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BUREAU OF AIR COMMERCE

SAFETY AND PLANNING DIVISION

NOTE NO. 3

IMPROVED RADIO HEARING AIDS

By
Rogers Humphreys
Chief, Air Transport Section

January - 1938

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When flying under conditions of severe static the crashing noises emanating from conventional earphones are sometimes so annoying and painful that it is impracticable to continue the use of radio.

In an endeavor to alleviate the condition, this section initiated experiments a few weeks ago to ascertain if the "bone-conduction" method of hearing could be efficiently applied to modern aviation radio reception. Briefly, this method consists of conveying the received radio signal to some bony portion of the head by means of a delicately tuned diaphragm from whence the vibrations are transmitted to the inner ear. In passing through the bony structure surrounding the inner ear these sound waves are filtered to some extent and the presence of static crashes, although detectable, are not painful or particularly annoying.

This method of hearing eliminates almost entirely the functions of the middle ear. To facilitate bone-conduction hearing the canal leading from the outer ear to the middle ear is blocked (preferably with moistened cotton) to eliminate extraneous sounds such as engine and propeller noises which, if unrestrained, offer considerable interference.

The objective in these experiments has been threefold. First: if it is possible to materially reduce the detrimental effects of static, better reception of the transmitted signals should be possible thereby enabling the pilot to more accurately maintain his position with reference to the radio range. Second: due to the fact that the middle ear and Eustachian tube are not involved in this method of hearing, rapid altitude changes which sometimes cause temporary deafness due to altered air pressures should have

no effect upon the ability of the listener to hear clearly at any reasonable altitude and at all times. Third: deafness of the conduction type which involves the middle ear is an occasional occupational disorder common to pilots who have been flying many years. By eliminating the use of the middle ear and in relieving it of sharp sound impulses by means of blockage, a tendency toward this type of deafness should be entirely removed and thereby the useful career of the pilot extended.

The most accessible device available for conducting preliminary experiments proved to be a hearing aid designed for those afflicted with deafness and manufactured by the Sonotone Corporation of New York. Through the courtesy and complete cooperation of their Washington representative, Mr. Hodge Lester, the necessary apparatuses were provided by Sonotone at no cost to the Bureau. The device consisted of a small hard rubber diaphragm held in place against the mastoid bone by a spring head clamp. A duplex cord extended from the diaphragm to a plug which could be inserted in the aircraft radio jack. Several types of these diaphragms varying in tone were supplied and all were tested under actual flight conditions.

Preliminary flight tests were conducted by the author as pilot in Bureau aircraft. At later dates flight tests were run by Mr. E. H. Griffin and Mr. W. T. Miller as pilots. Tests indicate that the method possesses merit. At times, when static was so severe as to be actually painful while using air conduction phones, the device just described could be worn without discomfort and at points near the range station the signals were received with reasonable clarity. Due to insufficient power the signal faded sharply

when flying away from the range station. Tests were suspended until a report of findings could be made to Sonotone and a more powerful device provided.

The redesigned diaphragms proved to be only slightly more efficient than the ones first used. It was felt by the author that there was a probability of Sonotone's research director not being fully and technically informed as to the exact nature of the problem and an interview with him was arranged. This took place in Washington, November 18.

Sonotone's Director of Research, Dr. Herman Scheibler, was not fully aware as to what we were seeking, but grasped the purport of our investigations quickly and assured the author that the Sonotone Laboratory would proceed immediately in the fabrication of a device which he felt confident could be made and which would answer the purpose.

On December 17 a letter was received from him which was acknowledged on December 18. Copies of both are appended to this note. His preliminary report, together with the graphs which he refers to, were enclosed with his letter. A copy of his preliminary report is likewise appended. The graphs are attached to the original correspondence and are on file in the Air Transport Section. No further word has been received from Dr. Scheibler.

As soon as there is an opportunity to test the devices referred to in Dr. Scheibler's preliminary report, this note will be made current.

Respectfully submitted,

Rogers Humphreys,
Chief, Air Transport Section,
Safety and Planning Division.

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December 18, 1937

Dr. Hermann Scheibler,
Sonotone Corporation,
Elmsford, New York.

Dear Dr. Scheibler:

Permit us to express our very sincere appreciation of your letter of December 15, the enclosed report and the graphs contained therein. We feel most enthusiastic with reference to the progress you have made.

The manner in which you have stated the problem clearly indicates that you realize what the problem is and we are hopeful that the research which is under way will be successful. Please feel free to call upon us in any way that we may be able to further this project, such as supply aircraft for actual tests, etc.

Due to the very technical nature of this project we shall call upon the Chief of our Radio Development Section to work with this section as soon as you feel that you are ready for further tests.

I hope you will continue to keep us informed as to the progress made. This is such an outstanding study from the standpoint of greater safety in the air that its importance cannot be overestimated.

We shall hold your preliminary report in our confidential files until we both feel that the time is proper for correct publicity.

Yours sincerely,

Rogers Humphreys,
Chief, Air Transport Section,
Safety and Planning Division.

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SONOTONE CORPORATION
Elmsford, New York

December 15, 1937

Bureau of Air Commerce
Washington, D. C.

Attention: Mr. Humphries

Dear Mr. Humphries:

With reference to the interview we had last month in Washington I would like to inform you that upon my return from California we have gone into considerable detail with studying the problem of improving the reception of Beacon Signals under favorable atmospheric conditions.

