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Eskimo Snow Goggles in Danish and Greenlandic Museums, their protective and optical properties

Mogens Norn

Man & Society
20 · 1996

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H. C. Gulløv, The National Museum of Denmark, Ny Vestergade 10, DK-1471 Copenhagen K, Telephone + 45 33134411, Telefax +45 33144421

Instructions to authors. See page 3 of cover

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MOGENS NORN

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Object: To assess the optical and protective properties of ancient Inuit snow goggles on the basis of a large number of specimens.

Methods: Measurements, drawings, photos, and calculation of visual field.

Results: Classification into eleven types of apertures, illustrated and described. Types A-C have rectangular slits of three sizes. D has slits on separate blocks for each eye. E has a single long slit for both eyes. The other types do not have a rectangular slit: Type F has a single long figure-of-eight-shaped slit for both eyes; G has a drop-shaped slit for each eye; H has a triangular slit, I several slits, J binocular-like openings and K a round opening, in some cases covered with glass.

The visual field of the user is limited upwards and downwards, so there is a compromise between purely visual requirements and protection.

Visibility is improved and dazzle is prevented (model experiments).

The snow goggles reduced harmful light to 2-8%. These snow goggles do not mist over. Other aspects examined are material, dimensions, blackening, fixation to the head, ornamentation, repairs, unilateral slit occlusion and dating.

Geographical differences: The Greenlandic goggles are often somewhat larger than the Canadian ones, and the slit is frequently figure-of-eight-shaped or drop-shaped, whereas triangular slits or a separate goggle for each eye are more common in Canada.

Key words: Snow goggles, slit spectacles, Inuit, Eskimos, Greenland, Canada, snow-blindness, perimetry, visual acuity.

Mogens Norn, M.D., The Medical History Museum, University of Copenhagen, Bredgade 62, DK 1260 Copenhagen K, Denmark.

Introduction

Purpose

The main purpose of the present study was to assess, for the first time on the basis of a large body of material, the limited area that can be viewed through the slits of snow goggles, i.e. the visual field of the Eskimo snow goggles.

The ancient snow goggles have eye slits of different sizes and shapes. I have investigated the visual field of each specimen, the protection it provides against harmful light, cold, and draught, and thus the possible improvement of central vision.

The largest possible number of Eskimo snow goggles in museums was examined for the purpose of grouping them into a limited, manageable number of types based on the properties of the slit, and comparing the resulting typing with the geographical origin of the snow goggles.

The individual types will be described in detail and illustrated by characteristic examples.

As a rule these goggles are cut from a wooden block and provided with two slits. The visual field of the goggles is restricted, as it is not possible to see upwards or downwards. This means there is a risk of stumbling, as the wearer cannot see depressions in the ground.

In spite of these difficulties, the snow goggles must have had a function known to the Eskimos.

The protective properties of the snow goggles include protection from strong sunlight, cold and draught. The present investigation has demonstrated the extent of protection from ultraviolet light and visible short-wave light, which cause snow-blindness by photochemically destroying the corneal surface.

The optical properties of snow goggles are evident from, among other things, the improvement of vision against the light and in cases of mild myopia (short-sightedness). Unlike sunglasses, the snow goggles do not mist or ice over in the polar climate.

Presentation of material

To investigate the protective and optical properties of the snow goggles, I studied all accessible Eskimo snow goggles in Denmark and Greenland, a total of 59 specimens.

43 of these were from the Department of Ethnography of the Danish National Museum: specifically 14 from Greenland and 29 from Canada. The remainder are in Greenland – ten in the National Museum of Greenland in Nuuk, three in the museum of Tasiilaq in East Greenland, one in the Medical History Museum at the University of Copenhagen, and two are owned privately. All 16 goggles are from Greenland.

Apart from this material, I know of Greenlandic snow goggles which I have not had the opportunity to examine. Some of these are owned privately in Greenland and Denmark and others have been given by the Danish National Museum to museums in Leipzig, Ottawa, New York, Turkey, Cambridge, and Sydney in 1922-24, a total of six pairs of snow goggles (according to the records of the Department of Ethnography).

Method

All 59 pairs of snow goggles were taken out of the exhibition cases or stores of the museums. They were described in detail, drawn from five different angles, and measured. Measurements were also made of the dimensions of the slits and their distance from the eye. Then the visual field was calculated for each pair of goggles.

Calculation of visual field

The visual field was calculated for an average person with an interpupillary distance of 60 mm, an eyelid thickness of 1.5 mm, and with the nodal point (optical centre) of the eye 7 mm behind the corneal surface (Duke-Elder 1970a).

The position of the eye in the slit of the snow goggles (fixation point of the eye straight ahead) was marked in the aperture of the snow goggles 30 mm from the centre of the goggles. The visual field was then calculated vertically, temporally and nasally.

Vertical visual field: The vertical visual field was calculated on the basis of the following formula (cf. Fig. 1): tangent (x) = $\frac{d}{a+b+c}$ where *d* is the height of the slit; c the distance from the anterior edge of the slit to the closed eyelid, measured with the snow goggles on the author's head with millimetre paper passed through the aperture of the snow goggles; b is the thickness of the eyelid; and a is the distance from the anterior corneal surface to the optical centre of the eye.

The temporal and nasal visual fields were measured with the same formula, where d is the distance from the fixation point of the eye straight ahead to the temporal and nasal end point of the snow-goggle aperture respectively.

Direct measurement of the visual field (arc perimetry) with the snow goggles on gave results approximately the same as the computed results (one pair of snow goggles examined).

The visual field was calculated on the basis of measurements made on one person (the author) for the entire sample of snow goggles, so that the visual fields of all goggles could be compared directly. The author's interpupillary distance is 60 mm (Eskimo average 60.26 mm for men – Skeller 1954: 150), exophthalmometry 17 mm (Eskimo 16.48 (Skeller 1954: 150)). With increasing exophthalmos the visual field will increase (about 1-2%/mm – cf. formula). The visual field will thus depend not only on the dimensions of the snow goggles, but also on the individual wearing them.

The summit distance (c in Fig. 1) is of great importance. Regrettably, this measurement was not done at the beginning of this study in Greenland. Accordingly, the visual field material comprises only 46 pairs of snow goggles.

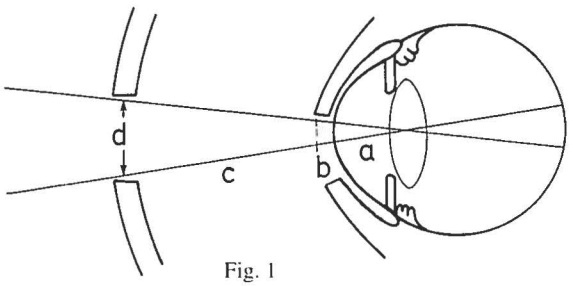


Fig. 1

Description of types of snow goggles

The optical and protective properties of the snow goggles mainly depend on the size and shape of the slit.

On the basis of the properties of the eye slit, the total sample of snow goggles can be divided into 11 different types (Table I and Fig. 2). A description of these types (A-K), illustrated by one or two characteristic specimens within each type, follows below.

Fig. 2. The specimens may be divided into the following 11 types: A-E with a rectangular slit (A short, C very long), D with slits on separate blocks in front of each eye, E with a single slit for both eyes.

The remainder do not have rectangular slits. Type F has a single long slit for both eyes, narrowing in the middle, G has a drop-shaped slit, H has a triangular slit for each eye, I has several slits, J is binocular-shaped, and K has a round opening covered with glass.

▶

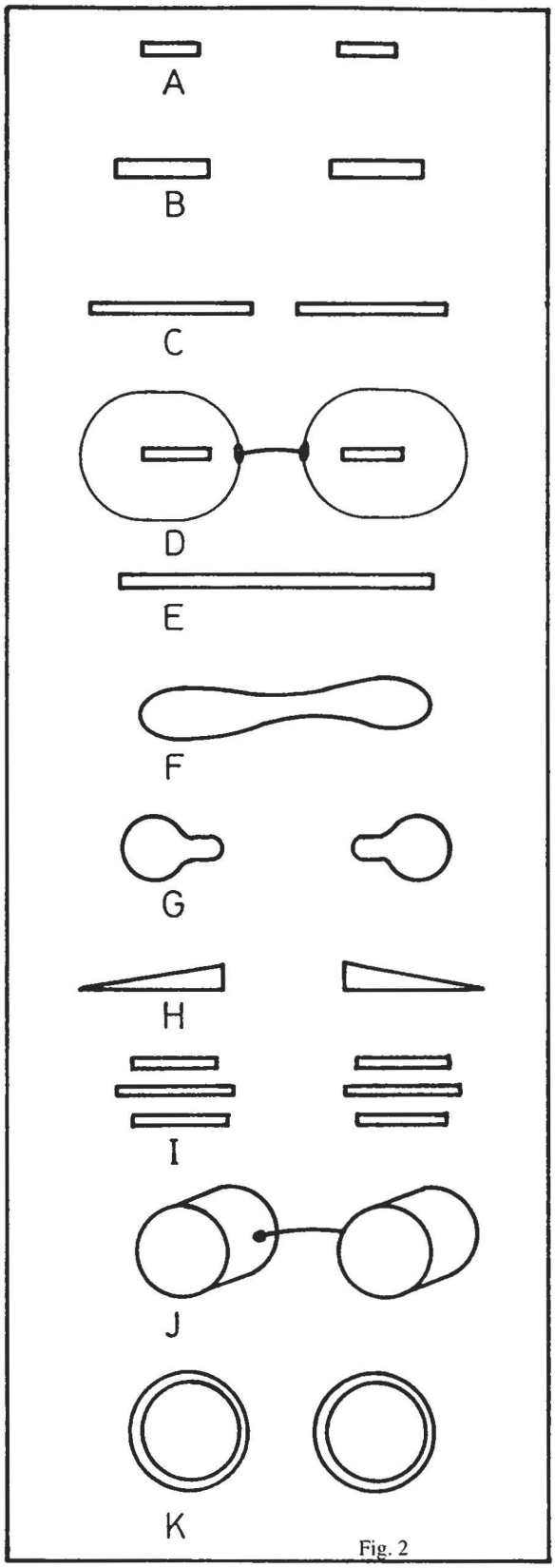
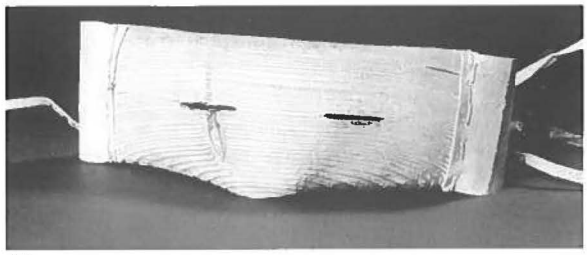


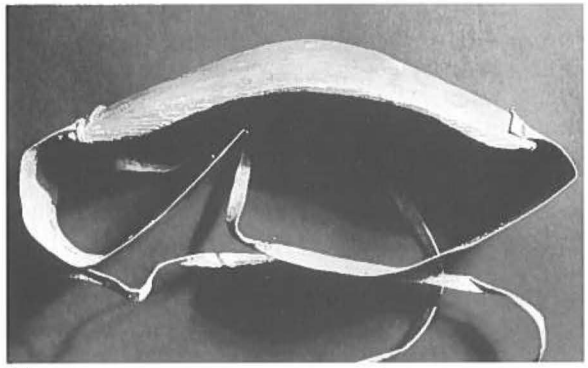
Fig. 2

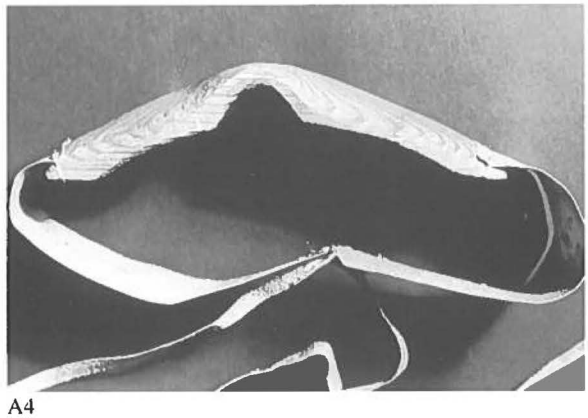
Type A

Definition: Snow goggles of Type A are characterized by small rectangular horizontal slits (apertures), one in front of each eye.


