THE AUDIBILITY OF THE AURORA AND ITS APPEARANCE AT LOW ATMOSPHERIC LEVELS

By C. S. Beals

THE earliest reference to a sound accompanying the Aurora, of which the writer has any knowledge, is due to Samuel Hearne.[1] It consists of a description of sounds heard by him in his famous journey from Hudson Bay to the Arctic Ocean in 1770. Hearne expressed surprise that the sound had not been heard by previous explorers, and describes it as "a rustling and crackling noise like the flapping of a large flag in a gale of wind." He claims to have heard this sound during auroral displays, both at Great Slave Lake and at different times on the Churchill river.

Another early reference is by David Thompson.[2] He spent the winter of 1796-97 at Reindeer Lake, Saskatchewan, and writes the following account of a brilliant aurora seen by himself and his men.

"In the rapid motions of the Aurora, we were all persuaded that we heard them, reason told me that I did not but it was cool reason against sense. My men were positive that they did hear the motions of the Aurora, this was the eye deceiving the ear: I had my men blindfolded by turns and then enquired of them if they still heard the motions of the Aurora. They soon became sensible that they did not and yet so powerful was the illusion of the eye on the ear that they still believed that they heard the Aurora".

In 1879 J. R. Capron[3] published descriptions by a number of observers, of the sounds which they considered to be associated with the aurora. These sounds are described as "hissing, whizzing, rustling, crackling or rushing". Capron himself was inclined to decide against the reality of the sound, partly because he had never heard it himself, and partly because of the negative evidence given by many arctic travellers and explorers.

There is a reference in Nature[4] to observations of Major Dawson

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[1] "Journey from Prince of Wales's Fort in Hudson Bay to the Northern Ocean in the Years 1769, 1770-1 and 1772." p. 235, Champlain Society's Edition, Toronto, 1911.

[2] Narratives of Exploration in Western America.

[3] Aurorae and Their Spectra, E. and F. N. Spon, London, 1879.

[4] Nature, *35,* 435, 1887.

in charge of the British Polar Station at Fort Rae, N.W.T., in the winter of 1882-83. He described the sound of the Aurora as "like the swishing of a whip or the noise produced by a sharp squall of wind in the rigging of a ship".

At about the same period there is the record of an investigation on the sound of the Aurora conducted by Sophus Tromholt[5] in Norway. He sent out a large number of circulars containing the following query—"Have you or your acquaintances ever heard any sound during Aurora, and if so, when, and in what manner?" He received some 92 affirmative replies against 20 negatives. The sounds heard were variously described as "whizzing, hissing and crackling, whispering, rushing, tearing of silk, as wind in the trees, like the crackling of a fire, as the flapping of a ship's sails, the noise of flying birds, the sweeping of sand, etc."

The following interesting report, dating back to 1888, has been communicated to me by an official of the Department of the Interior, Ottawa. It is by William Ogilvie, who is described as an exceptionally careful observer.

"As to the Aurora making an audible sound, although I often listened when there was a brilliant display and despite the profound stillness which is favourable to hearing the sound, if any sound occurs, I cannot say that I ever even fancied I heard anything. I have often met people who said they could hear a slight rustling noise whenever the Aurora made a sudden rush. One man, a member of my party in 1882, was so positive of this that on the 18th of November when there was an unusually brilliant and extensive display, I took him beyond all noise of the camp, blindfolded him and told him to let me know when he heard anything, while I watched the play of the streamers. At nearly every brilliant rush of the auroral light he exclaimed: "Don't you hear it?" All the time I was unconscious of any sensation of sound."

More recently, Dr. C. A. Chant, editor of this JOURNAL, has taken a keen interest in the Aurora and has conducted extensive investigations with the object of discovering new evidence concerning auroral sounds. The data which he has collected as well as contributions by others have appeared in different numbers of the JOURNAL, as follows:—[6]

In Vol. 17, p. 273, he has published some 20 or more letters or other communication from persons who have heard sounds accom-

[5]Nature, *32*, 625, 1885.

panying the aurora. In his discussion of the extensive data collected in this paper, Chant comes to the conclusion that the reality of the sound can hardly be doubted. The sounds are usually described as swishing or rustling; more rarely as crackling. In some letters references are made to sharp pops, cracks or reports.

