accurately noted, as is the fact that great variations of temperature and humidity in a climate generally cool and damp afford the conditions most extremely favorable "for pulmonary tuberculosis." One other point, which deserves constant attention in all our statistical studies of medical climatology to-day, is this:

Large numbers seek milder climates and perish there, whose cases should be set down to the country from which they came.

A chapter (XVII) on the *Permanence of the Principal Conditions of Climate* is appropriately included. A summary of the literature, so far as it was known to him, is given by the author. "For the whole of the vast historic period," he says, "there have been the same deserts in Africa and Asia, the same absence of water in the rocks and soil." As to the evidence for and against climatic "change," our author rightly holds that "real history would be more valuable than anything else if it could be relied on, but there is great looseness with much exaggeration in everything dating back beyond the use of instruments." Blodget believes that "the Northmen found the New England coast 860 years ago quite precisely the same in climate as now—wild vines growing in a very few of the most favored spots, and only in these." In Iceland and Greenland he finds no evidence of a change of climate; only a change in the conditions of people and of government. Dr. Hugh Williamson is quoted as saying, in 1770, that the winters of the last half century had been milder than formerly, and Prof. Samuel Williams, of Harvard College, whose lectures were among the foundation stones of American meteorology, asserted that "the winter is less severe, cold weather does not come on so soon." These views sound singularly like many that we hear expressed in 1913. For Europe and Asia authorities are cited, and the need of accurate observations, extending over long periods, is clearly recognized. The dates of the breaking up of ice in Russian rivers are given back to 1530.

In a section on *Physical Constants* [14] various temperature and pressure data and curves and some meteorological tables are given. Finally, at the end, in a discussion of the climate of the Northwest,[15] Blodget stands out as preeminently a *practical* climatologist. How crisp, clear, confident, and encouraging is his assertion made, we must remember, before the days of our western railway network; before the great waves of population had rolled over the West; before systematic and well-directed observations were available for all this region—that "it is impossible to doubt the existence of favorable climates over vast areas now unoccupied."

It is thus that I wish to conclude this appreciation of Blodget's *Climatology of the United States*, hoping that what I have written may refresh the memories of those who already know the book, and may stimulate others to turn to the original for the inspiration which no reviewer can hope to give.

IS THERE AN AURORAL SOUND?

By JOHN OXAAL, Christiania.

[Translated by Julius C. Jensen from the reprint from "Naturen," April, 1913.]

The northern or polar lights have from the earliest of times, by reason of their prominence in the polar night, attracted the attention of man and compelled him to examine and study them. When it now chanced that science undertook their investigation there remained certain attendant phenomena which defied all explanation. I have in mind a phenomenon in regard to which there have always been sharply defined differences of opinion, which, after all, can perhaps be scientifically explained.

It is this: Are strong auroral displays accompanied by sound? What kind of a sound is this? Under what conditions does it occur? Reports of distinct crackling noises in connection with strong, flaming auroras are almost numberless, but, so far as is known, this sound has has never been observed by those expeditions which have been sent out for the express purpose of studying the aurora, although there are many accounts in which other scientists purport to have heard it.

Sophus Tromholt made a long series of systematic observations of the aurora, and in old files of Naturen are found various discussions by him; but although his attention was directed especially to the question of the auroral sound, his investigations led to no affirmative results in regard to it. Haakonson-Hanson also made careful observations of a similar nature in Trondhjem, but heard no sound. However, it ought to be pointed out that a city is not a favorable location for observations of this kind.

Among the rank and file of the people a strong belief prevails that such a sound actually exists. How general this belief really is appears in an article in Naturen for the year 1892. In consequence of this belief Sophus Tromholt, in 1885, sent out questions concerning both the aurora and the auroral sound, to a large number of those interested in the subject in all parts of the country. Out of 143 who answered, no less than 56, or about 36 per cent, testified to having heard the sound themselves.

It is not merely scientists who, in the course of time, have applied themselves to this problem, and since in most cases the investigations have given a negative result, it is hardly to be wondered at that the numerous accounts which have come mostly from laymen should be regarded with skepticism. It must be remembered that the aurora belongs to that class of phenomena which tends in the highest degree to arouse the imagination. Is it not possible that one may be so influenced by the sight of a gloriously flaming, rapidly shifting aurora, playing in colors of sheerest blue, red, green, and violet, while rays of light suddenly shoot out and disappear again, as to imagine that one actually hears at the same time a crackling, rustling sound? Bearing this in mind, it is perhaps not unreasonable that one should have been led to question the word of scientists who, on other occasions, have shown themselves to be keen and sober observers, and thus have come to regard the whole phenomenon with doubt.