A1


A2


A3


A4

Dimensions: The specimen shown in Fig. A measures 14 x 5.8 cm. Its slits are only 1 mm vertically, 21 mm horizontally, 1 mm deep, and the distance from the anterior edge of the slit to the closed eyelid of the wearer is 21 mm. This entails a visual field of only 2° vertically (1° upwards and 1° downwards), 8° temporally and 25° nasally, the right eye seeing farthest to the left and the left eye farthest to the right, i.e. crossed vision.

Material: The snow goggles are cut from a piece of wood, and worn with leather straps.

Design: The wooden block is of an elegant shape, its central area at the front resembling a nose (Fig. A1).

From the back (Fig. A2) it is clear that the piece of wood is solid peripherally and temporally. This protects the sides from cold and wind, and forces the piece of wood forward, leaving ample room for the ocular region, while the snow goggles also fit well in a turned-up hood which further forces the wearer to use crossed vision.

At the top the goggles are of a nicely curved shape (Fig. A3), fitted to the curvature of the head. At the bottom the goggles are cut out for the nose (Fig. A4).

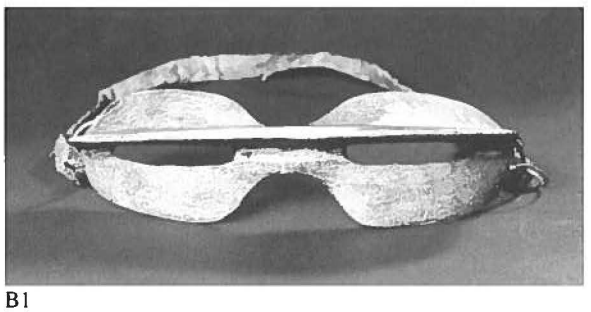
Fixation: The goggles are tied round the head with two leather strips 5.8 mm broad at the wooden block and gradually decreasing to 3 mm. Their length is 13 cm. The thick end is sewn to the wood through 12 holes on each side. The two leather strips are joined at the back by a 5 mm thick leather strap.

Blackening: The back of the goggles is blackened with soot to protect the eyes from reflected light escaping through the narrow slits. The great distance from slit to eye means a smaller visual field, but greater protection from the light.

Dating: The snow goggles from Maniitsoq donated to the National Museum of Denmark by I. M. Møller, colony principal, and dated 1800-1850, are normally kept at the Brede museum, but are at present on view at the Department of Ethnography (Museum No. Lc 78).

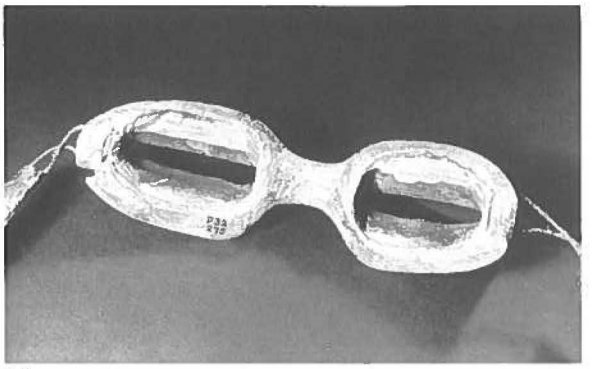
Type B

Definition: Like Type A, the snow goggles of Type B have rectangular, horizontal slits, but these slits are longer and consequently afford a wider visual field.

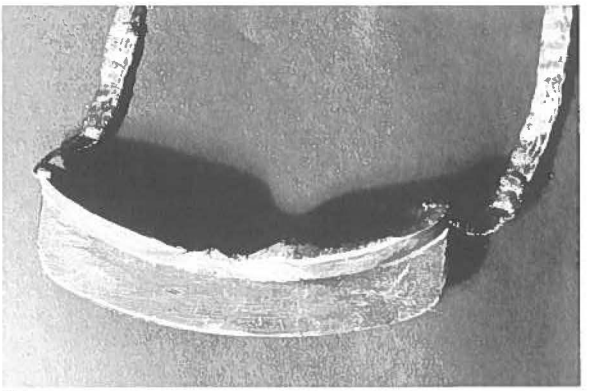


B1

B2



B3



B4

B5

Dimensions: The snow goggles shown in Fig. B measure 13 x 3.6 cm. The two eye slits, which are 40 mm long and 6 mm in height, afford an excellent visual field (8° vertically, 21° nasally, and a whole 29° temporally). They have a peak or shade projecting 2.5 cm in front of the eye slit. This shades the eyes from light from above, permitting a better visual field than Type A. On the other hand, the eyes are relatively unprotected from ultraviolet and visible light reflected from ice and snow.

Material: These snow goggles are cut from one piece of wood, and worn with a sealskin strap.

Design: The description in the National Museum records is: "two oval ocular areas connected by a narrow bridge". To this we can add that the two eye slits are immediately beneath the shade, and are connected by a concave groove which emphasizes the distinctive construction (Fig. B1). At the back there are two grooves with ample room for each eye (Fig. B3). There is a small defect in the wood beneath the left strap. Above (Fig. B4), the shade has a constant width, affording effective protection of the eyes. Below (Fig. B5), there is a relatively small notch making the wooden block project in front of the face.

Fixation: The goggles are fastened behind the back of the neck by a thick sealskin strap attached to the wooden block by two strings on each side through holes in the wood (cf. Fig. B3).

Blackening: There is blackening on the back immediately around the slits.

Dating: These snow goggles were collected by Knud Rasmussen during the Fifth Thule Expedition and brought to Denmark in 1924 (Museum No. P 32.275).

Conclusion: This specimen exhibits special features: it has a shade and a tendency towards a bowl-shaped depression for each eye. Both features indicate a Canadian origin (cf. Type D below). The other six specimens of Type B do not have these features, but resemble Types A and C except for the medium-sized eye slits.

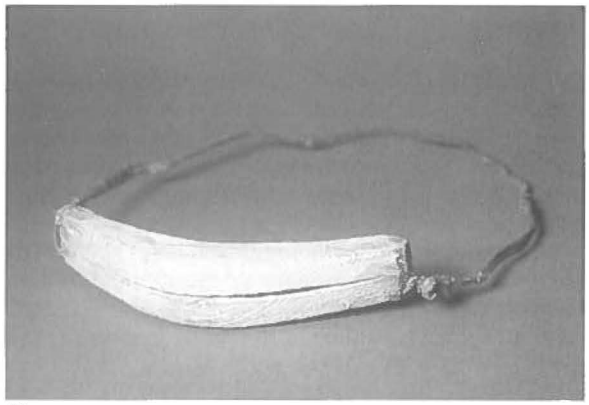
Type C

Definition: Snow goggles of Type C are also characterized by rectangular, horizontal eye slits, but of maximum length. This type thus provides a wide horizontal visual field, but not much of a vertical visual field.

Dimensions: Type C is 14 cm in length and 2.6 cm in height. The slit for each eye is 57 mm long and only 2 mm in height and 2 mm deep.

The vertical field of vision is only 4°, the nasal and temporal 43° and 49° respectively – a total of 92° for each eye.

A normal eye without goggles has a field of 60° nasally and 90° temporally, a total of 150° horizontally.



C1

C2

Material: These snow goggles are cut from one piece of wood.

Design: The goggles are slender and curved, with very long, narrow eye slits (Fig. C1). One might expect the slits to join in the middle, but in spite of the continuous anterior groove, it can be seen from Fig. C2 that there are two separate slits with a distance of 18 mm between them. The groove at the back of the piece of wooden leaves ample room for both eyes.

The groove for the nose may be seen below, and the cavity continues on the lower part at the back.

Fixation: These goggles are fastened to the head by tendon strings fastened to the wooden block in two grooves. The string is visible in the ocular cavity. The strings join up on each side of the wooden block, respectively 0.4 and 2 cm from the wood, and continue as a single string around the back of the neck.

Blackening: These goggles are apparently not blackened, but we cannot preclude the possibility that they once were.

Dating: These goggles were also brought to the Danish National Museum in 1924 by Knud Rasmussen (Museum No. P 29.65). They are from Netsilik, Canada.

Type D

Definition: Type D goggles have two slits on separate pieces of wood for each eye. The two pieces are joined by a cord across the nose. In shape the type resembles swimming or sun-bed goggles. Each wooden block covers one ocular region and protects the periocular area.

Dimensions: The snow goggles in Fig. D consist of two oval pieces measuring 60 x 33 x 15 mm (width x height x depth) joined by a 13 mm long sinew thread, so that the width of the entire pair of goggles is 133 mm.

At the front (Fig. D 1) it can be seen that the slit is approximately rectangular. The slit height is 1.5 mm, at the position of the normal eye (60 mm interpupillary distance), i.e. slightly nasally from the centre of the slit. The visual field may be calculated as 4° vertically, 32° nasally, and 50° temporally. The vertical visual field is slightly more on the temporal side.

If the string connecting the two wooden blocks were a little longer, the nasal visual field would be even smaller. Thus the length of the string is crucial to the effectiveness of the goggles and in this case has been well chosen, although it must have been difficult to calculate the correct length.

Material: These goggles are cut from two pieces of wood, and are connected with each other with sinew thread, and worn around the head with a string.

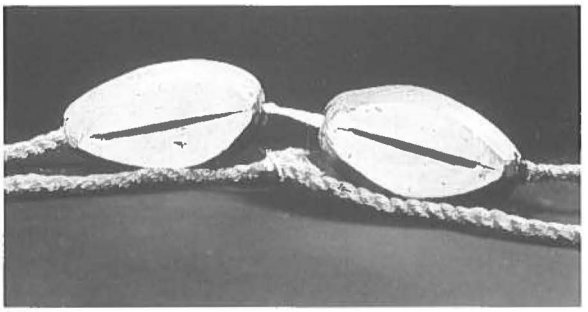
Design: The two oval pieces of wood are symmetrically shaped, each covering one eye region, and afford good protection of the eyes, as they rest snugly in the ocular surroundings.

Fixation: The two pieces of wood are joined by sinew thread passed through holes drilled in the nasal edges of the pieces of wood and stopped by knots inside the blocks.

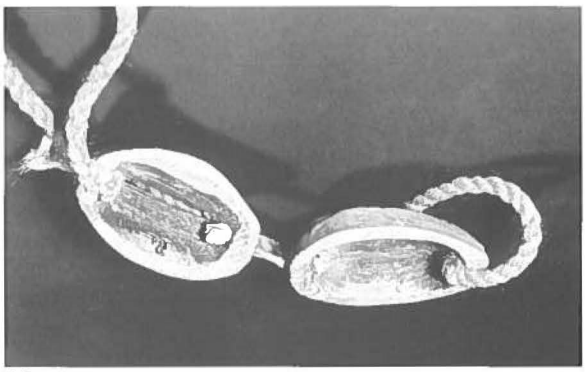
At the temporal ends there are similar holes through which a string is passed and stopped by a knot. The string fixes the goggles to the head behind the back of the neck, where there is another knot in the string.

Blackening: Fig. D 2 shows that the concave parts of the goggles are blackened at the back, and to a lesser extent at the periocular edge.

