WILEY

Acoustic Circumstances at the Shooting at the Vessel Albatross in 1915 and at the
Dynamite Explosion at Ljusnarsberg in 1920

Author(s): David Stenquist

Source: *Geografiska Annaler*, Vol. 4 (1922), pp. 109-115

Published by: Wiley on behalf of Swedish Society for Anthropology and Geography

Stable URL: <http://www.jstor.org/stable/519738>

Accessed: 22-06-2016 23:47 UTC

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at

<http://about.jstor.org/terms>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

Swedish Society for Anthropology and Geography, *Wiley* are collaborating with JSTOR to digitize, preserve and extend access to *Geografiska Annaler*

ACOUSTIC CIRCUMSTANCES AT THE SHOOTING AT THE VESSEL ALBATROSS IN 1915 AND AT THE DYNAMITE EXPLOSION AT LJUSNARSBERG IN 1920

By DAVID STENQUIST

On the 2nd of July 1915 the German vessel *Albatross* was shot at in the neighbourhood of the east coast of Gottland, on which occasion the sound of the cannonade could be heard over the whole of Gottland and Öland and over great parts of Småland and Östergötland. On the 25th of November 1920 an exceedingly violent dynamite explosion happened on the high-road 2 kilometers south of the railway station of Hörken near Grängesberg, when a cart loaded with explosive substances, 400 kilos of dynamite was blown up. In this case the area of the sound had only $\frac{1}{4}$ of the radius it had at the shooting of the *Albatross*. The following article will discuss partly the extension of both the areas of sound partly some other acoustic circumstances on the two occasions. Meteorologic-acoustic researches of a similar sort have been made by many authors as it is seen by the bibliography.

The area of sound at the shooting at the Albatross.

At 4 o'clock in the morning on the 2nd of July dull booms were heard from out at sea on the east coast of Gottland. These booms later became more and more loud. At 7,40 o'clock in the morning there could be seen in the hazy air, at some distance outside the bell-buoy of „The Britains”, a vessel, which had lost her foremast, lying almost still, and which vessel proved to be the German mine-cruiser *Albatross*. During the whole time a cannonade was heard from the sea. After a while an explosion was seen on board the *Albatross*, which vessel directly after the explosion made speed and steered north of the shoal „The Britains”, further round the holm of Östergarn and into the sound of Östergarn, during the whole time shot at by two Russian cruisers, which almost at the same time as the explosion happened, were discovered NO and SO of the bell-buoy. The first named of the Russian cruisers pursued, finally laying herself still on lat. $57^{\circ} 28' 20''$ N and long. 19° E, that is to say, within the Swedish

sea territory, all the time violently shooting at the *Albatross*, which vessel moreover during the whole time was receiving shots from the other Russian cruiser, which lay throughout SE of the bell-buoy. At 8,15 o'clock before noon the *Albatross* was run aground close below the signal station, and some minutes before this when she was on lat. $57^{\circ} 25' 36''$ and long. $18^{\circ} 57'$ the Russian vessel fired her last shot against her. When the shooting was most

violent the sound of the cannonade swept over the whole of Gottland from the east coast to the west coast. Over great parts of Gottland it could be observed that the window-panes rattled and that smaller objects (knives & forks) jumped about on the tables.

In order to find out the area within which the shots could be heard I applied to a certain number of persons living within and close outside the supposed area of the sound. From the answers it could be concluded that the sound had been heard over the whole of Gottland and Öland and at several places in Småland and Östergötland. Fig.

1 shows a map of the area of sound. The limit for the area of sound cuts a circle with a radius of 200 kilometers from

Fig. 1. Map of the area of sound at the shooting at the *Albatross*.

the source of the sound. The farthest situated place at which the shots were heard was Rydsnäs in Östergötland. From there mr C. Stiernsvärd (squire of Olstorp) gives the following information: „At the same time as the shooting took place I happened to be busy fishing”, the observer writes, „on Lake Östra Lägern in the district of Ydre. The morning was calm so that the water of the lake was quite smooth, but a slight breeze from the east could *however*, be felt. I perceived distinctly a dull rumble of a cannonade, often with the different shots distinguished from each other. On arriving home, I told my miller about the matter, and he also heard the cannonade, which was still going on. Some months after I met the second in command on the *Albatross* at that time and

could then establish that the said point of time exactly corresponded with the time of the shooting. Already when I had read about the shooting in the newspapers I suspected the connection and obtained information by telephone to Jönköping that no artillery had had any shooting that day either east of my estate or at any other place."

