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THE RELATION OF THE SOUNDS OF FOG SIGNALS TO OTHER SOUNDS.

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IT is now generally known that within the range of possible audibility of most, if not all, the fog signals which the various civilized governments have established along their coasts, each usually in connection with a lighthouse, there are certain areas within which the sound of these signals are inaudible. It is also known that areas of more or less complete inaudibility of sounds, when projected from certain directions, sometimes occur upon the land; but only those which occur upon the water will be specially referred to in this article, and they will be discussed only with reference to their relation to stationary fog signals. Such acoustic conditions being a constant menace to navigation during a fog, the various governments concerned have instituted inquiry into the character and limitations of those areas and, incidentally, into their causes. Our own government has been, and still is, active in experimental studies of this kind, but the records do not show that any of those studies have been more than incidentally directed to that particular phase of the subject which is indicated by the title of this article.

The areas of inaudibility referred to are of two kinds, each area of both kinds bearing a similar special relation to a neighboring fog signal. One of these kinds is made such in every case by a true acoustic shadow of a stationary visible object, usually a small elevated island, or a ridge of land running out into the water, at, or near, one side of which the fog signal is located. That is, such an area is simply one which an essentially permanent acoustic shadow occupies.

The areas of inaudibility of the other kind occur in broad open waters. There is never any visible indication of their presence, and in connection with, or near, none of them is there any visible object above the water surface, and therefore nothing which could cast a true acoustic shadow there. Whatever may be the cause or causes of inaudibility of the sounds of the neighboring fog signal in areas of this kind, it is evident that at least a considerable part of the acoustic conditions prevailing in them are in effect identical with conditions which characterize the other kind. That is, certain of the effects produced within these areas are the same as those which are produced by a true acoustic shadow in each of the first mentioned kind of areas.

It is impracticable to discuss these areas and to compare each kind with the other without applying to each kind a distinctive name. I have therefore selected for the first mentioned kind the name *montumbral*, and for the second, the name *pseudumbral*, areas. The first name is selected because the areas to which it is applied are in every case made such by the acoustic shadow of a hill or ridge. The second name is selected because the acoustic conditions which prevail in the kind of areas to which it is applied are, as has just been mentioned, largely identical with those which are produced in the other kind by true acoustic shadows.

The elevated island or ridge which lies between a fog signal and a *montumbral* area casts an acoustic shadow over the latter just as at night it casts an optic shadow over the same area by intercepting the light from the lighthouse with which the fog signal is connected. The boundaries of a *montumbral* area are therefore determined by the profile outline of the elevated island or ridge which causes it, but they are modified and restricted, as compared with those of an optic shadow, by the great lateral diffusion of the sound waves, and by their tendency to soon coalesce beyond any object which may separate or obstruct them. That is, the lateral boundaries of an optic shadow diverge beyond the intercepting object, while those of an acoustic shadow have a strong tendency to converge there. The diagram which follows further on approximately illustrates the character of a *montumbral* area besides other conditions which sometimes may be connected with it, as will presently be explained.

It will thus be seen that what I designate as *montumbral* areas are in each case identical in outline with an acoustic shadow which is necessarily permanent, or only slightly varying as to its boundaries with changes of atmospheric conditions. Beyond this, *montumbral* areas, unlike *pseudumbral* areas, as will presently be shown, are not potentially variable. Acoustic shadows occur under a great variety of conditions, but *montumbral* areas as I have defined them are not numerous.

Excepting the absence of the direct sounds of the fog signal within a *montumbral* area the acoustic conditions prevailing there are normally the same as are those which prevail on all the water surface adjacent to it. That is, in case no other acoustic shadows are cast there by other objects, intercepting other neighboring sounds, it is an area of inaudibility only of the sounds of the neighboring fog signal and of such other sounds as may be projected from points within a limited distance upon either side of the fog signal. This inaudibility is caused by a complete interception or destructive arrest, by the adjacent elevated island or ridge, of a portion of the sounds which the fog signal projects towards it. All other sounds of whatsoever kind, if sufficiently intense for such distances, may, with the following exceptions, be projected from, into, or across the area in any direction.

The exceptions are that, because the elevated island or ridge intervenes, sounds cannot be projected to points adjacent to its other side from points within the *montumbral* area, and of course such sounds cannot reach the place of origin of the neighboring fog signal's sounds. Also, the projection of other sounds than those of the neighboring fog signal into the *montumbral* area from points at such distances at either side of the fog signal as accord with the length of the elevated island or ridge, will be more or less completely prevented by the presence of the latter, just as it prevents the projection of the fog signal's sounds into that area.

Pseudumbral areas are of more frequent occurrence than are *montumbral* areas, and in various ways they are more important. Still, their discovery is always empirical because there is never any visible indication of their ex-