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A Simple Method for Determination of Threshold Value of Vibration Sense.

J. CHARNLEY MC KINLEY.

From the Division of Nervous and Mental Diseases, University of Minnesota.

Symns[1] has described the first method for the quantitative determination of vibration sense. In his fork 2 pieces of steel are attached to the prongs so that when the fork is vibrating strongly a small window is seen between them and this window disappears at a certain amplitude of vibration. On the disappearance of the window the fork is applied to a bony point of the patient and a stop watch started. When the patient no longer feels the vibration the watch is stopped. It is assumed then that vibration sense is relatively less acute, the shorter the time interval during which it is perceived. This work has been continued by Wood[2] and Ahrens.[3]

In observing a fork vibrating under a microscope it is evident that when the amplitude is small, the vibration recedes very slowly, so that even with the eye observing the fork directly and aided with an eyepiece micrometer, it is difficult to determine within several sec-

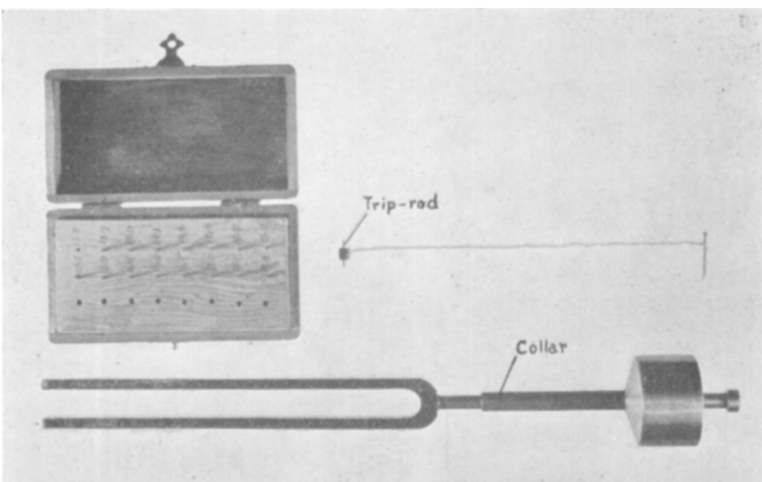

FIG. 1.
Materials necessary in this method of testing vibration sense.

[1] Symns, J. Ll. M., *Brit. Med. J.*, 1912, i, 539; *Guy's Hosp Rep.*, 1912, lxvi, 120; *Quart. J. Med.*, 1917, xi, 33.

[2] Wood, E. J., *Am. J. Med. Sc.*, 1922, clxiii, 19.

[3] Ahrens, R. S., *Arch. Neur. Psych.*, 1925, xiv, 793.

onds of time when the fork is vibrating exactly at a given amplitude. Then, too, from the physiologic standpoint it has often been stated that in testing sensation one should approach the threshold value from below rather than from above as is done with Symns' fork. Further, there is no easy method of keeping the pressure of the fork constant on the bony point of the patient.

With these difficulties of the former method in mind, the technique here described was developed.

The materials necessary are shown in Fig. 1. The tuning fork is 10½ inches in length and has a rate of 128 vibrations per second. The base of the fork has been weighted so that altogether it weighs 501 gm. Around the shank of the base is a metal collar which slides freely up and down. Thus the fork can be supported in a vertical position by holding the collar so that it will not tip over and it will then rest with approximately 500 gm. pressure on the portion of the patient to be tested. The contact phlange of the bottom of the fork which rests against the patient is 1.0 cm. in diameter. The small box shown in Fig. 1 contains 15 rods made from piano wire which is 1.50 mm. in diameter. These rods range in length from 13.90 mm. to 19.00 mm. ± 0.01 mm. The rods can be pushed through a small cylindrical piece of rubber which is attached to the end of a silk thread about 20 cm. in length. On the other end of this silk thread is a small metal rod for convenience in handling. The piano wire rods are pushed through the rubber on the tip of the thread and are placed between the prongs of the fork thus spreading the prongs at will from 13.90 mm. to 19.00 mm. Then by quick traction on the thread the rod is jerked from between the prongs of the fork and the initial vibration of the fork will correspond closely to the amount of spread produced by the piano wire rod. Kielhauser[4] states that rods have been used by Müller, Pouillet and Pfaundler to start forks vibrating.

