration with deep pressure over local painful spots; dysthesia or anæsthesia should be treated with frequently interrupted vibration applied with short stroke of the vibratode. The ordinary abdominal treatment with a multiple point or disc vibratode and rectal treatment should be employed for constipation. Treat conditions as they arise. Combine with the above vibratory treatment in the form of compressing interrupted vibration applied over the motor points of the affected muscles, particularly on the posterior aspect of the leg or a deep interrupted vibratory treatment of the segment of the cord controlling the affected muscles. A graded system of muscle exercise for muscle coordination is of great assistance to static treatment. See "System of Physiologic Therapeutics"—Cohen, Vol. VII, for exercises. Sometimes hydrotherapy as a "cold brief douche to the spine and to relaxed muscles" is a useful adjunct after the patient begins to improve. When possible the systematic employment of static electricity is invaluable in conjunction with vibration.

In **infantile spastic paralysis**, treat the rigid muscles with deep interrupted vibration, employing deep pressure. Apply also spinal tonic treatment daily for several weeks after which passive exercise should be combined with the vibration. Later the mechanical vibration should be followed by exercises consisting of "slow active movements, lying down; next like movements, sitting; practice in straight standing, at first supported, soon unhelped, co-ordinate movements, graduated from the simplest to the most complex."

Paralysis agitans, a functional nervous disease, characterized "by muscular weakness, tremors, and rigidity" may be treated by "passive over-extension of the limbs" vibratory friction, and lessening of the tension, which varies with different patients. Apply interrupted vibration with the ball as spinal treatment and vibrate painful areas. The best time for exercises of precision see Cohen's "System of Physiologic Therapeutics" in the treatment of the trouble should be guided by the tremors which may be less after massage or "passive over-extension." "Charcot thought very highly of treatment by vibration in this disease and used for it the shaking chair, as well as local vibrations,—manual or mechanical. The feeling of constraint, due to the muscular rigidity is relieved by this application, and its use is thought to bring about favorable alterations in the peripheral nerve-endings, by both reflex and direct stimulation."

Epilepsy, a functional nervous disease, is characterized by almost "abrupt loss of consciousness followed by tonic and clonic spasms ending in coma." The loss of consciousness may or may not be preceded by an "aura." The disease is either due to organic lesions of the brain associated with pressure or may be due to functional derangements. Spinal treatment with the ball vibratode and due attention to diet, hygiene and attention to any causes as gastric disturbance, adenoids or other sources of irritation is indicated. Also apply deep interrupted vibration with moderate pressure with a disc or multiple point vibratode over the solar plexus. In all cases a meat diet is prohibited.

Myxoedema is characterized by "hyperplasia of the connective tissue and mucoid infiltration of the cutis and surrounding organs. The thyroid gland also becomes atrophied, and it is probably upon the absence of the thyroid secretion that the condition depends." It has been successfully treated by the administration of general manual massage every other day. More recently thyroid extract has been used in connection with the treatment. General administration of mechanical vibration may be employed with great satisfaction.

Administer general spinal vibratory treatment for its tonic effect. Do not use heavy pressure. With the patient lying in the prone position apply deep vibratory friction to the soles of the feet from the heels to the toes six or seven times, interrupted vibration about the ankle, and vibratory friction to the posterior surface of the legs particularly. Follow this with interrupted vibration to the knees and vibratory friction to the thighs. After a short rest, with the patient lying on his back, apply vibratory friction anteriorly on the legs and thighs, thighs particularly, and interrupted vibration to the ankles, knees and inguinal glands. A vibratory treatment of abdomen, liver, spleen, and thyroid glands should follow, also of the face, tongue, hands, and arms if necessary.

Exercises adapted to the use of the particular group of muscles should be given daily. A daily cold sponge is advisable each morning if the patient reacts well. A static wave-current treatment over the stomach daily at first and hot air baths twice a week are indicated. Do not allow these patients to lead a sedentary life,—activity is necessary. Thyroid extract may be used in conjunction with vibratory treatment.

Goitre, enlargement of the thyroid gland, may be due to various causes and may be of various forms,—amyloid, anæmic (exopthalmic), aneurysmal, aqueous (cystic), calcareous, colloid, fibroid, follicular, menstrual and puerperal. Mechanical vibration will accomplish little or nothing for calcareous, or fibroid goitre but it is indicated in the other forms. Deep interrupted vibration should be applied to the spine with light and later moderate pressure, using the ball vibratode to affect the blood supply, especially in the interscapular region. Then use vibratory stroking and later friction of the neck anteriorly and at the side for its circulatory effect, avoiding the larynx and trachea. Then use a small vibratode to apply interrupted vibration directly to the goitre. Vibratory treatment of the axillary glands, liver and spleen should follow for the purpose of increasing their general functional activity. Vibration of the interscapular region will lessen tachycardia.

Hysteria is a functional neurosis characterized by lost control, either mental or physical or both, and marked by varying degrees of anæsthesia, hyperæsthesia, paralysis, contractions, or other perverted conditions. It is absolutely necessary in conjunction with vibratory treatment that moral restraint and control should dominate these patients. Tact, firmness and treatment of local conditions that are apt to influence the affection are of prime importance, calling for the careful investigation of every case. In addition in all cases give a vibratory spinal treatment with the ball for a general constitutional effect, and also treat paralyzed muscles and contractures locally, employing interrupted vibration with deep pressure. Apply vibination with exercise, static electricity, or some other point or rubber covered disc vibratode to the areas of anæsthesia.

In chorea, if the disease be in its acute stage, diet, rest, and vibration may be used. Later, when only light unimportant movements are made, vibration in connection with exercise is to be preferred, the treatments being twice daily of ten minutes each. The vibration should be prolonged with deep pressure to overcome spasms. Treat the motor points of affected muscles.

Vibration may be used more particularly in combination with exercise, static electricity, or some other measure to assist in obtaining the greatest degree of success in the treatment of many of the preceding conditions.

CHAPTER X.

RELATION OF VIBRATION TO THE DIGESTIVE SYSTEM.

The functions of digestion and assimilation are associated with physical (mechanical) and chemical processes, which under atonic or otherwise impaired conditions may be restored by the judicious employment of vibration, alone or in combination with indicated auxiliary measures.

Mechanical vibration is a valuable means for inducing the functional activity and correcting other derangements of digestion. The applications require skillful regulations and adaptations of speed, stroke, pressure, and time to the conditions present and to the patient's natural resistance.

Constitutional vibratory treatment, i. e., the spinal treatment, will produce a general sedative effect associated with a sense of buoyancy.

According to Landois and Stirling the salivary glands are supplied by the following nerves.

"1. The sympathetic nerves give branches (a) to the submaxillary and the sub-lingual glands derived from the plexus on external maxillary artery; (b) to the parotid gland from the carotid plexus." These nerve-fibres reach the gland along the arteries of the gland and are for the most part non-medullated nerve fibres. They can be traced to the superior cervical ganglion and from thence through the cervical sympathetic into the cord.

2. The facial nerve gives branches to the sub-maxillary and sub-lingual glands from the chorda tympani which accompanies the lingual branch of the fifth nerve. The branches of the parotid arise from the tympanic branch of the glossopharyngeal nerve (dog). "The tympanic plexus joins the otic ganglion, and this ganglion sends branches to the auriculo-temporal nerve (itself derived from the third branch of the trigeminus), which as it passes upwards to the temporal region under cover of the parotid, gives branches to this gland."

"The sub-maxillary ganglion, which gives off branches to the sub-maxillary and sub-lingual glands, receives fibres from the tympanico-lingual nerve (chorda-tympani) as well as sympathetic fibres from the plexus on the external maxillary artery."

If the sympathetic nerve which contains vaso-constrictor as well as secretory fibres be stimulated it causes a thick secretion in the sub-maxillary abounding in mucin, thereby increasing the normal specific gravity of the secretion. Contraction of the blood vessels and lessening of the rapidity of the venous circulation also result. It is probable that "the nerves exercise a direct effect upon the secretory cells, apart from their action on the blood vessels." Ludwig demonstrated that while secretion is active the rise in the temperature of the glands is 1.5° C., and according to Landois and Stirling, if glandular nerves be stimulated whether the stimulus be electric or other stimuli "of the peripheral end of a glandular nerve the following changes occur:

"(1) Vaso-motor changes, causing alterations in the blood supply and blood-flow.

(2) Chemical and histological changes in the gland-

cells connected with elaboration of the organic and possibly of the inorganic constituents of the saliva.

(3) Changes by which water is secreted, i. e., passes through the basement membrane and gland-cells, and the consequent movement of the fluid through the cells and ducts.

(4) Electrical changes which do not seem to be associated with the vaso-motor changes, for the electrical variations are readily abolished by atropin which does not affect the vaso-motor changes."

Stimulation of certain sensory nerves, as the sciatic, affects the parotid gland reflexly, causing secretion of the saliva (Owsjannikow and Tschierjew). When considering the effect of vibratory stimulation upon the glands it is well to mention the results of one of Colombo's experiments. He found that "the parotid gland did not respond so quickly as the salivary. Increased secretion occurred after 5 minutes' massage but 10 minutes were required for the maximum secretion." Much less time is required for the induction of a corresponding effect with mechanical vibration.

Mechanical vibration promotes to a marked degree the functional activity of the liver, stomach, and intestines—both promoting absorption and increasing peristaltic activity.

Hepatic activity may be induced (1) directly by applying over the liver interrupted vibration with moderate or deep pressure and medium stroke followed by vibratory friction; (2) indirectly or reflexly by the application of abdominal vibration or spinal stimulation.

Professor Colombo of Turin demonstrated in respect to biliary secretion that, "after ten minutes of trepidation (shaking or vibration) and of tapotement or percussion the quantity of bile increased considerably in the next four hours. The cholestrin and the biliary soda salts were most abundant. After twenty-five minutes of friction and of petrissage the same results were obtained as after ten minutes of trepidation and tapotement; the maximum result was obtained by combining ten minutes of trepidation and tapotement with ten minutes of friction and petrissage." These observations are of great interest and importance in vibration therapy as they well illustrate the relative effects of various modes of application in respect to time. Vibratory stimulation of biliary excretion assists in staying putrefaction, assists in the emulsification of fats, stimulates intestinal secretion and peristalsis, and acts as a natural purgative and intestinal antiseptic. According to Landois and Stirling, the effects of nerve stimulation on biliary secretion are as follows: "*All conditions which cause contraction* of the *abdominal blood-vessels*, e. g., stimulation of the ansa Vieussenii, of the inferior cervical ganglion, of the hepatic nerves, of the splanchnics, of the spinal cord, (either directly by strychnia, or reflexly through stimulation of sensory nerves), affect the secretion—*stimulation of the nerves around the hepatic artery* causes at first, an *acceleration*, and afterwards *slowing* of the *secretion*." The stimulation of the crural or sciatic suppresses the secretion. During secretion the blood vessels dilate." A more copious supply of blood to other organs, e. g., to the muscles of the trunk—during vigorous exercise, diminishes the secretion.

With the patient lying in a prone position, apply *interrupted vibration* with moderate pressure and medium stroke with a ball vibratode to the dorsal region of the spine. The vaso-motors of the bronchi are the 3d and

4th dorsal and thoracic ganglia. The vaso-constrictors of the portal system are the 3d, 4th, 5th, 6th, 7th, 8th, 9th, 10th, and 11th dorsal nerves, particularly the 5th, 6th, 7th, and 8th. When vibrating the liver posteriorly, apply vibratory friction outwards in the spaces between the ribs. After a short rest of a few minutes, in the first position, the patient should then lie upon his back and interrupted vibration with moderate pressure and medium stroke should be used over the liver anteriorly and the solar plexus with the flat rubber covered disc or multiple point vibratode. The speed necessary will depend on existing conditions. "One of the causes of the excretion of bile is the *interrupted periodic compression* of the liver from above by the diaphragm at every inspiration." "Stimulation of the spinal cord, from which the motor nerves of the larger bile ducts and gall-bladder pass, causes *acceleration of the out-flow,* which is afterwards followed by a diminished outflow. *Direct stimulation of the liver,* and reflex stimulation of the spinal cord *diminish the excretion.* By stimulation of the sympathetic at the lowest cervical and first thoracic ganglion, the hepatic vessels at the periphery of the liver lobules become contracted and pale (Cyon)." (See Landois and Stirling, pages 330 and 340). It must be remembered that mild treatments stimulate but strong or long continued exhaust or inhibit an action; therefore in vibratory applications proper discrimination must be observed. Vibratory treatment of the liver is serviceable in cases of torpidity.

