The Tuning Fork Tests*

By W. Harry Barnes, M.D., Philadelphia, Pa.

I consider the tuning fork the most important instrument for the otologist, so much so that if I could only have one instrument that would be the one I should select. It tells you more about the ear than even the otoscope and it tells you many things which it is impossible for you to ascertain in any other manner. It is of prime importance that you have a first class tuning fork and I shall mention a few of the requisites of a good tuning fork.

All sounds are of two kinds: "tones," having periodic vibrations, and "noises," having aperiodic vibrations. Most tones are composite tones. The tuning fork has a simple tone. The composite tones are simple tones plus over-tones, the latter altering the character of the fundamental. Sound is dependent on pitch, intensity and quality; pitch depends upon the number of vibrations per second; intensity depends upon the amplitude of the vibration and quality depends upon the shape of the sound-wave. Over-tones also modify the quality of sound-waves.

First, the tuning fork must be made of the best quality of steel, so constructed that both prongs vibrate synchronously or both together. It is possibly better that the fork is nickel plated as this prevents rust, and rusting is always irregular which may change either the pitch or the regularity of the vibration. The steel should be so tempered that it is not much affected by atmospheric or temperature changes. It should have a definite vibration length, or should vibrate a certain number of seconds. I prefer a fork vibrating 110 seconds, all of which period it is heard by normal air conduction, and about 70 seconds by normal bone conduction. This period is not long enough to tire the examiner, and yet is sufficiently long to make allowance for all extraneous factors and at the same time make the findings fairly consistent. The fork should be provided with two clamps which prevent over-tones. These clamps can also be used to modify the pitch of the fork for delicate tests.

Next, the fork should not be too heavy, as it may tire the examiner; nor too large, because of the concussion. When testing with the fork on the bone, the concussion may simulate the appreciation of sound, so that the patient thinks he is hearing the fork while he is only feeling the concussion of the large fork. The handle of the fork should be so constructed that it is easy to manipulate, as for instance, in making the Rinne test, you are continually changing the fork from the mastoid to in front of the ear. The best forks are constructed with some insulation so that the examiner's hand is not actually touching the vibrating metal. This has the advantage of preventing the examiner's hand from more or less damping the vibration or rusting the instrument. The end of the handle should be smooth and fairly large, so as not to feel uncomfortable when applied to the patient's mastoid process. C 256 double vibrations is the fork used for most of the tests.

Many contradictory findings will be obtained unless the examiner uses the fork in a systematic manner when testing. The fork should not be struck on any hard substance because of overtones, etc. (The thigh is good). The fork vibrates truly if held upside down. It should always be held the same distance from the patient's ear. The two prongs vibrate simultaneously and when one prong is held broadside opposite the ear, the patient hears the vibration of that prong fortified by the equal vibration of the other prong. If, however, the fork be rotated, it will be found that at certain points of the rotation the sound diminishes. At other places it is almost absent; but it is always loudest when one prong is broadside opposite the ear. These points at which the sound is almost absent are called nodal points or the positions where the sound-waves proceeding from two prongs over-lap each other.

It is also better in testing air conduction not to take the fork from the distance and draw it up to your usual point, as this will intensify the sound. It should rather be removed to one side or the other and always returned to the same position and at the same point.

In testing bone conduction on the mastoid process, it is more satisfactory to always place the fork directly over the mastoid antrum, because there the sound is heard most distinctly and is not interferred with because of the difference in the pneumatic or diploetic or diseased condition of the mastoid process. Allowance must always be made if the tuning fork is placed over a hairy part of the scalp. It goes without saying that the test should always be conducted in an absolutely quiet room with no extraneous noises and that the examiner should always use himself or some other person who has normal hearing as a control. Time

*This paper will be of use to the specialist only. I claim originality for nothing herein contained, but hope that in the "re-hash" some points will be mentioned which are new to each reader, and that some of the complications of these tests will be simplified.

is much the best noted with a stop-watch.

