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CONTENTS

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GILBERT H. GROSVENOR, EDITOR

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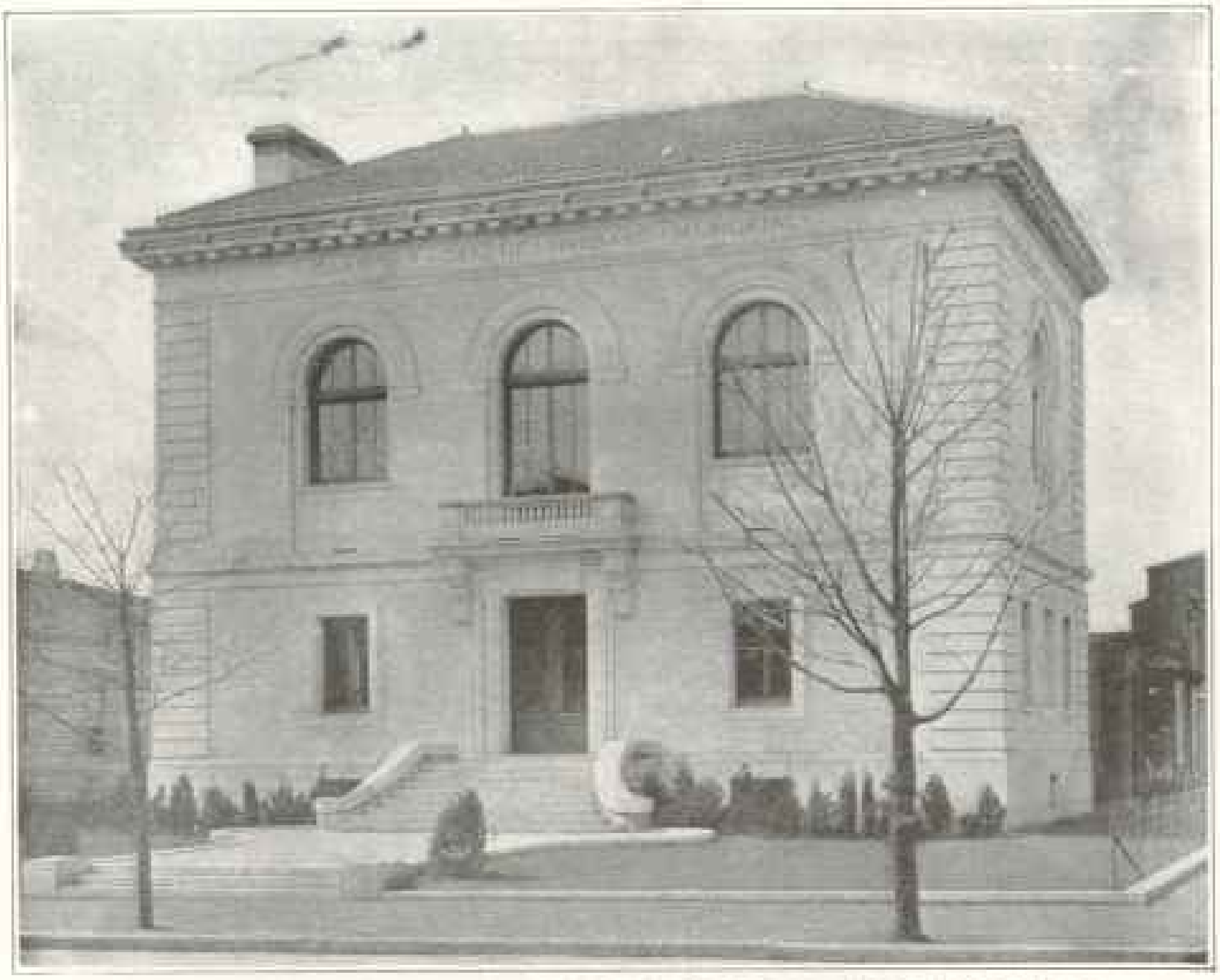

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VOL. XXII, NO. 6 WASHINGTON JUNE, 1911

THE NATIONAL GEOGRAPHIC MAGAZINE

A GEOLOGIST'S PARADISE

BY CHARLES D. WALCOTT

SECRETARY OF THE SMITHSONIAN INSTITUTION

NATURE has a habit of placing some of her most attractive treasures in places where the average man hesitates to look for them. Twenty-five years ago rumors came of a wonderful find of glaciers, forests, mountain peaks, and lakes along the line of the rugged pass through which the Canadian Pacific Railway was building.

A geological reconnaissance by Sir George M. Dawson, of the Canadian Geological Survey, outlined some of the broader geological features, and a somewhat closer study by Mr. R. G. McConnell in 1886 resulted in a more accurate description of the thousands of feet in thickness of sandstone, shale, and limestone that had been arched and broken before being dissected and laid to view by the agents of erosion which formed the canyons, cliffs, and mountains by removing grain by grain or by chemical solution the material that formerly occupied or surrounded them.

A young American, Walter Wilcox, taking his surveying instruments and camera, spent summer after summer sketching maps and photographing the scenery, and in 1896 he published the first of several beautiful volumes on "Camping in the Canadian Rockies." Later, with the development of the kodak, thousands of pictures were taken by tourists who had little thought of the geological treasures lying all about.

The study of the glaciers was begun early by an American, George Vaux, of Philadelphia, assisted by his sister Mary, and later an expedition sent out by the Smithsonian Institution under the leadership of William H. Sherzer, of the University of Michigan, resulted in the publication in 1907 of a memoir describing and illustrating many of the glaciers.

During the past three years an expedition from the Smithsonian has been making an examination of the four miles or more in thickness of bedded rocks forming the main range of the Rocky Mountains that has been pushed eastward by the great mass of the Selkirk ranges to the west. It is a curious and instructive feature of the geology that the strata of the Rockies, although crowded eastward and thrust out over the later rocks of the plains of Alberta, have not suffered nearly as much dislocation, injury, and alteration as the apparently more massive bedded rocks of the Selkirks. The latter are crumpled, broken, and altered in about the same manner as large blocks of brittle paper would be if subjected to side pressure in a hydraulic press.

Photo by Charles D. Walcott

CAMP CONTENTMENT MEADOW, ABOVE LAKE O'LAW, AT FOOT OF MOUNT STEPHEN

MOUNTAIN-BUILDING ON A GRAND SCALE

The study of the arched block of strata 16,000 feet or more in thickness from which the picturesque and impressive mountains and canyons have been carved has resulted in the discovery that the rocks in which the great Bow Valley is excavated form a part of the North American continental beds that were deposited in great fresh-water lakes before the waters of the ocean swept over the continent and began their task of depositing the 12,000 feet or more in thickness of rocks of Cambrian age that now contain the remains of the marine life of that period.

As the study of the formations developed it was found that in the eastward thrusting of the rocks massive limestones were often crushed and ground into fragments; in other places the thinner beds for 100 feet or more would be folded and crumbled between huge masses of even-bedded limestone that showed no traces of disturbance. In other places a series of beds, 1,000 feet or more in thickness, met some obstacle which they could not crush or surmount, and were driven upward at almost right angles, forming series of sharp, ragged ridges. On the east side of the

Lower Yoho Valley the limestones of Mount Ogden are lying nearly level, but on the eastern slope above Sherbrooke Lake Canyon the same beds are turned down at right angles and disappear beneath the canyon bottom. Everywhere the keen eye of the geologist will find evidence of mountain-building on a grand scale.

The panoramic photograph, taken by the author from Burgess Pass, 3,000 feet above Field, and published as a Supplement to this number of the NATIONAL GEOGRAPHIC MAGAZINE, shows at a glance over 9,000 feet in thickness of bedded rocks, 6,000 feet of it in an almost sheer cliff in the mass of Mount Stephen. Many thousand feet more may be seen to the westward in Mount Denis and in Mount Vaux. From Mount Stephen the eye follows to the left across the great canyon of the Kicking Horse River to the summit of Mount Field, two miles away, where the same limestone and shale beds carrying the same fossils indicate that thousands of feet in thickness and many million cubic yards of hard rock have been removed by erosion from between the two mountains, Stephen and Field. From Mount Field a gentle slope carries the same beds northward through Mount Wapta, where they undulate across the President Range and plunge to the westward beneath the corrugated and more readily broken Ordovician rocks of the Van Horne Range.

EARLY MARINE LIFE

All of the Cambrian rocks were deposited in waters teeming with marine invertebrate life. As far as now known, this was before the day of fish or of any other vertebrate animal; land plants and even marine vegetable life were almost unrepresented. Other animals of the sea, however, existed in great profusion, and here and there conditions were so favorable for their burial in the mud and sand of the Cambrian sea that they were preserved unbroken, and throughout all the processes of rock-making and mountain-building they have escaped destruction.

In one of these favorable places the most delicate of organisms, like the jellyfish, have been exquisitely preserved and we have crustaceans of many varieties. Among these many preserve the most delicate branchiæ and appendages, and one can hardly realize that they were buried in the mud 15 to 20 million years ago and have remained undisturbed while several miles of thickness of sediment were deposited over them, changed into rock, elevated into mountain masses, and later eroded into the present mountains and canyons.

We have long considered that the trilobite (page 516) was the most highly developed animal in the Cambrian time, but last summer a crustacean was found by the author in the fossil bed near Mount Wapta that was the king of the animal world in its day (page 517). That it was prepared to assert its right to the control of the Cambrian sea is shown by the claws with which it was armed.

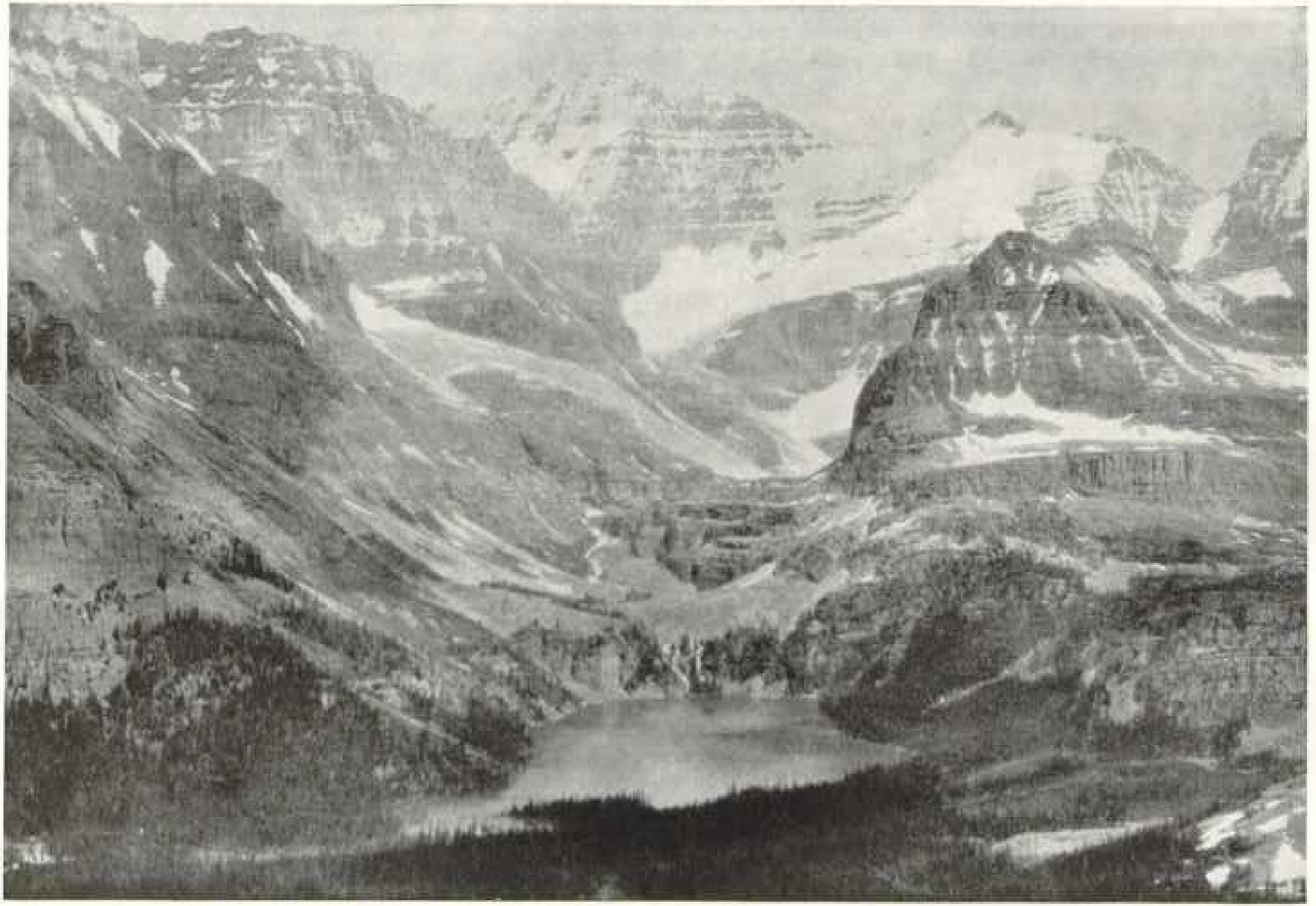
To the geologist interested in the volcanic rocks a great field is waiting in the Selkirks to the west, and for generations to come there will be unsolved problems for the special student in this great region of mountains, glaciers, and rivers.

SUMMARY OF GEOLOGIC FORMATIONS

In the long panoramic view the rocks seen in the distance, forming Mount Balfour, belong to the Sherbrooke formation of the Upper Cambrian, or the most recent rocks of the Cambrian section. Beginning with these and going downward, the following formations are passed through:

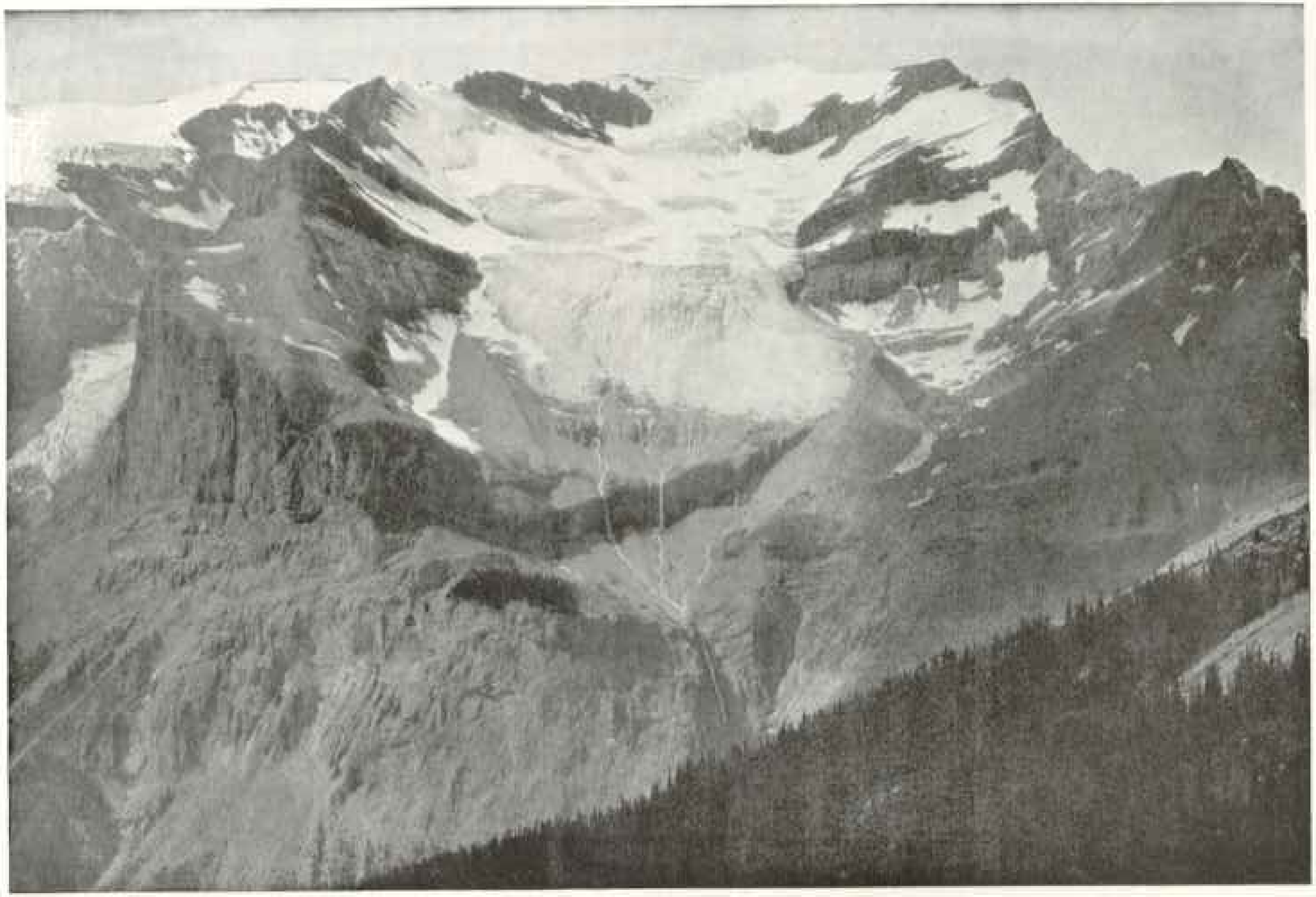
UPPER CAMBRIAN

	Feet
Sherbrooke formation (mainly limestones)	1,375
Paget formation (limestones and shales)	360
Bosworth formation (limestone and shale)	1,855+
Total Upper Cambrian	3,590+



LAKE O'HARA (6,664 FEET) RESTS IN A BOWL IN THE MOUNTAINS

From the lake to the top of Mount Lefroy 4,000 feet of Cambrian strata are seen in one unbroken section. Photo by Charles D. Walcott



VIEW OF THE PRESIDENT RANGE FROM A POINT ON THE TRAIL ON THE WEST SLOPE OF MOUNT WAPTA, 3½ MILES IN AN AIR LINE NORTH OF FIELD, ON THE CANADIAN PACIFIC RAILWAY, BRITISH COLUMBIA, CANADA

This view shows Emerald Glacier after a light snow-storm has whitened the ice. Note particularly the two lateral moraines formed of broken-up light gray limestone (see page 520). Photo by Charles D. Walcott

Photo by Charles D. Walcott

WAITING ON THE BURGESS TRAIL UNDER MOUNT WAPTA

MIDDLE CAMBRIAN	Feet
Eldon formation (siliceous and arenaceous limestones) ..... 2,700 to	2,800
This is the formation that caps Mount Stephen and many of the higher mountains.	
Stephen formation (limestones and shale)	630
Cathedral formation (arenaceous limestones)	1,503
Total Middle Cambrian	4,963

LOWER CAMBRIAN	Feet
Mount Whyte formation (limestones and sandstones)	390
Saint Piran formation (sandy shales and sandstones)	2,705
Lake Louise formation (siliceous shale)	105
Fairview formation (sandstones)	1,324
Total Lower Cambrian	4,524

SUMMARY	Feet
Upper Cambrian	3,590+
Middle Cambrian	4,963
Lower Cambrian	4,524
Total thickness of Cambrian section	13,077+

Beneath the old Cambrian sea-beach now forming the base of the Fairview formation there is a great series of sandstones and sandy shales of quite a different character. These rocks formed the land area which was submerged by the Cambrian sea that wore them away more or less in its advance over the continent.

These older rocks are supposed, owing to their character and the absence of marine fossils, to have been deposited in fresh water. They are referred to a series called the Algonkian, and are divided into two formations:

	Feet
Hector formation (sandstones and shales—gray, black, greenish, purple in color) ..... total thickness..	1,302
Corral Creek formation (sandstones)...	1,320

THE WASTING AWAY OF THE MOUNTAINS

The breaking down of the mountain summits by the action of rain, frost, and ice, so as to form strong pyramids and ridges, is constantly going on. This is

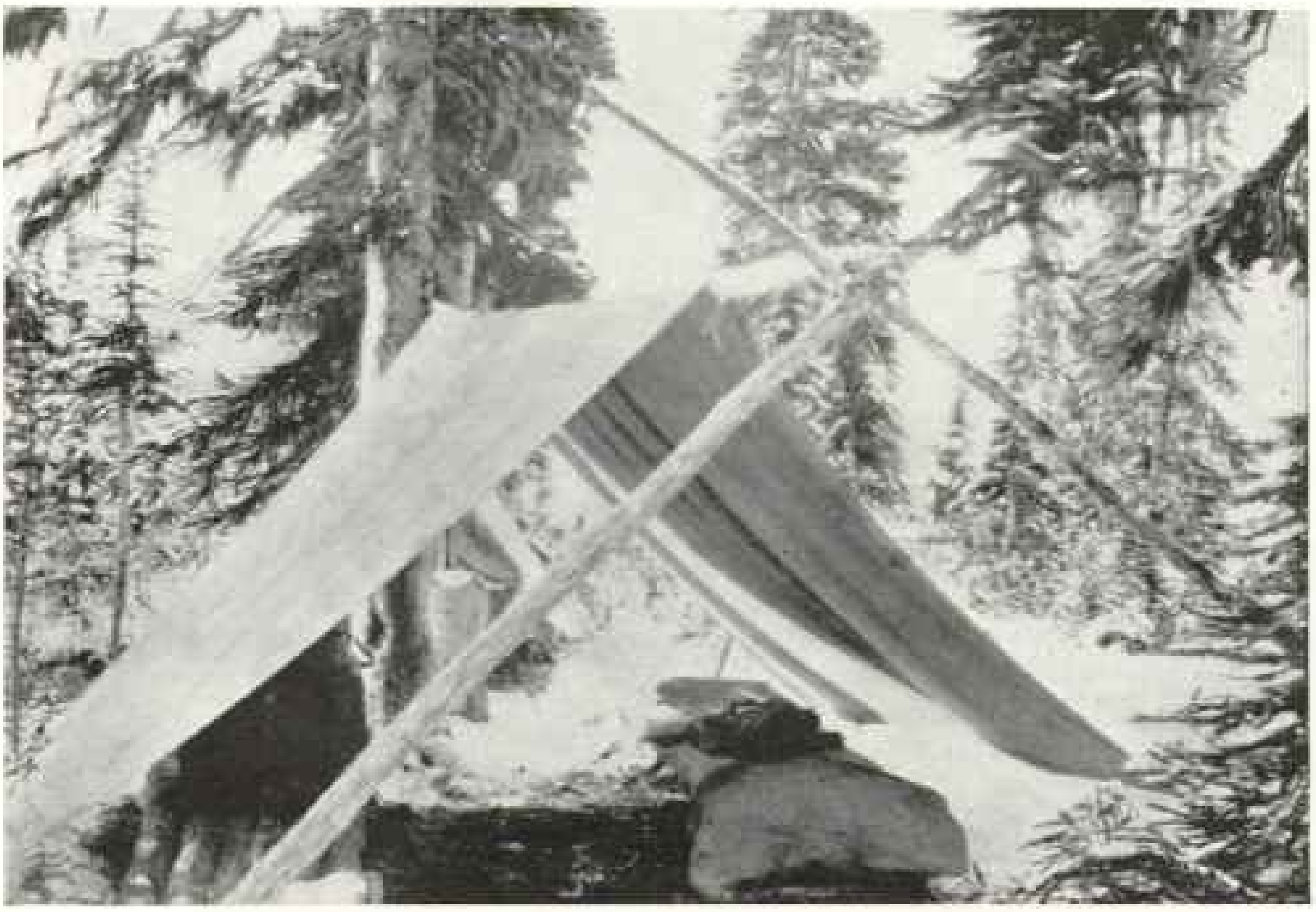


Photo by Charles D. Walcott

A COOL SEPTEMBER MORNING AT 7,000 FEET ABOVE SEA-LEVEL

well shown by the photograph of Mount Huber, on page 518.

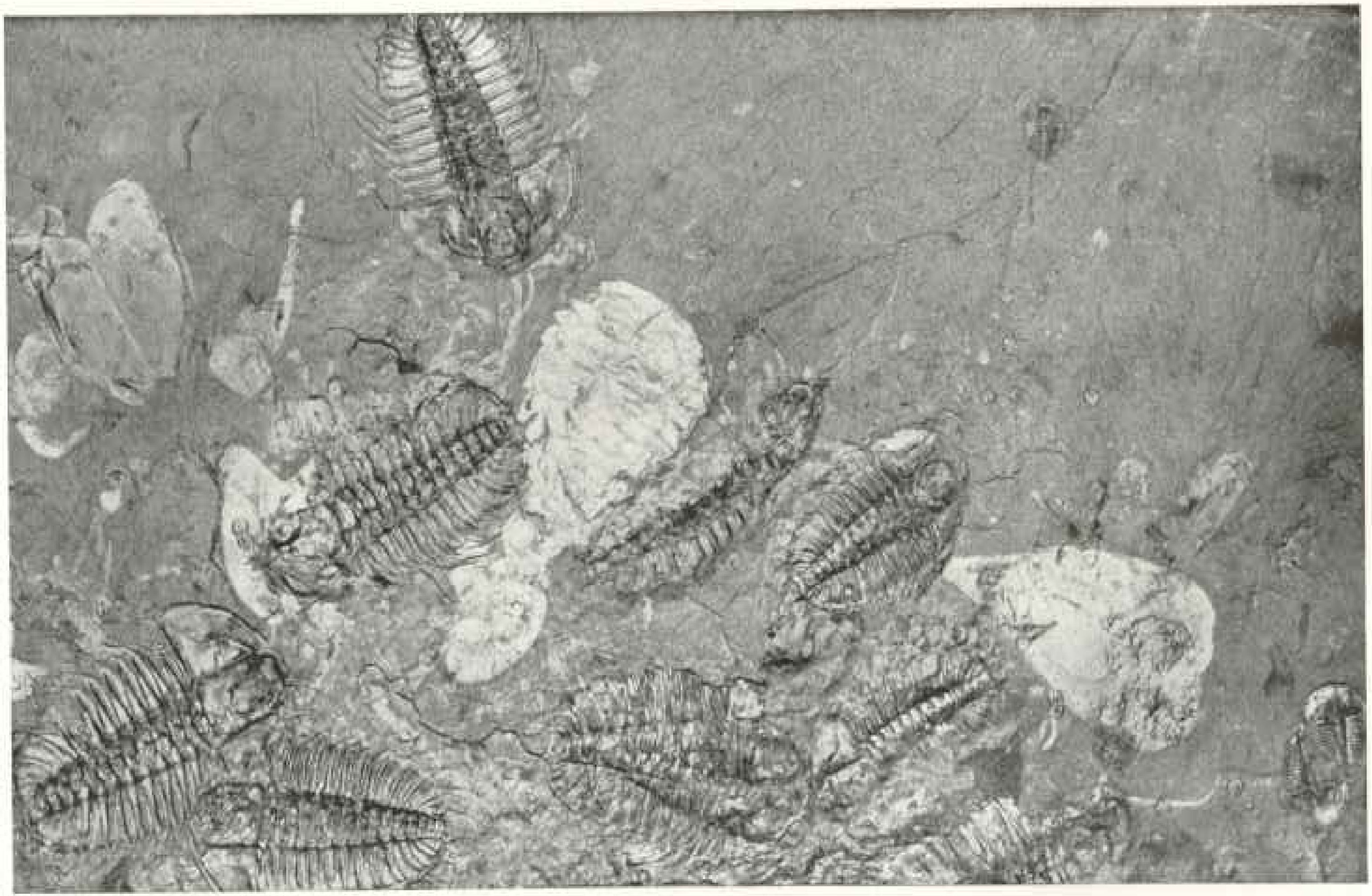
An illustration of a long summit ridge is given by Mount Daly, where every summer storm leaves a fresh coating of snow. I well recall stepping off the limestone onto the snow, thinking it hard and secure, and dropping in up to my armpits within a few feet of the rock. We were glad to paddle our way back and follow the rocky ridge for miles around to get back to camp.

Some of the deep canyons were filled up for 1,000 feet or more by dirt, gravel, and boulders washed down from the sides of the mountains, probably during the great Glacial period. Upon the withdrawal of the ice this accumulated material was rapidly cut away, but occasionally masses of it are left high on the sides of a mountain, and often most fantastic forms result from its erosion where the finer beds of gravel and clay are hardened and protected above by blocks of sandstone and limestone. One of the most noteworthy examples is that of the so-called Hoodoos, on the slope of Mount Vaux, 18 miles west of Field.

TAKING THE PHOTOGRAPHS

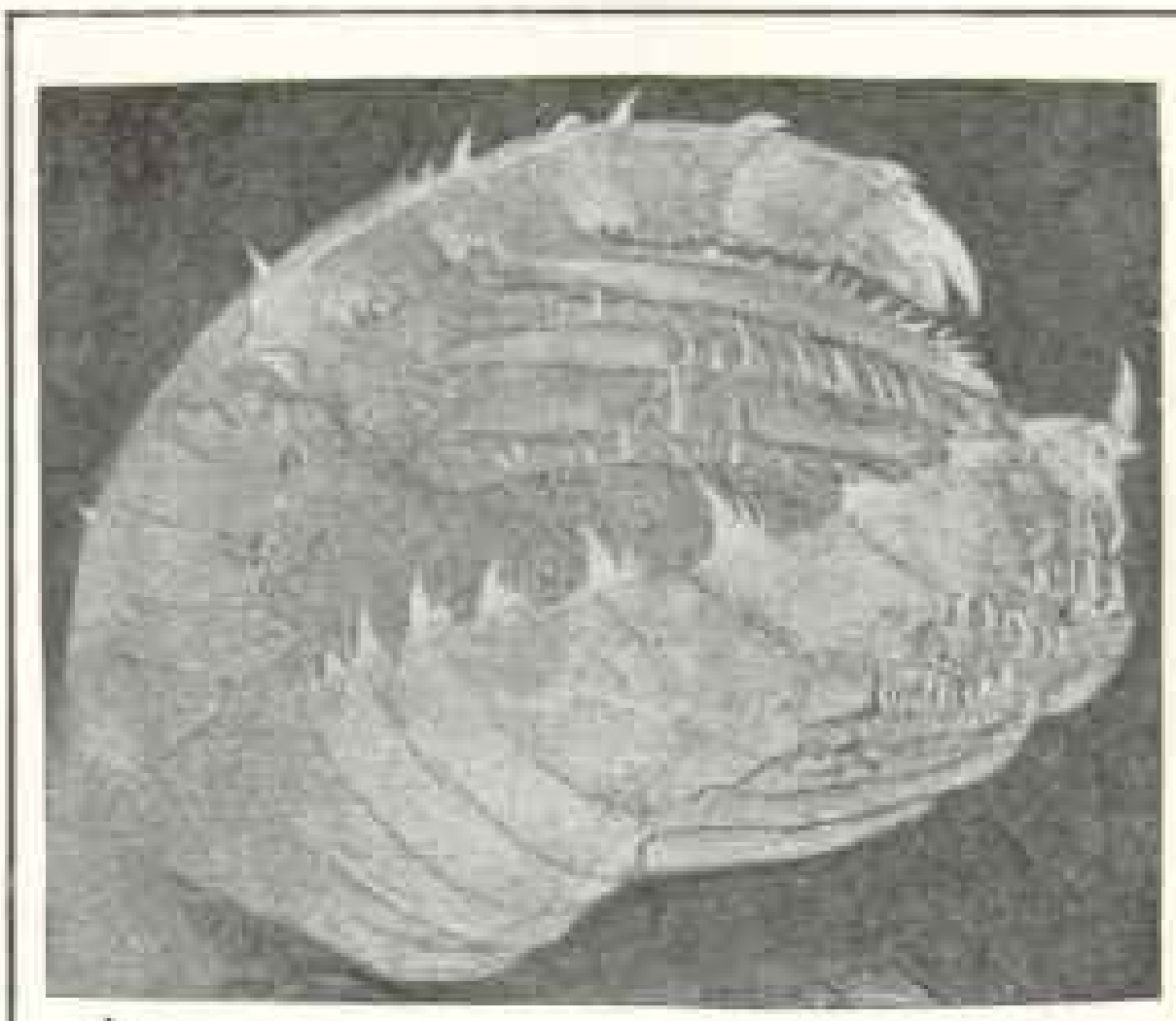
The panoramic photographs were taken with the Cirkut camera that is used by newspaper men and others for photographing processions and obtaining panoramic views of buildings, railway lines, etc. For use in the mountains several minor changes were made, so that the instrument could be used successfully under such adverse conditions as strong wind, hands and fingers numbed from cold, and often very insecure foundation for the tripod. As it is necessary to have absolute stability and the camera-bed level, the securing of perfect negatives is difficult.

The camera consists of the ordinary 6½ by 8½ outfit, with a panoramic attachment which is 10½ inches square by



FRAGMENTS OF A COLONY OF MARINE ANIMALS ON A SLAB OF BLACK ROCK, WITH MANY TRILOBITES (DARK) AND SHELLS OF THE SIDNEY CRAB (LIGHT), WHOSE CLAWS ARE SHOWN ON PAGE 517

These creatures and other animals, like the delicate jelly-fish, have been preserved many millions of years while sediment several miles deep was deposited over them (see page 511). Photo by Thomas W. Smillie



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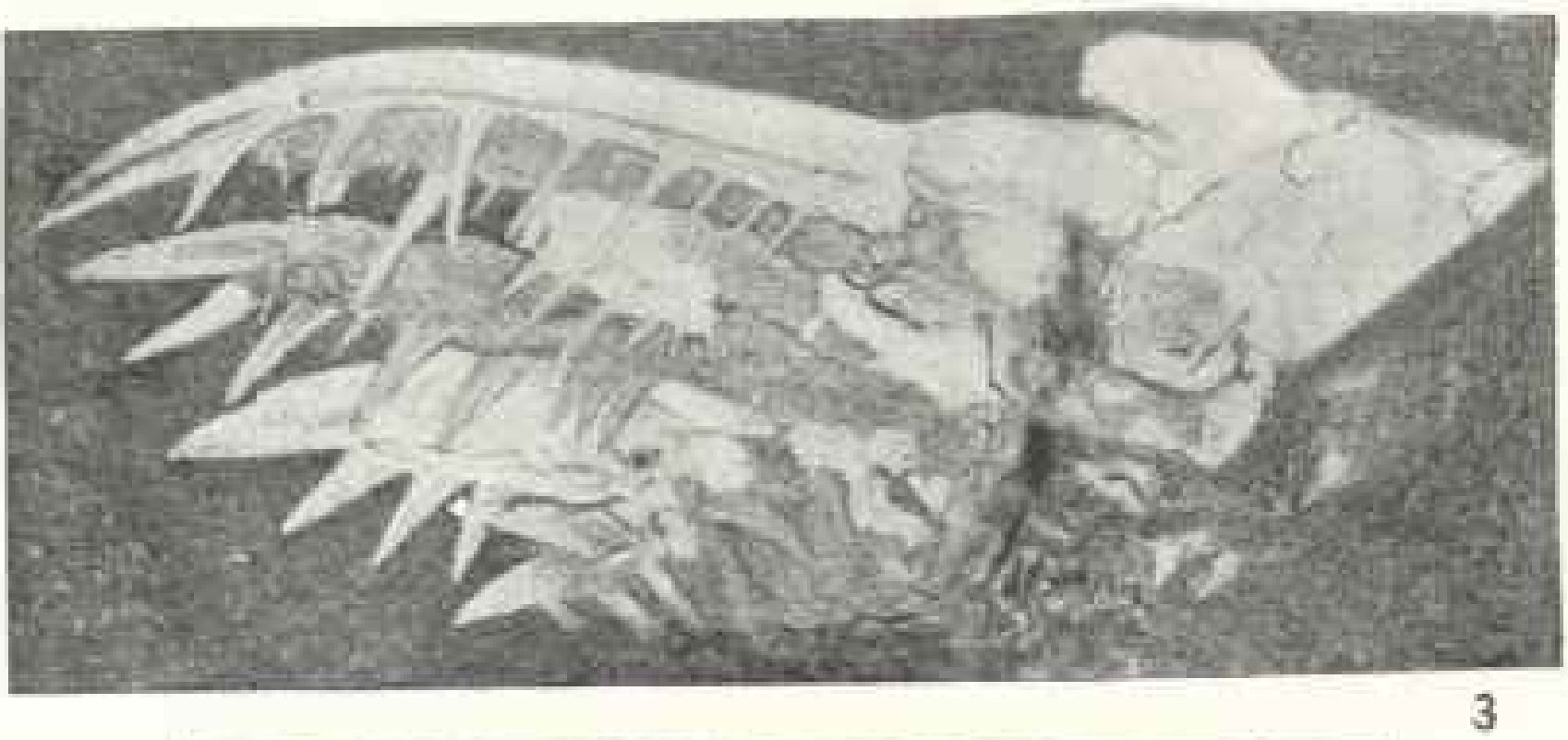

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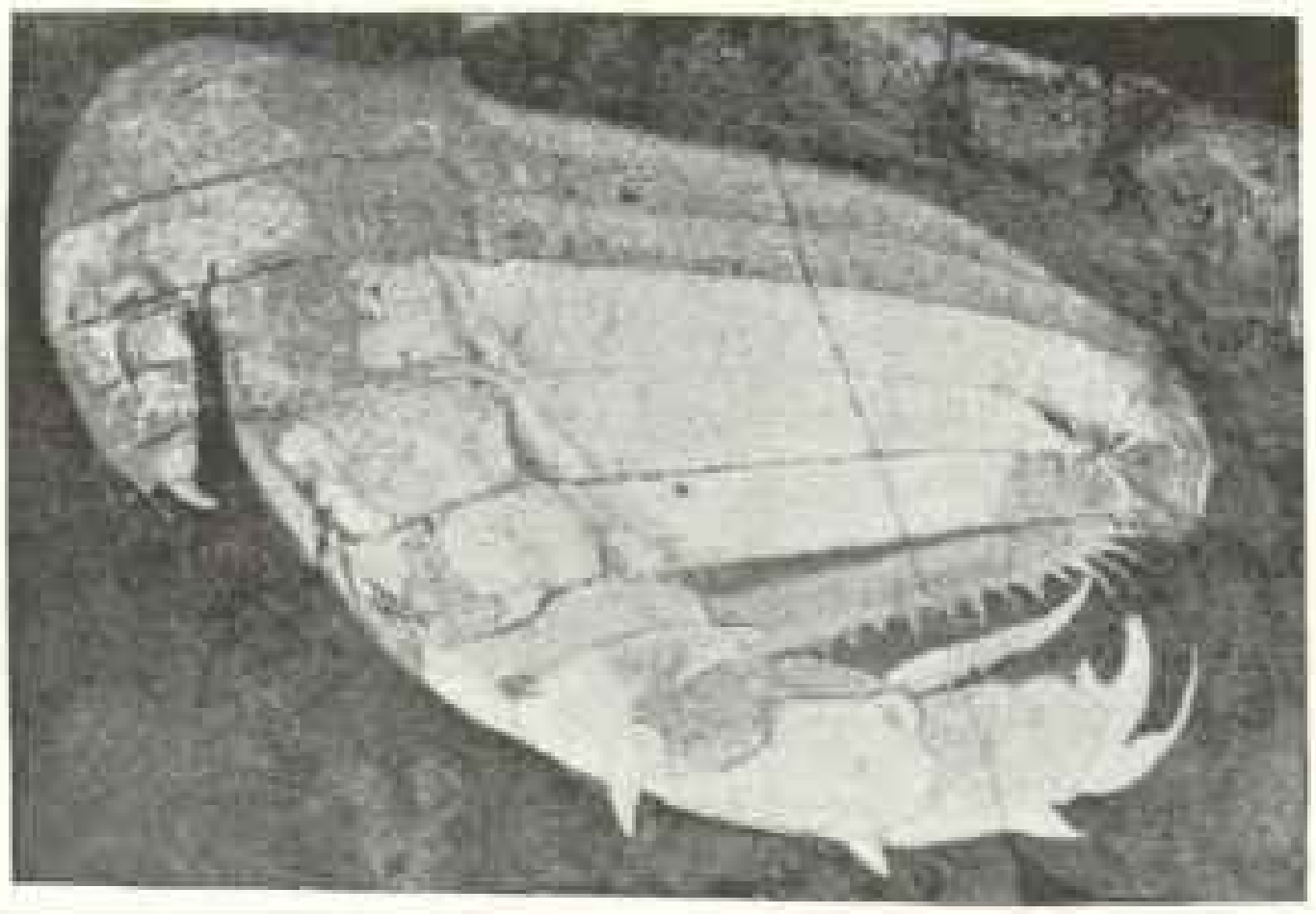