Vibratory treatment applied to the extremities will geratly relieve œdematous conditions due to interference with circulation as in cirrhosis of the liver and nephritis. The writer employs for this purpose a multiple point or rubber covered disc vibratode with interrupted vibration over the inguinal glands followed by vibratory friction centripetally from the knee to the groin. To the knee joint apply deep interrupted vibration with deep pressure and medium stroke, after which apply vibratory friction from the ankle to the knee, followed by deep interrupted vibration with medium stroke at the ankle. Then apply vibratory friction to the foot and interrupted vibration on the sole of the foot under the instep. When giving the above treatment, the posterior as well as the anterior surface of the limb must be treated. Properly applied joint movements may be used with advantage to assist the process. Vibratory treatment of the liver is contra-indicated in cancer of the liver, in acute attacks of hepatic colic, in cases of acute gastro-duodenitis, and in hepatic abscess.

To apply vibration to the gall bladder employ deep vibratory friction following the border of the 12th rib on the right side towards the median line. Follow the line described four or five times across. The vibratode best suited for the purpose is the ball, which should be crowded up to where the lower edge of the liver can be located, the greatest pressure being made during forced inspiration. During the administration the abdominal muscles should be relaxed.

Contraction of the gall bladder and common bile-duct may be induced by applying vibratory stimulation to the posterior roots of the 9th and 10th dorsal nerves. The gall-bladder and the ureters "are the parts least excited by stimuli." If interrupted vibration is applied with pressure with a ball vibratode relaxation is induced.

When gall stones are present, however, **vibration is** sometimes contra-indicated and in any case if applied the greatest care must be observed. In order to *break up biliary calculi* which have become impacted, Professor Bartholow recommends "that firm friction be made with the fingers along the inferior margin of the ribs toward the epigastrium and umbilicus while the opposite side posteriorly is supported by the other hand spread out and firmly applied." Vibration can be so applied and vibratory *spinal* stimulation will also favor expulsion.

The cardiac end of the stomach is situated "just below the level of the junction of the 7th costal cartilage with the sternum," and the pylorus is "near the end of the cartilage of the 8th rib." Any stimulation affecting stomach secretion affects proteid digestion. The peristaltic action of the stomach is also affected by direct stimulation as massage or mechanical vibration.

Gastric secretion may be induced by stimulation,—mechanical, chemical, or thermal. Landois and Stirling consider the function to be a reflex one, the special center for which is probably located in Meissner's plexus. The same eminent authorities acknowledge that there are indications also that a connection exists "perhaps indirect between the central nervous system and the gastric glands." It was said by Pilgrim that stimulation of the glands can be produced by stimulating the vagi in the neck, but on this point authorities differ. Landois and Stirling state that "there is no nerve passing to the stomach whose stimulation causes a secretion of gastric juice as the chorda tympani does in the sub-maxillary glands," but Pawlow "found that direct stimulation of the vagus produced a flow of gastric juice."

The vagi and solar plexus furnish the nervous supply to the stomach. Landois and Stirling regard Auerbach's plexus as its motor center, the vagi conducting the impulses. "*Stimulation of the vagi in the neck causes contraction of the pylorus,* (and contraction of the stomach) when the latent period may be seven seconds. *Stimulation of the splanchnics* in the thorax *arrests* the spontaneous pyloric contractions, the left splanchnic being more active than the right (Oser)." Other fibres "pass from the spinal cord in the anterior roots of the nerves from the sixth to the twelfth dorsal, passing in the splanchnic nerves to the solar plexus, and thence to the stomach." If the splanchnics be stimulated, the muscular movements of the stomach cease, and the *sphincter of the pylorus relaxes* (Kirke) The *cardia may be opened reflexly by stimulation of the sensory abdominal nerves,* (e. g., of the kidney, uterus, intestine)." Landois and Stirling locate the center for the contraction of the stomach itself in the corpora quadrigemina, but "the efferent paths lie in the vagi, but chiefly in the cord, and from the latter emerge to the ganglia of the sympathetic. Inhibitory centers lie in the upper part of the cord, and the efferent paths are in the sympathetics and splanchnics." Pilgrim claims that stimulation of the fourth dorsal will open the pylorus.

Colombo demonstrated that after massage the quantity of fluid exuded from a "gastric fistula for two hours was more than double that which flowed through in the same time without massage. A massage (manual) of fifteen minutes gave the maximum secretion. If massage was applied for a longer time the mucus increased, the gastric juice was more diluted, hydrochloric acid and pepsin did not increase." No experiments have been made to demonstrate the same as true for mechanical vibration, but the probability is that the duration of vibratory treatment to obtain the maximum secretion would be found to be less than fifteen minutes.

Experiments have also been made demonstrating the effects of manual massage upon the stomach with salol which is not soluble in the stomach. Ewald and Eccles experimented and found, according to Graham, that "in most cases under natural conditions without massage, salol could be detected in the urine in forty-five minutes after its administration; but after massage upon the abdomen for fifteen minutes the reaction of salol was obtained in thirty minutes," and according to the same authority, Hopadzë "showed that abdominal massage hastened the food from the stomach from fifteen to seventy-five minutes."

Mechanical vibration applied to the stomach improves the general tone, increases motor and glandular activity, thereby aiding nutrition.

Vibratory treatment of the stomach should never be administered sooner than one and one-half hours after eating, and the bowels should be as nearly evacuated as possible, and the bladder emptied. Vibration should not be applied over the abdomen with so much force as to cause pain. If the patient be ticklish avoid too light vibration. If the abdomen be sticky from perspiration dust it with talcum powder before vibrating. The patient should breathe deeply enough during abdominal vibration to expand the lower half of the trunk. Vibration may be followed by visceral lifting, if advisable, for the purpose of restoring the viscera to their normal positions.

Visceral lifting, a plan followed by Kellogg, is accomplished as follows: The operator standing at the left side of the patient, his back being toward the face of the patient, places "the ulnar edge of the two hands, with the fingers extended, just over Poupart's ligaments and parallel with the ligaments, the fingers pointing toward the pubes. From this position the hands are moved slightly upward, the edge of the hands being made to sink as deeply into the adomen as possible without severe pain. The arms being slightly rotated at the same time, and the hands drawn upward in such a way as to grasp the contents of the abdomen and drag them upward." This should be done during inspiration. At the same time use inspiratory lifting, that is, the patient having expired the air from the lungs should "make the movement of inspiration by lifting the upper chest forcibly while keeping the glottis closed." Vibratory stroking should be applied around the umbilicus from the centre outward, in order to increase peristalsis and glandular activity while the patient lies with the shoulders slightly elevated and if possible the legs flexed and held in such a position that the legs will be at right angles to the thigh.

Then standing at the patient's right begin to make the application on the left side of a line with the umbilicus laterally, and apply deep vibratory friction with a multiple point or flat rubber covered disc vibratode proceeding upward beneath the ribs on that side of the episgastrium. Support the stomach with the left hand and again vibrate upward. In this manner vibrate the stomach beneath the ribs on the opposite side particularly if it is sought to assist digestion. Also apply interrupted vibration with moderate or deep pressure and medium stroke, employing a multiple point or rubber covered disc vibratode. The application should be made during prolonged, forced inspiration, making the application over the stomach, solar plexus, and lumbar ganglia. Spinal stimulation should also be administered when indicated. Stimulation of the splanchnics through the 6th, 7th, 8th, 9th, 10th, and 11th dorsal nerves dilates a contracted stomach and relaxes the pylorus while stimulation of the vagus causes contraction.

Vibration applied for relief of dilatation of the stomach should be administered as follows: A multiple point or rubber covered disc vibratode with medium stroke should be applied over the stomach as in manual massage, the application being made chiefly from the left side upward and inward under the false rib (Graham). It is well in these cases to vibrate the abdomen at the same time. A vibratory massage of the stomach is thus given and the indication for additional spinal stimulation will depend upon the conditions of the case, it being of undoubted value in cases of *atony* and *neurasthenia*. The vagi should be stimulated to cause contraction. Dr. F. H. Morse of Boston reports the cure of an interesting case of chronic dilatation of the stomach preceded by chronic gastritis of five years' duration. "Treatment was given deeply (with ball) over the entire dorsal region, and the brush (multiple point vibratode) was applied to the vagi and epigastrium and abdomen." Treatment was given twice weekly for four weeks and then once a week for six weeks. The question remains whether spinal stimulation was necessary.

Vomiting is a reflex act induced by afferent and efferent stimuli which must be considered in connection with treatment. The "afferent impulses may be discharged from (1) the mucous membrane of the soft palate, pharynx, not of the tongue (glosso-pharyngeal nerve) as in tickling the fauces with the finger, (2) the nerves of the stomach (vagus and sympathetic), (3) stimulation of the uterine nerves (pregnancy), (4) the mesenteric nerve (inflammation of the abdomen and hernia), (5) nerves of the urinary apparatus (passing a renal calculus), (6) nerves of the liver and gall duct (vagus), (7) nerves to the lungs in phthisis (vagus).

The efferent impulses are carried by the phrenic (diaphragm) vagus (œsophagus and stomach), and intercostal nerves (abdominal muscles)" (Landois and Stirling). Dr. W. E. Green of Arkansas reports the cure of a case of persistent vomiting following two operations for its cure. The ball vibratode was used on alternate days for deep interrupted vibration "in the interspaces over the transverse processes of the third and fourth dorsal nerves, and throughout the splanchnic region." There was present at first a pyloric stricture. An inhibitory treatment is necessary.

The pancreas is situated behind "the linea alba, about two or three inches above the umbilicus." The nerves which supply it are "from the semilunar ganglion," one of the chief ganglia forming the solar plexus, and it is known that they "pass to the acini." If the "central end of the vagus or certain sensory nerves, as the crural or sciatic, be stimulated suppression of the normal (pancreatic) secretions results." The vaso-constrictors of the pancreas are from the fifth dorsal to the second lumbar. The vaso-dilators are said to be mostly in the vagus. Direct stimulation of the gland itself by induction shocks stimulates or excites secretion. Mechanical vibration applied over the gland should produce practically the same result. A multiple point or rubber covered disc vibratode should be selected and vibration applied to increase secretion, interrupted vibration being indicated when treating the gland itself.

The spleen is situated "beneath the 9th, 10th, and 11th ribs, between the axillary lines—lines drawn vertically downward from the anterior and posterior margins of the axilla. Its upper edge is on a level with the spine of the 9th dorsal vertebra and its lower with the spine of the 11th." Stimulation of (1) the central end of the sensory nerve; (2) of the peripheral ends of both splanchnics; (3) of the peripheral ends of both vagi, causes contraction of the spleen, as does also stimulation of the spleen itself by cold, electricity, or possibly direct application of vibration.

For the treatment of splenic congestion deep vibratory friction should be administered over the side of the gland with a multiple point or flat disc vibratode supplemented by interrupted vibration with the same vibratode.

Consideration of the subject of vibratory treatment of constipation calls for attention to a few preliminary details:

(1) It is essential that the bladder be emptied before beginning the treatment. (2) If the skin lacks firmness sponge it gently and quickly with tepid water not cool enough to shock the system before vibration. (3) If the skin is sticky owing to excessive perspiration dust a little talcum powder over it. (4) Heat applied dry or moist to a hyper-sensitive abdomen before vibratory treatment will add materially to the re-

sult. (5) An enema of warm water and soap suds preceding the vibratory treatment assists in obstinate cases of constipation. (6) Related abdominal muscles necessitating particular attention to position and deep and regular breathing are also essentials. The treatment should be conducted with due care in order to avoid contractions or pain, and during the external treatment the pressure should be graduated because of the likelihood of the induction of unpleasant effects, such as coldness, pain and a feeling of depression instead of exhilaration. As habit has a marked influence over constipation it is essential that the patient be trained to elect a particular time for going to stool, and sit for twenty minutes if necessary, always abstaining from exertion or straining. If the desire comes on during the day, ignore it if possible until the next day at the *stated* period and thus begin to establish a regularity.

Certain exercises advocated by Dr. Watson L. Savage, as the liver squeeze, flexion of the knees on the chest, describing a circle with the legs in apposition, knees being not flexed, and others executed with the patient lying on a hard surface or table, and untrammeled by corsets, skirts, etc., are useful adjuncts in some obstinate cases. These should be done before breakfast, after drinking a glass of water. Contra-indications for vibration treatment are "cancer or ulcer, acute or febrile states, and suspicion of a tendency to hemorrhage."

Vibratory treatment of the bowels may or may not be preceded by inspiratory lifting, the patient breathing deeply and lying with shoulders slightly elevated, the legs being flexed and held up. Inspiratory lifting is accomplished by "first emptying the lungs and then making the movement of inspiration by lifting the upper chest forcibly while keeping the glottis closed." While this is being done lift the contents of the abdomen as described relative to the stomach. The use of these preliminary measures must be left to the judgement of the operator. In the majority of cases they are not indicated. It is advisable to vibrate the spinal center of defecation, using a ball vibratode, medium stroke and moderate pressure. It is claimed by some that the defecation centers are under control of the sacral nerves and by others that the lumbar nerves govern defecation.

