It has recently been stated by a number of German writers (Jacoby, Waldvogel, Oswald) that phosphorus induces autolysis of the body's protoplasm. This is not true. If one administers phosphorus to a fasting dog, the proteid metabolism may be increased to 250 per cent. of that observed in starvation. If phlorizin diabetes be induced in a fasting dog this rise may extend to 500 per cent. This latter increase is due to the non-combustion of the carbohydrate derived from proteid. If now a phlorizinized dog be given phosphorus there may be absolutely no further rise in the nitrogen elimination in the urine. The mere administration of phosphorus, therefore, can not cause an uncontrolled activity of proteolytic enzymes in the organism. It is much easier to explain the rise in proteid metabolism in phosphorus poisoning as due to an incomplete combustion of lactic acid.

Another analogy in these two cases is the fatty infiltration found in the tissues both in phosphorus poisoning and in diabetes. The cause is similar in both cases. In diabetes, when the sugar does not burn in the cells, the "sugar-hungry" cells attract fat in greater quantity than they can burn it. The blood may become full of fat which is being transported. In phosphorus poisoning, there is a modified "sugar hunger" in that lactic acid, a primary cleavage product of dextrose, does not burn—hence the fatty infiltration. Whenever such conditions exist, fatty infiltration occurs. It has been found by Hoppe-Seyler and Araki that a diminished oxygen supply to the body results in the appearance of lactic acid, and in all such cases fatty changes occur. A local diminution in the blood supply to a part of the heart, for example, will produce this condition with resultant fatty infiltration. In the lactic glands, where dextrose is probably converted into milk-sugar, which latter can not be burned in the organism, there are "sugar hungry" cells which attract fat from the blood. Even the fatty degeneration observed on autopsy in fever cases may be due only to dyspnea which precedes the fatal outcome. These views have been gradually developed in this laboratory, and are but an extension of Rosenfeld's discovery of a physiologic antagonism between glycogen and fat deposit in the liver.

CHRONIC CATARRHAL DEAFNESS.

NOTES ON SOME VERY SIMPLE EXPERIMENTS AS TO THE INFLUENCE OF SOUND WAVES ON OSSICULAR RIGIDITY.*

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That most cases of chronic catarrhal deafness are due largely to rigidity of the ossicles depending on morbid changes within the tympanum is an etiologic truism. The correction of this condition by some form of passive exercise—exercise that will move, not segments of the drum membrane, but the drum membrane and ossicles together—is not yet within our grasp. It is a fascinating possibility, a problem the solution of which would be of more value to humanity than could possibly result from the most brilliant development of otology along any other lines.

METHODS USUALLY EMPLOYED.

I wish (1) to consider, briefly, the methods usually employed for exercising the drum membrane and ossicles, and (2) to speak of some very simple experiments as to the influence of sound waves on ossicular rigidity. Of the various measures employed, inflation and pneumatic massage are in most common use.

Inflation of the tympanum either by catheter or the Politzer method is of the greatest value in cases of tubal catarrh or obstruction as a means of replacing the drum membrane in its normal position and re-establishing the function of the tube. Beyond this, its value as a means of correcting ossicular rigidity is distinctly limited. I assume that this proposition will be accepted without argument.

Pneumatic massage is a term applied to passive movements of the drum membrane by means of any instrument producing alternate condensation and rarefaction of the air in the external auditory meatus. I have employed this measure in a considerable number of cases, using either Siegel's otoscope or a pneumatic pump connected with the electric motor. With either instrument I have invariably kept the drum membrane under direct inspection and endeavored in this way to guard against the employment of too great force. In some cases a considerable immediate gain in hearing has resulted from a first application of this procedure. This gain has rarely proved permanent, however, and progressive improvement has never resulted from repeated use of this form of massage. On the other hand, distinct loss has seemed to follow its routine practice in a considerable number of cases.

The unsatisfactory results of pneumatic massage are probably explained by two facts: 1. The movements of the membrana tympani are not those which Nature requires of it or which are necessary to the transmission of sound waves, and do not, therefore, exercise the drum membrane and ossicles in their normal function. 2. The undue strain to which the drum membrane is subjected tends to produce alterations in tension, reducing still further the patient's hearing power.