In addition to the evidence which Dr. Chant has collected on auroral sounds, he has published a number of communications from persons who claim to have observed auroral rays or curtains close to the earth's surface.[7]

16, 255, 259, 1922; *17,* 273, 1923; *22,* 28, 398, 1928; *23,* 464, 1929.

The evidence in some cases seems reasonably convincing, since the observers saw the auroral streamers against trees, buildings, or other objects on the earth's surface.

Another recent investigation of the reality of auroral sounds and low level displays, has been conducted by James Halvor Johnson,[8] Turner Terrace, San Mateo, California. Johnson had himself heard the sound of the aurora while in Alaska, and on one occasion had observed auroral streamers between himself and the face of a cliff, 1,200 feet high. This observation, which was published[9] in 1927, made such a profound impression on his mind that it led to an extensive investigation begun with the object of ascertaining whether the phenomena observed by him would be confirmed by the observations of others. His method of procedure was to enlist the aid of newspapers in Alaska, U.S., and the Yukon, Canada, and ask for letters from those who had heard auroral sounds or who had observed auroras at low atmospheric levels.

He received many affirmative replies from persons who had heard auroral sounds, and has published some 20 or more letters giving in detail the circumstances under which the sounds were heard, with descriptions of their nature. The sounds are variously described as swishing, hissing, sizzling, rustling and crackling. More than one observer tells of hearing sharp cracks or reports.

In addition to the evidence as to the audibility of the aurora, Johnson has published a number of communications from those

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[6]Journal R.A.S.C., *1,* 193, 1907; *5,* 154, 1911; *9,* 35, 268, 458, 1918;
[7]Journal R.A.S.C., *9,* 268, 369, 1918; *17,* 305, 1923; *23,* 194, 1929.
[8]Concerning the Aurora Borealis (privately published).
[9]Publ. A.S.P., *39,* 347, 1927.

who have observed auroral curtains or streamers close to the surface of the earth. In every case of such an observation, the auroral light was seen against some object, such as a tree, cliff or building, which would make possible an estimate of its minimum height.

In addition to the evidence presented above, there are two additional isolated references which are of particular interest because the observations in both cases were made by qualified scientists. One of these references, due to Dr. H. D. Curtis,[10] calls attention to certain observations made by him in Cartwright, Labrador, in July and August, 1905. On several nights he heard faint swishing, hissing and crackling noises, which he could only attribute to the brilliant auroral displays in progress at the time. He states that the observations were made under almost perfect conditions of isolation and quiet. On one or two occasions he had the impression, which could not be confirmed, owing to the lack of background objects, that patches of auroral light were close overhead.

A second reference is to an observation of Hans. S. Jelstrup,[11] astronomer to the Norwegian Geographical Survey. He and his assistant, on September 16, 1926, observed a curious faint whistling sound, distinctly undulatory, which accompanied a brilliant auroral display. The sound was heard by both observers to continue over a period of some ten minutes.

Some additional evidence as to low levels may be found in the records of antarctic exploration. In one case[12] an aurora was seen to descend between the observers and Mt. Erebus, and appeared to be as low as 5,000 feet from the observers. There is also an account of several observers together having seen an aurora in a velley below them.

New Observations

The present investigation was begun mainly as a result of interest in the subject aroused by Johnson's publication, which has already been mentioned. It has generally been considered that there is a zone of maximum auroral frequency which is roughly some 23 degrees from the magnetic pole. It occurred to the writer that a

[10]Science, *54,* 301, Sept. 30, 1921.
[11]Nature, *119,* 45, 1927.
[12]Shackleton, Heart of the Antarctic, p. 361.

greater length of this zone passed through Canada than through any country in the northern hemisphere. Accordingly, it would appear probable that the Canadian Arctic should present conditions exceptionally favourable to the hearing of any sound which might accompany auroral displays. Further, because of the extensive services maintained in Northern Canada by the Canadian Government, the Hudson's Bay Company and the Roman Catholic and Anglican churches, there is available as a source of information a large body of men whose intelligence and education is well above the average, and who have had years of experience in regions where brilliant auroral displays are of frequent occurrence.