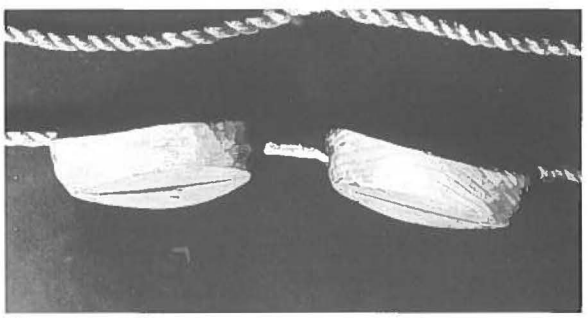
Dating: These goggles are from Eskimo Point, Canada, and were brought back by the Fifth Thule Expedition in 1924 (Museum No. P 28.66).



D1



D2



D3

Type E

Definition: This type is characterizéd by a single long horizontal slit for both eyes. As in the previous types, the slit is approximately rectangular.

Dimensions: The goggles in Fig. E 1-3 are 124 x 22 x 30 mm (width x height x depth). The ocular slit is 120 mm wide, taking up almost the entire width of the wooden block. It is 2 mm high and 1 mm deep. This gives the wearer a vertical visual field of 5°, a nasal one of 64° and a temporal one of 41° with a normal distance between the eyes (DIP 60 mm).

Fig. E 1 gives a good frontal impression of the long, narrow ocular slit. Towards the sides it narrows slightly, presumably because it is difficult to chisel a perfectly rectangular slit.

Material: These goggles are cut from a whole piece of wood with a distinct grain pattern.

Design: The view of these goggles from above (Fig. E 2) shows the surprisingly beautiful curvature, in fact almost a parabola, at the front of the wooden block, and a curvature corresponding to the shape of the head at the back, so that the goggles fit well around the head and protect the ocular region from wind and cold.

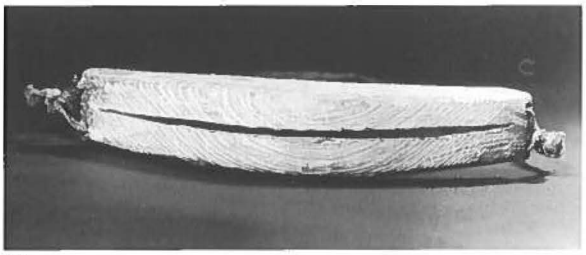
Fixation: These goggles are tied around the head with a string passed through two holes on each side

(Fig. E 1). The string visibly connects the two holes on the inside, passes through the holes in front, and continues around the head to end in a knot at the back of the neck.

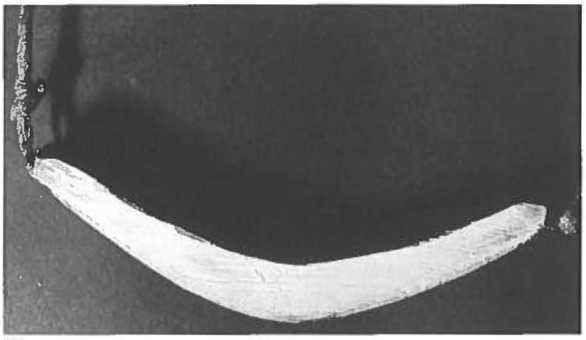
Blackening: There is no blackening, but it is possible that there may have been blackening at the back.

Dating: These goggles were brought to Denmark by the Fifth Thule Expedition in 1924 (Museum No. P 29.64). It has already been illustrated by one frontal view (Birket-Smith 1945: 34).

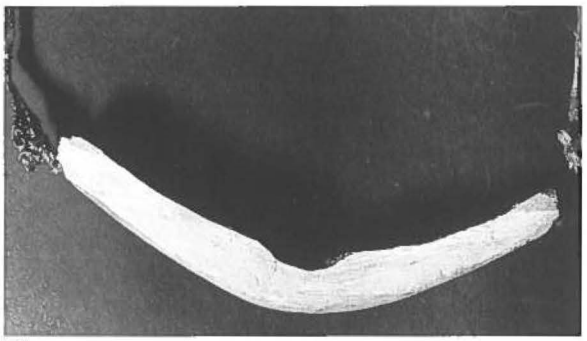
Birket-Smith wrote (op. cit., p. 34, Fig. 9a) "Snow goggles from Netsilik Eskimos immigrated to Re-



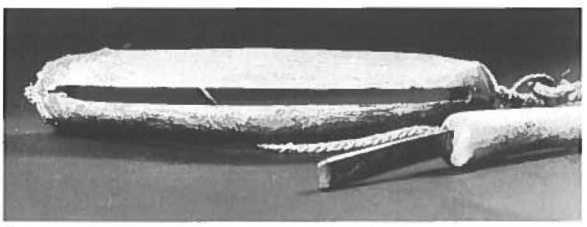
E1



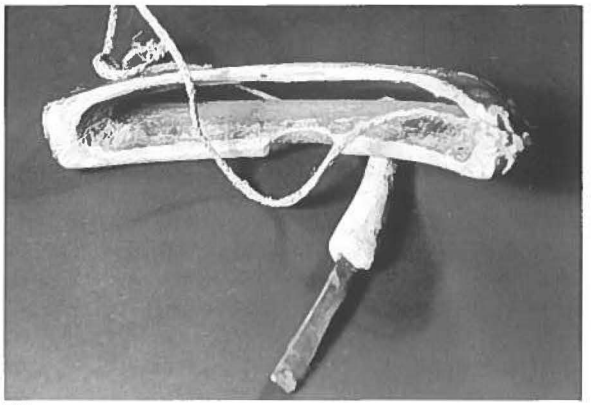
E2



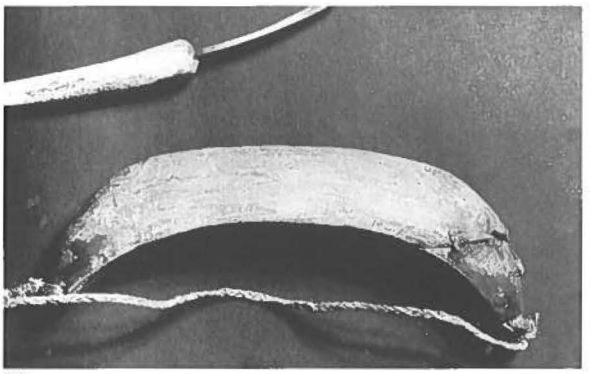
E3



E4

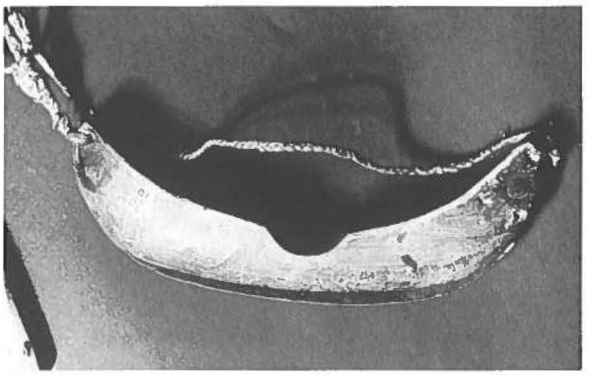


E5



E6

E7



E8

pulse Bay, are of wood, smooth on the front and cut away for the nose on the back. They have a single eyeslit and a headcord of ordinary string".

Fig. E 4-8 shows another example of Type E.

Dimensions: These goggles are deeper than those described above, i.e. 52 mm in depth, 24 mm in height and 140 mm wide.

They have a long eye slit (120 mm), vertical dimension 6 mm, depth 1 mm, distance from anterior surface to the closed eyelids of the wearer 28 mm, affording a vertical visual field of 9°, nasal 68° (more than optimal) and temporal 39°. In other words, we again have a kind of crossed visual field. By way of comparison it may be mentioned that ordinary modern spectacles (my own) have a vertical visual field of 46°, which is of course much better than the slit goggles. The nasal visual field of my spectacles is 44° as against the 68° of the slit goggles. My temporal visual field is 57° compared with 39° in the slit goggles.

Material: These goggles are cut from one piece of wood and are worn with a string.

Design: This specimen is of a more sturdy, clumsy appearance than the previous one in Fig. E1. Its curvature is most marked peripherally, almost banana-shaped (Fig. E 6-8). Furthermore, there is a fissure at one end, at a weak point in the construction, between the eye slit and the upper edge.

Fig. E 6 shows the goggles from above, E 7 is a lateral oblique view, and E 8 shows them from below, with the cut-out for the nose.

Fixation: These goggles are worn with a single string around the head.

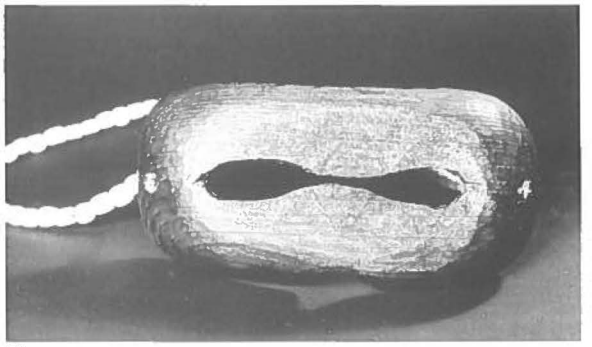
Decoration: From the head-cord hangs an object, according to the National Museum's records an "amulet" of forge iron with a handle made of antler. The object may of course have been an amulet, but it is not impossible that the snow goggles and a sharpening tool were tied together by the donator or collector to emphasize that they were found at the same site (Bahnsen 1993, pers. comm.).

Dating: This specimen was brought to Denmark in 1924 by the Fifth Thule Expedition, and originates from the Copper Eskimos on the Kent Peninsula in Canada (Museum No. P 30.76).

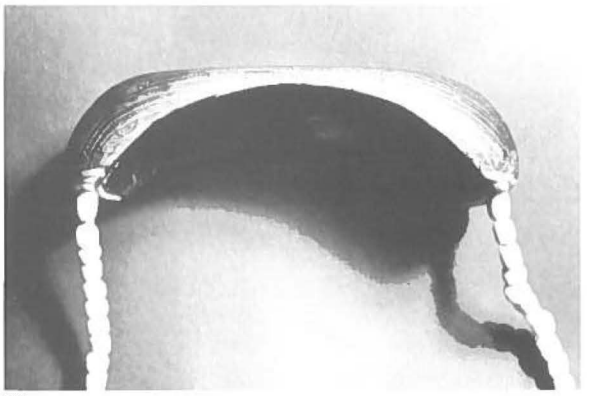
Type F

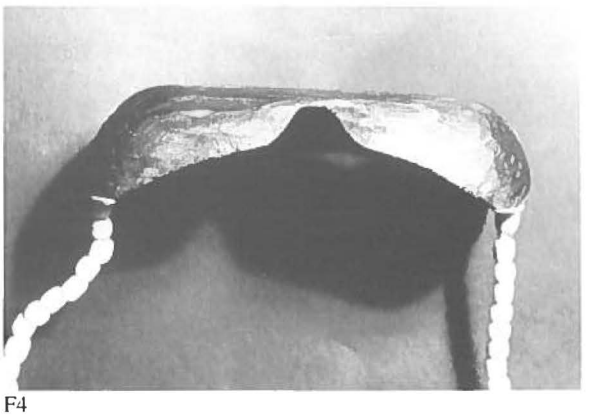
Definition: Snow goggles of Type F are characterized by a single slit for both eyes, like Type E; but unlike the types described above (A-E) it is not rectangular, but in the shape of a figure-of-eight lying on its side.

Dimensions: The goggles shown in Fig. F measure 130 x 63 x 35 mm (width x height x depth). The eye slit is shaped like a figure-of-eight on its side. It covers both eyes, with a length of 102 mm and a height of 13 mm at the middle but 17 mm at the two widest points. In a wearer with a normal distance between the eyes


F1


F2


F3


F4

these points correspond exactly to the position of the eyes. It thus gives the wearer the greatest possible vertical visual field at the centre (28°), and thanks to the slit connecting the two openings of the figure-of-eight it also provides an optimal nasal visual field (68°), while the thick piece of wood protects the face temporally, so that the temporal field of vision is only 32°.