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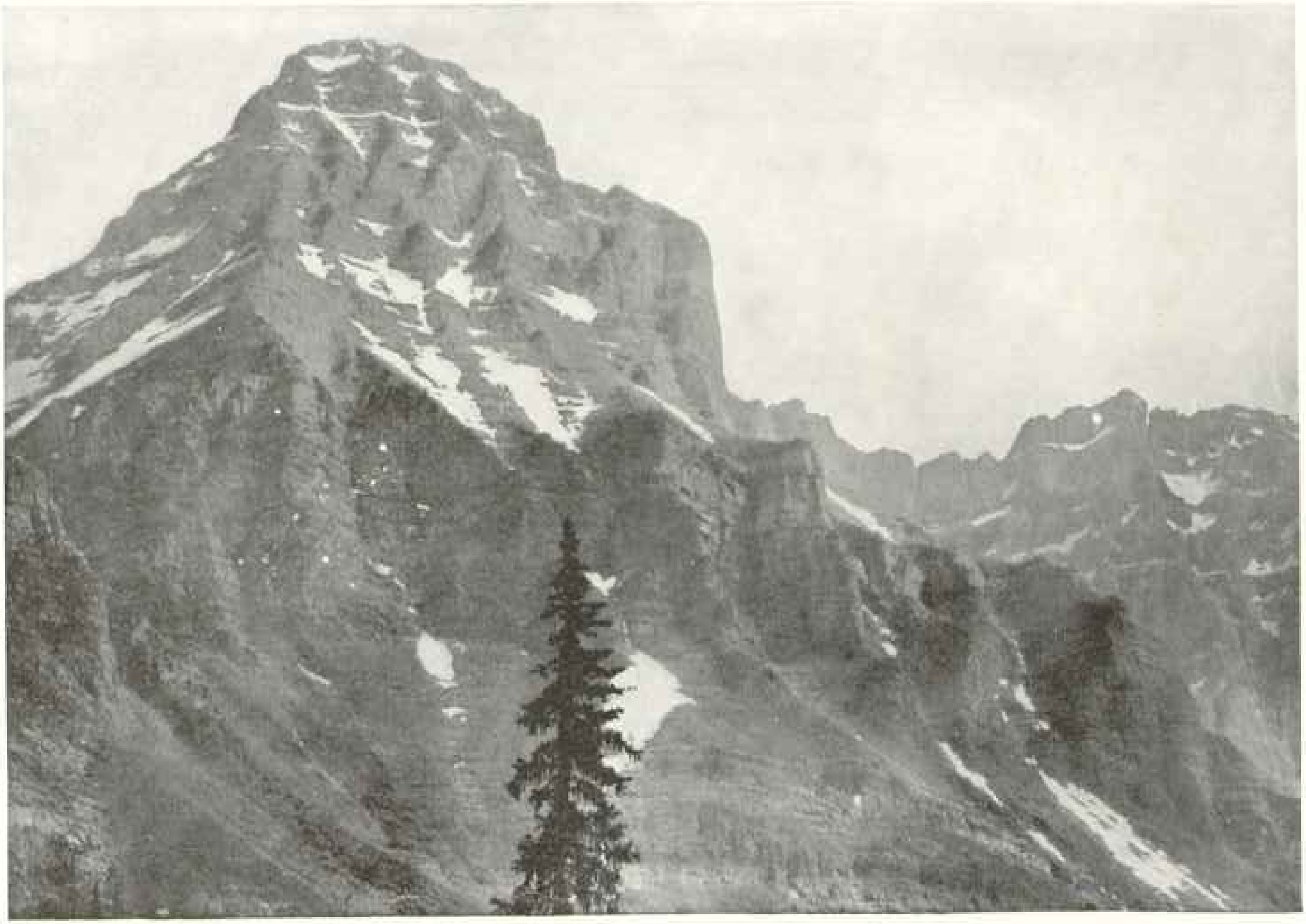
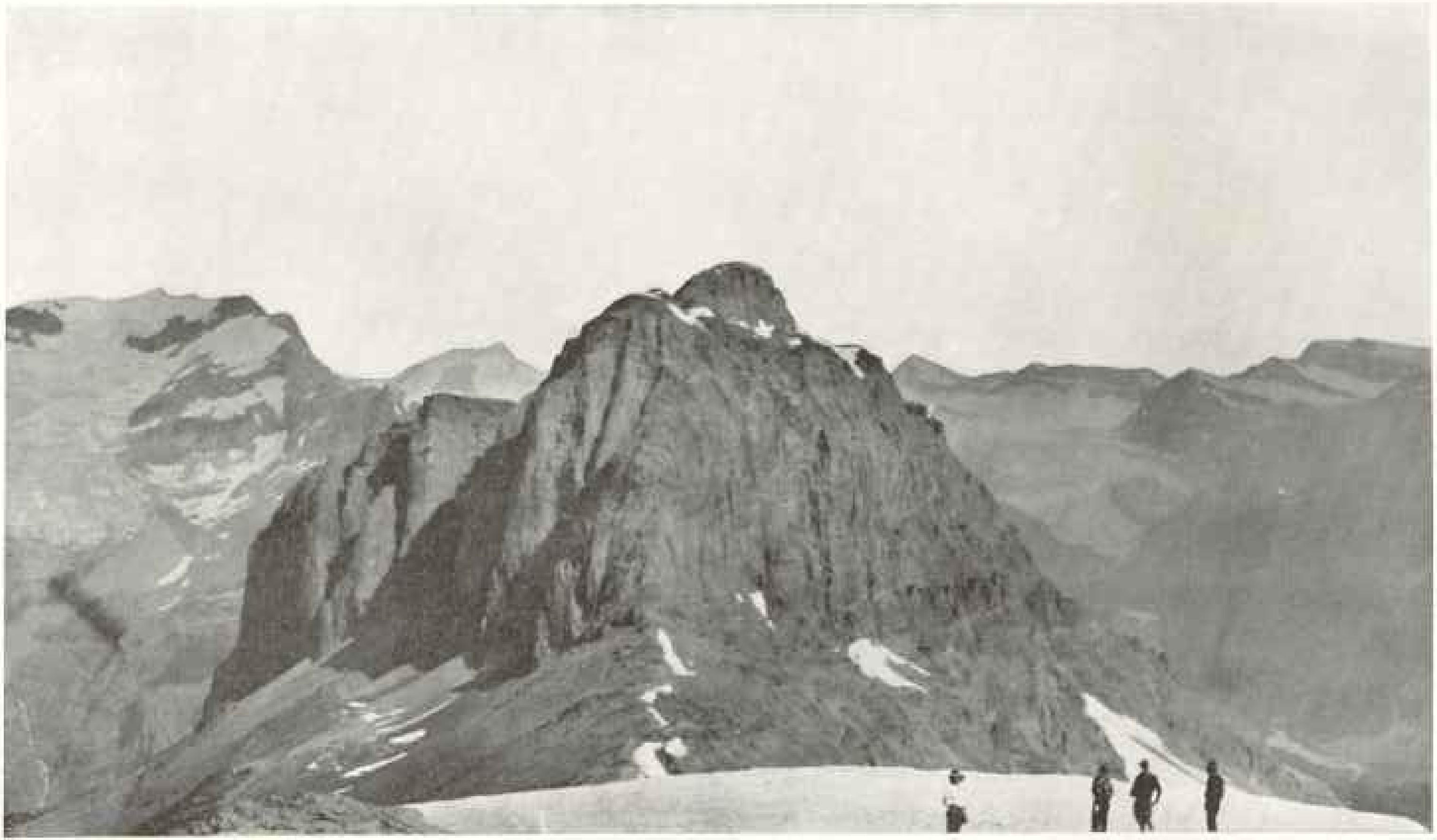
THE KING OF THE ANIMAL WORLD 15 MILLION YEARS AGO? DISCOVERED BY MR. WALCOTT

The spiny claws of the Middle Cambrian crustacean (*Sidneyia inexpectans*), shown as a light patch in the center of the figure on page 516 (see page 511)



VIEW OF MOUNT HUBER, SHOWING THE EROSION OF THE MASSIVE CAMBRIAN LIMESTONES ABOVE THE QUARTZITE SANDSTONES

View taken from a low ridge west of Lake O'Hara, six miles south of Hector, on the Canadian Pacific Railway, British Columbia, Canada (see page 514). Photo by Charles D. Walcott



COOLING OFF AFTER A HARD CLIMB UP THROUGH THE LIMESTONES

Panoramic view, at 9,000 feet, of the south face of Mount Wapta from the summit of Mount Field, 4,600 feet above Field, on the Canadian Pacific Railway, British Columbia, Canada. Photo by Charles D. Walcott

Photo by Sidney S. Walcott

THE AUTHOR READY TO TAKE A PANORAMIC VIEW FROM SUMMIT OF MOUNT FIELD

4 inches in thickness. When the latter is used the tripod head is a 12-inch graduated circle with the revolving bed above. A ratchet, driven by springs, moves the camera around the circle, the speed being governed by fans. Our lens is a Bausch and Lomb Zeiss Protar, Series VII.

The long panoramic view had an exposure of one-tenth of a second over each part of the film. The film moves past a vertical half-inch aperture from right to left as the camera is revolving from left to right. With this instrument a view can be taken 8½ inches in height and of any desired length up to 10 feet. Two persons can readily carry the outfit anywhere that one can ordinarily climb. Under unusually difficult conditions the camera can be drawn up by a rope.

Often in the Canadian Rockies days will pass in which the atmospheric conditions are unfavorable for an extended view—dust blown in from the plains, smoke from forest fires, or the indefinite summer haze and cloudy weather interfering. The best conditions usually occur just after a heavy storm of either snow or rain has cleared the air.

One really great panoramic view and a half dozen fine smaller views is a successful season with the camera when it is used as an adjunct to hammer and compass in geologic work.

From the vicinity of the Burgess Pass camp the views were most beautiful and varied, and changed from hour to hour during the day and from day to day with the varying atmospheric conditions. Emerald Glacier, directly facing camp (page 513), was always attractive, whether in the bright sunlight, the gray light of early morning, the shadows of sunset, or when snow and fog were sweeping over the range, giving only now and then a glimpse of the ice and cliffs. The light-colored moraines on either side of its foot and the dark rocks afforded a beautiful setting for the glacier. Across the Yoho Pass the cliff of Mount Wapta stood in bold relief, with a steep slope of broken rock on the western side and a huge bank of snow on the eastern side of its south ridge.

Rising back of camp was the beautiful cliff of Mount Burgess, a favorite haunt of the mountain goat. At its eastern foot on the narrow ridge is the point where the great panoramic view was

taken. Far below and almost at the foot of the great cliff is Emerald Lake, a spot famous for its scenic beauty. Our camp in the forest just below the ridge was visited quite frequently in September by heavy snow squalls that gave a welcome opportunity for a day's rest, reading, and cleaning up.

Our camp at Lake O'Hara was in a beautiful mountain meadow at the foot of Mount Schaffer. Morning and evening the views of the surrounding mountains were most inspiring. At this elevation (7,000 feet) snow squalls were not infrequent on the higher summits above, and on July 17 snow fell at the camp most of the day. From a slope of Mount Odaray, Lake O'Hara, resting like an emerald in a bowl of mountains (see page 512), reflected the glaciers of Mounts Lefroy and Hungabee.

Camping in the Canadian Rockies is a relatively simple affair if one is accustomed to going about with saddle and pack animals for conveyance. It is not difficult to obtain good camp outfits with horses and men, and much of the most beautiful scenery can be visited without riding on a trail or leaving wagon roads. Firewood and good water are well distributed and grass for the horses usually abundant.

OUR MOUNTAIN PANORAMA

NO ONE would be more surprised and delighted with Mr. Walcott's beautiful panoramic view, which is published as a Supplement to this number, than the American scientist whose discoveries gave a practical value to Daguerre's invention of photography, and the 100th anniversary of whose birth was celebrated last month. It is only 72 years since John William Draper in New York took the first photograph of a human face, but the progress in the photographic art since then is amazing.

Mr. Walcott's panorama is the most marvelous mountain view that has ever been published, and is remarkable not only for its exceeding beauty, but also because of the many lessons in geography learned by studying it.

Readers of this Magazine who have attempted to take photographs in high altitudes can appreciate the combination of patience and skill required to secure a panorama like our Supplement. Weeks usually elapse before the weather is favorable, and then the slightest error of judgment may make the exposure a complete failure.

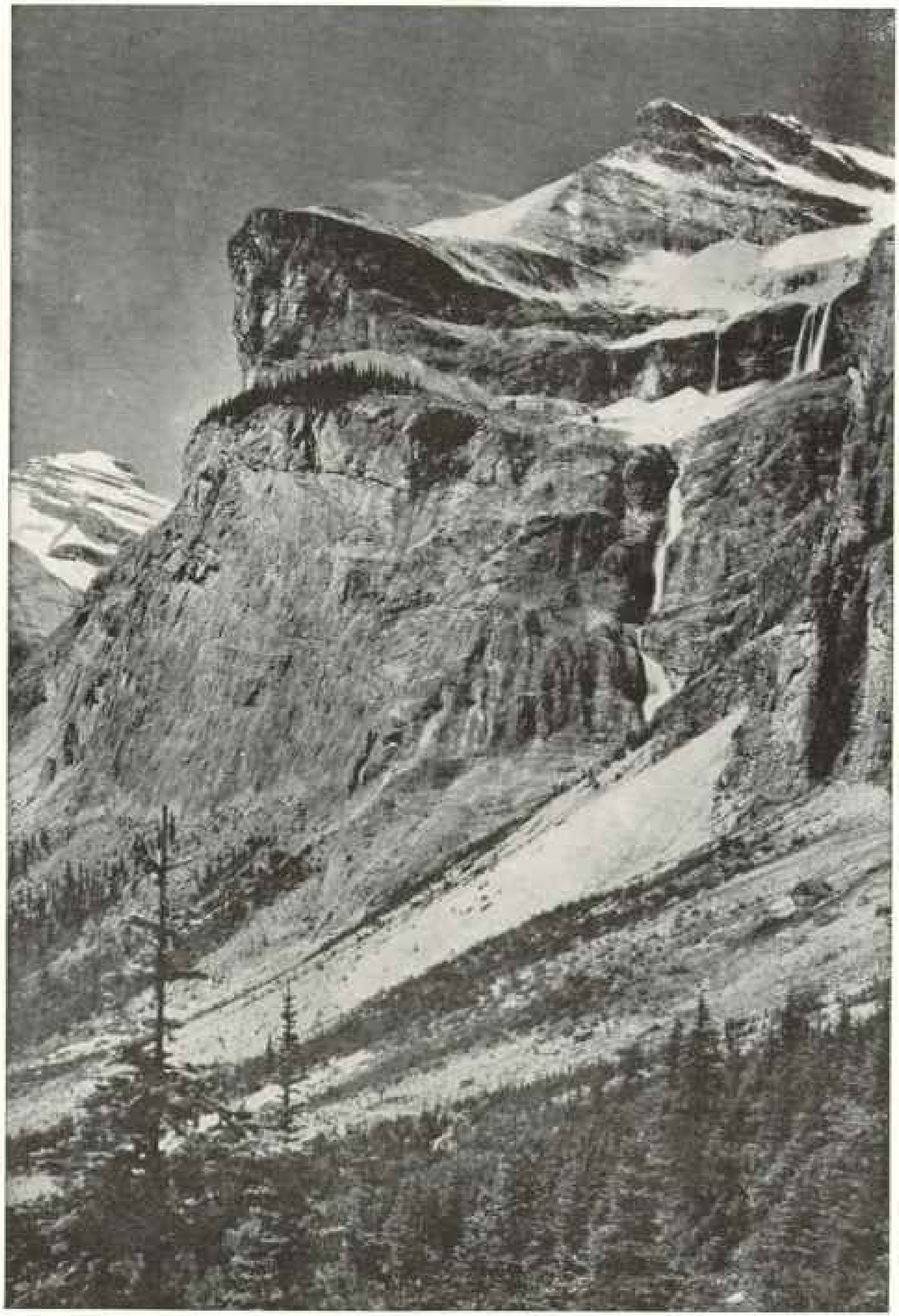
Perhaps equally difficult is the engraving, printing, and handling of 100,000 copies of the 9-foot picture. For the success of this part of the publication the NATIONAL GEOGRAPHIC MAGAZINE takes pleasure in acknowledging its indebtedness to the Matthews-Northrup Works, of Buffalo.

A few copies of the panorama have been printed on heavy art mat paper suitable for framing, and may be obtained at the office of the National Geographic Society at 50 cents per copy.

SCENES IN THE CANADIAN ROCKIES

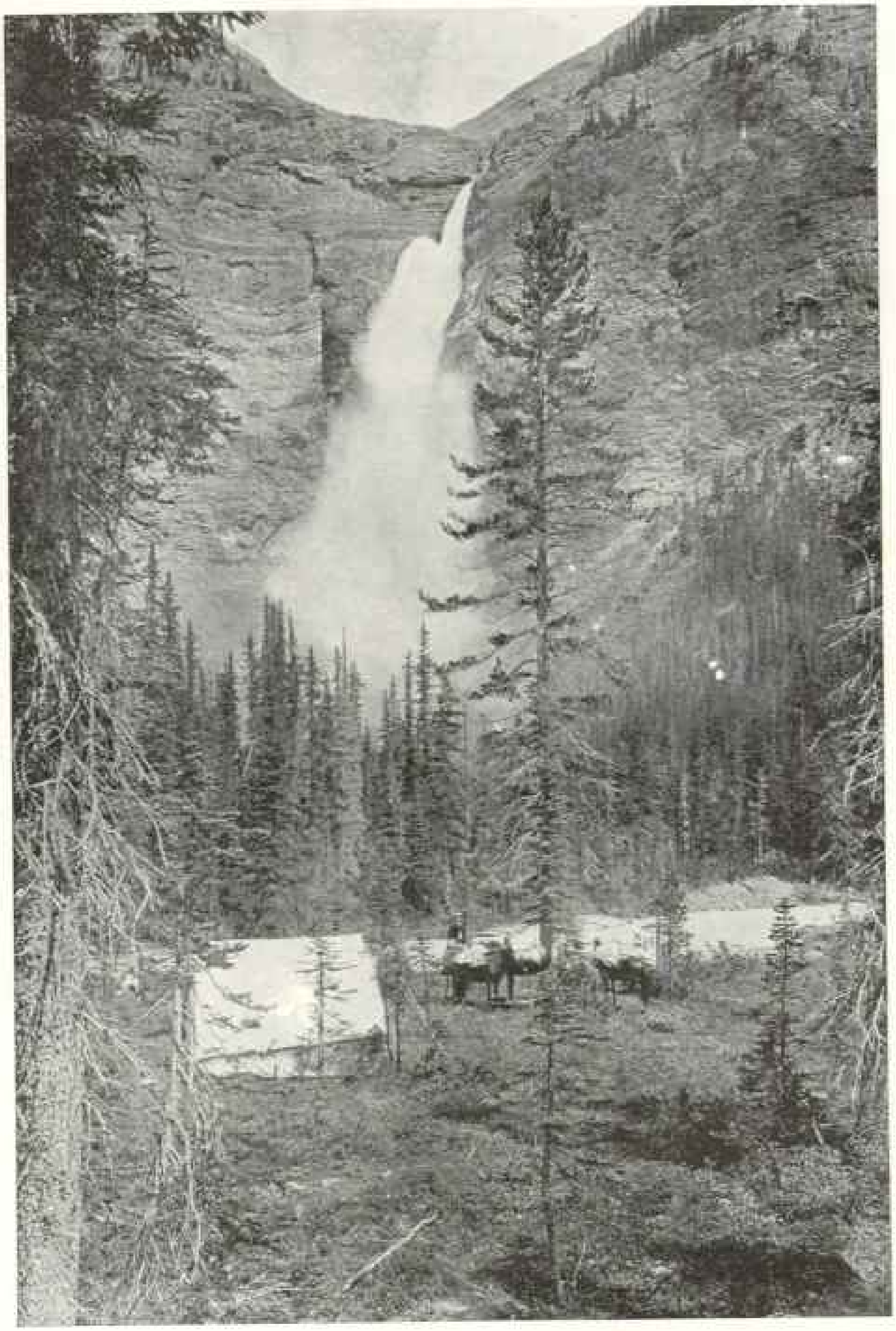
THE scenes in the Canadian Rockies, published on pages 522 to 536, are all from photographs by Rev. George Kinney, of Keremeos, B. C., Canada, who, with his companion, Duncan Phillips, has the distinction of being the first to ascend to the summit of Mount Robson, the highest mountain yet discovered in the Canadian Rockies.

Mount Robson is situated in the heart of the Rockies, some 50 or more miles north of Yellowhead Pass and hundreds of miles from civilization. The mountain can be reached only by pack-train after long weeks of strenuous endeavor through trackless forests and muskeg.



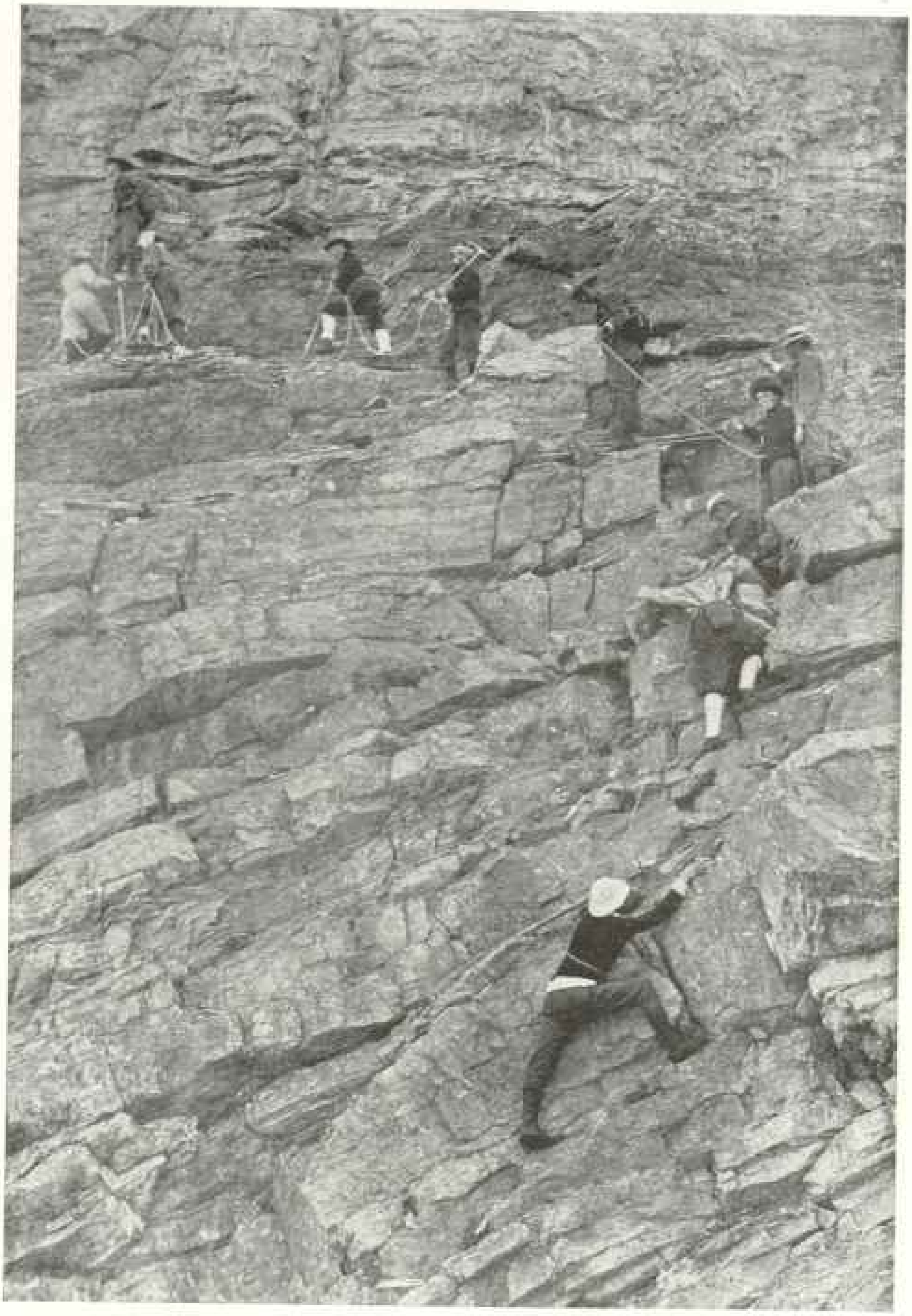
A SHOULDER OF MOUNT VICE-PRESIDENT, OVERLOOKING EMERALD LAKE, NEAR FIELD, BRITISH COLUMBIA

The upper falls in the photograph are about 200 feet high. Photo by Rev. George Kinney



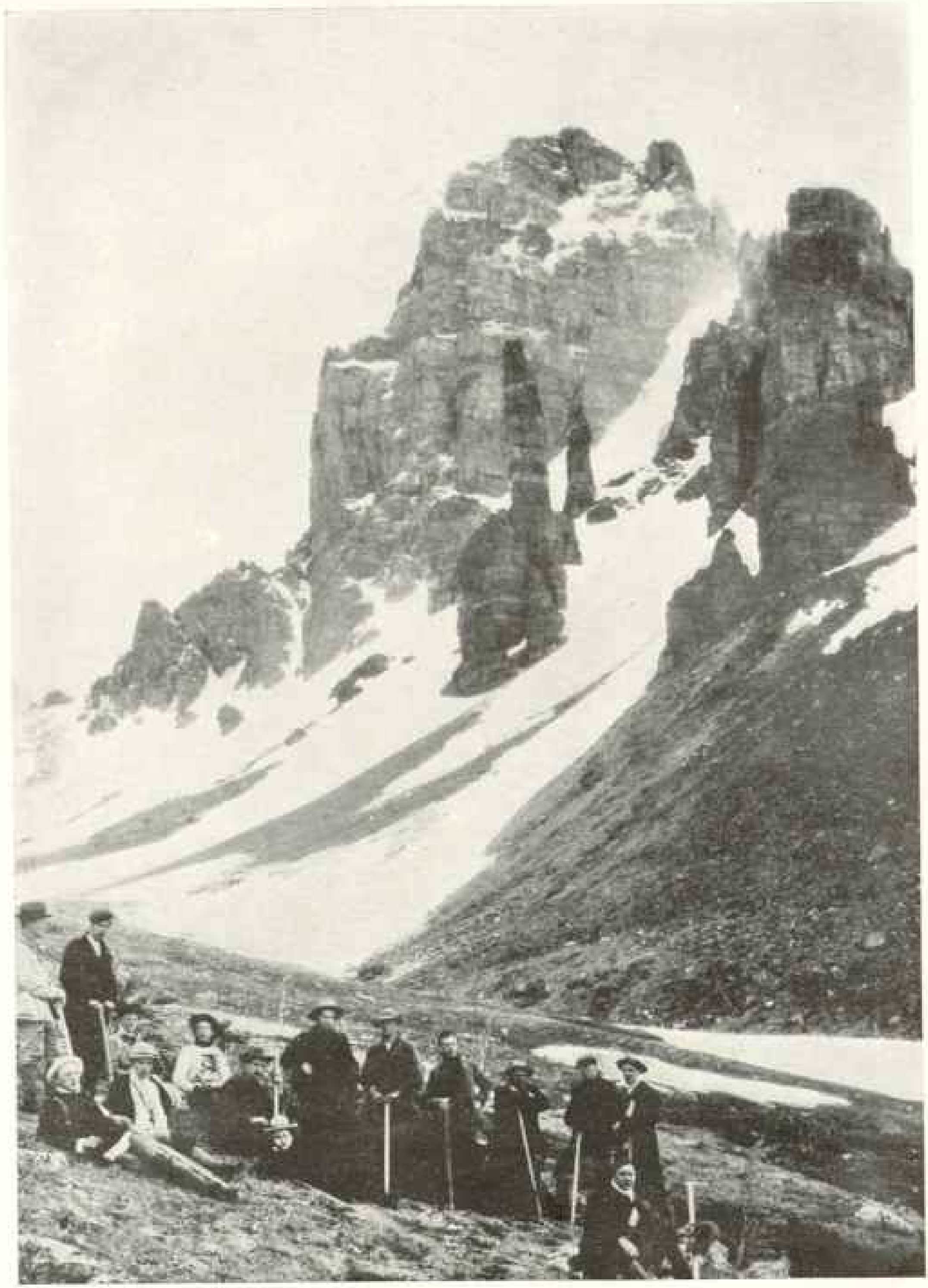
TAKAKKAW FALLS (1,200 FEET), IN THE VALLEY OF THE YOHO, BRITISH COLUMBIA

Fed by the great Daly Glacier, which is backed by a snow-field of many square miles in extent, the Takakkaw Falls leaps full fledged over a cliff 1,200 feet high, thus forming the crowning wonder of the marvelous Valley of the Yoho, near Field, B. C., in the Canadian Rockies. Photo by Rev. George Kinney.



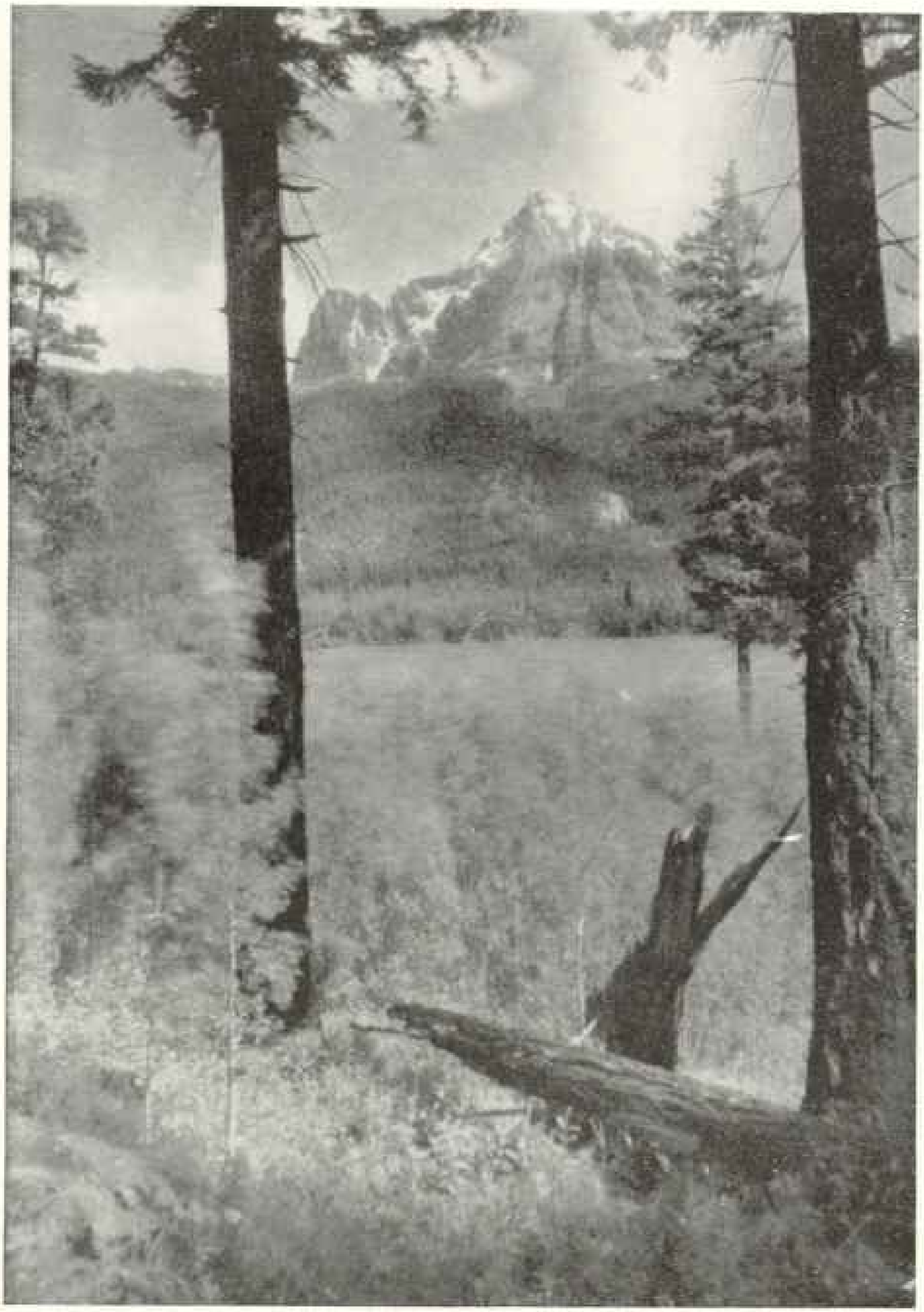
MEMBERS OF THE ALPINE CLUB OF CANADA ASCENDING MOUNT VICE-PRESIDENT

A difficult piece of rock-work. Under the care of expert guides the members thus qualify for active membership. Photo by Rev. George Kinney



MOUNT PINNACLE AND SENTINEL PASS, NEAR PARADISE VALLEY, BRITISH COLUMBIA

This splendid peak, rising out of Paradise Valley like a jeweled needle tipped with pearl, stands side by side with Mount Temple, in the Canadian Rockies, and overlooks the celebrated "Valley of the Ten Peaks." Photo by Rev. George Kinney.



MOUNT PEELER AND THE YELLOWHEAD LAKES: CANADIAN ROCKIES

Yellowhead Pass, sentineled by Mount Peelee and the Yellowhead Mountains, offers for the transcontinental railroads the lowest and easiest gateway through the Canadian Rockies. Gigantic Douglas firs make picturesque the shores of the lakes in this region. Photo by Rev. George Kinney.

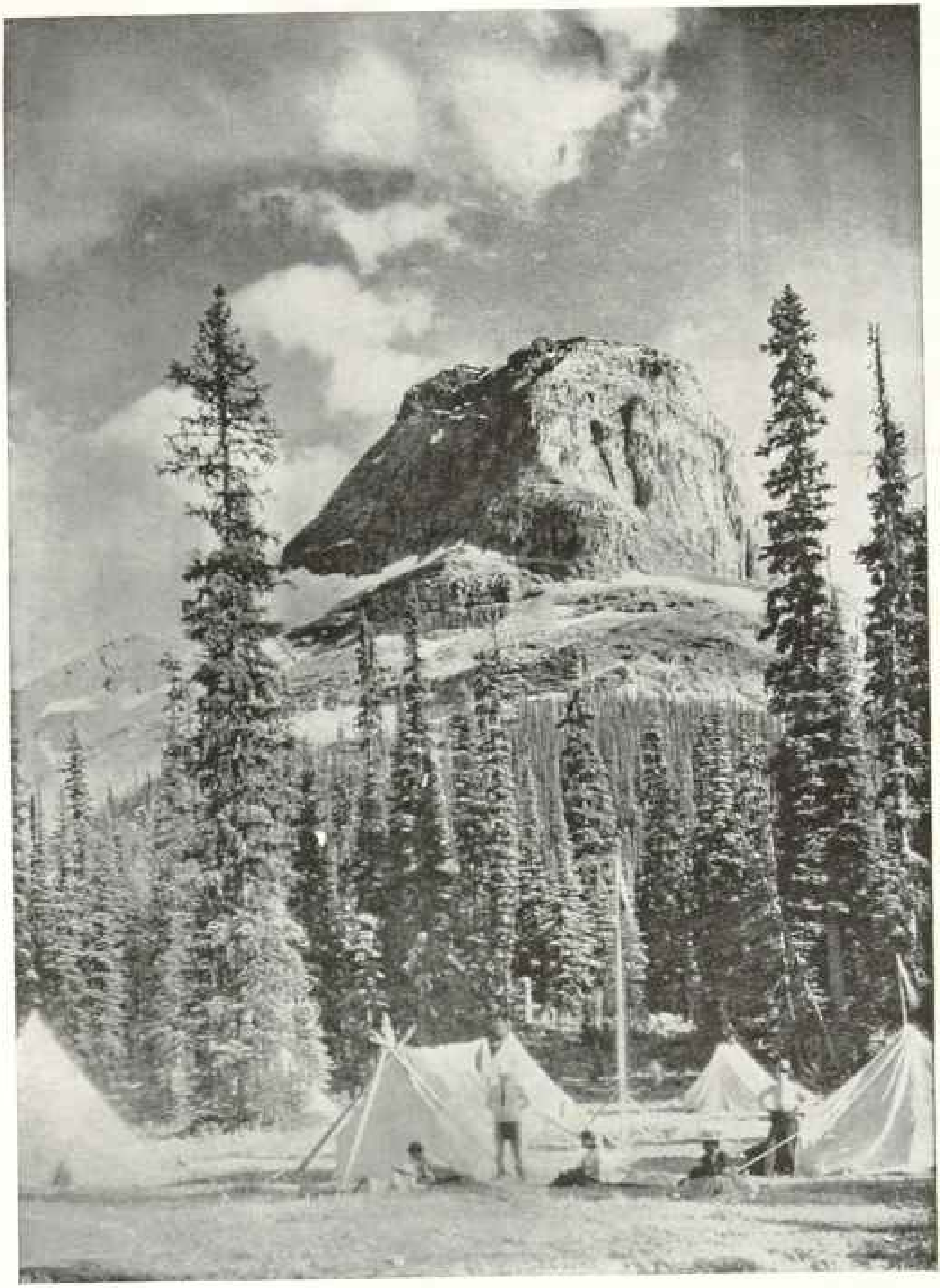
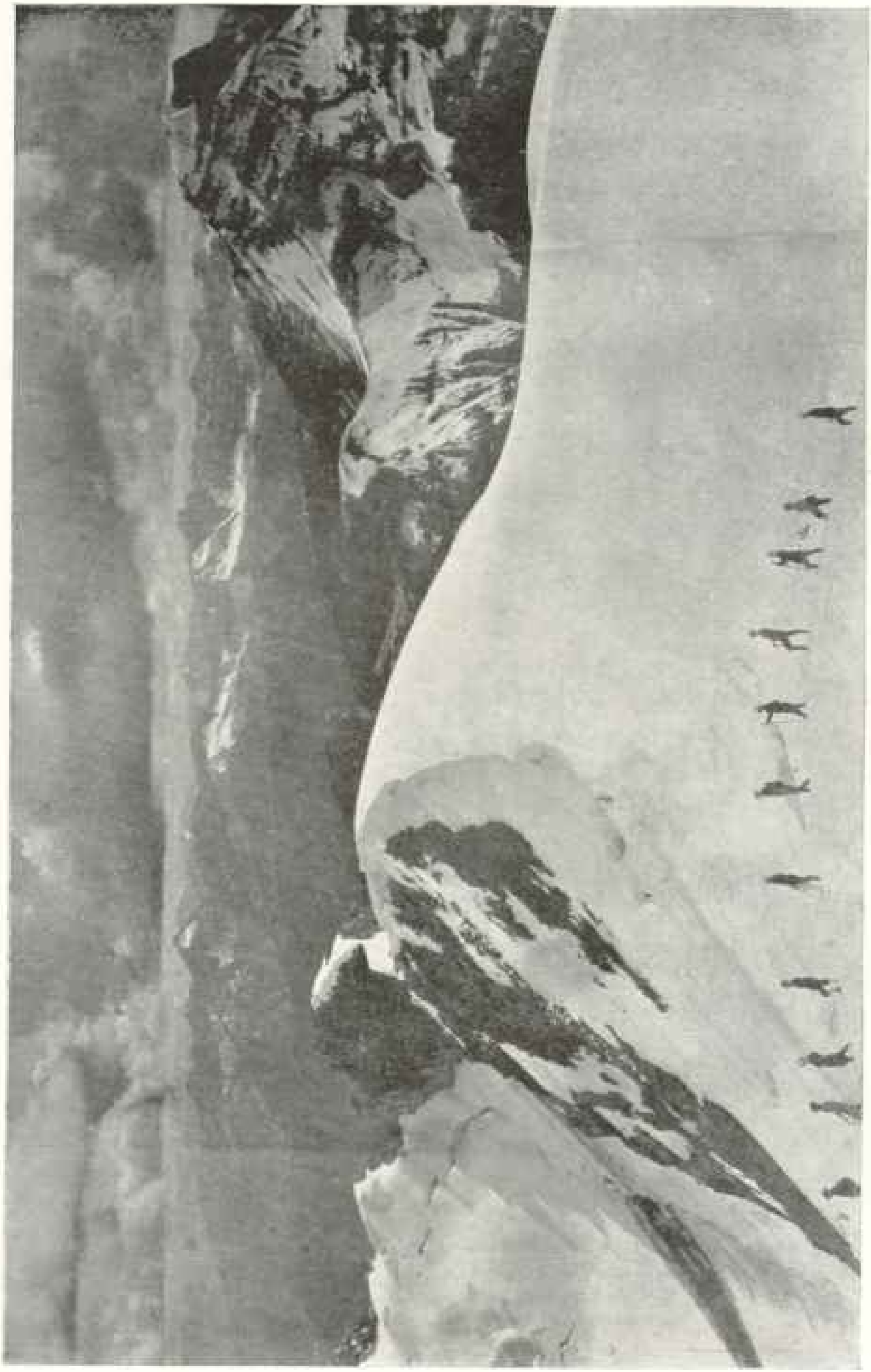


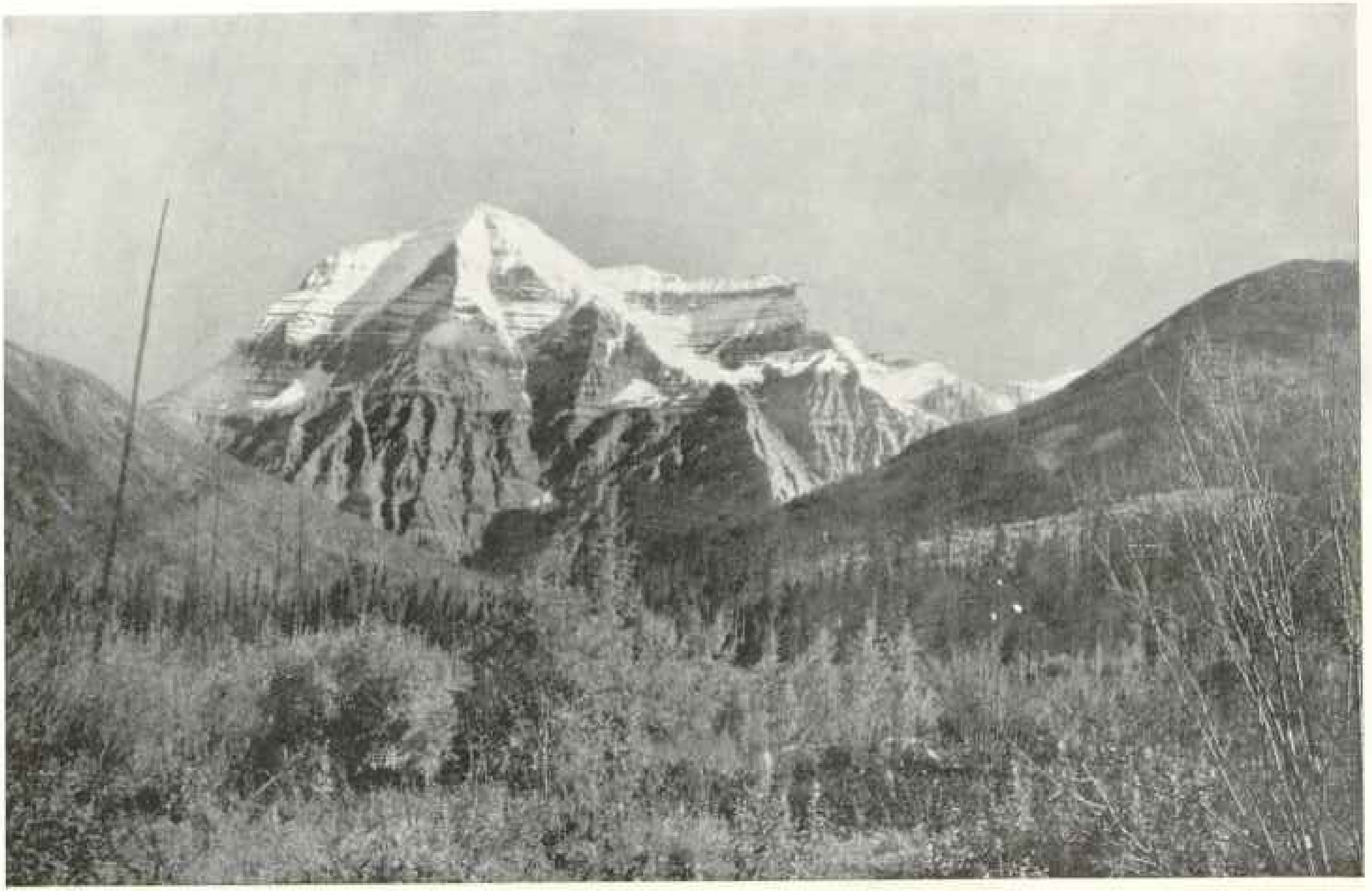
Photo by Rev. George Kinney

MOUNT WAPTA, NEAR FIELD, BRITISH COLUMBIA, AND THE FIRST CAMP OF THE ALPINE CLUB OF CANADA (SEE PAGES 519-520)