The method followed has been to send individual circular letters to persons who have lived or travelled in Northern Canada. Each circular contained the following questions:

1. Have you ever heard any sound accompanying the aurora? If so, what was the nature of the sound?
2. Have you ever observed auroral streamers approach close to the surface of the earth? If so, what were the circumstances under which the observations were made?

In distributing circulars and collecting addresses, the writer has had the assistance of the Commissioner, Royal Canadian Mounted Police; the Director General of Surveys; the Director of Signals, Department of National Defence; and various other officials of the Canadian Government. He has also been aided by the Fur Trade Commissioner of the Hudson's Bay Company and many members of the Roman Catholic and Anglican clergy of Canada and Alaska. Assistance has also been given by the Yukon order of pioneers, whose members have furnished a number of sworn statements concerning their experiences with the aurora. In addition to reports from these sources, many letters have been received from others whose addresses have been secured in one way or another during the past two years. Replies to questions have been received from practically every province in Canada, and from many widely separated points in the Canadian Arctic.

In order to gain an idea of the nature of the communications received, a considerable number of extracts from them have been printed here. Dr. J. S. Plaskett, Director of this Observatory, has kindly consented to read through the letters from which these abstracts are taken, and he is willing to certify that in no case is

the meaning or general impression altered by removal from the context. The extracts refer both to audibility and to the observation of auroral phenomena at low levels.

The extracts are as follows:—

(1)

With reference to your letter of the 22nd instant relative to the Aurora Borealis, I am rather at a loss to know just what to say. In reply to your first question, I feel quite convinced that I have heard, and quite distinctly heard, a sound accompanying the Aurora. On the other hand, I realize that scientists may prove conclusively that the Aurora makes no sound. In such case it would be apparent that I must have been mistaken. However, I do not think I was mistaken. The sound I heard on more than one occasion when living in the Yukon was, I believe, unmistakably caused by simultaneous flashes of the Aurora.

The nature of the sound might be described as swishing. To be more precise, it was like that produced by a handful of birdseed being thrown in the air to fall on a hardwood floor.

Signed, F. H. Kitto,
Director, National Development Bureau,
Department of the Interior, Canada.
Jan. 31st, 1931.

(2)

Q. Have you ever heard sound accompanying the Aurora? If so, what was the nature of the sound?

A. Yes, quite distinctly, and it was of a hissing or swishing noise, as of someone shaking a wisp of straw and in some cases it was so pronounced that one almost instinctively turned around to see if anything was following.

The observations giving rise to the above answer were made whilst at Langton Bay, N.W.T., during the winter of 1928-29.

Signed, A. F. C. Tudor,
Constable, Royal Canadian Mounted Police,
Winnipeg, Man., Jan. 13, 1931.

(3)

In reply to question No. 1, I might state that I have personally heard sounds accompanying a display. They were of a cracking nature not unlike the crack of a whip, and also a swishing sound. They were distinctly audible on a clear calm night of extremely low temperature, and the stars also appeared to assume an unusual brilliancy.

Signed, G. I. MacLean,
Gold Commissioner, Yukon Territory,
March 21, 1931.

(4)

Certainly where there is an unusual display of Northern Lights and where they are not only very active, but cover the whole sky, there is a peculiar faint noise, so faint that unless there is absolute silence it cannot be heard. Often I have heard it where the blanket was over my face and I did not know that "the lights were on". But whether it comes from the Aurora or not I was not able to determine. It sounds like two pieces of paper being softly drawn over one another. This description, of course, I had heard many times before I had seen the lights. But it fits very well. I made many experiments of stopping my ears and then suddenly exposing them, and always the same sound was again heard. I wondered at the time whether it might not be the action of the intense cold on the eardrums, as it is very akin to the singing in one's ears caused by coming down rapidly from a high to a low level. Moreover, the noise is not steady, but seems to wax as the streamers form and re-form into various patterns. On clear cold nights when there was no display of lights, I have tried to distinguish the same sound, but could not do so.