The area of sound at the dynamite explosion at Ljusnarsberg.

A cart loaded with explosive substances started from the dynamite manufactory at Grängesberg at about 8 o'clock in the morning in order to transport them to the Svartvik mines in the neighbourhood of Ställdalen in the parish of Ljusnarsberg. The load consisted of eight boxes containing 400 kg. express dynamite, one box with 1,000 dynamite percussioncaps and a sack with 300 rings of match-cord. The boxes were lying on a layer of sacks and over the whole load was thrown a tarpaulin. The explosion took place at 10,15 o'clock before noon about $2\frac{1}{2}$ km. south of the railway station of Hörken, only ca 50 metres from a power-station belonging to the Ställberg mines. The highroad was especially good and level. The explosion was exceedingly violent. The first persons who were called to the place by the detonation were some workmen from the Ställberg mines. They found some smallish pieces of the cart only and some metres forwards on the high-road the head and the forefeet of the horse. Of the driver there was no trace to be seen. In the high-road there had been blown a hole of a depth of $1\frac{1}{2}$ metres, and the trees around the place within a circuit of about 50 metres had been broken as if they had been sticks. All the window-panes in the power-station were broken into pieces and the tiles on the roof were thrown over each other.

As in this case also it was of interest to find out the extension of the area within which the sound could be heard, I asked for information from several persons living within a district with a radius of 80—90 km. from the place of the explosion. By comparing the information received the map in fig. 2 was constructed. This shows that the extension-district of sound is not at all like a circle with the source of the sound as centre. In the north-easterly direction the sound from the explosion could be observed at the greatest distance (about 80 km.), but in the north-westerly direction the explosion was heard only at a distance of 15 km. This last-named place is situated on Lake Väsman, over the surface of which it seems as if the so-called „acoustic clouds" mentioned by Tyndall must have appeared and hindered the spread of the sound (compare Tyndall *Der Schall* 3 Aufl. Braunschweig Friedr. Vieweg u. Sohn 1897 7th lecture). At the great explosion on the Jungfrau-railway in Switzerland in 1908 it seems as if moist streams in the air from the surface of the Lake of Lucerne had formed

a similar hindrance to the sound-waves. In certain cases not only a single sound but several followed by each other were observed, which is shown by the following observations:

Malingsbo: At first a weak sound was heard and then immediately after that a stronger one.

Neva: a clap of thunder heard far away.

Fig. 2. Map of the area of sound at the dynamite explosion at Ljusnarsberg.

Hällefors: something like the rumble of thunder far away, and something like uncarting of ore, coal or something similar from a railway vaggon.

Järnboås: A weak clap followed by a trembling in the air.

Bångbro: Doors and windows shaken.

Kopparberg: A little shake in some buildings.

Strömsdals Bruk: A blustering clap with 1 or 2 intervals.

The maximum distance for the audibility was about 240 km. at the shooting at the vessel *Albatross*. It is strange that at the siege of Antwerp, when considerably greater cannons were used, the extension district of sound was almost exactly the same. At the bombardment of Antwerp the siege artillery

consisted of 42 cm. mortars, whilst the *Albatross* was shot at with 28 cm. cannons. The charges of 42 cm. mortars and 28 cm. cannons are about 95 and 45 kilos respectively, and the energy-quantities are as these numbers i. e. as 2.1 to 1. The sound from the cannons at the bombardment of Antwerp ought to have reached at least $\sqrt{2.1}$ or 1.45 times as far as the sound at the shooting at the *Albatross*. That the same reach was nevertheless received can be explained by means of the theory given by A. du Bois Reymond (1920).

If a body is swinging with its resonance frequency, the greatest possible amplitude is independent of the greatness of the body but directly (adequate) to the greatest possible material strain and reversed (adequate) to the resonance

frequency. For a certain frequency the greatest possible amplitude is material constancy. According to A. du Bois Reymond, this material constancy varies rather little when passing from one material (an element) to another. One should then come to the result that the district for the audibility on the whole cannot exceed 200 to 300 km. The circumstances at the Krakatoa-eruption are seemingly contrary to this way of reasoning, because the detonation then could be heard 4,000 km. from the eruption of the volcano, on which occasion of 18 km^3 was blown up in the air and the dust particles were thrown up in the air to a height of 30 km. The exception is only apparent, however, as in this case an air-wave free from vibrations arose, which air-wave then gave birth to secondary air-waves for great distances.