Under these circumstances I believe each individual observation may have a significance, and I will therefore set forth the following:

On a trip to the most northerly part of Finland, in the autumn of 1911, I remained for some time 2 or 3 miles [1] south of Lake Enare. On returning to my hut after the day's work on October 10, while my Finnish guides were preparing supper I witnessed the most beautiful auroral display I have ever seen. Several parallel bands, now two, now three, which alternately united and divided, streamed across the sky from the west through the zenith to the east. They were in constant wave motion, one instant slow and deliberate and the next swift and impetuous, while rays of light darted out from them and disappeared again.

---

[14] Chapter XVIII. [15] Chapter XIX.

[1] Norwegian miles. One Norwegian mile equals 7 English miles.

On the northerly side the bands were of a reddish-violet hue while on the southerly, now bluish, now yellowish-green. The colors were repeated in each band.

Little by little the aurora lost its strength and I sat down to supper. Some time after—unfortunately I can not tell the exact instant—I heard in the north a peculiar, even insistent, rumbling noise not unlike distant thunder. It was so characteristic that I jumped up to see what was going on. The aurora appeared like a bow in the north. It struck me at once that this must be the much-talked-of mysterious auroral sound, and in order to make sure of it I asked my two attendants if it proceeded from the aurora. They replied in the affirmative and continued their work as if it were a well-known and common occurrence.

We may attribute the sound to other causes, but it will be difficult to find a satisfactory one. The air was calm; so it could not have been the soughing of the wind in the forest nor the sound of falling trees. It was 5 miles [2] to the nearest inhabited place toward the north and south, 2 toward the northeast, and several to the post road. It is not likely that any travelers were abroad at this time of the night in the winter's cold. A river flowed past our camp on the south. Its noise could be heard constantly, but it was even, continuous, and of a different character.

I wrote Mr. Waenerberg, superintendent of mines in Thule, west of Lake Enare, to ascertain whether or not the sound had been heard there. He has a long record of meteorological observations, at least 30 years in length, made for the Finnish Meteorological Institute, and is a very careful observer. He replied as follows:

> On October 10, 1911, we had a very beautiful, flaming aurora over the whole dome of the sky, but no sound was heard here. It is when the aurora sinks down low over field and forest that it is accompanied by a noise similar to that of a roaring and rushing stream. Four times in 34 years have I observed this sound and reported it to various observatories, of which Mr. Tromholt's is one.

It is 60 to 65 kilometers from my camp to Thule; so it is not at all unlikely that the sound might be heard at one place and not at the other. Again, it is specially noteworthy that this reliable observer also states he has heard auroral sound, but according to his experience it is seldom so pronounced as to be heard generally.

I might again remark that while the aurora flamed and played in the most brilliant hues no sound was heard.

Another phenomenon which I observed at the same time ought to be mentioned as it probably has some connection with the sound heard. As remarked above, the display gradually decreased in strength. The wave motion became weaker, the definite boundaries disappeared, and the illumination became more general. The sky was quite clear before the appearance of the aurora. After a little, light clouds began to form near the zenith where the aurora had been. The transition, which seemed quite uniform, was peculiar to observe and at a certain point it seemed difficult to determine whether the faint light proceeded from the last rays of the dying aurora or from the fine, light, newly formed cirrus clouds.

According to Prof. Störmer's measurements the aurora's average height above the surface of the earth is 150 km., and therefore much greater than the maximum height of the lightest cirrus clouds. Is there, then, any connection between the aurora and the cloud formation mentioned, has it in this instance dipped down much farther into the atmosphere than usual and is it perhaps only under these conditions that a sound phenomenon accompanies it? Superintendent Waenerberg's observation, that it is only when the aurora settles down low over the fields that it produces a sound, would seem to confirm this conclusion.

I have examined some much earlier works on the aurora in order to ascertain whether or not the older reports contain any accounts of the auroral sound, and shall set down what I have found.

I mentioned above an extract from Naturen, 1892, concerning answers which Tromholt had received in regard to this phenomenon. This article was the result of a discussion in the Chicago Skandinavien in the autumn of 1892. Several persons had there positively asserted that they had heard the sound themselves while others expressly denied its existence. So, in several other old files of Naturen we find reports of the auroral sound, viz, in those of 1880, 1883, and 1885.

