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VOL. XVII, No. 6 WASHINGTON JUNE, 1906

THE NATIONAL GEOGRAPHIC MAGAZINE

COTIDAL LINES FOR THE WORLD*

By R. A. HARRIS

U. S. COAST AND GEODETIC SURVEY

BEFORE calling attention to the accompanying charts, which are supposed to represent the lines of simultaneous high water at each hour and half hour of Greenwich lunar time, it seems well to remark that many systems of lines could be laid down which would satisfy all reliable data; for, with very few exceptions, observations away from land have never been attempted. In fact the lines could generally be drawn across the land instead of the water, the only requirement being that they be so numbered as to agree with the known times of tide along the coasts.

On account of the difficulties connected with the mechanism of the tides, and the want of sufficient data, it has heretofore been possible to incorporate but little rational theory into the charts of cotidal lines covering oceanic depths.

The object of this paper is to give a general idea of a system of cotidal lines for semi-daily tides so constructed as to agree closely with observational data and tolerably well with rational theoretical considerations. Numerous cotidal charts covering various parts of the world, including those here shown, together with a more detailed account of the tides represented upon them, constitute an appendix to the report of the Coast and Geodetic Survey for the year 1904.

Upon referring to the chart of the world (Supplement) it will be seen that even for oceans where the depth is fairly uniform the cotidal lines are in some places crowded together and in other places spread apart. The range of tide also undergoes great changes in value, as will be noted later on.

One nearly simultaneous region whose tidal hour is XII extends easterly from the Atlantic coast of the United States, the range of tide decreasing from about 4 or 5 feet along this coast to one foot on the northeastern coast of Porto Rico. In going southeasterly from this island the time of tide changes rapidly, and the range of the semi-daily tide is less than one foot throughout the greater portion of the Lesser Antilles. If the tide of this region forms part of a stationary wave of which the United States is an end boundary or loop, the Greater Antilles a lateral boundary, and whose nodal line lies easterly from Porto Rico, we ask at once, Where are the other loops, lateral boundaries and nodal lines? Is there a VI hour region which can be associated with the XII hour region? When it is

*An address to the Eighth International Geographic Congress, recently held in the United States.

high water along the coast of the United States, is it low water at a distance of ½ (*i. e.*, half a wave length) to the southeast? For a depth of 3,000 fathoms ½ λ is, by computation, 46.6 degrees of a great circle. This carries one from the American coast to a point southwesterly of the Cape Verde Islands; and here it will be seen the lines indicate that the tidal hour is approximately VI. But they indicate more, namely, that there is a region of considerable size over which the time of tide changes by only a small amount. The lateral boundaries consist of the northeastern coast of eastern Brazil, the African coast from Liberia to Bijouga Islands and the Cape Verde Islands.

Having shown the existence of a stationary wave in the ocean, we may now briefly consider what systems of stationary waves or oscillations are possible in the various oceans. Without going into details, it may be said that the regions or "areas" considered must have depths and horizontal dimensions such that their free periods of oscillation approach 12 lunar hours, or the period of the tidal forces by which the motions are sustained.

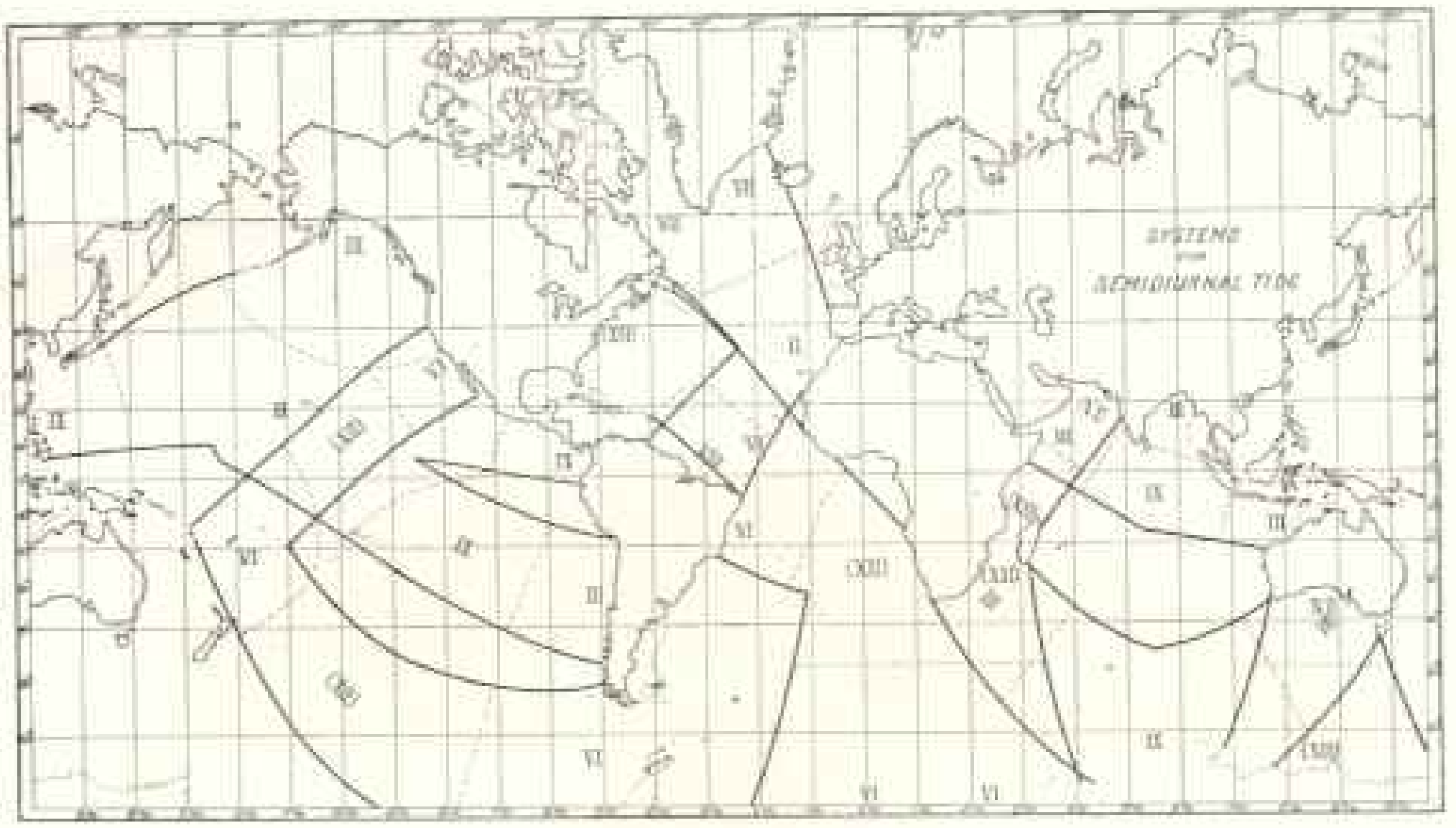
The determination of the free period and mode of oscillation of a body of water is usually a difficult mathematical problem, even when the depth is uniform, the boundaries are simple, and no account is taken of the deflecting force of the earth's rotation. If some of the boundaries are wanting, the oscillation is somewhat imperfect in its character and has not been investigated by mathematicians or physicists. A few experiments will, however, convince one that he can often obtain through the consideration of simple bodies an approximation to the periods of bodies having variable depths and having imperfect as well as rather complicated boundaries.

The systems or combination of "areas" possessing a period of approximately 12 lunar hours are shown on an accompanying chart (page 305) and may be briefly described as follows:

The North Indian system covers the more land-locked portion of the Indian Ocean. The South Indian system extends from the south coast of Australia southwesterly to the Antarctic Continent and thence northwesterly to Madagascar and South Africa. The South Atlantic system extends from the Antarctic Continent north, partly to Madagascar and South Africa and partly to the 27th parallel of south latitude west of South Africa. From this parallel one branch extends west-northwest to the eastern coast of Brazil, and another northwesterly to the Atlantic coast of the United States. The North Atlantic system extends northeasterly from the northeastern coast of Brazil to points west of Morocco; thence northwesterly to Greenland and Labrador. The South Pacific system comprises a belt extending from southern Chile and Graham Land westerly and northwesterly to the islands and shoals north of New Zealand; thence northeasterly to the coast of southern and Lower California. The North Pacific system extends over nearly all of the North Pacific Ocean and also covers a broad band extending from Chile westerly to and joining the North Pacific Ocean.

The tidal forces acting upon these systems cause the tides to occur at times which can be approximately determined *à priori*. Such times are written upon the loops of the systems, and in all cases approximately agree with the observed times of tide for these localities.

Upon referring to the chart of cotidal lines, it will be noticed that some of the loops of the systems are more conspicuous than others. For instance, the time of tide is nearly simultaneous over a considerable region at each of the following loops: East of Brazil, off Sierra Leone, off the Atlantic coast of the United States, off Gibraltar, off Panama, and off the Philippine Islands. Extensive progressions conceal in great measure the stationary waves occurring in the following localities: Between Java and northwestern Australia, near Cape Good Hope, near Cape Farewell, and along the coast of Chile.



Systems of Semi-diurnal Tide

The overlapping of systems obscures the loop around Cape Guardafui and the loop along the coast of southern and Lower California.

The proximity of a loop or region to a loop or region having a different tidal hour necessitates a somewhat gradual transition of the tidal hour as we pass from the one locality to the other. This tendency is quite universal, because in the irregularly shaped bodies of water found in nature it would be unreasonable to expect to find extended nodal lines and much less regions of any considerable extent having no tide at all.

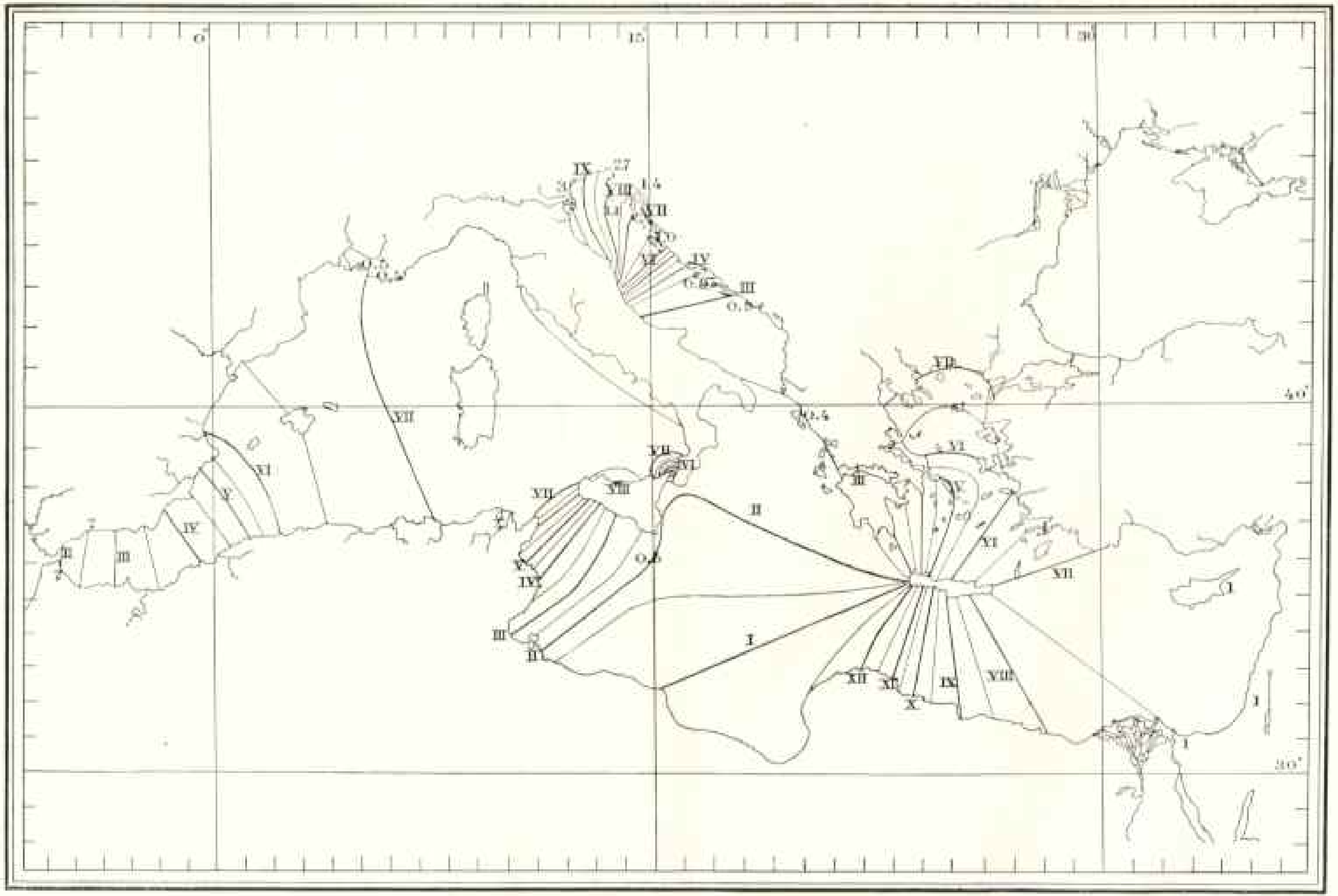
Several good approximations to nodal lines are noticeable through the crowding together of the cotidal lines: One extends from Ceylon to Sumatra; another extends northeasterly from the Windward Islands; another southwesterly from near Acapulco; another southeasterly from Japan.

Upon referring to the chart of cotidal lines, it will be noticed that there are several points from which the cotidal lines for all hours seem to radiate, and so must be points where the range of tide is zero. These points and radiating lines are caused by the overlapping of systems, by progressions due to secondary or dependent bodies of water into which a free wave progresses, and by the necessity of a gradual change between adjacent regions whose tides are not simultaneous.

The existence of such a point can be readily seen in the case of a square area having two stationary waves at right angles to each other, but differing in phase by some amount other than 0° or 180°. The no-tide point will be located at the intersection of the two nodal lines. Around this point the tidal hours will progress, completing a cycle of values in the period of the oscillation. Hence the radiating cotidal lines.

One, two, or three of the causes alluded to may be instrumental in bringing about a no-tide point around which the cotidal lines may be styled "amphidromic."

The no-tide points and amphidromic regions in mid-ocean are located as follows: Between Madgascar and southern Hindostan; westerly from the Azores; between California and the Hawaiian Islands; northwesterly from the Society Islands, and southeasterly from New Zealand.



Cotidal Lines for the Mediterranean Sea

In straits or channels are amphidromic regions caused by the deflecting force of the earth's rotation acting upon a stationary oscillation which otherwise would possess a nodal line. Examples of this are the North Channel, the arm of the North Sea between Holland and England, Norton Sound, and the Strait of Korea.

There are still other amphidromic regions due to other causes.

It has been supposed that the tides of the ocean advance westward around the globe, endeavoring to follow the moon in her apparent diurnal course in the heavens. A westerly progression was especially looked for in the southern seas, where a continuous zone of water encircles the earth. But what have we in reality? A remarkable eastward progression in the Pacific Ocean due to the opening between Cape Horn and Graham Land forming a break in the rigid boundary which constitutes the eastern support of the South Pacific oscillating system. The tide thus derived extends into the Atlantic as far north as Uruguay. By going eastward along the outer coast of Antarctic Continent from 10° east longitude to within 45° of the starting point, it is probable that whatever progression exists is easterly and not westerly, but no observations for the Antarctic Continent are available.

The tides in the Arctic Ocean proceed easterly from Greenland Sea to Bennett Island, Alaska, and northwestern British America.

The progression is easterly in the eastern half of the Indian Ocean.

Excepting off the northern coast of South America and off the southeastern coast of the United States, the progression in the Atlantic is generally to the north. This is due to the large openings in the far north through which tidal action is transmitted, to the particular trend of the continental coast lines, especially that of the western coast of Africa, and to the continuity of the Antarctic Continent.

The general progression in the North Pacific is westerly, due largely to there being many wave-producing openings located on the western side of the ocean, while none are located on the eastern side.

In small deep bodies of water the tide obeys the equilibrium theory, *i. e.*, the surface of the water remains normal to the direction of instantaneous gravity. Examples of this are Lake Superior, the eastern portion of the Mediterranean Sea (page 306), the southwestern corner of the Gulf of Mexico, and of the Caribbean Sea.

RANGE OF TIDES

A few examples will now be given for the purpose of showing that, unless obscured by other effects, relatively large ranges occur near the loops of the oscillations and relatively small ones near the nodal lines.

The range of tide between Ceylon and western Sumatra is probably less than 1 foot, while off the mouths of the Ganges the range is about 5 feet.

At the northern end of Mozambique Channel the range is 9 feet, while around Ras Hafun, Somaliland, the range is about 3 feet; going thence northerly, the range again increases, being 5.6 feet at Karachi and 8.8 feet at Bombay.

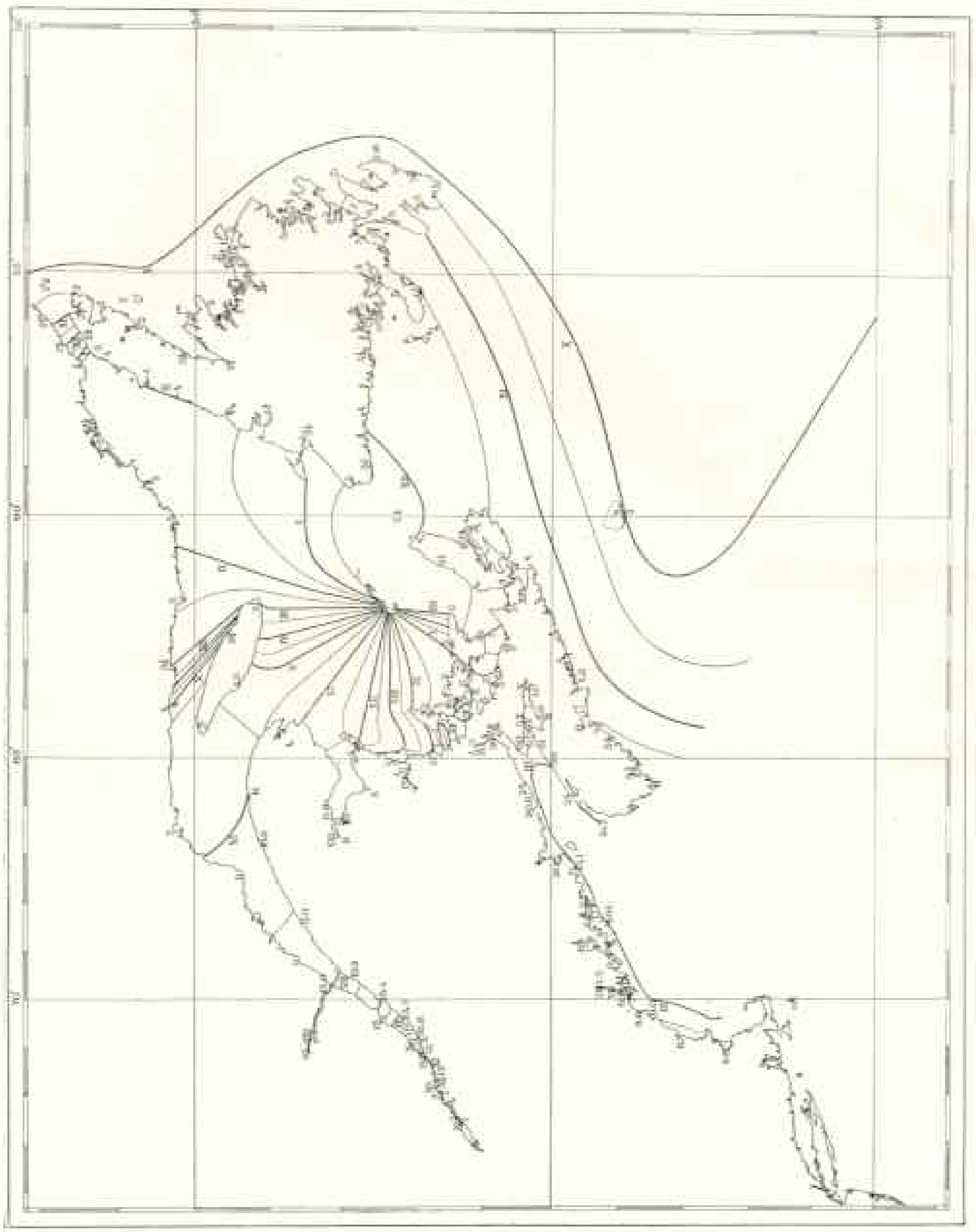
The range of tide at Savannah River entrance is 6.8 feet, while on the south side of St Thomas Island it is but 0.3 foot.