On both sides of the aperture there are minor defects.

Material: The goggles are cut from one piece of wood and tied around the head with a string of tusk beads.

Design: The piece of wood is oval-shaped (Fig. F 1), flat at the front and curved temporally (Fig. F 3), so that it also protects the face from side winds. Below, a wedge is cut out for the nose (Figs. F 2, F 4).

Fixation: These goggles are tied around the back of the head with a single string fastened to a couple of solid, flat pieces of tusk-like material, presumably walrus tusk, attached to the wooden piece farthest out on both sides (Fig. F 2).

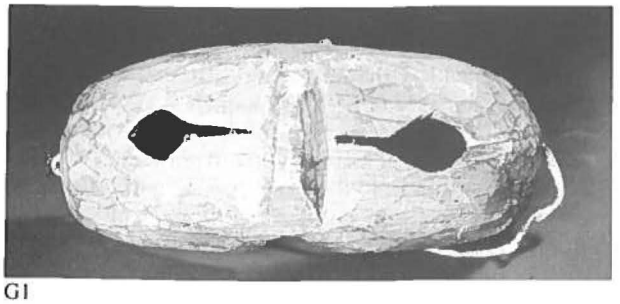
Blackening: There are no traces of any blackening at the back.

Decoration: The string is decorated at the back of the neck, with tusk beads (Figs. F 1-4).

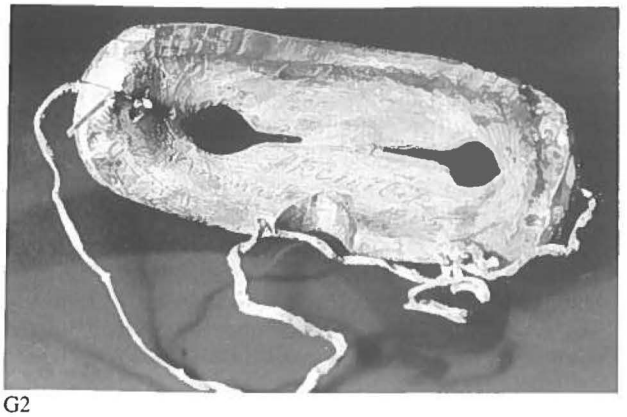
Dating: These goggles were bought by Johan Petersen, colony manager in East Greenland (Museum No. L 5055).

Type G

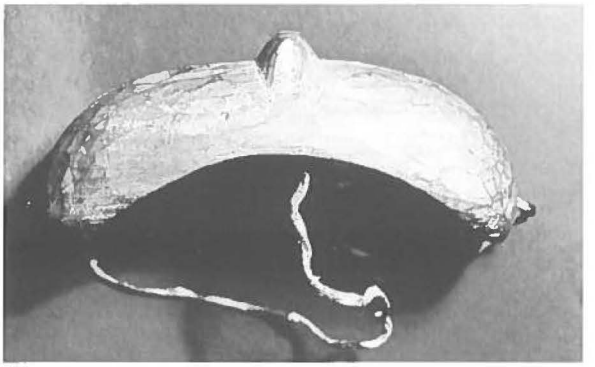
Definition: Snow goggles of Type G have a separate drop-shaped opening for each eye.



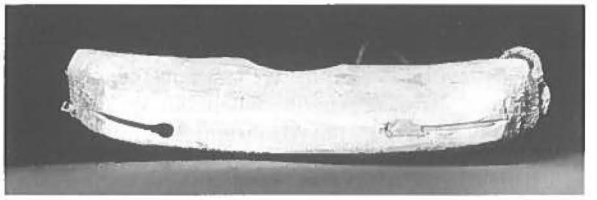
G1



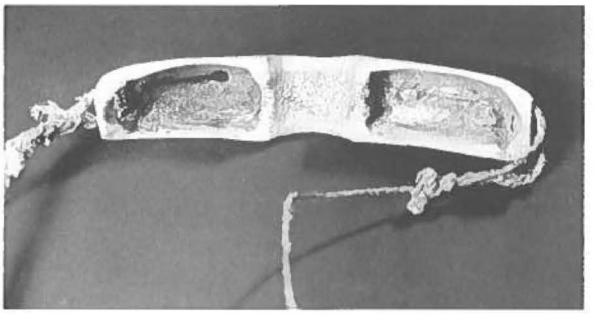
G2



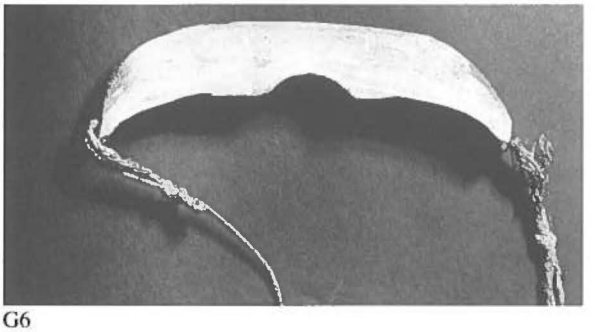
G3



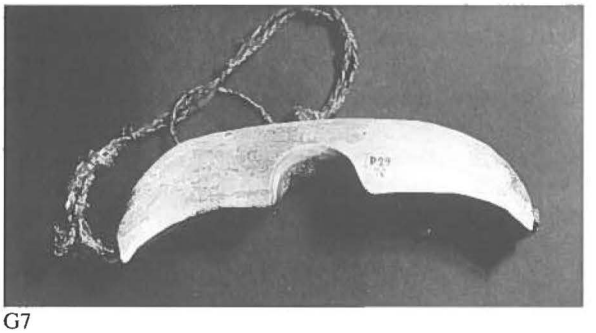
G4



G5



G6



G7

Dimensions: Fig. G 1-3 shows snow goggles of Type G, measuring 150 x 60 mm with a depth of 45 mm and a prominent nasal area in the middle, surrounded by two drop-shaped slits tapering towards the nose. If these two slits were connected, the result would be like the above-mentioned figure-of-eight aperture. In this case, however, the figure-of-eight is split in two by the nasal decoration, resulting in two drop-shaped openings.

Each drop-shaped slit is 35 mm long, and the maximum height is 15 mm. However, the opening is not on a level with the eye if the wearer has a normal distance between his eyes (DIP 60 mm). It would only be so if the interpupillary distance were 80 mm (which is quite unlikely).

The eye slit is 1 mm thick, and the distance from the closed eyelid is 33 mm. We can thus calculate that the vertical field of vision, when the wearer looks straight ahead, is 14°, the nasal field 21°, and the temporal field 26°, i.e. even larger than the vertical field of vision temporally.

Material: These goggles are cut from one piece of wood and are worn with a sinew thread.

Design: The view from above (Fig. G 3) shows the fairly rough, solid, curved piece of wood with a nasal area and particularly good temporal protection. Fig. G 2 shows a notch for the nose below. The right temporal edge of these goggles has a slight defect.

Fixation: A strip around the back of the neck, consisting of one sinew thread fastened through one hole on each side.

Decoration: These goggles are decorated with a projecting, rather primitive "nose", cut into the wood (Fig. G 1 and 3). There is no blackening.

Dating: This specimen is from East Greenland (Museum No. Ld 113). The identification comments state that October 1988 was the date when the photo was taken, but unfortunately there is no further history of the find.

On the back of the goggles (Fig. G 2) one can just make out an inscription in pencil – Akermilik, Ammas 1905 – possibly indicating the acquisition year, although Ammassalik is the more recent way of spelling what was then spelt Angmagsalik.

The following photos (Fig. G 4-7) show another drop-shaped specimen, but in this case the drop points in the temporal direction.

Dimensions: 130 x 26 x 32 mm (width x height x depth). The anterior view (Fig. G 4) shows the temporally located small, drop-shaped eye slits measuring 25 mm horizontally and about 2 mm vertically, but widening nasally to 4 mm. If the wearer has a normal interpupillary distance the eye is exactly level with the gap-like extension, where the vertical field of vision when the wearer looks straight ahead is greatest, i.e. 6°. The nasal field of vision is very small (5°) and the temporal field reasonably large, i.e. 30°. The left slit is blocked by a piece of wedged-in wood. Screening shows that the wood completely closes the slit in the antler block except for two gaps below which are so small that it is impossible to see through them. The largest hole gives a visual field of less than 1° in all directions.

One could conjecture that this closure might be practical for aiming a firearm with the right eye alone. However, the wedge is solid and permanent, so this explanation must be dismissed. The person may have suffered from a painful eye disease – a photophobic left eye in which the pain was relieved by the closure.

Painful eye diseases with impaired vision (acute glaucoma, iritis, traumas) are common, and were once even more common, among the Eskimo, so this explanation is more probable. Today we see children with a patch on their good eye to train a "lazy" eye. But this sort of occlusion therapy was not used at the time when the snow goggles were used in Greenland, so this explanation too may be dismissed.

Material: These goggles are made of caribou antler and are worn with a string.

Design: Fig. G 6-7 shows the curvature of the goggles. They are relatively flat in front but curve strongly temporally to protect the wearer from side winds. They are shaped like a thick banana.

Fig. G 5 shows the goggles from the back, showing the separate grooves for each eye and a vertical one for the nose. In all three grooves one can see the internal, porous structure of the caribou antler. The front surface, on the other hand, is smooth.

Fig. G 6 is a view of the goggles from above with the nasal groove and Fig. G 7 shows them from below with the larger notch.

Fixation: These goggles are tied with one string around the back of the neck, and fastened to the caribou antler block in two gaps on each side. The string connects the two grooves internally in the temporal concavity in the block (Fig. G 5), from which it passes out backwards as two strings tied with knots on each side about 4 cm behind the block at the temple (Fig. G 6). From there a single string passes to the right around the head to a firm knot at the back, while on the left two strings pass together to the left around the head to the same firm knot at the back.

Blackening: There is neither blackening nor decoration.

Dating: This specimen (Museum No. P 29.70) is from Pelly Bay in Canada, and was brought to Denmark by the Fifth Thule Expedition. It is exhibited in the National Museum and was described as "P 29.70, from the Arviligjuarmiut, is of antler, very convex, with an incision for the nose and two eye-slits, one of which is plugged with wood. The head-band is of plaited sinew" (Birket-Smith 1945: 36).

Birket-Smith did not offer any explanation of the strange closure of the left eye-slit.

Comments: All snow goggles of Type G have a drop-shaped opening. The drop may be of various

shapes, and is sometimes drawn out as if it has a stem. This extension points medially (to the nose) in five goggles, laterally in one (P 29.70), and in one there is a "stem" on both sides (Lu 113). The extension is drop-shaped, rounded in four specimens, and drawn-out like a slit with a stem in three. At a standard interpupillary distance (60 mm), when the wearer looks straight ahead, the visual axes are level with the centre of the maximum vertical aperture in one specimen (P 29.70), and displaced nasally in the extension of the drop in the remaining six, which thus have a wider temporal visual field.

Type H

Definition: In this type the eye slit is triangular and there is a separate one for each eye, with the base of the triangle oriented nasally.

Dimensions: 150 x 32 x 56 mm (width, height, depth). The eye slit is triangular, 40 mm long, base inward. The base of the triangle is extended nasally, so that the contour of the whole slit is nail-like, while other snow goggles of Type H have completely regular triangles.

The vertical field of vision was calculated as 6° at a standard DIP of 60 mm, the nasal field as 18° with an extended vertical field of vision, whereas the temporal field of vision, thanks to the triangular tip drawn out horizontally, reaches as much as 44°; but the vertical dimension is on the whole low, so the goggles provide fairly good protection from side winds.

Material: Each of these pairs of snow goggles is cut from one piece of wood.

Design: The piece of solid wood is regularly curved, almost like a segment of a circle. Its upper part looks like a cap peak, with a rather smaller radius of curvature, making the shade project most in the middle, up to 2 cm (Fig. H 3).