Tromholt's large catalogue of auroral observations in Norway up to 1878, published by Schroeter, has numerous discussions of this subject. The earliest, and in some respects rather unreliable, account is that of Absalon Pederssön, dated December, 1563. This recital is so amusing that I will repeat it here:

> One evening a little before Christmas I witnessed the following occurrence which began about 7:30 and continued until fully 9 p. m. Christern Ulff and a goldsmith and both their wives and servants saw it also. At first the moon shone clear in the east. Then a dark cloud which reached high up into the sky came over it. Presently a bright cloud, which shone like a white flame, formed and both remained stationary for some time. After they disappeared an unusually black cloud with scattered cloud wisps all about it approached from the south and overshadowed the moon so that it lost its light. After it had passed the sky grew red in the west and fire and flame darted back and forth so that a great noise was given off. I asked Christern Ulff what caused the sound, as I thought perhaps it came from the Alreichstadselff.[3] He replied, "Don't you see it is in the sky? It was the clouds that ran rapidly back and forth." Afterwards other clouds, some black and some white, overcast the moon and then disappeared.

On January 18, 1778, Dean Wilse of Spydeberg thought he heard the auroral sound.

However, in the large catalogue which contains reports of thousands of auroras, there are few instances of this sound recorded. On March 22, 1840, Ihle observed an aurora in Kaafjord which, according to his report, was accompanied by a peculiar noise. Ihle was a naturalist and has himself given an account of his observations which has been published. He is reported to have heard the sound on two other occasions during the same winter.

It is also reported to have been heard following marked displays in Okso on no less than four different occasions in the course of two and one-half years, viz, September 7, 1851; February 19 and April 21, 1852; and February 24, 1854. But Okso lies far out toward the sea, and even if the reports are true they can not be given much weight since the observations were made in such exposed places.

Sophus Tromholt, who devoted almost his entire life to the study of the northern lights and who has written much in regard to them, has published in the Proceedings of the Videnskapsselskapet for 1880 a paper on the auroral sound which contains many interesting recitals. One of the most interesting of these is perhaps one from Dr. Follum, of Alten, who writes:

> Once, in November, 1856, on Beskades, a mountain ridge between Alten and Kautokeino nearly 1,500 feet above sea level, on the occasion of an exceptionally brilliant aurora with gleaming rays of light shooting out from the crown I heard a peculiar, faint, crackling noise in the sky. My companion heard it also and I remember distinctly having stopped and remarked on the sound.

A more extended report by Tromholt's father, "a skillful and reliable meteorological observer about whose

[2] Norwegian miles.

[3] A river near Bergen.

trustworthiness there can not be the slightest doubt," is of great interest. He purports to have heard the sound three times in all and says that he is sure it could not reasonably be attributed to other causes.

The following contribution from Pilot O. J. Dahle (pilot on the *Haakon Adelsten*) dated March 30, 1910, was furnished me through the courtesy of Prof. Störmer:

> Eight or nine years ago I witnessed from the steamship *Erling Jarl* an extraordinarily interesting aurora. While our ship was crossing Vaags Bay, a little north of Harstad, a brilliant aurora in rapid motion was seen so low down in the air that it barely cleared the tops of the masts. It flamed forth in all the colors of the rainbow and was followed by a peculiar sound, precisely such a sound as would be produced by rubbing together a well-dried skin in the hands. It was neither imagination nor the mistaking of any sound on board, but undoubtedly the result of the movement of the aurora. I have noticed also on other occasions that auroras in rapid motion hanging low in the atmosphere have emitted sounds similar to those mentioned above.
>
> In the above-named display it seemed that the auroral rays had a horizontal position and appeared as separate layers, one above the other. But the probability is that it was a vertical ray which, by reason of its nearness and its position directly over the ship, appeared to to us to be horizontal and that the higher layers were the movements of the same ray seen through this identical ray from below.

The Finnish physicist, Lemström, has written a work entitled "The Polar Lights." Here also are several accounts, one by a miner from Göteborg who was in Lapland in 1842. He describes an aurora observed at night in midwinter in a temperature of − 45° C. A band of rays streamed up from the plateau between him and adjacent peaks and "a rushing sound could at the same time be plainly heard."