Signed, Geo. A. Mulloy,
Forest Service, Department of Interior,
Ottawa, Jan. 27, 1931.

(5)

I have certainly heard the Aurora many times, both in the Yukon Valley and in the western part of the North-West Territories. The sound resembles that produced by a fluid effervescing, or like the sound made by drawing silk over silk.

I may say that at times the aurora is active enough to produce sound, I have observed it in company with a number of other persons, all of whom agreed as to the sound and described it in a similar way.

Signed, L. T. Burwash,
N.W.T. and Yukon Branch,
Department of the Interior, Ottawa,
Jan. 27, 1931.

(6)

*One night in January, 1908, between one and two a.m., when returning to our house at five above Discovery on Sulphur Creek, Yukon Territory, from fifty below Discovery, where a dance had been held, Mrs. Baird and I saw a wonderful display of northern lights.

They were close at hand, exceedingly vivid and a noise like the swishing of a silken garment with an occasional crack, was distinctly audible.

We had seen many similar exhibitions, but had never before known them accompanied by the peculiar rustling noise.

Signed, Andrew L. Baird,
Manager, Yukon Consolidated Gold Co. Ltd.,
November 30, 1931.

(7)

*One night in January, 1908, the exact date I do not remember, approximately fifty people had gathered at a dance held in the hall at fifty below Discovery on Sulphur Creek, Yukon Territory.

Between one and two o'clock in the morning someone came into the hall and said that the northern lights were unusually brilliant and suggested that we go out and see the display.

Everyone in the hall went immediately and we saw the most beautiful panorama I have ever witnessed. The lights were quite close and the colours unusually bright. A sound like the swishing of silk was distinctly heard. Everyone present heard it and commented on it. Many said it was the first time they had heard the sound clearly.

Signed, R. L. Allen,
Land Registrar, Dawson, Y.T.,
November 30, 1931.

(8)

Answer to question No. 1:

Yes. On several occasions in the winters of 1924-25 and 1925-26 at Norman and Simpson, N.W.T. The sound is similar to the long drawn articulation of the word SHOE through pursed lips. The natives (Eskimos) along the arctic coast, that I have spoken to, all said that they had heard the aurora borealis.

Signed, A. N. Bames,
Aklavik, N.W.T.,
Inspector, Royal Canadian Mounted Police,
April 20, 1931.

(9)

I have several times in the past heard a distinct swishing noise accompanying the aurora, but only on very cold clear nights. The occasion that is very clear in my mind is that on about the 10th or 12 th of January, 1927, I was crossing Wellington Bay on the south side of Victoria Island and had camped about midway between the north end of Finlayson Islands and Cape Peel. It was a bitterly cold night and upon coming out of the Snow house about 10.30 p.m. the moon was full and the aurora borealis was very clear, close to the ground and active. By active I mean it was very vibratory and quick moving in form. I then heard a very loud swishing noise and the aurora seemed to take a downward sweep when the noise occurred, also there were two distinct streamers that seemed to come in contact with the tops of the range of hills about 15 miles north of me. After a few seconds the streamers disappeared and the noise ceased, the aurora was again natural. This was so unusual that I watched for some time, but there was no recurrence of noise or streamers. At this time my dogs were unharnessed and lying curled up in the snow. When the swishing noise came so suddenly and apparently so close, most of them immediately jumped up and commenced to

growl. On going into the snow house again I asked the native who was with me if he had heard any noise, and he stated that he had heard the northern lights move a short time ago.

Signed, F. Anderton,
Sergeant, R.C.M.P., Tree River, N.W.T.,
May 25, 1931.