In treating the abdomen apply *compressing or long vibratory friction*, employing the multiple point or flat disc vibratode using a medium stroke, for the purpose of relieving intestinal stasis and to assist in dislodging faeces as well as acting upon the vascular system. Begin so as to make pressure on the caecum, and then follow the line of the colon three or four times, then in the same manner over the transverse colon from right to left, followed by vibratory friction from beneath the ribs on the left median line downward and slightly inward following the colon. It is sometimes necessary if there be a large quantity of faeces present, to empty the lower part of the bowel before treatment. In that event commence on the left side a short distance from where the former procedure stopped. Use vibratory friction downward and inward six or seven times, then begin higher up and proceed from beneath the ribs downward and inward to the point of termination. Then vibrate the transverse colon, working from left to right, gradually lengthening the line of advance as you approach and pass the median line. Then begin on the right of the median line and apply vibratory friction in the manner described in the preceding description, using deep pres-

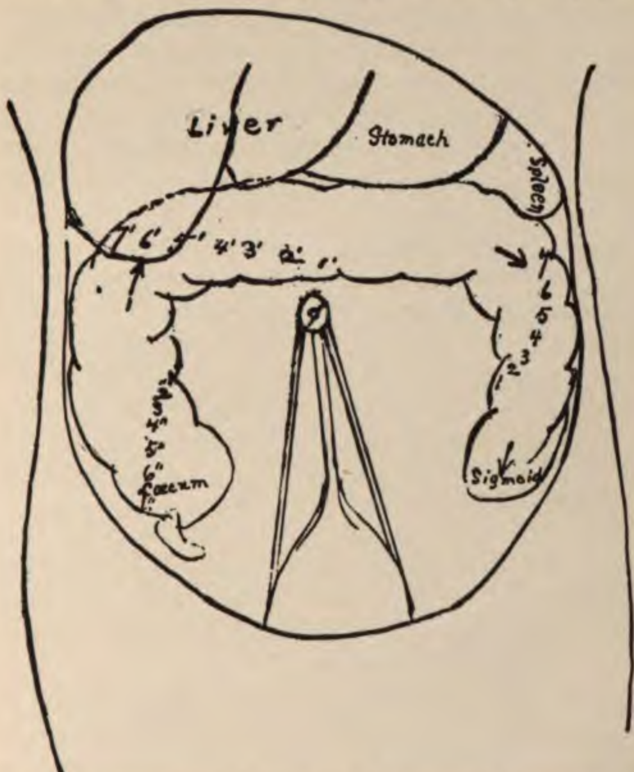

Fig. 51.—Diagrammatic illustration of abdominal vibration. The figures show the starting place and the arrows the end of each line of advance. The first line is from one to the sigmoid, and the last from the cæcum to the transverse colon. The treatment is finished by an abdominal vibratory massage with a ball vibratode, or cap shield of some machines, from the cæcum to the sigmoid like cannon-ball massage.

sure and moving upward six or seven times, gradually lengthening the line of advance. Then extend the vibration lower and lower until the cæcum has been thoroughly vibrated. Finish by a deep circular friction from right to left a few times, using a ball vibratode or the cap shield of some vibrators. The speed should be slow, because parts containing unstriped fibres after being stimulated react "for a long time after the stimulus is withdrawn." But few applications are necessary, for the small and large intestines are easily excited, requiring "no more stimulus than that of the air to excite them." The second method is preferable, for the vibratherapeutist seldom is called upon to treat mild cases. This should be followed by a rectal treatment described below. The following refers to the spinal treatment of the bowels. From the sixth to the twelfth dorsal inclusive controls inhibition of the small intestine, and the 2d, 3rd, 4th, 5th lumbar, and the 1st, 2d, and 3rd sacral govern inhibition for the large intestine.

In a Thiry-Velly fistula, Fubini estimated the rate of motion of a smooth sphere of sealing-wax along the intestine. It took 55 seconds to travel 1 cm. (2-5 of an inch); an induction current greatly increased the motion, to 1 cm. in 10 seconds.

In treating constipation due regard must be given to causes, whether there exists an obstruction due to stricture, intussusception or other condition, or whether it is caused by dryness of the fæces from taking too little fluid, diminished secretion of bile, irregular habit of going to stool, an excess of secretion in other parts, or disturbances of muscular or nerve functions caused by various pathological conditions. If due to lack of bile the liver and gall duct should be vibrated. In many cases a diet of triscuit, shredded wheat biscuit, home-made Graham bread, carrots, white turnips, spinach, lettuce, string beans, celery, stewed fruits, canned plums, peaches, or pears with thin syrup, fresh apples, or grape-fruit with farina, cracked wheat or oatmeal once a day, is necessary. No tea, coffee or milk should be allowed. A small baked sweet potato with the jacket on, which is to be thoroughly masticated, is allowed occasionally. Hot water at meals and a copious drinking of water, twelve to fifteen glasses per day, is advised. Meats, sweets and starches are to be prohibited. In some cases where such a diet would be too restricted for a person doing much work, meat broiled or roasted may be allowed once daily, unless the case is very obstinate.

Landois and Stirling state that "the strong peristalsis which precedes defecation can be aided, and to a certain degree excited, by rapid voluntary movements of the external sphincter and levator ani, whereby the *plexus myentericus* of the large intestine is stimulated mechanically, thus causing lively peristaltic movements in the large intestine;" these movements may also be excited by the action of mechanical vibration by the employment of an internal rectal vibratode (see Fig. 29) for from three to five minutes, using a moderate rate of speed and shortest stroke, which procedure should follow the abdominal vibration. The rectal vibratode should be well lubricated and introduced while in motion to avoid shock; great care must be taken, however, not to over stimulate the intestine lest dysperistalsis be induced, for "all stimuli applied to the plexus myentericus increase the peristalsis, which may become so very violent as to cause evacuation of the contents of the large gut, and may even produce spasmodic contraction of the musculature of the intestines." In very obstinate cases a flexible rubber vibratode 12 or 15 inches long (see Fig. 30) is of service; duration of this treatment should be about three minutes, a moderate rate of speed and the shortest stroke being employed. If the stimuli be strong and continued, over stimulation or exhaustion, otherwise termed "intestinal paresis," takes place, that is, "continued congestion of the intestinal blood-vessels ultimately causes intestinal paralysis."

If the vagus be stimulated, "the movements of the small intestine are increased." (Braam-Houckgeest). But Landois and Stirling state that stimulation of the vagi has no apparent effect on intestinal secretion.

The inhibitory nerve of the small intestine is the splanchnic while the capillaries contain aterial blood; when this changes the splanchnics are stimulated and peristalsis is increased. Stimulation of the splanchnics in "the dorsal region (under the same conditions), and even when general tetanus has been produced by the administration of strychnia, causes an inhibitory effect." The splanchnic supplies motor and vaso-motor nerves to the blood-vessels of the intestine, and also sensory fibres. Van Braam-Houckgeest says that "the intestine stops moving before the blood vessels contract, so it would therefore seem that the stimulation diminishes the excitability of the plexus myentericus." If the *nervi erigentes* be stimulated, contraction of the longitudinal rectal fibres occurs, and inhibits the action of the circular fibres, even when the hypo-gastric nerves are stimulated by which they are supplied, and whose stimulation has "an inhibitory effect on the longitudinal muscles." (Fellner). The

PLATE VIII. RECTAL TREATMENT.

vaso-constrictors of the jejunum are said to be governed by the fifth dorsal.

In the treatment of diarrhoea abdominal vibratory treatment followed by a general vibratory treatment should be given shortly following the meal if the fæces contain food that has not been digested. If dilatation of the stomach be present, causing retention of food, then the stomach should be vibrated. Chronic diarrhœa is sometimes due to irritation from retained fæces. In these cases give a high enema and follow with rectal vibratory treatment or static electricity in the form of the rectal administration of the wave-current to tone up the parts. In some cases inhibitory spinal stimulation is indicated.

Vibration of the abdomen has a curative effect on constipation, assists digestion by increasing the functional activity of the pancreas, liver and stomach, promotes muscular nutrition, increases absorption, and renal elimination, strengthens the muscles of the abdomen, and increases nervous and circulatory activity, and slows the pulse rate. In some cases of *colitis,* accompanied by constipation, diet the patient as above described, and treat as for constipation. High rectal injections of oil and iodoform once or twice a week are beneficial. When the injection is not given use the long rectal vibratode. Give exercises to strengthen the abdominal muscles.

The kidneys are situated "opposite the two lower dorsal and two upper lumbar spines;" the right one because of the liver is about "three-fourths of an inch lower than the left."

The nerve supply of the kidney is from the lesser splanchnics and the renal plexus, which is derived principally from the solar plexus. It is also known that the left vagus sends "fibres to the left kidney." The nerves contain vaso-dilator, vaso-constrictor and sensory fibres. Cl. Bernard and Eckhard claim that *stimulation of the splanchnics*, whose "renal vaso-motor fibres, which, in part at least, leave the spinal cord at the *first* dorsal nerve and pass into the sympathetic nerve," causes *polyuria*. Stimulation of the "spinal cord below the medulla oblongata increase polyuria." "Section of the renal nerves," as the contraction of the blood-vessels throughout the body, still further raises the blood pressure within the glomeruli. If the cord below the medulla oblongata be stimulated arterial contraction occurs, stopping the secretions. The vaso-constrictor nerves respond to electrical stimulation when rapid and of short duration. "Vaso-dilator fibres are best excited by slow rhythmical stimulation (2-5 shocks per sec.). The vaso-dilators of the kidney are most numerous in the 11th, 12th, and 13th dorsal." (dog.)

If the *kidney is displaced* Kellogg's method of replacement is recommended. After making movements to replace the stomach and bowels, the operator proceeds as follows for the right kidney. (The same is true for the left kidney and spleen, only "the fingers of the right hand" are placed behind). "Standing upon the right side of the patient the fingers of the left hand are placed behind, while those of the right hand are placed upon the abdomen; and by movements of the two hands the location of the kidneys is determined. While gently pressing the kidneys upward, the patient is asked to take repeated deep breaths. With each exhalation an effort is made to press the kidney up under the ribs of the right side by gentle pressure. As it moves upward and approaches its position, the right hand is shut and the closed fist is made to follow the kidney and hold it in position while the patient takes a number of deep respirations." This should be followed by abdominal vibratory friction for toning the relaxed abdominal muscles and also to increase the production of urine by accelerating the functional activity of the kidneys and elimination of excretions of "waste products, chiefly nitrogenous bodies and salts," the excretion of water and perhaps even the reabsorption of "water from the uriniferous tubules." The *amount* of urine excreted depends *upon the differences of pressure* between the blood in the glomeruli and the pressure within the renal tubules." According to Landois and Stirling, "Increase of the total contents of the vascular system so as to increase the blood pressure, or diminution of the capacity of the vascular system, provided the pressure within the renal area be thereby increased," which latter may be caused by stimulation of the vasomotor center, or "increased action of the heart," increases the quantity of "water which filters through the glomeruli," the fullness of the renal artery governing the amount of urinary secretion. The blood's composition also affects it slightly.

The Brandt method, as used by Dr. W. S. Bagot of Dublin, for treating *incontinence* might be applied with vibration. As given by Graham it is as follows: "He introduces the index-finger of the left hand into the vagina (the rectum in children), slightly flexed and passed obliquely so as to partially encircle the neck of the bladder. The right hand grasps the wrist so as to regulate the pressure used, and then the finger in the vagina or rectum is made to vibrate against the neck of the bladder, compressing it with moderate force against the pubes. This is done three or four times, and then the opposite side of the bladder is treated in the same way with the index-finger of the right hand." Compressing interrupted vibration applied with proper technique should accomplish the same purpose as the finger. Vibration may also be employed to relieve œdema when present in cases of renal trouble; the effect, however, is only palliative. In certain conditions, especially inflammation of the kidneys, it must be applied with the utmost caution in order not to overstimulate the organs.

The treatment of diabetes mellitus demands the recognition of various conditions. Dr. Kellogg states after speaking of Zimmer's showings that "vigorous muscles, even when at rest, destroy more sugar than do feeble ones" and that "Bourchard also has shown that exercise of the muscles increases the consumption of sugar, and thus diminishes the amount of sugar found in the urine in cases of diabetes."