The tuning forks are mainly used to find out the condition of the external auditory meatus, the patency of the eustachian tube, the proper functioning of the tympanic membrane and ossicles, the condition of the middle ear and the accessory cavities; but most important, the degree of functioning of the internal ear and the eighth nerve, particularly the cochlea and the auditory branch of the eighth nerve. However there are many other aural uses. It is also used by the rhinologist for determining the presence of fluid in the accessory sinuses of the nose. It is very striking in cases of unilateral pansinusitis.

Most of the tuning fork tests have for their purpose the differential diagnosis between disease of the perceiving apparatus (the internal ear) and the conducting apparatus (the external and middle ear).

I. Air Conduction Test—

The test for air conduction is conducted as follows: A middle register fork (C 256 double vibrations) is held a certain distance from the patient's ear and the length of time he hears it is compared with the length of time a normal individual hears it. Fatiguing of either the patient or the control is very frequently the cause of irregular findings. For that reason it is better to rest the patient and control from time to time. Next the C fork of 125 vibrations is held before the ear and a second fork of 2048 vibrations is held so as to determine whether or not the patient has better perception for high tone forks or low tone forks. Patients with disease of the perceiving apparatus appreciate the low tone forks better than the high ones and patients with disease of the conducting apparatus appreciate high tones better than low tones. Sometimes a patient will notice on one side a different pitch from on the other, with the same fork, which indicates congestion of one labyrinth.

In all these tests of air conduction it is better to have the patient insert a moistened finger into the ear not being tested. This prevents the appreciation of any sound except by the ear being tested.

Barany's noise apparatus is used for the same purpose. When fitted to the ear and started, it makes so much noise that that ear cannot perceive any other sound. But, unfortunately, the sound can be heard by the other ear and consequently its appreciation for the testing fork is diminished so much, that the findings are unreliable.

II. The Schwabach Test —

This test is conducted by applying the tuning fork (C 256) to the mastoid of the patient, and comparing the length of time it is heard by the patient with the length of time it is heard by a control or a normal individual. If the patient hears the fork longer than the control, we conclude there is disease of the conducting apparatus. It is best to note the time in seconds it is lengthened beyond normal, which also helps us to note whether the patient is improving under treatment. If the patient hears the fork for a shorter period than the control, we conclude that the patient has disease of the perceiving apparatus.

These tests are obviously apt to be irregular and ofttimes unreliable for the reason that bone conduction is always the sum of bone conduction of both ears, rather than the bone conduction of the tested ear. For instance, if a patient has the entire labyrinth removed on the right side and the tuning fork be placed upon the right mastoid, the patient will hear the fork, which is obviously being heard by the left labyrinth. I have a patient under my observation who appears to hear the tuning fork in the left ear when placed upon the right mastoid. Another objection is that we must rely upon the patient's statements which are often intentionally or unintentionally unreliable. The high and low forks are also used upon the mastoid and the results interpreted the same as the high and low forks in the air.

III. The Weber Test—

This test is used to differentiate between disease of one side and the other. The vibrating fork is placed on the mid-line of the forehead and the patient asked whether he hears the fork or not and if so in which ear does he hear it better. If the patient seems to hear it equally in both ears, we conclude that both ears are in about the same condition. If, however, he appears to hear it better in one ear, if that ear is the better hearing ear or the good ear, we consider the patient has disease of the perceiving apparatus (internal ear). If, conversely, he hears it better in the worse hearing ear or the diseased ear, we consider he has disease of the conducting apparatus (the middle or external ear).

This test may be elaborated further by comparing the length of time the patient hears it with the length of time a normal individual hears it, when the test is similar to a Schwabach test being taken of both ears at the same time. Again if the fork be heard in one ear when placed on the mid-line, we can move the fork across the skull toward the other ear until we find the point where it is heard equally in both ears. This is very useful in the course of treatment to find out whether or not the patient is improving, when this point will move nearer to the mid-line. The vertex, the bridge of the nose, the upper incisor teeth and the middle of the mandible are sometimes used to advantage instead of the forehead.