(10)

Both Reg. No. 10521, Constable May and myself are positive we have heard the aurora many times. I have also questioned a number of Indians, and they definitely assert that they have heard them, especially when camped in the higher altitudes.

The aurora streamers have a sound like the faint swishing of pure silk. I have noticed when the aurora is brilliant, the dogs' ears stand up as if they were listening.

Signed, Corporal A. B. Thornthwaite,
R.C.M.P., Old Crow Detachment, Y.T.

(11)

I believe that sound does accompany the displays, and on many occasions while on hunting trips, sleeping in the open, I have heard this sound which might be compared to the distant rustling of silken drapes, and on these occasions I have noticed distinct uneasiness manifested by dogs in camp.

This uneasiness I have noticed particularly in the white Siberian breed, and the dogs whine and turn about in circles when this sound becomes noticeable.

When sheep hunting in the mountains of the Alaska Range, I have seen brilliant displays and have seen the streamers come down in front of the mountain at night when camped in the valleys.

The brilliant nights in the mountains make the snow covered mountains stand out very clearly, and at times the auroral rays distinctly come between one and the background.

Signed, Douglas G. Preston,
Fairbanks, Alaska, Sept. 23, 1931.

(12)

In reply to your request re aurora borealis: On the night of August 8, 1924, fifteen minutes after twelve, I saw the northern lights, as we call it, waving close to the ground and among the poplar trees, with clear sky above. I went out into a field of wheat close to the house and the light played around me and among the wheat like whirlwings, with a sound like silk rustling, or tissue paper.

Signed, S. G. Squires,
Valparaiso, Sask., Feb. 19, 1931.

(13)

On September 2nd. 1906, I certainly had positive evidence that the auroral streamers came close to the surface of the earth. I was on the south bank of the Yukon river, which at this point is about half a mile wide. The north shore is high wooded hills. The streamers came between me and the north shore and came right to the water's edge. Of this there was not the slightest doubt, as the trees could be seen through the openings in the auroral streamers. I might say that the whole sky was covered with these darting streamers, but to the north I had a special opportunity of observing them. At the time we were attempting to exchange time signals with Vancouver, but the telegraph circuit refused to function.

Signed, F. A. McDiarmid,
Geodetic Survey of Canada,
Formerly Astronomer, Dominion Observatory,
Ottawa, Jan. 29, 1931.

(14)

Report of F. Wolki, half-breed Eskimo:

On Banks Island, N.W.T., F. Wolki said he appeared to be in the midst of auroral curtains coming right down to the ice.

Signed, I. Neary, S.M. (W.O.I.)
Department of National Defence,
Aklavik, N.W.T.

(15)

Q. M. S. Griswold, engineer at this radio station, states that at about eleven p.m. one night late in September or early October of 1925, he personally saw a curtain of aurora approach to within four feet of the surface of the earth. The weather at the time was calm, clear and frosty, but not very cold, and the display was particularly brilliant and coloured, though lasting for only about an hour between eleven and twelve. The curtain, which approached the ground, was pale green, and a two-story building could be seen beyond and through the curtain of light. No sensation could be felt on walking right into the curtain, which disappeared from the view of anyone approaching closely; however; other people about a hundred yards from the curtain could see the observer enter and pass through the curtain. This phenomenon was visible at the same time to groups of observers stationed about three hundred yards apart, with the curtain extending east and west between them. No sound accompanied the display.

Signed, J. C. Pearson, S.M. (W.O.I.),
Department of National Defence,
Port Smith, N.W.T.

(16)

In Juneau it was between 7 and 8 o'clock, if my memory is right. I was to ferry the channel from Juneau to Douglas. Quiet, silent, clear sky.

The aurora consisted of big waves of white rolling from behind the mainland mountain walls, (to the east), and tumbling below some few hundred feet, over the channel whose entire width they covered in the shape of a sheet.

There was audible now and then a light sound as the rustle of a stiff silk robe of a person walking.

The waves had the shape of heavy cylindrical masses rolling down on the channel, and after unrolling themselves into a sheet, they would ascend in spreading over the hills (low mountains) on each side.