A general vibratory treatment, or even in some cases of enlarged abdomen, an abdominal treatment, following a quick walk of a certain length which had been preceded by Winternitz's method of hydrotherapy,—"a cold sponge, followed by a steam bath, this in turn succeeded by a cold plunge or shower," is useful in *obesity*, due regard being given to properly graduated exercise and diet. Special attention must be given to the heart's action. Another method of treating obesity which has been most successfully tried by Dr. Clem C. Greene, of Atlanta, is to follow a deep vibratory treatment with an arc-light or hot air bath.

Morphine habit and alcoholism and other drug habits in connection with moral restraints may be successfully treated by mechanical vibration, either by em-

PLATE IX. APPLICATION OF ABDOMINAL VIBRATION.

ploying Dr. Pilgrim's method of "mesenteric flushing" as described in Chapter III, or by administering the abdominal and intestinal treatment described in the preceding pages. *For the insomnia* and restlessness, a general vibratory treatment is indicated.

In the cocain habit peripheral circulation must be strengthened, and in *alcoholism* the vibration must be directed to the strengthening of the feeble heart as well. (See chapter on circulation.)

The application of vibration therapy to the pelvis is indicated for the treatment of contracted muscles which should be treated as muscular contractions of other parts of the body as well as applications to the other organs and structures including the rectum, the vagina, uterus, ovaries of the female, and male genital organs.

The motor fibres of the uterus are supplied "from the sympathetic chain,—chiefly from the fourth to the sixth lumbar ganglia." If the hypo-gastric plexus whose fibres come from the "last dorsal and upper 3 or 4 lumbar nerves, run into the sympathetic and then reach the hypo-gastric plexus" (Frankenhauser), be stimulated uterine contraction follows. If the nervi erigentes be stimulated, movement results (v. Basch and Hofmann). The uterus may be made to contract reflexly by stimulating the central end of the sciatic.

The pelvic plexus supplying the rectum, bladder, prostate, vagina and uterus, according to Gray, is formed "by branches from the 2d, 3d, and 4th sacral nerves and by a few filaments from the first two sacral ganglia." Vaso-constrictors of the internal generative organs are from the 2d, 3d, 4th, and 5th lumbar nerves.

Vibratory treatment of the pelvic organs is valuable in *amenorrhea, dysmenorrhea, menorrhagia, inflammatory exudates, endometritis, metritis, oöphoritis, rectocele, cystocele, rectal prolapse, certain prostatic conditions* and *coccygodinia.* In the administration of treatment to the pelvic organs the patient should lie on the back, knees being drawn up, and separated, hips slightly raised, and a small pillow should be placed beneath the head if the end of the table upon which the head rests is not slightly elevated.

Preliminary movements or exercise as (1) "deep breathing, (2) lifting abdominal contents, (3) inspiratory lifting as before described," may be employed to assist in relieving pelvic displacements if desired.

If exercises do not precede, the bowels and bladder having been evacuated, administer vibration as follows: First apply a ball vibratode to the region of the spine indicated and then apply a multiple point or rubber covered flat disc vibratode over the abdomen over and above the pubes, applying compressing interrupted vibration with short stroke, the speed being varied to suit the condition under treatment. Deep regular breathing greatly facilitates the action, for the parts cannot then remain contracted. The abdominal treatment should be followed by a short application of either a vaginal or rectal vibratode during which place the right hand over the abdomen, for the purpose of increasing the resistance. In cases of *atony, subinvolution, relaxation* or *passive congestion,* where increased circulatory activity is necessary, also apply interrupted vibration either through the vagina over the hypo-gastric plexus, on the anterior aspect of the sacrum, or in the spinal region; in the latter instance employ a round ball spinal vibratode. The *ganglion impar* is located anterior to the coccyx. Com-

pressing interrupted vibration is contra-indicated in active congestion. If hyperæsthesia exists use the shortest stroke and a rapid vibratory frequency of the machine.

It may be necessary that the above treatment be followed by vibration of the lower abdominal muscles and inner part of the thighs, first applying vibratory friction centripetally, followed by vibratory stroking.

Mechanical vibration is contra-indicated in pyosalpinx, tumors, and plevic abcess.

Vibratory treatment of the vagina is indicated in **rectocele, cystocele, relaxed walls** and **vaginismus.** If there be general relaxation or prolapsus lift the abdominal organs, uterus and bowels, and then vibrate the vagina either per vagina or from the rectum, using the vaginal or rectal vibratode, and apply interrupted vibration over the perineum to increase circulatory activity and produce dilatation of the blood vessels, thereby imparting warmth and promoting nutrition. The treatment should not be continued for more than four or five minutes.

The application of spinal treatment over the sacrum will vary with indications and must be left to the discretion of the operator. The perineal treatments may be supplemented by stretching the tissue outward "from the median line" with the thumbs, "the fingers resting upon the buttocks."

Enlarged prostate and **prostatitis** are best treated by preceding the local treatment by abdominal vibration. In respect to spinal treatment it is well to note that the visceral afferent fibres of the prostate are governed by the 10th, 11th, 12th thoracic and the 1st, 2d, and 3d sacral. Locally introduce a rectal or a specially constructed previously lubricated soft rubber vibratode while in motion into the rectum. Treatment should be for from three to five minutes. As with all pelvic administrations the bladder and bowels should be evacuated before treatment. This method is of no avail in the treatment of chronic enlargement with hyperplasia. It "accelerates the function of the glandular epithelium," and causes a "more abundant afflux of blood, which favors filtration."

Schmidt believes that the cases of chronic prostatis that are most benefited are "(1) where mental condition is influenced by prostatic results; (2) where there are small inflammatory foci; (3) isthmical inflammations combined with old infiltrations in the prostatic urethra; (4) simple sexual exhaustion."

Bubo, following specific urethritis, has been successfully treated by Dr. Fechner of New York, in which cases "application by deep pressure was made over the 8th and 12th dorsal and 5th lumbar spinal nerves, and to the inguinal glands."

For the treatment of the *coccyx* introduce the rectal vibratode into the rectum a short distance, the left hand being placed over the coccyx, the patient lying on her right side with knees drawn up. Use compressing interrupted vibration if the coccyx is bent inward, great care being taken to avoid causing pain. If the parts are sensitive very light pressure if any should be used at first and pressure should be gradually increased.

Vibratory treatment of the rectum with the rectal vibratode for five minutes, employing the shortest stroke, will tone up the parts and relax spasm of the sphincters. Spinal stimulation may or may not be necessary. In the treatment of *hemorrhoids* vibration lessens pelvic congestion, and stimulates the venous circulation. Apply a prolonged rectal treatment for inhibition. In the treatment of pelvic conditions vibration can be employed to advantage in connection with electricity, hydrotherapy, or exercise acording to indications.

TABLES USEFUL IN MECHANICAL VIBRATORY TREATMENT.

For the treatment of some conditions, especially those of a spasmodic nature, the following relative to motor points of nerves from Mosher's "Electro-Diagnosis" and the action of groups of muscles, with their origin, insertion, and nerve supply based on Dunglison's Medical Dictionary, Gray's Anatomy, and Gould's Medical Dictionary, is appended. For the motor points of individual muscles see Mosher's "Electro-Diagnosis."

Nerve.	Action.	Motor Points of Nerves.
"Fifth nerve	Elevation and forward and lateral movements of the lower jaw.	In the sigmoid notch of the lower jaw, just below the zygoma for the masseter muscle. In a perpendicular line through the zygoma a finger-breadth within the border of the hair.
Seventh nerve	Drawing of the face to the stimulated side and closing of the eyelid. The frontalis and corrugator supercilii often contract very weakly or not at all.	1. In the angle between the mastoid process and the ramus of the lower jaw. 2. In the depression just above the tragus. (Not constant.)
Upper branch of seventh.	Wrinkling of the forehead and eyebrow, and closing of the eyelids.	At the outer end of the superciliary ridge.
Middle branch of seventh	Expression of laughing, wrinkling of the nose and of the upper lip, or pouting of the lips.	At the junction with the zygoma of a perpendicular line dropped from the outer angle of the orbit.
Lower branch of seventh.	Elevation of chin, pouting of the under lip, and retraction of the mouth downward and outward.	At the border of the lower jaw just back of the groove for the facial artery.

Nerve.	Action.	Motor Points of Nerves.
Eleventh nerve	Extension of the head, and elevation and rotation of the chin toward the opposite side.	About two finger-breadths below the upper angle of the posterior cervical triangle, near the trapezius.
Twelfth nerve	Movements of the tongue.	Close behind and above the hyoid bone.
Cervical nerves—external branches of posterior division.	Drawing the head backward and downward.	Over the belly of the muscle close under the mastoid process for the splenius capitis.
Phrenic	Ballooning of the epigastrium and a noisy rush of air into the air passages.	Behind the edge of the sterno-cleido mastoid, between the upper and middle thirds, sometimes farther below (push vibratode beneath the muscle).
Brachial plexus	Depending on the point, usually the distribution of the median and circumflex; flexion of the hand and fingers; elevation of the arm from the thorax, etc.	Mainly in the whole lower and inner third of the supra clavicular fossa; parts also may be easily stimulated outward therefrom.
Dorsalis scapulæ nerve (3, 4, 5 c. nerves)	Elevation of shoulder-blade with retraction toward spinal column.	In the middle line of posterior cervical triangle, three finger-breadths above the clavicle.
Posterior or long thoracic.	Movement of the shoulder-blade outward and forward; or, visible contraction of the digitations of the serratus magnus.	Close above the clavicle in front of the edge of the trapezius.
Anterior thoracic nerves	Adduction of the arm to the thorax.	1. Close above and behind the clavicle, near the outer border of the sterno-cleido - mastoid. 2. Just below the clavicle at the upper border of the pectoralis major.
Erb's supraclavicular point.	Backward elevation of the arm from the thorax, and strong flexion at the elbow in position of pronation.	Two finger-breadths above the clavicle, and one finger-breadth behind the border of the sterno-cleido mastoid.
Circumflex nerve	Elevation of the arm backward from the thorax.	In the middle line of the posterior cervical triangle, two finger-breadths above the clavicle.

Nerve.	Action.	Motor Points of Nerves.
Musculo-cutaneous nerve	Flexion of the forearm	Two finger-breadths below the anterior axillary fold, at the inner border of the biceps.
Median and ulnar nerve	....	Throughout the groove at the inner side of the biceps muscle.
Median nerve	Pronation of the forearm, flexion and abduction of the hand, opposition and flexion of the thumb, flexion of the second and third phalanges of the fingers.	(1) In the middle of the elbow joint, usually directly outside of the biceps tendon. (2) In the middle of the wrist joint, between the tendons of the flexor carpi radialis and palmaris longus, or at the ulnar border of the latter.
Ulnar nerve	Ulnar flexion of the hand and the first phalanges of the fingers; abduction of the thumb.	(1) Between the inner condyle and the olecranon, about one finger-breadth above the condyle. (2) On the ulnar side of the forearm a little above the wrist.
Musculo-spiral nerve.....	Extension of forearm, hand and fingers with supination.	Slightly outside the point between the external condyle and the insertion of the deltoid.
Upper intercostal nerves	Movements of the ribs.	On the upper borders of the intercostal spaces.
Lower intercostal nerves	Retraction of the abdomen.	
Obturator nerve	Abduction of thigh.	At the outer end of the horizontal ramus of the pubis.
Anterior crural nerve....	Extension of the leg.	(1) Above and behind the middle of Poupart's ligament. (2) In Scarpa's triangles just outside the femoral.
Superior gluteal nerve...	Extension of hip and abduction of thigh.	Between the trochanter major and the crest of the ilium for the gluteus medius.
Small sciatic nerve......	Extension, abduction and rotation of thigh outward; elevation and adduction of buttock.	Several points over the belly of the muscles for the gluteus maximus.
Great sciatic nerve......	Flexion of the leg and plantar flexion of the foot.	Midway between the trochanter major and the tuberosity of the ischium in the gluteo-femoral crease, or just below it.

Nerve.	Action.	Motor Points of Nerves.
Internal popliteal (tibial) nerve.	Flexion and wrinkling of the skin of the sole, and plantar flexion of the toes. The wrinkling of the skin of the sole is particularly characteristic.	1. Just above the middle of the popliteal space. 2. Between the internal malleolus and the tendon of Achilles.
External popliteal (peroneal) nerve.	Dorsal flexion of the foot and extension of the toes.	At the outer angle of the popliteal space close to the inner border of the tendon of the biceps.

ACTION OF GROUPS OF MUSCLES, THEIR ORIGIN, INSERTION, AND NERVE SUPPLY.

HEAD.