On account of the explosion pressure all the window-panes in the power-station — as before mentioned — were broken and the power-station was situated about 50 metres from the place of the explosion at Ljusnarsberg. In this connexion it was observed that the window-panes were pressed *inwards* on the side facing the place of the explosion, but *outwards* on the opposite side of the house. This case is contrary to a case named by Tyndall, when a powder-magazine exploded near the village of Erith in England. The window-panes of the houses in the village were destroyed on the sides facing the powder-magazine as well as on the opposite ones. All the windows in the church were pressed *inwards*, as the lead frames had given way to the pressure. (Arrhenius: Kosm. Physik 11 page 812).

On the ground of effects on trees, window-panes etc. the pressure at a distance of 50 metres at the explosion at Ljusnarsberg could be estimated at about 100 kg. pr m^2 . Starting from this value of the pressure, and from the known weight of the exploding dynamite, I have calculated the effect and the energy evolution at the explosion and the amplitude of the air-waves. If a plain air-wave hits a plain perfectly reflecting surface the pressure is fixed by the equation $p = \frac{2}{V} E$

where E is the energy per second falling on the surface and V the speed of the sound (Rayleigh 1902). If the equation is solved with regard to E (the effect)

you will obtain $E = \frac{1}{2} p V \frac{\text{erg}}{\text{cm}^2 \cdot \text{sek.}}$ The pressure 50 metres or 5,000 cm. from

the place for the explosion was 100 kg. per m^2 or $9,810 \text{ dyn./cm}^2$. As the then prevailing temperature of the air was -3° C you can put $V = 32,900 \text{ cm.}$

From this you get the effect $\frac{1}{2} \cdot 9,810 \cdot 32,900 = 1.6 \cdot 10^8 \frac{\text{erg}}{\text{cm}^2 \cdot \text{sec.}} = 0.02 \text{ horse-}$

power per cm^2 . As this value is valid for 1 cm. surface 5,000 cm. from the place of the explosion, you will have, as the total effect, $2 \cdot \pi \cdot 5,000 \cdot 5,000 \cdot 0.02 = 3.1 \cdot 10^6 \text{ horse-power.}$

8 *Geografiska Annaler* 1922.

The energy evolution is obtained from the weight of the exploding body in the following way. 1 gram of dynamite gives 800 cm^3 gas at a common atmosphere-pressure and thus 400 kg. of dynamite will give 320,000 litres of gas. But 1 liter—atmosphere corresponds to 24.19 little calories and thus the whole exploding dynamite quantity corresponds to $320,000 \cdot 24.2 = 8 \cdot 10^6$ little calories or $3.4 \cdot 10^6$ kgm. From the developed energy and the effect the time of the explosion t will be obtained from the expression $\frac{3.4 \cdot 10^6}{75 t} = 3 \cdot 10^6$ as 0,015 sec.

The time of the explosion thus came up to only *a fractional part of a second*.

A. du Bois Reymond has calculated the following table over the greatest possible swinging-amplitude for some different materials:

steel	2.4 — 9.7 mm.
bronze	2.6 — 3.3 »
brass	2.0 — 2.6 »
wood	4.0 — 8.0 »

The table shows that the greatest possible amplitude varies within rather narrow limits from one material to another, between 3 and 10 millimetres. In order to compare these figures with reality I made done an estimated calculation about the maximum-amplitude which occurred at the explosion at Ljusnarsberg. The energy of sound per cubic centimeter is $= \frac{1}{2} S U^2$, where S is the specific weight of the air and U the greatest speed which occurs with the wave-motion. According to what has been said above, the quantity of energy which during a second passes through a square with a side of 1 cm. and at a distance of 5,000 cm. is $1.6 \cdot 10^8$ erg. If further V is the speed of sound you will find that $1.6 \cdot 10^8 = V \cdot \frac{1}{2} S U$. If V is fixed at 32,900 cm. and $S = 0,00129$ you will have $U = 2,800$ cm. in the second. If you fix the swing-number n at 400, you will find that the maximum amplitude a will be 1.1 cm according to the formula $U = 2 \cdot \pi \cdot a \cdot n$. The value 11 mm. found through this calculation does not greath differ from the values named by A. du Bois-Reymond, 3—10 mm.