The range of tide at Panama is 12.6 feet, while at Acapulco it is but 1.2 feet.

(It has already been noted that the tide of southwestern corner of the Caribbean Sea obeys the equilibrium theory. The observed range at Colon is 0.6 foot.)

On the eastern coast of the Philippine Islands the range of tide is 4 feet, while at the Island of Guam it is 1½ feet.

In many land-locked arms of the sea the difference in range at loop and node is still more apparent. Examples of this are the Gulf of Suez, the English Channel, and the Irish Channel. I shall con-



Cotidal Lines for the Gulf of Saint Lawrence

clude this paper by noting the variety of ranges occurring in the Gulf of St Lawrence and the Gulf of Maine (page 308).

The cotidal lines indicate a nodal line north of the Magdalen Islands. East of this the range increases to about 3 feet in Cabot Strait, while to the west the range increases rapidly. At the mouth of the Saguenay River it is 15 feet. Above this point the wave is progressive, while below this point it is chiefly stationary. At one point on the south side of Nantucket Island, the range of tide is 1.2 feet; at Boston, it is 9.6 feet; at St John, 20.8 feet; at the head of the Bay of Fundy proper, 30 feet; at Moncton, 40 feet, and at the head of the Basin of Mines, 43 feet.

From C. C. Georgeson, Department of Agriculture

A Garden at Eagle, Alaska (64° 45′ north latitude), where the temperature varies from 87° F. in June to — 68° F. in January

Mr C. C. Georgeson, director of the four government experiment stations in Alaska, in "Vegetable Growing in Alaska" (Bull. No. 2, Alaska Agric. Exp. Stations, published by the Department of Agriculture), gives an interesting summary of the work. Radishes, mustard, turnips, kale, lettuce, carrots, parsnips, parsley, peas, cress, cabbage, cauliflower, broccoli, Brussels sprouts, onions, spinach, endive, leek, beets, potatoes, rhubarb, and, among the herbs, caraway, catnip, marigold, mint, sage, thyme, can be grown anywhere in the coast region in Alaska, and in the interior nearly to the Arctic Circle if the gardens are selected with due reference to shelter and exposure to the sun. Asparagus, beans, celery, cucumber, squash, salsify can be grown in favorable seasons if planted in warm spots and given the proper care and protection. Vegetables which cannot be grown in Alaska out of doors under ordinary garden culture are: sweet corn, melons, tomatoes, peppers, eggplant, pumpkins.

WHERE THE WIND DOES THE WORK

By Collier Cobb

Professor of Geology in the University of North Carolina

NO portion of the North American Continent is so widely known, and at the same time so little known, as the chain of low-lying islands and fringing sand reefs extending along the North Carolina coast for a distance of more than three hundred miles. This is especially true of Hatteras Island, a sand spit whose dangerous projection and shifting shoals have made this portion of our Atlantic seaboard a veritable graveyard of American shipping.

Distinguished scientists on both sides of the Atlantic have discussed the origin of Cape Hatteras without having set foot on the island or coasted along its shores. The origin of well nigh all the features of this coast have been discussed at long range, and yet hardly half a dozen people from the outside world have any personal acquaintance with the island.

It was on this coast that Fessenden and Thiessen experimented successfully with wireless telegraphy. At Kitty Hawk, on these banks, the Wrights conducted their experiments in mechanical flight.

Though difficult of access, the inhabitants of these islands are in close touch with the rest of the world by means of the telegraph and telephone lines of the U. S. Weather Bureau and the Life Saving Service, as well as by the wireless telegraph.

Sail Car on Church's Island, N. C.

Those who watch the reports of shipping need not to be told that winds are constant in this region. The strong winds of midwinter come from the north, and the gentler steady winds of midsummer and of the greater part of the year blow usually from a little west of south.

These constant winds were early taken advantage of by the inhabitants, and windmills for grinding corn dot the whole chain of islands, though most of them have now fallen into disuse. A small boy on Church's Island hauls freight for the people of his village on a car furnished with a sail and propelled by the wind.

The frequency of wrecks upon this coast is too well known to require comment, though such is the efficiency of the life-savers, who brave the perils of any storm, that life is

Map of Sand Reefs Along the North Carolina Coast

rarely lost here; but the lightship has sometimes been broken from its moorings on Diamond Shoals and driven upon the Hatteras Banks.

The strong north winds pile the sands up into great barchanes or medanos, crescentic sand dunes known locally as whaleheads, which are moving steadily

Shackleford Sandwave advancing on Forest

Wind-mill on Harker's Island, N. C.

Forest covered by Shackleford Sandwave

southward. These are best developed along the Currituck Banks, from Virginia as far south as the Kill Devil Hills, and numbers of them may be seen to the north and to the south from the top of Currituck Light. These whaleheads are composed of singularly homogeneous blown sands, the horns or cusps of the barchanes pointing to leeward, which is almost due south.

The prevailing winds from a little west of south have rippled the heterogeneous sands on Hatteras just south of the cape, on Shackleford at its southwest extremity, and on the southwest side of Smith's Island. These wind ripples, started in sands exposed by the removal of a strip of forest next the shore, have grown in size to great sand waves, which are advancing on forests, fields, and homes. As the sand wave has advanced it has taken up several feet of the loose soil over which it has passed, undermining houses, laying bare the roots of trees, and exposing the bones of the dead in the cemeteries.

Diurnal winds from the sea have piled the sands into small wandering dunes and hillocks, and even sometimes into sand waves, which are marching steadily inward and shoaling the waters of the sounds. At Nag's Head a large hotel, constituting a solid obstruction, soon had a sand wave built up a short distance in its rear until the level of its roof was reached, when the wave moved forward and engulfed the hotel. In the immediate neighborhood two cottages suffered a similar fate. Here the land gained on the sound 350 feet in 10 years.

On the northern end of Hatteras Island a fishing village has been similarly buried, while the sand has entirely crossed the island at several places north of the cape. This movement of the sand was started just after the Civil War by the cutting of trees next the shore for ship timbers, and the section is still known as The Great Woods, though not a stick of timber stands upon it today. Pamlico Sound for two miles from the Hatteras shore is growing steadily shallower from the deposit of blown sand.

On Smith's Island a pilot's village has

The Wreck of the *Priscilla*

been buried beneath the sand wave for a number of years, but this has been quite recently resurrected and its houses are again occupied. On Currituck, below Caffey's Inlet life-saving station, the sand has advanced entirely across the land, and one man, moving before the advancing sand, has at last built his house on piles in the sound.

The writer has found by experiment that heterogeneous sands, consisting essentially of quartz, orthoclase, some mica, iron, bits of shell, and many mineral substances, showing little if any decomposition,* ripple readily in the wind and are easily arrested. This he accomplished in one instance by planting the seed of a native pine and covering the dune with brush. In another case the movement was checked by the unassisted growth of grass upon dunes from which hogs and cattle were fenced out. Several native grasses on these islands are excellent sand-binders; but so far he has found no means of checking the movement of homogeneous sands that do not ripple, these consisting entirely of well rounded and wind-sorted quartz grains of the same size throughout a single dune.

Cemetery on Hatteras Island, N. C., laid bare by the winds

Other trees besides the pine may be used as sand-binders. Some live oaks and myrtles serve well in this capacity, and on Hat-

* I consider these sands to be of glacial origin, scraped off the granite rocks of New England by the ice-sheet of the last glacial epoch.—C. C.

Wreckage above Hatteras

teras Island young olives and palms have been observed growing on the dunes, though this is the northern limit of both these trees, and they are even unknown on Ocracoke Island next to the south.

As already pointed out, the movement of these sands was in every case started by the deforesting of a strip of land next the shore; but in several instances nature has herself grown forests on dune sands. Above Kitty Hawk Bay large dunes are covered with a growth of pine, maple, oak, cedar, sassafras, elm, locust, beech persimmon, sycamore, hickory, and, in the damp interdune areas, gums and cypresses. Here are many veteran pines, some of them having attained a diameter of three feet. An essentially similar forest is found growing on the high dunes to the southwest of Cape Hatteras, but here we have to add the olive to the list, and there are broad interdune palmetto swamps.

On Bogue Banks, where deforesting has only just begun at two points, we have 20 miles of woodland, the virgin forest extending down to the water's edge and preventing the formation of dunes.

From Southport westward into South Carolina the dunes have moved northward and inland, in some places completely filling the lagoons. At one point such a filled lagoon has produced a pine forest in something more than forty years.

The checking of these moving dunes presents a problem of increasing importance not only to the inhabitants of these sand keys, but to the navigators of the inland waterways as well, and it is of interest to know that its solution is at hand, and that the encroachment of the sand upon the land and upon the sounds may be effectually stopped.

It is fortunate that the strong north winds that pile up the sands and the strong east winds that cause the greater amount of the sand movement blow in the winter months rather than in the season of plant growth. The spring rains are usually of light intensity and long duration, and on Hatteras Island at least they come with the gentler south-

Palmettos on Smith's Island, N. C.

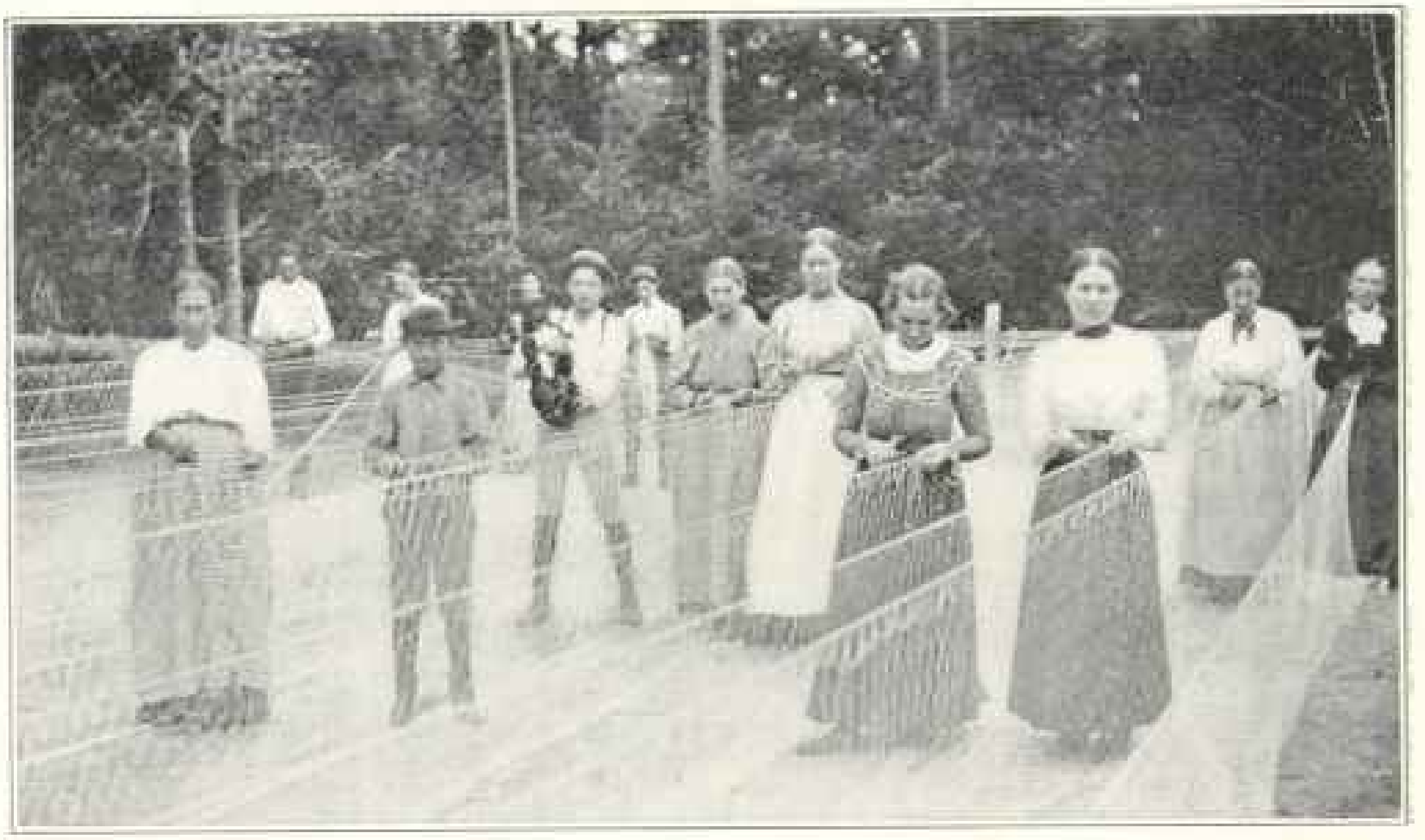
west winds. Hence it is comparatively easy to plant grasses and shrubbery in late winter or early spring and have them gain a firm footing and accomplish something of their growth before the strong winds come.

In January, 1886, the writer planted the seed of the loblolly pine on the back of a dune and covered the area with brush cut from a near-by road in process of making. The brush served not only to break the wind but to conserve the moisture of the sands, and today there is a forest of several acres where twenty years ago was a moving sand waste. The method so common abroad of building a barrier dune by means of wind breaks has been tried several times along this coast, but always without success.

The atmospheric humidity of Hatteras Island is greater than that of any other station in the United States except in the Puget Sound region, and even there the excess over Hatteras is not great. Yet there are more days of sunshine on Hatteras than at Cape Henry, or Norfolk, or Wilmington. The heaviest rains come between late July and mid October, after the plants have done most of their growing for the year and when plants in many parts of the country are suffering greatly from the drouth.

The people of these islands are not the slothful bankers and rude wreckers pictured in song and story. They are fair women and brave men, most of whom live and do for others — life-savers, heroes. Their homes are comfortable and well kept; they attend regularly upon the services of the church, and their children are in school for eight months of the year, for the inhabitants of Dare County have voted upon themselves a special tax for this purpose. The islanders have herds of small wild ponies and flocks of sheep and goats, as well as cattle, on some of these islands.

True, some primitive customs are preserved among them and some early English forms of speech. Their lodges used in fishing and hunting are built after the most primitive type of straw thatch, while a higher type, similar to that used in the village of Gabii in the days of Romulus and Remus, is used as a temporary residence during their camp meetings in the summer, and this higher type of dwelling is on Hatteras built of palmetto thatch.



Making Fishing Nets, Manteo, N. C.

There is no better type of the average man than the native North Carolina banker.

The possibilities of these islands are as yet undreamed of by their inhabitants and utterly unknown to the outsider, who visits only the most barren of them in the duck-shooting season.

The regaining of the shore strip by reforesting the sands, and the retention of the dunes that are devastating the meadow lands, would make of Hatteras Island, at least, a subtropical garden, where southern fruits and early vegetables once plentiful here might come into the market. The game still lingering among the wooded dunes would be greatly multiplied, and the herds of wild ponies now dwindling away would again increase in numbers. Then conservative lumbering could be added to the industries of the island.

It is also within the range of possibilities that the black beach sands which are concentrated by wave action at a few points might be made to yield from their iron ores a return for the labor of gathering them.

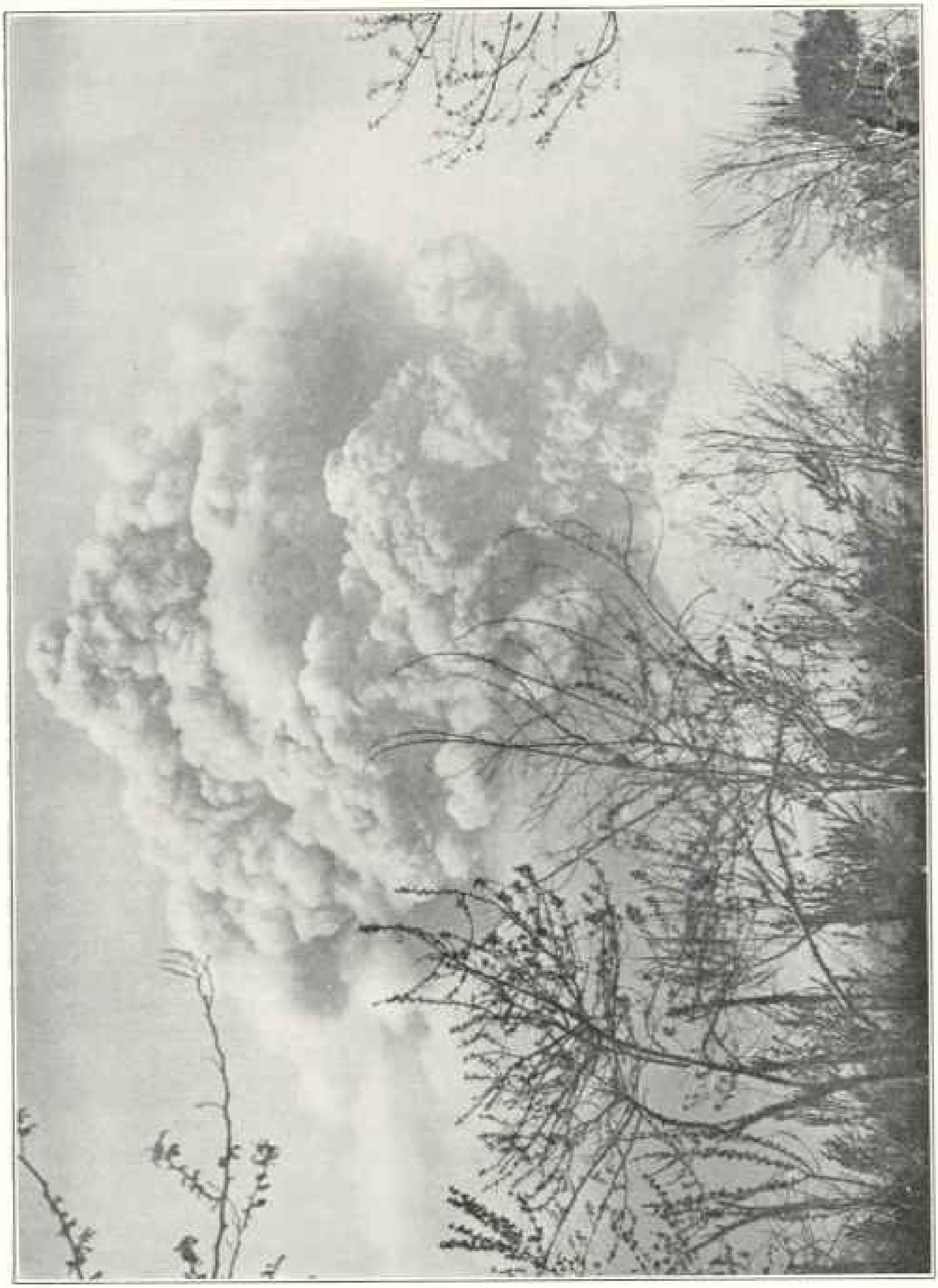
THE ERUPTION OF MOUNT VESUVIUS, APRIL 7-8, 1906

By Thomas Augustus Jaggar, Jr.