The accuracy of the method has been tested out as follows:

The fork is clamped in a horizontal position by its shank in a vise. Its tip is observed through an erecting microscope fitted with a Spencer eyepiece micrometer. The tip of the fork is illuminated by an arc light and a bull's eye condenser. A tiny scratch at the tip of the fork is located by the very bright light which it reflects into the microscope. When the fork is caused to vibrate, this tiny scratch becomes a line which is easily measured for length by means of the eyepiece micrometer. The length of this line, of course, corresponds to the apparent amplitude of vibration of the fork and the actual

[4] Kielhauser, E. A., *Verlag von B. G. Teubner*, Leipzig, 1907.

amplitude is computed from the fact that, with the magnification used, each distance between any 2 lines in the eyepiece micrometer corresponds to 0.14 mm. in actuality. This distance between any 2 lines of the eyepiece micrometer is of such size that it is easy to estimate tenths of the distance and tenths, therefore, correspond to 0.014 mm.

Determinations were made of the initial vibration produced by each one of the 15 rods. Twenty-five readings were taken from each rod. Their average values are plotted in Fig. 2. Opposite each average observation in this figure is placed the numerical expression for the average and this is followed in parenthesis by the extreme range of the observation. Since the distance between the prongs of the fork at rest is 13.75 mm. one would expect the 14.00 mm. trip rod to produce a vibration of 0.25 mm. and the 19.00 mm. rod to produce an initial amplitude of 5.25 mm. It is seen in Fig. 2 that the 14.00 mm. rod produces an average initial amplitude of vibration of 0.238 mm. while the 19.00 mm. rod produces one of

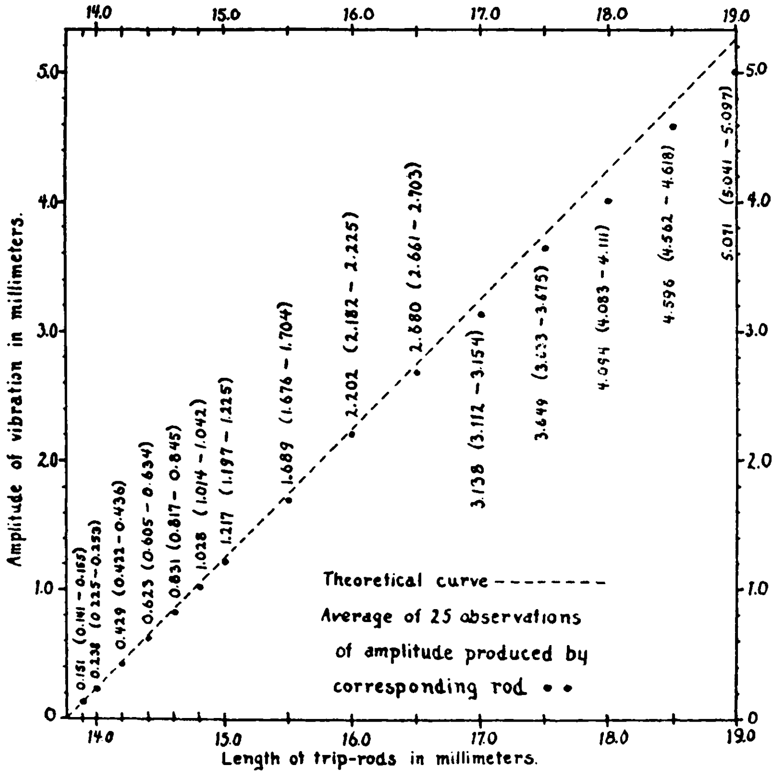

FIG. 2.
Theoretical curve and average amplitudes produced by the various rods.

5.071 mm. The theoretical curve which one would expect these readings to follow is plotted in the dashed line of Fig. 2, while the average of the actual observations is shown by dots. It is seen that as the longer rods are used, the amplitude of the initial vibration becomes progressively less than one would expect from the theoretical curve. No doubt this discrepancy is due to the increased friction, air resistance and the like which becomes more and more marked as the length of the rods is increased. The greatest range of variability of the readings of initial amplitude is found to be with the 18.50 mm. and the 19.00 mm. rods, which show a range of 4.562 mm. to 4.618 mm. and 5.041 mm. to 5.097 mm. respectively. The extreme range of error, therefore, is only 0.056 mm. In making these readings it has been found that if the trip-rod is pulled from the fork in a direction more than 5° or 6° towards one or the other prong of the fork, the initial vibration is larger than when the rod is pulled more in the axis of the fork. This seems to be the only technical point of any difficulty which one must remember in using this fork.