This test has the same faults as enumerated under the Schwabach test because the patient must be relied upon and the sound is appreciated by both labyrinths. Many contradictory findings also ob-

viously occur; as both ears may be diseased equally or both ears diseased with the same affection but one side more so than the other, or one side may have disease of the labyrinth and the other disease of the middle ear, or one side may have both middle ear and labyrinth diseased. These mixed types could be multiplied indefinitely.

IIIa.—The Bing Test—

This test is a modification of the Weber test and is applied as follows: when the tuning fork is placed on the mastoid and ceases to be heard, if the moistened finger tightly closes the external canal, the sound will be heard again. This is because the sound-waves which had been escaping through the external meatus are forced backward and reenforce the other sound-waves, and the external meatus also acts as a resonating chamber. If the tone is not heard again, we conclude that the patient has diseased conduction or middle ear disease. If there is pronounced deafness and it is heard again, it denotes labyrinth disease. Again if the vibrating fork placed in the mid-line is heard equally in both ears, and one ear is closed, the sound will be referred to the occluded ear. In diseased conditions with the Weber lateralized to one side, occluding the ear in which it is not heard generally refers the sound to the occluded side, but if extensive middle ear disease exists on the experimentally occluded side, it will not be so referred. If both external meatuses are equally closed, the Weber should be referred the same as with both ears opened and in this manner air conduction is entirely eliminated as an influencing factor.

IV. Rinne Test—

This test depends upon the fact that the normal ear hears the vibrating fork longer by air than by bone. Tuning forks differ in the exact relation of the time of bone and air conduction. My fork is heard 70 seconds by bone and 110 by air, or 40 seconds longer by air which is Rinne normal. Rinne plus is always a relation where the fork is heard longer by air than by bone, and Rinne negative is in conditions where the fork is heard longer by bone than by air; Rinne normal is of course a certain Rinne plus; in the case of my fork plus 40.

The test is conducted as follows: The vibrating fork is held first before the ear then upon the mastoid and when it ceases to be heard at either place the time is noted until it disappears at the other. This test is very good as it is a test for one ear at a time and needs no control. If the Rinne is negative, we usually conclude that the patient has middle ear disease or conductive disease; if Rinne is positive, and the hearing diminished, we conclude that the patient has labyrinth disease; if the Rinne is negative but the bone conduction below normal, it is a case of mixed perceiving and conductive disease with the conductive disease preponderating. These mixed types may give us any form of Rinne, plus or minus, or a plus-minus (which means that the air conduction and bone conduction are the same); but whenever there is any perceiving disease, the bone is shorter than it should be for the amount of conductive disease, although the latter may increase the bone conduction above normal. This demonstrates the importance of the Schwabach test.

Many formulae have been devised for recording the Rinne findings, from the algebraic formula of Dundas Grant to the graphic formula of G. W. Mackenzie. The latter is simple and useful.

Mackenzie's method is to draw two parallel lines from a base line. The parallel lines are marked off in equal segments representing ten seconds each. One line represents air conduction and the other bone conduction. A diagonal line is drawn from the normal bone conduction height to the normal air conduction height. (The Mackenzie fork is heard normally by bone, seventy seconds; and by air, one hundred ten seconds, or normal Rinne plus forty.) The patient's air and bone conduction are charted, and at a glance you can compare it with normal. The Rinne thus obtained can be compared with the Rinne obtained in the usual manner, to see if your technique has been good, and the results are the same.

It also acts as a check on your technique of the other tests—the Weber, air, and Schwabach. If you should get an air perception of 100 seconds and a Schwabach of possibly 5 seconds lengthened but found the Rinne normal, these would so nearly agree that you could conclude that your tests were carefully made. Also if your Weber were lateralized to one side, you would expect to find your bone conduction longer on that side.

V. The Gelle Test—

The vibrating tuning fork is placed upon the mastoid or vertex or bag and a Gelle bag fitted with an olive pointed tip is made to fit tightly into the external canal. Then the bag is forcibly compressed, then released. If the sound of the tuning fork is diminished during compression and is again increased with aspiration, we conclude that the foot-plate of the stapes is movable, being jammed in the oval widow by compression but again released at aspiration. If compression and aspiration have no effect on the loudness of the tuning fork, we conclude that the foot-plate of the stapes is ankylosed or bound fast to the oval window. This must not be confused with the Gelle test for fistula of the semi-circular canals which is conducted in the same manner, without the tuning fork compression or aspiration giving nystagmus, vertigo, etc.