The well-known French balloonist, Rollier, who with an attendant ascended from Paris in 1870 during the siege and came down in Lifjeld, Telemarken, reports that he observed polar light rays through the light fog and, "presently a peculiar rushing sound was heard. A short time after, strong, almost suffocating fumes of sulphur were encountered."

Lemström himself, according to his own report, has never heard the auroral sound, but he specifically states that he is convinced of its existence, and this assertion is repeated several times. He speaks of the Laplanders' firm belief in the sound in the following language:

> They say that a rumbling sound can often be heard and since it has frequently been observed by skilled observers, their belief that it actually exists in connection with strong, energetic auroras at low temperatures is absolute.

In a work by Prof. Hermann Fritz of Zurich, in 1881, concerning the polar lights, there is also collected from all sources a great number of accounts of the auroral sound. Upon examining these we come across many well-known men, even eminent scientists, who believe in the existence of this sound, for instance, Prof. Hansteen. We find also in this book various old Norwegian reports.

One would think since so many well-known and highly esteemed men have given such indisputable evidence of having heard the sound that all doubt would gradually be dispelled. But this is so far from being true that, on the contrary, many scientific men, for instance, the famous explorers, Leopold von Buch and Alexander von Humboldt, assert unqualifiedly that it is nothing but imagination. Humboldt says the native population knows nothing of the auroral sound and that it is the transients who have brought the belief with them. But this is a singular misapprehension of the facts, for the belief is especially widespread among the natives. "The polar lights have grown more taciturn," says Humboldt, "since we have learned to observe them more closely," and that is quite possible, for there are probably numerous false reports of the auroral sound, especially those that report it as audible at the time the lights are most active and vivid, for it requires a certain time in which to traverse the distance to the observer.

On the other hand it is not always when the aurora drops down moderately near the earth that it can be heard. There are numerous accounts of the polar lights which, judging from the observers' descriptions, have been very near the surface of the earth and which according to these descriptions have not been accompanied by any sound.

In a work on the height of the aurora by Cleveland Abbe in Terrestrial Magnetism, 1898, are cited a great number of reports of such displays which have been seen against the mountains and hence very near the earth, as for instance, that of the well-known polar explorer, Parry. Sir William Hooker saw the same phenomenon at Ben Nevis, Scotland. General Sabine observed an aurora that was so low that it lay like a fog over the ground, through which he walked. Galle, the famous astronomer, saw a cloud growth following an aurora and also a display very similar to that which I observed in Finland, and I cite Galle's observations here because the account of such a man surely ought to be given great weight. It seems therefore incontrovertible that the aurora, under certain conditions, may reach down into the atmosphere at least to the altitude of the cirrus level, approximately 6,000 meters.

EDITOR'S NOTE.—In a letter from the author, dated Christiania, November 27, 1913, he adds:

> * * * It will perhaps interest you to hear that the only Norwegian member of the Scott Antarctic Expedition, Mr. Trygve Gran, once heard a peculiar noise attending an Aurora Borealis [i. e., Aurora Australis] and Mr. Gran also told me that the party of Lieut. Campbell had repeatedly heard such a noise.

THE METEOROLOGICAL ASPECT OF THE SMOKE PROBLEM.[1]

By HERBERT H. KIMBALL.

THE ATMOSPHERE AND ITS CONTENTS.

Atmospheric gases.—The terrestrial atmosphere consists of a mixture of gases that may be divided into two quite distinct classes: (1) The elementary gases, such as nitrogen, hydrogen, oxygen, and the gases of the argon group; (2) the compound gases, such as vapor of water, ammonia, ozone, carbonic acid gas, etc.

The gases of the first group are practically fixed in amount with respect to one another at any given level (1), while those of the second group are constantly varying not only with respect to the atmospheric conditions, such as temperature, pressure, and humidity, but also with respect to place. This is especially true of gases generated in the processes of combustion, which may be almost unknown in thinly inhabited districts, but which have to be taken into account in the atmospheres of large cities (2).

The gases of the atmosphere hold in suspension considerable quantities of solid and liquid particles. The latter consist principally of condensed water vapor, forming fog and clouds, which may hold in solution substances of various kinds, including some acids, as has been shown by numerous analyses of rain water and snow. The solid particles may be divided into several

[1] Condensed, with additions and revision, from Smoke Investigation Bulletin No. 5, Mellon Institute of Industrial Research and School of Specific Industries, University of Pittsburgh, 1913.