Assistant Professor of Geology, Harvard University

THE writer's first near view of the volcano after the eruption of this year was on the afternoon of April 24, when he took his way toward Dr Matteuci's observatory. The electric train was pushing slowly with its cogged wheels upward toward the observatory station; beyond that point the road was destroyed. The fields outside of Naples showed one or two inches of dust, brown, gray, and gray-green, but most of the vegetable gardens had been cleared of it. A little farther the pines and palms were heavily loaded with sand, as in a snowstorm. It was three inches deep on the walls. It had drifted in places to a depth of two or three feet. On nearing the observatory the lava fields of 1872 and 1858 were found buried under 5 or 6 inches of sand and dust, which formed a heavy mantle, but not sufficient to wholly disguise the slaggy contortions beneath. The whole cone of Vesuvius became cleared of clouds in the course of the afternoon and it was seen to be covered with straight sand slides of whitish-gray color which occasionally slipped downward as on the steeper

Looking Down into the New Crater of Vesuvius, April 25, 1906

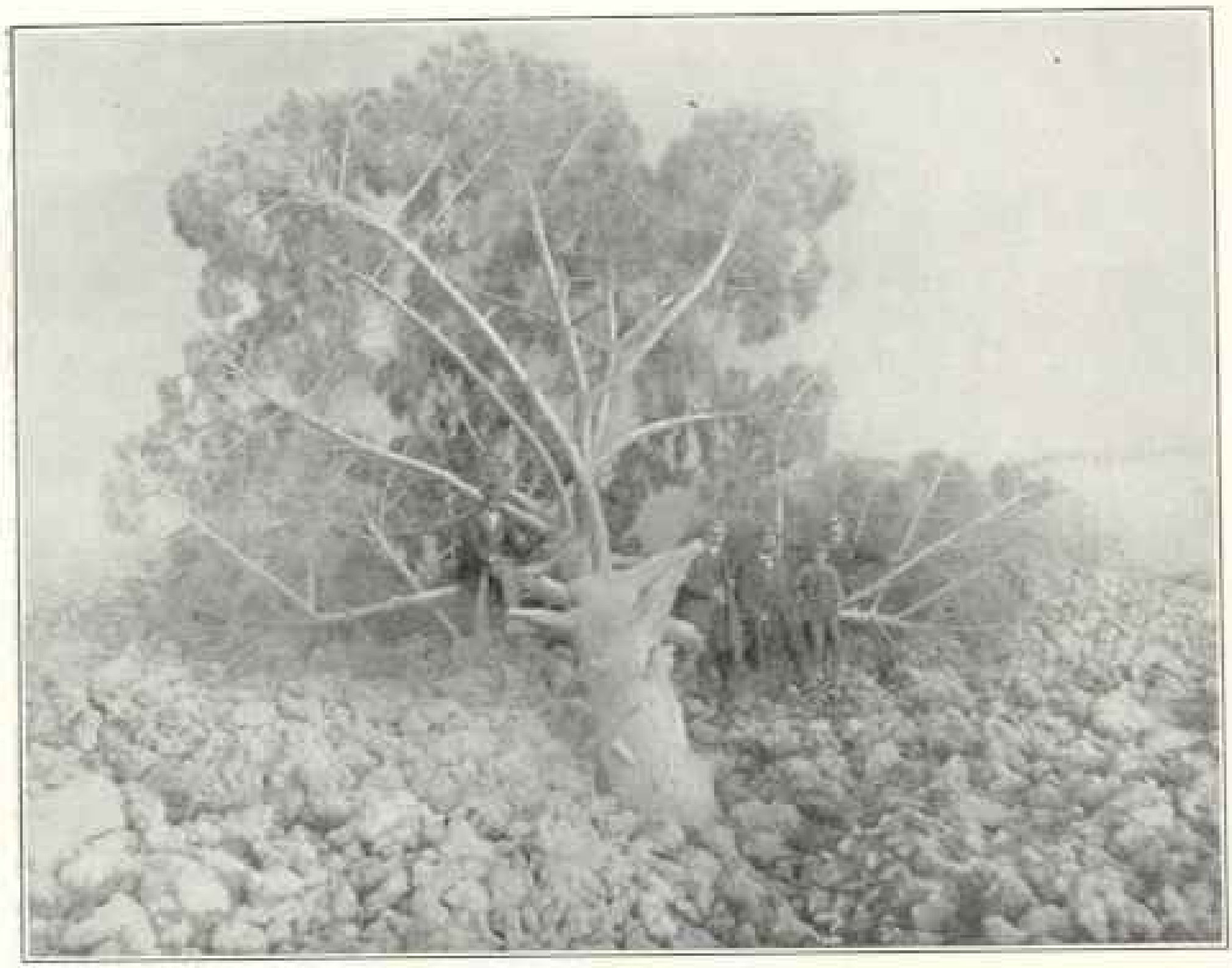


The Cauliflower Cloud from above Vesuvius, April 7, 1906

The Ruins of Boscotrecase, 1906, the Work of Flowing Lava. The stone heap on the left is lava

slopes of a dune. Pure white steam boiled up slowly from the crater. In one instance it burst out radially over the edge of the crater, showing a ring on the border, a dome of cumulus above and within, and a second still higher outer ring made of an older rain-cloud which had been punctured and pushed up bodily. The effect was like a hat on the mountain's crown. At night the cone was clear and entirely without luminosity. Professor Mattenci was found on his return from an ascent, in which he had been accompanied by Dr Sjögren, of Stockholm, and Mr Perret, a graduate of the Brooklyn Polytechnic. They had been in the clouds, and their faces were most picturesquely plastered with blown dust, but they had been unable to see anything, so dense was the fog of steam and sand.

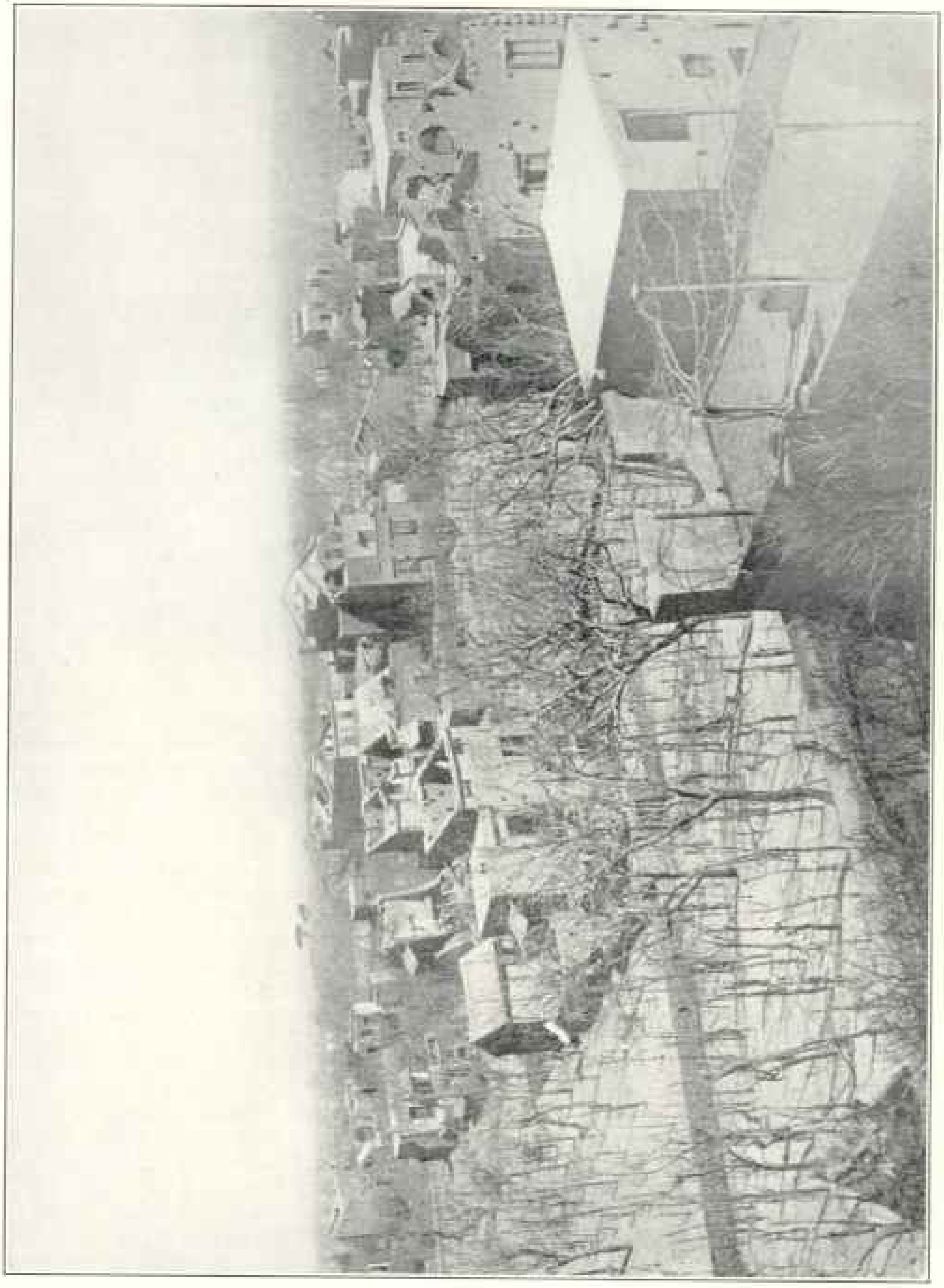
The next morning, with a strong west wind, we started up. Besides the writer, the party consisted of three members of the Alpine Club of Great Britain and a guide. The Alpineers were Dr Tempest Anderson and Messrs Yeld and Brigg, all of Yorkshire. The steam was settling down in clouds on the summit from time to time, in alternation with clear spells. The route followed the extension of the tramway to the place where the lower Funicular station had been, and then the western profile of the cone was followed straight up. The rails along the foot of the cave had been twisted and torn by landslides. Most of the old track and the lower station were buried, but not under lava. No new lava was anywhere



A Pine Tree Overwhelmed by Lava, Boscotrecase, 1906

visible on this side of the mountain. Everything was covered with pebbles, sand, and dust. Vesuvius was never more completely a "cinder cone" in outward appearance than it is at the present time. The slope of the main cone averages about 29°, and the ejecta seem to have slipped down this slope to form thick taluses at the bottom. Here and there large angular pieces of hard rock have fallen, up to 5 feet in diameter.

Climbing the cone was not especially difficult, though it was very steep in places. By making a somewhat zigzag track and keeping on the radial elevations rather than in the shallow troughs, hard pan could be found to walk upon. Some of this was scoured old hard lava, otherwise it was closely wedged or plastered fragments, whereas the gullies were filled with deep sand. It was necessary to be very cautious to avoid starting rocks down on those below. The steepness increased up to a point near the edge of the crater, and then it became slightly less. The edge of the crater itself is the upper rim as seen below; there are no intervening ridges. Therefore the abruptness of the fall-off, when we finally came to it, was startling in the extreme. The wind had steadily increased and was pelting our necks with stinging sand grains which surged in whirling clouds all about us. It was impossible to face this bombardment except during lulls in the gale; hence photography was accomplished under difficulties and the flying dust was ruinous to cameras. Only occasionally did the dim sunlight sift through the mixture of sand, steam, and cloud. In those lucent intervals, however, we could make out an inward slope of 35



Ruins of Ottajano, April, 1906. The roofs have caved in under the fallen ashes

or more degrees, covered with hot sand and broken rock fragments, terminated about 120 feet (vertically) below by jutting ledges which appeared to be precipitous. Beyond was steam and sulphurous heat and obscurity. The ledges fumed in places. No noise could be heard above the howling of the wind. The curvature of the crater edge was irregular with embayments, and it showed much irregularity in height. We could not see the opposite side of the cauldron, but from the curvature it was estimated that the crater could not be less than from one-fourth to one-half mile in diameter—unusually large for Vesuvius. The summit was 4,000 feet above the sea by Aneroid, or some 350 feet lower than before the eruption, according to the data furnished us by the officers of the observatory. The east-west diameter is much greater than the north-south. The depth of the crater is at least 150 feet and no one knows how much more. There is a great notch or caving-in on the north-east rim of the crater, where thousands of tons of gravel and sand were hurled clear over the crest of Monte Somma and fell on Ottajano and San Giuseppe with most disastrous results. On the south side of the cave, toward Boscotrecase, a radial rift opened, letting lava escape from different elevations progressively lower until finally the great outflow came from a mouth or "bocca" only 2,000 feet above tidewater, half way down the mountain, and quite below the cone proper.

The history of the eruption, as gleaned from the accounts of men of science who were on the spot, is briefly as follows: In 1904 there was a lava flow which stopped in September of that year. In May, 1905, lava flowed from a split in the northwest side of the cone and continued in active motion throughout the year. It ceased flowing at the time when the present eruption opened a new vent on the south side of the cone. On April 4, 1906, a splendid black "cauliflower" cloud rose from the crater. On April 4, 5, 6, and 7 lava mouths opened along the southern rift above mentioned, first 500 feet below the summit, then 1,300 feet lower, and finally 600 feet lower still, all in the same radial line. The lowest mouth was more than half way down the mountain, and from this orifice came the destructive streams. It should be borne in mind that these flows are not floods of lava which cover the whole slope of the mountain, but relatively narrow snake-like trickles, none the less deadly when they push their way through a closely built town. The molten rock crusted over and cracked, making a tumble of porous boulders at its front.

At 8 p. m., April 7, a column of dust-laden steam shot up four miles from the crater vertically. The cloud snapped with incessant lightnings. New lava mouths opened and the flows moved forward, crushing and burning and swallowing parts of Boscotrecase, the stream forking so as to spare some portions of the town. Meantime torrents of ashes fell on Ottajano on the opposite side of the volcano, and many roofs collapsed and lives were lost. At the observatory Dr Matteuci and his colleagues were obliged to retreat, as the observatory was rocking violently and heavy stones were falling.

They went only half way down the mountain, however, and returned to their posts next day. The observatory was uninjured, although stones had fallen weighing as much as five pounds. The stones and sand of the eruption are mostly composed of ancient lavas broken up by the steam blast. On April 8 the electrical dust cloud still hung over the volcano, but thereafter through a fortnight the explosions diminished in violence until only quiet steam rose. On the 18th bad gases were blown downward on the observatory by a strong southeast wind, and some persons nearly lost their lives by asphyxiation. The gases were probably both carbon dioxide and sulphuretted hydrogen.

Boscotrecase was ruined wholly by lava; Ottajano by falling gravel. Boscotrecase is traversed in two places by the clinkery lava stream and in some cases

The New Cone of Vesuvius from the Road to the Observatory, shrouded in Snow-white Ashes

houses were literally cut in two. The stream of lava had forked about a spur of the mountain, leaving the higher land with its vineyards untouched. The lower land with its town was invaded. There is so little timber in the Italian masonry construction that the uninvaded part of the town was not burned at all. At Ottajano the roofs fell in under the weight of sand and gravel. The roofs were largely flat or slightly sloping tiled affairs. The ash and lapilli reached a depth of three feet on level surfaces. The roofs carried the walls with them in many cases, but there was no significant earthquake. There was no fire, destructive lightning, nor strong wind. The persons who perished were all found in the houses, where the sole cause of death was entombment in the ruins.

In both these towns suitable rebuilding might avert a similar catastrophe in the future. Arches and domes are the architectural forms best fitted to shed the sand-fall. Rebuilding on higher land and avoidance of the bottoms might do much to protect such a town as Boscotrecase from another attack of lava.

The Japanese have made systematic experiments to test the resistance of different forms of masonry to earthquake shocks. Similar experiments might well be made on volcano-proof construction, if human beings continue to insist on living within the five-mile limit of an active crater.

THE CALIFORNIA EARTHQUAKE

THE illustrations on the following pages picture very vividly the devastation wrought by the earthquake in California and need no further explanation. The Governor of California has appointed a commission to investigate the earthquake and to report how destruction from future earthquakes may be avoided. The commission consists of Messrs G. K. Gilbert, Andrew C. Lawson, George Davidson, J. C. Branner, H. F. Reid, and A. O. Leuschner, all of whom are well-known American geologists. Until the commission reports there is little to add to the explanation of the earthquake given by Mr Frederick Leslie Ransome in his article, "The Probable Cause of the San Francisco Earthquake," published in the May number of this Magazine. The Japanese government has sent Dr F. Omori, Professor of Seismology in the University of Tokio and inventor of the seismograph, to San Francisco to report on the earthquake.

About 1,400 earthquake shocks are recorded yearly in Japan, but less than 50 of them are sensible.

Photo by L. H. Hicks, Courtesy of The Mazamas

A Difficult Bit of Rock Climbing. This perpendicular cliff (300 feet in height) is just below the summit of Mount Jefferson, middle ridge of the north side

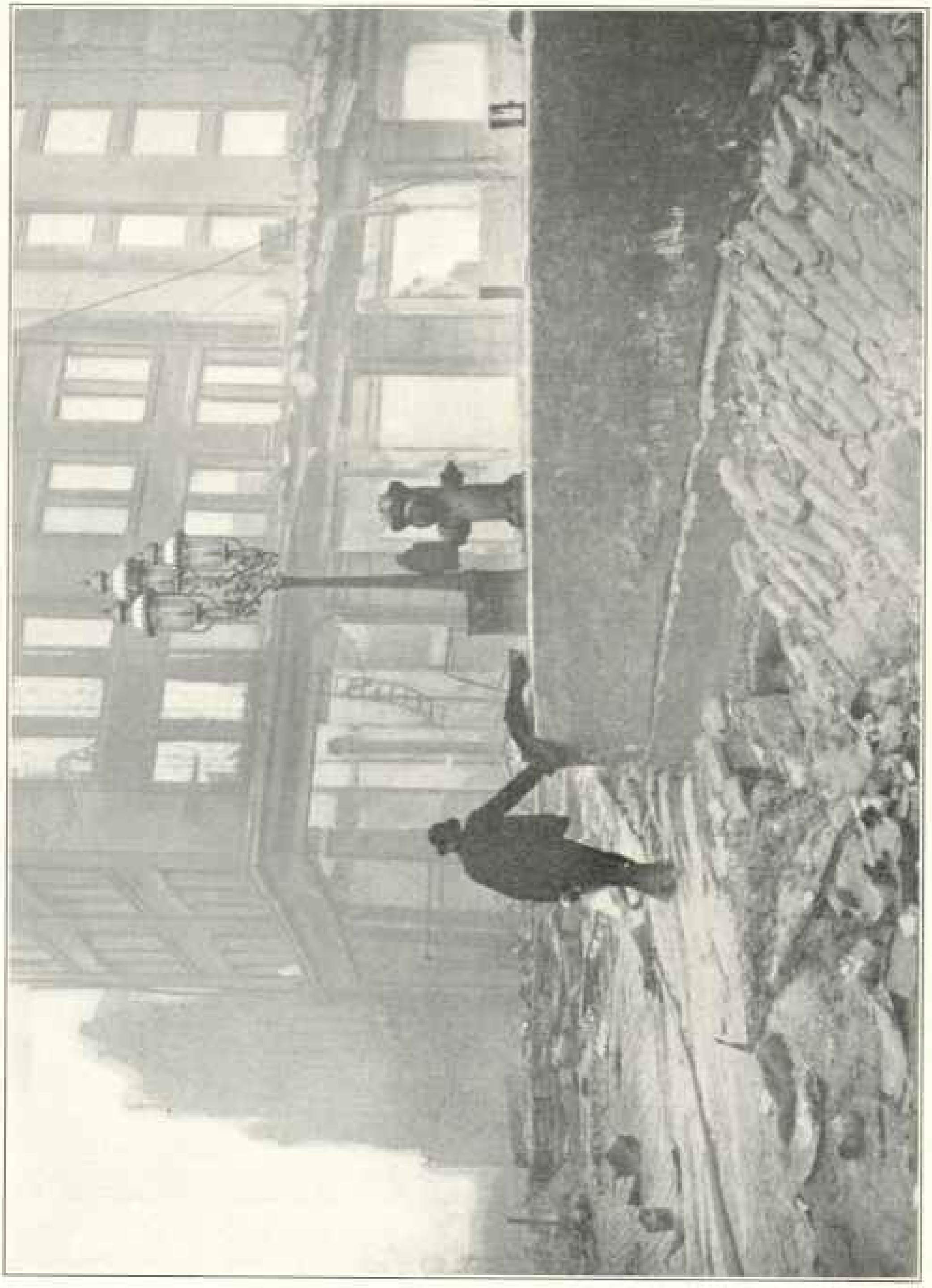
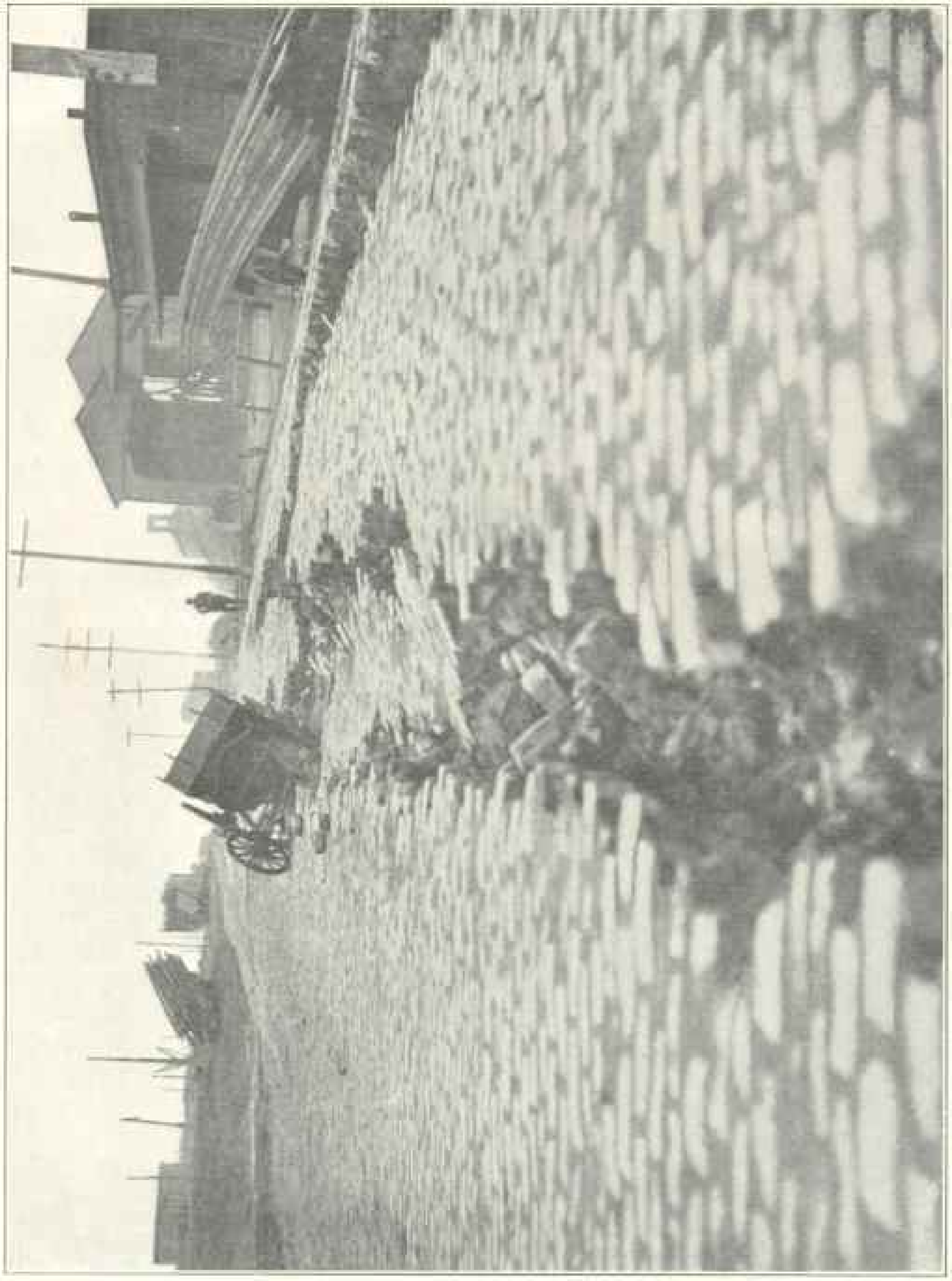