VI. The Politzer Test—

The vibrating tuning fork is held before the open mouth and the patient instructed to swallow. If the eustachian tubes are patulous, the sound will be intensified during the swallowing. If one only is patulous it will be heard and intensified on that side only. Some normal persons cannot hear it at all.

VII. The Bing Entotic Test—

This test is to differentiate between ankylosis of the foot-plate of the stapes or other pathological conditions interfering with the motion of the ossicles. A eustachian catheter is passed and a speak-tube applied to its end. If the patient hears better through the eustachian catheter and speaking tube than through the external meatus, removal of the ossicles is indicated. The voice may be used instead of a fork.

VIII. Stenger's Test—

This test is used to detect malingering of unilateral deafness. Stenger's test is conducted with two high forks, [AA(435)] exactly alike and perfectly synchronized. If one synchronized tuning fork is brought in juxtaposition with another one which is vibrating, the former will be set into vibration. The distance from the ear at which the forks can be heard is less than aerial distance from one ear to the other. The exact distance (8 inches) is also known by the examiner. The patient is blindfolded and the vibrating fork placed at the farthest distance it can be heard from the normal ear. Both forks are set into vibration, the one before the normal ear being held beyond the hearing point and the one on the supposedly deaf side held within the hearing point. If under these conditions, the patient hears the fork, he is malingering. Again, with both forks held within the hearing distance, the fork is normally heard by the ear which has a fork nearer it. Also one fork may not be set into vibration.

Conclusions: The above include all the tuning fork tests I have found useful. The results of all these are indeed far from satisfactory but by careful attention to the details of the tests, fairly consistent findings are possible. Whereas, if performed in a careless or un-uniform manner, the findings will be consistently contradictory. It is clearly evident that these tests have outlived their usefulness, but we have nothing else to supplant them. I hope that my readers have understood my presentation, and that they will do some original work upon the tuning fork tests or else give us something to take the place of this indispensable otological instrument.

State Control of Venereal Diseases*

By Alex N. Thompson, M.D., Director Dept. Medical Activities, A. M. S. H., and Franklin O. Nichols, Educational Dept., A. M. S. H.

In the history of the control of public health menaces, some one individual or group of individuals has generally stepped forth with a key to the situation whereby the problem was solved. Jenner gave the world an effective vaccine for smallpox and the problem of eradicating the plague which had baffled civilized nations for so long a time was in a fair way of being solved. The contribution of the anti-diphtheritic serum by Behring largely made possible the control of diphtheria. In yellow fever Walter Reed's work in demonstrating the role played by the Stegomyia fasciata in the dissemination of the disease facilitated its successful control.

But all efforts to discover some one key measure for the control of the venereal diseases have proven futile. Since prostitution is admittedly the greatest reservoir of venereal infection there were those who advocated medical examination of the prostitute to make prostitution safe, thereby eradicating the diseases. This proved fallacious. Others urged education as the sole measure. Still others economic improvement. But these were imcomplete in themselves alone. Public health workers were compelled to recognize that they had no analogous method of control as in the case of other communicable diseases. The problem of the control of venereal diseases involved greater complexities and demanded a more elaborate approach.

From the many suggested methods there has evolved in recent years an intelligent and well balanced combination of all measures and factors known by previous tests to have some value. These have been organized into a program of procedure which is inclusive of medical, educational, law enforcement, and recreational measures. It is known as the American Plan and is fast being proven effective in its practical application. While no one person may hope to become master in the application of the several measures, complex and unrelated as they seem to be, it devolves on all engaged and interested in any phase of the problem to become familiar with the broad scope of the program. By this plan we may aspire to even-

*Read before the Fifth Annual Meeting of the John A. Andrew Clinical Society, Tuskegee Institute, Ala., April, 1922.