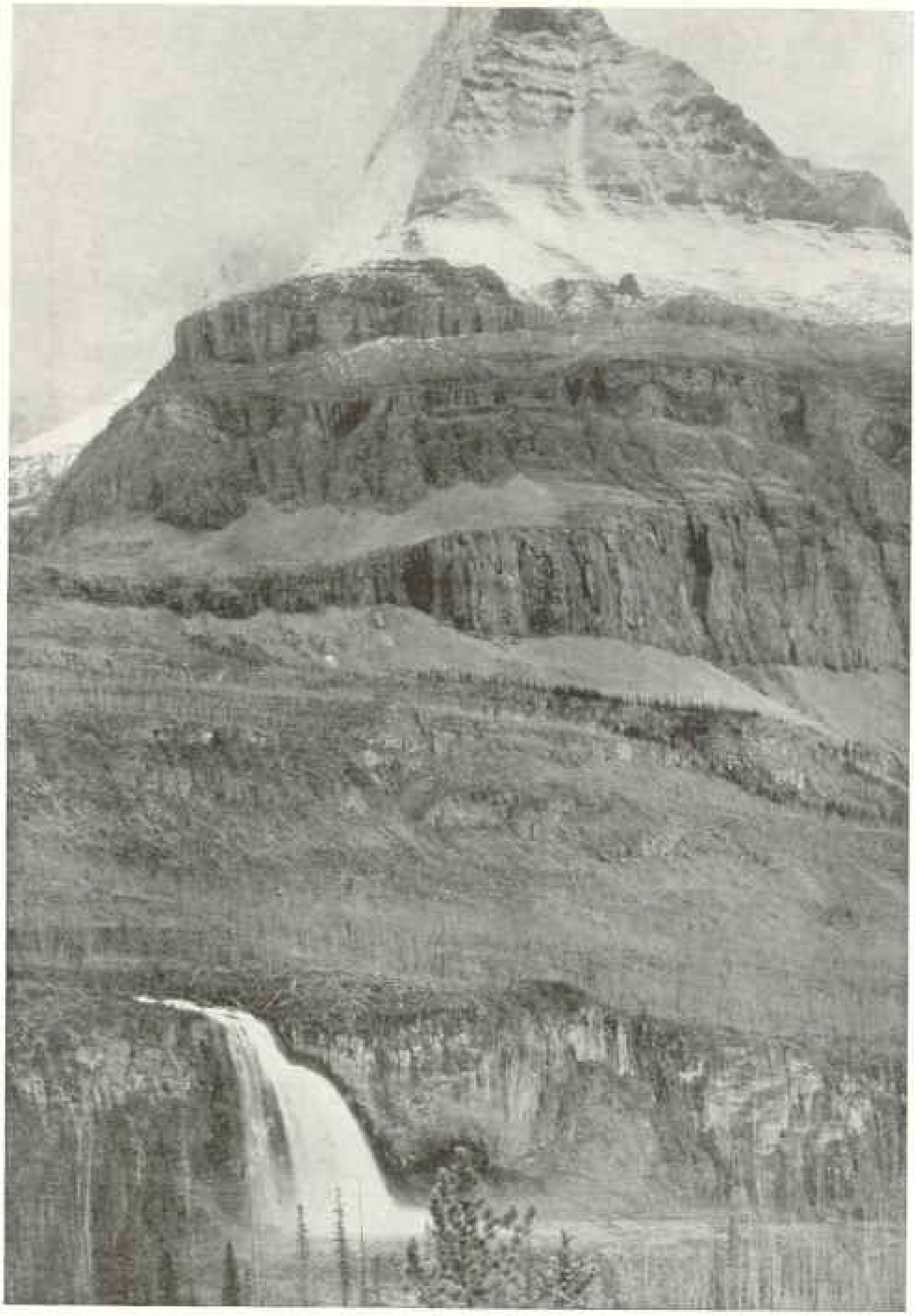
TWO ROPE PARTIES OF THE ALPINE CLUB OF CANADA CROSSING THE GREAT SNOW-FIELD ON THE SUMMIT OF MOUNT VICE-PRESIDENT, NEAR FIELD, BRITISH COLUMBIA, AT OVER 10,000 FEET ALTITUDE

Photo by Rev. George Kinney

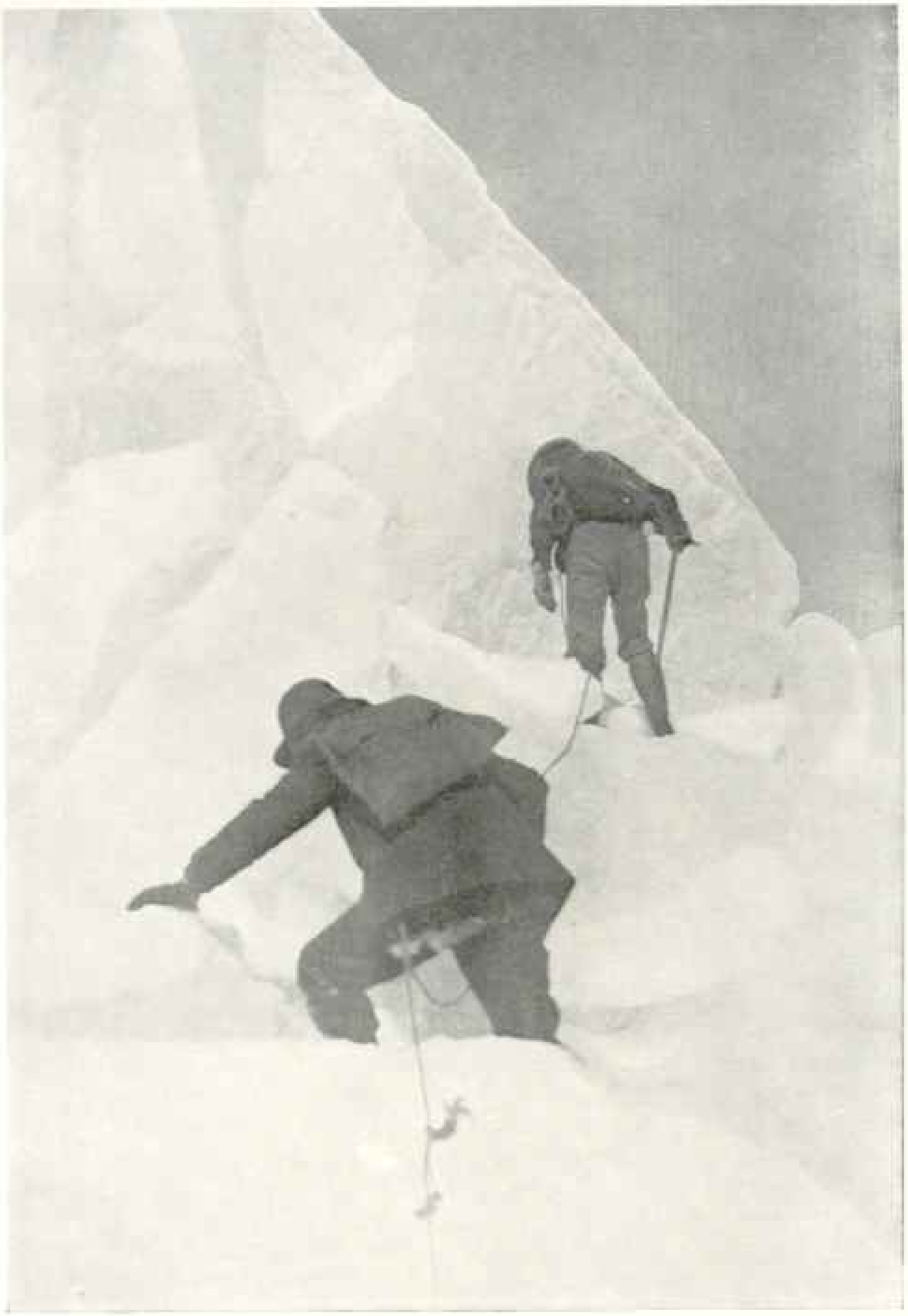


MOUNT ROBSON (NEARLY 14,000 FEET ALTITUDE), KING OF THE CANADIAN ROCKIES

As the tourist on the Grand Trunk Pacific will see it, from the mouth of the Grand Forks, on the Fraser River. This monster peak, towering over 10,000 feet above Lake Kinney, in the valley below, at an average angle of over 60 degrees, was finally captured, in 1909, by two Canadians, Rev. George R. B. Kinney and his companion, Donald Phillips. It is the highest mountain yet discovered in the Canadian Rockies. Photo by Rev. George Kinney.

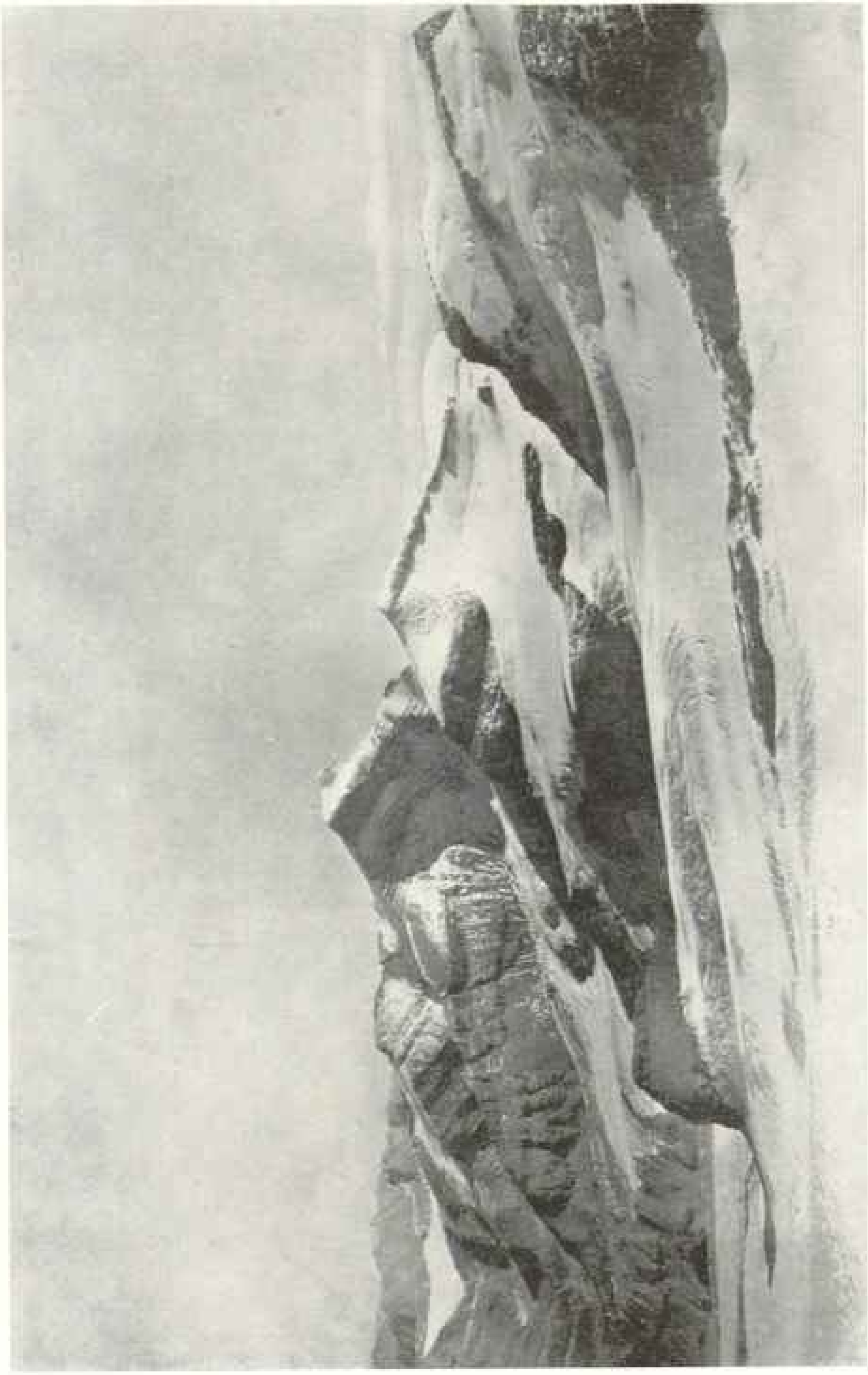


The north face of Mount Robson rises abruptly in a series of precipitous cliffs, rank on rank, to the very skies. At its base the Grand Forks River, swiftly flowing from Berg Lake, leaps a cliff as high as a Niagara and, plunging in a succession of superb falls through a gorge over 3,000 feet deep, sweeps through the "Valley of a Thousand Falls" on its way to the Fraser. Photo by Rev. George Kinney.



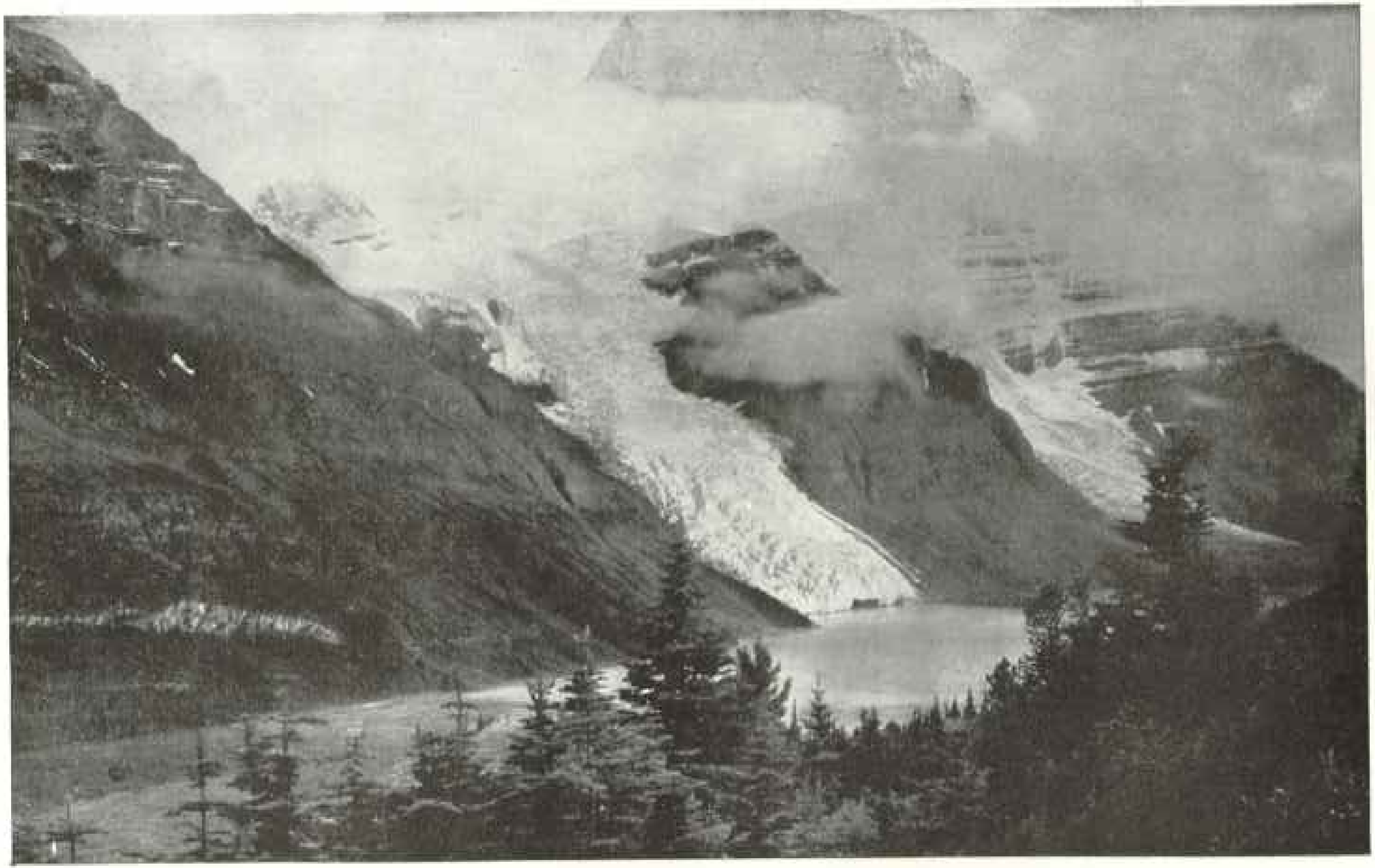
CLIMBING THE ICE-CLIFFS OF THE EAST SIDE OF MOUNT ROBSON: CANADIAN ROCKIES

Dr. A. P. Coleman, L. Q. Coleman, and Rev. George R. R. Kinney working their way up the fearful ice-cliffs of the east side of Mount Robson in their unsuccessful attempt to climb the mountain in 1908. Leaving their camp at tree-line, for 14 hours they fought their way up those treacherous walls of ice amid constant dangers from hidden crevasses and roaring avalanches, but only attained an altitude of 11,700 feet. Photo by Rev. George Kinney.



LOOKING EAST AND SOUTH FROM MOUNT ROBSON: CANADIAN ROCKIES

This view was taken from the crest of ever more dizzy, high up on the one side of Mount Robson at an altitude of 9,000 feet, from which the great East Glacier flows (see page 534). From this altitude the mountain's rugged climb, the snow-capped peaks to the south spread out like the surface of a rugged chart. Photo by Rev. George Kinney.

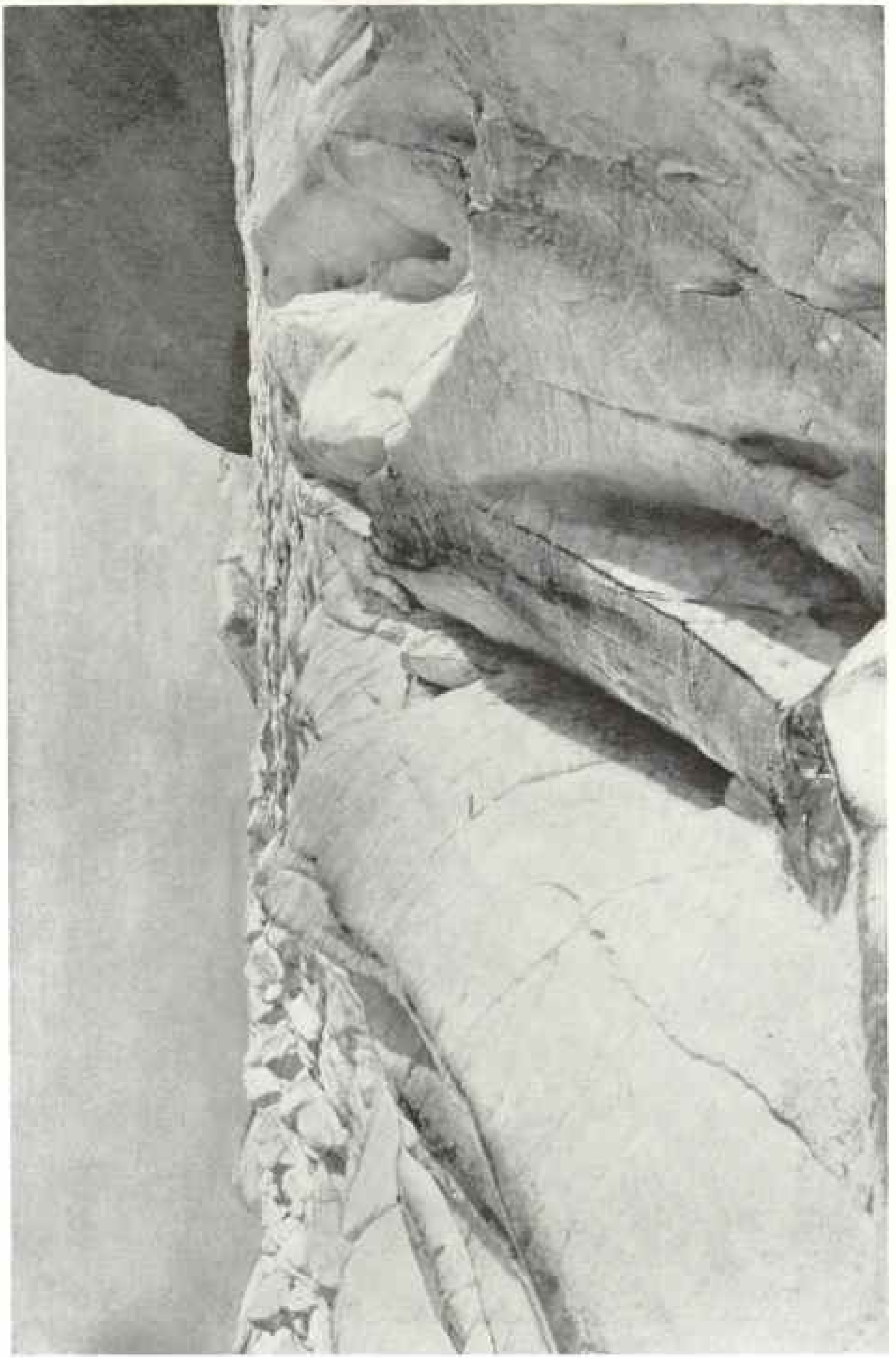


EAST SIDE OF MOUNT ROBSON, CANADIAN ROCKIES, FROM TIMBER LAKE

Looking from the east, Mount Robson, in the Canadian Rockies, rises out of one of the most beautiful valleys in all the world of alpine scenery. Six mighty glaciers, the least of which measures not less than a quarter of a mile wide, flowing from his rugged sides and those of the mountains opposite, pour their turbulent streams into the quiet waters of Berg Lake. This lake received its name because of its surface being constantly dotted with huge icebergs that plunge into it from Tumbling Glacier midway its length. Photo by Rev. George Kinney

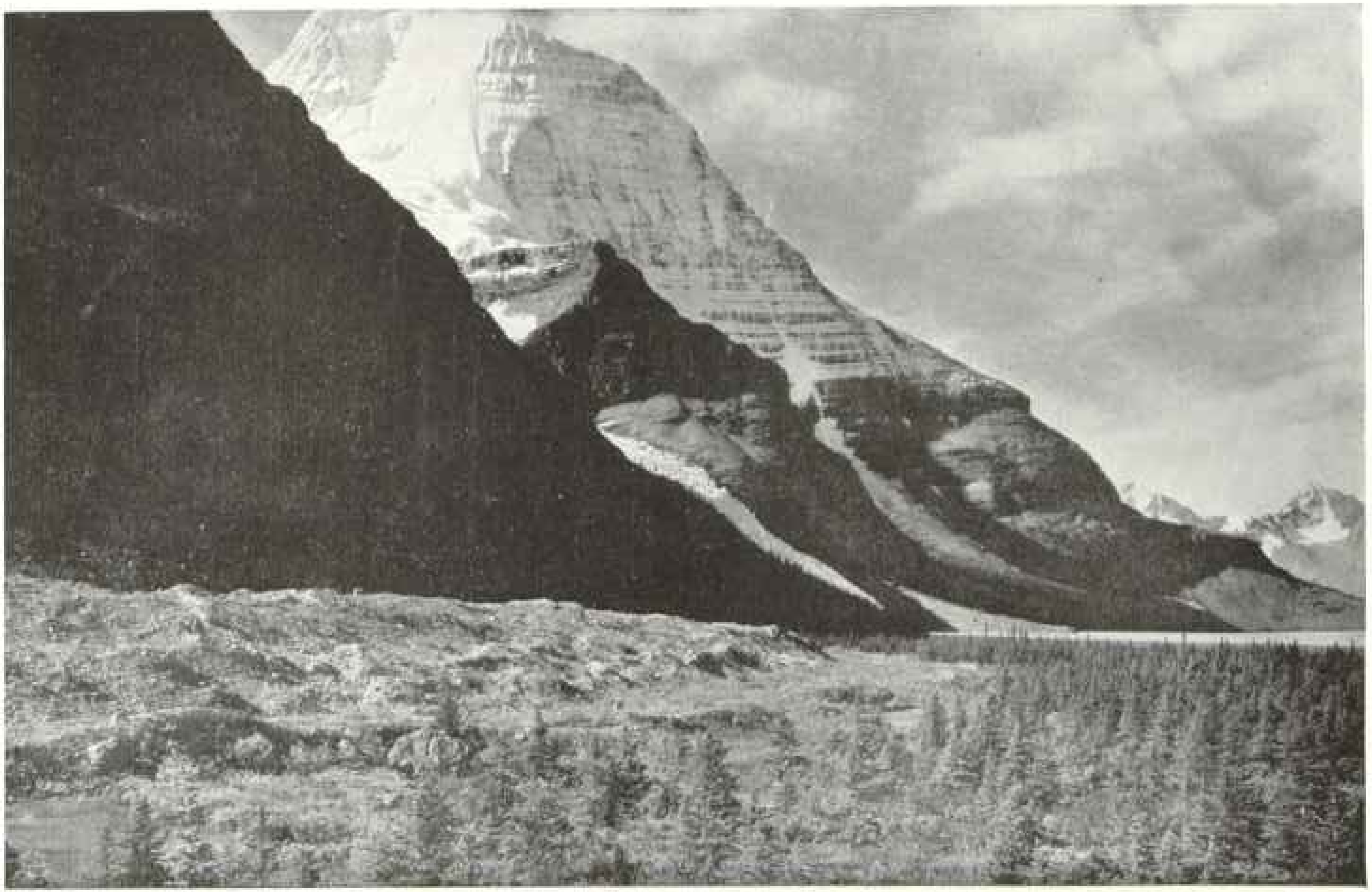
THE BIG GLACIER ON THE EAST OF MOUNT ROBSON

This mighty glacier, flowing from a huge snow-field on the east side of Mount Robson and curving in a wide crescent around the base of Mount Rearguard, is a mile wide and five miles long. The glacier forms a watershed, part of its waters flowing into the Pacific and part into the Arctic seas. Photo by Rev. George Kinney.



SCENE OF THE BIG EAST GLACIER OF MOUNT ROBSON

The crevasses of this glacier are in some places several hundred feet deep, while its lateral and terminal moraines are thrown high on every side, and a splendid medial moraine mark its course. Photo by Rev. George Kinney



MOUNT ROBSON AND BERG LAKE FROM THE NORTHEAST: CANADIAN ROCKIES

So frightfully steep are its rugged sides, and so high does it rise out of its valleys (over 10,000 feet), and so frequent are the severe storms of the region that of all the expeditions that tried to capture Mount Robson, Mr. Kinney's, in 1909, was the only one that ever reached its summit. Even then he and his companions had to sleep several nights on its lofty snow-covered ledges and nearly perished. Photo by Rev. George Kinney.

THE NATIONAL GEOGRAPHIC SOCIETY RESEARCHES IN ALASKA

By Lawrence Martin

Leader of the National Geographic Society's 1910 Expedition to Alaska

The Research Committee of the National Geographic Society has made an appropriation of $3,000 from the research fund to continue the studies of the Alaska glaciers which were conducted by the Society in 1909 and 1910. The work this year is in charge of Prof. Ralph S. Tarr, of Cornell University, and Prof. Lawrence Martin, of the University of Wisconsin. These gentlemen were also in charge of the work in 1909, but in 1910 Professor Tarr had engagements in Europe, so that the entire work of that summer rested upon Professor Martin. An account of the National Geographic Society's 1909 expedition to Alaska was printed in the January, 1910, number of the National Geographic Magazine.

DURING the summer of 1910 nearly four months were devoted to a continuation of the glacier studies commenced in 1909 under the direction of the Research Committee of the National Geographic Society. It is fortunate that this fund is available just at the time when unusual activity of glaciers in Alaska is in progress. The glaciers are now so active that it is perhaps the opportunity of a century or more.

The field investigated in 1910 was Prince William Sound, but a two weeks' visit was made to Yakutat Bay in June to record the latest news from the unusually interesting active glaciers there, and a fortnight at the end of the season was devoted to the glaciers of the lower Copper River.

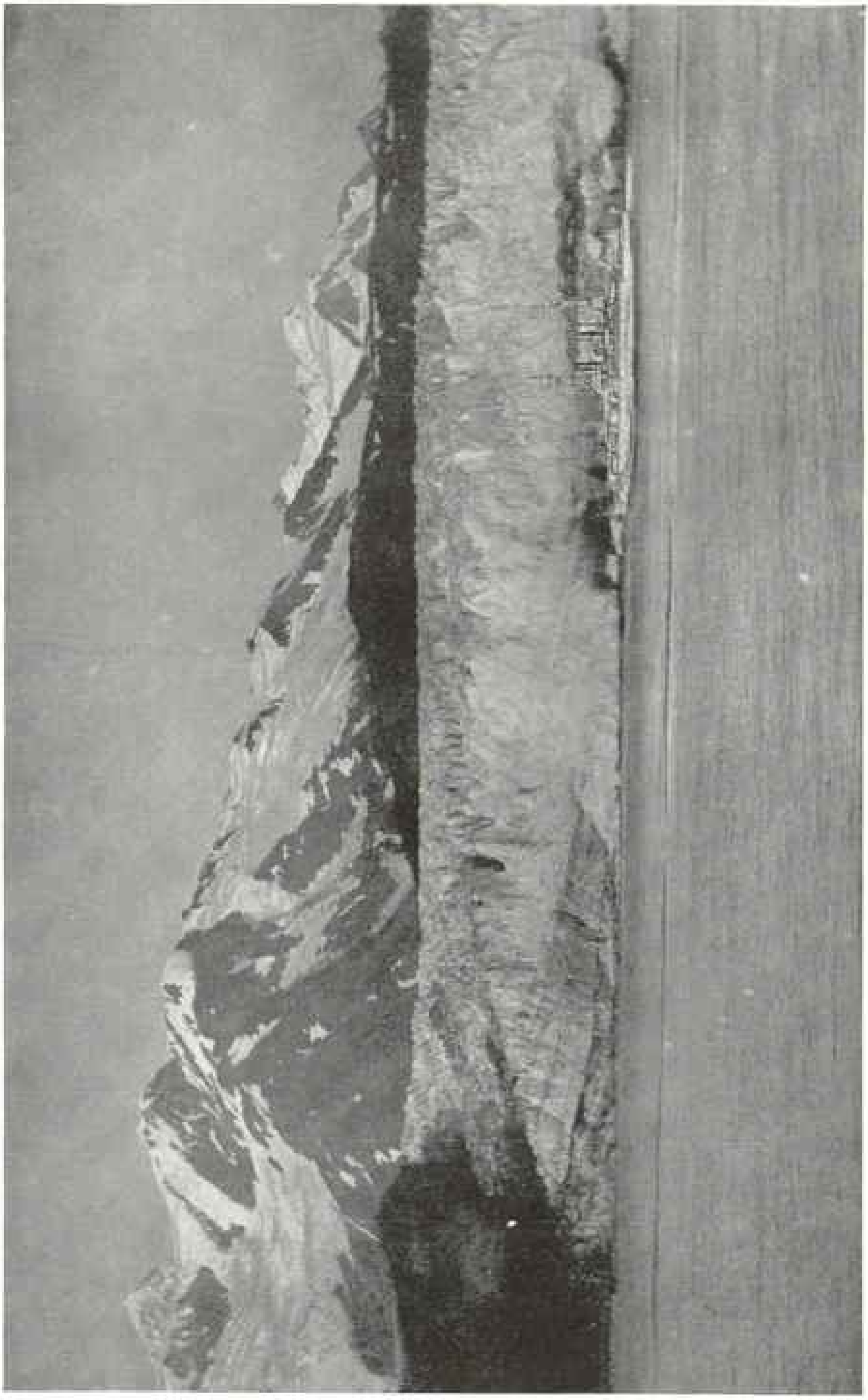
The party consisted of seven men—the author; W. B. Lewis, of the U. S. Geological Survey, topographer; E. F. Bean and F. E. Williams, of the University of Wisconsin, the former taking charge of the sounding and weather records, the latter acting as rodman; E. A. Connor and R. F. Byers, of the University of Washington, respectively boat engineer and photographer, and a Japanese cook. F. M. O'Neill, of Memphis, Tennessee, was also employed as engineer the latter part of the season. We started May 28 and were gone until Sept. 23.

One of the large glaciers in Yakutat Bay, the Nunatak, had changed a great deal since the year before. It had advanced decidedly, different parts of its front having come out 700 to 1,000 feet up to June 17, 1910. From 1890 to 1909 the Nunatak Glacier receded steadily, going back over two miles and a half in this time. We had anticipated that it would eventually advance, however, as was predicted in the National Geographic Magazine for January, 1910, and the forward movement commenced between July 6, 1909, and June, 1910. This was due to the accession of unusually large quantities of snow to the reservoirs of this glacier by avalanches during the 26 days of severe earthquakes of September, 1899.

The Nunatak was the ninth glacier in the Yakutat Bay region to respond since 1899 to this new cause for glacier advances in mountain regions. Their responses have come after a certain delay, dependent in part upon the length of the glacier, as the accompanying table shows.

Glacier.	Date of advance.	Length of glacier.
Galiano	After 1895 and before 1905	2 or 3 miles.
Unnamed glacier	1901	3 or 4 miles.
Haenke	1905–6	6 or 7 miles.
Atrevida	1905–6	8 miles.
Variegated	1905–6	10 miles.
Marvine	1905–6	10 miles.*
Hidden	1906 or 7	16 or 17 miles.
Lucia	1909	17 or 18 miles.
Nunatak	1910	20 miles.

* Excluding expanded lobe in Malaspina.



PORTION OF THE CLIFF OF LA PEROUSE GLACIER, COMPARED TO THE BATTLESHIP MICHIGAN

Photo by Lawrence Martin

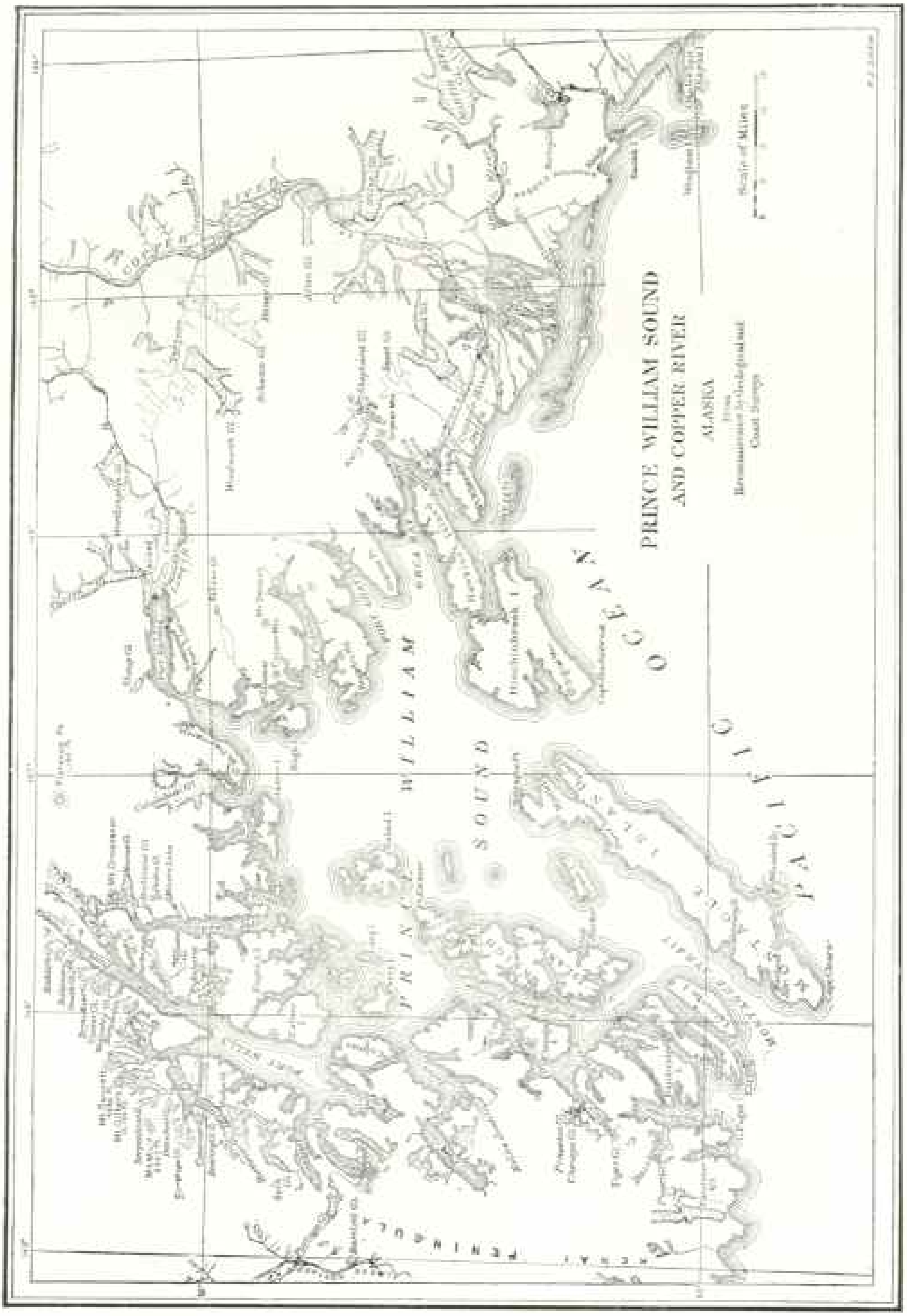
GLACIER RESPONDING TO EARTHQUAKE

The retreat of Nunatak Glacier from 1905 to 1909 (*a* to *c*), followed by advance (*c* to *b*) before June, 1910. Photo by Lawrence Martin

The second of these glaciers, which is a small unnamed ice tongue between Haenke and Hubbard, was stagnant and moraine covered in 1899 and 1905, and I had not learned until the winter of 1910 that it was crevassed and advancing in 1901, as a photograph proves. Besides these nine, three or more of the smaller glaciers probably advanced between 1899 and 1905, and the neighboring Turner and Hubbard glaciers have each had one or more minor advances, perhaps due to the thrust from some responding tributary far back in the mountains. Hubbard Glacier, which may be twice as long as Nunatak, began such a minor advance in 1909, but in 1910 it had not progressed very far, though the west part of the ice front had come forward 600 feet and the crevassed area of the east margin had increased slightly. Other points on the ice front had retreated 500 to 1,000 feet between 1909 and 1910.

Lucia Glacier, which was advancing so rapidly in 1909, had perhaps nearly ceased its unusual activity; at least, when we saw it in 1910 it had not overridden the Lucia nunatak, which it surrounded and nearly covered the year before, and no great abundance of new streams emerged from its borders to Yakutat Bay. This, I am sorry to say, was all we were able to determine about Lucia Glacier, for we were unable to visit it and see more because of the unusual ice-jam in Yakutat Bay in June, 1910. From what we were able to see of it from a distance with field glasses, however, it was apparently behaving as all the other glaciers have when affected by the earthquake avalanche supply. The advance was sudden, the transformation great, and the activity was soon over. This seems to be the case in Lucia Glacier.

How great the advance of Nunatak Glacier will be is impossible to predict at present, for this is the first great tidal glacier in Yakutat Bay to advance since the earthquakes. If the slightly smaller



MAP SHOWING LOCATION OF THE GLACIERS OF PRINCE WILLIAM SOUND
This sound was formerly entirely covered by a glacial sheet (see page 550)

non-tidal Hidden Glacier could move two miles under this impulse, however, the Numatak Glacier might be expected to respond similarly, unless (1) this is only a minor thrust from some tributary or (2) the tidal condition introduces some complication not previously observed in studying glacial oscillations due to this new cause.

A GLACIER THREATENING A RAILWAY BRIDGE

On the lower Copper River is Childs Glacier, which is seriously threatening to destroy a steel railway bridge just completed. The rate of glacier motion in Childs Glacier increased during the winter of 1909-1910 so that part of the margin of the glacier changed its forward movement from nothing to two and as much as eight feet a day.

This glacier, as the map shows (page 543), is the smallest of three great ice tongues—Miles, Childs, and Allen glaciers—projecting into the Copper River valley. Around these three the Copper River winds through a succession of rapids and lake-like stretches. The Copper River and Northwestern Railway has just been built between Childs and Miles glaciers and on over 5½ miles of the stagnant ice of Allen Glacier. Childs Glacier is 10 to 12 miles long, not much over a mile wide in the mountain valley, but it widens to over three miles in Copper River valley.