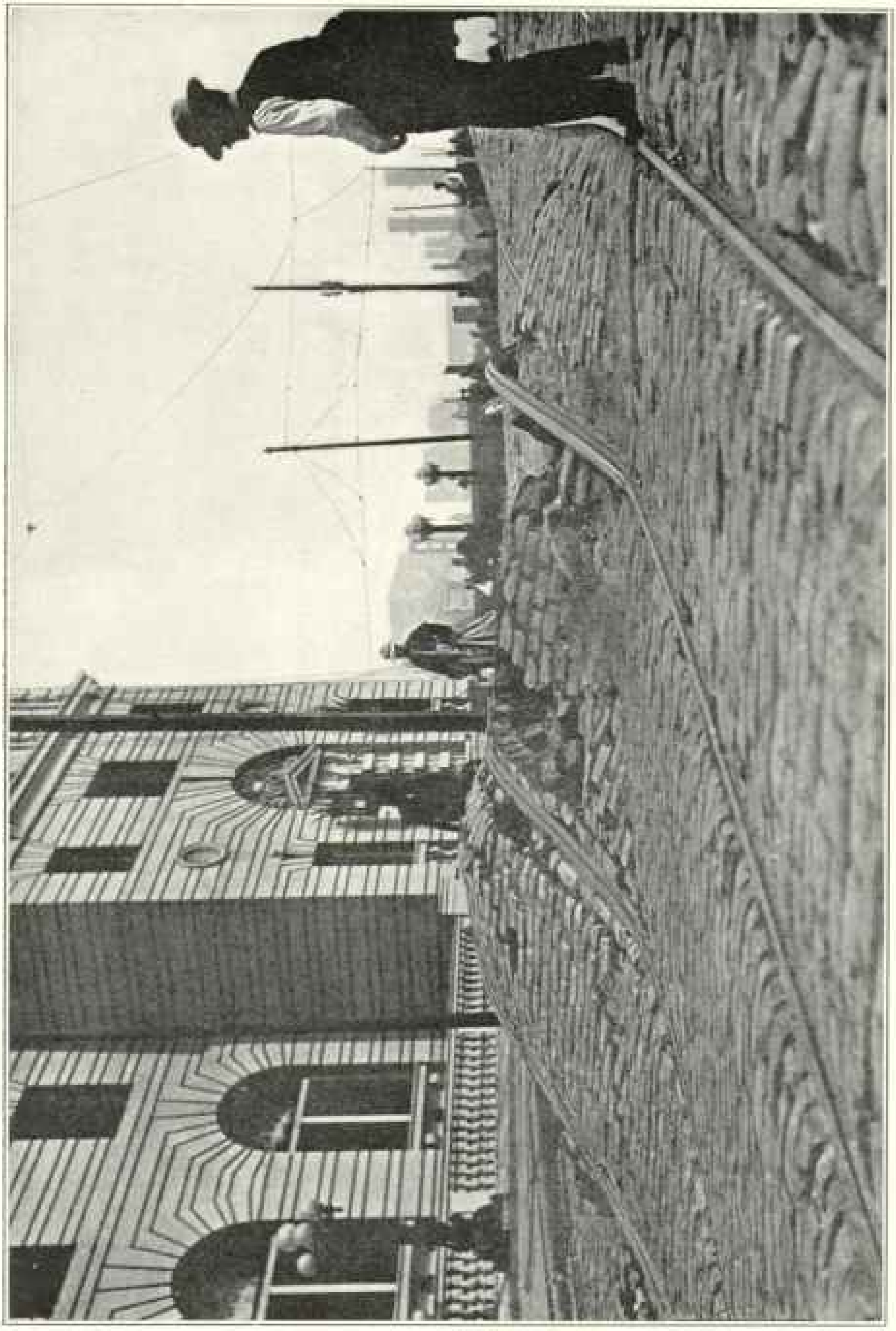
Photo by W. C. Mendenhall, U. S. Geological Survey

Sinken Area on Market Street near the Ferry Building. The street has dropped 4 feet from the curb



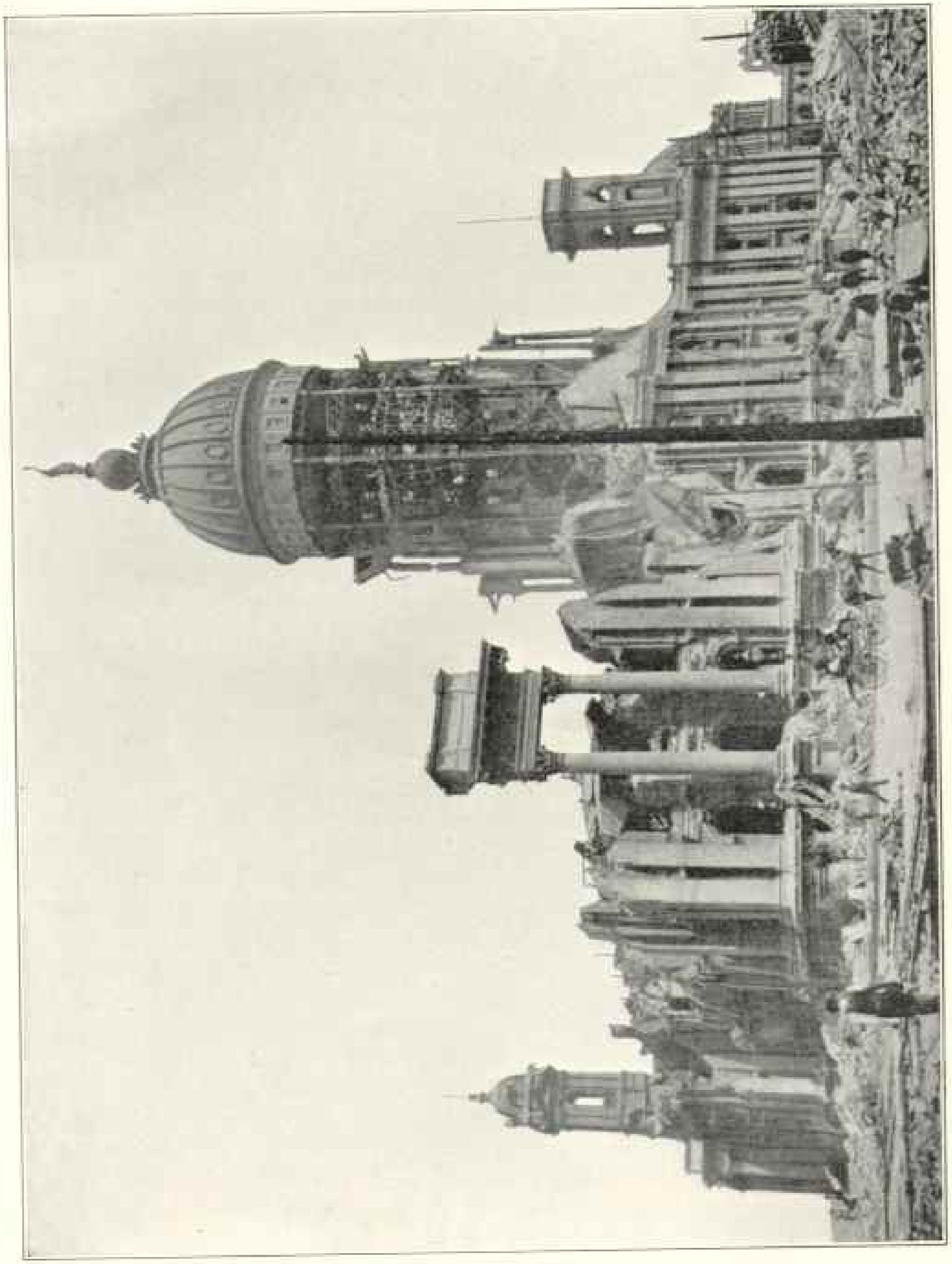
A Fissure Opened by the Earthquake on East Street

Photo from Wallace Lindgren, U. S. Geological Survey



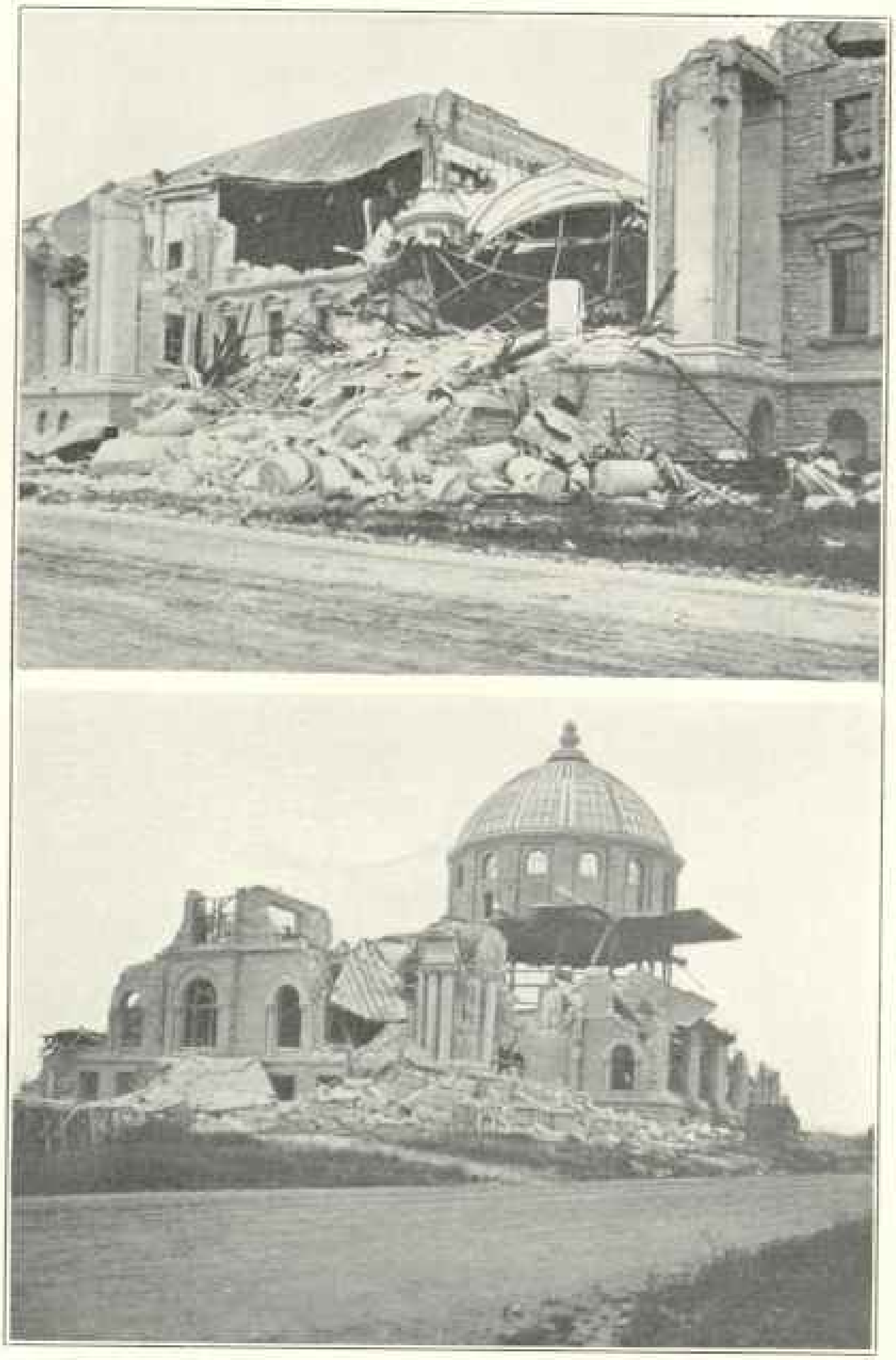
An "Earthquake Wave" at Seventh Street and Missouri Avenue at the Corner of the new U. S. Post-office

Photo from Waldemar Lindgren, U. S. Geological Survey



The City Hall. Most of the damage on this structure was caused by the earthquake

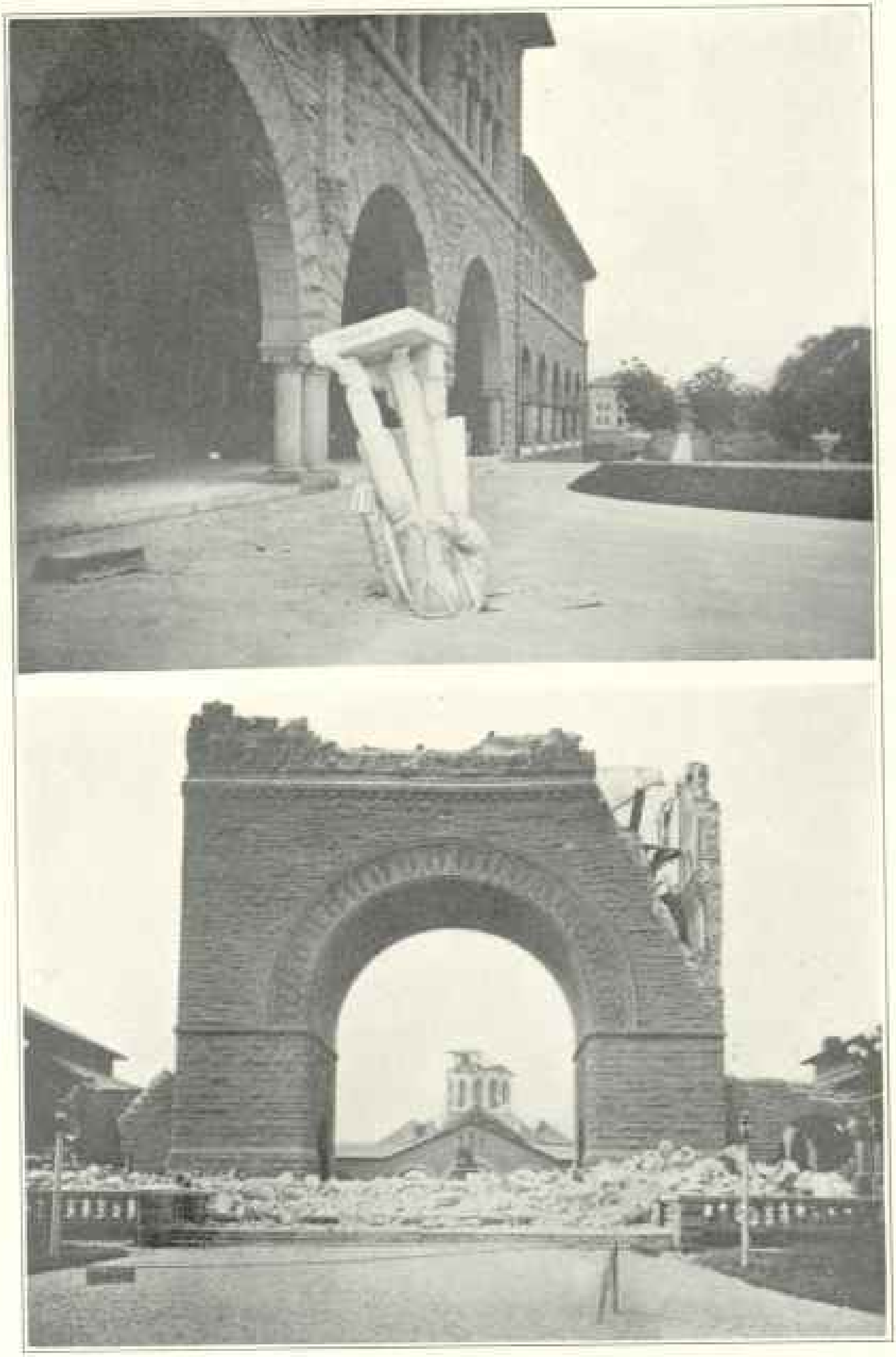
Photo by W. C. Mendenhall, U. S. Geological Survey