Signed, Joseph R. Crimont, S.J.,
Bishop of Alaska,
February 11, 1931.

(17)

Answer to Question 2:

Yes, at the same time as the audibility mentioned in question one. The approximate date was in the month of October, 1921. I was in a canoe on the Slave river, probably half a mile above Fort Fitzgerald, Alberta, returning from a short patrol up river. The time would be about 10 p.m. Weather very clear and a cloudless sky. Suddenly the whole surface of the river was lighted up and the northern lights appeared to be right on the surface of the water, accompanied by the sound referred to in question one. Both banks of the river were discernible, the light being so strong, and at this point the river is of considerable width. It might be of interest to mention that this phenomenon was noticed at a point two miles above the head of a 16-mile rapids, and the greatest display of surface contact appeared to be nearest the head of the rapids.

Signed, Corporal R. A. G. Baker, R.C.M.P.,
Jasper, Alberta, Jan. 26, 1931.

(18)

Answer to Question 2:

Yes. During the month of November, 1929, I was camped on Tagish Lake, Carcross District. Between the hours of 7 and 8 p.m., I walked to the lake for some ice and upon my return to the tent, walking through the willows for about 100 feet, the aurora was all around and through the willows. Everything was very bright and hard on the eyes, in the tent everything I touched seemed to be electrically charged.

Signed, Corporal E. Blatta,
Carcross Detachment, R.C.M.P.,
February 24, 1931.

(19)

One evening several years ago in St. Stephen, N.B., I was about two hundred yards from a building blocking the end of a dead end street when I noticed the streamers of the aurora apparently almost touching the building and extending very close to the ground in the vacant lots adjoining to

the south, then apparently almost touching an old chapel, the next building to the south. The streamers appeared much below the eaves of the two buildings.

There was a slight rustling sound or crackling noise accompanying the streamers.

Signed, H. P. Moulton,
Geodetic Survey of Canada,
Department of the Interior,
Ottawa, Feb. 6th, 1931.

(20)

*9 a.m. a miner by occupation. In the winter of 1914-15 I was residing on Gold Run creek, south-east of Dawson, Yukon.

My cabin was situate on a hillside, approximately 2,000 feet above the creek bottom. I left to visit a fellow miner residing a distance from the creek. When at half a mile from my cabin I suddenly became enveloped by streamers of the aurora, and to tell the truth I thought "my time had come". I didn't know what to do, but made the dash of my life for my cabin. I could see the cabin plainly through and by the light of the streamers. The noise occasioned was a shu, shu, shu, as near as I can describe it. There were also sharp quick cracks, something like a rifle report in the distant bush would sound. That's the best description I can give of the cracking, which was quite distinct.

Signed, James Lloyd.

*Testimony made under oath.

The extracts quoted above are representative specimens of the reports. Many other similar accounts have been received and the data as a whole may be briefly summarized as follows:

Total number of letters received	141
No. of persons reported as having heard auroral sound	144
No. of negative reports as to audibility	40
No. of actual descriptions of sounds	106
Reports of sound heard but not described	38
No. of reports of auroral light seen at low levels	22
Cases in which a background object was clearly seen behind the auroral light	10
Cases in which the auroral light appeared in actual contact with ground	8
Cases where observers had the impression of a low level display, but evidence unconvincing owing to lack of background object	12

The description of sounds were almost monotonously similar to one another. Fully 95 per cent. of them come under the headings of hissing, swishing, rustling or crackling. Presumably the terms "hissing" and "swishing" are different ways of describing the same type of sound. The terms "swishing" and "rustling" also seem to be used almost synonymously, as some speak of the "swishing of silk", while others speak of the "rustling of silk" in describing the sound. The term "crackling", on the other hand, seems to refer to a different type of sound, and many observers speak of hissing and crackling or swishing and crackling as though there were a clear distinction between the two. This is illustrated by the following examples of individual descriptions: "feeble crackling, also rustling of silk"; "faint 'sh' sound accompanied by faint crackle"; "shu, shu, shu, sound accompanied by quick cracks"; "hissing, cracking sound", etc. It seems probable, therefore, that the reports may be interpreted as definitely indicating only two distinct types of sound which correspond to swishing and crackling, respectively.