If you start from the fact that the amplitude of the wave-motion 50 metres from the place of the explosion was 11 mm., the amplitude at a distance of 100 km. is $5.4 \cdot 10^{-5}$ mm. Rayleigh has by experimenting found that the amplitude with the tone which is most faintly audible is 10^{-6} mm. At the explosion at Ljusnarsberg, therefore, the amplitude of sound at the farthest situated places where it could be observed was about 50 times greater than the weakest audible. If one can suppose that the maximum amplitude in the neighbourhood of the source of sound also in the *Albatross* case was 11 mm., one will have for a distance of 240 km. (the observation in Rydsnäs, Östergötland) an amplitude of $2.2 \cdot 10^{-6}$ mm. or about 20 times greater than the minimum value given by Rayleigh.

Bibliography.

- 1904 G. v. D. BORNE: Über die Verbreitung der durch die Dynamitexplosion zu Förde in Westfalen verursachten Schallphänomene (Die Erdbebenwarte, IV Jahrg, 1904—05, p. 1).
- 1906 G. v. D. BORNE: Über die Fernwirkung der Roburitaufflammung in Witten—Annen. (Die Erdbebenwarte, VI Jahrg 1906—07, p. 110).
- 1908 A. DE QUERVAIN: Die Fernwirkung der Explosion an der Jungfraubahn am 15 November 1908. Ann. d. Schweiz, Met. Zentralanstalt 1908.
- 1910 G. v. D. BORNE: Über die Schallverbreitung bei Explosionskatastrophen (Physik. Zeitschr., 11 Jahrg 1910, p. 483).
- 1912 F. OMORI: The Eruptions and Earthquakes of Asama-yama (Bulletin of the imperial earthquake investigation committee. Vol. VI, N:o 1, Tokyo, 1912.
- 1912 S. FUJIWHARA: On the abnormal propagation of sound wave in the Atmosphere, Bull. of the Centr. Meteor. Obs. of Japan. Vol. II, N:o 1, 1912, Vol. II, N:o 4, 1916.
- 1912 H. GROSS: Akustische Erscheinungen und Kriminalistik. Archiv für Kriminalanthropologie und Kriminalistik. Bd 49, p. 266, Graz, 1912.
- 1913 H. GROSS: Die Zone des Schweigens. Die Umschau, XVII Jahrg., N:o 5, 25 Januar 1913, p. 83.
- 1913 S. SANO: Some Problems on Waves Propagating in Air at an Uniform Temperature. Bull. of the Centr. Meteor. Obs. of Japan. Vol. II, N:o 2, 1913.
- 1913 J. N. DÖRR: Über die Fernwirkung der Explosion Steinfelde bei Wiener—Neustadt (1912, juni 7) Sitzungsberichte der Kaiserl. Akademie der Wissenschaften in Wien, Bd 122, Abt. IIa, Oktober 1913, p. 1686.
- 1914 E. VAN EVERDINGEN: De hoorbaarheid in Nederland van het Kanongebulder bij Antwerpen op 7—9 October 1914, Hemel en Dampkring 1914.
- 1915 A. WEGENER: Vervielfältigung des Schalles, Met. Zeitschr. 1915, Heft. 9.
- 1915 W. SCHMIDT: Zu Erklärung abnormer Hörbarkeit, Met. Zeitschr. 1915, Heft 8.
- 1915 W. MEINARDUS: Die Hörweite des Kanonendonners bei der Belagerung von Antwerpen. Met. Zeitschr. 1915, Heft. 5.
- 1918 CHARLES DAVISON: The Sound-Waves and other Air-Waves of the East London Explosion of Jan. 19 1917, Proc. Edinburgh 38 p. 115—129, 1918.
- 1919 K. GYLLENSTIERNA: Ljudmätning, Artilleri-Tidskrift 1919, p. 95.
- 1920 J. WÜRSCHMIDT: Über die Zone des Schweigens. Erlangen Ber. 50—51, p. 115—146, 1920.
- 1921 G. VON FEILITZEN: Dynamitexplosion i Ljusnarsberg, Teknisk Tidskrift, Stockholm 1921.
- 1921 K. BÜHLER: Albatrosser, A.-B. Chelius & C:o, Stockholm 1921.