Photos by W. C. Mendenhall, U. S. Geological Survey

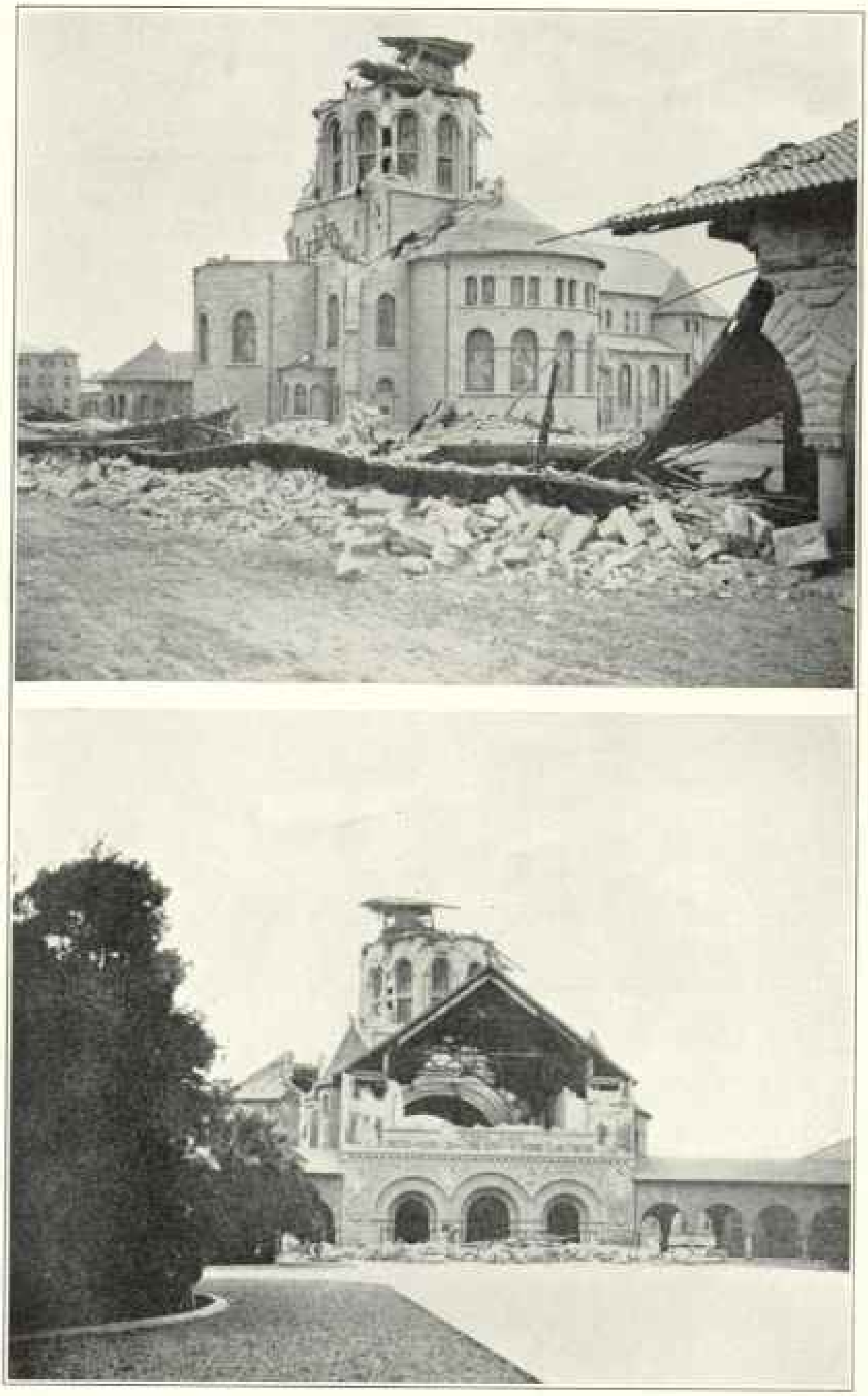
Scenes at Leland Stanford, Jr., University. The Gymnasium and the Library

While the larger buildings of the University were seriously damaged, the lecture halls and dormitories, being one story structures, escaped with slight injury



Photos by W. C. Mendenhall, U. S. Geological Survey

Scenes at Leland Stanford, Jr., University. The Agassiz Statue and the Great Arch



Photos by W. C. Mendenhall, U. S. Geological Survey

Scenes at Leland Stanford, Jr., University. The Chapel and Collapsed Corridor from the rear. The Chapel as it Appears from the Inner Quadrangle

Photos by W. C. Mendenhall, U. S. Geological Survey

Scenes at Palo Alto. Opposite the depot. A Wrecked Building on University Avenue

Photo by T. R. Wilton, U. S. Weather Bureau

The Two Spires of St Dominic, Destroyed by Earthquake

Photo by W. C. Mendenhall, U. S. Geological Survey

At the Junction of Pine and Market Streets

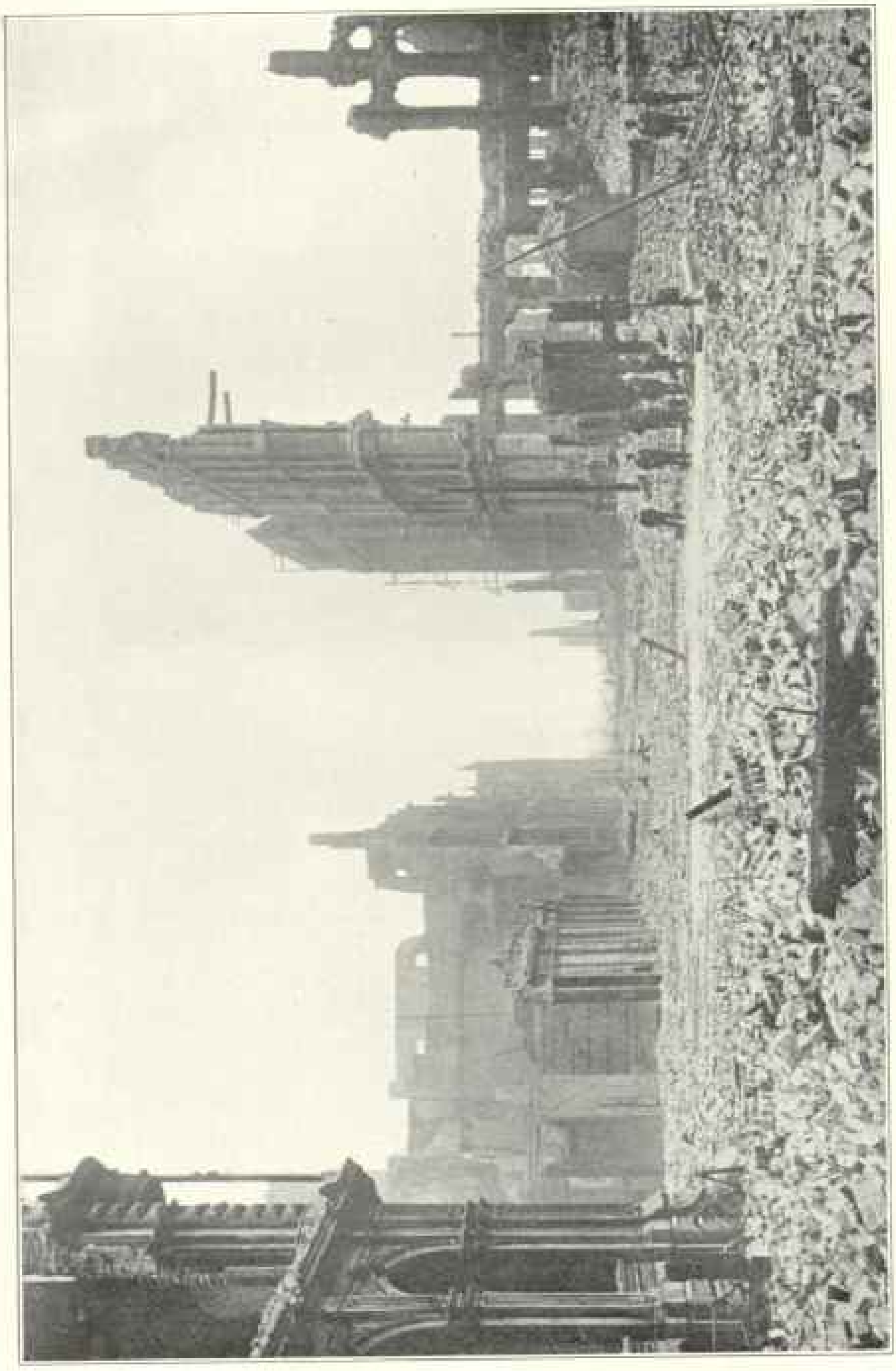
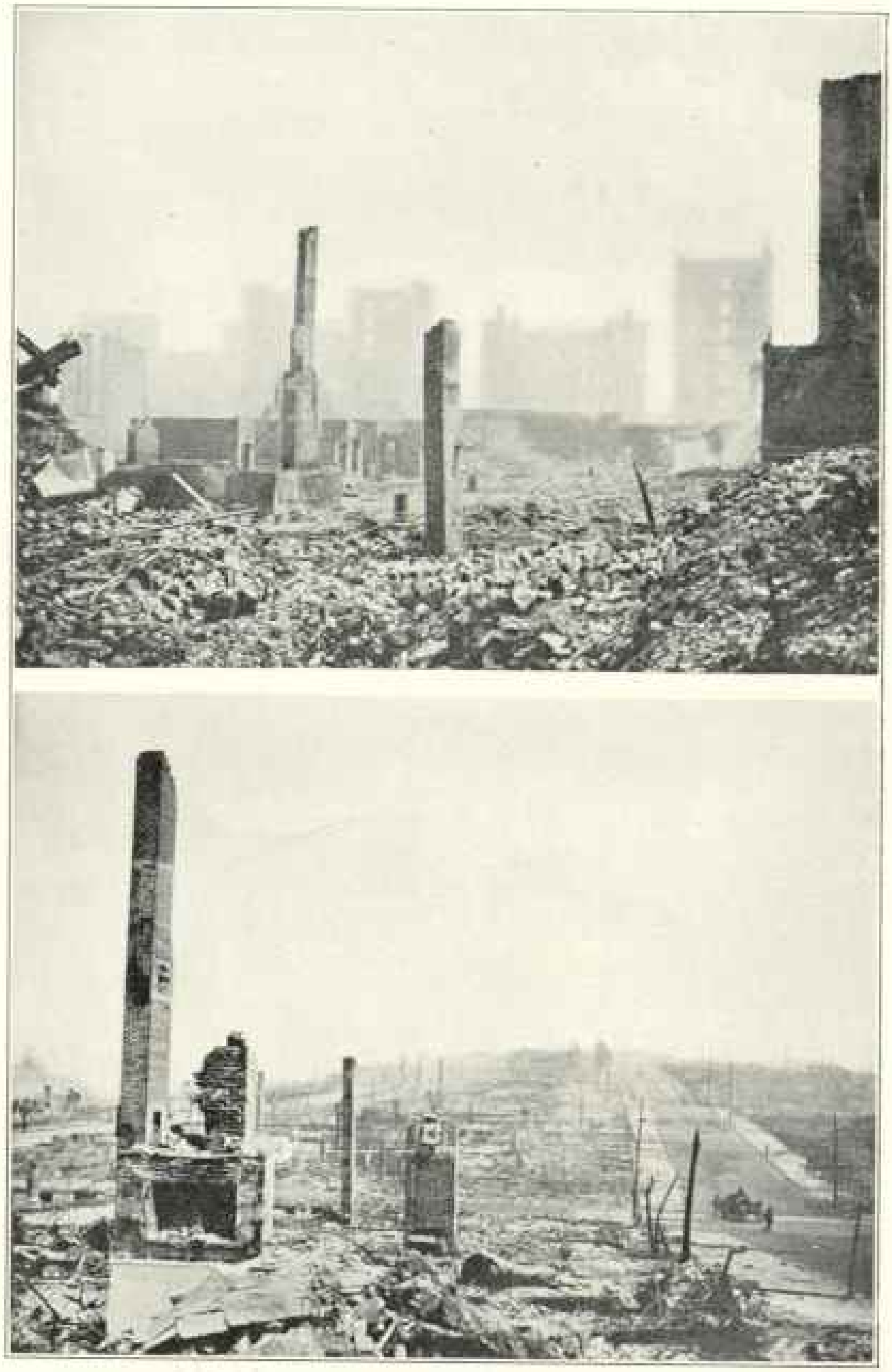


Photo from Waldemar Lindgren, U. S. Geological Survey

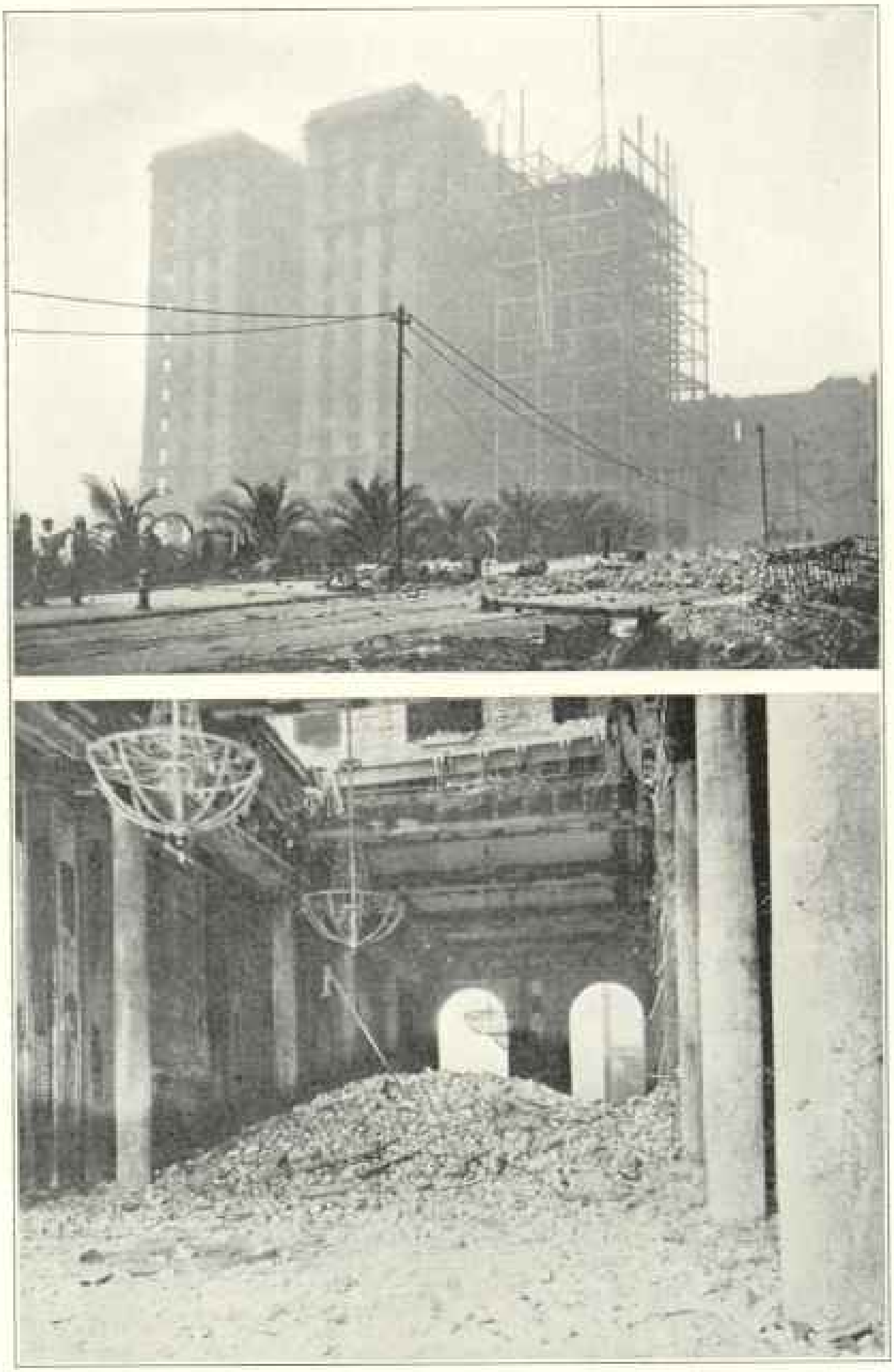
Looking down Pine Street, the Nevada Bank on the left, and Headquarters of the California Miners' Association

The High Wall on the right is the Stock Exchange Building



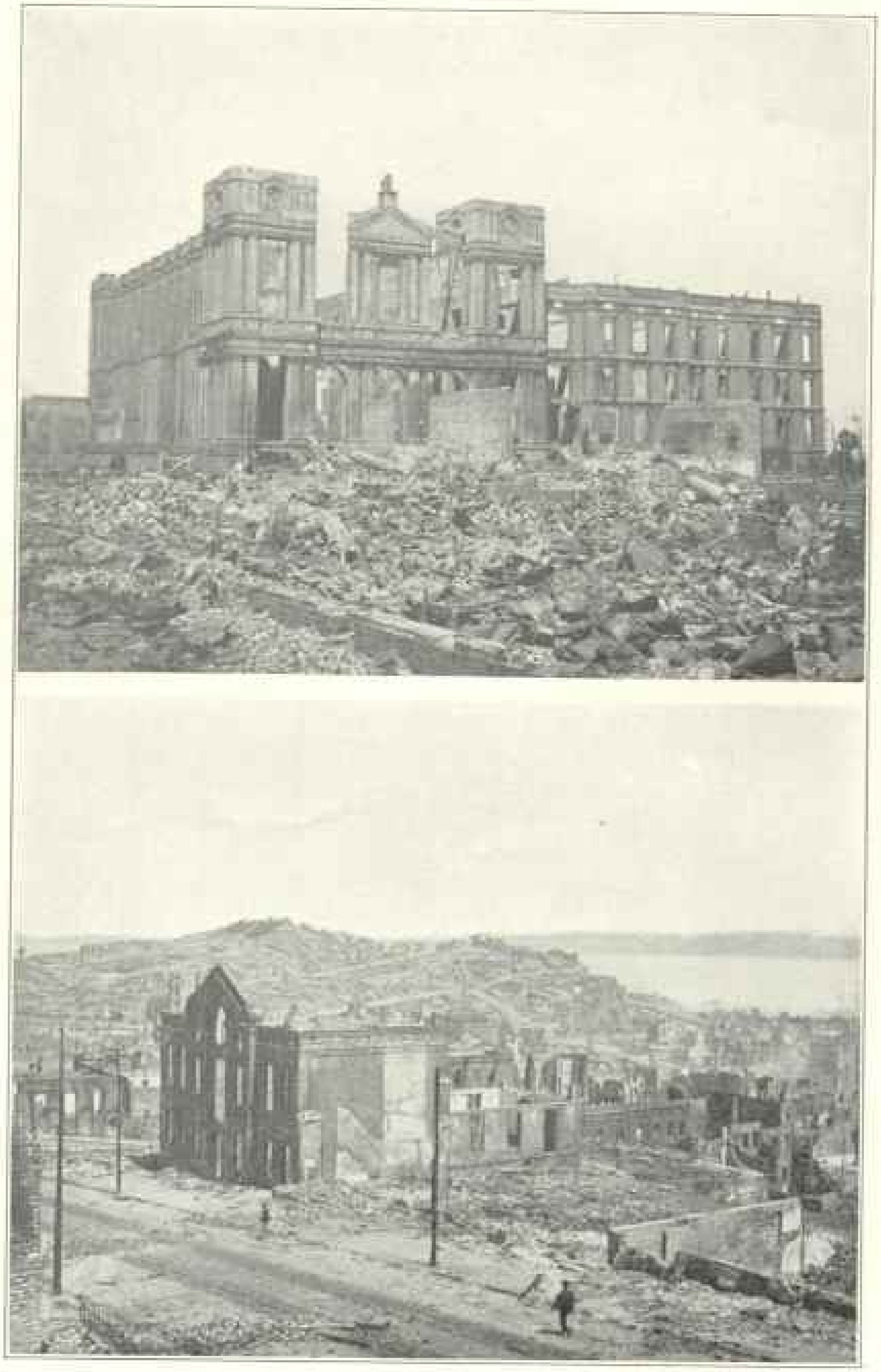
Photos by W. C. Mendenhall, U. S. Geological Survey