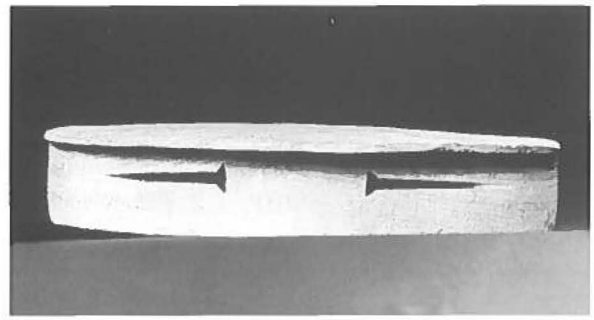
At the back of the wooden block there are grooves for both eyes and down through the centre there is a smaller groove for the nose (Fig. H 2).

The means of attachment to the head has been lost.

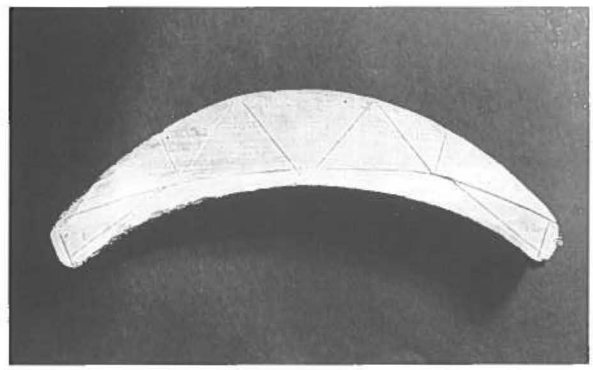
Blackening: No traces of any blackening.

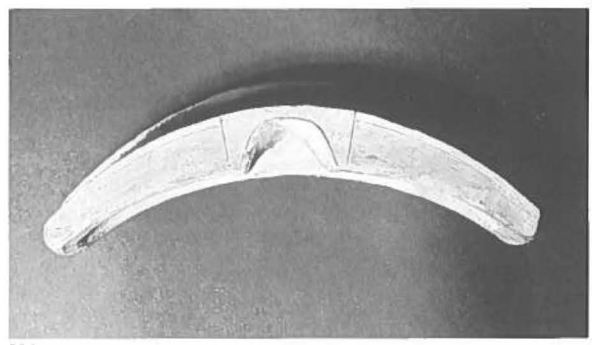
Decoration: The view from above gives an impression of the peak, which is beautifully decorated with deep notches in the form of triangles, filling up the entire surface. There is room in the middle for equilateral triangles which overstep the common baseline at the centre. Peripherally the block becomes so narrow that the triangles become thin isosceles triangles with the narrow base oriented temporally. The block is highly curved at the front at the point where the shade is broadest, and less curved at the back to fit the shape of the head.

The view from below shows the corresponding curvatures without the shade, a central groove for the nose and less detailed ornamentation, which is hardly visible when the snow goggles are on the head (Fig. H 4).


H1


H2


H3

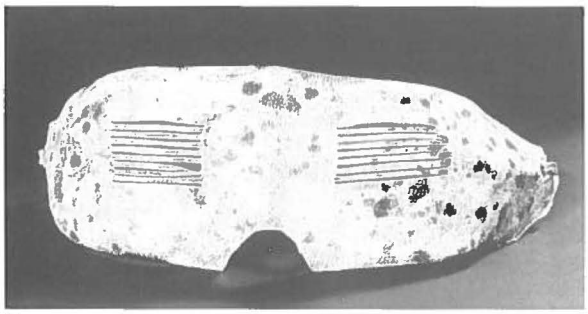

H4

Dating: This specimen (Museum No. 29.71) is from Netsilik, and was brought back to Denmark by the Fifth Thule Expedition.

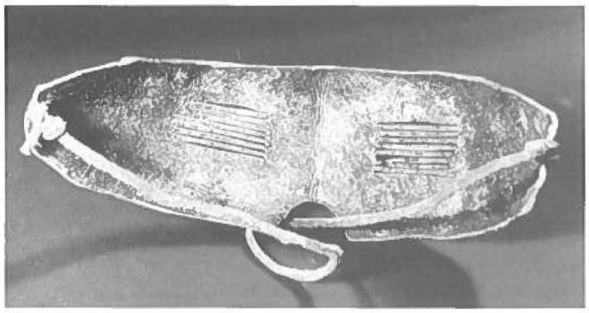
Type I

Definition: This type is characterized by several horizontal slits parallel to one another, i.e. they are "multi-slit" goggles.

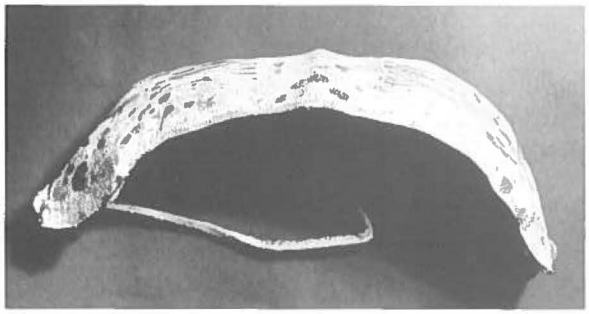
Dimensions: The goggles in Fig. I are longitudinally oval, 220 mm wide, 69 mm high, and only about 0.5 mm thick.



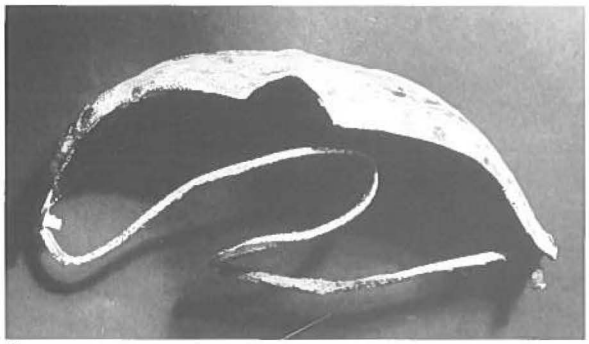
I1



I2



I3



I4

There are eight horizontal slits in front of the right eye and nine in front of the left one, covering an area of 35 mm horizontally and 19 mm vertically in front of each eye. Each slit is about 1 mm high. The wearer is conscious of the "grating", but can quickly get used to it (cf. digital pictures and the multifaceted eyes of insects). Disregarding the grating-like effect, the visual field is amazingly large vertically (31°), compared with that of other snow goggles; the temporal field of vision is also quite large (44°), whereas the nasal field at the normal interpupillary distance is only 9°, because of the broad middle piece for the nose.

Material: This type of goggle is made of depilated seal skin. There are dark patches on the skin.

Design: These rather stiff goggles are shaped like a long oval bowl whose curvature fits the shape of the face with a cut-out for the nose below in the middle. It must once have been less stiff, and could presumably be rolled up until it was small enough to carry in the pocket.

Fixation: Fig. I 2 shows the goggles from the back with the solid leather strap which goes around the back of the neck and is attached to the seal skin with knots through a hole on each side.

Blackening: Neither blackening nor decorations.

Dating: According to the description from the National Museum these goggles, collected in the Godthaab district, were acquired by "Gustav Holm, Captain of the Navy, in 1892" (Ld 113).

I have been able to trace only two specimens of the multi-slit goggles; the other specimen is from East Greenland.

The present specimen has been shown in an anterior view (Birket-Smith 1924: 192): "From Godthaab there is a pair of snow goggles, Ld 113 made of skin. In front, before the eyes, there are a number of fine horizontal slits").

Comments: While the present specimen has 8-9 horizontal slits in front of each eye, the other specimen of this type (I) only has three pairs of horizontal eye slits (trifocal), which makes it easy to read through the lowest, look straight ahead through the middle ones, and look upwards with the uppermost (Tasiilaq Museum, snow goggles of wood).

Type J

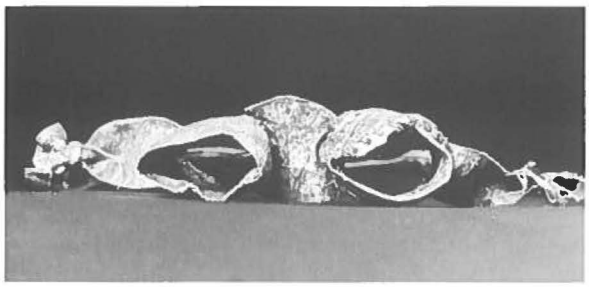
Definition: Snow goggles of Type J are shaped almost like binoculars, and are made entirely of depilated seal skin.

Dimensions: The goggles in Fig. J are 130 mm wide, 30 mm high, and 45 mm deep.

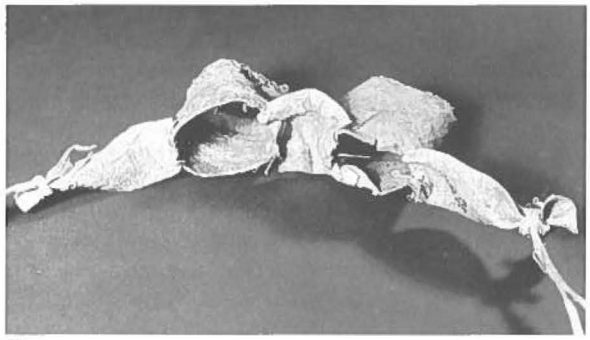
The "binocular tube" in front of each eye is an oval opening with the dimensions 40 x 20 x 45 mm (H x W x D). This gives the wearer a reasonably large visual field of 24° vertically, 20° nasally, and 26° temporally. In other words, these goggles have a particularly

large vertical field of vision compared with slit goggles; on the other hand they provide little protection from light, draught, and cold.

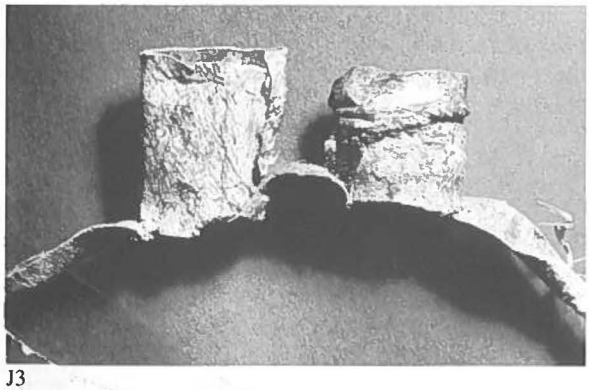
Material: Depilated seal skin.



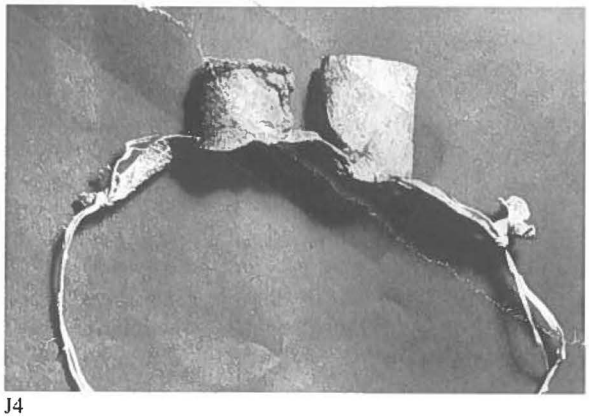
J1



J2



J3



J4

Design: These goggles are shaped like binoculars with two tubes connected by a rectangular flap which functions as a nose piece.

Fixation: The goggles are worn with a strap around the back of the neck. Fig. J 2 shows the back of the goggles, where it is possible to discern that the nose flap, "binocular tubes", and side flaps of the same material have been stitched together. A thinner back strap has been tied to the side flaps. (The width of the goggles is 18 cm if the side flaps are included).