In observing a tuning fork it becomes evident that the more forcibly the fork is started, the more rapidly it runs down at first, whereas it will continue to vibrate at a relatively small amplitude for a rather long period of time. In order to obtain some data on this point, a kymograph drum was rotated at a constant speed. On this kymograph drum seconds were marked off with an electric time-marker activated by a metronome. Another signal magnet was placed on the drum in a different electric circuit so that one could make contacts at recorded intervals of time. The tuning fork was observed under the microscope as already described. The fork was then activated by the longest (19.00 mm.) rod. As the fork was started a contact was made in the circuit and as the amplitude receded past the first 8 marks in the micrometer a second contact was made. As it ran past the 16th mark in the micrometer another contact was made and then one for each successive alternate mark. In this way it was possible to determine fairly accurately the time intervals which were used up by the fork in receding from its maximum amplitude through successively smaller amplitudes of vibration. The curve of the recession is shown in Fig. 3. On the inner side of each vertical margin of Fig. 3 are indicated the various trip-rods which are identified by their respective lengths, and are arranged in the position of the average amplitude which they produce in terms of micrometer graduations. It is seen that, in receding from the initial vibration amplitude produced by the 19.00 mm. rod to the 18.50 mm. rod, about 0.5 seconds are used up. A similarly small interval of time is required for recession to the 18.00 mm.

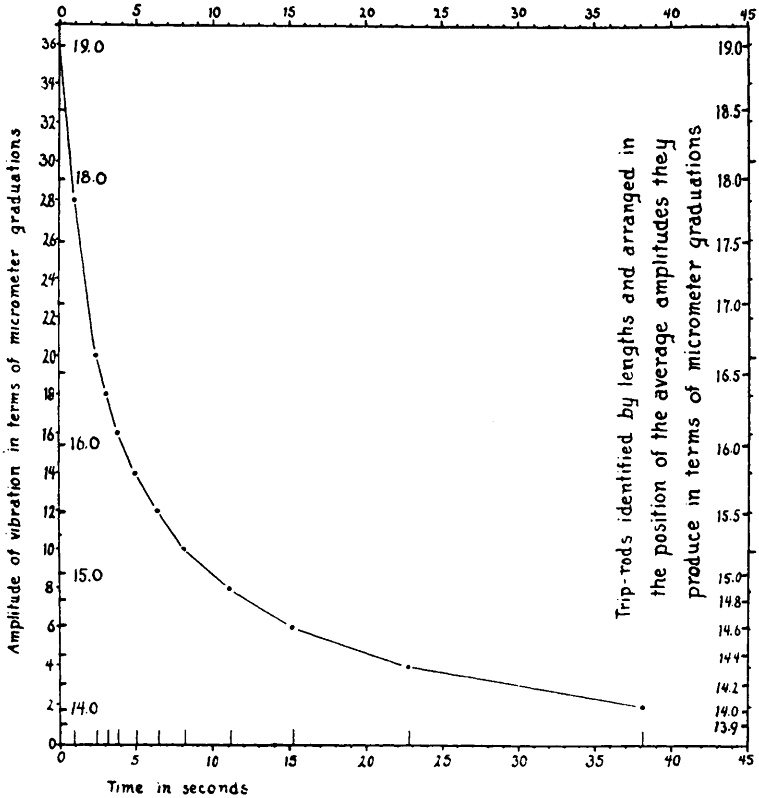

FIG. 3.
Curve of recession of the amplitude of vibration of the fork. The fork did not come to rest until approximately 145 seconds in all had elapsed.

rod and again to the 17.50 mm. rod. From the 17.00 mm. rod on down the time intervals become longer and longer. It is evident from this plotting that a patient who is being tested will have such a short interval in which to recognize the vibration initiated by the longer rods that it is probably impractical clinically to use rods of greater length than 17.00 mm. or 17.50 mm. with this particular fork.

Conceivably, temperature might change the amplitudes set up by the trip-rods. This was tested by making 5 measurements at room temperature with one of the rods, and then by 5 measurements with the fork heated by a Bunsen flame to a temperature almost unbearable to the naked hand. The average difference in the 2 sets of readings was less than 0.014 mm. which, in turn is less than the range of variability of the readings already presented.

Clinical work with the method described in the foregoing is in progress and will be reported later.