The descriptions of low level auroras are less numerous than reports on audibility, but a number of the observations appear to have been very carefully made, and in some ten cases a low minimum height is fixed by the observation of a background object on the earth's surface. In a majority of cases, trees or nearby buildings provided the background objects, but in two cases the auroral light was seen against a mountain background. The observations of F. A. McDiarmid (No. 13), and H. P. Moulton (No. 19), seem especially convincing, as both of these men are well-known and highly qualified observers.

Discussion of Data

In discussing the data of this and previous investigations, the first question to consider is whether the phenomena observed have genuine objective reality or whether they are in some way due to the imagination of the observers. The suggestion has frequently been made that the "sound" of the aurora is purely imaginary and due to the rapid motion of the streamers suggesting a sound to the mind. Another suggestion put forward by Samuel Sexton,[13] an American physician, in 1885, is that the so-called sound of the aurora is in reality due to noises in the head, a complaint from

[13] Nature, *32*, 625, Oct. 29, 1885.

which about 50 per cent. of persons suffer. Still another ingenious suggestion has been made to the writer by a number of persons including F. J. Davies, physicist with the Byrd Antarctic expedition. Davies said that he had observed on more than one occasion certain swishing and crackling noises due to the rapid freezing of the moisture in the breath at extremely low temperatures. The possibility that this effect is responsible for the widespread belief in the sound of the aurora must be seriously considered. Finally, there remains the fact that many competent observers who have spent years in the arctic and who have witnessed hundreds of brilliant auroras, have never observed any sound associated with them.

Probably the best evidence in favour of the reality of auroral sounds is that practically all observers who have heard them describe them in the same way. From Samuel Hearne in 1771 to persons who have submitted reports in connection with the present investigation, there is general agreement that sounds associated with the aurora are of a swishing, rustling or crackling nature. Even the descriptions published by Capron, who apparently did not believe in the reality of the sound, correspond closely to those given in communications received during the present investigation.

The suggestion that the sound is due to noises in the head should, perhaps, not be taken too seriously. If this is the real cause it is difficult to see why the sound should be heard only during auroral displays, or why it should be heard only during an occasional display.

The idea that the sound is due to freezing of moisture from the breath is subject to similar objections. There is no reason why it should be heard only during auroral displays. Moreover, it should always be heard when the observer listens intently during a display at 40 or 50 below zero. That this is not so is evidenced by many reports that the sound is heard rarely. Even more convincing evidence against this suggestion is the fact that numerous reliable observers report sounds detected in midsummer, or in the fall when the weather was not extremely cold. *E.g.*, Dr. H. D. Curtis, who heard the sound in Labrador during July and August, 1905.

Probably the greatest obstacle to belief in the reality of the auroral sound is the fact that many residents in the arctic and many

arctic and antarctic explorers have never heard it. Even though the weight of evidence of this and previous investigations is on the affirmative side, it is necessary, if the sound be not attributed to the imagination, to find some logical explanation of this considerable body of negative evidence. From the data of this investigation a number of considerations bearing on this aspect, occur to the writer and it seems probable that, taken together, they should help to reconcile conflicting accounts given by different observers.

1. The first consideration has already been mentioned, and has been repeatedly forced to the writer's attention. It is that the hearing of auroral sounds is a rare occurrence. One observer has estimated that of the brilliant displays which he has witnessed, less than 5 per cent. give rise to audible sounds. Several others state that the hearing of sounds is infrequent in comparison with the frequency of the displays themselves, while there are numerous reports from persons who have spent 20 or 30 years in the arctic but who have heard the sound on only one or two occasions.

2. The second consideration is that of locality. There is some reason to believe that there is a zone of maximum auroral frequency, roughly some 23° from the magnetic pole. It seems very unlikely, however, that conditions along this zone are completely uniform as regards intensity and audibility of the displays. It would appear reasonable to expect a certain amount of local variation, particularly where audibility (presumably a low level phenomenon) is concerned. If this is the case the hearing of a sound might depend on the observer being in a favoured locality.