Looking East from Jones Street. Nob Hill from Van Ness and Washington Streets



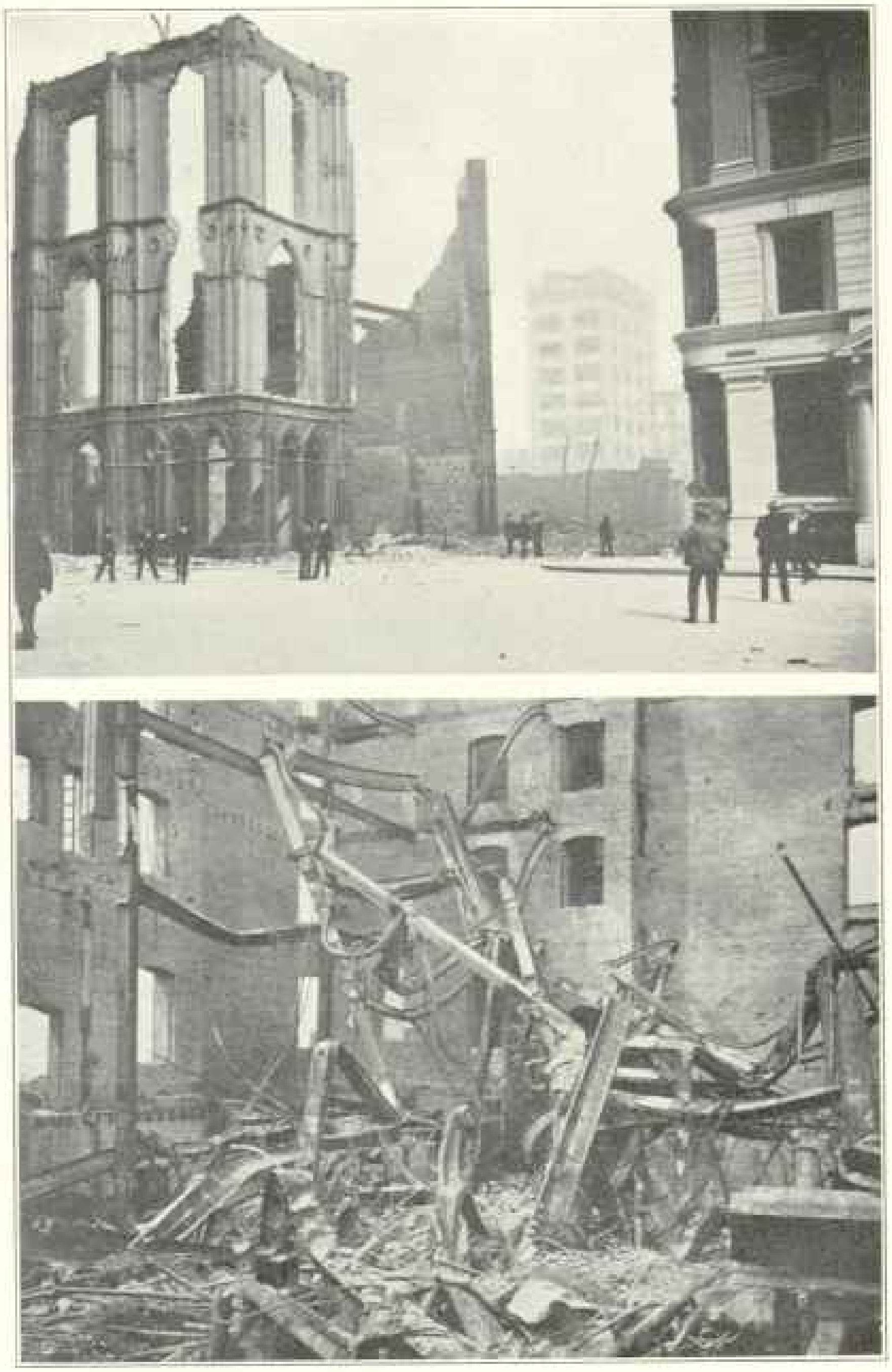
Photos by W. C. Mendenhall, U. S. Geological Survey

St Francis Hotel. Blue and Gold Room, St Francis Hotel, after the Fire



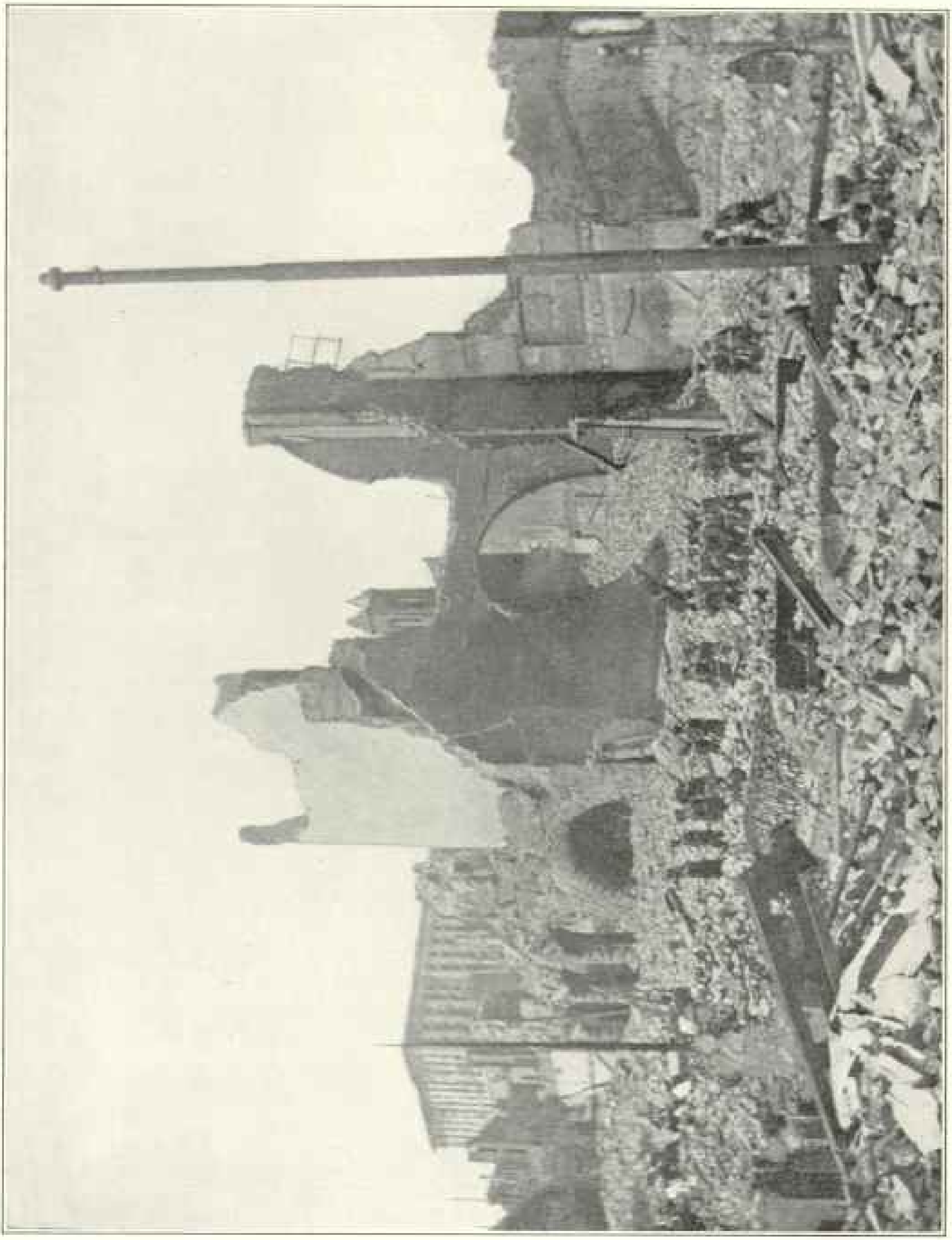
Photos by T. H. Wilton, U. S. Weather Bureau

The Commercial High School
St Ignatius Church and College destroyed by Earthquake and Fire.



Photos by W. C. Mendenhall, U. S. Geological Survey

Montgomery Street from Market Street. An Interior



The Remains of the California Hotel. Fairmont Hotel in the distance. Soldiers marching to Relieve a Squad

Photo by T. H. Wilton, U. S. Weather Bureau

Photo from Waldemar Lindgren, U. S. Geological Survey

The Custom House (Appraisers' Building), Corner of Washington and Battery Streets. This building was built by and belongs to the U. S. government, and, like the Mint, escaped with slight injury, though surrounded by burning buildings

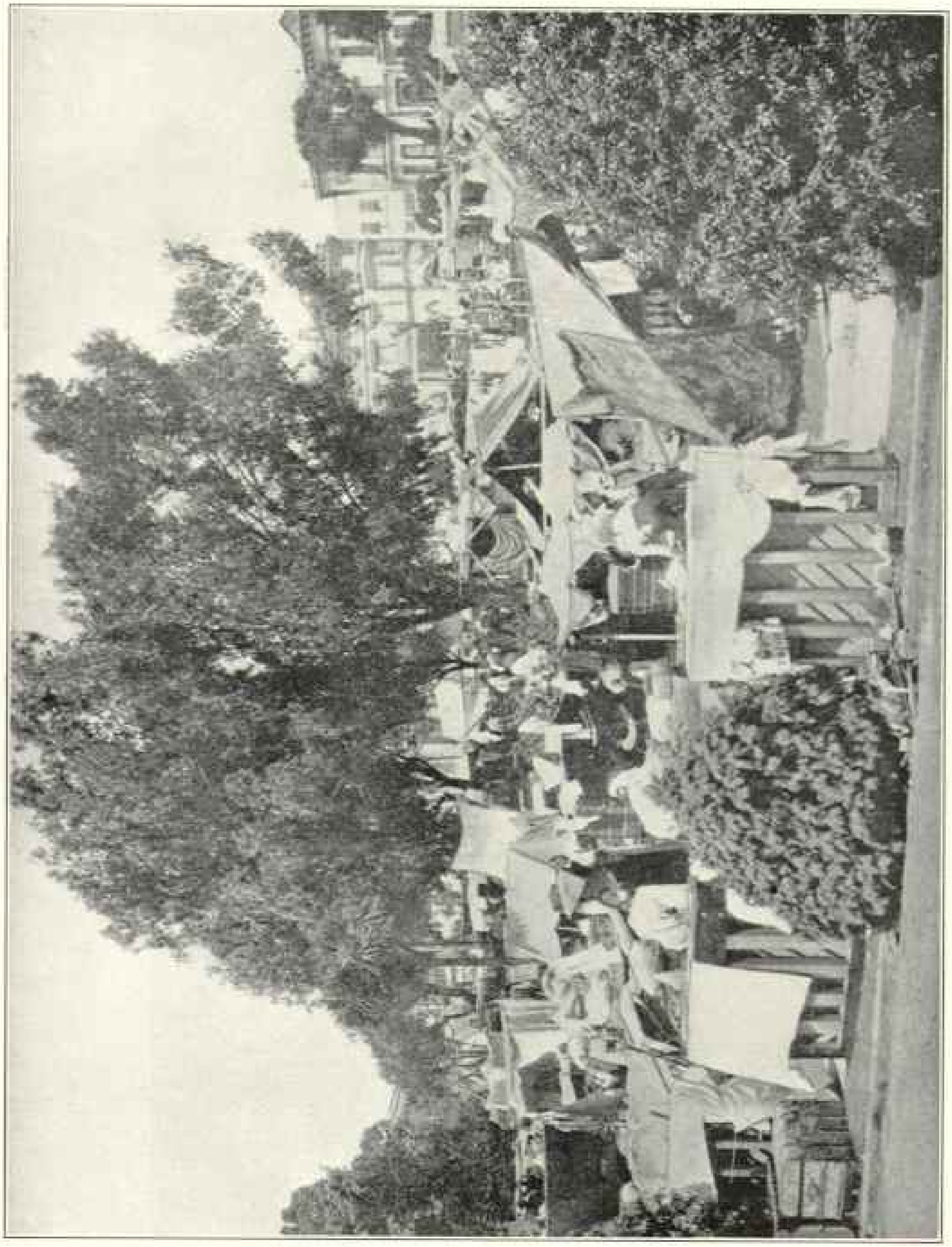
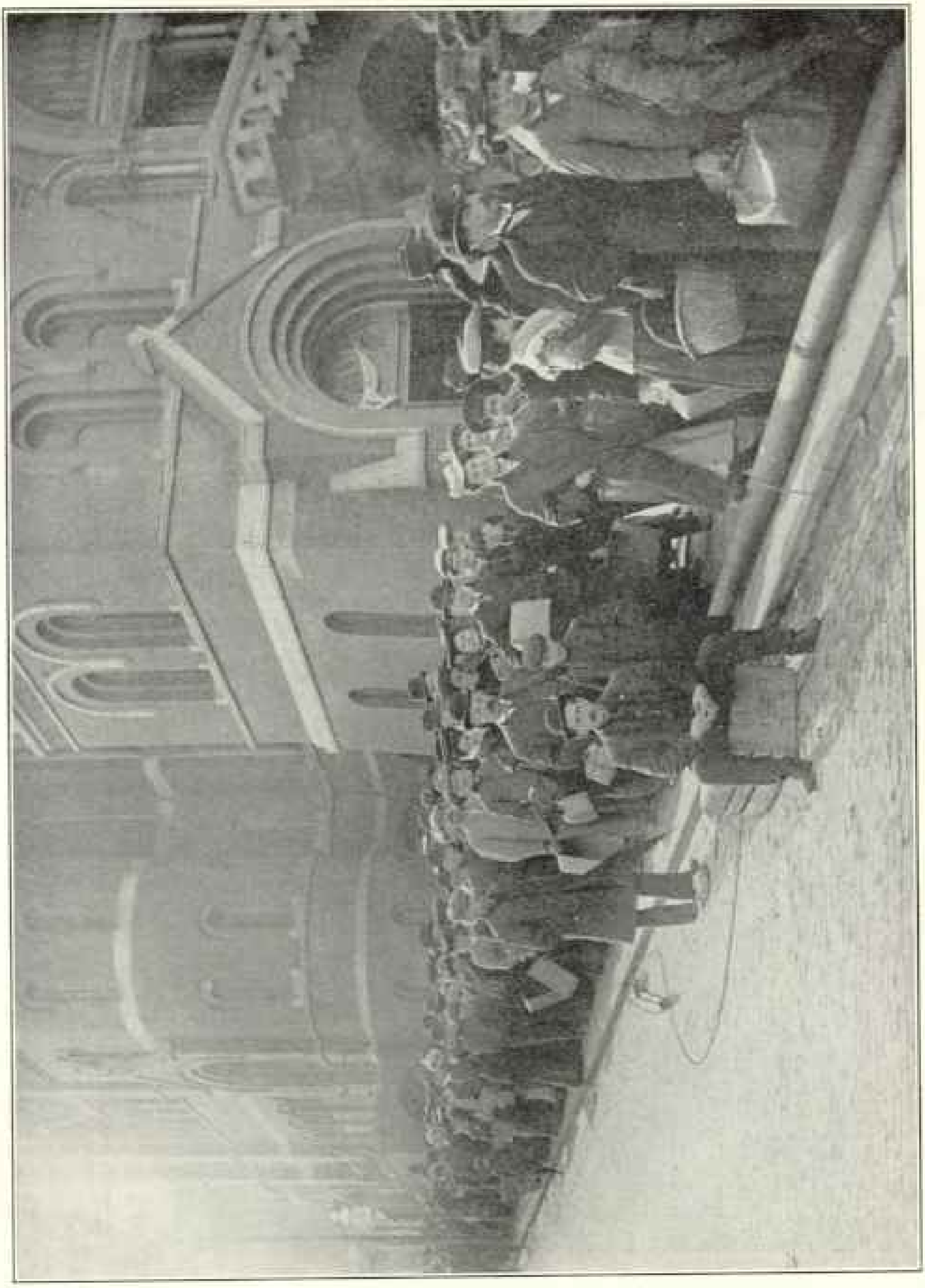


Photo by W. C. Mendenhall, U. S. Geological Survey

Camping Out in Jefferson Square



San Francisco Getting Fed. The "Bread Line" at a Relief Station near St Mary's Cathedral. Government Supplies. Note the good humor of the crowd, characteristic of all the people during and since the catastrophe

Photo from Waldemar Lindgren, U. S. Geological Survey

THE DIAMOND MINES OF SOUTH AFRICA

By Gardiner F. Williams
General Manager of the De Beers Diamond Mines

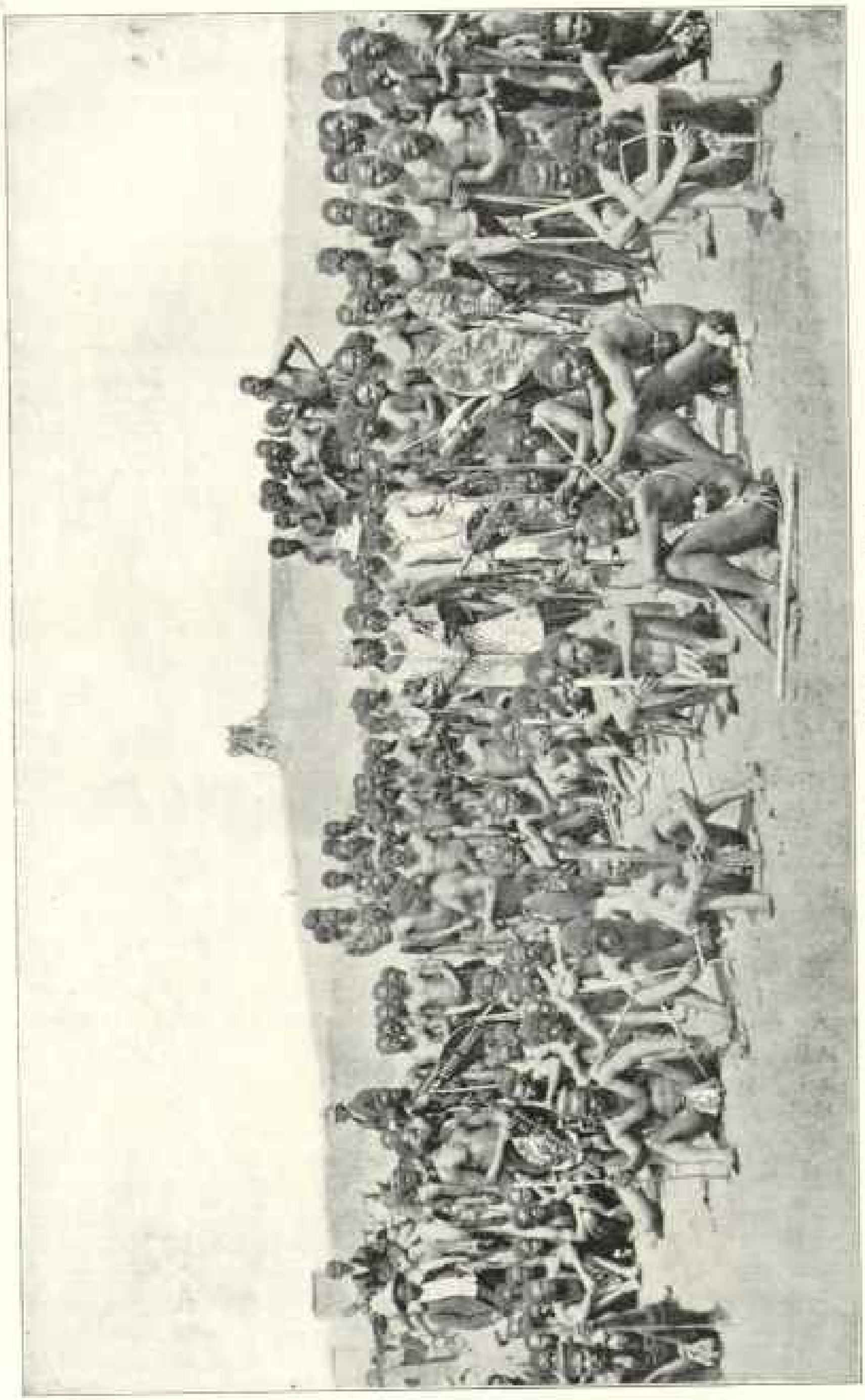
The following article, which is the substance of an address to the National Geographic Society, is largely derived from two handsome volumes by Mr Gardiner F. Williams, "The Diamond Mines of South Africa," a new edition of which has been recently published by B. F. Buck & Co., of New York. In this work Mr Williams gives an interesting account of the Zulus and other South African natives, of the Boers and of their terrible struggle with the Zulus, of the coming of the Englishman, and the discovery, exploitation, and development of the wonderful De Beers mines. The article and pictures are copyrighted by Mr Williams.

NOWHERE else on the face of the earth is there an assemblage of workers of such varied types of race, nationality, and coloring as are to be seen in the South African diamond fields. There is hardly a nation of Europe or colony of the British Empire that has not some representatives. There are adventurers from the United States, Mexico, and South America, and white men from all the colonies of South Africa mingle with the masses of native Africans of every shade of dusky hue shown by the tribes that range from the Cape to the Equator. Even the American Indian is not unknown in the fields, one specimen at least having resided there for many years. Add to this motley throng a sprinkling of dark East Indians, Malays, and Chinese, and the kaleidoscopic shifts and colorings of this babel in the diamond fields may be dimly conceived.