Its front is a precipitous white wall 250 to 300 feet high, and is swept at the base by Copper River. How a small section of the front of Childs Glacier compares with the Capitol building at Washington is shown in the photograph on page 546. The map on page 543 compares Childs Glacier graphically with the Nisqually Glacier, one of the largest ice tongues on Mount Rainier, and Miles Glacier with four of the largest and best-known glaciers of the Canadian Selkirks and the Glacier National Park in the Montana Rockies.

In August, 1909, Childs Glacier was advancing at about its normal rate—four feet a day at a point near the north side and perhaps six or seven feet a day in midglacier. The melting and the many icebergs discharged from the terminal cliff at that time just about balanced this advance, so that the front of the glacier remained in about the same place. Near the north margin there was no advance when we saw Childs Glacier in 1909, and probably there had been none since 1905 and perhaps none to speak of since 1884, though its relationship to the river had varied slightly during this period, and slight crevassing had begun in 1906 and 1909 where there was none in 1905.

During the winter and early spring of 1909-1910, however, the glacier began to advance more rapidly, buckling up the ice of the frozen river. In June, 1910, the ice front had moved forward from 920 to 1,225 feet, narrowing the river to 400 or 500 feet.

Every time the ice cliff was sufficiently undercut by the river, great masses of ice would cascade down the front, raising a gigantic wave in the river. People in Alaska speak of the discharge from the front of Childs Glacier as "slough-ing." A "slough" has always raised waves in Copper River, making it dangerous to shoot the rapids in front of Childs Glacier in a boat, or to line a boat up the opposite bank; but in the spring of 1910 the conditions were accentuated by the advance of the glacier and the pushing of the river eastward.

During the advance the waves washed up over a bank 5 to 25 feet in height and rushed back 100 or 200 feet into the alder thicket. Ice blocks up to 10 tons in weight were thrown in among the trees. Stones a foot or two in diameter were hurled into the thicket. Alders 9 to 11 inches in diameter were stripped of leaves and bark and bent backward or broken off short, or uprooted or buried beneath the gravel and boulders and macerated trunks of other trees.

The river bank, which was cut back some in the preceding year, was in 1910 being fairly eaten up by the iceberg waves which crossed the river, 50 to 60 feet by actual measurement having been removed along the bank of the stream facing the glacier.

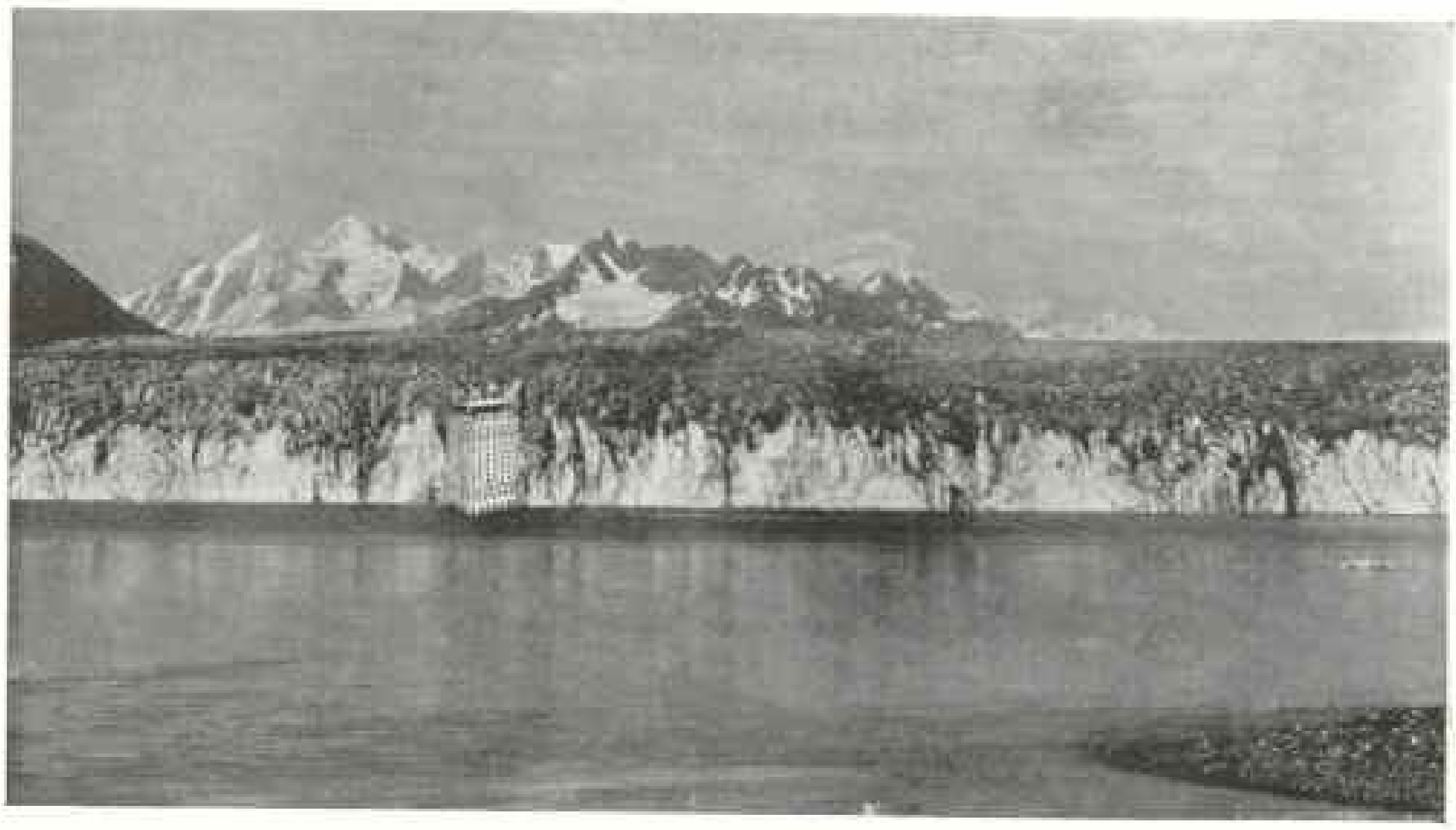


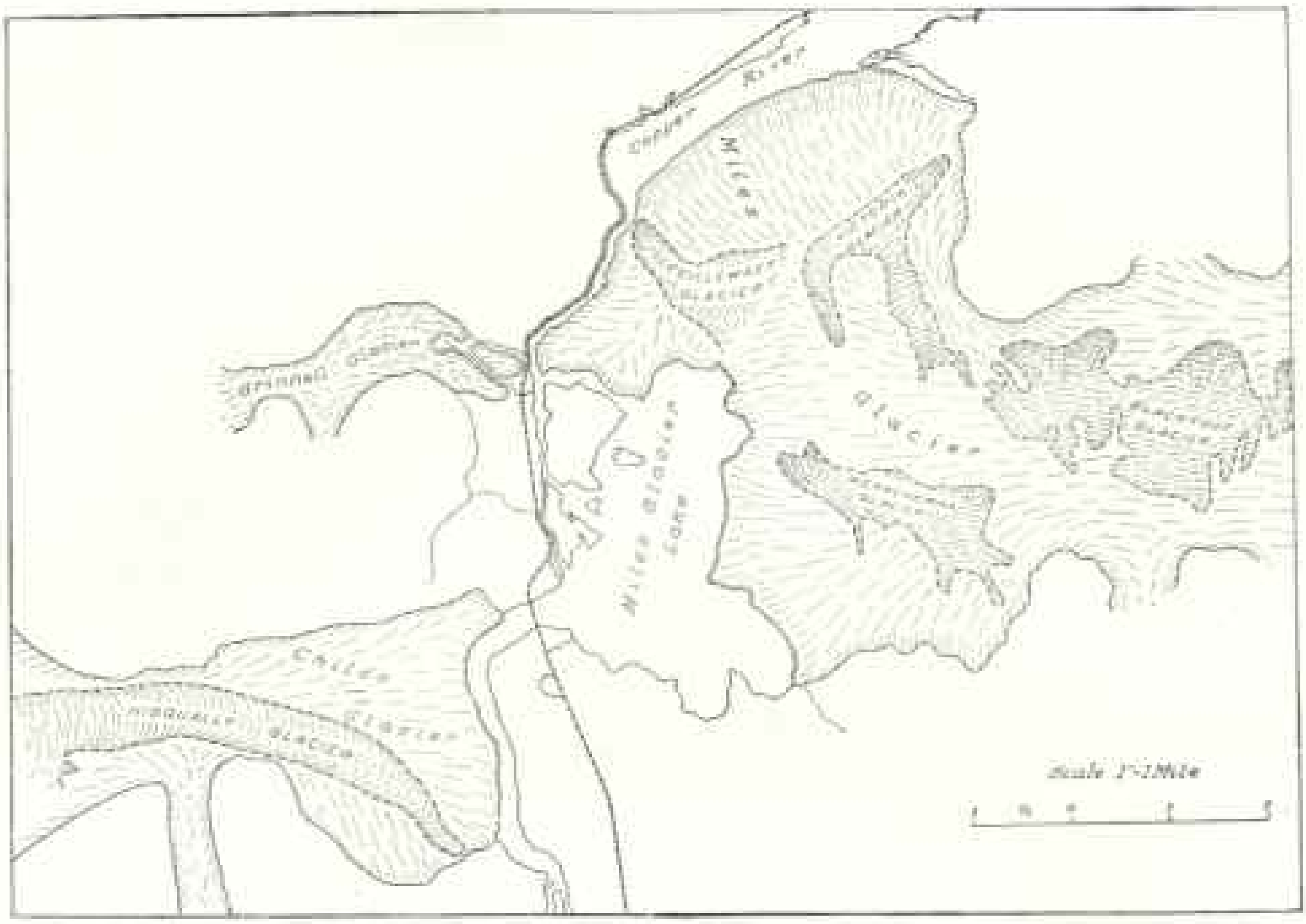
Photo by Lawrence Martin

A SMALL PORTION OF THE FRONT OF MILES GLACIER, FROM THE BRIDGE ON COPPER RIVER & NORTHWESTERN RAILWAY, COMPARED GRAPHICALLY WITH THE HOTEL LA SALLE, IN CHICAGO, WHICH IS 310 FEET HIGH

Late in August, 1910, when the waves were not as powerful as they had been earlier in the summer, the largest ice fall, or slough, from Childs Glacier which I saw sent a wave across the river with lightning rapidity, causing the water to splash up over the 15 or 20 foot bank, near where I stood, and back a short distance into the forest. It of course rose highest directly opposite the ice fall, the height of the wave on the bank decreasing both up and down stream. Six or seven ring-waves in succession splashed far up the river bank, the first one visibly running upstream against an eight or nine mile an hour current. It was easy to see how the larger waves during the first part of the summer were able to cut back the river bank so easily.

Near the north margin of the glacier is an easily accessible portion of the ice front which ends upon a nearly-flat outwash plain of glacial gravels, overgrown with alder and cottonwood trees 50 to 100 years old. Here the glacier was nearly without motion from 1905 to 1909, and probably for some years before, so that small shrubs had begun to grow upon the stagnant ice margin. This part of the glacier advanced 1,500 to 1,600 feet before June 10, 1910, and 204 feet more up to October 5. The rate of

Dates of observations.	Number of days.	Advance, in feet.		Rate per day, in feet.	
		Fastest.	Average.	Fastest.	Average.
June 10 to July 29	49	124	116	2.5	2.37
July 29 to August 6	8	26	23	3.25	2.87
August 6 to August 11	5	41	8	8.2	1.60
August 11 to August 17	6	27	4	4.5	.66
Agunst 17 to August 29	12	42	19	3.5	1.58
August 29 to September 19	21	37	27	1.76	1.28
September 19 to October 5	17	13	7½	0.7	.44



MAP COMPARING SIZES OF COPPER RIVER GLACIERS WITH GLACIERS IN THE ROCKY MOUNTAINS, SELKIRKS, AND CASCADES OF THE UNITED STATES AND CANADA

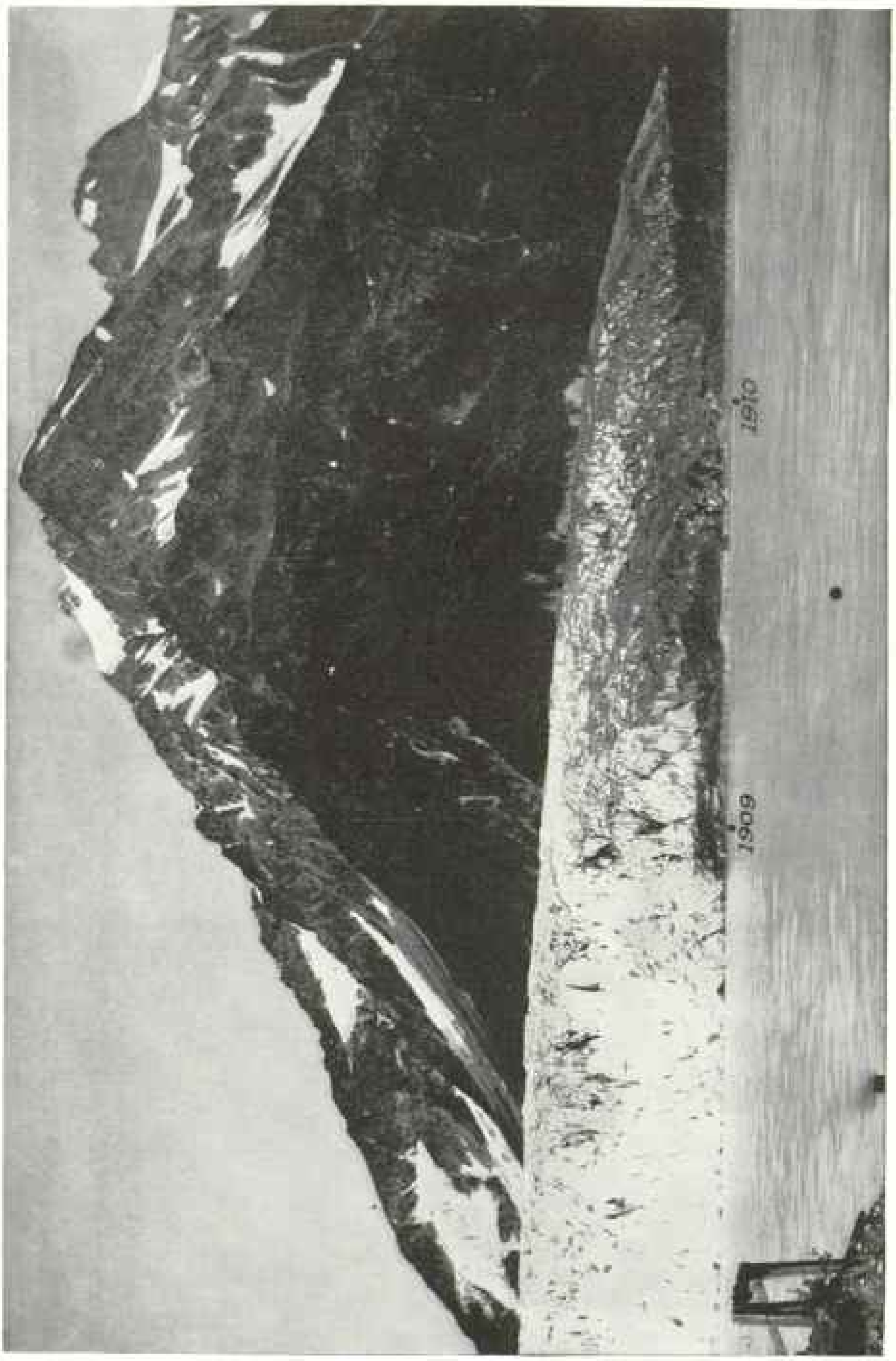
Note that the largest glaciers of the United States are in the Cascades, where the Nisqually Glacier of Mount Rainier exceeds in size the Blackfoot Glacier of the Glacier National Park, in the Montana Rockies. These and the Illecillewaet and other glaciers of the Canadian Rockies and Selkirks are much smaller than the Alaskan glaciers.

advance is phenomenal, averaging two to eight feet a day, and especially remarkable for the edge of a glacier, where movement is always slowest. The railway engineers made most of the surveys before we reached Childs Glacier and one after we left, but we made supplementary observations on a number of days between their surveys, finding the ice front advancing at rates intermediate between those shown on the maps. The rates per day are shown in the table on preceding page.

The rates of average movement show variations in velocity, with two maxima; the fastest movements show a very rapid increase in rate of advance to the maximum, between August 6 and 11, and an unusually rapid decrease again. This is one of the most rapidly increasing and decreasing series of glacier movements yet mapped.

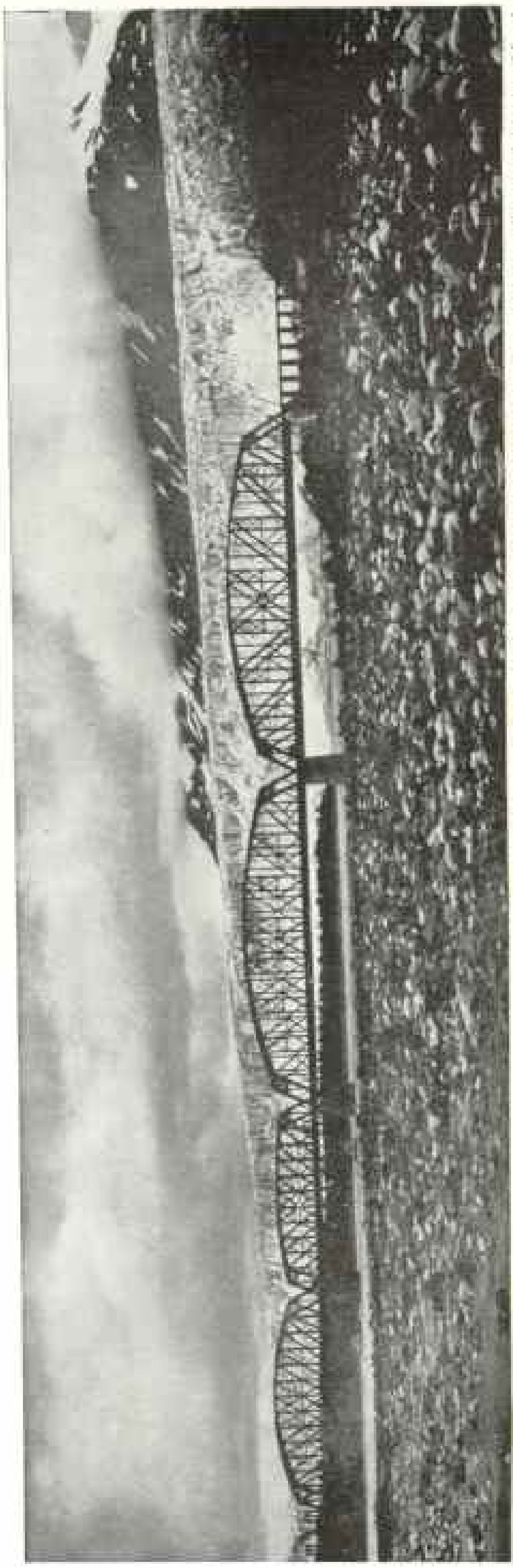
It was a rare opportunity to see the visible forward movement of Childs Glacier into the forest. A series of lobes developed, though some of them were not persistent, and at the ends of these lobes the day-to-day changes were most pronounced. Ice blocks were sliding down the frontal slope, some of them being rolled many feet into the forest; trees were overturned, turf and grass were ploughed up and carried on the ice of the glacier.

Yet one saw and heard little of a spectacular nature while traversing the ice front. It was an irresistible, steady movement, but slow, as the movement of the hour hand of a clock is slow. As impressive as anything was to find tons of



VIEW OF CHILLAS GLACIER, AUGUST 21, 1910

Showing how much it had advanced in 14 months, or since our former visit, on June 20, 1909. The advance was 1,500 to 1,600 feet on the north bank, where the advance was less than in mid-glacier. Photo by Lawrence Martin



THE BRIDGE WHICH IS MENACED BY THE ADVANCE OF CHILDS GLACIER (SEE PP. 544, 545)

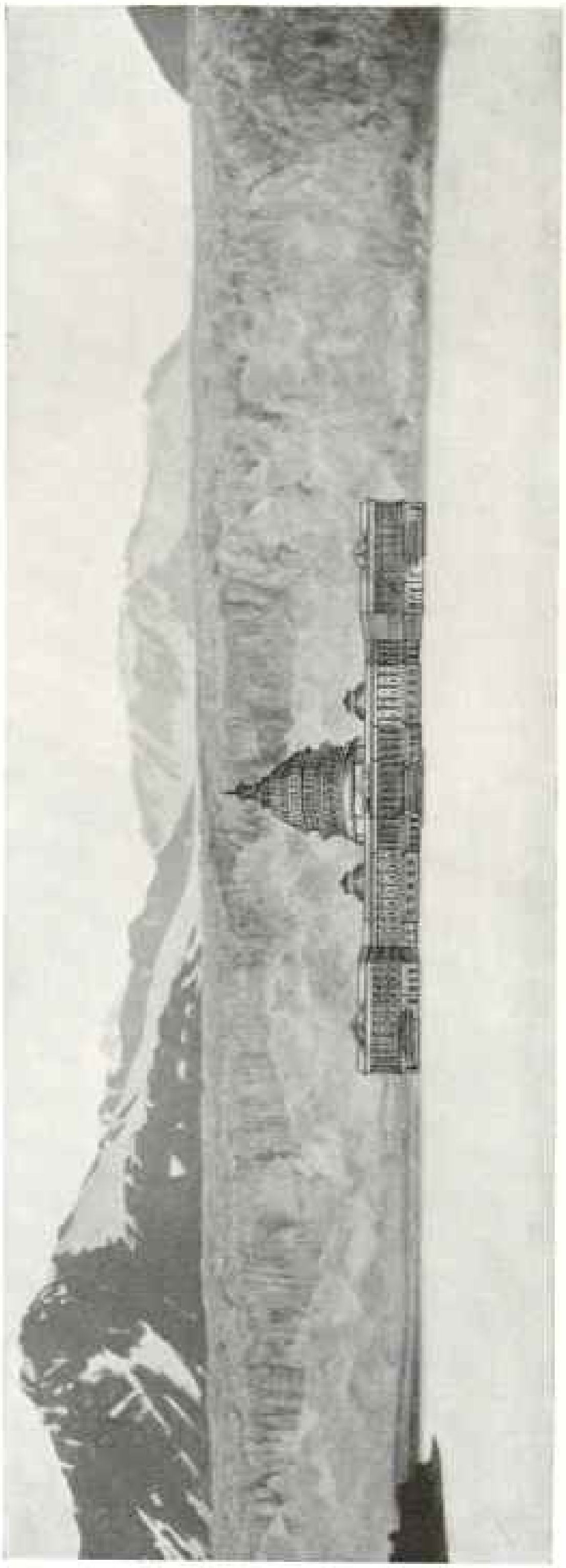
Photo by Lawrence Martin

ice resting where one stood to take a photograph the day before, or to find some great tree, 100 years old, prone on the ground with the butt beneath the glacier, where the day before the tree was upright with the ice just touching it or with room to go between the glacier and tree.

The rate of movement in midglacier during the summer was not determined, but it would not be improbable, judging from the rate at the north margin and from rates at intervals across other glaciers that have been measured, that it was at least six times the rate in 1909, or 30 feet a day, and even more at times.

But the middle of the glacier did not advance as far during the summer as the north margin did, and between June 10 and August 11 it retreated 450 feet. From August 11 to August 17 it retreated 65 feet more. This retreat was occurring while the north margin was advancing most strongly, and it seemed to the National Geographic Society's party that this retreat was not due to a cessation of advance, but wholly to undercutting by the Copper River, which rose over six feet between June and August because of summer melting of snows and glaciers.

We accordingly predicted in August that the ice front in the river would readvance the latter part of September, when the river was lower. This prediction proved correct, the ice front advancing 390 feet up to October 5, plus the amount of additional retreat between August 17 and the date when the advance commenced, the level of the river having fallen nine feet meantime. As the middle of the glacier advanced 390 feet in the 49 days between August 17 and October 5, the minimum rate of actual advance was fully eight feet a day, if there was advance on each of these days. As (*a*) icebergs were discharging all the time and melting was in progress; as (*b*) the advance was surely over 300 feet; and as (*c*) the forward movement began not on August 17, but probably after the middle of September, when the river was much lower, the rate of advance was much faster and may easily have been 30 feet a day, as previously estimated.



PART OF FRONT OF CHILDS GLACIER (1,575 feet from the north margin of the railway bridge, which is 287½ feet high and which varies from 250 to 300 feet in height, with the Capitol, in Washington, within it)

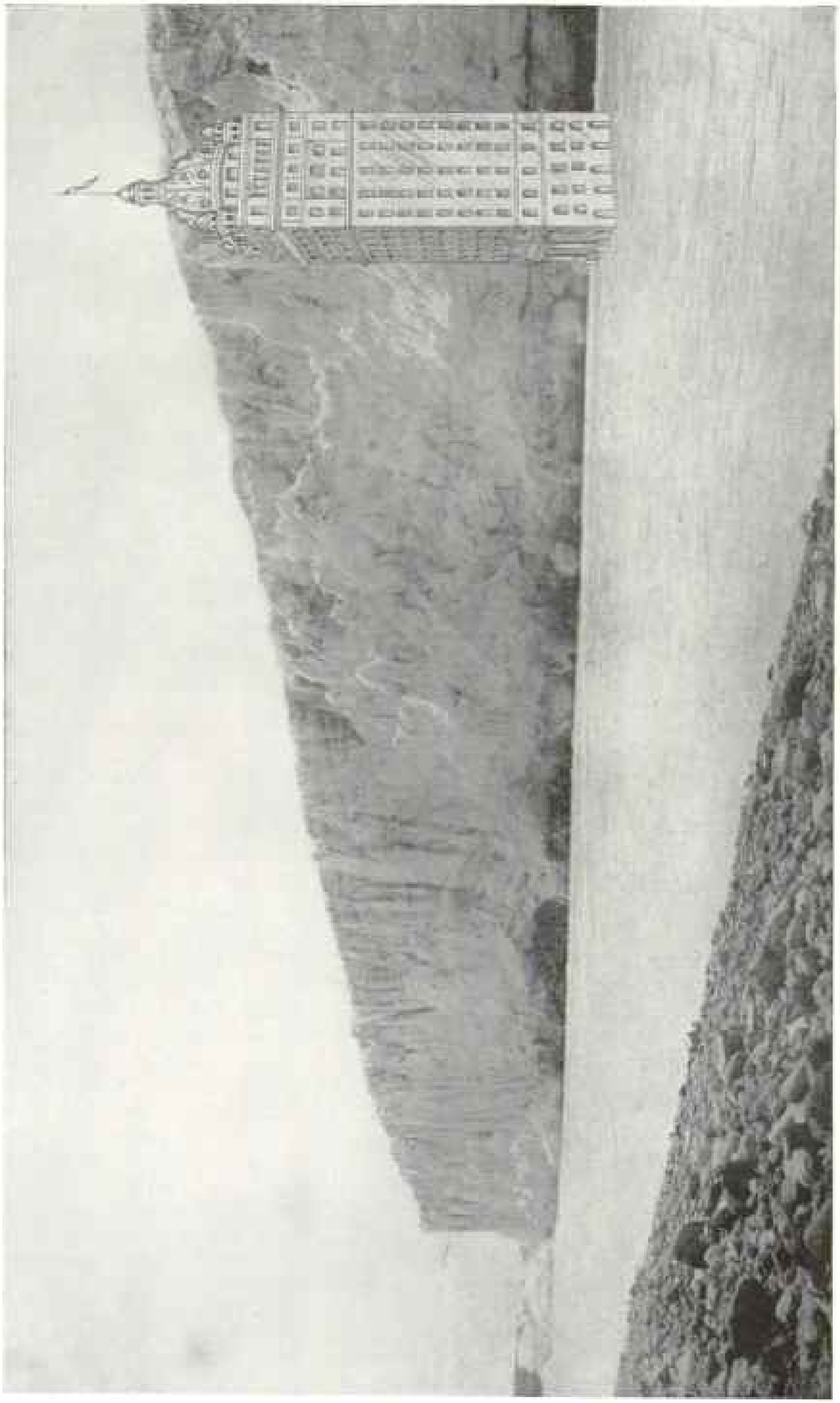
Showing comparison of ice cliff. Photo by Lawrence Martin

What Childs Glacier is doing this year is of the greatest interest. It may continue to advance, or the diminishing rate of advance on the north margin after August 11 may suggest that the strongest advance is over. If advance continues, will the glacier move up to and destroy the railway bridge, which is only 1,575 feet distant from the north margin, or will it stop before getting there? The bridge cost $1,400,000 and is the key to the $20,000,000 railway to the copper mines.

It is absolutely certain that no corps of engineers living could save the bridge and railway if the glacier is destined to advance that far. We have seen Hidden Glacier, in Yakutat Bay, advance two miles, or over 10,000 feet, and bury a bench mark near the former terminus beneath 1,100 feet of ice, and Haenke Glacier advance over 5,000 feet in less than 10 months.

On August 11 the railway was about 4,500 feet from the middle of the glacier, which would easily have advanced this distance between May and October, if it is moving at the rate of 30 feet a day. If its front had not been swept by Copper River the rapidly moving middle of the glacier would pretty surely have advanced this distance, while the more slowly moving margin was advancing the observed 1,700-1,800 feet, at the rate which increased from practically zero in 1909 till it reached two to eight feet a day in 1910.

If the river had not had its normal summer rise of six feet or more the middle of the glacier would surely have advanced a good part of this distance, as it did advance 1,225 feet before the rise came, and as it may do this fall and win-



THE CLIFF OF CHILLS GLACIER COMPARED TO THE CLAUS SPRECKLES BUILDING, OF SAN FRANCISCO

The picture shows how the icebergs break off from it on the extreme left, where the Copper River undercuts the ice cliff, giving rise to a great water wave, which may be seen in the picture (see page 547). Photo by Lawrence Martin

THE ADVANCING TERMINUS OF CHILDS GLACIER, NEAR THE NORTH EDGE, IN AUGUST, 1910, WHEN THIS PORTION WAS ADVANCING ABOUT 3½ FEET A DAY

ter when the water is low and the river weak. It is evident, therefore, that the preservation of the railway bridge is due to the river, the very thing which necessitates the bridge.

It will be most interesting to see if the advance continues during the low-water stage from October, 1910, to May, 1911, with gradual forcing of the river eastward, the cutting back of the river bank in the unconsolidated gravels, the interference with stream flow and icebergs discharge from Miles Glacier, and many accessory phenomena.

Grinnell Glacier, a smaller ice tongue north of Childs, also began to advance between 1909 and 1910.

ADVANCING GLACIERS IN PRINCE WILLIAM SOUND

An unusually large number of glaciers in Prince William Sound were advancing in 1910. Of these the largest is Columbia Glacier. This ice tongue, west of Valdez, is three to four miles wide and 25 miles or more in length. It has two tidal fronts, separated by Heather Island, upon which the middle of the glacier terminates. It had its last important advance about 1892, as determined by G. K. Gilbert in 1899, and began the present advance during or just before 1908. This has progressed as follows, as observed by Prof. U. S. Grant and the National Geographic Society's 1909 expedition:

After July, 1905, to July 15, 1908, advance, 100 feet.

July 15, 1908, to June 24, 1909, advance, 310 feet.

June 24, 1909, to August 23, 1909, advance, 70 feet.

These observations are on Heather Island.

ANOTHER VIEW OF THE ADVANCING FRONT OF CHILDS GLACIER, NEAR THE NORTH EDGE, IN AUGUST, 1910, WHEN THIS PORTION WAS ADVANCING ABOUT 3½ FEET A DAY: THE GREAT BLOCKS ARE ICE

Between August, 1909, and June 30, 1910, when the Society's 1910 expedition returned to the region, the main ice cliff of Columbia Glacier west of the island had advanced over 600 feet, the advance upon the island being about 135 feet. From July 4 to September 5 the advance at the same point was 132 feet.

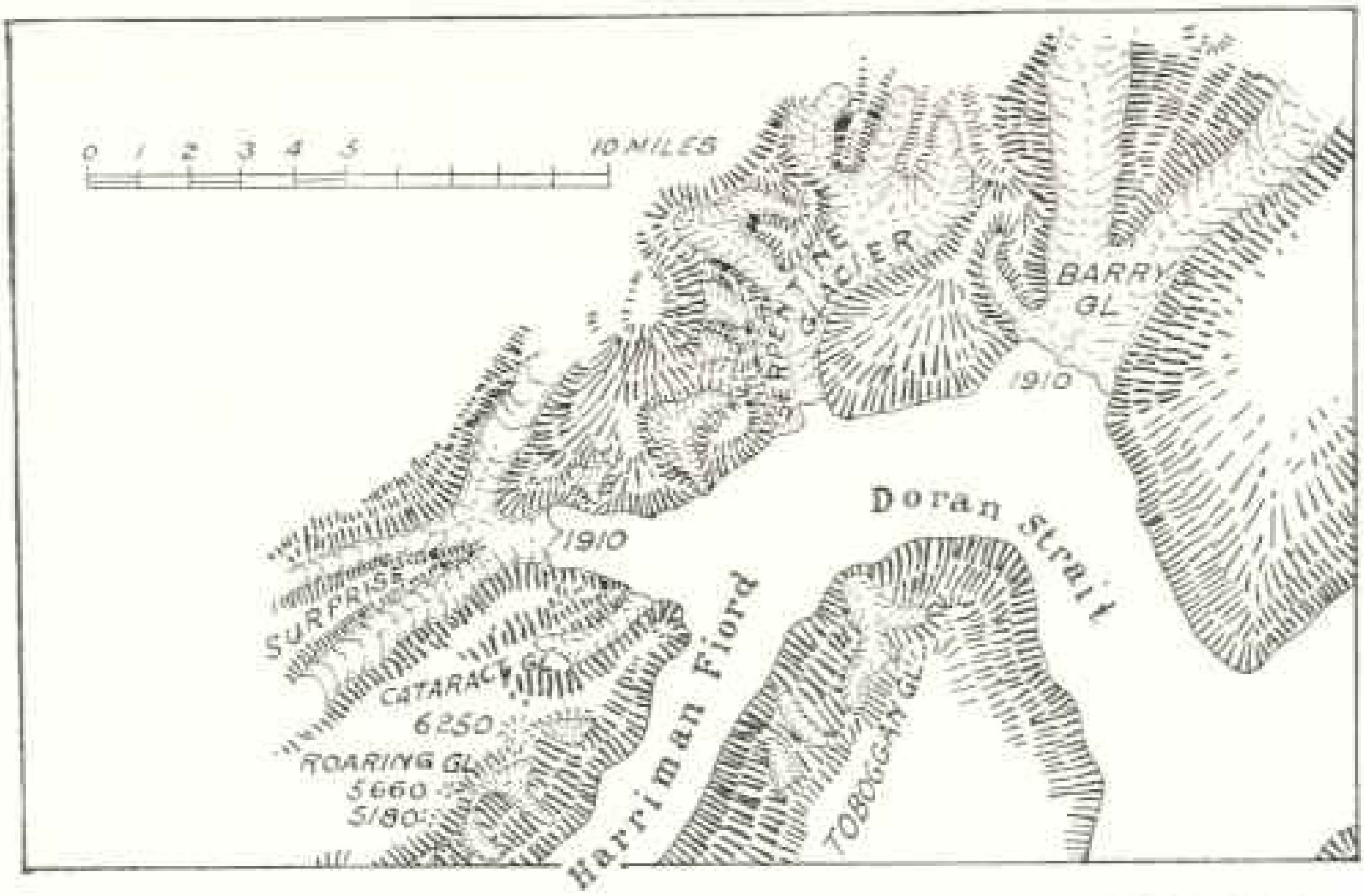
Columbia Glacier forms an interesting contrast with Childs, the rate of advance in the Childs increasing rapidly from 2.5 feet to 8.2 feet a day and decreasing again to .7 foot a day, all in four months, while the Columbia has slowly increased its rate of motion for two years from .9 foot a day in 1908 to 2.1 feet a day in 1910.

The phenomena accompanying this advance during the summer of 1910 were of great interest. The glacier was advancing into forests at its borders and on Heather Island, as in 1909, and overturning mature evergreen trees, which had grown undisturbed for a century or more, the advance having exceeded the 1892 maximum.

A whole grove on the west edge of Heather Island was overturned between 1909 and 1910, on our last visit, in September, practically not a tree remaining which was not overturned or leaning. Peat bogs were rolled up in great bolsters five or six feet high. Isolated trees in the peat were pushed forward a hundred feet or more without being overturned. A push moraine 15 to 25 feet high faces the ice front, the material being, variably, beach gravel, glacial till, mud flows, peaty soil, and macerated heaps of tree trunks and roots. In the bay east of Heather Island marine deposits with shells are being pushed up above sea-level.

On the east margin of the glacier a

SKETCH OF PORT WELLS, PRINCE WILLIAM SOUND, ALASKA, IN 1899



SKETCH OF PORT WELLS IN 1910, SHOWING THE EXTRAORDINARY RETREAT OF BARRY AND SURPRISE GLACIERS (SEE PAGE 551)

lake was formed where there was only a marginal stream in 1909. At the outlet of this lake the turf covering the glacial deposits, which were being pushed forward by the advancing glacier, was gashed with irregular cracks where the former covering of the soil had proved too small to fit the bulging hill. Between June and September, 1910, when we revisited Columbia Glacier, the waterfall at the lower end of this lake was cut back, the lake level was lowered a little, and the stream-course shifted.

As at Childs Glacier, the advance was not spectacular, and noises were absent. One could clamber all over the advancing margin of the glacier. From one day to the next, however, we saw great changes, as when a part of the ice front was seven feet from a blazed tree on July 6 and touched the tree on July 9.

From July to September the changes were far more noticeable, the most spectacular transformation being the decrease in height of a portion of the glacier from about 60 feet to less than 15 feet, while its margin in the same place advanced. If this was due to melting it was at the rate of nine inches a day, taken off by vertical ablation. The measured rates of surface melting on other glaciers in Alaska are one, two, four, and seven inches a day, all on retreating glaciers. As the terminus of the glacier was advancing, we think it probable that there may have been a collapse of this portion of the glacier surface by the moving away of the ice beneath—a phenomenon exceedingly suggestive of viscous flowage.

West of Columbia Glacier in Unakwik Inlet is Meares Glacier, the north side of which advanced slightly between 1909 and 1910. This is the glacier which the Spanish explorer Fidalgo, in 1790, called a volcano, because of the discharge of icebergs from below sea-level with thundering reports. Above it rises Mount Grosvenor, named for the National Geographic Society's Director and Editor.

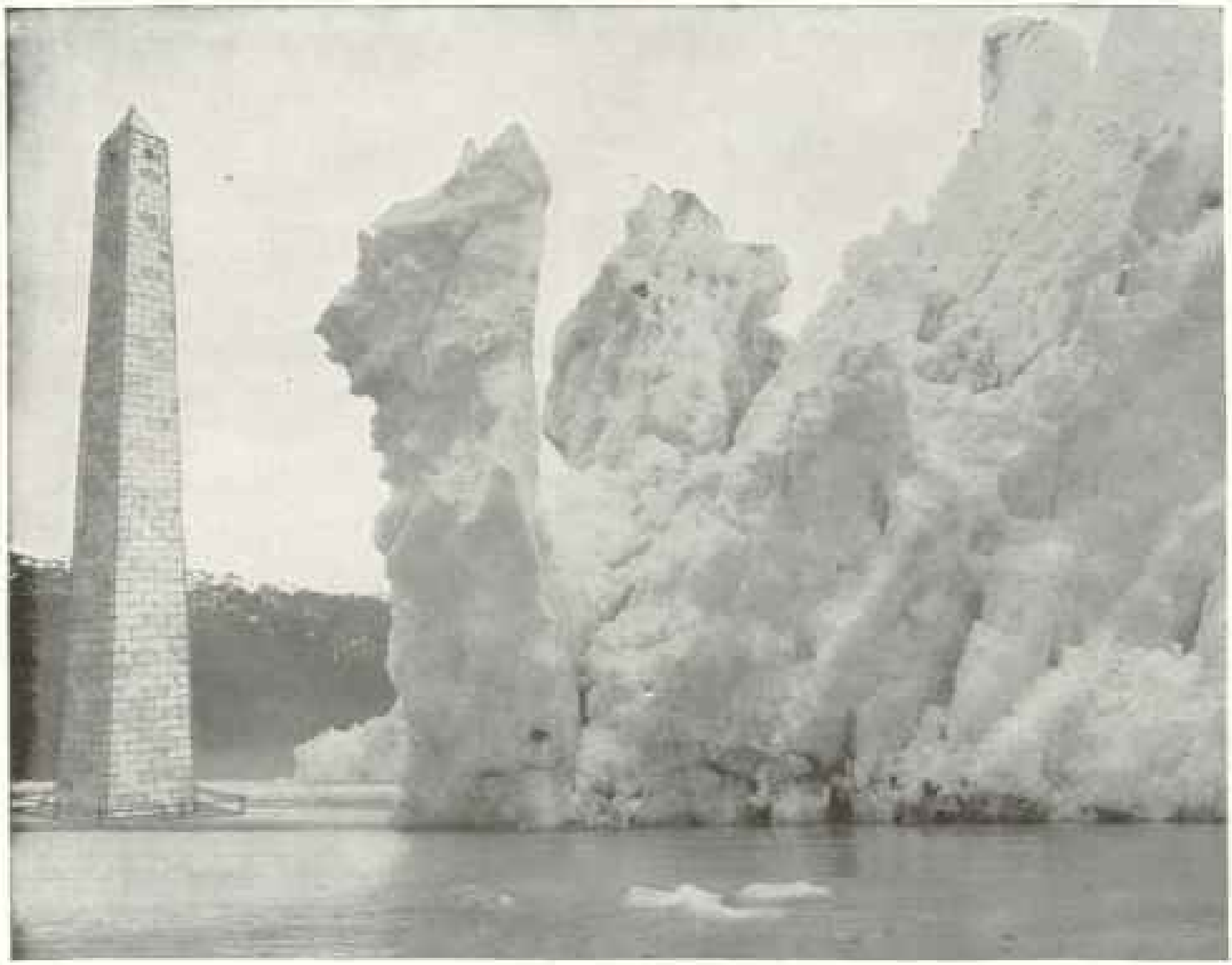
In the northwest corner of Prince William Sound is Port Wells, a broad fiord whose branches—College Fiord, Harriman Fiord, and Passage Canal—contain large glaciers. In College Fiord seven glaciers were advancing simultaneously in 1910, two of them perhaps commencing in 1909, as observed by Grant. The Harvard, Yale, Radcliffe, Smith, Bryn Mawr, and Wellesley glaciers displayed activities similar to that of Childs and Columbia glaciers, after having been stagnant for a long time before. Yale Glacier had advanced 750 feet in all since 1899, when it was studied by the Harriman expedition and mapped by Gannett. All these glaciers were destroying the forests at and upon their margins, and splinters of ice were being pushed forward by faulting, as at Columbia Glacier.