Dating: These goggles were brought back by the Fifth Thule Expedition in 1924 (Museum No. P 29.74) and were described by Birket-Smith (1945: 35): "From Arviligjuarmiut immigrated to Repulse Bay, is of a different type". The specimen consists of two short cylindrical tubes of depilated sealskin tied together with a piece of the same material and with a similar piece on each side, to which the head-cord is fastened. The latter is of plain sinew-thread 17 x 3 cm".

Comments: There are in all only three specimens of Type J. Two are binocular-shaped as described here. The third is formed in one piece like a boat which covers the face and is provided with two oval holes, one for each eye, and a groove for the nose, i.e. it is a kind of mask that fits the face closely, and is worn with a single strap around the back of the neck (Museum No. KNK 0920116, National Museum in Nuuk).

Type K

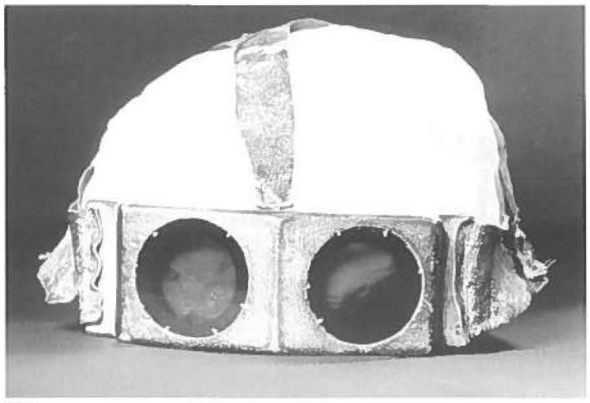
Definition: Snow goggles of Type K have a round opening covered with dark glass.

Dimensions: Goggles of Type K are 14 cm wide, 4.9 cm high, and 4.5 cm deep.

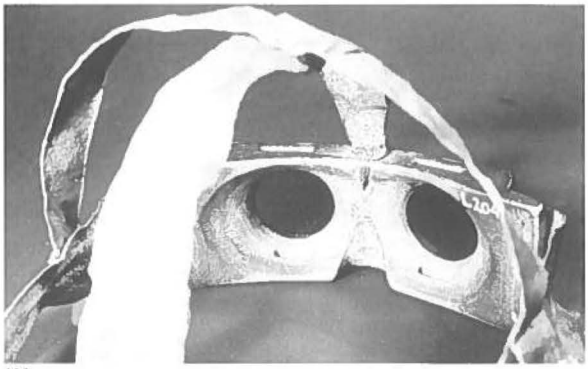
In front of the eyes there is a flat disc of dark-grey-tinted glass with no optical strength, anterior diameter 38 mm. The disc is inserted in a fold in the wood. At the back, the free part of the glass measures only 30 mm (the fold is 4 mm wide). The glass is fitted accurately into a fold and fastened with no more than eight pins at the front, so that it cannot fall out of the goggles. The distance between the centres of the two glass discs corresponds to the standard interpupillary distance (DIP 60 mm), so that they are correctly centered. The distance from glass to eye is 25 mm.

The field of vision is large, as in ordinary sunglasses: 42° vertically and 24° nasally, and temporally.

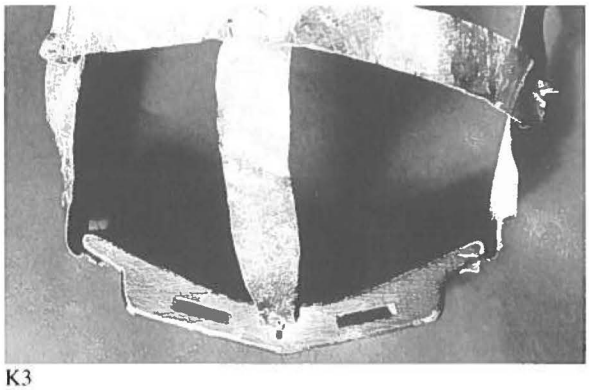
These goggles have the advantages of modern European sunglasses with a relatively large field of vision that is not restricted upwards and downwards as in most Eskimo slit goggles. On the other hand, the protection from visible light is only moderate, and presumably there is far from sufficient protection from ultraviolet light. The goggles are also very like-



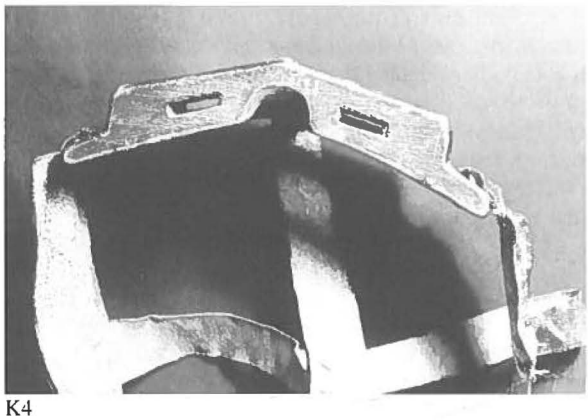
K1



K2



K3



K4

ly to mist and ice over in an Arctic climate, so they are frequently unusable.

Material: These goggles consist of one piece of wood with two holes covered with dark glass, and are provided with leather straps.

Design: The square piece of wood is angled to fit the shape of the head. Fig. K 1 shows the goggles from the front. Here paper has been used to give an impression of the fastening-straps.

Fig. K 2 shows the goggles from the back, with the dark circular glasses and the cavity for the nose. The grooves on which the glasses rest leave ample space for the eyes, which are at the same time well protected – in particular temporally – by the solid wooden frame.

The view from above shows the curvature of the piece of wood. Here the front is plane, like the glass, but the wood is angled in the middle, and this creates a suitable curvature for the face, as the posterior surface is almost parallel to the anterior surface, except that the posterior surface is a little thicker temporally, where it continues in a 2 cm large, flat piece to which the leather strap is fastened (Fig. K 3).

There are two rectangular 12 x 2 mm ventilation holes at the top, and Fig. K 4 shows two corresponding holes in the lower surface. These holes are needed to let some air into the otherwise completely sealed eye chambers.

Fixation: The piece of wood is fastened to the head with a horizontal leather strap around the head and back of the neck, from the flattened temporal part of the wood, and with a sagittally-running tape fastened anteriorly to a small duct at the top of the centre of the wood (Fig. K 2 and 3) and stitched to the horizontal tape at the back of the neck. A frontal strap also joins up the ends of the horizontal strap in the right and left temporal regions, and the frontal strap crosses underneath and is stitched to the sagittal one at the vertex – in other words there is a robust, crossed system for attachment to the head.

Blackening: The goggles are not blackened or decorated, but their details are elegant.

Dating: These snow goggles were donated to the Danish National Museum by Professor W. Thalbitzer in 1902, are dated 1900 and came from North Greenland (Museum No. L 2041).

Comments: There are a total of five specimens of this type (Table I), four of them with circular openings, and the fifth with transversely oval, brown glasses (No. 1167, privately owned in East Greenland). Two of these pairs of snow goggles have ventilation holes, and two have decorations (nose or eyebrows).

It may be concluded that these are well-made goggles, inspired by European sunglasses, executed in genuine Greenlandic materials and in some cases supplemented with the ventilation holes needed to prevent misting and icing inside the glasses.

Analytical Section

Optical Properties

The Eskimo snow goggles do not have lenses with optical strength. Nevertheless, they do have an optical function, improving vision by increasing definition in depth (stenopeic slits) and counteracting dazzle.

The visual field is diminished. This is an unwanted side-effect, but cannot be avoided if the snow goggles are to have the required protective properties.

Visual Field

Vertical visual field: This averages 10.5° (N = 48), and should be compared with the vertical field of the normal eye, which is 120° (60° up and 60° down).

The visual field is most restricted in the rectangular types (A-E) and does not correlate with the width of the slit (Type A 5.7°, Type B 5.6°, Type C 4.3°, and Type D 7.8°) or the use of a single long slit (Type E 5.3°). The field may also be rather small with a triangular slit (Type H 7.2°) (Fig. 2, page 5).

In other types of slit (Type F 14.2°, Type G 10.0°) the maximal slit height is generally outside the position of the eye in the slit (fixation point of the eye straight ahead, and this affords still better vertical vision, whereas multifocal (Type I) and round/oval ones afford a large vertical field of vision – on average about 30°, and in one case even 42°.

The drop-shaped apertures (Type G, where the aperture is generally extended temporally to the fixation) have a larger vertical dimension in the temporal part of the visual field compared with the central vertical visual angle calculated here.

Nasal field of vision: The nasal field of vision is smallest with the drop-shaped slit (Type G: 10.6°), but increases as the length of the quadratic slits increases (Type A 16.0°, Type B 30.1°, Type C 39.3°), with mean values for Types D and H of 28.2° and 27.1° respectively. The goggles with a single slit for both eyes exhibit the maximum values (Type E 61.0° and Type F 58.0°). The round types have fairly high values (Table I).

Temporal field of vision: Throughout the material studied the temporal field of vision averages 33.6° compared with a rather smaller nasal field (28.9°).

The temporal field of vision increases as the length of the rectangular slit increases (Types A-C). It is large in Type D and those with a triangular slit (Type H).

Where there is a single long slit (Types E and F) the temporal field is smaller than the nasal one in all the goggles measured. This was particularly striking in Type F (temporal field 14.8°, nasal field 58.0°). This means that the right eye perceives most of the left visual field and the left eye most of the right visual field. This crossed field of vision make sense, since the snow goggles provide temporal protection against cold and draught where they are closed.

A crossed field of vision (nasal field larger than temporal field) was occasionally found in the other types (6/34 = 18%).

Practical experiments: Experiments using one pair of original snow goggles, i.e. Type C with a vertical field of vision of 6°, nasal field 36° and temporal field 40°, slit height 3 mm, RIN 100200, Medical History Museum (Norn 1992), revealed that it was possible to move about without much difficulty on ordinary ground; but on uneven ground the wearer becomes unsteady, and on encountering unexpected obstacles runs the risk of stumbling. The very small downward field of vision is the greatest disadvantage, and is difficult to compensate for by moving the head.

Model experiments, also with a horizontal slit (Type C, slit height 2 mm), provided quite a good general view, e.g. of the flight and position of birds, whereas the corresponding vertical slits prevented any general view, occasionally resulted in diplopia, and the advantage of the improved vertical field of vision was negligible.

Dimensions of the snow-goggle aperture: These can be seen in Table I. The distance from the vertex is 12 mm with goggles of Type D, but strikingly larger in the other types, and extremely large in Types F, G, and J because of the thick piece of wood (F and G) and the binocular-like shape (Type J). A long distance between the eye and the slit of the snow goggles correspondingly affords a smaller field of vision and thus greater protection of the eye.

Improvement of vision

In model experiments with a 3 mm stenopeic slit there was a visual improvement without glass from 6/24 (= 0.25) to 6/18 (= 0.33) in a -2.0 spherically myopic subject. With a smaller slit height there was a visual improvement. In cases of suspected or moderate myopia, a visual improvement can be obtained with snow goggles with a small aperture height (in Types A-E and H, negligibly in Types F, G, or I, and not at all in the round Types J and K). Even in normal subjects the increased definition in depth (less scatter) optimizes visual acuity.

It is possible to read with snow goggles without using reading glasses that would otherwise be needed (in cases of presbyopia).

Dazzle: The snow goggles prevent glare. This is important when the wearer is sledging or walking against the sun – especially in Greenland, where the sun is very low and is often reflected from snow, ice, or water.

It can be difficult to get one's bearings or to shoot animals against the sun in polar regions without the help of snow goggles to prevent dazzle.

Model experiments investigating dazzle (Type C, 2

mm slit height) have demonstrated threefold visual improvement (from 6/60 (= 0.1) to 6/18 (= 0.33)) when the slit goggles face the sun. With original snow goggles (RIN 100200) there was the same improvement, even when the sun was just visible at the periphery of the slit. Reading against the light was improved from Letter Size N8 to N4.5.

Protective Properties

The snow goggles protect the wearer from ultraviolet light and visible light and thus from snow-blindness, band-shaped climatic keratopathy, cataract, and possibly also age-dependent (senile) retinal degeneration.

