From: Jim O'Loughlin, AFRL/DEHA 853 8183 30 Aug 01
To: Ken Callahan, JA
Subject: Comments on AFB00148, RF Hearing

1. Sorry that I have been so long in making a reply. Having reviewed the comments from the PTO and also the new claims you are preparing, I notice that there is a serious fundamental misconception of the process by both the PTO and yourself. The claims both old and new have managed to depart from the explanations that I intended and I though made clear in the original disclosure. The following is a more loquacious and simplified rendition of that same material that I hope will provide a better understanding of the basic facts of the invention.

The major previous error in the claim is to imply that the brain acts as an acoustic transducer or demodulator, that is not so. The acoustic demodulation is accomplished by the inner ear just the way it responds to any acoustic stimulation. Such as, an acoustic stimulation transmitted through the air and the outer ear, or more significantly related to the case at hand, by an acoustic stimulation transmitted to the bone and tissue structure of the head. Such as one would experience by tapping on ones skull with ones finger, a hammer etc. Acoustic stimulation of the bone/tissue structure is also possible by an electro-mechanical transducer such as used in some types of hearing-aid devices. The inner ear converts these acoustic signals into nerve signals that are then transmitted to the brain for processing. Everything of an acoustic nature is sent to the brain from the inner ear by nerve signals, the brain cannot hear acoustic signals directly nor can it hear RF signals directly. Everything of an acoustic nature received by the inner ear is from two possible sources, the air acoustic stimulation, such as speech, passed through the outer ear, eardrum, ossicles, and cochlea; or by the conduction of an acoustic signal through the bone/tissue structure of the head directly to the cochlea. Within the cochlea is the basilar membrane that converts the acoustic input to nerve signals, be the original source of the acoustic signal from the outer ear or from bone/tissue conduction. The nerve signals from the basilar membrane go to the brain and the brain does not recognize nor distinguish between the two primary acoustic origins. The acoustic stimulation in material such as bone/tissue is a mechanical vibration, or pressure or relative motion of the material in the form of compressions and rarefactions that compromise the textbook definition of sound or acoustic waves. This stimulation can be accomplished by the application of direct mechanical force or as in the case of the invention by thermally induced-mechanical force or pressure wave. When material such as bone/tissue is heated it expands or moves and if the application of heat is applied at a periodic rate, a thermal-mechanical force and corresponding acoustic pressure wave is the result. The Radio frequency heating of biological matter is well documented and the coefficients of absorption have been measure and are well documented, for example in the Handbook, XXXX . Since Radio frequency power heats bone/tissue material of the head; therefore, applying pulses of radio frequency power to the head will result in the generation of acoustic signals that will be converted to nerve impulses by the cochlea and perceived by the subject as sound. This is precisely how the perception of sound is generated by Radar signals, incident to the head, and it is well documented and has been know for many decades. It follows that if radio frequency power incident to the head can

create the sensation of sound, then it suggests that it may be possible to establish intelligible speech communication by the direct creation of Radio frequency thermally induced acoustic pressure waves in the bone/tissue of the head. This process would by-pass the normal air transmitted mechanism of acoustic pressure wave transmission through the normal functioning of the ear. Prior to the invention, attempts to accomplish the transmission of intelligible speech failed because of the various distortions that garbled the signal. The problem the invention solves is, how one begins with a speech signal, then converts it to a radio frequency signal such that when it is incident to a head, it will thermally induce an acoustic wave in the bone structure that will have the same acoustic characteristics as the original speech.

To better understand the invention we first consider the differences between basic operation of a conventional transducer such as a loudspeaker and that of a thermal-acoustic transducer such as the bone/tissue of the head when subjected to Radio frequency heating. When an electrical signal is applied to a loudspeaker it causes the cone or diaphragm to move and create an acoustic pressure wave in the air to which it is in contact. The acoustic pressure wave has essentially the same amplitude-frequency characteristics as that of the amplitude-frequency characteristics of the impressed electrical signal. Therefore if the impressed electrical signal in turn has the same amplitude-frequency characteristics of an intelligible speech message, the acoustic pressure wave from the loudspeaker will be a reproduced intelligible acoustic pressure wave signal. It is important to note that it is the amplitude-frequency characteristics of the electrical signal that is reproduced by the loudspeaker as an acoustic pressure wave having the same amplitude-frequency characteristics. In the case of a thermal-acoustic transducer it is the power of the thermal signal, *not the amplitude* that is reproduced as an acoustic pressure wave. Therefore the reproduced acoustic pressure wave has an amplitude-frequency characteristic that replicates the power-frequency characteristics of the thermal signal.

Power is proportional to the square of the amplitude, therefore if thermal-acoustic transducer is to replicate the amplitude-frequency characteristics of given acoustic pressure wave, it must be driven by a signal that has an amplitude that is proportional to the square-root of the amplitude of the given pressure wave. This is the basic essence of the invention. That is, given an acoustic speech signal to be transmitter via the RF hearing phenomena such that the recipient will perceive it as intelligible speech; that signal must modulate the Radio frequency signal such that the power of that radio frequency signal is proportional to the square root of the amplitude of the input speech signal.

If for example a normal Amplitude Modulated Radio frequency signal, such transmitted by a common broadcast station, is applied to an thermal acoustic transducer, the resulting acoustic pressure signal output from the acoustic transducer will have an amplitude-frequency characteristic that is severely distorted relative to the original signal and will therefore be unintelligible. This has been experimentally demonstrated and the fact that when the signal is processed by the teachings of the invention the signal is intelligible has also been experimentally demonstrated.

There are several ways to implement the correct power modulation of a Radio frequency signal to accomplish the objective of the invention using existing methods and apparatus as described in the disclosure. Successful experiments have been conducted using the double side-band balanced modulator approach.