Pneumatic massage by the method under discussion seems to be based on the theory that whatever will move the ossicles will improve the hearing. Its practice does not seem to be governed by any rules based on scientific investigations, the method of its application to different cases being largely a matter of guess work. Should this statement be objected to, it may easily be disproved by any one who will throw light on the following questions: By what established rules is the relation between the degree of deafness and the number of vibrations employed to be determined? Should the length of the piston stroke vary in different cases? If so, by what method other than guess work are such variations to be regulated in accordance with the varying degrees of deafness or ossicular fixation? Recognizing the obvious fact that any loss of tension in the drum membrane will necessitate the employment of greater force, i. e., a longer piston stroke, in order to produce a given movement in the ossicular chain, how are such variations in tension to be determined and allowed for? Employing sufficient force to move the ossicles, how is undue relaxation of the drum membrane to be guarded against? These questions would seem idle except in so far as they may show weak points in a method of treatment from which much has been expected and which is still advocated by many distinguished aurists.

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To be effective, I believe that exercise of the drum membrane should fulfill the following conditions, all of which are violated by the usual form of pneumatic massage: (a) The drum membrane should not be subjected to any strain likely to destroy its normal tension (i. e., to produce relaxation, stretching); (b) it should be made to execute movements similar to those excited in the healthy drum membrane by sound waves; (c) the number of vibrations per second should bear some relation to that note in the musical scale which marks the lower tone limit of the patient's hearing power.

With patients whose perception of musical tones reaches below C' (256 double variations), there is strong clinical evidence that the ossicular chain may in some cases be thrown into more or less vigorous vibration down to, and below, their estimated lower tone limit by a system of tuning forks especially devised for this purpose. If impressions of sound reach the inner ear chiefly through vibrations of the conducting mechanism excited by sound waves from without, why may we not make use of selected sound waves to exercise the drum membrane and ossicles in just those movements (sounds) for which their mobility is shown to be impaired? In other words, if it be shown by careful testing with small tuning forks (e. g., the Hartmann set) that the hearing is impaired, but not lost, for a given note, e. g., C, 128 double vibrations, why is it not a rational procedure to exercise the drum membrane and ossicles for that particular note by means of a larger fork of the same pitch, whose greater amplitude of vibration is sufficient to throw the drum membrane into more vigorous motion? That this theory is not without practical bearing on the question of treatment in cases of deafness due to ossicular rigidity may in some cases be demonstrated by a very simple experiment. Supposing, for example, a patient who can but faintly hear the small Hartmann fork of 128 double vibrations (C), when set in maximum vibration, let the physician subject him to the following test: Taking a much larger unclamped fork of the same pitch, let him hold it while vibrating vigorously with the broad side of the prong as close as possible to the patient's ear without touching the auricle, keeping it there until its sound is no longer heard. Let him repeat this eight or ten times. Now let the ear rest a minute or two, and test again with the small Hartmann fork of 128 double vibrations, when it will be found in some cases that the sound is heard with greater distinctness and, therefore, during a longer period of time. While by no means invariable, this result occurred with sufficient frequency to induce me to make a series of experiments with forks of different pitch.

EXPERIMENTS AS TO THE INFLUENCE OF SOUND WAVES ON OSSICULAR RIGIDITY.

Tuning Forks.—The tuning forks employed in these experiments were especially designed for exercising the drum membrane and ossicles. For this purpose it was essential that each fork should be capable of the most vigorous vibration possible for its fundamental note. Roughly speaking, the amplitude of vibration increases with the length of the fork, or rather with the length of its prongs. And as a maximum amplitude of vibration was a chief desideratum, I ordered a set of unclamped forks, the prongs to be $\frac{3}{4}$ inch wide and as nearly as possible of uniform thickness; the variations in pitch to be regulated by gradations in the length of the prongs. After some failures, this order resulted in a set of forks with prongs of uniform width, producing all the notes of

the musical scale from 32 double vibrations (C—²) to 512 double vibrations (C²), four octaves higher. They present a broad, flat surface which, when set in vigorous vibration, and held close to the external auditory meatus, can not fail to throw the drum membrane, even though thickened by disease, into more or less vigorous motion.

Routine of Experiments.—The hearing is first tested in much the usual way. The hearing distance for the acoumeter and for the conversational or whispered voice is ascertained. The lower tone limit is roughly estimated by means of the Hartmann set of tuning forks, and the upper tone limit by the Galton whistle. Increase or diminution of hearing by bone conduction is carefully noted. If the result of these tests points to a tympanic lesion, and the lower limit of the patient's hearing power is not above 256 double vibrations, a more exact estimate of the lower tone limit is made.