The goggles also protect the eye from cold and draught.

UV light: The snow goggles allow a limited number of rays to pass through the slit. The remainder will be absorbed or reflected from the material. In diffuse lighting the amount of light is reduced with the ratio between the visual field of the ocular aperture and the normal visual field. For Types A-C the amount of light may be calculated as 2-3%, while the round aperture (Types J and K) allows most light through, but only about 8%. Against the sun the snow goggles further protect the wearer from direct sun and strong sun reflection.

It would be useful if we could measure the light protection with an UV meter. However, the results would depend upon the background lighting, the orientation of the goggle slit, etc. This would require spectrometric analysis of all wavelengths and would be costly. A calculation of the relationship between the visual field of the aperture and the normal field of vision ought to be sufficient (Finn Poulsen, Technical University of Denmark, pers. comm. 1995).

Icing, misting, frostbite: Snow goggles do not have the disadvantages of ordinary spectacles, except for Type K, which has "spectacle glasses". The snow goggles without glass cannot mist over (Myers 1988-89: 64, Fig. 88), and vision is not blurred by dried tears (crystallization), or ice coatings.

Metal spectacles may cause frostbite, while snow goggles of wood have tolerable temperatures in the cold surroundings.

Practical experiments: In a refrigerator, I found that ordinary glass spectacles mist over in a few minutes and that this misting completely obscures vision for several minutes after they have been removed from the fridge. Original snow goggles (RIN 100200) do not mist at all, and vision remains intact although they have been in the refrigerator.

Dimensions

Height: The maximum height of the snow goggles is unusually great in the case of the multifocal goggles, as there has to be room for several slits above one other (Type I). The height is considerable in Types F and G (43-44 mm), while Types D and H are lighter goggles with a lower height (29-30 mm, Table I, Fig. 2).

Width: The width of the goggles (all specimens) averages 13.6 cm, regardless of height. The width of D and J includes the connecting string.

The average width of the individual types varies little. All 59 pairs were within the fairly narrow interval of 12-16 cm, except for one multifocal specimen (L 113, consisting of a 22 cm wide depilated seal skin mask, close-fitting around the head and tied with a leather strap at the back of the neck. In other words the "width" of this specimen does not bear any relation to the facial width of the wearer).

Depth: The depth of the snow goggles may be quite considerable, as can the vertex distance. The depth may be considerably greater than the vertex distance, among other reasons because some goggles are extended backwards temporally to protect against side winds, and in a few cases the nasal area projects forward.

The average depth of the goggles was 34.0 mm, the average vertex distance was only 21.4 mm. The depth is quite striking in the case of goggles with a single slit for both eyes (Types E and F) and those with a drop-shaped slit (Type G), and of course in the binocular-shaped ones (Type J).

The depth is remarkably small in Type D and the multifocal Type I.

Material

The snow goggles are usually carved from a block of wood. Sometimes, however, they are of musk-ox horn (one specimen), caribou antler (one), walrus tusk (two), bone (one), or depilated seal skin (four).

The material for attaching the snow goggles to the head was, in most of the 49 cases with a preserved attachment device, sinew, and more rarely string. In 16 instances it was wholly or partially leather, and in one case silk.

The use of string instead of sinew may be due to repairs of older goggles for which sinew had previously been used.

Shape of Nose

The snow goggles rest on the nose, except for nine specimens in Type D (two pieces of wood joined by a string over the nose) and Types I and J (depilated skin, binocular-like).

In the remaining 50 cases there is a curvature corresponding to the shape of the nose, at any rate at the lower edge, and sometimes also at the upper edge of the goggles.

In 35 cases there was also a longer notch behind to fit the bridge of the nose, and in six cases there was an anterior curved cavity which may have been function-

al (Ld 85, Type K literally fits the nose tightly) or may have been for purely decorative purposes.

In L 19248 there is a circular 10 mm hole between the two apertures (Type G); function unknown. Types E and F usually only have a simple notch for the nose.

Surroundings of the nasal groove on wooden goggles: At the back there may be an oblique cut inwards, so ingeniously executed that the cleft could be carried farther in nasally on the front, resulting in a better nasal field of vision (P 27.526 Type B and P 51 Type H).

Fixation

The snow goggles rest on the nose and are worn with a string from the temporal edge of the goggles which goes around the back of the neck, in some cases also from the upper edge of the central part of the goggles across the forehead and vertex to the back of the neck.

In 49 cases the fixation material was preserved, and in 46 specimens enough was preserved to indicate the method of fixation.

Most snow goggles are worn with one string around the back of the neck. This string may issue from one temporal hole on the block or, when there are two strings, from two holes on the same side. These strings are joined around the head (they are often of different lengths on the two sides), so that they continue as one string knotted at the back of the neck. In two cases, however, there was a double string (P 27.529 Type B and P 29.64 Type E).

In another two cases there was a double string on one side and a single string on the other (P 29.70 Type G and P 29.66 Type H).

In a few cases there was also a string across the vertex. This could issue from the temporal part of the block (like the back-of-the-neck string) and then pass the vertex to be joined by another string from the vertex to the knot at the back (3 cases). Or the vertex string could issue from the centre of the upper edge of the snow goggles (nasion), and pass the vertex to join up with the back-of-the-neck knot (Tasiilaq Type I and Ld 85 Type K).

Finally, there may be a cross-shaped system over the vertex, where a string from the upper edge of the goggles (nasion) passes to the back-of-the-neck knot, and a supplementary string from the temporal part of the string, also passing the vertex (L 2041 Type K).

The material was sinew in 32 cases, leather in 16, and a string in 8.

Holes: The strings are attached to the block of snow goggles through holes. The smallest number of holes was two, i.e. one on each side of the block for the back-of-the-neck string (19 cases). There may also be four holes, two on each side (24 cases) or two holes on one side and only one on the other (4 cases) or three holes, one of which is in the nasion and one on each side (1 case).

More than four holes were observed in six cases, maximally 10-14 holes for the fixation of a leather flap continuing in a sinew or string. In 54 cases it was possible to establish the number of holes, and in the remaining five cases the snow goggles were defective in the areas where there may have been holes.

Fixation to a leather flap (a total of 16 cases) or to a hole in the block (33 cases) varies. Sometimes the knot at the hole is inside the block (6 cases), sometimes it is outside (4 cases); or the string may pass through a hole (2 cases) or through two holes on the same side (20 cases) to be joined in a knot at the cheek position.

One specimen had an internal knot (nasion) and two external knots temporally (Tasiilaq Type I). A total of 49 cases had knots at the holes.

To sum up, it may be concluded that the problem of fastening the snow goggles to the head was solved in a number of different ways, and sometimes in different ways on the two sides.

Blackening

The posterior surface of the snow goggles was sooty, at least in the concave part around the aperture, in at least 17 of the 59 goggles. Blackening may have disappeared in the course of time. Blackening further inhibits the penetration of harmful light.

Decoration

Often, the snow goggles exhibit beautiful craftsmanship. One polished, well-shaped specimen in walrus tusk was ornamental in its own right. A few goggles had further decoration:

A Z-shaped pattern on the front (P 29.71, Type H) or horizontal lines (two cases).

A forehead eyeshade: One was a maximum of 15 mm wide (anterior width), and was positioned at the upper edge of the snow goggles (P 29.71 Type H), and another was 25 mm wide, positioned just above the horizontal slit (P 32.275, Type B). These were the only two cases.

Threaded glass beads: Two cases in all, one 3 cm long, fastened to the nasion (Ld 96 Type C) and the other (L 5055 Type F) fastened temporally on an ornamental plate of walrus tusk.

Beads: One pair of goggles had two small beads in the wood, white with a black spot centrally, placed in the apertures (P 29.69 Type H).

Modelled brows: Only one case (1167, Type K), while several had a more or less prominent, modelled nasal area anteriorly, in some cases only as a doubtful trace.

Piece of wood (15 x 30 mm) temporally positioned in snow goggles of walrus tusk, so skillfully done that it can hardly be a repair. It is more likely that a defect in the original material was exploited for decorative purposes (L 9263 Type B).

Repairs: A block of wood (P 29.67) broken in two, the pieces joined tightly by two sinew strings. Another specimen (P 29.69) has been repaired with sinew in several places. A third (KNK 1418) was made from or repaired with three pieces of wood.

Summary

Optical properties

The slit goggles protect the wearer from dazzle, a common nuisance caused by the low sun in the polar regions and by reflexes from ice and snow.

Visual acuity is increased as much as threefold, depending on the direction from which the dazzle comes. Definition in depth is increased, and when the wearer suffers from myopia visual acuity is improved.

On the other hand, the field of vision is diminished, in particular the vertical field, and this is unpleasant, especially on rough ground with unexpected obstacles.

The temporal field of vision is somewhat limited, but the wearer is protected from draught and there is room for the hood. In some cases, however, the field of vision will be crossed, i.e. the right eye will see farthest to the left and vice versa.

Protective properties

The goggles protect the wearer from visible light and ultraviolet light, as the amount of light is reduced to 2-8%.

The goggles protect the eyes from cold and wind.

Modern sunglasses may mist over and metal glasses may cause frostbite where the frame touches the skin. The Eskimo slit goggles of wood and other natural materials can be worn in the cold. They neither mist over nor cause icing in front of the eyes.

Geographical differences

As far as we know, these snow goggles have been used only in circumpolar areas where they are particularly useful because of the low position of the sun. Snow goggles have been used by the Sámi (Lapp) peoples (Forsius 1972). "Modern" slit goggles were used by railway workers during the construction of the ore track from Sweden to Narvik, Norway.

Greenlandic versus Canadian snow goggles: As will be apparent from the above, the design of snow goggles has varied with individual inventiveness. There are certain minor differences between snow goggles from Greenland and from Canada.

Dimensions: The Greenlandic snow goggles tend on the whole to be somewhat larger than those from Canada, and thus protect a larger part of the face. This is only statistically significant in the case of height (Table II), and there are individual exceptions.

Types: Goggles with the curved, continuous, figure-of-eight-shaped slit for both eyes (Type F; cf. Malaurie 1979: 364) and with the drop-shaped slit (Type G) are generally from Greenland.

The type with a triangular slit (Type H) and the type with a piece of wood in front of each eye (Type D) have only been found in snow goggles from Canada.

Otherwise, the types are mixed in both geographical areas.

Decoration has been found in both regions. Carved patterns and carved forehead shades are more common in Canada.

Design: In Greenland the goggles may be flat, like a thick board or with three bulges. As a rule, they are forward-convex in both geographical regions (Table III).

Dating

Snow goggles were invented and used by Eskimo populations from Siberia to Greenland about eight hundred years before ordinary spectacles were invented in Europe (see the dating table (Table IV), which also gives an overview of the present material).

Discussion

Types of snow goggles: From the above, it will be evident that snow goggles have been designed in a number of different ways, each with its advantages and disadvantages.

To establish an overview of the numerous variations, it was necessary to subdivide the goggles into types on the basis of the 59 specimens available to me.

I was mainly interested in the optical properties, in particular the visual field. Accordingly, it seemed natural to group the snow goggles in terms of the shape of the eye slits, i.e. into rectangular, drop-shaped or triangular eye slits and other less common types.

In order to deal with all 59 specimens, I preferred a more detailed classification into a total of 11 types (see Table I and Fig. 2).

Terminology: The term "snow goggles" (Danish: *snebriller*) applies to all 59 specimens. The term "slit goggles" (Danish: *spaltebriller*) is more accurate, but strictly speaking it does not include Types J and K with round or oval apertures.

In French the term *lunettes esquimaudes* and in English: Eskimo glasses is not so appropriate, since

glass is only exceptionally present (only in three specimens of Type K).