Harriman Glacier was the only one in the fiord of that name which was advancing in 1910, having come forward 300 feet since 1899. In Blackstone Bay, a branch of Passage Canal, several of the glaciers are advancing.

RETREATING GLACIERS

Below Mount Gannett in Harriman Fiord is the Barry Glacier, which nearly separated that body of water from the sea in 1899, when the Harriman expedition discovered and explored it. Between 1899 and 1910 Barry Glacier retreated about 3½ miles, as is shown on page 550, where Gannett's map is reproduced with the latest one. Approximately 600 feet of this retreat took place between Grant's visit in 1909 and ours a year later. Moraine-veneered ice was still present in 1910 on the site of the margin of the glacier in 1899, over two miles from the present ice front. Surprise Glacier went back a mile and a quarter in this same period of 11 years.

Tiger Glacier in Icy Bay was shortened about seven miles between 1794, when Vancouver's lieutenant, Whidbey, mapped it, and our visit in 1910. Not only has the fiord been lengthened by this amount, but the Icy Bay glacier of 1794 has been dismembered into the Tiger, Chenega, and Princeton glaciers. Valdez and Shoup glaciers had retreated slightly since 1909. Nellie Juan Glacier was little changed. Many other glaciers



FRONT OF COLUMBIA GLACIER IN 1910, COMPARED IN HEIGHT TO BUNKER HILL MONUMENT

The ice pinnacle, rising over 200 feet above the base, fell a few minutes after this picture was taken. Photo by Lawrence Martin

had retreated small amounts since visited by earlier parties, and a number seemed to have maintained their positions.

REASONS FOR OSCILLATIONS OF GLACIERS

It is not perfectly clear why these glaciers in Prince William Sound and on Copper River are oscillating—some advancing and some retreating. Of course the fundamental cause is involved with snow supply and with rate of melting as determined by temperature. Climatic records are so incomplete that we cannot settle this question. On the other hand, it is possible that the snow supply of any glacier or group of ice tongues might have been increased by avalanching during earthquakes, as is the case in Yakutat Bay, rather than by increase of precipitation. These Prince William Sound and Copper River glaciers are outside the zone affected by great avalanching during the Yakutat Bay earthquakes of September, 1899, though the advance of La Perouse Glacier may possibly be due to that seismic disturbance. There are many other earthquakes, however, whose origins were in or near the region of these advancing glaciers, and one such in October, 1900, was of considerable intensity.

The Yakutat Bay glaciers which have so far advanced as a result of the earthquakes, including Nunatak Glacier, in 1910, are of variable sizes and have responded in order of size, the smaller ones first. These advancing glaciers in Prince William Sound are also of vari-

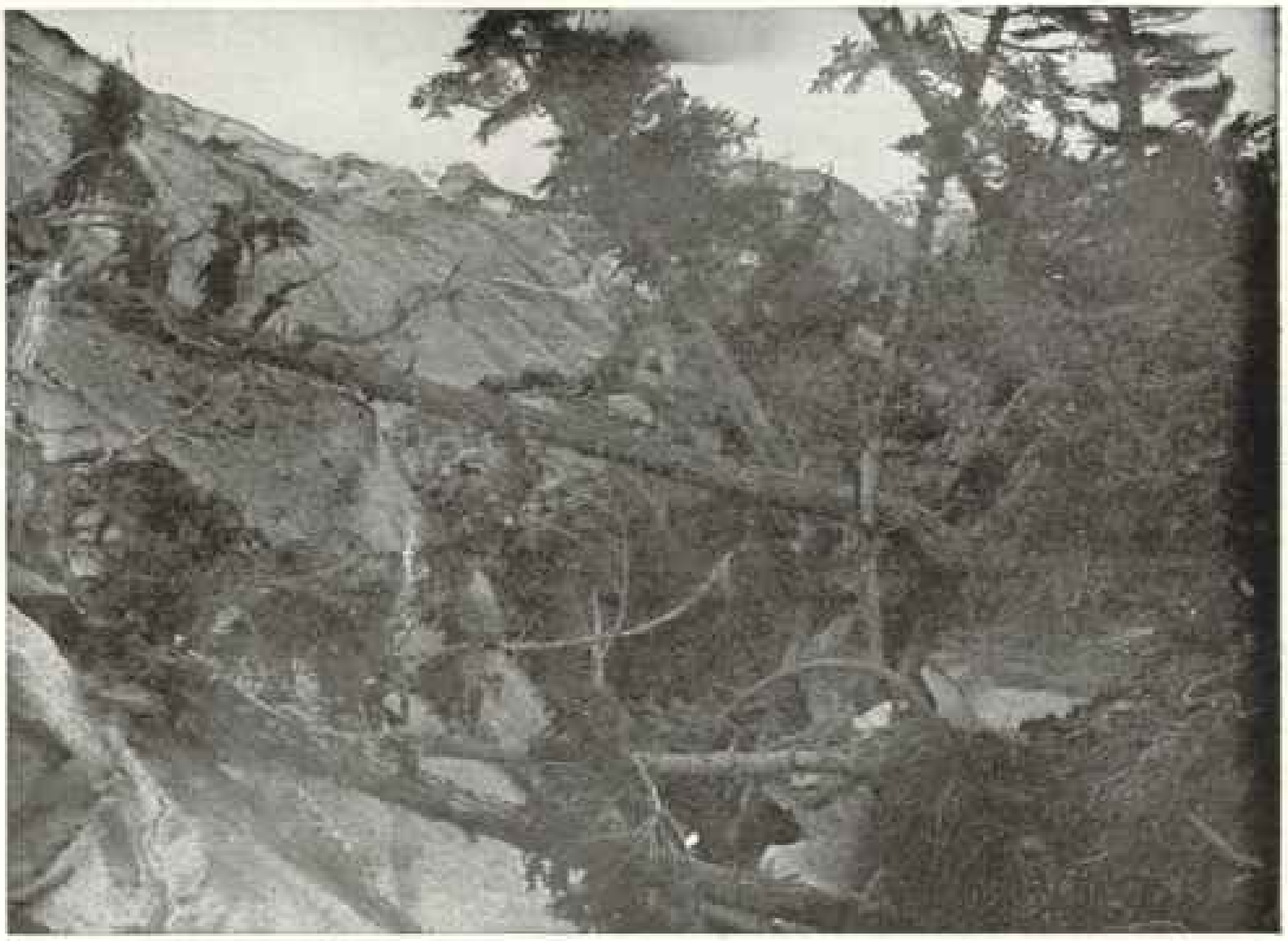


Photo by Lawrence Martin

COLUMBIA GLACIER OVERRIDING A FOREST (SEE PAGE 549)

able sizes, and the largest, Columbia and Valdez, seem to have begun to advance in 1907-'08, before the smaller ones of College Fiord, where seven ice tongues—the large Yale and Harvard, and the smaller Wellesley, Vassar, and others—all began to advance together in 1909-'10.

This absence of relation between size and period of advance and the lack of spasmodic transformation to activity, with rapid return to stagnation observed in Yakutat Bay, suggests that the advances now in progress may be climatic. An increase in precipitation at Valdez from 56 inches in 1904 to 91 inches in 1907, and back to 70 inches in 1909, supports this hypothesis, though we do not feel at all sure that the increase was more than local, for such great variations are common in Alaska and are usually not widespread.

The only satisfactory course for the present is to ascribe the great awakening of certain of these glaciers either to climatic variations or to earthquakes, and then wait to see whether the other glaciers, now retreating, also advance, and whether those now advancing behave as have the Columbia Glacier and certain advancing glaciers in the Alps, suggesting a climatic explanation, or whether they develop the characteristics of the earthquake-stimulated Yakutat Bay glaciers, as the Childs Glacier seems possibly to be doing. It would be most desirable if some one could revisit these glaciers in a year or two to obtain evidence bearing on this question.

OLDER ADVANCES DUE POSSIBLY TO EARTHQUAKES

I studied the previous history of a group of glaciers in Harriman Fiord carefully, and it furnishes clear evidence of two previous periods of advance. The best evidence comes from the Barry,

Photo by Lawrence Martin

NORTH SIDE OF SMITH GLACIER, SO NAMED BY HUDSON OF SMITH COLLEGE

Serpentine, Toboggan, and Baker glaciers, all of which are now retreating.

Around the termini and lower borders of a number of the Prince William Sound glaciers are conspicuous barren zones, where the glaciers have melted back from their farthest recent advance. There was such a barren zone around Columbia Glacier in 1899 when Gilbert visited it, but before 1909 most of this barren zone was overridden by the advancing glacier, and in 1910 it was all covered, as were parts or all of the barren zones bordering the College Fiord glaciers in 1899 and 1909. In Harriman Fiord these barren zones are still present near most of the glaciers. My first impression was that the advances preceding the retreats that exposed these barren zones were synchronous, and that an examination of the ages of shrubs that had sprung up in the barren zones would reveal the approximate date at which the last advance of these glaciers had taken place.

Serpentine Glacier was studied first, and in its barren zone the scattered willows, alders, and spruces were none of them more than 27 years old. An earlier moraine outside this had trees up to 93 years of age. Baker Glacier, just south of Serpentine, had a nearly barren inner moraine with shrubs 18 years old, and a more thickly forested outer moraine with spruces up to 110 years old. Toboggan Glacier, near by, has 20-year-old shrubs on the last moraine of its barren zone and conifers of 70 years' growth on an older moraine.

Many trees were cut down in determining these ages, the oldest ones being cited here.

Photo by Lawrence Martin

THE TERMINAL ICE CASCADE OF CHENEGA GLACIER, ICY BAY, WHICH IS ABOUT 550 FEET HIGH, COMPARED GRAPHICALLY WITH THE WASHINGTON MONUMENT

At the borders of these older deposits there are usually moraine ridges, beyond which is thick-set, mature forest with trees from 100 to 225 years or more of age. Barry Glacier is bordered by a barren zone with the oldest shrubs only 11 years old, and there are not two belts, but one, outside which a very perfect push-moraine ridge on each side of the glacier separates the barren zone from the thick forest.

I had found, therefore, that the advances were not synchronous, and that in three cases out of the four the glacier had advanced twice, for it is hardly conceivable that each glacier stood at the inner moraine while the shrubs grew for 50, 66, and 92 years. The data for the last of these two advances may be arranged as follows, suggesting glacial maxima in the years shown in the right-hand column, if we assume that retreat began as soon as the glacial maximum was reached in each case:

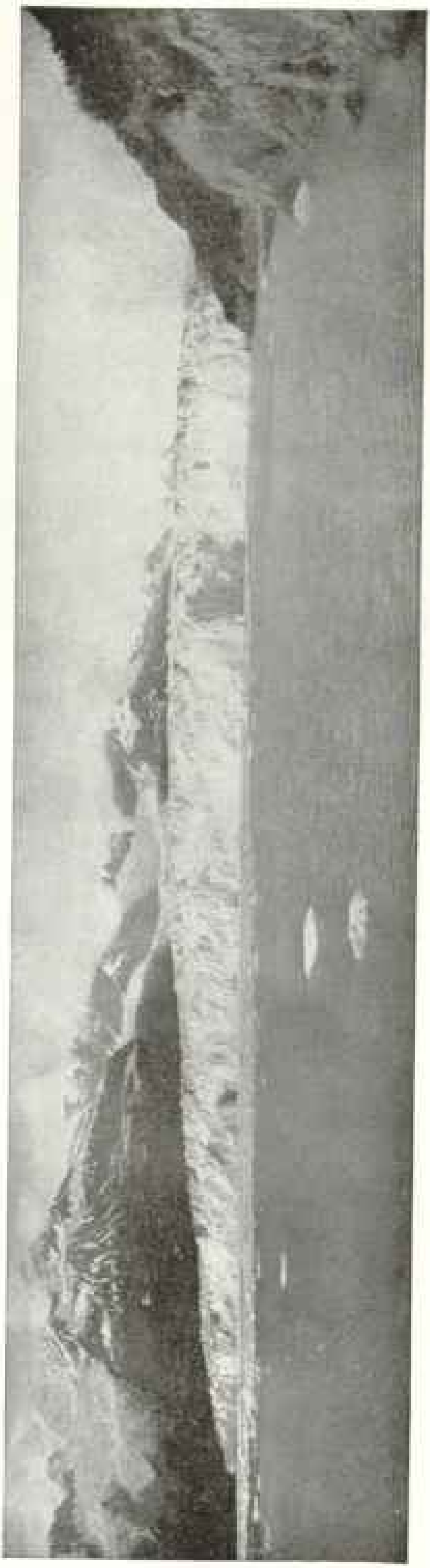
Glacier.	Age of trees.	Possible date of advance.
Serpentine	27 years	1852
Toboggan	20 years	1889
Baker	18 years	1891
Barry	11 years	1898

There are no known visits of white men by which to check any of these dates, except in the case of the Barry Glacier, which had retreated slightly from the edge of the barren zone when the Harriman expedition visited it in 1899. In 1898 some army officers saw it from a distance and the advance had already taken place, but they were not near enough to see whether it was still advancing.

This group of advances, 11-27 years ago, may possibly be due either to climatic variations or to earthquake avalanches. If it was the former, we must explain why all these glaciers, which are fed from adjoining snow-fields, did not advance approximately together instead

PANORAMA OF BARRY GLACIER AND MOUNT GANNETT, 9,240 FEET

Named for the President of the National Geographic Society, who in 1899 first mapped the Barry Glacier



Photos by Lawrence Martin

HARVARD GLACIER FROM SHORE NORTH OF COLLEGE POINT (SEE PAGE 558)

NONE OF THESE GLACIER ENDS ARE AFLOAT

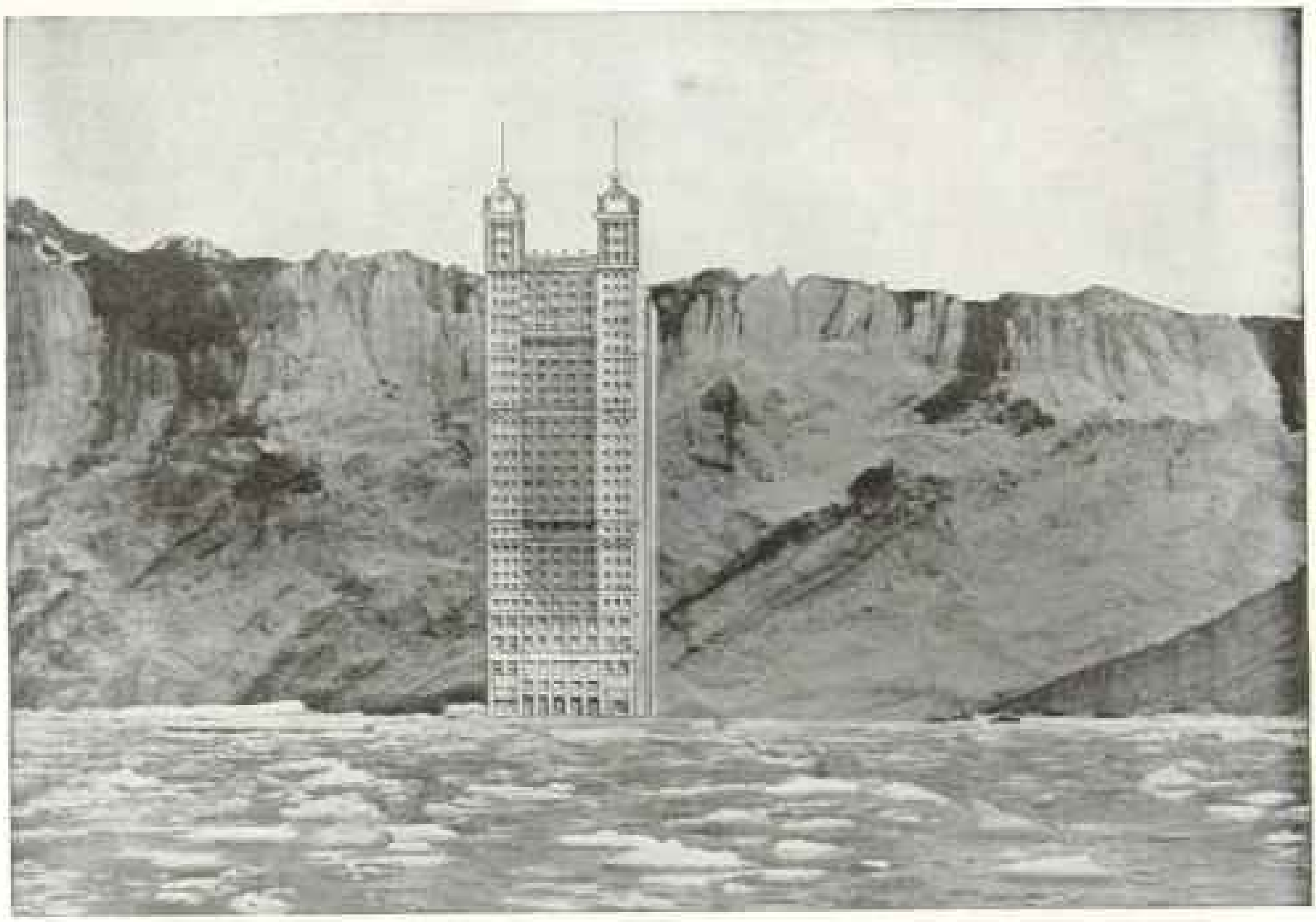


Photo by Lawrence Martin

THE TERMINAL ICE CLIFF OF HARVARD GLACIER, COLLEGE FIORD, 350 FEET HIGH, COMPARED IN HEIGHT WITH THE PARK ROW BUILDING, NEW YORK CITY, WHICH IS 390 FEET HIGH

of through a period of 16 years: but we know too little about the sizes, shapes, and slopes of the snow-fields to raise this as a valid objection.

If earthquake avalanching is thought to have caused the advances, we see the likeness to the Yakutat Bay glaciers at once, for Barry Glacier is longer than Serpentine and Baker than Toboggan. The two last are shorter than Serpentine, but have very different grades. There was a severe earthquake in 1880, and the advances show an apparent time relationship to this that warrants the retention of this hypothesis as possible. It would be most valuable if we knew whether these advances were abrupt, like the earthquake-stimulated Yakutat Bay advances, or not, and how long they lasted.

In the case of the group of still earlier advances, the short Baker Glacier advanced before the longer Serpentine, with the Toboggan Glacier still later. The absence of a record for Barry Glacier suggests that the 1898 maximum went beyond this earlier one and destroyed the records of it, as Columbia Glacier has now destroyed practically all the evidence of the 1892 maximum, which was plainly visible from 1899 to 1909. The only safe conclusion regarding the two sets of advances, 11-27 and 70-110, years ago, is that the progressive development of advances in adjacent glaciers of several sizes suggests the possibility of an earthquake origin, just as the synchronous advance of the seven, variable sized, contiguous, College Fiord glaciers in 1910 suggests the possibility of climatic origin.

SUBMARINE TOPOGRAPHY

The map reproduced on page 559 illustrates the results of a typical day's

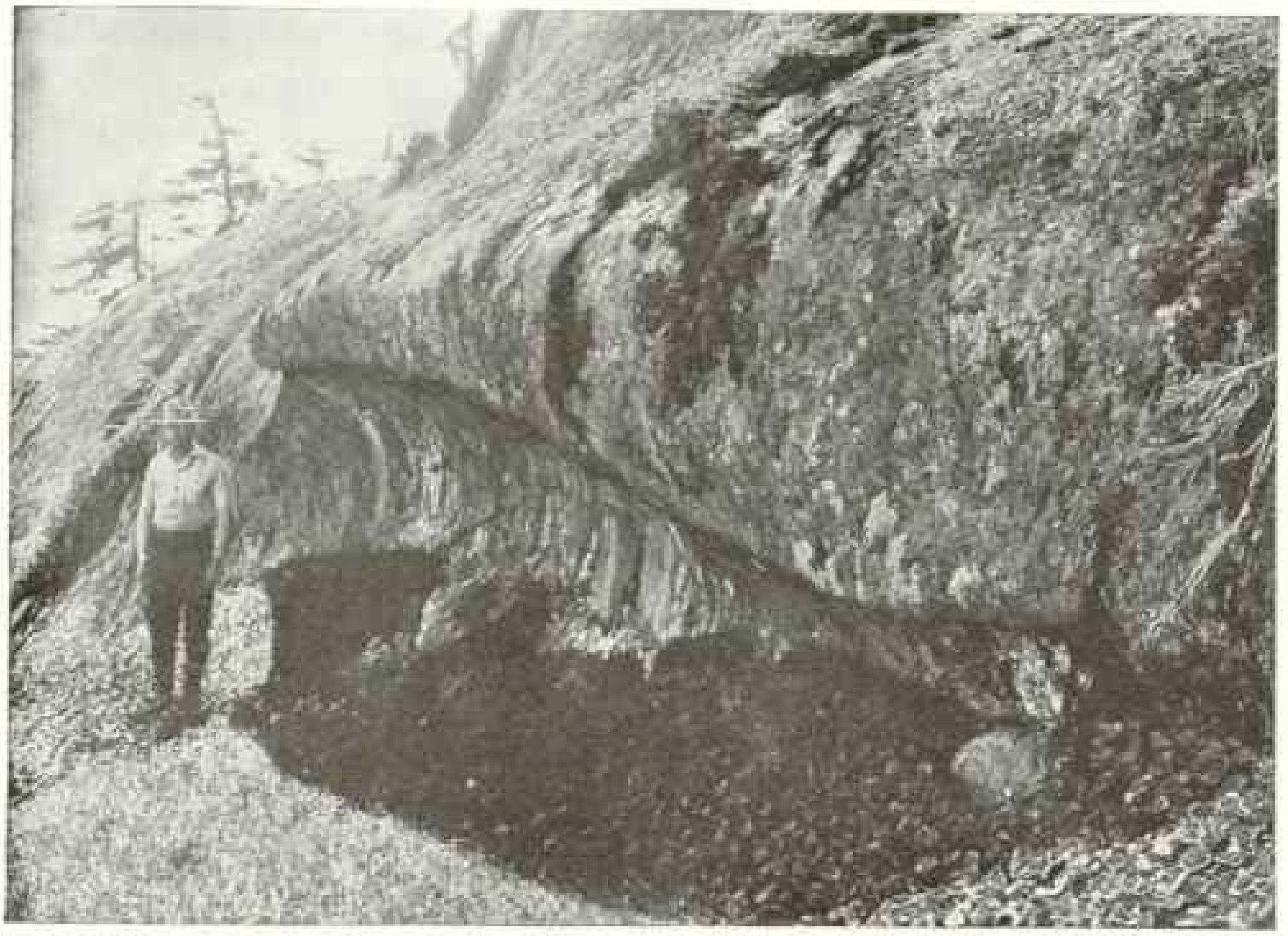


Photo by Lawrence Martin

A GREAT GROOVE CUT IN HARD ROCK BY A GLACIER AS IT ADVANCED: PORT DORAN, HARRIMAN FIORD

work in the study of the submarine topography produced by glacial sculpture and deposited in a fiord. On that particular day we made only 29 soundings, but most of them were deep ones and one of the party calculated that we had wound up five miles of wire during the day.

As we looked up at Mt. Gilbert, 10,194 feet, on the way to camp that night, we imagined an equal mountain placed on top of it and over half a third one, thinking what it would have meant if we had been on top of such a 26,000-foot peak with a 20-pound lead at the base and had had to wind it up with our small hand reel all at once instead of in 500-1,400 foot lengths. Then the day's work seemed larger, especially as we had discovered an invisible moraine below sea-level, together with two submerged hanging valleys, and had located an uncharted rock and made a 22-mile longitudinal section and two cross-sections of a wonderful glacially sculptured fiord.

Our other soundings revealed similar groups of results. The depths of water, as near the fronts of the several large tidal glaciers studied as we dared venture in our launch, varied from 90 feet in the case of Harriman Glacier to 636, 600, and 555 feet near Harvard, Columbia, and Nunatak glaciers, respectively. This shows that none of these glacier ends could be afloat, for the visible 200-300-foot ice cliff, if floating, would have six or seven times that depth below sea-level, and in no case is the part of the fiord near the glacier deep enough.

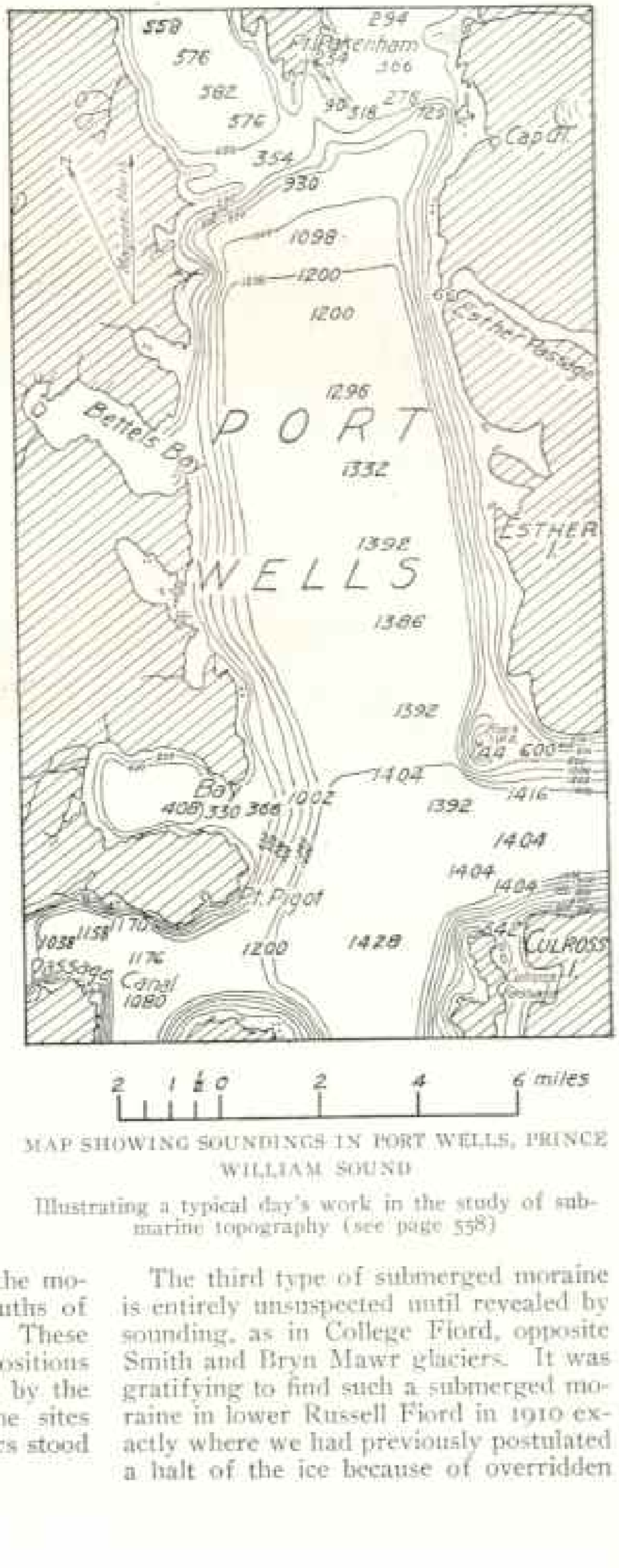
We made many other longitudinal and cross-sections of inlets in Prince William Sound and Yakutat Bay, finding them all

of such form as to support our belief that all these fiords have been chiefly widened and deepened by glacial erosion. The submarine topography in each case was not greatly different from that above sea-level. Some rock basins were also eroded in the fiord bottoms, but these and the submerged moraines are hard to distinguish by soundings alone.

Many other submerged hanging valleys were discovered in soundings, as Granite Cove and the channel east of Heather Island, near Columbia Glacier; Siwash Bay, in Unakwik Inlet; Yale Arm of College Fiord; the cove near Tebenkof Glacier, in Blackstone Bay; the cove of Serpentine Glacier, in Harriman Fiord; Nunatak Fiord, Seal Bay, and the channel east of Haenke Island, in Yakutat Bay, and many others.

The submerged moraines which we found were of three types. The first type is the moraine bar, rising nearly to or just above sea-level, and like the familiar sand bar or pair of spits, except that it is made up of angular striated boulders of various sizes instead of pebbles and sand. It differs from the recessional moraine on the land, too, in having most of the clay in its till washed away by the tides. Such moraine bars are found in Unakwik Inlet and Blackstone Bay.

The second type of moraines is partly revealed without sounding and may be deeply submerged in the middle, but with normal sand pits growing upon the moraines near shore, as at the mouths of College Fiord and Barry Arm. These moraines may also have their positions suggested by irregular shoals or by the stranding of icebergs, as on the sites where Barry and Nunatak glaciers stood in 1899.



2 1 ½ 0 2 4 6 miles

MAP SHOWING SOUNDINGS IN PORT WELLS, PRINCE WILLIAM SOUND

Illustrating a typical day's work in the study of submarine topography (see page 558)

The third type of submerged moraine is entirely unsuspected until revealed by sounding, as in College Fiord, opposite Smith and Bryn Mawr glaciers. It was gratifying to find such a submerged moraine in lower Russell Fiord in 1910 exactly where we had previously postulated a halt of the ice because of overridden

glacial deposits to the north and abandoned glacial lake shore lines to the south.

The nature of the glacial deposits accumulating now in shallow water is easy to see, as in Russell Fiord, near Yakutat, where the sands and clays of Hidden Glacier delta have grown forward 1,600 feet between 1899 and 1910, and in Harriman Fiord, where one can land at low tide on the till and boulder moraine shoals which were being built by Barry Glacier only 11 years ago, when the Harriman expedition was here. In more profound depths we know less about these deposits, except that they must be mostly muds and clays in these deep waters, with scattered stones dropped by floating icebergs. There are many other illustrations of each of the glacial features cited above, but the ones mentioned here must suffice as samples until the complete book on our glacial studies is published.

THE GLACIERS ARE REMNANTS OF GIANT PREDECESSORS

In Prince William Sound a few points stand out clearly in connection with the former great glaciers that flooded this arm of the sea when the existing glaciers were much more expanded. It is clear that they filled the whole sound, rising up in the present fiords high above the level of the existing glaciers, perhaps 4,000 feet above sea-level near Columbia Glacier and Port Wells. They did not cover all of Hinchinbrook and Montague islands, at the entrance of the sound, and these mountainous islands are largely driftless, as we proved by observations there, and formerly rose as nunataks through a piedmont glacier that extended out, as Malaspina Glacier does now, and probably reached Middleton Island, 55 miles offshore, ending in the Pacific with a great tidal ice front similar to the great snow barriers of the Antarctic region.

The existing glaciers are shrunken remnants of their great predecessors, and are largest near the highest mountains and greatest snowfields and very small in the lower regions, as on Knight and Montague islands.

The expanded glaciers eroded deeply, rounding the overridden islands in the north part and sculpturing the whole sound, which is 1,500 to 2,400 feet deep in some of the inner stretches and 1,200 to 1,300 feet deep in Hinchinbrook entrance, where the ice was constricted and moved rapidly, while the adjacent sea bottom of the Pacific is shallow, 200 to 300 feet, for over 50 miles offshore. Glacial deposits above sea-level are thin and scattered in Prince William Sound. The great work of the ice was erosion, with deposition mainly offshore. Dense mature forests extend up close to the present ice fronts, and there has been no episode of recent great expansion of glaciers, as in Yakutat Bay, though minor oscillations have, and still are, taking place.

The Copper River glaciers were also greatly expanded in the past and modified the valley profoundly. There is reason for thinking that the former great glaciers of the Wrangell Mountains and Alaska Range did not find an outlet down this valley, though much of the drainage may have come this way. Mr. Alfred H. Brooks, of the Geological Survey, had called my attention to peculiarities of this drainage, and I am inclined to think, after a brief journey up the Copper River to the mouth of the Chitnia, that the present course of Copper River across the Chugach coast range is entirely due to glacial modifications in a way to be explained in the forthcoming book.

The glacier studies in 1910 carry the previous researches by the National Geographic Society much farther than in 1909, supplementing the facts already established in Yakutat Bay, and their interpretation, and adding new data of considerable importance in glacialogy.

ACKNOWLEDGMENTS

THE National Geographic Society has much pleasure in expressing its thanks and appreciation to the following companies and individuals for material assistance rendered to its Alaskan expeditions:

Copper River & Northwestern Railway Co., Cordova, Alaska—transportation, subsistence, maps, storing launch for winter, etc.

Bausch & Lomb Optical Co., Rochester, N. Y.—loan of lens for camera and pair of field glasses.

Williams Bros. Co., Detroit, Mich.—pickles, mustard, catsup, pork and beans, preserves.

Borden's Condensed Milk Co., 108 Hudson St., New York city—Eagle Brand condensed milk; Pioneer Brand evaporated milk; Borden's milk chocolate.

Franco-American Food Co., Franklin St. and Central Ave., Jersey City—assorted soups, potted beef, plum pudding.

Walter Baker & Co.—milk chocolate.

Rainier Grand Hotel, Seattle, Wash.—discount on accommodations.

Schwabacher Hardware Co., Seattle, Wash.—discount on camp equipment.

H. O. Wilbur & Sons, Philadelphia, Pa.—chocolate and cocoa.

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We are also much in debt for courtesies to our party in Alaska and on the way by President S. W. Eccles and General Manager E. C. Hawkins, of the Copper River & Northwestern Railway Co.; Messrs. O'Neel, Van Cleve, Johnson, Withers, and Corser, of the Katalla Company, and Messrs. Murchison, Shields, and Whiting, of M. J. Heney's force; to Mr. John Dalton, of Cordova; to Messrs. Luthrop, Peterson, Crawford, and Cimicia, of Valdez; to Rev. Mr. Rasmusson, and Messrs. Beasley, Stimson, Robinson, Flenner, and Gray, of Yakutat; to Captain MacGilvary and Mr. Inglis, of the steamship *Bertha*, and Messrs. Barber and Macgregor, of the steamship *Portland*; to the mine operators at La Touche; to Professors Landes and Meany, of the University of Washington; Messrs. Jamme, of Seattle, and R. P. Tarr, of Tacoma; Prof. U. S. Grant, of Northwestern University; Prof. R. S. Tarr, of Cornell University, and many others.

THE WONDERS OF THE MOSI-OA-TUNGA: THE FALLS OF THE ZAMBESI

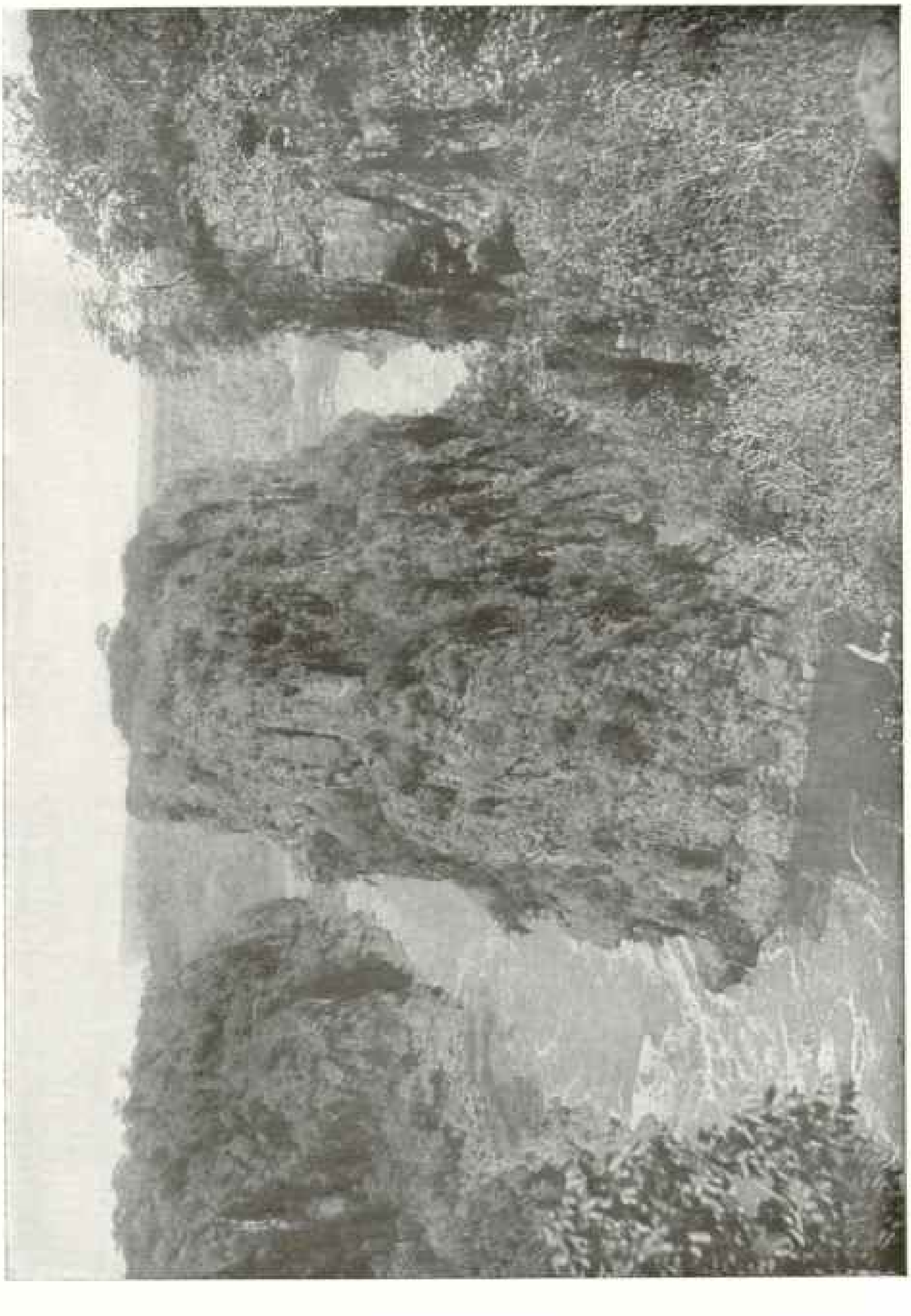
By Louis Livingston Seaman, M.D.

IN A far-away land, separated from the great basin of the Kongo by a low range of mountains, whose declivities point toward the Indian Ocean and which half a century ago was a veritable terra incognita, lies a scene of wonder and radiant beauty that is destined to become the Mecca of the globe-trotter, the geologist, the artist, and the poet who seeks inspiration from communion with the romantic, the picturesque, and the beautiful in nature.

Only within a few years has this spot been accessible to the traveler without tiresome treks by bull-cart or saddle through a country of dust and desert; but modern engineering has brought its prodigality of splendors almost to the doorstep of the visitor, as three days of comparative comfort by rail from Cape Town, or an equal time from Beira, on the east coast, lands one amid its unsurpassed glories.

And well indeed will the visitor be rewarded for his undertaking, for in that curiosity shop of the continent he will find a concentration of beauties and charm unrivaled by any scene hitherto witnessed by human eye. Here is the Grand Canyon of the Zambesi, in its tropic setting; here is the native kraal, where the great Livingstone passed many years in the labor that made his name a household word; and it was here, too, that he first saw the "Mosi-oa-Tunga," and beheld Victoria Falls, a spectacle of wonderful sublimity, a Triton feared by the savages, a marvel to the geologists, a source of energy coveted by the vandalism of commerce, and an inspiration alike to painter and poet.

It is far and away the most romantic spot in the Dark Continent, and constitutes the greatest attraction of the Zambesi, from its source in the great divide of the mountains of the Kongo to where



FIRST BEND IN THE CANYON BELOW VICTORIA FALLS

it finally fades into the Indian Ocean. The whole vast energy of nature—all the roused and slumbering elements—seem to have combined in its production, for nowhere has the Almighty revealed His might and glory in more varied form or with greater prodigality of charm.

It has been my good fortune to see the foaming waters of the Yellowstone, as they rushed over its precipice 210 feet to the Grand Canyon below and lost themselves amid the cathedral towers and picturesque spires of sandstone and chrome, whose brilliant tints and artistic grandeur are the admiration of the world. In our wonderful Yosemite I have gazed from the dizzy cliffs of El Capitan to where the Bridal Veil and Rainbow Falls dash into misty spray, half a mile below. At Niagara I have stood awe-struck and dumb in contemplation of the Almighty's masterpiece.

In the Himalayas, in Japan, in Switzerland and Lapland, in Alaska, in Uganda, at the Ripan Falls, and in South America I have seen waterfalls of wonderful beauty and charm, and while the Zambesi lacks many of the individual features which make these great natural attractions unique in their beauty, it nevertheless possesses, in its exquisite setting of emerald and tropic luxuriance, its grottos and rain forests, its dancing cascades and raging cataracts, its roseate sprays and frolicking rainbows, a diversity of charms surpassing them all.

So remote is this gem of nature from the beaten paths of the great world that no apology is made for inviting the reader to share in a further description of its beauty.