Only about one-sixth of the workers in the mines are whites, and the larger part of these are employed above ground on the floors, in the workshops, and in the offices of the mining companies.

The majority of the white workers above and below ground have their homes in Kimberley and the other neigh-

A Zulu and His Ten Wives



Zulu Workmen of the Diamond Mines

boring mining towns. Wages paid to European day laborers on the surface range from 10s. to 15s. ($2.40 to $3.60) a day; mechanics receive higher pay, which ranges from 16s. 8d. to 1 pound ($4 to $5) per day, and white miners are paid the same rate. Miners who prove their competence are given contracts for specified work, by which their earnings are usually materially increased.

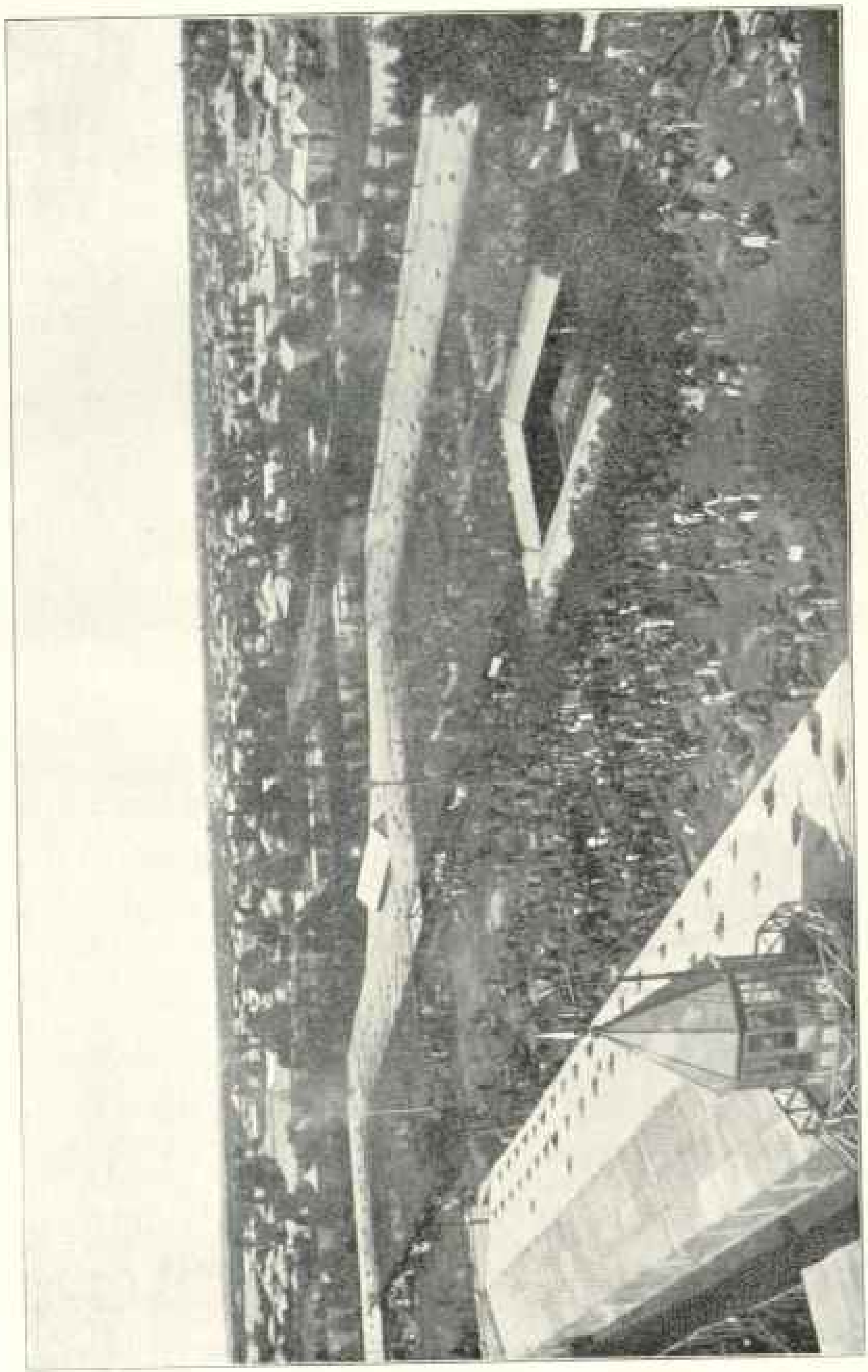
Employees' houses in Kimberley are scattered through the town and many of them own their own homes. Some of the miners' houses cost 500 pounds or over.

In the mines operated by the De Beers Company alone more than eleven thousand African natives are employed below and above ground, coming from the Transvaal, Basutoland, and Bechuanaland, from districts far north of the Limpopo and the Zambesi, and from the Cape Colony on the east and the south to meet the swarms flocking from Delagoa Bay and countries along the coast of the Indian Ocean, while a few cross the continent from Damaraland and Namaqualand and the coast washed by the Atlantic. The larger number are roughly classed as Basutos, Shanganes, M'umbanes, and Zulus, but there are many Batlapins from Bechuanaland, Amafengu, and a sprinkling of nearly every other tribe in South Africa. Many travel hundreds of miles, and some more than a thousand miles, in order to reach the diamond fields, and many of these arrive half starved and so weak and emaciated that they are almost worthless as laborers for weeks afterward. The natives, as a rule, are generally muscular, sinewy men, but not fleshy. Their feet are broad and flat, but their legs and arms are commonly well rounded and their thigh and shoulder muscles are large. The living skeletons who come in from the far interior districts of Africa gain flesh as rapidly when they reach a field flowing with meat and porridge as lean cattle do in green pastures. In the early years of the mines the raw recruits were hooted at and sometimes pelted with stones by their kinsmen at the mines, but of late years this rough greeting and hazing has very largely passed away.

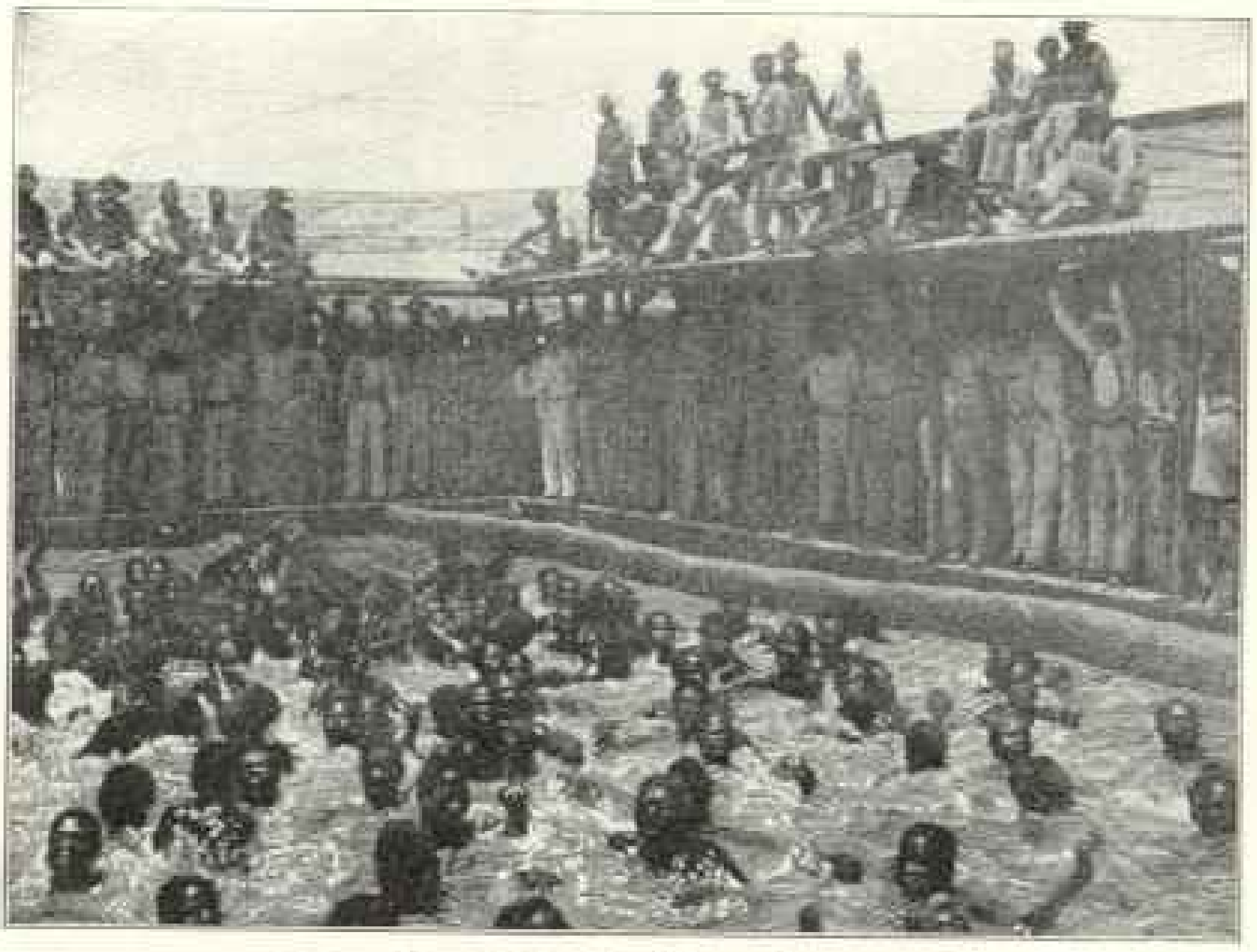
THE DE BEERS COMPOUND

For the lodging and feeding of this great force of native Africans special provision is made by the erection of large walled enclosures, called compounds, at the mines and on depositing floors. There are 17 of these compounds on the diamond fields, twelve of which are owned by the De Beers Company. The largest of all is one at De Beers mine, and the description of this will serve for all, as they are essentially alike except in size.

Fully four acres are enclosed by the walls of the De Beers compound, giving ample space for the housing of its 3,000 inmates, with an open central ground for exercise and sports. The fences are of corrugated iron, rising ten feet above the ground, and there is an open space of ten feet between the fence and the buildings. At the northern end of the compound there is an entrance gate. Iron cabins fringe the inner sides of the enclosure, divided into rooms 25 feet by 30 feet, which are lighted by electricity. In each room 20 to 25 natives are lodged. The beds supplied are ordinary wooden bunks, and the bed clothing is usually composed of blankets which the natives bring with them or buy at the stores in the compound, where there is a supply of articles to meet the simple needs of the natives. Besides these stores there is a hospital and dispensary, where any needed medical attention is promptly given, and a church for religious services, conducted by missionaries delegated by the various church denominations. During week days this church is also used as a school for the instruction of the natives. Compartments with entrances opening through the walls are set apart for latrines and cared for with strict attention to sanitation. In the center of the enclosure there is a large concrete swimming bath, in which most of the natives are at times found diving and swimming, as is vividly shown in the accompanying illustrations. If any fail to show the



De Beers Compound, showing Swimming Bath in Center



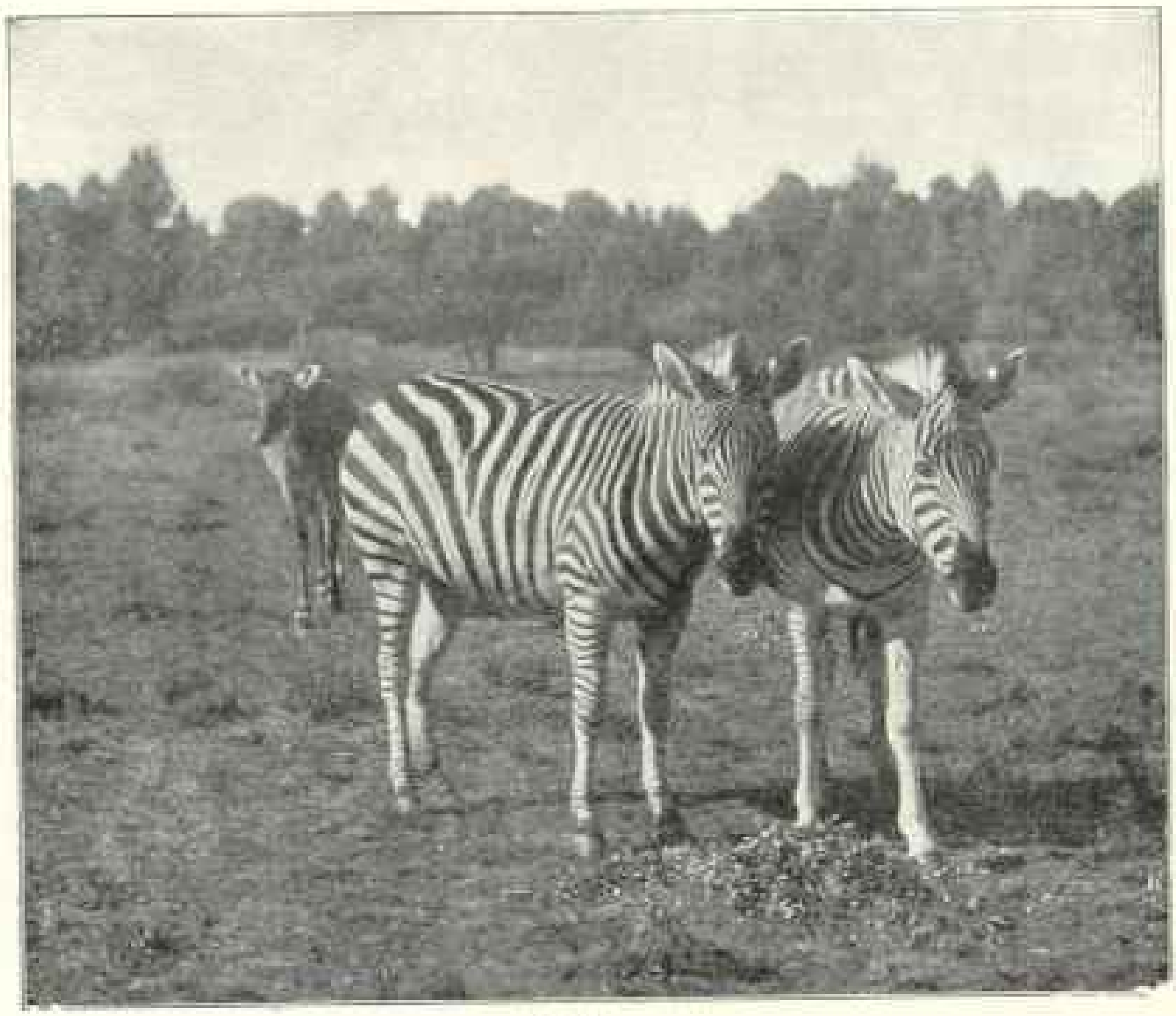
Swimming Bath, De Beers Compound

necessary regard to cleanliness they are compelled to keep themselves clean.

A competent manager is in charge of the compound and his assistants are intrusted with the charge of preserving order and enforcing the compound regulations. The natives look upon the manager as their great white chief. He settles any disputes which may arise among them, and in conjunction with the mine manager investigates any complaints in reference to the amount of pay which has been allowed them or any punishment or ill treatment by their white "baases, which, needless to say, is contrary to the regulations.

The compound is lighted by electricity, arc lights being hung within and without the enclosure. When a newcomer or a number of natives, for they usually come in little troops, apply at the gate of the compound for employment, the applicants are admitted into the compound only by the immediate direction of the manager or his assistants. As soon as they enter, their clothes are searched to prevent the smuggling in of liquor, playing cards, or other forbidden articles; then the officer in charge of the dispensary examines each separately and carefully. No diseased man is given work, and any suffering from contagious diseases are sent at once to a quarantine building outside the compound, where a temporary provision for such cases has been made. Within 24 hours a second examination of every one admitted who shows any symptoms of the disease is made by a physician in the employ of the company who daily visits the compound.

To enter the service of the company, each applicant must sign a written contract binding himself to live in the compound and work continuously and faithfully for a period of at least three months or longer if he so desires. At the expiration of a contract the applicant may leave if he chooses or his contract may be renewed indefinitely. Some of the natives in De Beers compound have been employed continuously for ten years or more in the service of the company, for



Zebras

the more industrious prefer the certainty of wholesome food and steady pay to the shifting to any other occupation that is open to them or to return to their old savage life.

The ordinary dress of the natives in the compound is a woolen shirt, trousers, and shoes. They rarely wear any underclothing, and when at work in the mines a pair of ragged trousers, a blanket, or old breech cloth will often be their only covering. Occasional visitors to the mine are startled by the native disregard for cover; but the natives are commonly alert to pass the word "umfas" (woman) from one to another when a lady visitor is seen in the mines, and then the native workers on the level ahead scramble for cover or hiding.

When any injuries happen to the men from accidents in the mines, the suffering natives show remarkable fortitude in bearing pain and enduring the necessary surgical operations. Their blood is warm and pure, and cuts in their flesh, or bruises, heal very rapidly. They suffer most from diseases of the lungs, especially phthisis and pneumonia, which are common maladies of the native tribes outside of the mines as well as within the compounds. They can readily obtain fresh vegetables and fruit, but the common choice of food, such as mealie meal and meat, exposes them to attacks of scurvy.

ATTEMPTS TO STEAL THE DIAMONDS

No corporal punishment of the natives by white employers is allowed. If a boy is unruly he may be placed in a room by himself until he can be taken to jail and charged with whatever offense he has committed. The most common offense is petty thieving.

There can be no doubt that the covert purloining of diamonds would be a fre-

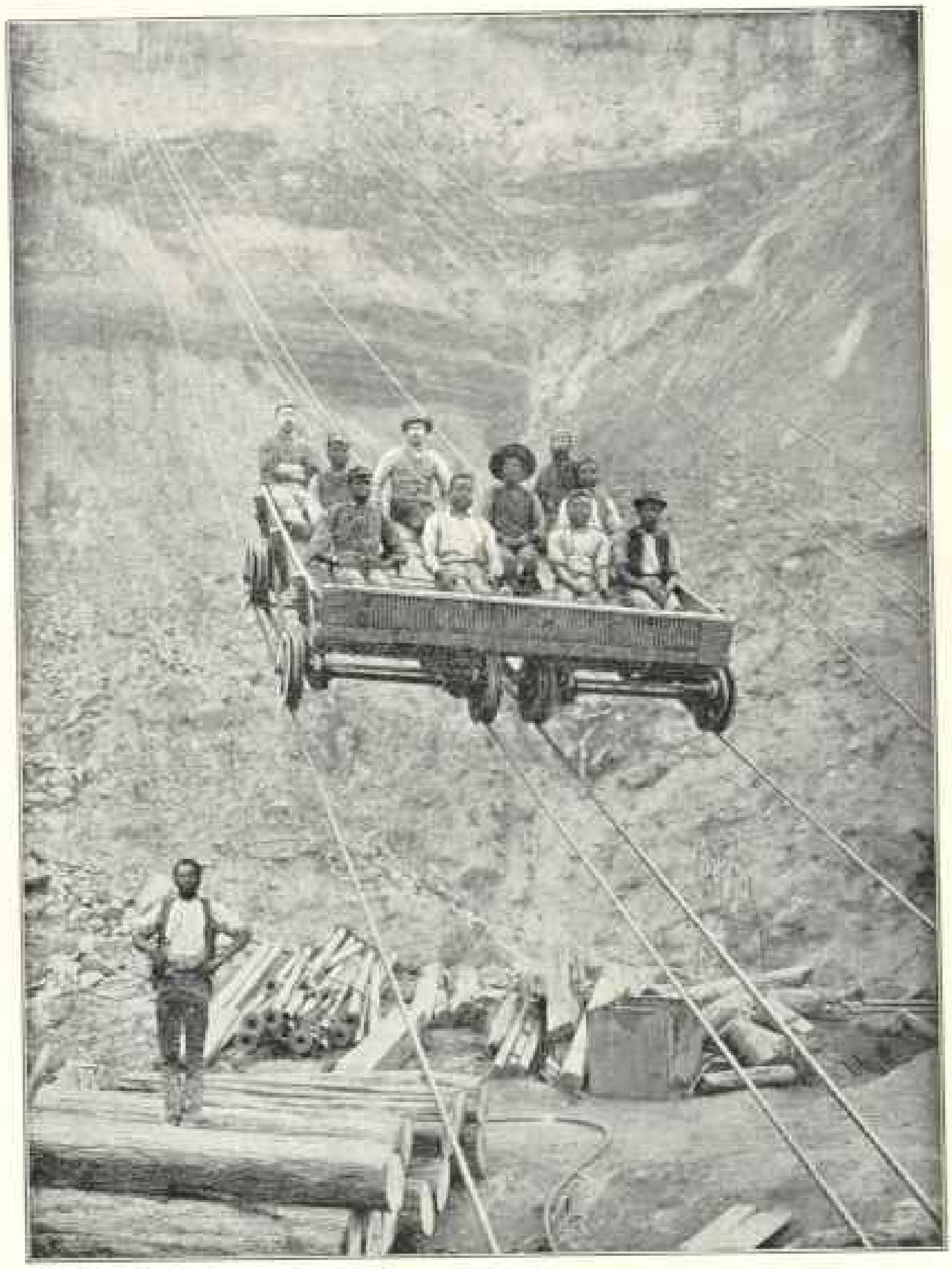
A Diamond Thief, and the Diamonds which he had Swallowed and which were Recovered by the Guards in the Compound

quent practice and cause heavy losses to the diamond mining companies if it were not for the compound system, which makes it impossible for natives to take any diamonds out of the compounds with them.