Travelling against a low, strong sun in Greenland, one feels the need for goggles. Instinctively, one hand goes up to shade the eyes. However, strong light reflected from below can be as much of a nuisance, since the sun is reflected from the sea, snow crystals and ice, so that the ultraviolet irradiation is almost doubled. And in fact one often has to place the other hand beneath the eyes, forming a slit between parallel hands, through which one can see distinctly without being dazzled. In other words, one creates a snow-goggle effect.

A shade over the eyes has been used in Greenland and in Alaska (Thalbitzer 1914: 593).

The Inuit eye has certain ethnoanatomical properties which in themselves provide some protection like that of snow goggles. The slanting of the eyes has reduced the height of the eyelid fissure, and the Eskimo or "Mongolian" fold narrows the medial part of the fissure. In pure Eskimos of East Greenland, Skeller found that 47% had the so-called Mongolian fold, 44% had "Eskimo folds", and the remainder had varying appearances. The prominent cheekbones, also characteristic of the Eskimo, partially protect them from sunlight reflected from below (Skeller 1954: 123).

UV damage: The snow goggles shield the wearer against visible and ultraviolet light, and thus protect him from UV damage in the ocular region – i.e. snow-blindness, possibly cataract, frostbite, etc.

Snow-blindness is caused by the photochemical destruction of the corneal surface by ultraviolet and visible short-wave light. The destruction causes oedema with blistering. The small blisters burst, and the small wounds cause severe pain. If the patient then avoids light, the oedema diminishes, the wounds heal spontaneously, and the pain subsides in about 24 hours. The pathology is exactly the same as in other forms of UV corneal damage e.g. "welders" eyes (Norn & Franck 1992), and damage caused by natural or artificial sunbathing.

Permanent blindness: Snow-blindness has been reported as the cause of actual blindness (Mathiasen 1928: 195). This is perhaps not quite correct, unless the wounds are infected and central keratitis arises as a complication and causes scar formation.

Another possibility is that cumulative exposure to UV can give rise to corneal degeneration in the form of climate keratopathy, which may extend in band-shaped form across the cornea. This impairment of vision is known as Labrador keratopathy, whereas the less severe keratopathy in Greenland is unlikely to cause blindness (Forsius 1972; Norn 1982, 1995).

Cataract etc.: Short-wave light and UV light may damage the cornea and presumably also the lens and retina. A. Klauber demonstrated (1981) an increased incidence of cataract in Greenland, where UV light may be assumed to be one of the causes. Age-dependent degeneration of the retina (so-called retinal calcification) is common and serious in Greenland, and may also be due to the sharp light.

Cold may cause frostbite, perhaps also of the cornea. The distinctive Eskimo eye anatomy (the flat chamber) counteracts this, because the vascularized iris is closer to the cornea, so that the chamber fluid counteracts cooling. It is doubtful whether scarring of the cornea following frostbite can cause blindness in Greenland (cf. Norn 1992).

Draught causes lacrimation and transient visual difficulty.

Visual acuity: The slit of the snow goggles acts as a stenopeic slit (Duke-Elder 1970b). Similar slits or holes are used today in black testing glass to make rough estimates of visual acuity (using a letter board in practice). This gives an impression of the maximum visual acuity that can be expected from subsequent optimal correction with spectacles.

Snow goggles consequently increase visual acuity in cases of myopia, which is however rare in true Eskimos. According to Skeller (1954: 176, 177) the percentage of true myopia (myopia of -1.0 and -1.25 spherical) found in East Greenland in 1950 was 1.2%. Since that time myopia has increased considerably. It must be added, however, that in 1950 24% were theoretically myopic, but of these 12% were only -0.25 spherical. Such mild myopia would not call for correction in Denmark, among other reasons for fear of over-correcting. Spectacles that were too strong would cause accommodation headache. Snow goggles do not give rise to this complication, but do increase visual acuity. In Greenland maximum visual acuity (preferably well above 6/6) would improve hunting ability. In addition, astigmatism may be improved by goggles. Astigmatism is remarkably common in Eskimos.

The slit goggles also optimize visual acuity in people with normal vision.

Geography: The present study is quantitatively the largest overall analysis to date of snow goggles from Greenland, compared with those from Canada. The similarities between the two geographical groups are greater than the differences, although certain regularities can indicate geographical origin. In both regions the relevant optical-ophthalmological problems have been solved.

Snow goggles are a tool of survival in the Arctic zone. Technical skill has made their design successful in various ways, judging from the available material.

Modern technology makes it possible to produce protective spectacles and face shields for every purpose (welding (UV), glass blowing (IR), work with laser beams), but there are some problems in choosing the correct protection in the various situations (work, hobby, sport) where sunglasses are often used unnecessarily (cosmetic aspect) and where new pur-

chases are often preferred to repairs, unlike the constructions and repairs used by the self-reliant Eskimo. Even to-day, the Eskimos repair and improve their bought spectacles.

Conclusions

From the study of 59 Eskimo snow goggles it may be concluded that:

(1) There are many different types. From the optical-ophthalmological point of view the snow goggles may be divided into 11 types, depending upon the appearance of the eye slit (Fig. 2, page 5).

(2) The snow goggles protect the wearer from ultraviolet light and visible light, reducing the amount of light to between 2 and 8%.

(3) The snow goggles protect the wearer from cold and draught.

(4) The snow goggles give the wearer better vision in cases of mild myopia and astigmatism, they increase depth definition and allow presbyopics to read. In dazzle conditions visual acuity is increased as much as threefold. Vision is not impaired in the cold weather, because the slit goggles do not mist or ice over.

(5) The field of vision – in particular the vertical field – is restricted, whereas nasal vision is preserved, sometimes with a crossed visual field where the right eye sees farthest to the left and the left eye farthest to the right.

(6) The visual field obtained is the result of a compromise between purely visual requirements and protective requirements.

(7) There are moderate differences between snow goggles from Greenland and from Canada: the Greenlandic ones are often rather larger than the Canadian ones.

The figure-of-eight-shaped and drop-shaped eye slits are most common in Greenland, the triangular slit or the use of one goggle for each eye is most common in Canada.

Tables

Table I: Visual field with snow goggles (vert.=vertical; nas.=nasal; temp.= temporal); aperture (hor.=horizontal; vert.=vertical; th.:=thickness of slit; peak=peak distance from anterior edge to closed eye of wearer); and height and width of snow goggles. Total material: 59 snow goggles.

Type	No.	Visual field in degrees			Aperture in mm				Dimensions in cm	
		vert.	nas.	temp.	hor.	vert.	th.	peak	height	width
A	3	5.7	16.0	19.7	22.0	2.7	1.5	19.7	3.87	13.7
B	7	5.6	30.1	38.3	37.3	2.7	1.7	18.1	3.33	13.6
C	4	4.3	39.3	40.3	43.5	2.0	1.1	17.8	3.67	14.7
D	5	7.8	28.2	42.0	32.6	3.0	0.9	12.2	2.96	14.0
E	6	5.3	61.0	33.0	97.0	4.8	1.0	22.0	3.90	13.6
F	8	14.2	58.0	14.8	78.9	7.9	1.0	33.0	4.26	12.9
G	7	10.0	10.6	26.2	28.9	8.3	0.6	34.2	4.37	13.7
H	9	7.2	27.1	41.9	38.3	3.1	0.8	16.8	2.90	13.2
I	2	31.0	9.0	44.0	32.5	10.5	0.5	23.0	6.10	18.5
J	3	28.0	18.5	21.5	36.0	22.0	0.1	37.5	3.10	13.3
K	5	27.0	21.3	19.0	23.8	19.2	2.0	21.8	3.72	13.0

Table II: Dimensions of snow goggles in Greenland and in Canada (mm ± SEM).

	Greenland	Canada	p
Height	45.4 ± 2.03	29.0 ± 0.62	< 0.001
Height, range	28-69	22-36	
Width	139.2 ± 4.2	133.1 ± 2.0	n.s.
Depth	36.9 ± 2.70	31.3 ± 2.07	n.s.
Number of goggles	30	29	

Table III: Shape of goggles.

	Greenland	Canada	Total
Flat board	8	0	8
Angular at nose, otherwise flat	3	2	5
Forward convex, one curve	12	26*	38
Three-dented (nose + sides)	4	0	4
Soft material	3	1	4
Total	30	29	59

* $p < 0.02$.

Table IV: Dating of Eskimo snow goggles

Year AD	
0-500	Snow goggles from the "Old Bering Sea Culture" found in Siberia (Arutiunov & Sergeev 1975).
Before 1000:	Dorset snow-goggle fragments from Newfoundland (Meldgaard, pers. comm. 1992).
At the end of the 13th century	Real optical goggles invented in Italy (Lundsgaard 1913).
ca. 1600	Snow-goggle fragments from Thule (Meldgaard, pers. comm. 1992).
1721	Hans Egede colonizes Greenland.
1752	Merchant Lars Dalager describes snow-blindness, or at least ocular infirmity in men (quot. Lange 1864).
1867	W.H. Dall: "In Youkon Eskimos used a kind of wooden goggles, blackened inside and provided with a narrow slit to restrict the glare" (quot. Fortuine 1991).
1878	Nordenskiöld's NE passage expedition used wooden snow goggles of the Greenlandic type when sledging ("allowed only a narrow range of vision"). Only four developed snow-blindness (quot. Forsius 1993).
1891-92	The Danish Expedition to East Greenland: Each member brought a pair of wooden snow goggles (quot. Gulløv 1991).
1908-11	V. Stefansson photographs seven Inuits with snow goggles pushed up on the forehead and one pair in use from Prince Albert Strait, Canada (Stefansson 1925).
1908-09	C.M. Norman-Hansen (1861-1947), the first ophthalmologist in Greenland, studies snow-blindness (quot. Norn 1992).
1929	Valdemar Hertz (1869-1959), ophthalmologist, prescribes snow goggles (Norn 1992).
1951	Jean Malaurie experiences snow-blindness (without sun goggles!) in Thule. Had heard in 1979 that Canadian Inuits treated snow-blindness with a few drops of kerosene in the eyes (Malaurie 1979).
1969	J.S. Philpotts (ophthalmologist) mentions the continued use of snow goggles in the village of Tiniteqilaq, East Greenland (Norn 1992).
1994	Tasiilaq Museum acquires snow goggles (Type F) made by Odin Maratse in the village of Sermiligaaq, East Greenland. Snow goggles are no longer used there.
1994	Every year Kurt Albøge, district physician, Tasiilaq, treats about 20 cases of snow-blindness. However, this number must be far greater, because the Inuit do not go to a doctor with such a well-known condition. Prophylaxis is colour-changing UV-absorbing sunglasses.
1995	International Scientific Workshop on UV B damage held in Kangerlussuaq on December 2nd-5th (Norn 1995).

Author's Material

Only a few snow goggles can be dated prior to the donations listed below:

Date	Donator
1840	I.M. Møller, colony principal (Lc 78, Type A).
1844	Fasting, colony inspector for North Greenland (Lc 190, Type C)
1886	Gustav Holm's umiak expedition, East Greenland (1418, Type E, 1419, Nuuk Museum, Type F).
1888	Søren Hansen, physician (Ld 85, type K with glass).
1892	Gustav Holm, Godthåb (Ld 113, Type I and Ld 114, Type J).
1900	Amdrup, from Nuunaalik, north of Ammassalik (L 6516, L 6517, Nuuk Museum, Type F, and L 6518, Type G).
1902	Professor W. Thalbitzer (L 2041, Type K with spectacle lenses).
1908	Roald Amundsen, the Gjøa Expedition (P 49, Type A).
1908	Alfred Bertelsen, district physician (RIN 100200, Type C Medical History Museum, Norn 1992).
1911	Johan Petersen, colony inspector, Ammassalik (L 5055, Types F and L 5058, Type G).
1924	Fifth Thule Expedition to Arctic North America 1921-24. A total of 24 snow goggles, i.e. all specimens of Type D, some of Types B, C, E, G, H, J, and Type K without spectacle lenses.

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