From immemorial times an atmosphere of mystery and superstition has hung over the Falls, so profound that Livingstone, who discovered them in 1855, had the greatest difficulty in persuading his followers to accompany him, as they believed the region to be the home of monsters and devils of destruction. Vestiges of these traditions still exist, although the Cape to Cairo Railroad, which crosses the river less than half a mile below the Falls is rapidly dispelling them.

Our approach was made by rail from the Indian Ocean at Beira, near the mouth of the Zambesi (that hotbed of micro-organisms, described by James Brice as the most deadly in Africa), and across the narrow belt of swamp and jungle forming the coast; thence up the gradual slope to the volcanic plateau that forms the real continent of Africa.

By morning an altitude of nearly 6,000 feet was reached, and a transition from the excessive heat and moisture of the lowlands was experienced that was most grateful and exhilarating.

This section still abounds with antelope, elephants, lions, and other large game, which find excellent cover in the tall elephant grass or the dense forests and jungles, while in the river hippos still gambol and flounder in ungainly herds amid the floating islands of rank vegetation of Nile reeds and papyrus.

With the altitude, however, came another and less grateful change. The forests were no longer in evidence, but in their stead were vast arid, birdless plains, with parched and hungry vegetation whose anæmic and stunted growth bears witness to the scarcity of moisture that so severely affects Rhodesia and the great stretches of veldt far away to the Transvaal.

Early in the morning of the third day we were suddenly awakened by the guard and treated to a scene of beauty never to be forgotten. Some 10 miles distant five enormous columns of vapor were shooting their roseate-tinted shafts hundreds of feet heavenward, while the faint roar of the Falls told us the Mosi-oa-Tunga—the smoke that sounds—was no longer a mystery.

Each moment increased the beauty and vividness of the scene. With the first rays of the rising sun came a picture of color of wondrous loveliness. Delicate tints of violet, crimson, and beryl played through the mounting spray as it shot higher and higher, ultimately disappearing as virgin clouds in heaven, while the

ever-increasing thunders of the waters lent an added solemnity to the view.

Hardly could we wait to reach our destination, so great was our enthusiasm. But our hopes were doomed to momentary disappointment, only to be more than realized after a study of the environment; for, notwithstanding their magnitude, the first view of Victoria Falls is decidedly disappointing.

Although nearly a mile in width and 400 feet in height, the grandeur of their proportions is eclipsed by the sudden disappearance of the river, as it plunges into a narrow, rocky fissure extending across its entire width. Only at a single central point is there a breach in this fissure through which the Falls can be seen and appreciated in their full proportions, where the converging waters rush madly to the zigzag canyon below. So restricted is this view that there is an entire absence of that awe-inspiring and almost paralyzing effect which strikes the visitor dumb with wonder and amazement when Niagara bursts on his near vision. On first sight of the Victoria Falls one involuntarily exclaims, "Oh, how beautiful!" but they lack the majesty of our grand Niagara.

No single visit can adequately reveal the fulness of their charms, but repeated excursions must be made to their islands and precipices, their grottos and palm gardens, their rain forests and projecting crags, their rainbows and cataracts and many-sided views of their exquisite setting in the emerald framework of tropic forests, before their indescribable beauty can be appreciated. The fascination of discovering new and hidden charms from different points of view grows on the visitor and becomes one of the greatest attractions.

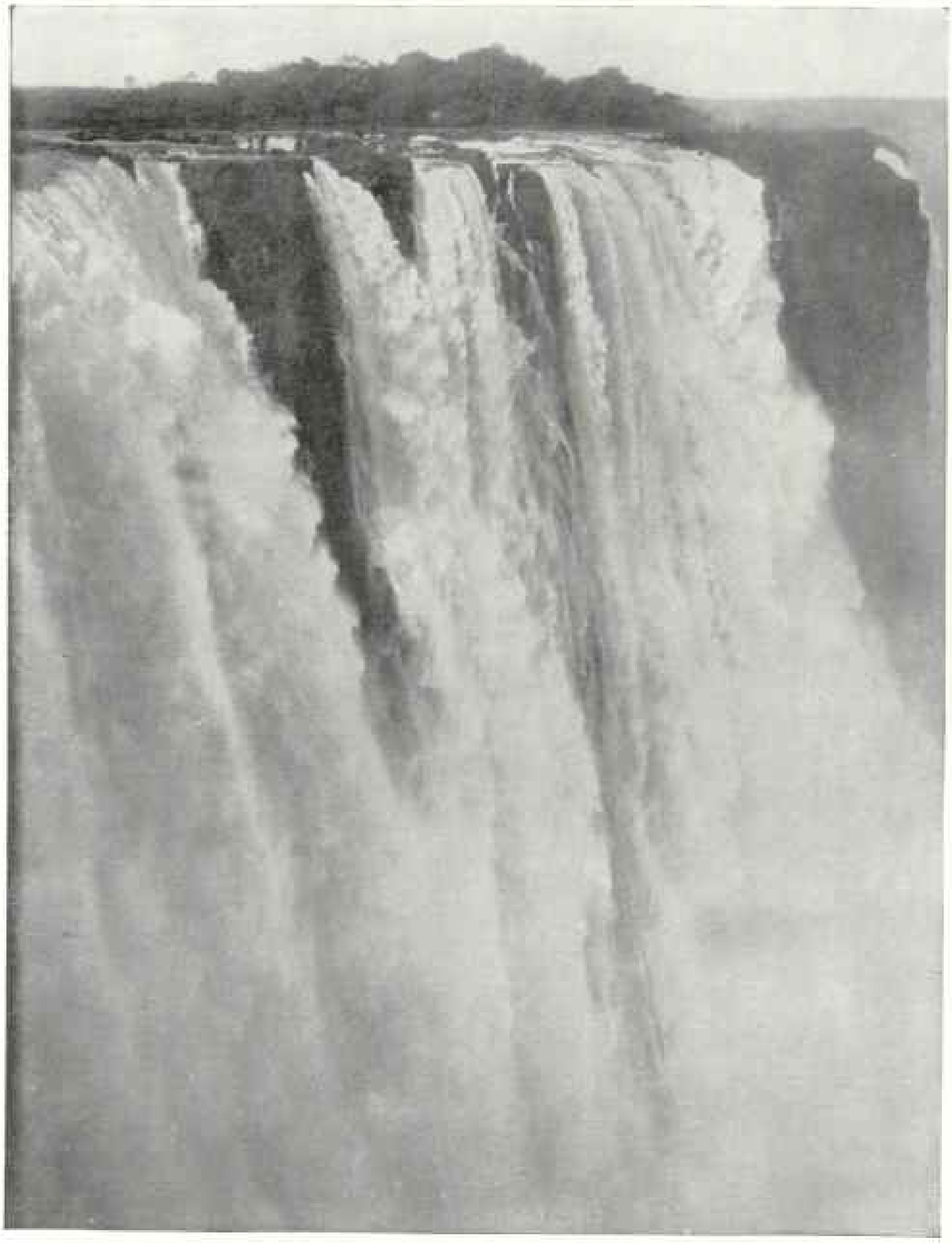
Had the Falls been in America, the Indians would surely have named them Minnehaha, Laughing Waters; for like a coy maiden are their fascinations, half concealing, half betraying their beauties, and requiring much wooing before revealing all their loveliness of hidden treasures and charm.

As the rainy season commences in Rhodesia in November and continues in the form of tropical showers until April, the most advantageous time to see the Falls is in May, when the seething torrents are at their flood. November also has its attractions, when the river is low, for then the chasm is comparatively free from mist, disclosing vistas and views of the great abyss of rare beauty, which before were wholly obscured by the whirling columns of spray.

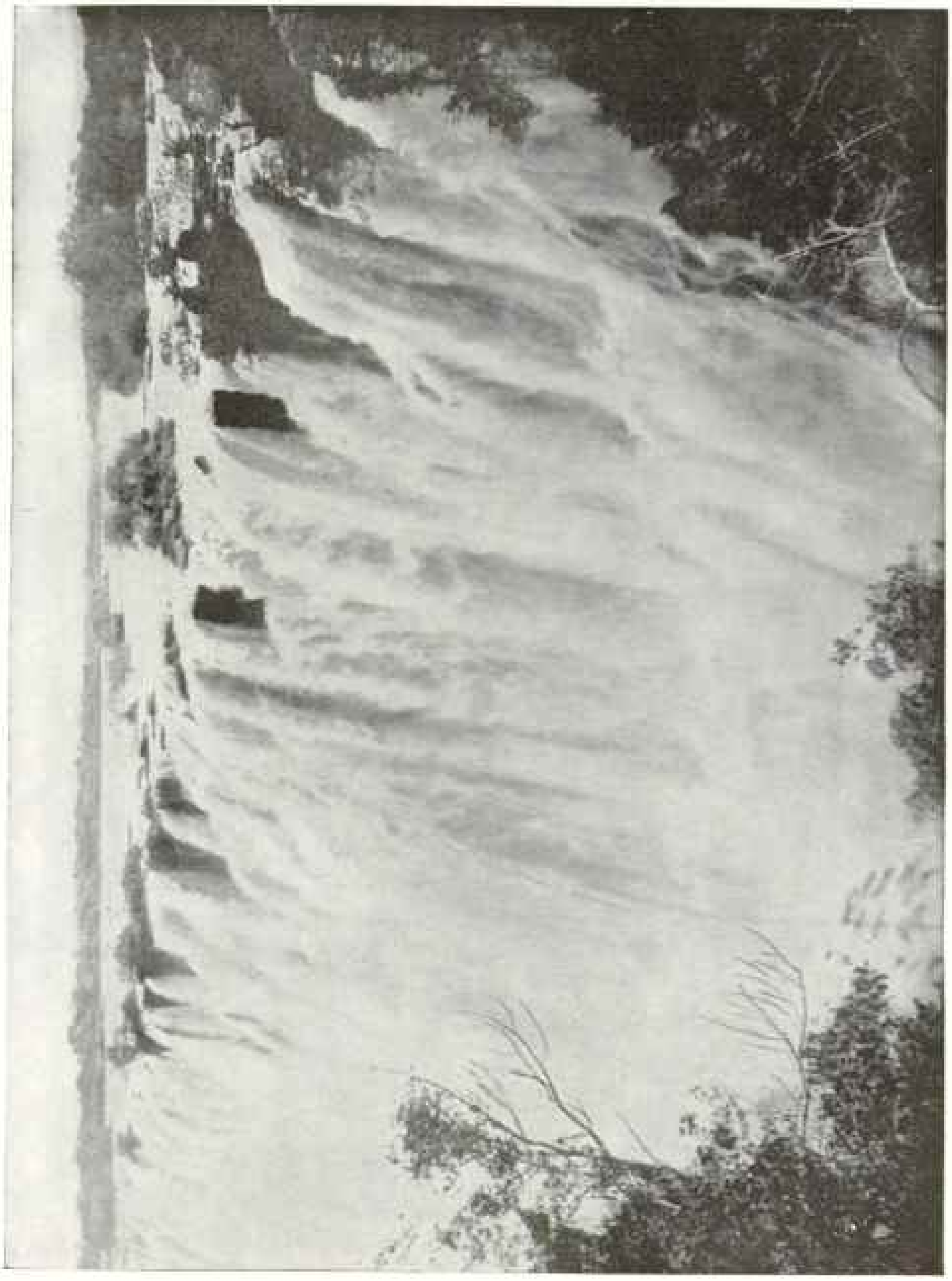
The bridge of the Cape Town and Cairo Railroad is the favorite point selected by artists, as the picture through the narrow gap at Danger Point exhibits the full extent of the angry waters, as they leap from the precipices to the abyss below.

The Chartered Company of Rhodesia, which controls the reservation miles above and below the Falls (as well as most everything else, movable and immovable, in South Africa), has erected a temporary hotel near the railway, where visitors are fairly well entertained, while from its verandas a magnificent panorama of the canyon and Batoka Gorge can be seen.

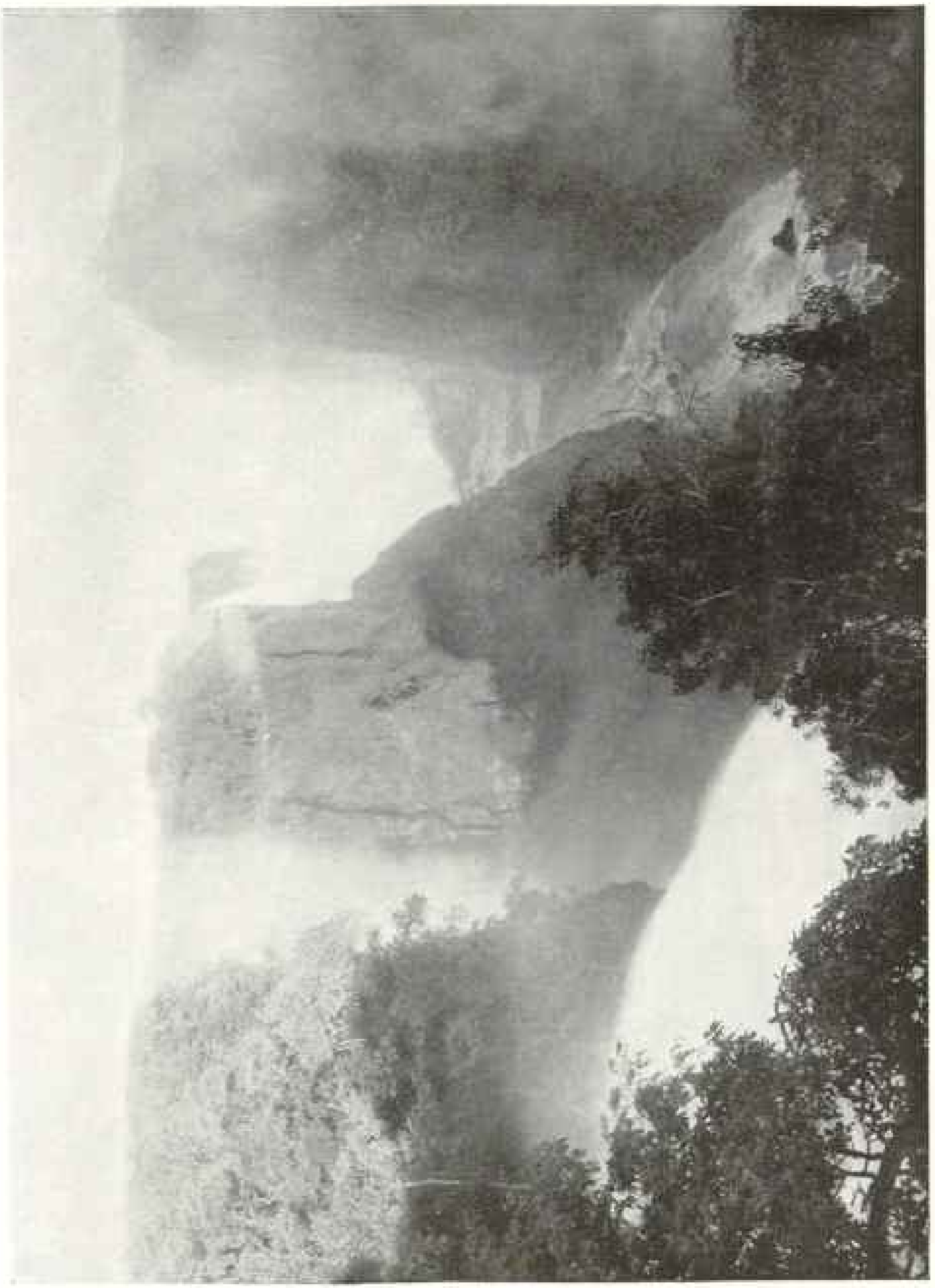
A walk of half a mile brings one to "the place where the rain is born," as the natives call the Rain Forest. This is a phenomenon of rare beauty and interest, especially to the botanist, for here the tropic heat and constantly falling spray produce a wealth of vegetation of wonderful luxuriance and variety. Every living thing bursts forth spontaneously here, from the delicate maiden-hair fern to the feathery-leafed palm and the hoary baobob, 70 feet in circumference, and under conditions so favorable that the great struggle for existence and the survival of the fittest is fought out with the intensest bitterness. Parasites and hungry climbing vines seize, like monster pythons, upon the great monarchs of the forest, sucking their life-blood or strangling them in their desperate effort for supremacy, only in turn to be reduced to mould or to fall the victims of new appearing and equally destructive enemies.



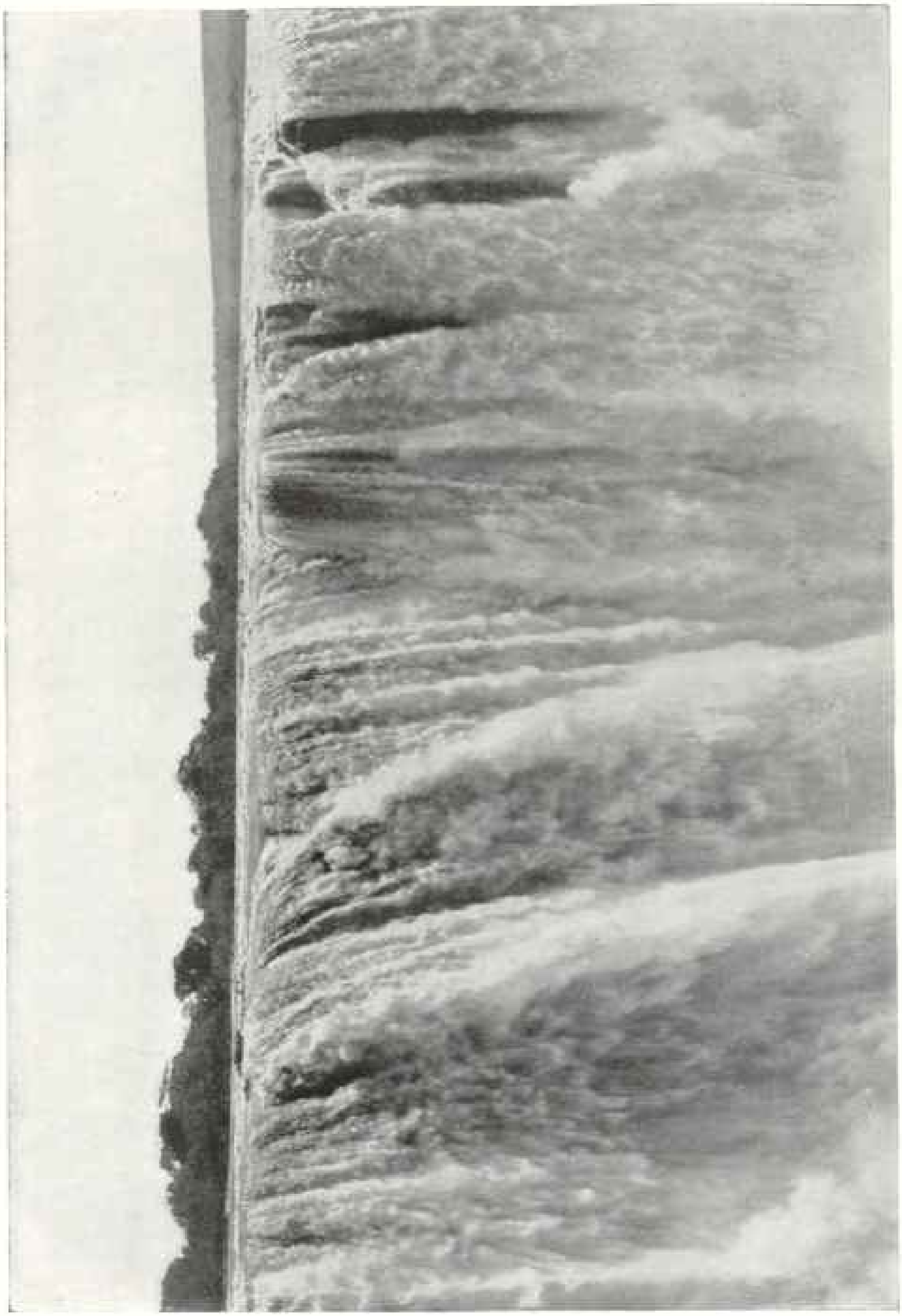
THE FALLS FROM CATARACT ISLAND



EASTERN END OF VICTORIA FALLS FROM THE "DEVIL'S CATARACT," SHOWING HARBON'S "ECHO" SPRING



THE DEVIL'S CATARACT FROM WEST END (SEE PAGE 565)



A VIEW FROM "THE RAIN FOREST," ON THE OPPOSITE SIDE OF "THE CLIFF AND TWO WHICH THE WATERS (SEE PAGE 569) (SEE PAGE 569)

FLOOD LASTS TWO WEEKS (IN SOME PLACES)

From the western extremity of the Rain Forest the leaping waters of the "Cascade" can be seen to best advantage, while its entire front, bordering on the great crevasse into which the river hurls itself, furnishes a superb view of the crest of the Falls from end to end, except when interrupted by the whirling masses of spray that shoot from the seething cauldron below. Here, too, innumerable brilliant rainbows, "those frolic children of the wanton sun," are seen in great perfection and varying positions, while white-winged swallows sportively shoot through their radiantly prismed arches, as they take their bath in the tinted spray (see page 568).

But the most thrilling scene is from the eastern extremity of the Rain Forest at Danger Point, where the treacherous vines and grasses, clinging to the rocks with hungry, desperate roots, tempt one to the very verge of the precipitate cliffs that seem to tremble with the terrific shock of the cataract. So dense here at times is the mass of vapor hurled from the seething cauldron that the sun's rays can no longer penetrate it, and complete darkness envelops one as he is delayed by the downpour, while the terrific thunder of the Falls drowns all other sounds and makes his own voice inaudible (see page 567).

Occasionally a violent blast opens a rift through the blackness and mist, disclosing a momentary view of the lashing waters in the boiling cauldron, whose heaving, battling surface and pyramids of emerald foam change with kaleidoscopic rapidity. It has been appropriately suggested by Mr. Knight that this spot be called Valkyrie, on account of its resemblance to the legend of the heroic daughter of Odin and its wild expression of the music of Wagner. Certainly no more fitting environment for the wild ride of the soul of the brave over the Rainbow Bridge to the Valhalla could be imagined.

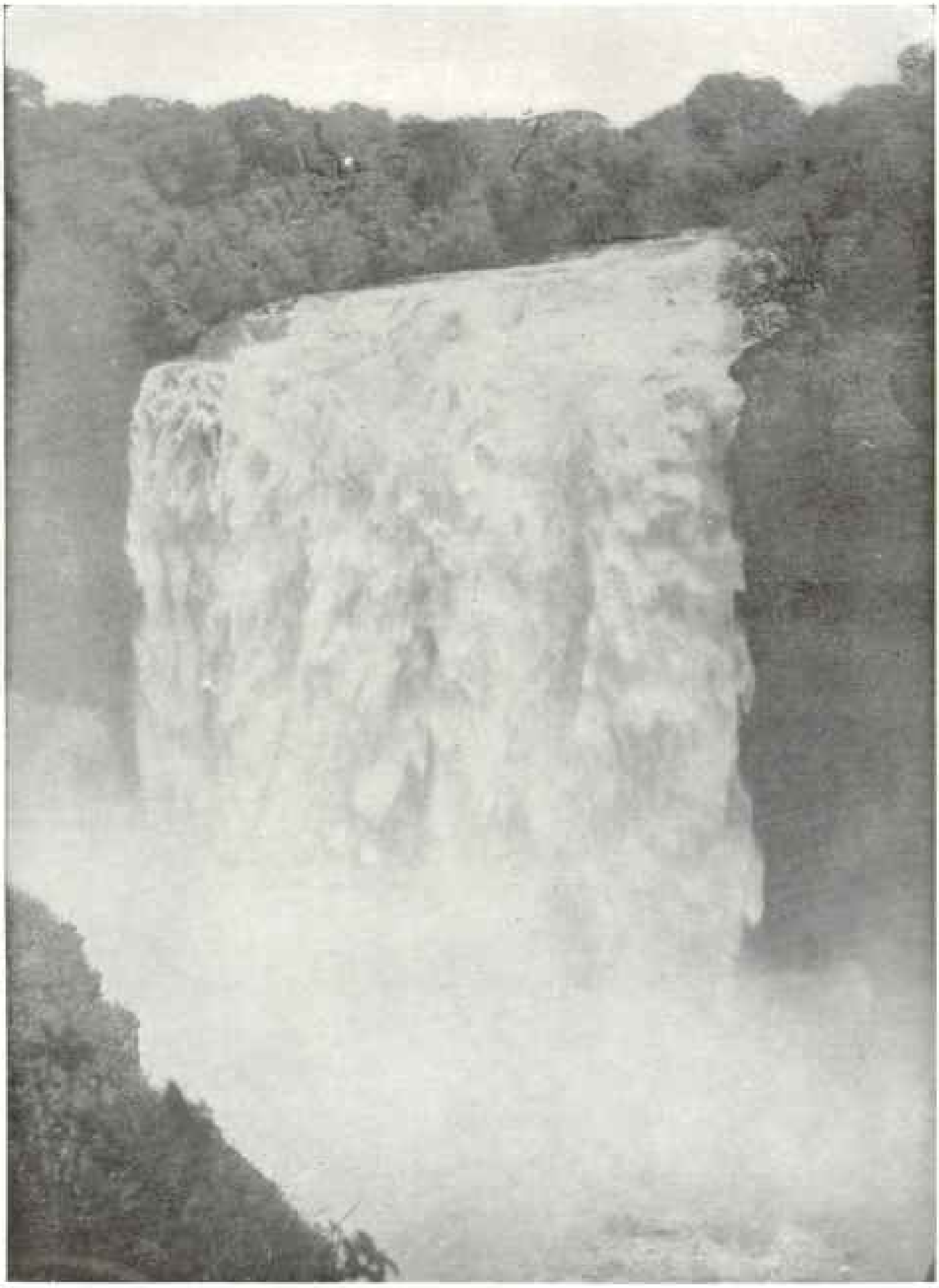
Even the Inferno of Dante, in the passage over the Styx, as pictured by Doré, does not surpass this as a spectacle of terrifying fury.

Another favorite study is the Kloof, or Palm Garden, hidden in the first of the serpentine curves of the canyon below the Falls and reached from the bridge by a zigzag pathway, which descends in comparatively easy stages through a tangled primeval jungle to the rushing waters of the gorge below. Here again Nature, with lavish hands, has shown her prodigality. Palms of enormous size and variety, bathed by eternal spray, mingle so densely with other forest growths as completely to shut out the direct rays of the sun and form a safe refuge for the richly plumed parrots and monkeys that frolic in their branches. From the edge of the waters of this tropic jungle an upward view of the Falls enables one to appreciate them in their full height and beauty, and to carry away a lasting impression of their majestic grandeur as seen from below.

The lip of the Falls is broken by four islands, which interrupt its flow just as Goat Island divides Niagara. The natives appropriately named the first of these Boruka Isle—"divider of waters." Between this point and the shore the river channel is deep and shelving, and the leaping waters of the cascade rush with fearful impetuosity, shooting clear from the precipitous walls, in their mad flight to the abyss 250 feet below, while the echoing woods ring with the thunder of their boisterous glee.

No less interesting is the second or Livingstone Island, both because of its historic interest and for the fascinating views of the chasm it affords. It was from this island the great explorer first peered into the awful fissure that seemed to engulf and swallow up the river forever. Singularly, too, the natives' name for it was Kempongo, meaning Goat Island; and, like its fellow at Niagara, it occupies an almost identical position on the extreme edge of the Falls, near their center.

In his own description Livingstone, who saw it in the late autumn, says: "In coming hither there was danger of being swept down by the streams which rushed along each side of the island; but the



THE DEVIL'S CATARACT

river was now low, where it is totally impossible to go when the water is high. But though we had reached the island and were within a few yards of the spot, a view from which would solve the whole problem, I believe that no one could perceive where the vast body of water went: it seemed to lose itself in the earth, the opposite lip of the fissure into which it disappeared being only 80 feet distant. At least, I did not comprehend it until, creeping with awe to the verge, I peered down into a large rent which had been made from bank to bank of the broad Zambesi and saw that a stream of a thousand yards broad leaped down a hundred feet and then became suddenly compressed into a space of 15 or 20 yards. The entire Falls is simply a crack made in a hard basaltic rock from the right to the left bank of the Zambesi, and then prolonged from the left bank through 30 or 40 miles of hills. The walls of this gigantic crack are perpendicular and composed of one homogeneous mass of rock. The edge of that side over which the water falls is worn off two or three feet, so as to give it somewhat of a serrated appearance. That over which the water does not fall is quite straight. Upon the whole it is nearly in the state in which it was left at the period of its formation."

Geologists of the present day, however, deny Livingstone's theory regarding the phenomenon of the formation of the Falls, claiming that it is due entirely to the processes of erosion, and that the river, by increasing friction through innumerable ages, has gradually frittered to granular atoms the dense rock and engraved the deep channels of the tortuous canyon. The basaltic rock which forms the greater portion of Rhodesia is of volcanic origin, proof of which is evidenced in the great lava-flows, which have been poured out in successive waves, covering the country in differing strata of varying porosity hundreds if not thousands of feet deep. Through this the percolating waters have deposited in the cavities the beautiful agates, chalcedony of various hues, quartz crystals, and zeolites that are found in abundance along the projecting surfaces of these amygdaloidal rocks, many specimens of which I found in the exposed gravel of the river bed.

It is said that these Batoka lavas, in consolidating, created a system of shrinkage cracks, with occasional long lines of "faultings," or fractures, which constituted planes of weakness that materially facilitated the erosive action of the river.

If this theory is correct, it is possible that the fissure into which the river plunges at the Falls is due to a fault-plane, where a vertical belt of comparatively soft material breaks the continuity of the harder basalt, and this belt or vein, connecting with others of the same or similar character, has been washed out or excavated by the undermining action of the river, thus explaining the complex phenomena of the Falls and zigzag canyons.

In the not distant future, when the Cape Town and Cairo Railway has reached the Kongo, and commodious passenger steamers ply directly to that great artery of Africa from American and English ports, a trip to the Valley of the Zambesi and its wonderful Falls will be among the popular pastimes of the day.

A FLASHLIGHT STORY OF AN ALBINO PORCUPINE AND OF A CUNNING BUT UNFORTUNATE COON

By George Shiras, 3rd

Author of "Photographing Wild Game with Flashlight and Camera," with 72 Illustrations, in The National Geographic Magazine, July, 1906, and "One Season's Game Bag with the Camera," with 70 Illustrations, in The National Geographic Magazine, June, 1908

WHEN one goes into the wilderness, whether in the destructive pursuit or in the quiet study of animal life, the greater the experience the more certain is the conclusion that only on rare occasions is it possible to become acquainted with the habits, the appearance, or the special characteristics of any individual member of a species.

In some 40 years' familiarity with the white-tail deer, a portion, at least, of each season spent in the same locality, and more often than not, watching them feed, night after night, in front of the jack-light, I have never in all such time felt certain of having recognized any of these animals on a succeeding season.

A magnificent stag, which could be repeatedly identified during one season by the shape of the antlers, was shorn in the winter time of these emblems of his sex, and the new horn-growth of the following season was, presumably, quite dissimilar in size and shape.

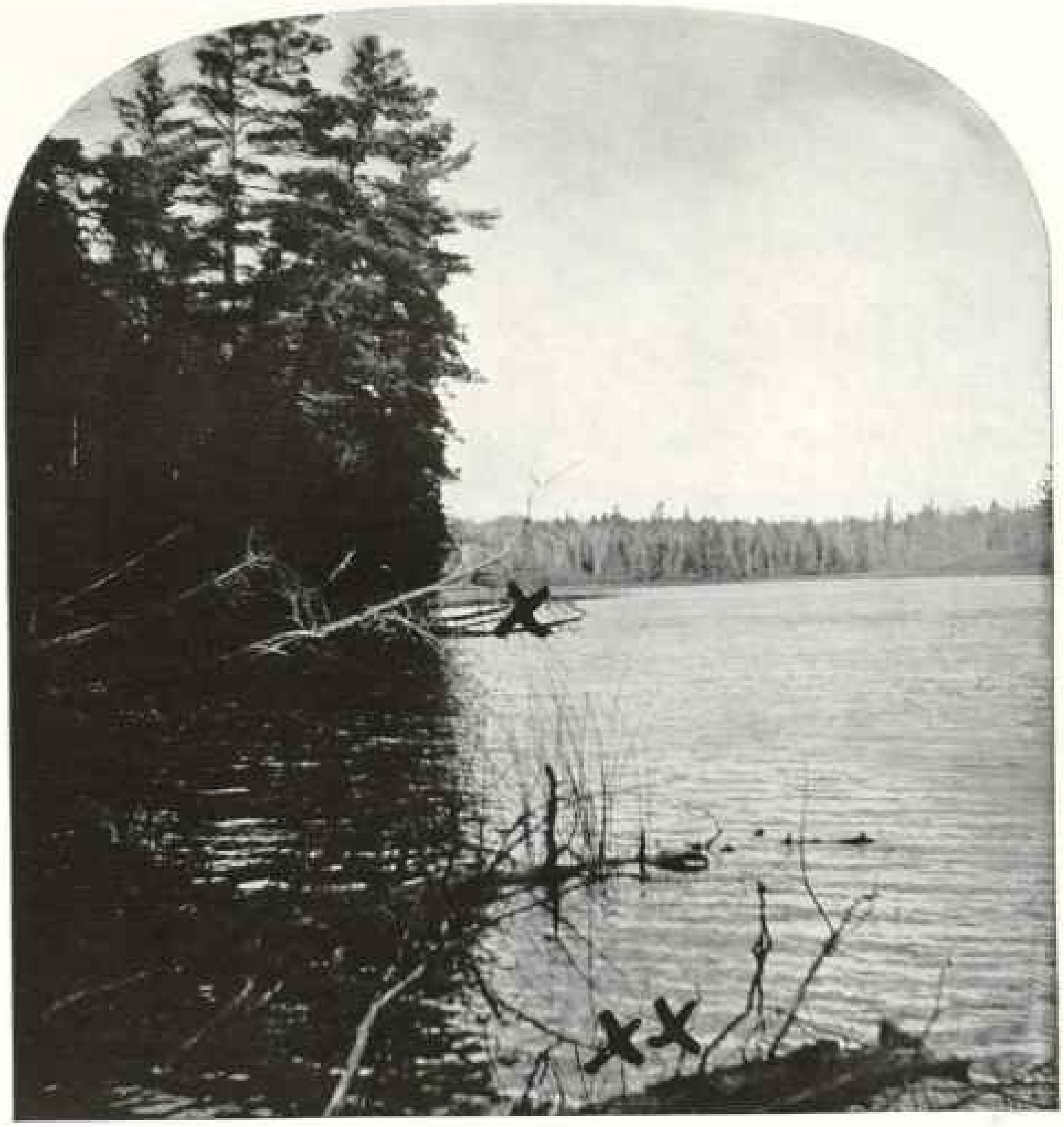
A doe accompanied by peculiarly marked spotted fauns could be easily recognized in the same general locality, when feeding on aquatic plants or when splashing in the water to escape the insect pests; yet, if in the fall or winter this little family escaped the hunters or the timber wolves, who would know the mother the next summer with her new and differently marked young, or the separated yearlings, in their unspotted coats? With the moose, elk, caribou, and bear it was the same, and the exceptions, in the writer's case, relate largely to the smaller varieties of quadrupeds.

The examples taken in the present article are the porcupine and the raccoon, which, by reason of one species occupying nearly all the country from our northern States to the tree-limit in the Arctic circle, and the other from lower Canada to the Gulf of Mexico, are ones that we are either personally familiar with or ought to be willing to acquire information about.

The porcupine is a rodent of the North—the denizen of the dark-green coniferous forest—where half the year the snow lies deep and the animal slumbers in a winter torpor far within the cavernous rocks or hollow logs, protected from the biting cold by drifting snows that conceal all evidence of the animal's retreat.

During the winter thaws, and more often in the early spring, the deep, wide furrows of this clumsy animal may be seen criss-crossing the surface of the receding snow as he seeks to break his long fast on the tender bark of the pine sapling, the swelling buds of the sugar maple, or by climbing to the uttermost limb of a spreading elm, where he is able to seize in his stubby paws the half-open leaves of his favorite tree.

Generally this animal, though of the coldest climes, is quite susceptible to sudden changes of temperature, and even in midsummer, if the wind is northerly, or the air damp and penetrating with the drizzling rains of such a latitude, one

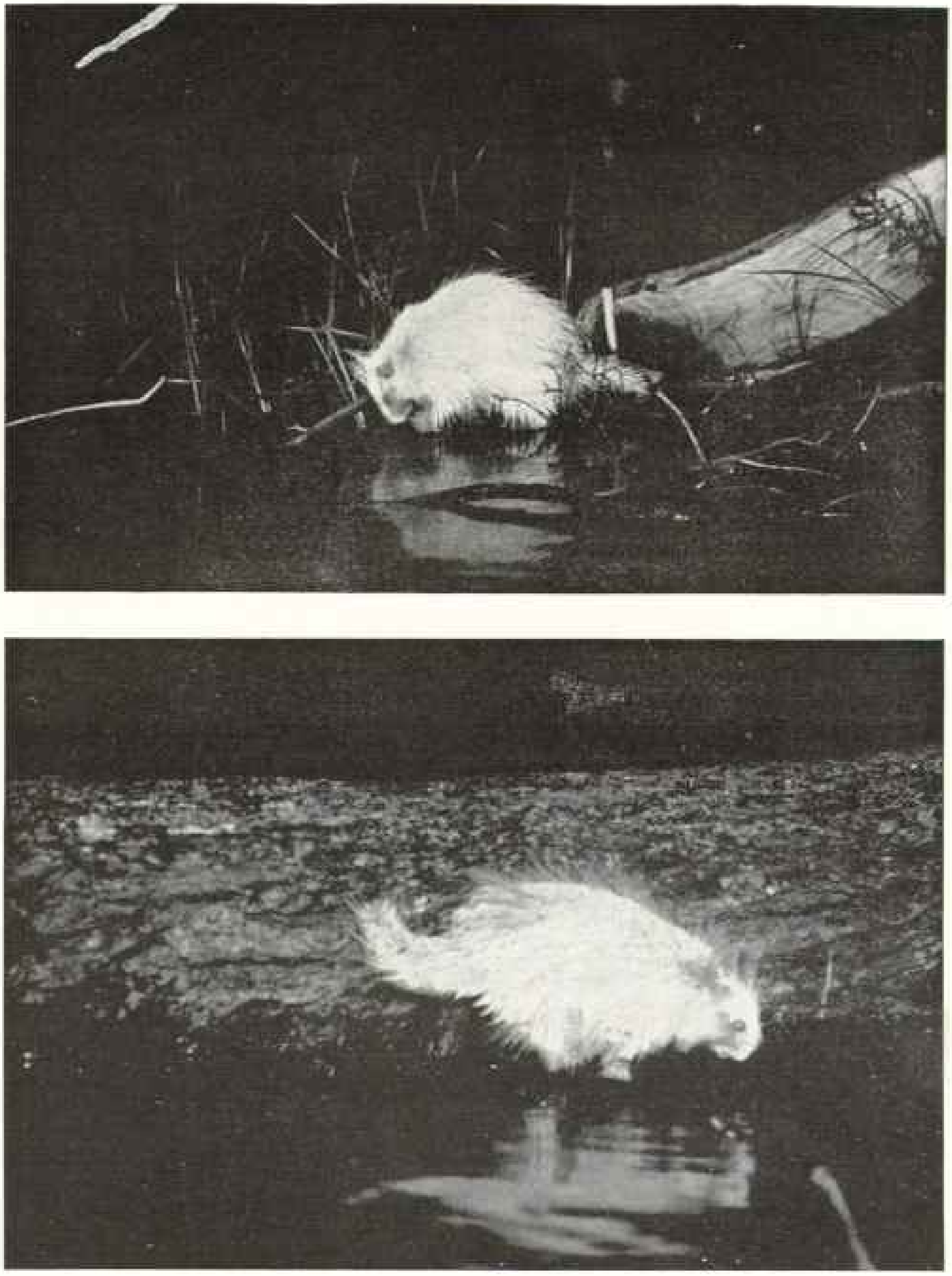


NORTHEAST SHORE OF WHITEFISH LAKE, WHERE ALL THE PICTURES IN THIS ARTICLE WERE SECURED BY THE AUTHOR

The porcupine always came to the water at X and returned to its cave on a deer trail back of X X. All the coon pictures were taken on the shore back of X X. Photo by George Shiras, 3rd.

may look in vain for it just as the shores of little lakes and ponds may fairly bristle with these waddling creatures whenever the soft winds blow and the setting sun leaves the darkening shores still radiating in the afterglow of a summer day.

In the days of the rifle, long ago, and when the game season opened much earlier than now, the appearance of porcupines along the watercourses, as evening approached, was the almost certain harbinger of venison before the twilight dimmed the sights, for deer move about much more freely under the conditions last described.



Photos by George Shiras, 3rd

FIRST FLASH OF THE ALBINO PORCUPINE WHEN EATING FRAGMENTS OF MOSS: JULY 1, 1901, 8 P. M. (SEE PAGE 586)

SECOND FLASH, ON SAME EVENING: THE ANIMAL IS VAINLY ENDEAVORING TO FIND FOOD IN FIVE FEET OF WATER

Photo by George Shiras, 3rd

THE ONLY FLASH OBTAINED THE SECOND SEASON: FEEDING IN A DARK AND PROTECTED CORNER, JULY 20, 1902, 8.15 P. M.

THE THINGS A COON WON'T EAT ARE THE ONLY THINGS A PORCUPINE WILL EAT

The coon, on the other hand, is an inhabitant largely of the deciduous forests, in the temperate and semi-tropical zones, especially where such tracts contain abandoned clearings, swamps, ponds, watercourses, and open glades, with the infinite variety of wild fruits and berries, the eggs and young of nesting birds, and frogs, mussels, and the crayfish of submerged lands; and, while he is forced to hibernate in his more northerly range, he greatly prefers a climate where he can indulge in nightly rambles and in gratifying a most omnivorous and endless appetite. Like his nearest prototype, the black bear, he can go for a long period on a single and limited form of diet, but is always willing, when the opportunity comes, to partake of about every variety of natural and artificially prepared food which Nature or man may grant him. In fact, the only things he won't eat are the only things a porcupine will eat, namely, bark, leaves, and water plants.