Head moved forward by

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Platysma myoides	Clavicle, acromion and fascia covering upper part of pectoral, deltoid and trapezius muscles.	Inf. maxil., angle of mouth, cellular tissue of face.	Facial and superficial branches of the cervical plexus.
Sterno-cleido-mastoid	Two heads, sternum and clavicle.	Mastoid process of temporal bone, and outer 2-3 of sup. curved line of occiput.	Sp. accessory, and deep branches of cervical plexus.
Rectus capitis anticus major.	Transverse processes of 3d to 6th cervical inclusive.	Basilar process of occiput...	Sub. occipital and deep internal branches of cervical plexus.
Rectus capitis anticus minor.	Root of trans. process and lateral mass of atlas.	Basilar process of occipital bone.	Sub. occipital and deep internal branches of cervical plexus.
When the lower jaw is fixed the movement of the head forward is assisted by			
Mylo-hyoid	Mylo-hyoid ridge of inferior maxillary.	Body of hyoid and raphé...	Inf. dental.
Genio-hyoid	Inf. genial tubercle on inner side of symphysis of jaw.	Ant. surface of body of hyoid	Hypo-glossal.
Genio-hyo-glossus	Superior genial tubercle on inner side of symphysis of jaw.	Body of hyoid bone a few fibres being continued to side of pharynx, under surface of tongue.	Hypo-glossal (12th cranial).
Digastric: Anterior Belly....	Inner surface inferior maxillary near symphysis.	A central tendon held in connection with hyoid bone by a fibrous loop.	(Ant.) Inf. Dental.
Digastric: Posterior Belly...	Digastric groove of mastoid process.	Supra-hyoid aponeurosis is attached to body and great cornu of hyoid bone.	(Post.) Facial.

Head moved backward by			
Part of trapezius...........	Superior curved line of occiput, spinous processes of 7th cervical and all dorsal, lig. nuchæ, and supraspinous ligament.	Clavicle, and crest of spine of scap., and acromion and tubercle of scapula.	Spinal accessory and branches from anterior divisions of 3d and 4th cervical nerves.
Splenius capitis	Half of lig. nuchæ, and spines of 6 upper dorsal and last cervical vertebræ and supraspinous ligament.	(Splen. cap.) Into occiput and mastoid process of temporal bone. (Splen. colli.) Into trans. process. of 3 or 4 upper cervical vertebræ.	Ext. branches of post. divisions of cervical nerves.
Complexus	Transverse process of 7th cervical and 3 upper dorsal, and articular process of 4th, 5th and 6th cervical.	Occipital bone	Sub.-occip., great occip., and internal branches of post. divisions of cervical nerves.
Trachelo-mastoid	Transverse process of 3d, 4th, 5th and 6th dorsal and articular process of 3 or 4 lower cervical.	Mastoid process	Ext. branches of post. divisions of cervical nerves.
Rectus capitis posticus major	Spine of axis..............	Inf. curved line of occiput and surface of bone below it.	Sub-occipital.
Rectus capitis posticus minor	Post. arch of atlas.........	Rough surface beneath inf. curved line of occip. bone nearly as far as foramen magnum.	Sub-occipital.
Oliquus capitis superior.....	Transverse process atlas....	Occipital bone between the two curved lines external to the Complexus.	Sub-occipital.
Head moved to either side by			
Platysma myoides	Clavicle, acromion, and fascia covering upper part of pectoral, deltoid, and trapezius muscles.	Inf. maxillary, angle of mouth, cellular tissue of face.	Facial and superficial branches of the cervical plexus.

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Sterno-cleido-mastoid	Two heads, sternum and clavicle.	Mastoid proc. of temporal bone, and outer 2·3 of sup. curved line of occiput.	Sp. accessory and deep branches of cervical plexus.
Part of trapezius...........	Sup. curved line of occipital, spinous processes of 7th cerv. and all dorsal, lig. nuchæ, and supraspinous ligament.	Clavicle, and crest of spine of scapula and acromion, and tubercle of scapula.	Sp. accessory and branches from anterior divisions of 3d and 4th cervical nerves.
Splenius capitis et colli.....	Half of lig. nuchæ, and spines of six upper dorsal and last cervical vert. and supraspinous ligament.	(Splen. cap.) Into occiput and mastoid process of temporal bone. (Splen. colli.) Into trans. proc. of 3 or 4 upper cervical vertebræ.	Ext. branches of post. divisions of cervical nerves.
Trachelo-mastoid	Trans. proc. of 3d, 4th, 5th and 6th dorsal and artic. proc. of 3 or 4 lower cervical.	Mastoid process of temporal bone.	Ext. branches of post. divisions of cervical nerves.
Complexus	Trans. proc. 7th cervical and 3 upper dorsal, and artic. proc. of 3d, 4th, 5th and 6th cervical.	Occipital bone	Sub-occipital, great occipital, and internal branches of post. divisions of cervical nerves.
		NECK.	
Neck moved forward by			
Platysma myoides	Clavicle, acromion, and fascia covering upper part of pectoral, deltoid, and trapezius muscles.	Inf. maxil., angle of mouth, cellular tissue of face.	Facial and superficial branches of the cervical plexus.
Sterno-cleido-mastoid	Two heads, sternum and clavicle.	Mastoid proc. of temporal bone, and outer 2·3 of superior curved line of occiput.	Sp. accessory and deep branches of cervical plexus.

Digastric — Anterior belly	Inner surface inf. maxillary near symphysis.	A central tendon held in connection with hyoid bone by a fibrous loop. Suprahyoid aponeurosis is attached to body and great cornu of hyoid bone.	(Ant.) Inferior dental.
Digastric — Posterior belly	Digastric groove of mastoid process.		(Post.) Facial.
Mylo-hyoid	Mylo-hyoid ridge of inferior maxillary.	Body of hyoid and raphé	Inferior dental.
Genio-hyoid	Inf. genial tubercle on inner side of symphysis of jaw.	Ant. surface of body of hyoid.	Hypo-glossal.
Genio-hyo-glossus	Superior genial tubercle on inner side of symphysis of jaw.	Body of hyoid bone, a few fibres being continued to side of pharynx, under surface of tongue.	Hpyo-glossal (12th cranial).
Omo-hyoid	Upper border of scapula and occasionally from transverse ligament.	Body of hyoid.	Branches from loop of communication bet. descendens and communicans hypoglossi.
Sterno-hyoid	Sternum and clavicle	Lower border of body of hyoid bone.	Branches from loop of communication bet. descendens and communicans hypoglossi.
Thyro-hyoid	Side of thyroid cartilage	Body and greater cornu of hyoid.	Hypo-glossal.
Rectus capitis anticus minor.	Root of trans. proc. and lateral mass of atlas.	Basilar process of occipital bone.	Sub-occipital and deep inter. branches of cervical plexus.
Longus colli — Sup. oblique portion	Trans. proc. 3d, 4th, 5th cervical.	Tubercle on anter. arch of atlas.	
Longus colli — Inf. oblique portion	Trans. proc. first 2 or 3 dorsal vert.	Trans. proc. 5th, 6th cervical.	Anterior branches of lower cervical nerves.
Longus colli — Vertical portion	Bodies of lower 3 cervical, and upper 3 dorsal.	Bodies of 2d, 3d, 4th cervical.	

Neck moved backward by

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Part of trapezius	Sup. curved line of occipital, spinous proc. of 7th cervical and all dorsal, lig. nuchæ, and supraspinous lig.	Clavicle and crest of spine of scap. and acromion, and a tubercle of scapula.	Spinal accessory and branches from anterior divisions of 3d and 4th cervical nerves.
Rhomboideus minor	Lig. nuchæ, spines of 7th cervical and 1st dorsal.	At root of spine of scapula	Branches from 5th cervical nerve.
Serratus posticus superior	Lig. nuchæ, spines of last cervical and 2 or 3 upper dorsal vertebræ.	2d, 3d, 4th and 5th ribs by four digitations.	External branches of posterior divisions of cervical nerves.
Splenius capitis et colli	Half of lig. nuchæ and spines of 6 upper dorsal and last cervical vert. and supraspinous ligament.	(Splen. cap.) Into occiput and mastoid process of temporal bone. (Splen. colli.) Trans. proc. 3 or 4 upper cervical vertebræ.	External branches of posterior division of cervical nerves.
Complexus	Trans. proc. 7th cervical and 3 upper dorsal and artic. proc. of 4th, 5th and 6th cervical.	Occipital bone	Sub-occip., great occipital, and internal branches of post. divisions of cervical nerves.
Trachelo-mastoid	Trans. proc. 3d, 4th, 5th and 6th dorsal and art. proc. of 3 or 4 lower cervical.	Mastoid process	External branches of posterior divisions of cervical nerves.
Transversalis colli	Transverse process, 6 upper dorsal vertebræ.	Posterior tubercles of trans. processes of 2d to 6th cervical.	External branches of posterior divisions of the cervical nerves.
Interspinales colli	Bet. spines of contiguous vert. The interspinales in cervical region consist of six pairs, the 1st bet. axis and third vertebra, the last bet. last cervical and first dorsal.	....	Internal branches of posterior division of cervical nerves.
Semispinales colli	Trans. proc. upper 4 dorsal, and artic. proc. of lower 4 cervical.	Spines of cervical from axis to 5th cervical vertebra.	Internal branches of posterior division of cervical nerves.

Rectus capitis posticus major.	Spine of axis	Inf. curved line of occiput and surface of bone below it.	Sub-occipital.
Rectus capitis posticus minor.	Post. arch of atlas..........	Rough surface beneath the inf. curved line of occip. bone nearly as far as foramen magnum.	Sub-occipital.
Obliquus capitis superior....	Transverse process of atlas..	Occipital bone bet. the two curved lines external to the complexus.	Sub-occipital.
Obliquus capitis inferior....	Spinous process of axis.....	Trans. process of atlas.....	Sub. and great occipital.
Scaleni postici	2d rib	Trans. processes of lower 2 or 3 cervical vertebræ.	Anterior branches of lower cervical.
Levator anguli scapulæ.....	Trans. processes of 3, 4, or 5 upper cervical.	Posterior border of scapula..	Interior divisions of 3d and 4th cervical nerves.
Neck moved laterally by Various combinations of those muscles which separately move it forward and backward, assisted by the scaleni, inter-transversales and recti laterales.			
		TRUNK.	
Trunk moved forward by Rectus abdominis	Pubic crest, small portion interlaces with its opposite being connected with ligaments covering the symphysis.	Cartilages of 5th, 6th and 7th ribs. Occasionally some fibres connected with costoxiphoid ligaments and side of ensiform cartilage.	Lower intercostal, ilio-hypogastric, ilio-inguinal nerves.
Pyramidalis	Os pubis and ant. pubic ligament.	Linea alba	Lower intercostal, ilio-hypogastric, ilio-inguinal nerves.

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Obliquus externus abdominis	Eight lower ribs............	Outer lip of crest of ilium. Aponeurosis interlaces with its opposite, forming linea alba; above it is connected with pectoralis major, below from ant. sup. spine of ilium to pubic spine and linea ilio pectinea.	Lower intercostal, ilio-hypogastric, ilio-inguinal nerves.
Obliquus internus	Lumbar fascia, iliac crest, Poupart's ligament.	Cartilages 4 lower ribs, linea alba, pubic crest, pectineal line.	Lower intercostal, ilio-hypogastric, ilio-inguinal nerves.
Psoas magnus	Bodies and trans. proc., and intervertebral substance of last dorsal and all lumbar vertebræ.	Lesser trochanter of femur..	Ant. branches of lumbar nerves.
Psoas parvus	Bodies of last dorsal and first lumbar vertebra and the intervertebral sub.	Ilio-pectineal eminence, and continuous with iliac fascia.	Ant. branches of lumbar nerves.
Assisted when arms are carried forward by			
Pectoralis major	Clavicle, sternum, and costal cartilages of all the true ribs except frequently 1st or 7th or both, and aponeurosis of Obliquus externus abdom.	Ant. bicipital ridge of humerus.	Anterior thoracic nerves.
Pectoralis minor	3d, 4th and 5th ribs, and intercostal aponeurosis.	Coracoid process of scapula.	Anterior thoracic nerves.
Serratus magnus	8 upper ribs and intercostal aponeurosis.	Anterior aspect of posterior border of scapula.	Posterior thoracic nerves.
Trunk moved backward by			
Trapezius	Sup. curved line of occiput, spinous proc. of 7th cervical and all dorsal vertebræ, lig. nuchæ, and supraspinous ligament.	Clavicle, and crest of spine of scapula, acromion, and a tubercle of scapula.	Spinal accessory and deep branches from anterior divisions of 3d or 4th cervical nerves.