If, for example, the patient can hear the Hartmann C' fork (256 double vibrations), but not the C fork (128 double vibrations), I next test the hearing with my forks representing the intermediate notes of this octave, i. e., 240, 213, 192, 170, 160 double vibrations, etc., until the correct lower tone limit is reached. In using these forks for testing purposes they should be struck with only moderate force and, overtones being carefully eliminated, held with the space between the prongs opposite the ear.

Supposing that the lower tone limit is by this test shown to be 160 double vibrations, this fork and four or five others immediately below it in the musical scale (i. e., 144, 128, 120, 107 double vibrations, etc.) may be employed for the purpose of throwing the drum membrane and ossicles into forcible vibrations. Using first the highest fork, 160 double vibrations, it is set in maximum vibration and held with the flat surface of the prong close to the ear until its sound is no longer heard. This should be repeated 8 or 10 times. Then the next lower fork, 144 double vibrations, is employed in the same manner, and so on through the series of successively lower forks, 128, 120, 107 double vibrations, etc., until one is reached which can not be heard even in maximum vibration. Used in this way, tones four to six notes lower in the musical scale will be perceived. As each successively lower fork is heard during a shorter period of time, it is well to repeat the initial stroke somewhat oftener as we descend in the musical scale, the lowest fork being heard but a few seconds. Letting the ear now rest for one or two minutes, it will be found in some cases that an appreciable gain in hearing has resulted.

VALUE OF EXPERIMENTS.

I wish to avoid the error of exaggeration in speaking of the value of these experiments. The results have varied greatly in different cases, some cases of fairly marked deafness responding favorably, while others of slight impairment have shown little or no improvement. Such contradictory results have occurred in cases apparently equally favorable for this experiment. They apparently depend on differences in the character of the lesion, rather than its stage or duration. In those cases in which the experiment has resulted favorably, the improvement has been in the direction of improved audition for the lower musical tones and increased hearing distance for the watch or acoumeter. The improvement in certain cases has been marked, the hearing distance for the acoumeter being more than doubled and the range of tone perception being considerably extended.

The method is cumbersome, and its application neces-

sitates an expenditure of time rendering it unavailable as a routine measure by men in large practice. Nor have the results thus far demonstrated a sufficiently definite value in excess of what may be accomplished by other means to justify one in proclaiming this measure as a valuable addition to our therapeutic armamentarium.

All that I claim for these experiments is that they furnish additional proof that in certain cases of chronic deafness the mobility of the ossicles may be increased and the hearing thereby improved by sound waves rationally employed. They also suggest a field of experimental work through which in time we may arrive at a system of auditory massage which will yield more valuable and permanent results.

I believe that some form of effective auditory massage is a possibility; but that its development must be along rational lines, i. e., in accordance both with the physics of sound and the physiology of the sound-conducting mechanism. In this direction lies the greatest need in the development of practical otology.

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DISCUSSION.

DR. C. J. BLAKE, Boston, said that it is evident that the application of the grosser forms of massage, for the purpose of mobilization of the sound-transmitting apparatus of the ear, should be supplemented by a more delicately applicable method of mobilization. Dr. Blake assisted Professor Politzer in a series of experiments as to the effect on the hearing, in cases of chronic non-suppurative middle ear disease, of tuning forks of low pitch electrically actuated. These experiments showed apparently an improvement in hearing in cases of rigidity of the articulation of the ossicles. The fact that the tuning forks were electrically actuated and therefore presented a continuous tone led, he thinks, to their application for a longer period than would otherwise have been the case, that is to say, than if they had been actuated by striking and allowed gradually to come to rest. One of the results of these experiments was the development in many of the cases of auditory fatigue, and it was found that the exposure of the ear to the tone of a low pitch tuning fork continued for a period, say of three or four minutes, resulted in the appreciation on the part of the patient, when the tuning fork was brought to rest or removed from the ear, of another sound, a false sound, which was a complimentary tone, and many patients, after subsection of a few minutes to the tuning fork sound, heard, when that sound ceased, the third or fifth of the tone used for periods of from a few seconds to half a minute or more. Under these circumstances the experiments were not continued, the ground taken being that the ultimate expenditure of force, of these deep tones of considerable volume being in the labyrinth, there was a possibility of injury from the fatigue caused. In the experiments which Dr. Kerrison reported, however, there is a means of applying massage, phono-massage, for limited periods of time, and it is distinctly understandable that there is an efficient means for purposes of mobilization. When the limit of sound transmission of the sound-transmitting apparatus, ranging from the lowest sound appreciable, 60 vibrations in a second, up to about 40,000 vibrations in a second, is considered, it is evident that the use of tones of low pitch will be most serviceable in effecting mobilization of the articulation of the ossicles. Aside from the immediate therapeutic value of the treatment, it is sure to lead up to better information concerning the transmission, through the sound-transmitting apparatus, of tones of low pitch, and it is inevitable that the following out of a series of such investigations as are indicated in the paper, will help much in determining, more specifically than has yet been done, the value of tones of low pitch in the differential diagnosis of disturbance of sound transmission.