Comparing and contrasting the porcupine and the coon, one finds so many dissimilarities that little can be rated in common. It is true that there is somewhat of a resemblance in size and shape, and in the general blending of the black, the white, the gray, and the yellow, so that when one sees a fat coon or a chubby porcupine curled up asleep in the higher crotch of a shaded treetop; or, again, in the distance observes one of these animals walking a log or ambling beneath the alders in search of aquatic

THIRD STAGE: THE PORCUPINE IS SAVED FROM FALLING INTO WATER BY SEIZING STICK IN TEETH AS HIS SPINES AT REAR QUILL UP (see page 578). Photo by George Shiras, 3rd

This action it was known that the animal was blind. July 6, 1907, 8.10 p. m. (see page 578).

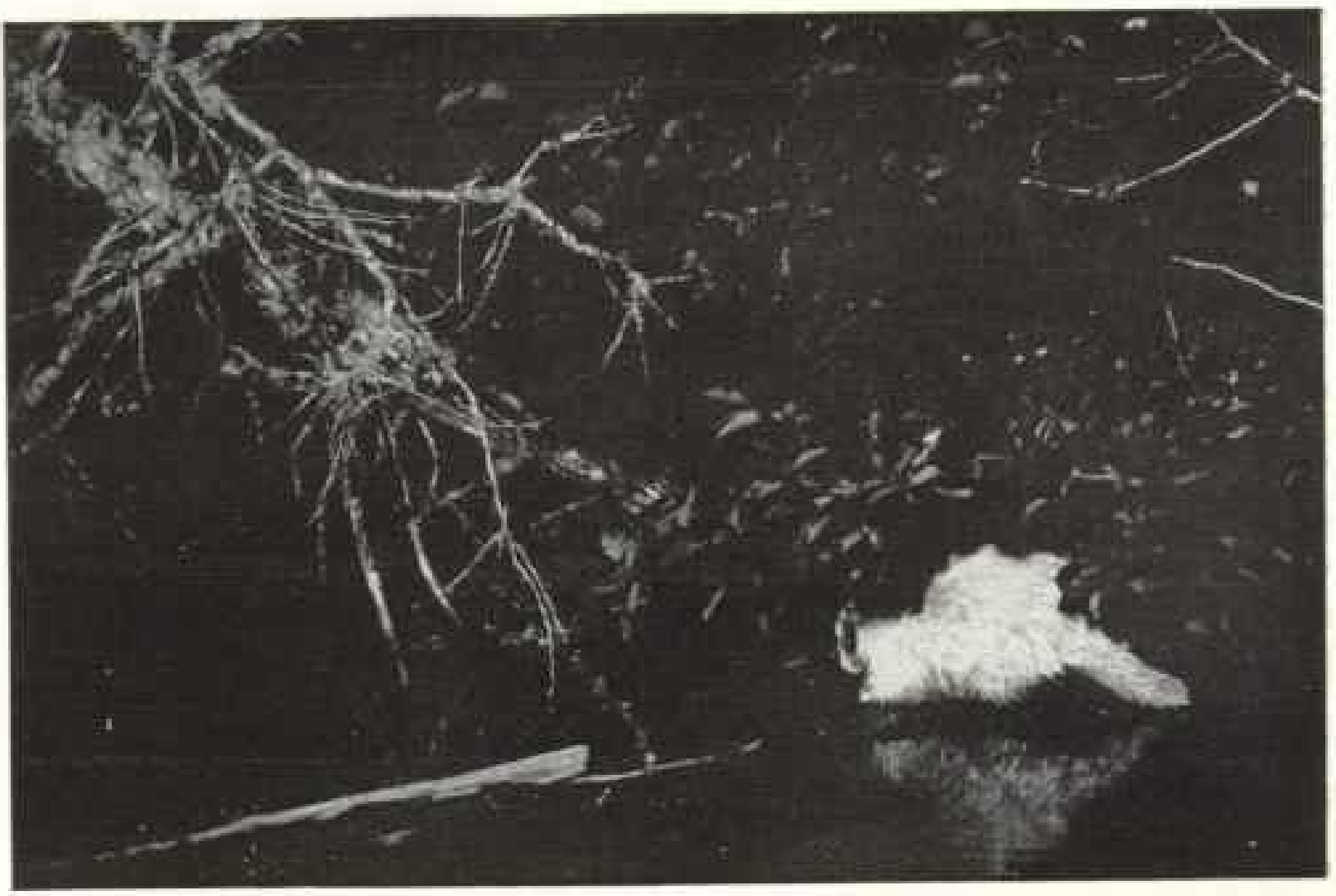


Photo by George Shiras, 3rd

PICTURED WHEN TRYING TO PASS UNDER BRUSH WHERE THE WATER WAS TOO DEEP: JUNE 28, 1903, 7.20 P. M.

food, he may be momentarily in doubt; but otherwise it is hard to imagine two animals that in habits or physical characteristics are less alike.

A porcupine is slow, clumsy, dull witted, solitary, and of limited range; the coon is quick, canning, often gregarious, and a most energetic traveler. One occupies crevices in the rocks or hollow logs and in seclusion whenever possible, while the other prefers comfortable quarters high up in the cavity of a living tree, or in some portly stub that will shelter all the members of his family or such bachelor companions as he may wish to consort with.

THE PORCUPINE'S LOVE OF SALT IS IRRESISTIBLE

While the porcupine usually bears but one young, it has so few predaceous enemies willing to risk impalement upon the thousand bristling quills that this animal would ordinarily increase more rapidly than the coon, with its numerous progeny, were it not for the fatal habit of visiting every human habitation near its range in search of salt or anything possessing a saline flavor.

Each homestead, trapper's cabin, or lumber camp will in the spring attract every porcupine for miles about; and, if these habitations be temporarily unoccupied, the destruction is often most extensive, for after devouring empty pork barrels and everything about the kitchen door that has been saturated with brine or grease from the sink, they are then content to gnaw anything containing the slightest salty flavor, and this includes ax-handles, garden implements, gun-stocks, pack-straps, harness, wooden latches, door-jambs, or anything else that the sweat from the hand leaves a trace of salt upon.

Many years ago, when it was customary to leave my hunting skiffs turned bottom up beneath some heavy hemlock,

Photo by George Shiras, 3rd

FOURTH SUMMER: THIS FLASH SHOWS THE ALBINO MOTHER WITH HER BLACK YOUNG ONE FEEDING BY HER SIDE: JULY 24, 1904, 9 P. M. (SEE PAGE 591)

I remember going once in the early summer for the purpose of examining their condition, and, on approaching the spot, was greeted with a sound of grinding and crunching not unlike a distant sawmill. Within the interior of a decked-over ducking-skiff, brought the previous year from the East, I found three large porcupines putting the finishing touches upon all the ribs and other projections that could be scored by their flat, yellow teeth. The boat was nearly a wreck, and for a time I was puzzled, because such a thing had never happened before.

My guide, standing by, suggested the solution by asking whether I had not used this boat the previous season on Long Island Sound, and although he had never seen salt water, he knew just as well as these animals what this meant.

Every year thousands of porcupines are killed by indignant hunters and lumbermen, and not a few by tenderfeet and young boys, whose first sight of this apparently ferocious beast leads them to believe it a work of heroism to shoot or club to death the most stolid and least aggressive animal of the American forest.

At a time when the Indians were numerous along the Great Lakes these animals were not only used for food, but the longer quills afforded the principal means, when variously colored, of ornamenting their moccasins, hunting-shirts, birch-bark baskets, and the like, but in recent years very few practical uses are made of this animal, except in Alaska, where the natives and transient explorers still seem to regard it as a toothsome article.

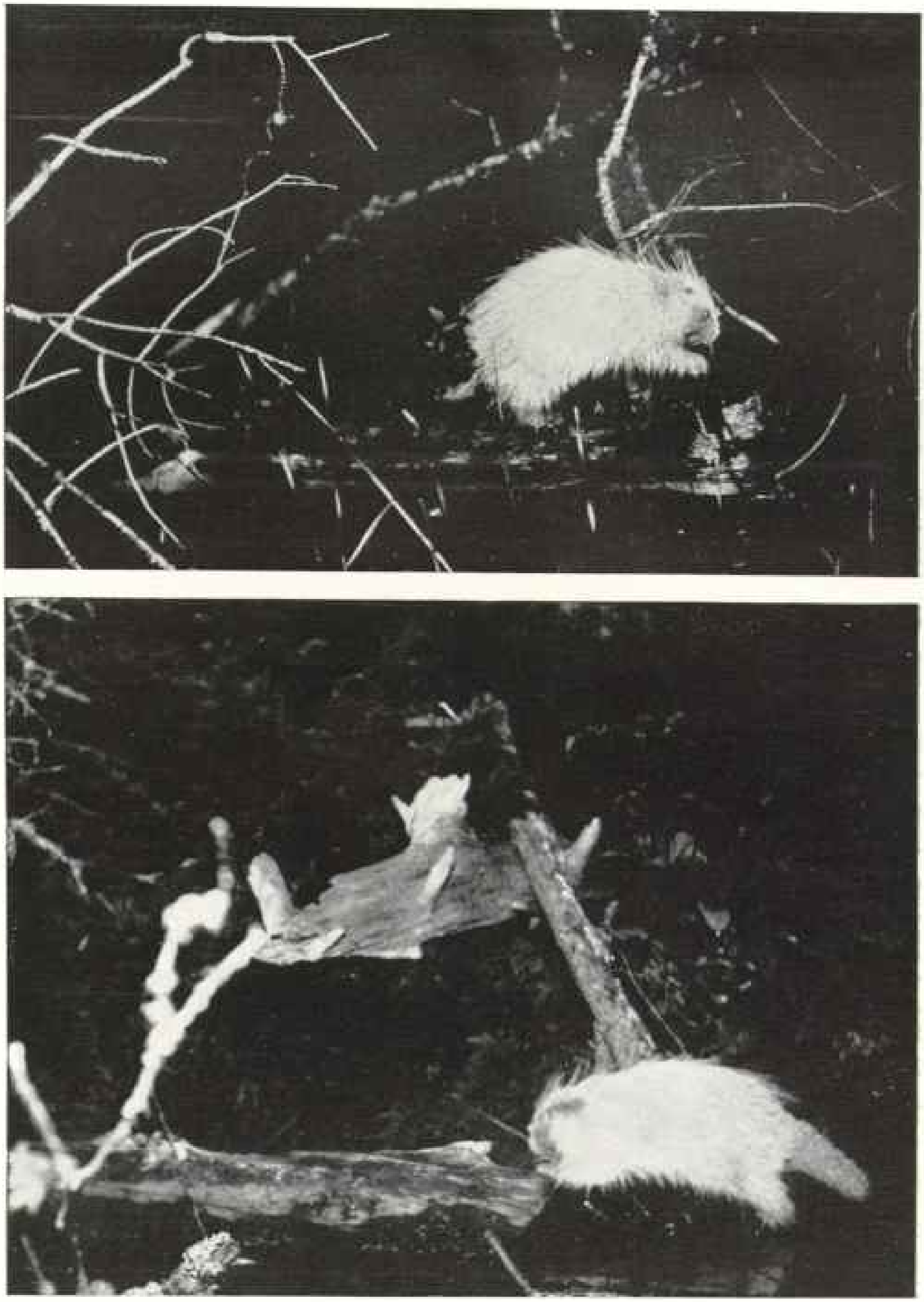
Sometimes one hears a lumberman complain of the extensive destruction of growing timber by porcupines. My ob-

Photo by George Shiras, 3rd

PERHAPS THE BEST FLASH TAKEN DURING THE SIX YEARS: JULY 25, 1904, 8.20 P. M.

servation on that point suggests that it depends largely upon the abundance and variety of the food. Along the south shore of Lake Superior, during a period of nearly forty years I never saw any particular evidence of such destruction. Though many elms were pruned year after year of their terminal limbs, so that such trees grew long and straight like a poplar, and sometimes sugar maples were partly girdled at the base, yet apparently by some provision of instinct there was usually enough bark left to prevent the tree from dying. Again, I have seen a few young pines more or less injured and occasionally destroyed by this animal. But so scattered and inconsequent were these injuries that they attracted little attention.

However, in this region the forest is composed of a great variety of mixed timber, besides second growth and shrubbery. On the northwest end of Lake Superior, in Minnesota particularly, I saw much evidence of injury to the young pines. From the canoe I could often notice the white trunks and limbs of trees that had been recently denuded of their bark, and sometimes as many as fifteen or twenty in a group were destroyed. On the higher ranges of the Rocky Mountains I also saw many trees that had been killed by porcupines; but in both these localities the trees were practically all coniferous and there was a marked absence of the hard and soft wood timber found along the south shore of Lake Superior.



FIFTH SUMMER: WALKING ALONG A LOG IN A MASS OF DEAD LIMBS:
JULY 1, 1905, 9 P. M.

AWKWARD POSITION, DUE TO BLINDNESS, WHEN TRYING TO CLIMB ON LOG:
JULY 12, 1905, 8 P. M.

Probably the porcupine is the only animal which could exist unharmed so many years when both blind and deaf. Photos by George Shiras, 3rd

Photo by George Shiras, 3rd

SIXTH SUMMER: A DIFFICULT PICTURE TO SECURE, IT BEING NECESSARY TO LOWER CAMERA AND FLASH MACHINE TO SURFACE OF WATER TO CATCH THE ANIMAL, WHICH WAS ALMOST HIDDEN UNDER A MAPLE BOUGH: AUGUST 13, 1906, 10 P. M.

The wide distribution of the coon and his abundance in the more settled portions of the country, together with his voracious appetite, often makes him a nuisance to the farmer. Ground-breeding birds, as well as those in the highest trees, are greatly reduced in localities where the coon is at all numerous. In the Southern rivers, lakes, and along the Gulf of Mexico, all the large colonies of breeding birds are located on islands and sandbars; otherwise they would be unable to rear any of the young. Just what a single coon can do in a poultry yard is referred to later (see page 592).

In the following biographies of a white porcupine and a coon it may be noted that all the pictures were taken by flashlight, and that each series represents two quite distinct methods of night photography. The porcupine was taken from the bow of the canoe, the flash being fired by hand, and at the instant when the animal was in focus and in the best attainable position—a method that I have generally followed in photographing moose and deer; while all the pictures of the coon were taken automatically by the animal pulling on a piece of bait attached to a string connected with the flashlight apparatus, the variety in surroundings and in position being regulated by preparations made in advance.

Though fully 30 pictures were made of

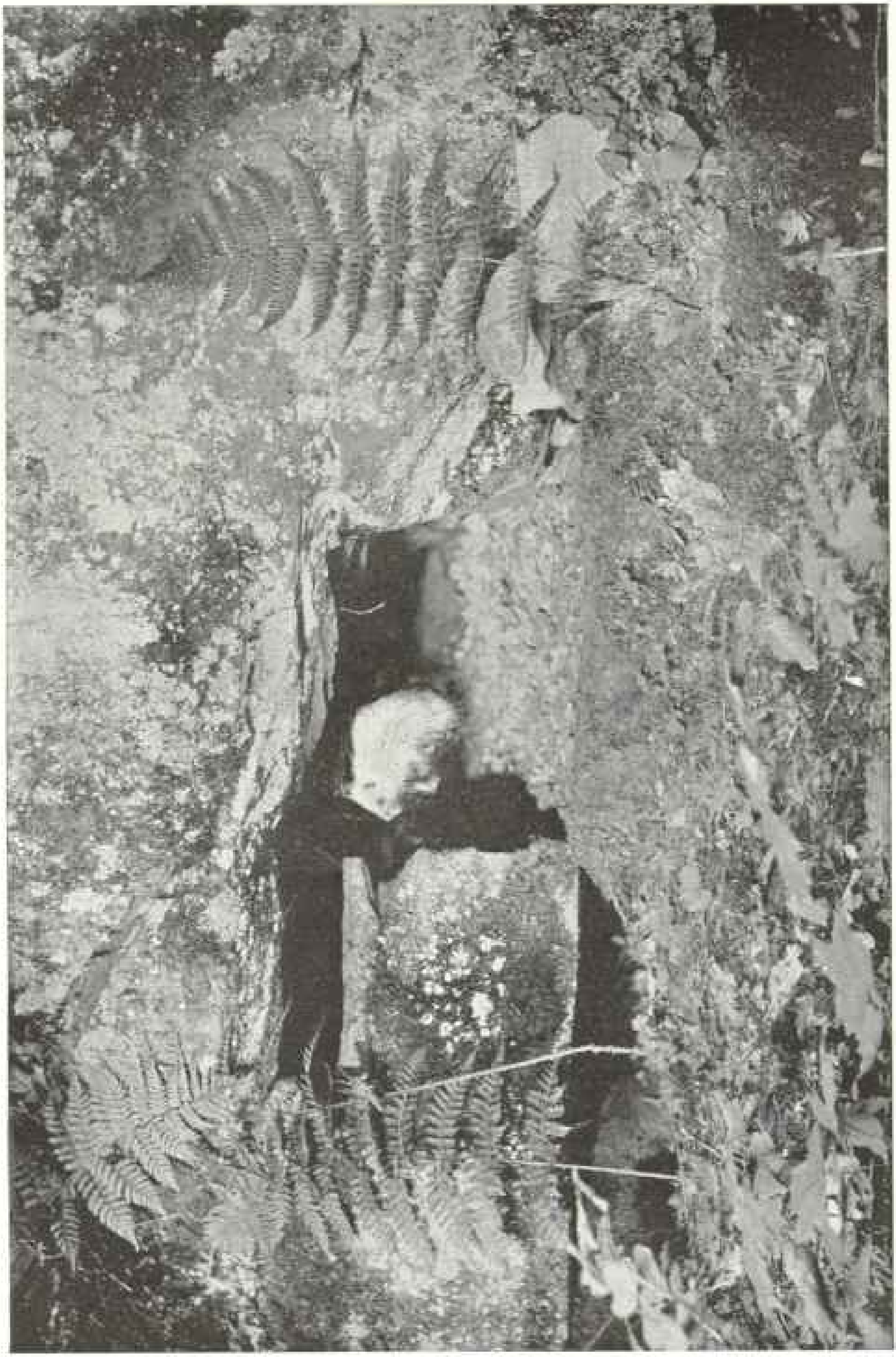


Photo by George Shiras, 3rd

THE DEN OF THE WHITE PORCUPINE IN SUMMER: DOUBLE PRINTING

Photo by George Shiras, 3rd

THE TOMB OF THE WHITE PORCUPINE, IN WINTER

this one coon—with several cameras set at different angles—I never saw the animal during the entire bombardment.

This latter method is by far the most effective in taking night pictures of many predaceous animals—as they are not only hard to locate from a canoe, but usually show great distrust of the approaching jack-light, which, however, is only regarded with slight curiosity by the different members of the deer family.

THE ALBINO PORCUPINE OF WHITEFISH LAKE

When the writer was a lad intent upon killing his first deer, one early autumn he followed in the wake of an old Ojibway trapper, and on the second day reached the shores of a beautiful little lake twenty miles east of Marquette, Michigan, and located, as was determined in after years, some eight miles south of Lake Superior. This lake was situated in what was then not only one of the wildest and least known portions of the Upper Peninsula, but the very center of the summer range of the whitetail deer. Of each successive trip thereafter and the many victims of the gun there is no need of giving an account here—for the score with the flashlight and the sensitive plate has long ago surpassed the record of former destruction. And it was here in 1888 that night pictures of wild animals had their inception, and many innocent lives have been saved by reason thereof.

On the afternoon of July 1, 1901, I had been photographing deer in a long, narrow slough at the end of the lake, which received the waters of the upper river and lay mortised in between sloping

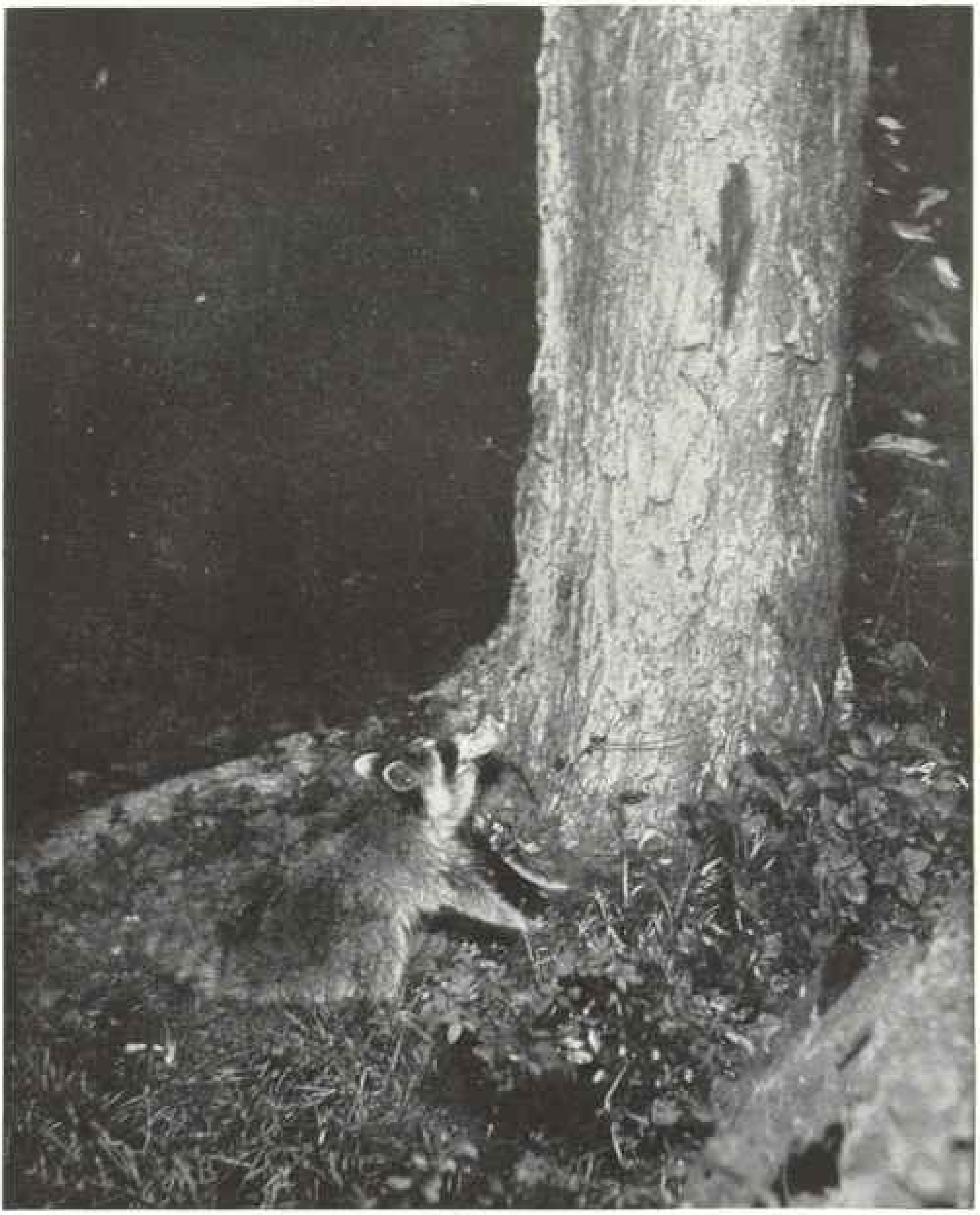
THE COON TAKING HIS OWN PICTURE BY PULLING STRING BAITED WITH CHEESE AND FISH (SEE PAGE 594)

Picture shows he preferred the cheese to the fish. Note how he holds the cheese in his paws, eating like a monkey. Photo by George Shiras, 3rd

hills nearly four hundred feet in elevation. As the sun lowered behind the tops of the great pine forest the canoe was pushed out from the blind of freshly cut balsam, and under the impetus of two paddles we entered the lake on a rapid run for camp, situated half a mile below the lake, on the banks of the lower river.

On approaching the outlet I noticed a small, snow-white object, which, in the darker shades of the western bank, was doubtless much more conspicuous than would have been the case in sunlight. What was it? At this season of the year the rabbits, weasels, and the owls were no longer white, and as the object showed motion and there was no breeze to stir a fugitive paper that might have been carried from my house-boat in an adjoining bay, it was certain that we were gazing upon an animal never seen heretofore during the many years this little lake had been traversed by a canoe.

When within 100 yards my guide said it looked like a young polar bear but walked like a porcupine—a view that I concurred in. Just then it walked into some thick brush, and we cautiously approached, to be gratified in a few minutes by the appearance of a most perfect specimen of an albino porcupine. It seemed wholly unconcerned about our presence and intent upon pulling out of the water fragments of tender moss, which were eaten with great relish. Every portion of the body was white—quills, hair, claws, and nose—while it was certain it did not have the beady black eyes of the normal animal; but whether they were pink could not be determined at the time.



THE NEXT NIGHT ONLY CHEESE WAS USED FOR BAIT, A PIECE OF WHICH CAN BE SEEN BETWEEN HIS OPEN JAWS

The flash was fired for all these coon pictures by the coon itself. Photo by George Shiras, 3rd

Photo by George Shiras, 3rd

THIS FLASHLIGHT SHOWS THE CHEESE AT THE END OF THE STRING, AND WAS TAKEN WITHIN A FEW FEET OF THE WATER

After a careful inspection of the animal the trip was continued to camp, as it was then too dark for an instantaneous daylight picture and too light for a flashlight. Finishing a hurried meal, we returned for a flashlight picture, and as the moon was full that night there was no need of using a lantern. Reaching the locality, we found that the moon was up, and directly opposite, so that its rays penetrated beneath the overhanging bushes. But not a sight or a sound of the animal.

Slowly the canoe passed along, and at a point about 75 yards south of where we had last seen it the soft, crooning notes of a porcupine were heard back some distance in the bushes, but as the night was warm and this locality much frequented by porcupines it might not be the one we were looking for. After waiting some 10 minutes the bushes slowly parted, and out walked the animal in full view.

As it stood broadside and was in the act of raising a mouthful of food, I fired the flash (see page 574); and although the little circle was filled with a dazzling light, equalling that of the sun, and much more pronounced in contrast with the evening light, the animal did not even raise its head, but went on feeding. The plate-holders were reversed, the flash reloaded, and a moment later the animal was pictured when walking toward the deeper water on a half-submerged log.

This time the flash made a consider-

Photo by George Shiras, 3rd

A STAKE WAS DRIVEN INTO THE GROUND WITH BRUSH BEHIND IT, SO THAT THE PHOTOGRAPH WOULD SHOW THE ANIMAL FROM THE REAR: NOTE THE HANDSOME BUSHY TAIL

able report, but neither the noise nor the illumination had any effect, the animal advancing further along the log and vainly running a paw through the surface of the water in search of aquatic plants. Two more flashes were fired, and our powder became exhausted.

The mystery of this animal's indifference to light and sound and the fruitless effort to find food in deep water was not explained for several years.

Although we watched the shore on many flashlight trips after deer during this season, nothing more of this strange animal was seen.

In 1902 I had been on this lake several days, and on the evening of June 28 we became aware that the albino was still alive and still occupying its old quarters. When seen it was partly concealed behind a number of dead limbs, and only the illuminating and pene-

Photo by George Shiras, 3rd

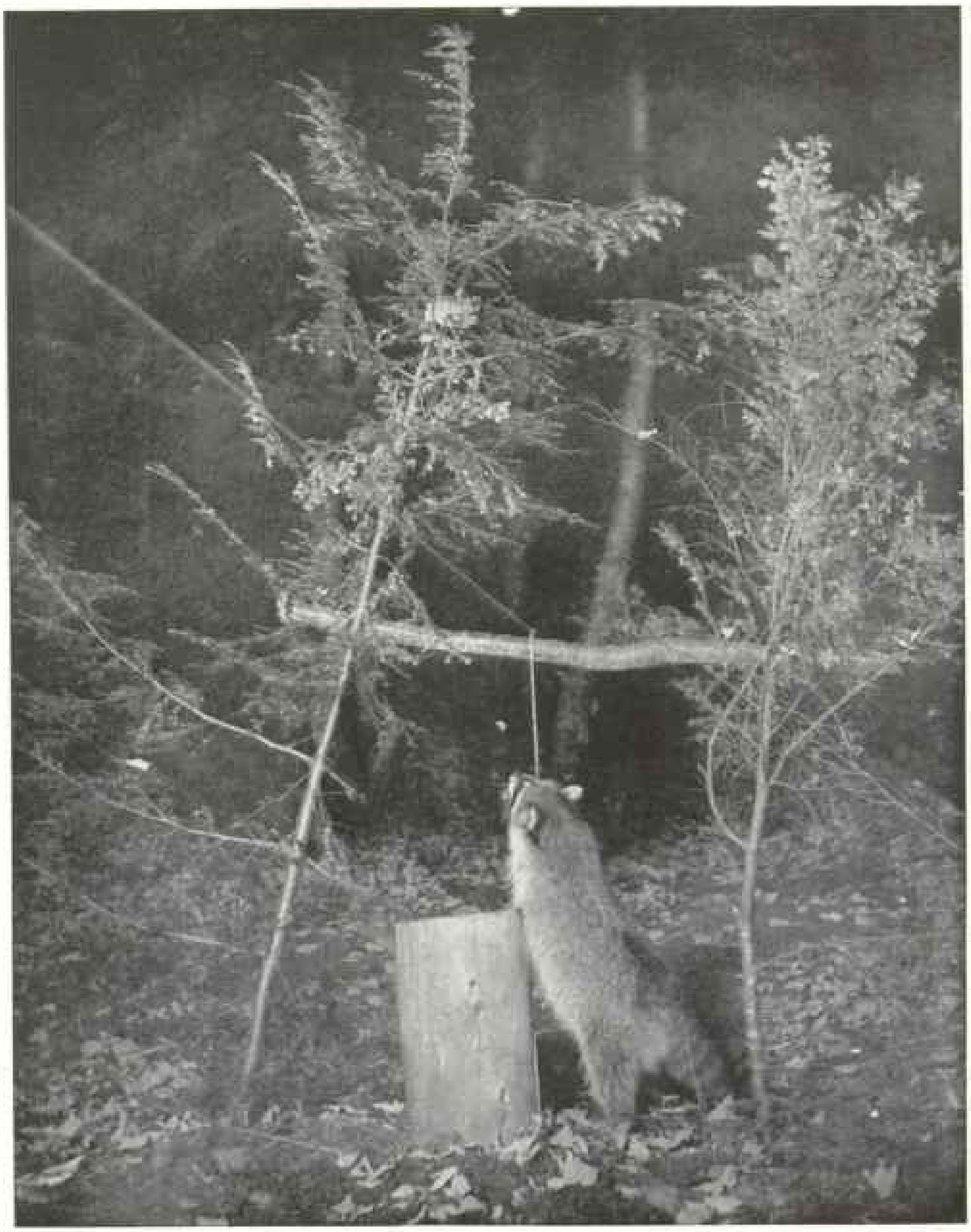
THIS PICTURE SHOWS THE ANIMAL FACING THE CAMERA AND PULLING VIGOROUSLY WHEN THE FLASH WENT OFF

trating power of the flashlight made such a picture possible. Some of the smoke of the powder drifted toward it, causing instant departure and suggesting an unusual development of scent in an animal not ordinarily dependent upon it, due, perhaps, to the impairment of the other senses (see page 575).

The several pictures of the previous year had brought out the fact that only one other albino specimen was known to exist, now preserved in a Vermont museum, and in consequence it was suggested that I capture or kill the animal in case it appeared the following season. This I was unwilling to do, and, as events proved, the wisdom of letting this freak of nature live and die a natural death was duly rewarded, for every year from 1901 to 1906 I succeeded in getting from one to ten flashlight pictures of this animal, and, aside from the pictorial value, was able to learn much about habits that were greatly modified through infirmities due to albinism.

Only once was it seen in full sunlight, and on that occasion I was not only able to substitute "her" for "it," but to determine the color of the eyes and the question of eyesight, scent, and hearing.

It was during June, 1904, that I entered the lake one morning with a party of friends, en route to Whitefish Falls, and we then observed three porcupines



THE STRING WAS CONNECTED WITH THE FLASH IN SUCH A WAY AS TO SHOW THE ANIMAL FULL LENGTH

The author varied the arrangement of the bait and flash so as to secure portraits of the coon in different positions. Photo by George Shiras, 3rd

Photo by George Shiras, 3rd

HERE AN INVISIBLE BLACK THREAD HELD BAIT IN MIDAIR

on a large log in the reeds 50 yards from shore. One was a large, dark-colored male, and the others were the white porcupine and a little black cub.

As the loaded canoe approached within 50 feet of the group the male became restless, and, scrambling along the log, fell off into the shallow water and waded ashore through the reeds. Getting a little closer, the little one first tried to huddle up to its mother, but as the latter was wandering about continually, the young one then looked at us suspiciously and finally made for the shore, taking a route somewhat to the left of the first one.

The albino, apparently not being aware of the sudden departure of her family, continued to make efforts to find some kind of an edible plant in the water, crooning softly to herself all the time. The eyes were of a bright, translucent pink, with the fire of the ruby. What had heretofore been a strong suspicion in regard to its blindness was then apparently settled, for repeatedly placing the blade of a bright-colored maple paddle in front of her, there was an unexpected collision every time, and by the way the animal seized the paddle and investigated it with teeth, nose, and feet, it was apparent that this obstacle was a great mystery.

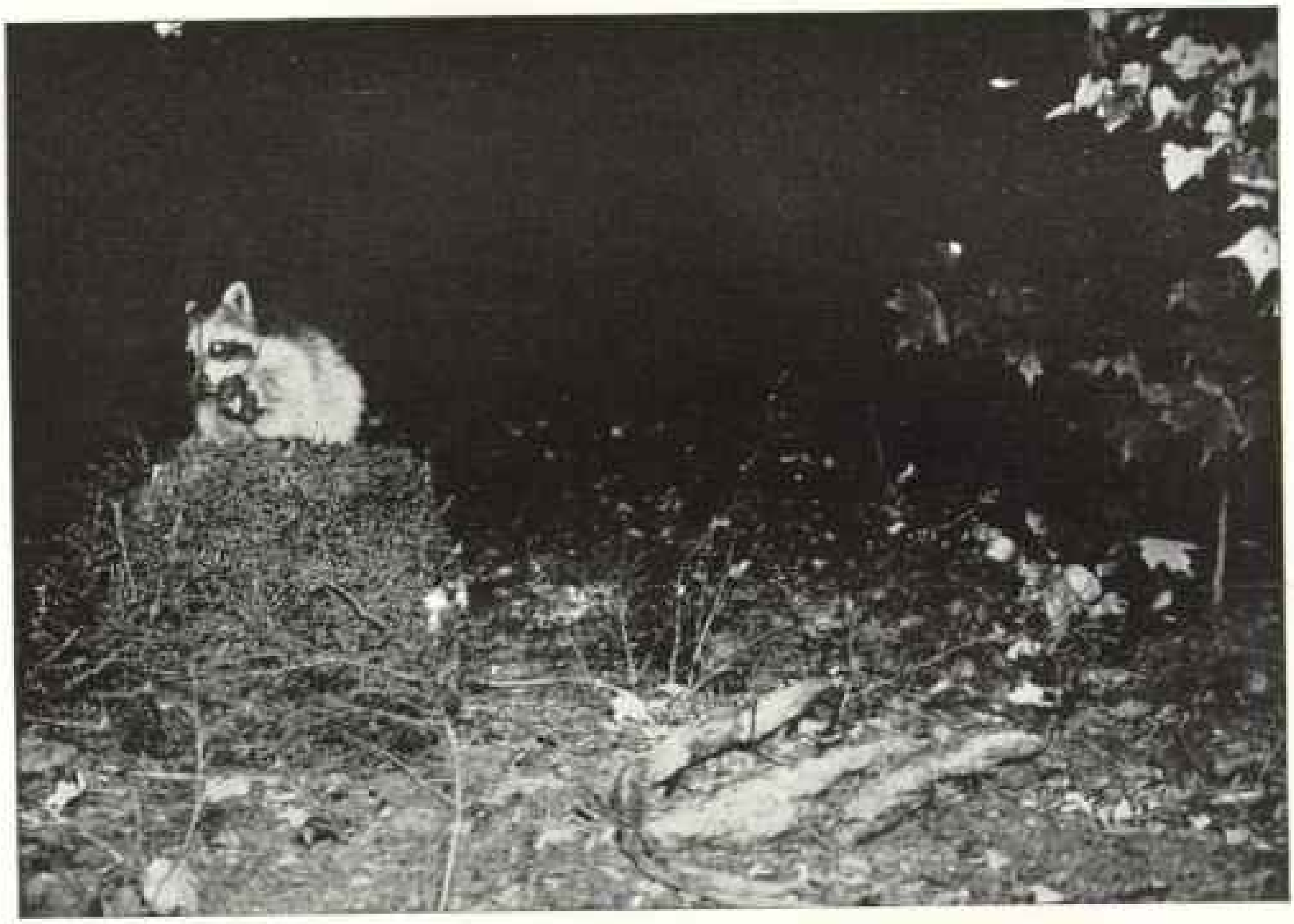


Photo by George Shiras, 3rd

THE TOP OF A MOSSY LOG WAS BAITED WITH CHEESE: NOTE REFLECTION OF EYE OF COON

Feeling sure it was similarly deaf, we all cried out in unison, but the animal showed not the slightest heed. Finally pushing around to the windward, the porcupine showed instant alarm when the scent reached it, and prepared to go ashore.

When off the log she circled a few yards and finally took the same course pursued by her young; of this we were certain, as she climbed over the same log upon which the young porcupine entered the forest. Several nights later the camera pictured the white mother and her little black cub astride the same log, feeding on the damp, green moss at the edge of the water (see page 578).

During the six years that this animal was under frequent observation, it never, when alone, departed from the trail along the shore or returned other than by the well-worn path to its cave. Often we were on the lake awaiting its appearance, and invariably the animal came down to the bank at the same spot, usually between the hours of 7 and 8, and, after going south for a distance of about 75 yards, it returned for the remainder of the night to a narrow crevice in a big glacial rock, located a short distance behind the path leading to the water. It may be worthy of note that the wind was south every evening it appeared, and that consequently the animal always fed down wind—further evidence, perhaps, of the dependence placed upon the nose.

The several pictures tell their own story of these evening journeys, year after year, and of its cavernous home, which later, enshrouded in the immaculate snows of Lake Superior, became its tomb, in the winter of 1907.

Photo by George Shiras, 3rd.

BY STREWING CHEESE FROM THE BANK ALONG THE SURFACE OF A LOG EXTENDING INTO THE LAKE THE ANIMAL WAS TAKEN IN THE POSITION SHOWN

STORY OF AN ITINERANT COON

The following extracts from a camp diary chronicle the events of one week on White Fish Lake and preface the story of a wandering coon:

"*August 21, 1903.*—After arising and before I had breakfast, Jim came from the barn with the announcement that all the young chickens had been killed during the night—some 60 in number. The various broods were more than half grown, and for several weeks had been consorting together at night by huddling in a narrow recess between two adjoining buildings. Jim having noticed that they were not about the yard in the morning, found them all dead in the narrow space referred to. Pulling a few bodies out with the aid of a rake, he found the throats had been cut by some predaceous animal, and he proceeded to investigate.

"I recalled a somewhat similar tragedy several years before, when a large number had been killed by a half-grown skunk. Jim, however, said it was a coon in the present case, and the statement excited some derision on my part, since this animal was utterly unknown in the region. Jim's conclusion, it appeared, was not a matter of guesswork, for he found that the bodies of a number of chickens had been torn open and the liver eaten—a coon trick, according to Jim.

"He further found that the animal had entered the poultry yard by removing some heavy flat stones from beneath the wire fence—a thing that neither a fox, skunk, nor weasel was capable of doing—while the concluding evidence be-

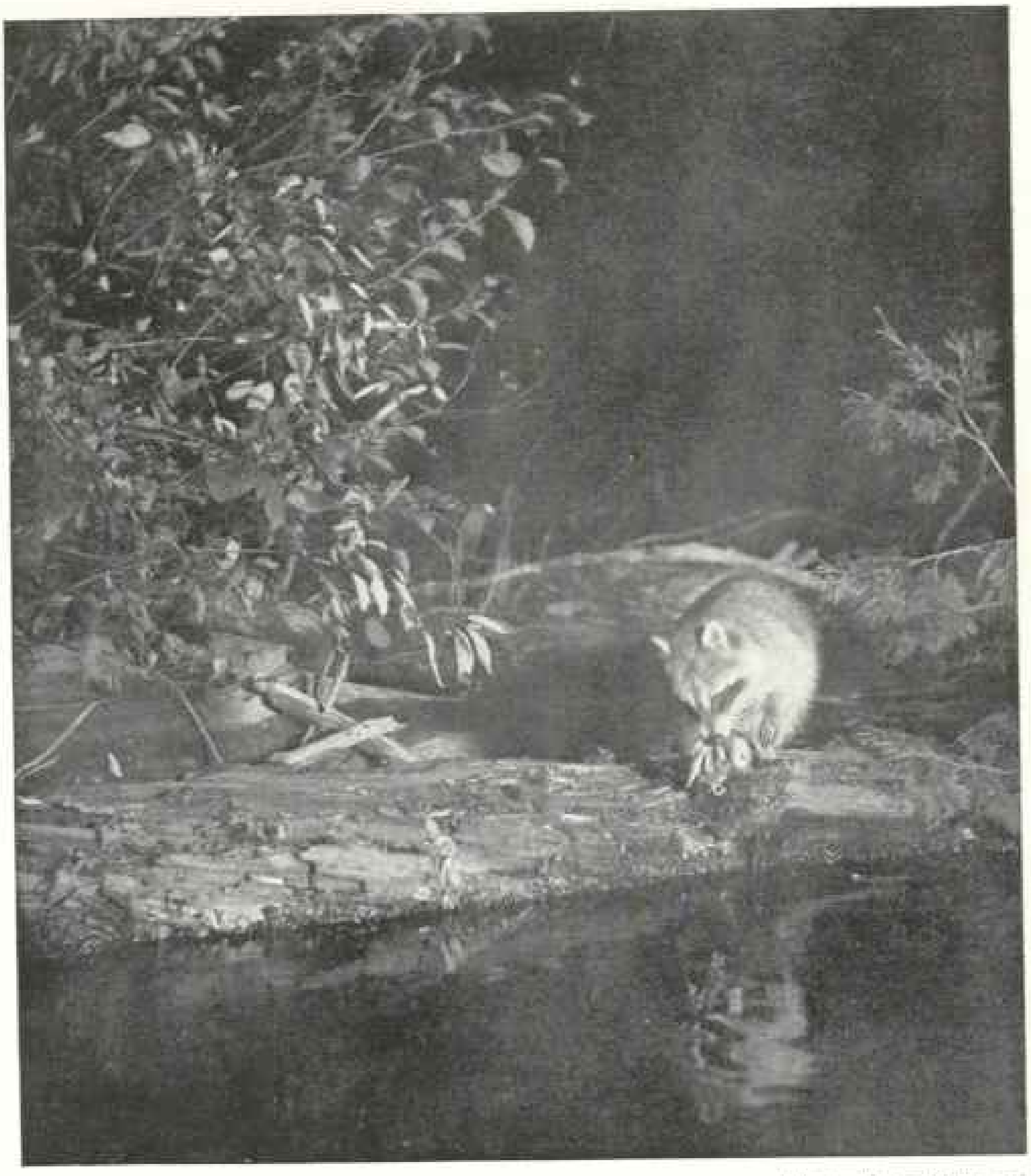


Photo by George Shiras, 3rd

A FRONT VIEW OF THE COON, OBTAINED BY THE SAME METHOD AS EMPLOYED TO SECURE THE PRECEDING PICTURE

came invincible when he pointed out, in the moist ground around the water-trough, an imprint that in miniature resembled the track of a bear or that of a child; so this plantigrade track must have been made by a coon. This was a most interesting discovery, especially as we knew the animal would return again that night.