Rhomboideus major	Spines of 4 or 5 upper dorsal and supraspinous ligament.	Into an arch attached to triangular surface near the spine and inf. angle. Occasionally into the scapula.	Fifth cervical.
Latissimus dorsi	Spines of 6 lower dorsal and lumbar and sacral vertebræ, supraspinous lig., crest of ilium and 3 or 4 lower ribs.	Inner lip and bicipital groove of humerus. Lower border of tendon unites with teres major.	Long subscapular.
Serratus posticus superior...	Lig. nuchæ, spines of last cervical and 2 or 3 upper dorsal vertebræ.	2d, 3d, 4th, and 5th ribs by 4 digitations.	External branches of posterior divisions of cervical nerves.
Serratus posticus inferior...	Spines of last two dorsal and first 2 or 3 upper lumbar vertebræ and interspinous ligaments.	Four lower ribs............	External branches of posterior divisions of lower dorsal nerves.
Sacrolumbalis	Is a part of erector spinæ..	Angles of 6 or 7 lower ribs.	External branches of posterior divisions of lumbar and dorsal nerves.
Longissimus dorsi	Is inner part of erector spinæ.	Trans. and artic. proc. of lumbar and trans. processes of all dorsal vertebræ and from 7th to 11th lower ribs, and aponeurosis of transversalis abdominis.	External branches of post. divisions of lumbar and dorsal nerves.
Spinalis dorsi	Last 2 dorsal and first 2 lumbar spines.	Spinous processes of dorsal vertebræ from 4 to 8 in number.	Dorsal branches.
Semispinales dorsi	Trans. proc. lower dorsal from 10th or 11th to 5th or 6th.	Spines last 2 cervical and upper 4 dorsal.	Internal branches of posterior divisions of dorsal nerves.
Multifidus spinæ	Sacrum and an aponeurosis of origin of erector spinæ, iliac spine, post. sacro-iliac lig., artic. proc. lum. and cer. ver. and trans. proc. of dorsal.	Laminæ and spines of vertebræ next above.	Internal branches of posterior division of cervical, dorsal, and lumbar nerves and of sacral nerves.

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Intertransversales dorsi et lumborum.	Bet. transverse processes of contiguous vertebræ.	....	Branches of post. division of cervical, dorsal, and lumbar nerves.
Trunk moved laterally by			
Obliquus externus	8 lower ribs...	Outer lip of crest of ilium. Aponeurosis interlaces with its opposite, forming linea alba. Above it is connected with pectoralis major, below from ant. sup. spine of ilium to pubic spine and linea ilio-pectinea.	Lower intercostal, ilio-hypogastric, ilio-inguinal.
Obliquus internus	Lumbar fascia, iliac crest, Poupart's ligament.	Cartilages of four lower ribs, linea alba, pubic crest, pectineal line.	Lower intercostal, ilio-hypogastric, ilio-inguinal
Quadratus lumborum	Ilio-lum. lig., crest of ilium. Trans. proc. 3d, 4th, 5th lumbar vertebræ.	Last rib, trans. proc. of the 4 upper lumbar vertebræ, lower margin of last rib.	Anterior branches of lumbar nerves.
Longissimus dorsi	Is inner part of erector spinæ.	Trans. and artic. proc. of lumbar and trans. proc. of all dorsal and from 7th to 11th ribs and aponeurosis of trans. abdominis.	External branches of posterior divisions of lumbar and dorsal nerves.
Sacrolumbalis	Is a part of erector spinæ...	Angles of 6 or 7 lower ribs.	External branches of posterior divisions of lumbar and dorsal nerves.
Serratus postici — Superior ...	Lig. nuchæ, spines of last cervical and 2 or 3 upper dorsal.	2d, 3d, 4th, and 5th ribs by 4 digitations.	External branches of posterior divisions of cervical nerves.
Serratus postici — Inferior ...	Spines of last 2 dorsal and first 2 or 3 upper lumbar vertebræ and interspinous ligament.	Four lower ribs............	External branches of posterior divisions of lower dorsal nerves.
Latissimus dorsi	Spines of 6 lower dorsal and lumbar and sacral vertebræ, supraspinous lig., crest of ilium and 3 or 4 lower ribs.	Into lip and bicipital groove of humerus. Lower border of tendon unites with teres major.	Long subscapular.

SCAPULA.

Scapula moved upward by			
Trapezius	Sup. curved line of occiput, spinous proc. of 7th cervical and all dorsal, lig. nuchæ and supraspinous ligament.	Clavicle and crest of spine of scapula and acromion and a tubercle of scapula.	Spinal accessory and deep branches from anterior divisions of 3d or 4th cervical nerves.
Levator anguli scapulæ......	Trans. proc. 3, 4, or 5 upper cervical vertebræ.	Post. border of scapula.....	Interior division of 3d and 4th cervical nerves.
Rhomboidei — Major	Spines of 4 or 5 upper dorsal and supraspinous lig.	Into arch attached to triangular surface near the spine, and inf. angle. Occasionally into the scapula.	5th cervical.
Rhomboidei — Minor	Lig. nuchæ, spines of 7th cer. and 1st dorsal.	At root of spine of scapula..	Branches from 5th cervical nerve.
Scapula moved downward by			
Lower part of trapezius....	Sup. curved line of occiput, spinous processes of 7th cervical and all dorsal vertebræ, lig. nuchæ and supraspinous ligament.	Clavicle and crest of spine of scapula and acromion and a tubercle of scapula.	Spinal accessory and branches from anterior divisions of 3d and 4th cervical nerves.
Latissimus dorsi	Spines of 6 lower dorsal and lumbar and sacral vertebræ, supraspinous lig., crest of ilium and 3 or 4 lower ribs.	Inner lip and bicipital groove of humerus. Lower border of tendon unites with teres major.	Long subscapular.
Pectoralis minor	3d, 4th, 5th ribs and intercostal aponeurosis.	Coracoid process of scap....	Ant. thoracic nerve.
Scapula moved forward by			
Pectoralis minor	3d, 4th, and 5th ribs and intercostal aponeurosis.	Coracoid process of scap....	Ant. thoracic nerve.
Serratus magnus	8 upper ribs and intercostal aponeurosis.	Ant. aspect of post. border of scapula.	Post. thoracic nerve.

Muscle	Origin	Insertion	Nerve supply
Scapula moved backward by			
Part of trapezius	Sup. curved line of occiput, ligamentum nuchae, 7th cervical and all dorsal vertebrae [illegible]	Clavicle [illegible]	[illegible]
Rhomboideus Major	Spines of [illegible] upper dorsal and [illegible]	[illegible]	[illegible]
Rhomboideus Minor	Lig. nuchae, [illegible] and 1st dorsal	[illegible] spine of scapula	[illegible] cervical
Latissimus dorsi	Spines of 6 lower dorsal, lumbar and sacral vert., [illegible] crest of ilium and 3 or 4 lower ribs	Inner lip and bicipital groove of humerus. Lower part [illegible] of tendon unites with teres major	Long subscapular
Humerus moved forward by			
Part of deltoid	Clavicle, acromion and spine of scapula	Middle of outer side of shaft of humerus	Circumflex
Part of pectoralis major	Clavicle, sternum and costal cartilages of all the true ribs except frequently the 1st or 7th or both, and aponeurosis of obliquus externus abdominis	Ant. bicip. ridge of humerus	Anterior thoracic nerves
Assisted in some circumstances by			
Biceps	1. Long head: Glenoid cavity. 2. Short head: Coracoid process	Tuberosity of radius	Musculo-cutaneous
Coracobrachialis	Coracoid process of scap. and intermuscular septum	Inside shaft of humerus	Musculo-cutaneous
Humerus moved backward by			
Part of deltoid	Clavicle, acromion and spine of scapula	Middle of outer side of shaft of humerus	Circumflex

Teres major	Inf. angle scap. and fibrous septa bet. the teres major and teres minor and infraspinatus.	Post. bicipital ridge of humerus.	Lower sub-scapular.
Teres minor	Axillary border of scapula, and 2 aponeurotic laminæ.	Great tuberosity of humerus and bone below.	Circumflex.
Long head of triceps.......	From a depression below the glenoid cavity.	Olecranon process of ulna..	Musculo-spiral.
Latissimus dorsi	Spines of 6 lower dor. and lum. and sac. ver., supraspinous lig. crest of iliuin and 3 or 4 lower ribs.	Inner lip and bicipital groove of humerus. Lower border of tendon unites with teres major.	Long sub-scapular.
Humerus moved inward by			
Part of pectoralis major....	Clavicle, sternum, and costal cartilages of all the true ribs except frequently 1st or 7th or both, and aponeurosis of obliquus externus abdominis.	Ant. bicipital ridge of humerus.	Anterior thoracic nerves.
Latissimus dorsi	Spines of 6 lower dorsal and lum. and sacral ver., supraspin. lig. crest of ilium and 3 or 4 lower ribs.	Inner lip and bicipital groove of humerus. Lower border of tendon unites with teres major.	Long sub-scapular.
Humerus rotated inward by			
Subscapularis	Subscapular fossa and tendinous laminæ and an aponeurosis.	Lesser tuberosity of humerus and neck of humerus.	Upper and lower sub-scapular nerves.
Assisted occasionally by			
Pectoralis major	Clavicle, sternum, and costal cartilages of all the true ribs except frequently the 1st or 7th or both, and aponeurosis of obliquus externus abdominis.	Ant. bicipital ridge of humerus.	Anterior thoracic.

Flexor digitorum sublimis...	1. Internal condyle and int. lat. lig. of elbow-jt. and intermus. septum. 2. Coronoid process. 3. Oblique line of radius.	2d phalanges by 4 tendons..	Median.
Flexor carpi ulnaris........	1. Int. condyle .... 2. Olecranon by an aponeurosis from ulna, and intermus. septum.	Base of 5th metacarpal, unciform bone, annular lig., and pisiform bone.	Ulnar.
Supinator longus	Ext. condyloid ridge of humerus and ext. intermustermus. septum.	Styloid process of radius....	Musculo-spiral.
Forearm moved backward by			
Triceps	1. Ext. head—post. surface of shaft of humerus, external border of humerus and ext. intermuscular septum. 2. Internal head from post. surface of shaft of humerus, internal border of humerus and intermuscular septum. 3. Middle or long from a depression below the glenoid cavity.	Olecranon process of ulna...	**Musculo-spiral.**
Anconeus	Back of ext. condyle of humerus.	Olecranon and shaft of ulna.	Musculo-spiral.
Forearm rotated inward by			
Pronator radii teres........	Humerus above internal condyle and common tendon and fascia of forearm and intermus. septum and coronoid process.	Outer side shaft of radius..	Median.
Flexor carpi radialis........	Int. condyle and from fascia of forearm and intermus. septum.	Base of metacarpal bone of index.	Median.
Palmaris longus	Int. condyle, deep fascia and intermuscular septum.	Palmar fascia. Frequently sends a tendinous slip to short muscles of thumb.	Median.

Muscle	Origin	Insertion	Nerve supply
Flexor digitorum sublimis	[illegible]	[illegible] tendons	Median
Pronator quadratus	[illegible]	[illegible]	[illegible]
Forearm rotated outward by Biceps	[illegible]	[illegible]	[illegible]
Supinator brevis	[illegible]	[illegible]	[illegible]
Extensor ossis metacarpi pollicis	[illegible]	[illegible] thumb	[illegible]

FLEXION

Muscle	Origin	Insertion	Nerve supply
Carpus moved forward by Flexor carpi radialis	Int. condyle and from fascia of forearm and intermuscular septum	Base of metacarpal bone of index	Median
Palmaris longus	Int. condyle, deep fascia and intermuscular septum	Palmar fascia. Frequently sends a tendinous slip to short muscles of thumb	Median

Flexor digitorum sublimis...	1. Inner condyle and int. lat. lig of elbow-jt. and inter. septum. 2. Coronoid process ...... 3. Oblique line of radius..	2d phalanges by 4 tendons..	Median.
Flexor carpi ulnaris........	1. Inter. condyle .... 2. Olecranon bet. an aponeurosis from ulna and inter. septum.	Base of 5th metacarpal, unciform bone, annular lig. and pisiform bone.	Ulnar.
Flexor profundus digitorum.	Shaft of ulna and coronoid proc., post. border of ulna and interosseus membrane.	Base of last phalanges by 4 tendons.	Ulnar and ant. interosseus.
Flexor longus pollicis.......	Shaft of radius, interosseus membrane, and sometimes base of coronoid process.	Base of last phalanx of thumb.	Ant. interosseus.
Carpus moved backward by			
Extensor carpi radialis longior.	Lower 1-3 ext. condyloid ridge of humerus and intermuscular septum.	Base of metacarpal bone of index finger.	Musculo-spiral.
Extensor carpi radialis brevior.	Ext. condyloid ridge of humerus, ext. lat. lig. of elbow jt., an aponeurosis and intermuscular septum.	Base of metacarpal bone of middle finger.	Post. interosseus.
Extensor secundi internodii pollicis.	Post. sur. of shaft of ulna and interosseus membrane.	Base of last phalanx of thumb.	Post. interosseus.
Extensor proprius indicis....	Posterior sur. of ulna and interosseus membrane.	2d and 3d phalanges index finger.	Post. interosseus.
Extensor communis digitorum	Ext. condyle of humerus, deep fascia and intermuscular septum.	All 2d and 3d phalanges....	Post. interosseous.
Carpus moved outward by			
Extensor carpi radialis longior.	Lower 1-3 ext. condyloid ridge humerus and intermuscular septum.	Base of metacarpal bone of index finger.	Musculo-spiral.