DR. LOUIS J. LAUTENBACH, Philadelphia, said that musical tones thrown into the ear can exercise little or no influence on the attachments or articulations of the ossicles but influence rather the nerve endings. Physics teaches this. Tun-

ing forks give not massage, but stimulation, often an over-stimulation of the nerve. Clinical work in this line carried out for any length of time will prove this. Dr. Lautenbach has found that primary stimulation by tones of high pitch produces the greatest effect on the hearing, but that if long continued it is followed by great and sometimes permanent depression. He has found that low tones do stimulate the hearing, but it takes a long time and is not followed by so great depression. He said that he can not recall any permanent bad effect resulting from low tone stimulation. He considers the condition resulting in these cases as due primarily to the effect on the nerve structures of the ears and not at all to any effect on the structures of the middle ear. If it be desired to affect the middle ear structures, they must be dealt with by ordinary mechanical means. The function of the ossicle is to transmit sound. In part, it is known how sound is transmitted, but in reality very little is known about it. The chain of bones can be thrown into any desired position and will carry the tone if the articulations are perfect. In most of Dr. Lautenbach's experiments he has used the syren; with it any number of vibrations can be obtained and kept up for as long as desired. Quick results can be obtained, and it can be readily determined how much can be gained by tones of varying pitch. He thinks that the use of electrically operated tuning forks is valuable. Anything too continuous in the way of sound is followed by bad effects on the ear. Pneumo-massage has a distinct and positive purpose and effect; by this means good effects can be produced and bad effects if it is overdone. Physicians as well as patients are prone to want to overdo it. To get the maximum effect in vibratory massage, vibrations are needed, varying from 250 a second to 5,000 or 10,000 a second, depending on the case. In pneumo-massage the best possible results are obtained by impulses varying from 50 to 400 a minute.

DR. CULLEN F. WELTY, San Francisco, said that tuning forks will differentiate the different forms of deafness almost to a certainty, but when the tuning fork is used as a treatment for otosclerosis (ossicular rigidity), he is almost confident that it will not yield practical results. It is questionable to him if otosclerosis (pure) should have mechanical treatment at all. He is confident that some forms should not. In adhesive processes (ossicular rigidity) practical results can not be obtained by the vibrations given the drum membrane by the tuning fork. More can be accomplished by the catheter. This, however, can be abused.

DR. PHILIP D. KERRISON, New York, said that it seemed evident that some of the speakers misunderstood him. He stated distinctly in advance, he said, that he did not propose the use of forks as a valuable therapeutic measure. He also stated in the course of the paper that whatever practical value these experiments might have would be in possibly suggesting certain methods of pneumatic massage, by which more valuable and permanent results might be obtained. He said that Dr. Lautenbach's statement regarding the number of vibrations was accompanied by no explanation of his reasons for this belief. If any definitely good results are to be obtained, reasons for the technic used should be given. One of the most obvious dangers of pneumatic massage, as usually employed, is readily appreciated, he said, if we remember that Helmholtz proved by experiments that the maximum movements of the umbo are 0.25 mm. By the usual method of auditory massage, the drum membrane or segments of it, are made to execute movements much greater than this; and it is difficult to conceive how such exaggerated excursions can fail to result either in lesions of the ossicular joints or in undue stretching or relaxation of the drum membrane.

Management of Diabetics.—Hershey, in the *Denver Medical Times*, states that no diabetic should be considered as being under proper treatment until his case has been thoroughly studied for at least a month, either under strict hospital supervision or at home under the care of an intelligent trained nurse. Thus we are able to study the effect of exercise during restricted diet, the effect of rest under the same régime, and the effect of the ingestion of carbohydrates during rest and during exercise.