"The damage having been done, I requested Jim not to set the steel trap, but to leave some of the dead chickens out-

Photo by George Shiras, 3rd.

THIS NIGHT A STAKE WAS DRIVEN INTO THE WATER WITH BAIT SO ARRANGED THAT THE ANIMAL HAD TO STAND UP AND REACH FORWARD WHEN PULLING

side the fence for the animal's temporary entertainment, that I might in a night or two set out a flashlight after returning from a several days' trip to the house-boat, where I was about to try for a shot at a pack of timber wolves.

"On the way up the river that afternoon I noticed the ripples caused by a swimming animal under the alders, and supposed it to be a muskrat until the gray body of a coon suddenly crossed a foot or two in front of the canoe. And although I had a chance to disable it with a blow from a hard-wood paddle, I let it go for the same reason that withheld the setting of the steel trap.

"Returning to the house-boat after dark without having gotten a shot at a wolf, though one howled dismally in a dense covert not 50 yards from the canoe, we were surprised as well as gratified at seeing a coon sitting on the gangplank of the house-boat. We thereupon set up a couple of cameras with the flashlight machine a little above them, and ran a string 10 feet to an eye-screw at the base of a hemlock, with cheese and fish fastened to the end of it.

This was the last picture taken, and the coon was induced to climb 15 feet up a maple by baiting a detached string every 6 inches. At the top he was rewarded with a fat duck, connected by a string with the flash. However, the flash so frightened him that he fled without the duck. Photo by George Shiras, 3rd.

While at work I heard a slight movement in the dry leaves beyond, and turning the jack-light in that direction, saw only the two glowing eyes of the hungry visitor. And here it may be remarked, parenthetically, that while the eyes of all predaceous animals possess a wonderful luminosity when reflecting back the rays of a light at night, the porcupine and all other rodents, with one or two exceptions, do not glow at all.

"Returning to the house-boat and putting out the light, only a few minutes elapsed before the brilliant glare of the exploding flashlight was seen through the open windows. Quick as we were, the coon had disappeared on discovering what terrible things resulted from simply pulling at a little piece of cheese on the end of a string.

"*August 22, 1903.*—Went down the river to camp in order to develop last night's flashlight of the coon, and found, on developing the negative, he preferred the cheese to the fish (see page 584). The dead chickens left beyond the fence at camp were undisturbed—fairly conclusive evidence that our visitor at the house-boat was the one guilty of the former depredation. Getting a good

Photo by George Shiras, 3rd

"THE END OF MOST WILD ANIMALS IS A TRAGEDY." (SEE TEXT BELOW.)

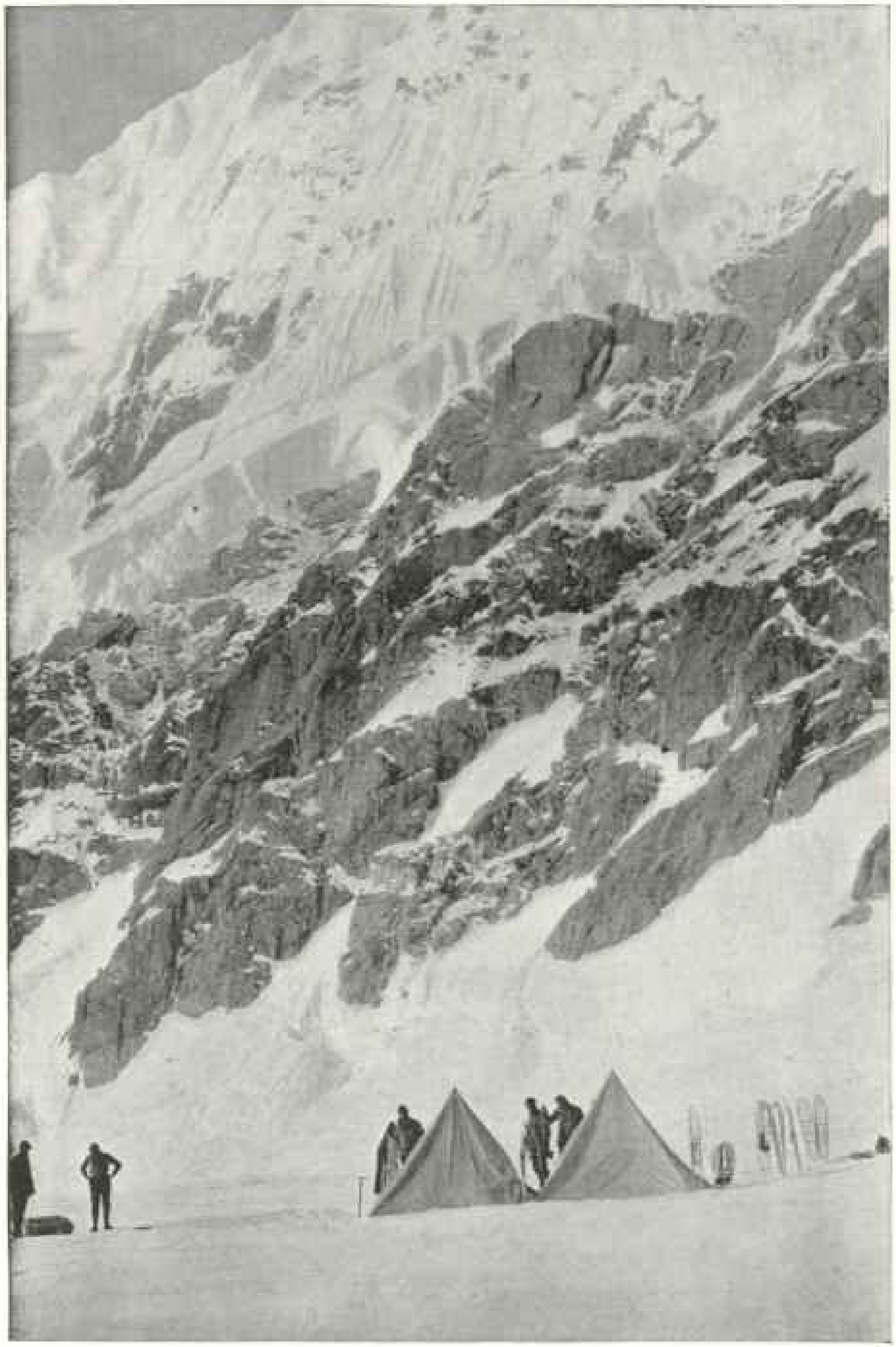
supply of flashlight powder and plates, we returned in the evening to the lake, determined to give the coon plenty of extra bait with the hope that it might be induced to take a number of its own pictures during the night. In this we were successful, as the flash was fired first about 9 o'clock, then two hours later, and finally just before daybreak.

"While the coon is cunning, he is not only very inquisitive, but extremely daring when after a choice meal. Possibly a million coons are trapped every year, and yet few are shot except at night, with the aid of dogs. The coon is almost wholly nocturnal, for I have been on islands in the Gulf of Mexico which harbored untold thousands, and yet, although they were not molested, I seldom saw one in daytime."

It would take many pages to describe the nightly bombardments of the two weeks that followed. Finding that pictures taken in the same spot meant many duplications in coon portraiture, we tried each night to select some new place, and, by arranging the bait differently, thereby obtain a greater variety in position and surroundings.

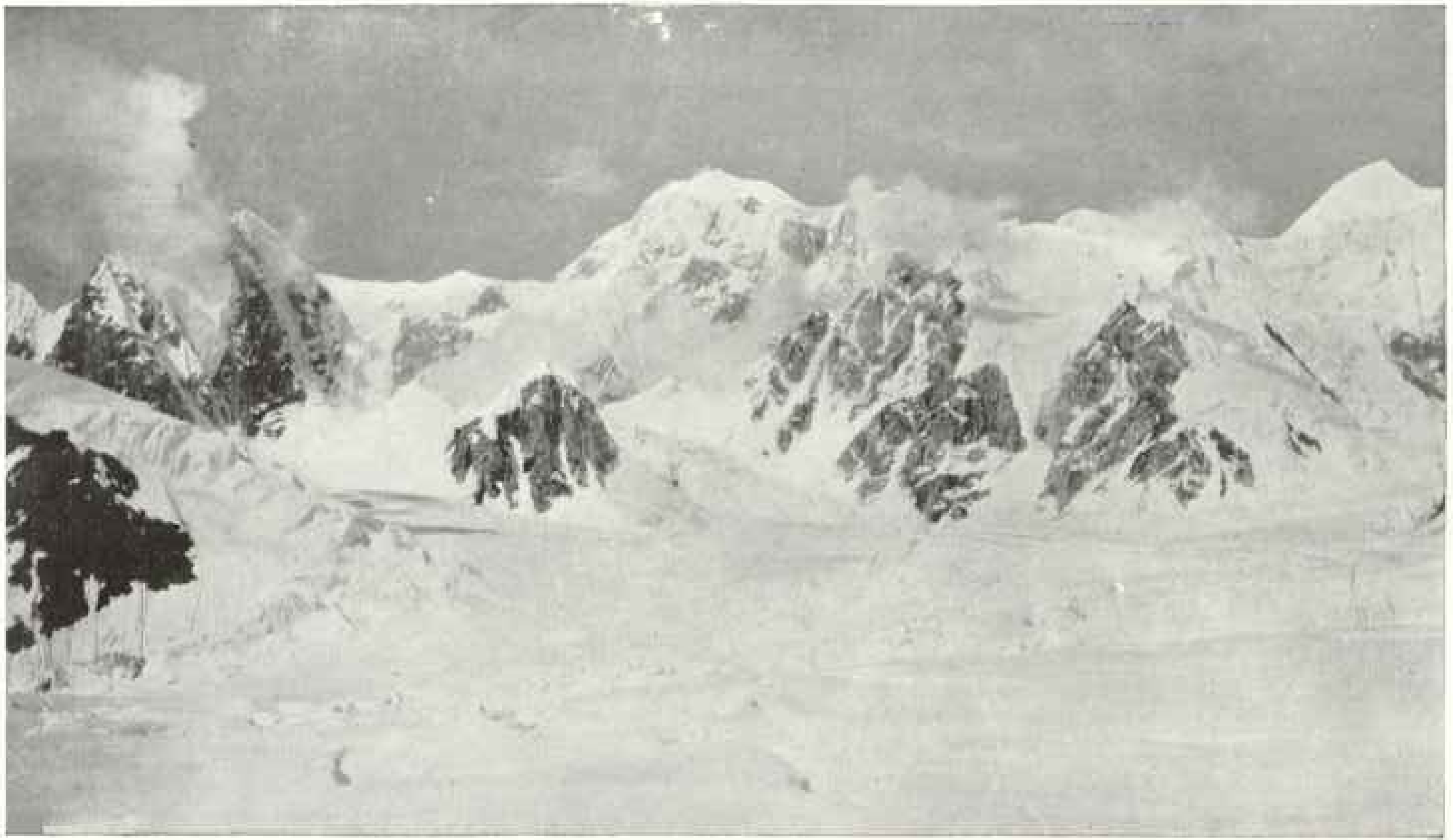
The day before departing on a camping trip to Canada, my guide and I endeavored to arrange for a concluding picture that would be in striking contrast to all the others. A thread 15 feet long was baited every half foot with cheese, and one end was suspended from the upper half of a maple tree. A fish-duck, shot for the purpose, was made the final goal at the end of the string. The result of this experiment is shown in the final picture of the coon (see page 595).

A month later I returned to camp, and as Jim, the hostler, came out to unharness the team, I asked him with some curiosity whether "my coon was still about." "Yes," replied Jim, much to my pleasure; "it is still here, and has two young ones. And they are not far away, either," he remarked, after some hesitation, pointing towards the end of the barn, where the trio of pelts were drying in the sun.



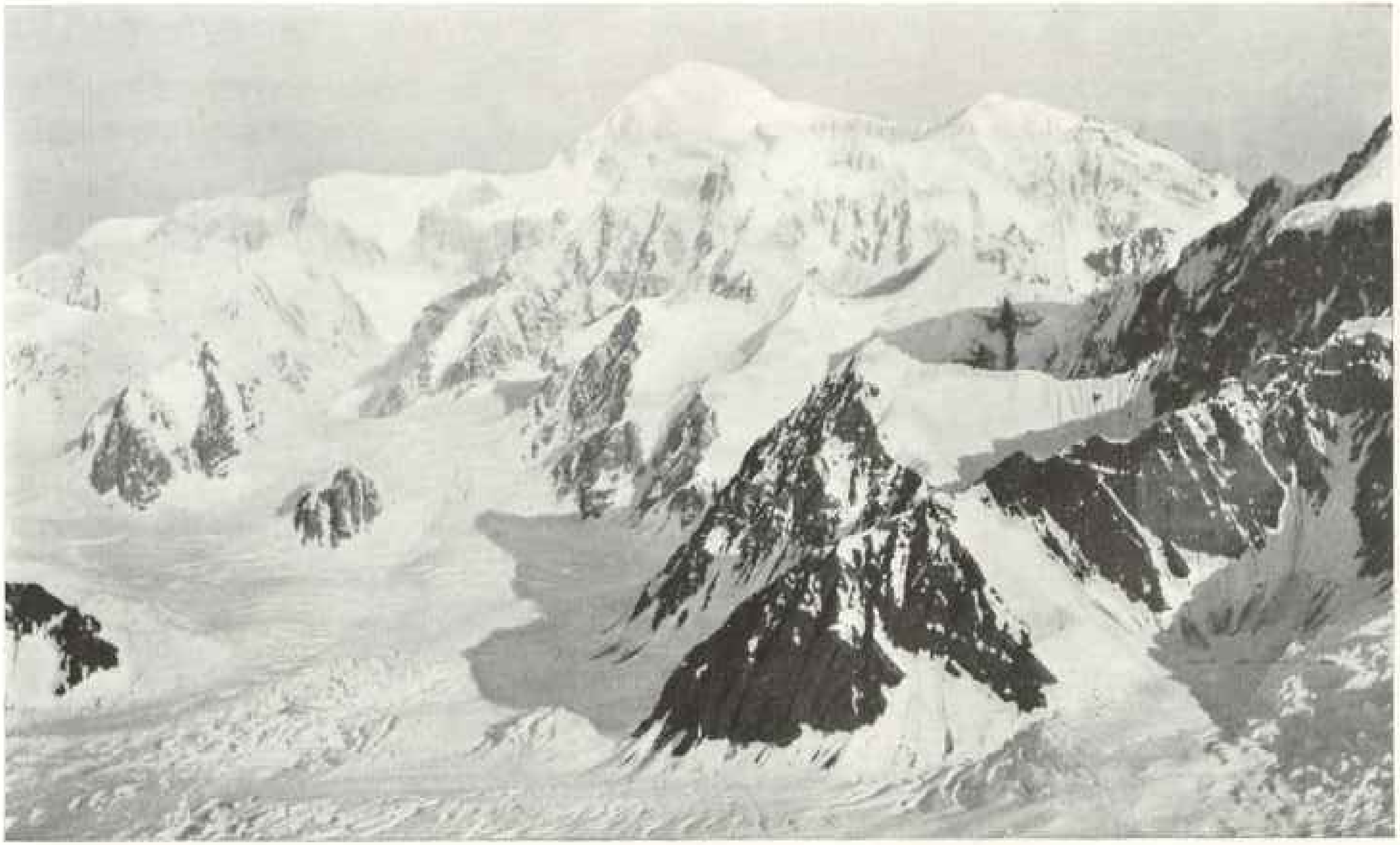
CAMP UNDER THE CLIFFS OF MOUNT HUNTINGTON

The cliffs are still 2 miles away. Mount McKinley's neighboring peaks are splendid mountains, though dwarfed by McKinley's grandeur. Photo from Waldemar H. Grassi



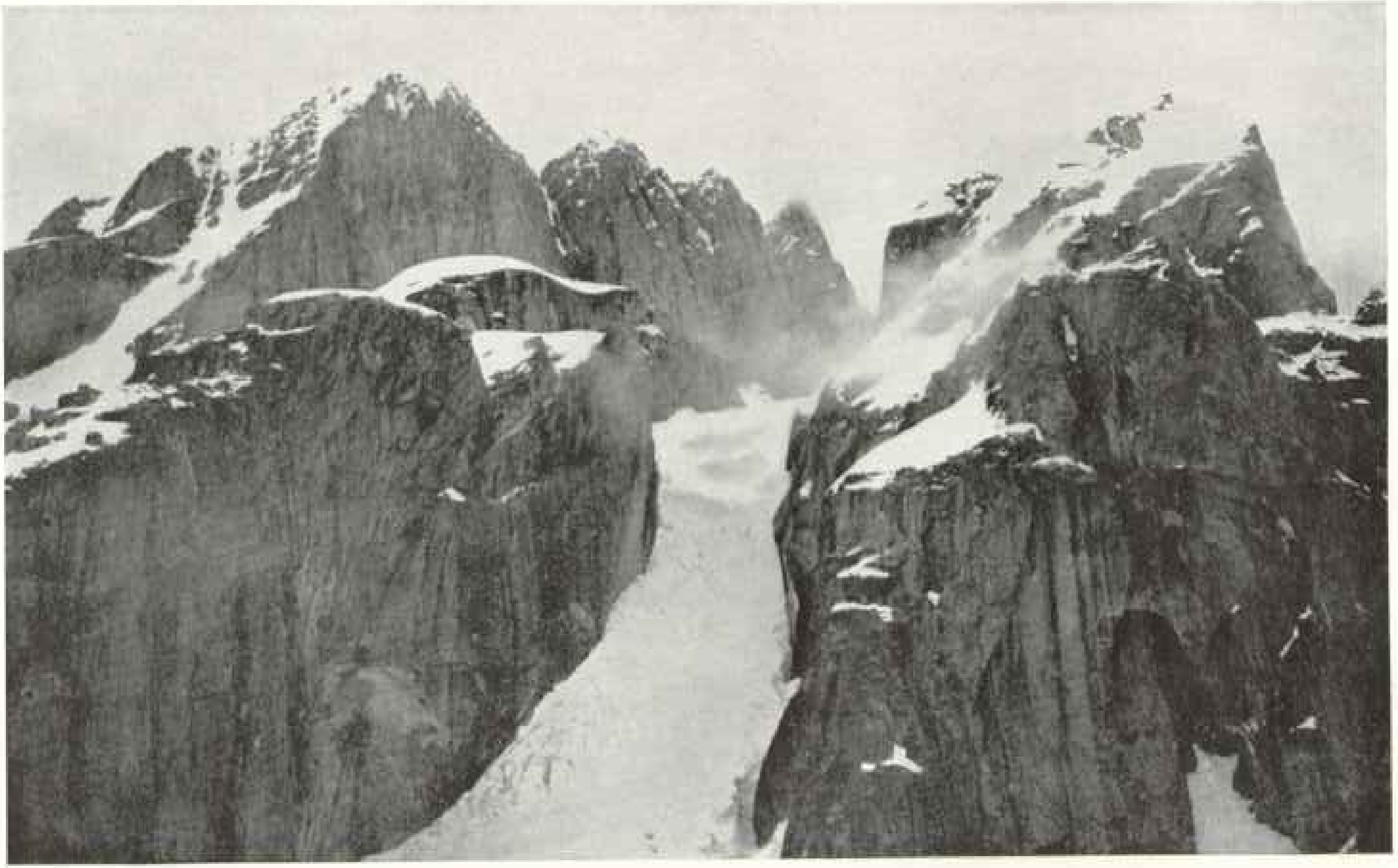
VIEW OF MOUNT McKINLEY FROM THE EAST, 7 MILES DISTANT, AT AN ELEVATION OF 7,000 FEET

Mount McKinley lifts its head 20,300 feet over the wastes of west Alaska. It is the highest mountain of North America, and has the longest snow and ice slope of any of the world's great mountains. Mount McKinley demands about 18,000 to 19,000 feet of snow and ice-work, while Mount Everest, in the Himalayas, the world's highest peak, has a perpetual snow-line of between 17,000 and 18,000 feet, leaving only 11,000 to 12,000 feet of snow. Yaks can even be taken to over 20,000 feet in the trans-Himalayas. Photo by Waldemar H. Crasset.



VIEW OF MOUNT McKINLEY FROM THE TOP OF "EXPLORERS' PEAK," 8 MILES DISTANT

This photograph, taken from an elevation of 9,000 feet, brings out the mountain's great size. The Parker-Browne Expedition to Mount McKinley spent fifty nights continuously on the ice, and experienced difficulties as great in attaining an elevation of 10,300 feet as any to be encountered in reaching an altitude of 20,000 feet in the Himalayas. "Mount Aconcagua in the Andes was ascended to its summit—23,080 feet—without putting a foot on snow, while we spent fifty nights and days on the ice in reaching an altitude less than half as high." Photo by Waldemar H. Grassi.



A HANGING GLACIER ALONG RUTH GLACIER, WHICH WINDS ITS WAY NORTHWARD TO THE GREAT AMPHITHEATER BASIN AT THE SOUTHERN BASE OF MOUNT McKINLEY

Weather conditions in Alaska are sub-arctic, and the excessive glaciation has digged out tremendously steep amphitheaters with precipitous cliffs. The glaciers pouring into these amphitheaters are all "hanging" and bristling with seracs. The attempts to scale Mount McKinley, all of which have thus far proved failures, show that the only method of ascent is from the northern side, according to the program outlined in the NATIONAL GEOGRAPHIC MAGAZINE in January, 1903, by Alfred H. Brooks, Chief of the Alaskan Division of the U. S. Geological Survey. Photo by Waldemar H. Grassi.

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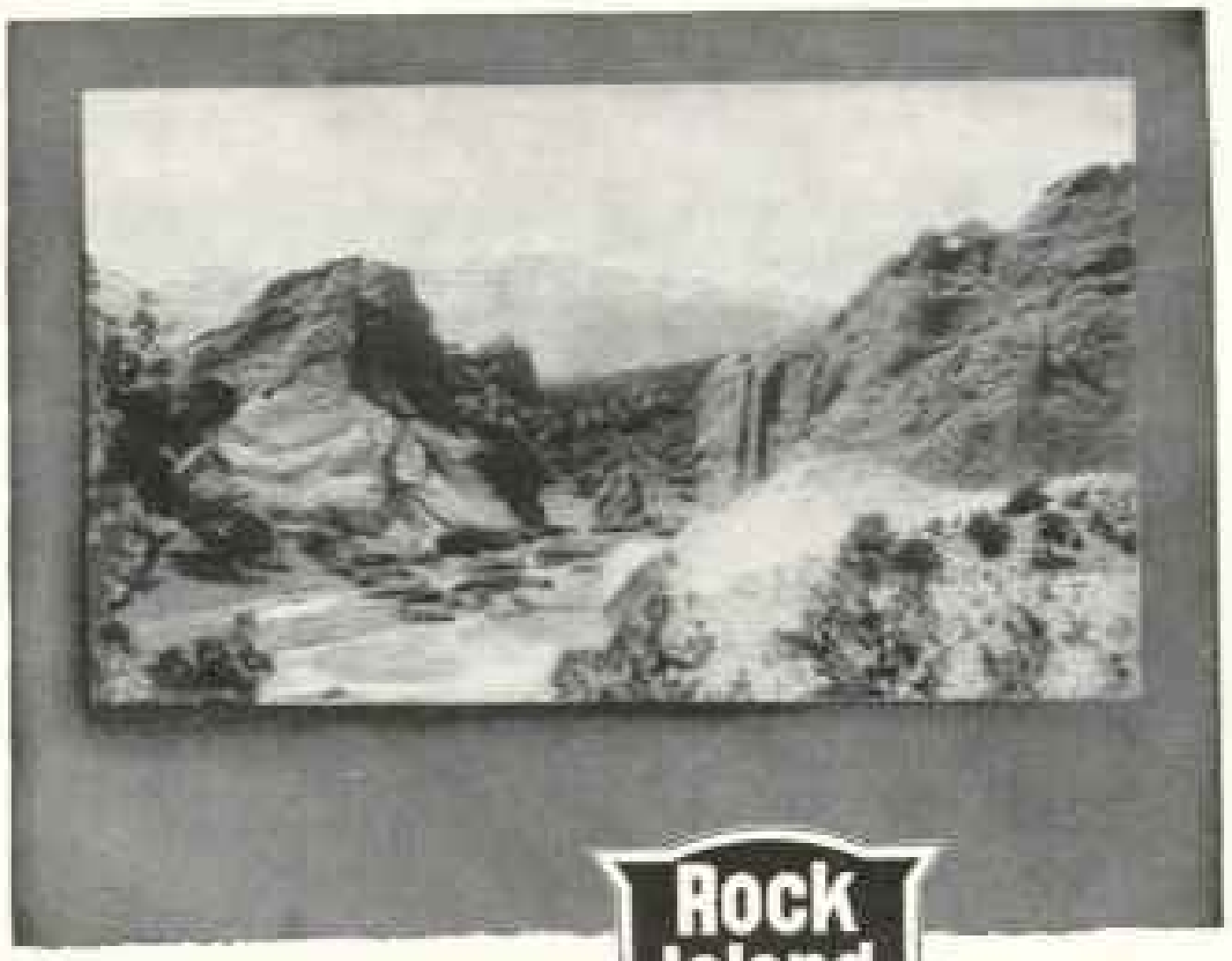

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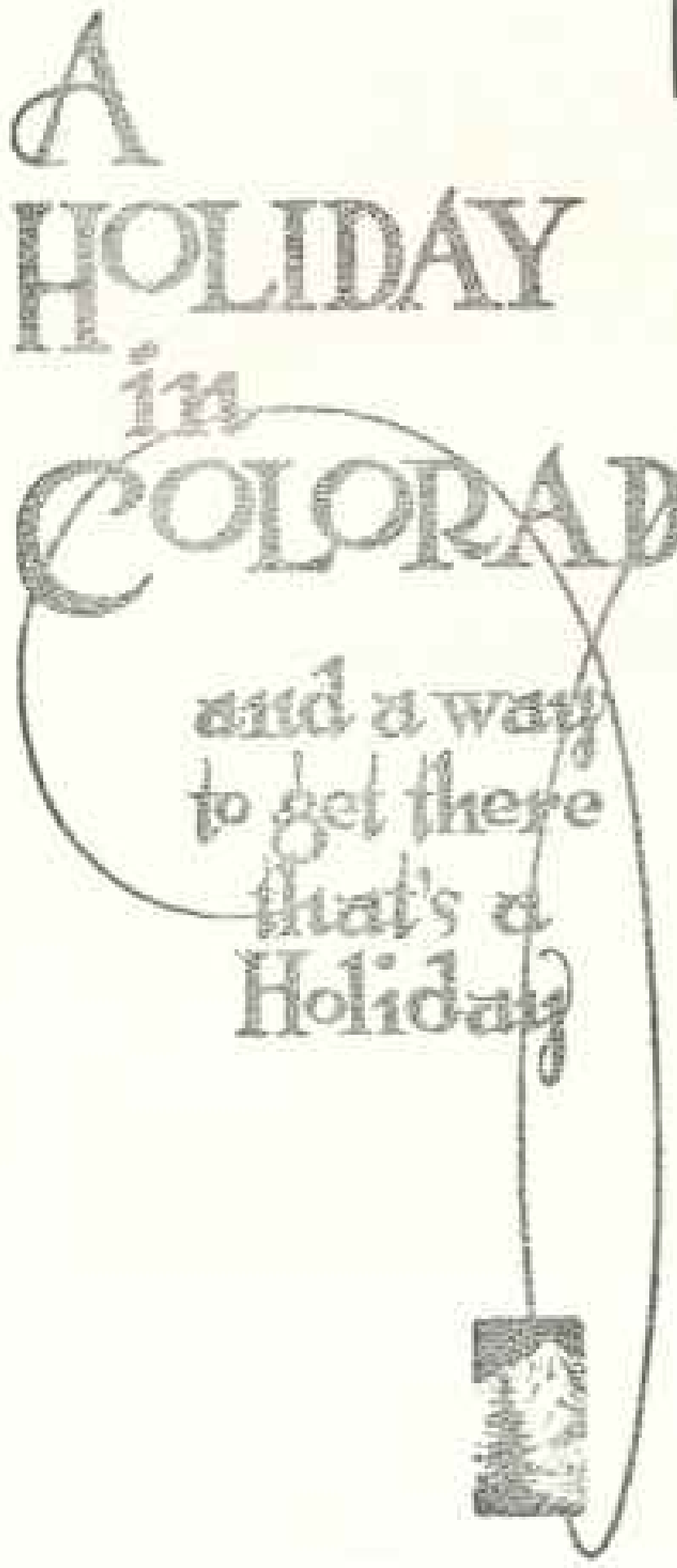

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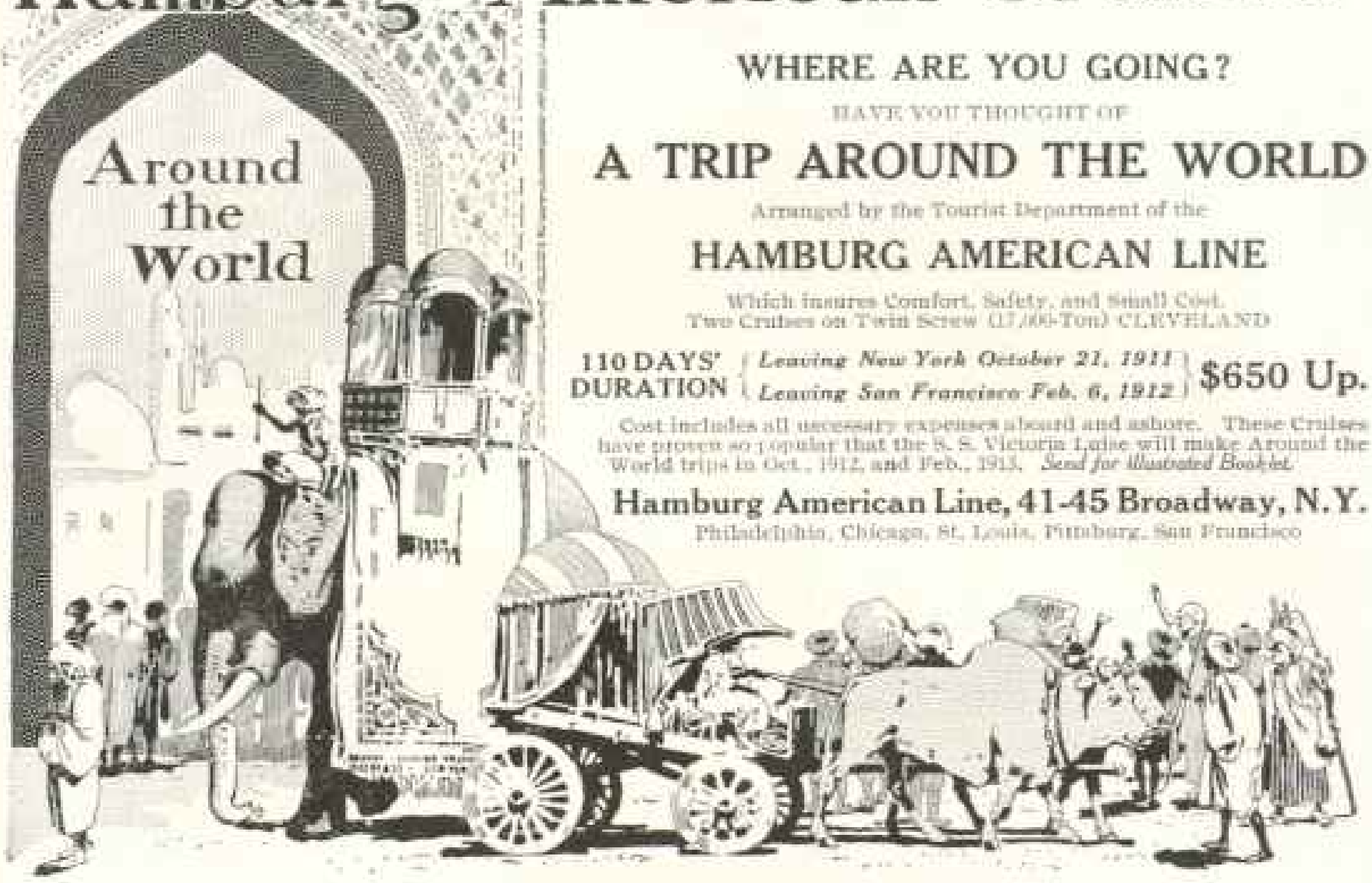

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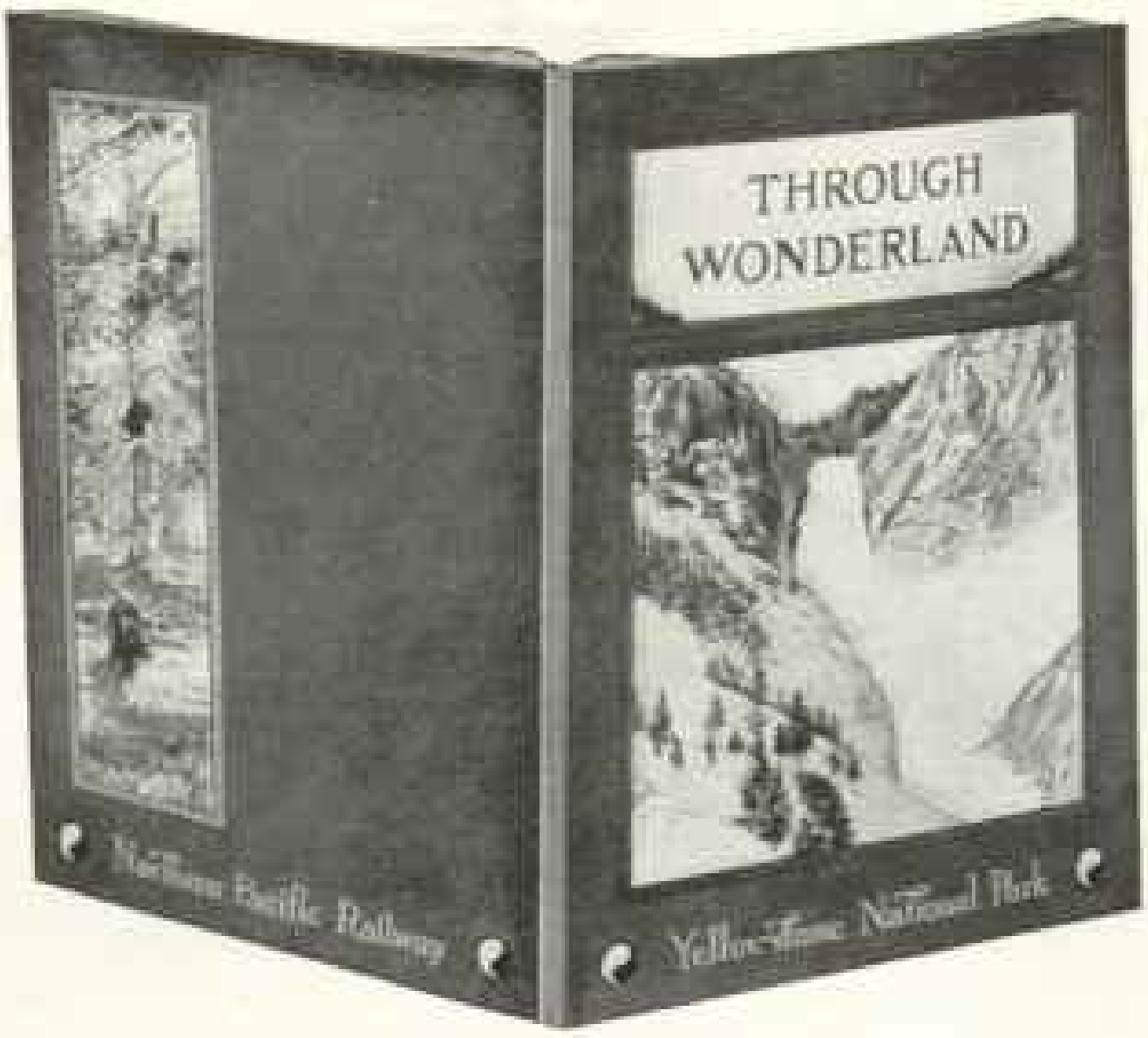

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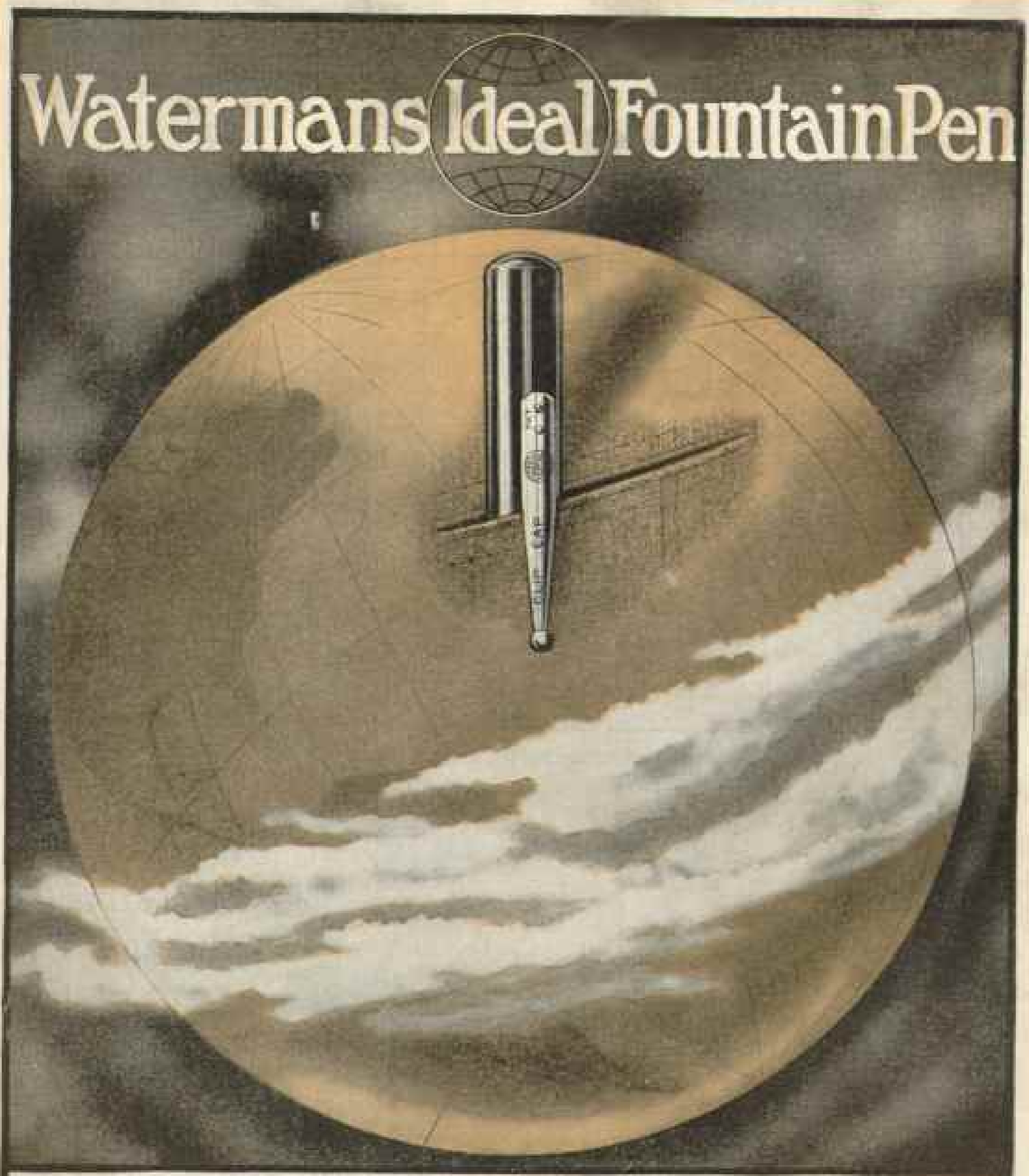

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