We have not yet covered the entire field but we have made good progress during the past weeks and I am taking pleasure of sending you enclosed herewith a preliminary report on what we have done so far giving also an indication how we expect to progress further.

Yours very truly,

SONOTONE CORPORATION

/s/ Hermann Scheibler
Director of Research

Dr. Hermann Scheibler
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Preliminary Report on the Study made by the Sonotone Corporation Research Laboratories in view of improving the Reception of Beacon Signals by Pilots

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The problem to solve is, shortly, as follows:

Under normal conditions with clear weather the pilot seldom needs the advantage of the Beacon Signal. The Beacon Signal, however, is of outstanding importance as soon as the visibility is impaired. It happens quite frequently that when the visibility is impaired static interferes with the reception so that just at these times when the pilot would need the advantage of the Beacon Signal he is deprived of it either because the Beacon Signal is completely suppressed by static or because the static is so painful to the ear that the Beacon Signal is completely masked.

Accordingly, the problem under question crystallizes into the problem of elimination or at least considerable reduction of static.

We have endeavored to solve this problem in three stages, or in other words, to attack it from three distinctively different points of view.

Stage 1. - Based upon the investigation I made with the aid of my two collaborators, Dr. Koren and Mr. Shapiro, upon two visits to the Newark Airport and one test flight by the courtesy of the Eastern Airlines, we found that the methods used to suppress static were inadequate. We are now actually working out a special high quality crystal filter which as we hope will be more efficient in suppressing static than the present systems employed, and thus, this factor alone will constitute a step in the desired direction.

Stage 2. - In measuring sound levels in the cockpit of the pilot at an altitude of about 5,000 feet at a normal cruising speed we found that the masking effect of the noises in the cockpit upon the human ear differs very greatly at various frequencies. As the enclosed audiogram shows there is a very marked tendency for a decrease of masking as the frequency of the signal to be received as being increased. So, for instance, while we found that at 256 and 512 cycles per second there was a masking effect of over 70 decibels and at 1,024 cycles it still was about 65 decibels, at 2,048 cycles the masking effect decreases to 30 decibels

Stage 2. (continued)

and at 8,192 cycles the masking effect is only 20 decibels. As these figures and the chart enclosed show the sharpest drop in the masking effect, occurs between 1,000 and 2,000 cycles. These two points showing the tremendous difference of 35 decibels.

These data show very clearly that it is a fatal error to transmit the Beacon Signal at a frequency of 1,020 cycles instead of at around 2,000 cycles because at 1,000 cycles with the noise normally present in the cockpit about 100 times more power is needed to make Beacon Signals audible to the human ear than at 2,000 cycles. This, however, means also that with 100 times greater amplification of the Beacon Signal the static with the reception at around 1,000 cycles is similarly amplified x 100 times more than at around 2,000 cycles.

Thus, this second step of our investigation reveals a very important and definite conclusion, namely, that by simply changing the frequency of the Beacon Signal from 1,000 to 2,000 cycles a considerable improvement can be obtained. In our final report we will also make definite suggestions as to the most economical and practical way of making this improved change. However, our final recommendation in this respect will be subject to the conclusion we shall reach as regards our third stage.

Stage 3. - We studied the possibility of substituting the perception of the Beacon Signal thru the ear by the tactile sense in such a way that instead of using our oscillator on the mastoid bone for the purpose of creating the sound reception of the Beacon Signal in the hearing nerve, we would use the oscillator on the wrist of the hand or possibly shin bone and thus convey the Beacon Signal to the pilot thru the tactile sense. As the chart enclosed shows the maximum perceptibility of the tactile sense of man for vibrations is between 200 and 400 cycles and in all circumstances where the masking noise exceeds about 65 decibels the use of the tactile sense seems to offer decided advantage over the hearing nerve as receiving organ for the Beacon Signals. The use of this latter method would have the tremendous advantage that the detrimental effects of static upon the hearing nerve of the pilot would be eliminated completely. Conversion of the 1,000 cycle Beacon Signal to about 300 cycles (with proper amplification) would be decidedly superior to the present method in use. However, in view of the very important improvement in reducing the effect of static by changing over to

Stage 3. (continued)

2,000 cycles and the further improvement we expect to obtain thru a properly constructed filter system we are at the present moment not yet in a position to make final recommendations and statements as to whether by reception of the Beacon Signal over the tactile sense would be preferable over the reception of the Beacon Signal improved as per methods and changes as recommended in Stages 1 and 2 of this report. We believe that final conclusions on this subject can be reached best by actual experimentation, and accordingly, we are now working on both lines.

In other words, we are constructing a receiver with a most powerful filter system and a frequency converter from 1,020 cycles per second to about 2,000 cycles per second and parallel to this we are constructing a receiver with proper filter system and frequency converter from 1,020 to 300 cycles per second. On the basis of these two methods it then will be possible to find thru practical experimentation the best solution to this problem.

In concluding this report I would like to emphasize once more that as yet it is only possible to give a general view of the present stage of our investigations. We are not yet in a position to make final and definite recommendations but we can, however, state that regardless of what our final conclusions will be it is quite certain that on the basis of our recommendations it will be possible to obtain considerable improvement over the conditions as they are at present.

Dr. Hermann Scheibler
Research Department
December 15, 1937