MUSCLE	ORIGIN	INSERTION	NERVE SUPPLY
Extensor carpi radialis brevis.	Ext. condyloid ridge of humerus, ext. lat. lig. of elbow jt., aponeurosis and intermuscular septum	Base of metacarpal bone of middle finger	Post. interosseous
Extensor ossis metacarpi pollicis	Post. surface of shaft of ulna and interosseous lig., and 1/3 of post. surface of shaft of radius	Base of metacarpal of thumb	Post. interosseous
Extensor carpi ulnaris . .	Ext. condyle of humerus, post. border of ulna, fascia of forearm.	Base of metacarpal of little finger.	Post. interosseous
Carpus moved inward by			
Flexor digitorum sublimis .	1 Inner condyle and int. lat. lig. of elbow jt. and inter. septum 2 Coronoid process . . 3 Oblique line of radius	2d phalanges by 4 tendons	Median
Flexor carpi ulnaris . . .	1 Inner condyle . . . 2 Olecranon by an aponeurosis and intermus. septum	Base of 5th metacarpal, unciform bone, annular lig., and pisiform bone	Ulnar
Flexor profundus digitorum	Shaft of ulna and coronoid process, post. border of ulna, and interosseous membrane	Base of last phalanges by 4 tendons	Ulnar and ant. interosseous
Extensor communis digitorum	Ext. condyle of humerus, deep fascia, intermuscular septum	All 2d and 3d phalanges	Post. interosseous
Extensor minimi digiti . . .	From common tendon and intermuscular septa.	2d and 3d phalanges little finger.	Post. interosseous
Extensor carpi ulnaris .	Ext. condyle of humerus, and posterior border of ulna, also fascia of forearm.	Base of 5th metacarpal .	Post. interosseous

THUMB.

Thumb moved inward and forward across palms by			
Opponens pollicis	Trapezium and annular lig..	Metacarpal of thumb.......	Median.
Flexor brevis pollicis.......	Trapezium, trapezoid, os magnum, base of 2d and 3d metacarpal, annular lig. and tendon flex. carpi radialis.	Base 1st phalanx of thumb..	Median and ulnar.
Flexor longus pollicis.......	Shaft of radius, interosseous membrane, and occasionally from base of coronoid.	Last phalanx of thumb......	Ant. interosseous.
Thumb moved outward and backward by			
Extensor ossis metacarpi pollicis.	Post. surface of shaft of ulna and interosseous lig., and 1-3 of post. surface of shaft of radius.	Base of metacarpal of thumb	Post. interosseous.
Extensor primi internodii pollicis.	Post. surface of shaft of radius and interosseous membrane.	Base of 1st phalanx of thumb	Post. interosseous.
Extensor secundi internodii pollicis.	Post. surface of shaft of ulna and interosseous membrane.	Base of last phalanx of thumb	Post. interosseous.
Thumb moved upward and forward away from other fingers by			
Abductor pollicis	Trapezium and annular ligament.	Base of 1st phalanx of thumb	Median.
Assisted by			
Part of flexor brevis pollicis.	Trapezium, trapezoid, os magnum, base of 2d and 3d metacarpal, annular lig., and sheath of tendon flexor carpi radialis.	Base of 1st phalanx of thumb	Median and ulnar.

Thumb moved backward and inward to other fingers by

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Adductor pollicis	Lower 2/3 of metacarpal bone of middle finger.	Base of 1st phalanx of thumb and internal sesamoid bone.	Ulnar.
Extensor primi internodii pollicis.	Post. surface of shaft of radius and interosseous membrane.	Base of 1st phalanx of thumb	Post. interosseous
Extensor secundi internodii pollicis.	Post. surface of shaft of ulna and interosseous membrane.	Base of last phalanx of thumb	Post. interosseous

FINGERS.

Fingers moved forward or flexed by

Flexor digitorum sublimis...	1. Inner condyle, and int. lat. lig. of elbow jt., and intermus. septum 2. Coronoid process 3. Oblique line of radius	2d phalanges by 4 tendons..	Median
Flexor profundus digitorum.	Shaft of ulna, and coronoid process, post. border of ulna, and interosseous membrane.	Base of last phalanges by 4 tendons	Ulnar and anterior interosseous.
Lumbricales 4..............	Tendons of deep flexor.....	Tendinous expansion of extensor communis digitorum	Median and ulnar.
Interossei 4 dorsal	From sides of metacarpal bones.	Into base of first phalanges and into aponeurosis of common extensor tendon.	
Interossei 3 palmar...	From metacarpal bones	Into side of base of 1st phalanx and aponeurotic expan. of common extensor tendon of same finger.	
Flexor brevis minimi digiti..	Unciform bone, and annular ligament.	Base of 1st phalanx of little finger.	Ulnar.

Abductor minimi digiti.....	Pisiform bone and expansion of tendon of the flexor carpi ulnaris.	Base of first phalanx of little finger.	Ulnar.
Fingers moved backwards or extended by			
Extensor communis digitorum	Ext. condyle of humerus, deep fascia, and intermuscular septum.	All 2d and 3d phalanges....	Post. interosseous.
Extensor minimi digiti......	From common tendon, and intermuscular septum.	2d and 3d phalanges of little finger.	Post. interosseous.
Extensor proprius indicis...	Post. surface of ulna, and interosseous membrane.	2d and 3d phalanges index finger.	Post. interosseous.
Fingers moved outward to radial border by			
Abductor indicis	Os trapezium, and metacarpal bone of thumb.	First bone of forefinger.....	
Abductor minimi digiti......	Pisiform bone, and expansion of tendor of flexor carpi ulnaris.	First phalanx of little finger.	Ulnar.
Interossei: 4 dorsal	From sides of metacarpal bone.	Into base of first phalanges and into aponeurosis of common extensor tendon.	
Interossei: 3 palmar........	From metacarpal bones.....	Into side of base of first phalanx and aponeurotic expan. of com. extensor tendon of same finger.	
Fingers moved inward by			
Abductor minimi digiti......	Pisiform bone, and expansion of tendon of flexor carpi ulnaris.	Baes of first phalanx of little finger.	Ulnar.
Interossei: 4 dorsal	From sides of metacarpal bone.	Into base of first phalanges and into aponeurosis of common extensor tendon.	
Interossei: 3 palmar........	From metacarpal bone......	Into side of base of first phalanx and aponeurotic expan. of com. extensor tendon of same finger.	

TABLE II

Thigh moved forward by Muscle	Origin	Insertion	Nerve supply
Psoas magnus	Sides of bodies, intervertebral substances, and transverse processes of last dorsal and all lumbar vertebrae	Lesser trochanter of femur	Anterior branches of lumbar nerves
Iliacus	Iliac fossa, [illegible] ilio-lumbar ligament and ant. sup. and ant. inf. spinous processes of ilium, [illegible] and capsule of hip joint	Tendon of psoas and oblique line from lesser trochanter to linea aspera	Anterior crural
Tensor vaginae femoris	Outer crest and ant. sup. spinous process of ilium	Fascia lata, fascia continued to head of tibia	Superior gluteal
Pectineus	Ilio-pectineal line and surface of bone in front of it and [illegible] Gimbernat's ligament	Rough line from trochanter minor to linea aspera	Ant. crural, obturator and accessory obturator
Adductor longus	Front of pubis	Middle third of linea aspera of femur	Obturator
Adductor brevis	Outer surface of descending ramus of pubis	Upper part of linea aspera of femur, and lower part of line from lesser trochanter to linea aspera	Obturator
Thigh moved backward by Gluteus maximus	Sup. curved iliac line, and part of bone and crest immediately behind it, sacrum and coccyx, great sacro-sciatic lig., and aponeurosis of erector spinae muscle.	Fascia lata, and rough line leading from great trochanter to linea aspera	Small sciatic and branch from sacral plexus
Part of gluteus medius	Outer surface of ilium bet. sup. and mid. curved lines, outer lip of crest, and gluteal aponeurosis	Oblique line of outer surface of great trochanter	Superior gluteal

Pyriformis	Front of sacrum, grooves leading from foramina, margin of great sciatic foramen, gt. sacro-sciatic lig.	Upper border of great trochanter.	Sacral plexus.
Obturator internus	Inner side of obturator foramen, inner surface of obturator membrane, and tendinous arch which completes obturator canal.	Upper border of great trochanter.	Sacral plexus.
Parts of adductor magnus	Descending ramus of pubes, and ascending ramus and tuberosity of ischium.	1. Rough line from trochanter to linea aspera. 2. All linea aspera and upper part of its internal bifurcation below. 3. Tubercle above inner condyle of femur.	Obturator and great sciatic.
Long head of biceps	Tuberosity of ischium	Outer side of head of fibula and external tuberosity of tibia.	Great sciatic.
Semitendinosus	Tuberosity of ischium and the adjacent aponeurosis.	Upper part of inner surface of shaft of tibia.	Great sciatic.
Semimembranosus	Tuberosity of ischium	Inner tuberosity of tibia	Great sciatic.
Thigh moved inward by			
Psoas magnus	Sides of bodies, intervertebral substances, and trans. proc. of last dorsal and all lumbar vertebræ.	Lesser trochanter of femur	Anterior branches of lumbar nerves.
Iliacus	Iliac fossa, crest, base of sacrum, ilio-lumbar lig., and ant. sup. and ant. inf. spinous proc. of ilium.	Tendon of psoas and oblique line from lesser trochanter to linea aspera.	Anterior crural.
Pectineus	Ilio-pectineal line and surface of bone in front of it and from prolongation of Gimbernat's ligament.	Rough line of femur from trochanter minor to linea aspera.	Ant. crural obturator, and accessory obturator.

MUSCLE	ORIGIN	INSERTION	NERVE SUPPLY
Gracilis	Ramus of the pubes and ischium	Upper part of inner surface of shaft of tibia	Obturator
Adductor longus	Front of pubes	Middle third of linea aspera of femur	Obturator
Adductor brevis	Outer surface of descending ramus of pubes	Upper part of linea aspera of femur, and lower part of line from lesser trochanter to linea aspera	Obturator
Adductor magnus	Descending ramus of pubes and ascending ramus and tuberosity of ischium	1. Rough line from great trochanter to linea aspera. 2. All linea aspera and upper part of the internal supracondylar line. 3. Tubercle above inner condyle of femur	Obturator and great sciatic
Obturator externus	Obturator foramen and membrane, and tendinous arch, which completes canal for obturator vessels and nerves	Digital fossa of femur	Obturator nerve
Quadratus femoris	Tuberosity of ischium	Quadrate line on post. surface of trochanter major	Sacral plexus
Thigh moved outward by			
Tensor vaginae femoris	Iliac crest, and ant. sup. spinous proc. of ilium	Fascia lata. Fascia is continued to head of tibia	Sup. gluteal
Gluteus maximus	Sup. curved iliac line and part of bone, and crest, immediately behind it; sacrum and coccyx, great sacrosciatic lig., and aponeurosis of erector spinae muscle	Fascia lata and rough line leading from great trochanter to linea aspera	Small sciatic and branch from sacral plexus
Gluteus medius	Outer surface of ilium bet. sup. and mid. curved lines, outer lip of crest, and gluteal aponeurosis	Oblique line of outer surface of great trochanter	Sup. gluteal

Gluteus minimus	Outer surface of ilium bet. mid. and inf. curved lines, margin of great sacro-sciatic notch.	Great trochanter	Sup. gluteal.
Pyriformis	Front of sacrum, grooves leading from foramina, gt. sciatic foramen, great sacro-sciatic lig.	Upper border of great trochanter.	Sacral plexus.
Thigh rotated inward by			
Tensor vaginæ femoris......	Iliac crest, and ant. sup. spin. process of ilium.	Fascia lata. Fascia is continued to head of tibia.	Sup. gluteal.
Part of gluteus medius.....	Outer surface of ilium bet. sup. and mid. curved lines, outer lip of crest, and gluteal aponeurosis.	Oblique line of outer surface of great trochanter.	Sup. gluteal.
When the leg is extended by			
Sartorius	Ant. sup. spinous proc. of ilium and upper half of notch below it.	Upper part of inner surface of shaft of tibia.	Ant. crural.
Semitendinosus	Tuberosity of ischium, and the adjacent aponeurosis.	Upper part of inner surface of shaft of tibia.	Great sciatic.
Thigh rotated outward by			
Gluteus maximus	Sup. curved iliac line and part of bone, and crest, immediately below it—sacrum and coccyx, gt. sacro-sciatic lig., and aponeurosis of erector spinæ muscle.	Fascia lata and rough line leading from great trochanter to linea aspera.	Small sciatic and branch from sacral plexus.
Part of gluteus medius......	Outer surface of ilium bet. sup. and mid. curved lines, outer lip of crest, and gluteal aponeurosis.	Oblique line of outer surface of great trochanter.	Sup. gluteal.