3. The third consideration has to do with possible difference in acuteness of hearing. In this connection the report of William Ogilvie, quoted in the introduction to this paper, may be of considerable importance. His report appeared to offer conclusive evidence of two observers side by side, one of whom heard the sound, while the other did not. We may be practically certain that there is a considerable range in the ability of persons of "normal" hearing to detect faint sounds or sounds of high pitch. It might well be, therefore, that one observer of ordinarily acute hearing would be incapable of hearing the sound produced by the aurora on ordinary occasions, but might hear it more rarely when it was unusually intense. A second observer with an exceptionally keen sense of

hearing might hear a sound which was completely inaudible to the first. This hypothesis may account for the fact that some observers with wide experience of auroras, report hearing the sound often, others report hearing it very rarely, and still others not at all.

In the matter of low levels auroras the evidence is in most cases reasonably definite and unequivocal. The observers saw the auroral light or streamers outlined against some background object, which seems definite evidence that the displays occurred close to the earth's surface. The evidence as to low level displays provided by the present investigation is substantially similar to that presented by Chant and Johnson. From all three investigations there are some 20 communications in which the observations, as described, seem satisfactory from a scientific point of view and a number of others which are reasonably convincing. It would be easy to dismiss one or two of these observations as due to self-deception or to optical illusion. The majority of them, however, give the impression of being reliable. The fact that two of the observations were made by persons trained in astronomy and precise surveying, adds a considerable amount of weight to the positive evidence.

Interpretation

The only interpretation of the observations which seems to fit all the facts is that both the sounds and the low level apparitions are real, and that they constitute normal though perhaps unusual accompaniments of other auroral phenomena. If this is so, then there must be some definite physical process taking place close to the earth's surface which is able to produce the effects that have been observed. As far as the writer is aware, suggestions which have been made as to the nature of this process have all tended in one direction. Dr. C. A. Chant[14] has pointed out the similarity of the auroral sound to that of a brush discharge, and has definitely made the suggestion that there is present an unusual electrical condition of the atmosphere, which results in the production of some sort of an electrostatic discharge. A similar suggestion has been made by J. P. Henderson,[15] who has studied the matter from

[14]Jour. R.A.S.C., *17*, 273, 1923.
[15]Jour. R.A.S.C., *17*, 375, 1923.

the point of view of the influence of the aurora on wireless reception. In one of the communications published by Johnson,[16] an observer in Wasilla, Alaska, had frequently seen faint sparks on a metal horse on top of his flagpole during an intense auroral display.

[16]Concerning the Aurora Borealis.

The writer has received numerous communications, both written and verbal, from persons who considered that the sounds which they heard during a display were identical with those heard during certain types of electrical discharge. There have also been received a number of communications stating that land telegraph lines have been seriously affected or put out of commission during intense auroral displays.

The aurora has long been considered to be electrical in origin and the hypothesis that the auroral sounds and low level displays are due to some sort of electrical discharge near the surface of the earth, seems a very reasonable one. There exists convincing proof[17] that some of the phenomena connected with the aurora take place many miles above the surface of the earth. The fact that this is the case does not, however, preclude the existence of electrical and luminous effects at lower levels. Certainly the data of this investigation and the previous ones of Chant and Johnson strongly support the idea that such effects are real. Finally, there remains to point out the fact that the hearing of auroral sounds and the observation of auroral light at low levels represent mutually confirmatory data

[17]Stormer, on the Height of the Aurora Borealis.

in so far as the reality of the phenomena are concerned. If the sounds are due to electrostatic discharge of sufficient intensity to be audible, luminous effects at low levels would be expected to accompany them, and vice versa.

If the evidence presented in this and preceding investigations be accepted as valid, the conclusion necessarily follows that theories of the aurora must be modified in such a way as to take account of the low level phenomena.

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