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Pyriformis	Front of sacrum, grooves leading from foramina, margin of gt. sciatic foramen, gt. sacro-sciatic lig.	Upper border of great trochanter.	Sacral plexus.
Gemellus superior	Ischial spine	Upper border of great trochanter.	Sacral plexus.
Obturator internus	Inner side of obturator foramen, inner surface of obturator membrane, and tendinous arch which completes obturator canal.	Upper border of great trochanter.	Sacral plexus.
Gemellus inferior	Tuberosity of ischium	Upper border of great trochanter.	Sacral plexus.
Quadratus femoris	Tuberosity of ischium	Quadrate line on post. surface of troch. major of femur.	Sacral plexus.
Obturator externus	Inner side of obturator foramen, and obturator membrane, and tendinous arch which completes canal for obt. ves. and nerves.	Digital fossa of femur	Obturator
Psoas magnus	Side of bodies, intervertebral sub., and trans. proc. of last dorsal and all lumbar vertebræ.	Lesser trochanter of femur	Anterior branches of lumbar nerves.
Iliacus	Iliac fossa, crest, base of sacrum and ant. sup. and ant. inf. spin. proc. of ilium.	Tendon of psoas and oblique line from lesser trochanter to linea aspera.	Ant. crural.
Adductor longus	Front of pubes	Middle third of linea aspera of femur.	Obturator.
Adductor brevis	Outer surface of descending ramus of pubes	Upper part of linea aspera of femur and lower part of line from lesser trochanter to linea aspera.	Obturator.

Adductor magnus	Descending ramus of pubes and ascending ramus and tuberosity of ischium.	1. Rough line from gt. trochanter to linea aspera. 2. All linea aspera and upper part of bifurcation below. 3. Tubercle above inner condyle of femur.	Obturator and great sciatic.
Biceps cruris slightly.......	Long head—Ischial tuberosity. Short head—Out. lip of linea aspera. Ext. supracondyloid line, ext. intermus. septum.	Outer side of head of fibula, ext. tuberosity of tibia.	Great sciatic.
Leg moved backward or flexed by	LEG.		
Semitendinosus	Tuberosity of ischium and the adjacent aponeurosis.	Upper part of inner surface of shaft of tibia.	Great sciatic.
Biceps	Long head—Tuberosity of ischium. Short head—Outer lip of linea aspera. Ext. supra-condyloid line, external intermuscular septum.	Outer side of head of fibula, and ext. tuberosity of tibia.	Great sciatic.
Semimembranosus	Tuberosity of ischium......	Inner tuberosity of tibia....	Great sciatic.
Gracilis	Ramus of the pubes and ischium.	Upper and inner surface of shaft of tibia.	Obturator.
Sartorius	Ant. sup. spinous proc. of ilium and half of notch below it.	Upper part of inner surface of shaft of tibia.	Ant. crural.
Popliteus	Ext. condyle of femur. and post. lig. of knee-joint.	Post. surface of shaft of tibia above oblique line and into ten. expan. covering the surface of the muscle.	Int. popliteal.
Leg extended by Rectus femoris	Short head—Ant. inf. spin. process of ilium. Long head—Groove above brim of acetabulum.	Patella	Anterior crural.

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Crureus and vastus internus.	Line from inner side of neck of femur to linea aspera, shaft of femur, inner lip of linea aspera, a ridge from linea aspera to int. condyle and intermuscular septum.	Patella	Anterior crural.
Vastus externus	Tubercle of femur, ant. border great trochanter, its outer surface, and linea aspera, and rough line from troch. major to linea aspera, tendon of gluteus maximus, and ext. intermuscular septum.	Outer border of patella.....	Anterior crural.
	FOOT.		
Foot moved forward or flexed by			
Tibialis anticus	Outer tuber., and upper part of ext. surface of shaft of tibia, interosseous mem., deep surface of fascia, and intermuscular septa.	Int. cuneiform bone and base of metatarsal bone of great toe.	Ant. tibial.
Extensor proprius pollicis...	Ant. surface of mid. of fibula, and interosseous membrane.	Base of last phalanx of great toe.	Ant. tibial.
Extensor longus digitorum..	Outer tuberosity of tibia, ant. surface of shaft of fibula, interosseous membrane, deep surface of fascia, and intermuscular septa.	2d and 3d phalanges of the 4 lesser toes.	Ant. tibial.
Peroneus tertius	Lower ¼ of ant. surface of fibula, interosseous membrane, and intermuscular septa.	Base of metatarsal bone of little toe.	Ant. tibial.

Foot moved backward or extended by			
Gastrocnemius	Int. condyle, and ext. condyle of femur, and ridges from condyles to linea aspera.	Os calcis by tendo Achilles..	Int. popliteal.
Plantaris	Outer bifurcation of linea aspera, and post. lig. of knee-joint.	Post. surface of os calcis...	Int. popliteal.
Soleus	Shaft and head of fibula, oblique line of tibia, and mid. third of its internal border, and tendinous arch.	Os calcis by tendo Achilles..	Int. popliteal.
Flexor longus digitorum....	Post. surface of shaft of tibia, and intermus. septum.	Bases of last phalanges of the 4 lesser toes.	Post. tibial.
Flexor longus pollicis.......	Lower 2-3 of post. surface of shaft of fibula, except 1 in. at its lowest part, interosseous mem., intermus. septum, and fascia covering the tibialis posticus.	Base of last phalanx of great toe.	Post. tibial.
Tibialis posticus	Post. surface of shaft of tibia, upper 2-3 of int. sur. of fibula, deep transverse fascia, intermuscular septa, and post. surface of interosseous membrane.	Tuberosity of scaphoid and int. cuneiform.	Post. tibial.
Peroneus longus	Head and 2-3 of ext. sur. of shaft of fibula, deep surface of fascia, intermus. lar septa.	Base of 1st metatarsal bone of great toe, and int. cuneiform bone, occasionally the base of second metatarsal bone.	Musculo-cutaneous.
Peroneus brevis	Lower 2-3 of ext. sur. of shaft of fibula, and intermuscular septa.	Base of metatarsal bone of little toe.	Musculo-cutaneous.

Foot inclined inward by

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Extensor proprius pollicis...	Ant. surface of mid. of fibula, and interosseous membrane.	Base of last phalanx of great toe.	Ant. tibial.
Flexor longus digitorum....	Post. surface of shaft of tibia, and intermuscular septum.	Bases of last phalanges of the 4 lesser toes.	Post. tibial.
Flexor longus pollicis.......	Lower 2-3 of post. sur. of shaft of fibula, except 1 in. at its lowest part, inteross. mem., intermus. septum, and fascia covering tibialis post.	Base of last phalanx of great toe.	Post. tibial.
Tibialis posticus............	Post. surface of shaft of tibia, upper 2-3 of int. sur. of fibula, deep transverse fascia, intermuscular septa, and post. surface of interosseous membrane.	Tuberosity of scaphoid and int. cuneiform.	Post. tibial.
Foot moved outward by			
Peroneus longus	Head and 2-3 of ext. sur. of shaft of fibula, deep surface of fascia, intermus. septa.	Base of metatarsal bone of great toe and int. cuneiform. Occasionally the base of second metatarsal bone.	Musculo-cutaneous.
Peroneus brevis	Lower 2-3 of ext. surface of shaft of fibula, intermuscular septa.	Base of metatarsal bone of little toe.	Musculo-cutaneous.
Extensor longus digitorum..	Outer tuberosity of tibia, shaft of fibula, interosseous mem., deep surface of fascia, and intermus. septa.	2d and 3d phalanges of the 4 lesser toes.	Ant. tibial.
Peroneus tertius	Lower ¼ of ant. surface of fibula, interos. mem., and intermus. septa.	Base of metatarsal bone of little toe.	Ant. tibial.

TOES.

Toes moved backward or flexed by			
Abductor pollicis	Inner tubercle os calcis, int. annular lig., plantar fascia, and intermuscular septum.	Base of first phalanx of great toe.	Int. plantar.
Flexor brevis digitorum.....	Inner tub. of os calcis, plantar fascia, intermus. septa.	Second phalanges of lesser toes.	Int. plantar.
Abductor minimi digiti......	Outer tubercle and under sur. of os calcis, inner tubercle, plantar fascia, and intermuscular septum.	Base of first phalanx of little toe.	Ext. plantar.
Flexor longus pollicis.......	Lower 2-3 of post. sur. of shaft of fibula, except 1 in. at its lowest part, interos. mem., intermus. septum, and fascia covering the tibialis posticus.	Base of last phalanx of great toe.	Post. tibial.
Flexor longus digitorum.....	Post. surface of shaft of tibia, and intermus. septum.	Bases of last phalanges of 4 lesser toes.	Post. tibial.
Flexor accessorius	1. Inner sur. of os calcis and calcaneo-scaphoid ligament. 2. Under surface of os calcis.	Tendon of flexor longus digit.	Ext. plantar.
Lumbricales 4	Tendons flexor longus......	Expansion of long extensor and base of first phalanx of corresponding toe.	Two inner—Int. plantar. Two outer—Ext. plantar.
Flexor brevis pollicis.......	Cuboid and ext. cuneiform bone, and prolongation of tendon of tibialis posticus.	Base of first phalanx of great toe.	Int. plantar.
Adductor pollicis	Tarsal ends of 2d, 3d and 4th metatarsal bones and sheath of tendon of peroneus longus.	Base of first phalanx of great toe.	Ext. plantar.

MUSCLE.	ORIGIN.	INSERTION.	NERVE SUPPLY.
Flexor brevis minimi digiti	Base of metatarsal bone of little toe and sheath of peroneus longus.	Base of first phalanx of little toe.	Ext. plantar.
Interossei { 4 dorsal	From adjacent sides of two metatarsal bones.	Base of first phalanx of corresponding toe and aponeurosis of common extensor tendon.	Ext. plantar.
Interossei { 3 plantar	From shafts of 3d, 4th, and 5th metatarsal bones.	Bases of first phalanges of same toes and aponeurosis of common extensor tendon	Ext. plantar.
Toes moved forward or extended by			
Extensor longus digitorum..	Outer tuberosity of tibia, shaft of fibula, interos. mem., deep surface of fascia, and intermus. septa.	2d and 3d phalanges of the 4 lesser toes.	Ant. tibial.
Extensor proprius pollicis...	Ant. surface of middle of fibula, and interosseous membrane.	Base of last phalanx of great toe.	Ant. tibial.
Extensor brevis digitorum...	Os calcis, ext. calcaneo astragaloid lig., and ant. annular ligament.	First phalanx of great toe and long extensor tendons of 2d, 3d, and 4th toes.	Ant. tibial.
Toes inclined inward by			
Abductor pollicis	Inner tubercle of os calcis, int. annular lig., plantar fascia, and intermuscular septa.	Base of first phalanx of great toe.	Int. plantar.
Interossei { 4 dorsal	From adjacent sides of two metatarsal bones.	Base of first phalanx of corresponding toe and aponeurosis of common extensor tendons.	Ext. plantar.
Interossei { 3 plantar	From shafts of 3d, 4th, and 5th metatarsal bones.	Bases of first phalanges of same toes and aponeurosis of common extensor tendon	Ext. plantar.

Toes moved outward by			
Abductor pollicis	Inner tubercle of os calcis, int. annular lig., plantar fascia, and intermuscular septa.	Base of first phalanx of great toe.	Int. plantar.
Interossei: 4 dorsal	From adjacent sides of two metatarsal bones.	Base of first phalanx of corresponding toe and aponeurosis of common extensor tendon.	Ext. plantar.
Interossei: 3 plantar	From shafts of 3d, 4th, and 5th metatarsal bones.	Bases of first phalanges of same toes and aponeurosis of common extensor tendon	Ext. plantar.
Abductor minimi digiti......	Outer tubercle and under surface of os calcis, inner tubercle, plantar fascia, and intermuscular septa.	Base of first phalanx of little toe.	Ext. plantar.

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