A fine wire netting is stretched over the top of the compound to prevent the sly tossing of precious crystals over the walls, to be picked up by confederates outside the mining areas. Precautions are also taken to prevent the smuggling away of diamonds from the compounds, and all communication by the natives with persons outside the walls is carefully restricted. Until the expiration of his contract, no native can go through the compound gate except by special permission or when he is taken under guard before a magistrate for some offense. If convicted, when his term of imprisonment expires or after he has paid his fine he must return to the compound and complete his contract. Before leaving the compound his clothes and person are thoroughly searched to prevent the disappearance of diamonds with them. Gems were sometimes found secreted in clothing, or shoe heels, or canes, or cans with false bottoms—in fact, in anything that the natives were allowed to take out with them. Even this close inspection did not bar the practice of stealing, and there was an inexplicable trickle of diamonds from unlooked-for quarters until it became known that natives on the point of leaving the compound were swallowing diamonds and conveying them away.

In 1895 one native had the nerve and capacity to swallow a lot of diamonds worth 750 pounds, and did not appear to suffer from this strain upon his digestion. There has been only one authentic instance where a native has embedded diamonds in his flesh; this was done by a native in De Beers convict station, who made an incision under the shin bone and concealed several small diamonds wrapped in a rag. This native had symptoms of tetanus, and the visiting physician searched the man's body, and finding an ugly looking wound on his leg, cut it open, and to his great surprise found a rag full of diamonds. The native soon recovered, a wiser, if a poorer, man. There is no apparent fear of swallowing any stone which can be forced through the throat, and in one instance a diamond as big as a large chestnut and weighing 152 carats was hidden for seven days by this means.

The swallowing of a rough diamond is evidently so easy, but so difficult to detect, that it was necessary to put an end to the practice by providing a longer period of detention and search. At the close of their contracts, natives whose terms of service have nearly expired are placed together in a commodious room capable of holding two hundred men or more. They enter this room entirely naked. Their clothes and baggage are deposited in sacks marked in accordance



Miners Going to Work

with the number on the arm band. Blankets are supplied for clothing and as wraps when sleeping. They are fed, and generally well cared for, free of cost to themselves. While in the detention room they are under strict supervision of white guards, so that any diamonds they may have swallowed must be left behind before they leave. Natives have been known to keep diamonds in their bodies for over seven days. At the end of five days of detention, generally on Saturday morning, they are released. Meanwhile the clothes placed in the sacks have been

thoroughly searched, and departing natives are not allowed to take away with them anything but soft goods. In fact, they are even required to leave their boots behind, for cunning smugglers used to insert diamonds in their boot heels so neatly that the trick could not be detected without cutting away the greater part of the sole of the boot. Boots and shoes and other articles which are not allowed to be taken from the compound are sold or given away to customers or friends before their owners leave.

It may be that De Beers compound is a "Monastery of Labor," as was wittily said by a lady visiting the fields as a correspondent of the *London Times*, but the testimony of all careful observers on the ground affirms the beneficial effect of the restrictions from dissipation and the general good cheer of the workers. Mr Thomas H. Leggett, an entirely independent and competent American witness, wrote of his inspection of the men of the compounds: "These chaps are well cared for, contented, and happy, as proven by the fact that many have been there for years; and the secret of it lies in their not being able to get drink."

Traction Engine for Harrowing Blue Ground

WINNING THE DIAMOND

The diamonds exist in a hard blue ground which millions of years ago gushed up from the interior of the earth and filled the throats of volcanoes.

Thousands of tons of this blue ground

are brought up daily from a depth of more than one thousand feet and spread over the floors. These floors are made by removing the bush and grass from fairly level stretches of ground. After clearing the face of the ground it is hardened and smoothed with heavy rollers until it is fit for use.

After the blue ground has been spread out, it is necessary to wait patiently until the sun and rain have contributed their service in disintegrating the breccia. The effect of the exposure of this curious compound to heat and moisture is very remarkable. Large pieces of blue, which are as hard as sandstone when freshly taken from the mine, soon begin to crumble on the depositing floors. To hasten the disintegration, the bed of blue is harrowed several times to turn up the bigger lumps and expose fresh faces of the ground to the sun. Spans of mules were originally used to drag the light harrows used in those days, but steam traction engines are now employed to draw wheeled harrows with huge teeth back and forth across the floors. So the great spread of the floors looks like some vast plowed farm where the laborers are preparing the soil for seed.

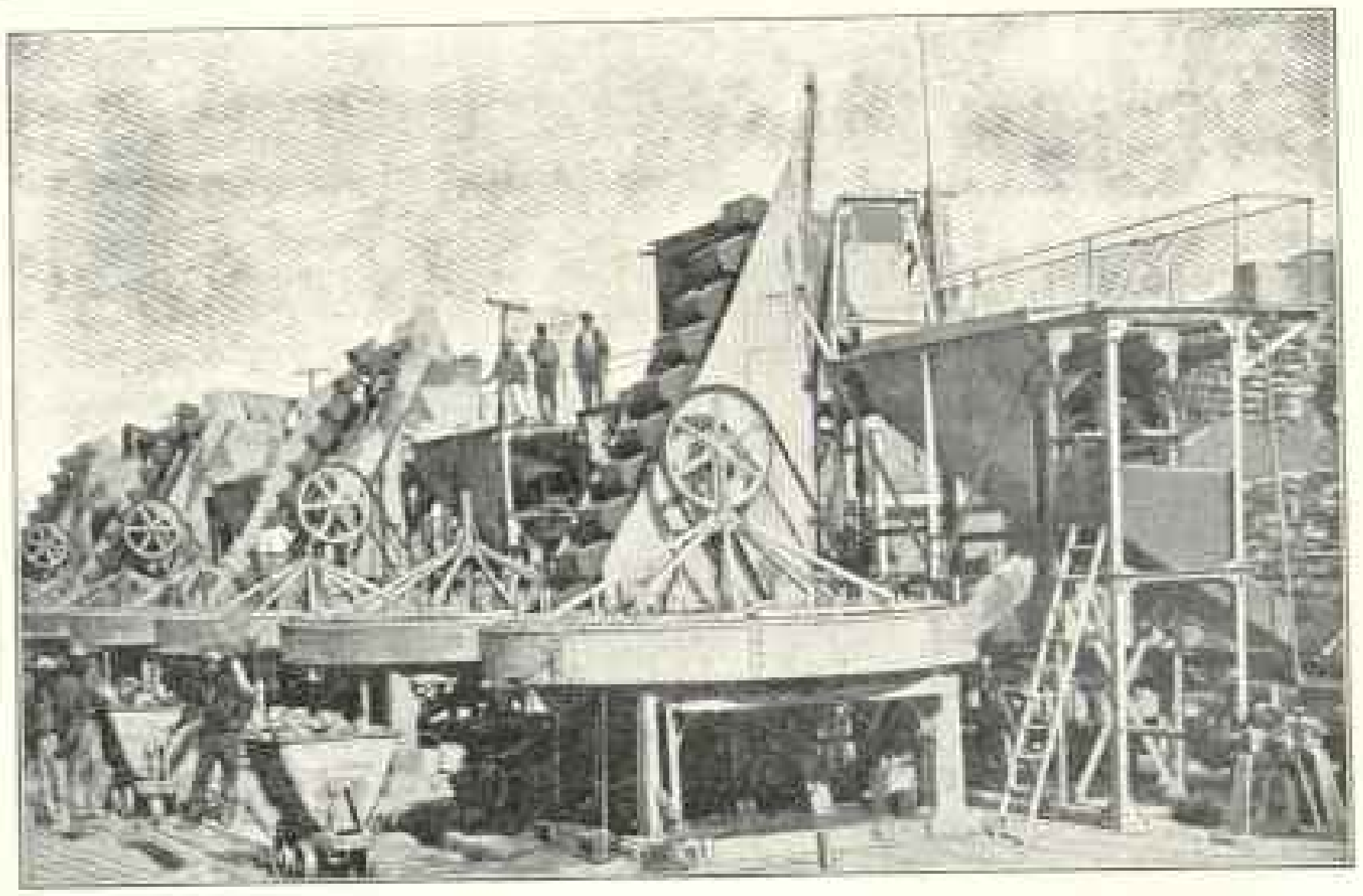
The diamonds are invisible. During the fifteen years of my charge of the De Beers mines I have never found a diamond on the floors.

Under normal conditions soft blue ground becomes sufficiently pulverized in from four to six months, but it is better to expose it for a longer period, even for a whole year.

The ground is then carried in automatic trucks to the washing machines, where it is mixed with water to a very thin mud and passed through a series of pans and screens. Fifty per cent of De Beers ground, when well pulverized, will pass through a screen with holes one-sixteenth of an inch square.

When the day's work is completed, the pans, through each of which three hundred loads have passed, are emptied or "cleaned up," and the concentrated deposits of diamonds, mingled with other heavy but valueless minerals, are then sent to the pulsator, which separates the diamonds sufficiently for the sorting tables.

The work of picking out the diamonds by hand from the concentrate on the sorting tables was, of course, necessarily slow and tedious. It was the only divis-

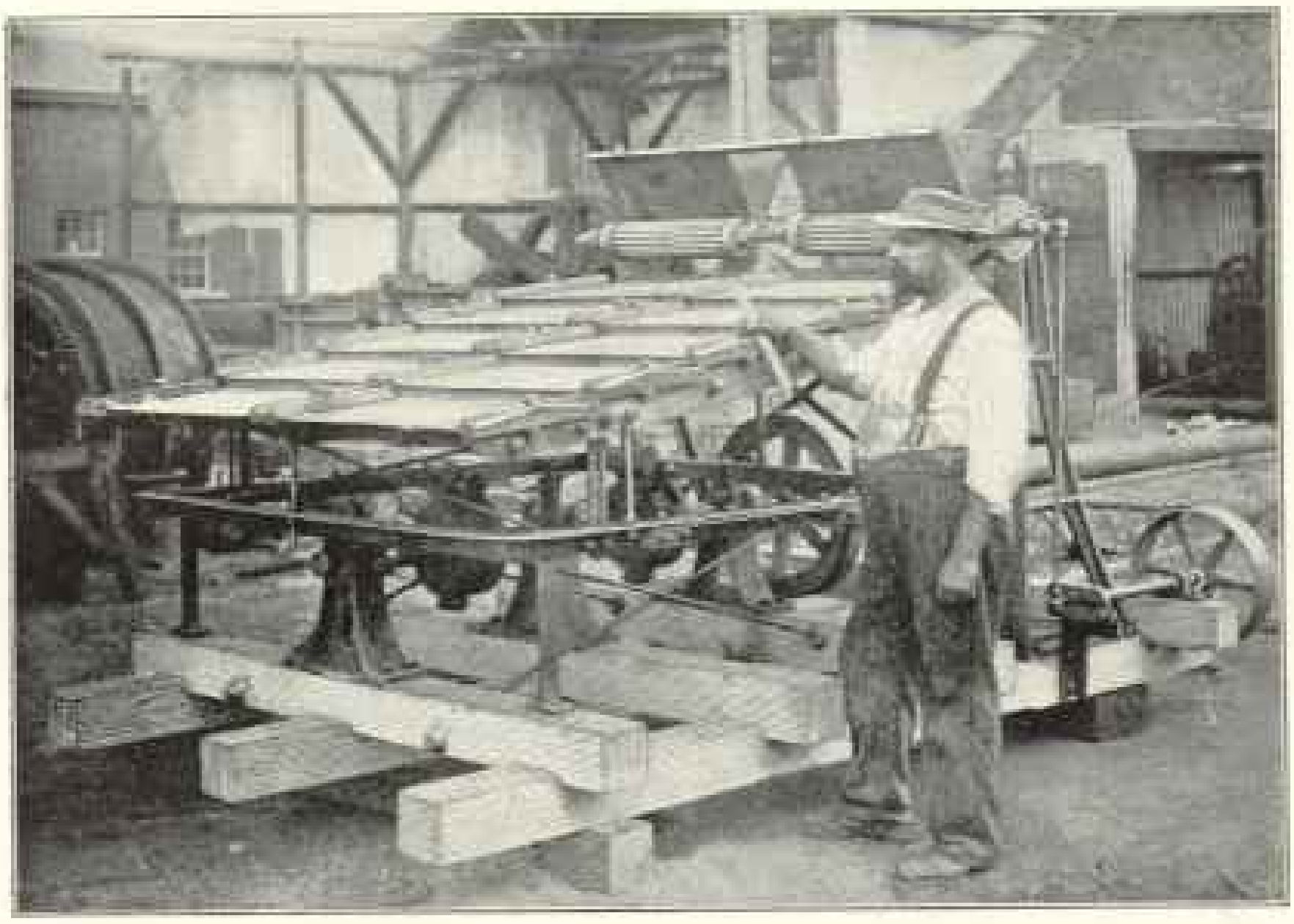


Washing Machine

The Old Method of Separating the Diamonds—Picking them out of the gravel by hand.

ion of diamond mining and winning which seemed beyond the application of blind and unconscious machinery. But men today are not inclined to admit that anything greatly worth doing is impossible.

A series of experiments was initiated by me with the object of separating the diamonds from the heavy valueless concentrates with which they are associated. An ordinary shaking or percussion table was constructed, and every known means of separation was tried without success. One of the employees of De Beers, Mr Fred Kirsten, was in charge of the experimenting, under the supervision of the late Mr George Labram, the manager of the large crushing plant and afterward mechanical engineer to the company. Notwithstanding the fact that the specific gravity of the diamond (3.52) was less than that of several of the minerals associated with it, so that its separation would seem a simple matter, it was found in practice to be impossible, owing to the slippery nature of the diamond. The heavy concentrates carried diamonds, and diamonds flowed away from the percussion tables with the tailings. When it seemed that every resource to do away with the head sorting had been exhausted, Kirsten asked to be allowed to try to catch the diamonds by placing a coat of thick grease on the surface of the percussion table with which the other experiments had been made. Kirsten had noticed that oily substances, such as axle grease and white or red lead, adhered to diamonds when they chanced to come into contact, and he argued to himself, if these substances adhered to diamonds and not to the other minerals in the concentrates, why should not diamonds adhere to grease on the table, and other minerals flow away? In this way the remarkable discovery was made that diamonds alone of all minerals contained in the blue ground will adhere to grease, and that all others flow away as tailings over the end of the percussion table with



Automatic Diamond Sorter, called the Greaser, the new method of separating the diamonds. See text below

the water. After this was determined by thorough experiments, more suitable shaking tables were constructed at the company's workshops. These were from time to time improved upon, until now all the sorting (except for the very coarse size) is done by these machines, whose power of distinction is far superior to the keenest eye of the native. Since the discovery of the affinity of grease for diamonds, experiments have been made with rubies and sapphires from Burma, and it was found that grease caught these gems with the same certainty that it catches diamonds.

After a thorough trial a number of these unique diamond-catching tables (see picture) were constructed and are now working on De Beers concentrates. Each shaking table is made of corrugated cast-iron plates in five sections, with a drop of about an inch from one division to another. Thick grease is spread on the plates to cover them to the top of the corrugations.

Strange to relate, the descending diamonds stick on the face of the grease, while all other minerals pass over it. Only about one-third of 1 per cent of diamonds is lost by the first table, and these are recovered almost to a stone when the concentrates are passed over the second table. The discrimination of this sorter is surely marvelous. Native workers, although experienced in the handling of diamonds, often pick out small crystals of zircon, or Dutch boart, by mistake; but the senseless machine is practically unerring. It will catch rubies, sapphires, and emeralds as well as diamonds; but, so far as it has been tested, it will not cling to anything but a precious stone. The grease which is used loses its power to catch diamonds after a few hours' work, owing to its becoming more or less mixed with particles of water. It is then scraped off the tables, together with the diamonds adhering to it, placed in a kettle made of finely perforated steel plates, and steamed. The grease passes away to tanks of water, where it is cooled and is again fit for use.

Formerly, of 12,000 loads, which is about the daily average of the quantity washed at De Beers and Kimberley mines, 160 cubic feet had to be assorted by hand.

When the stones are cleaned they are carefully assorted with reference to size, color, and purity and made up in parcels for sale. For several years past the De Beers Company has sold in advance its annual production to a syndicate of London diamond merchants who have representatives residing in Kimberley.

When the bare statement is made that nearly five million truck-loads, or more than four million tons, of blue ground have been washed in a year, the mind only faintly conceives the prodigious size of the mass that is annually drawn from the old craters and laboriously washed and sorted for the sake of a few bucketfuls of diamonds. It would form a cube of more than 430 feet, or a block larger than any cathedral in the world, and overtopping the spire of Saint Paul's, while a box with sides measuring two feet nine inches would hold the gems.

Diamonds are so highly prized and so imperishable that the amount of these gems in existence may almost be reckoned as the total of the world's production, ranging in value through hundreds of millions of dollars. Mr Kunz does not estimate a loss of 5 per cent in a hundred years, and the South African diamond fields alone have contributed over $400,000,000 in value to the world's stock. Yet the demand increases apace with the world's growth in wealth, and no diversion of the world's fancy is apparent.

CANADIAN IMMIGRATION

THE Canadian Commissioner of Emigration in London, Mr W. T. R. Preston, talking on the successful efforts of the Canadian government to induce emigration to that country from Great Britain, said:

"Five years ago Canada was receiving 12½ per cent of the total of from 60,000 to 70,000 emigrants from Great Britain to North America. Now she receives over 50 per cent. In these five years the immigrants into Canada from Great Britain have increased from 8,000 annually to 65,000. Canada wants population. A net bonus of $1.75 per head is given by the government to every emigration agent in Great Britain sending out emigrants to settle the land. Each British agricultural emigrant averages a total cost of $13 to the Canadian government, and each continental emigrant costs the sum of $5. Consequently the Canadian government is paying $8 per head more for British than for continental emigrants."

The Colonizer of London publishes an interview with a firm in that city which makes it its business to send children to Canada. The head of the firm stated that for $125 they would send a boy, pay his fare, and take care of him until he has settled with some farmer. The boy is paid from $5 to $12 per month by the farmer.

The payments by the Canadian government to the emigration agents in Europe for each emigrant sent to Canada accounts for the large increase of emigration to that country in recent years.

Map showing the Location of the Principal River Stations maintained in the United States by the U. S. Geological Survey

The object is to find out the amount of water available in our rivers for irrigation, manufacture and commercial purposes

From F. H. Newell, Chief Engineer

PHOTOGRAPHS OF WILD GAME

THE July number of this Magazine will contain an article by Hon. George Shiras, 3d, entitled "Photographing Wild Game with Flashlight and Camera." It will be accompanied by more than 60 pictures, most of them full-page illustrations, of deer, bull moose, raccoon, wild cat, porcupine, pelican, blue heron, white heron, gulls, ducks, kingfisher, woodpecker, etc., taken by Mr Shiras during his camera hunting trips of the last fifteen years.

THE LURAY CAVERNS

THE Luray Caverns were visited by about 450 members of the National Geographic Society on May 19, and again on May 26 by about 250 more members, for whom accommodations could not be provided on the first excursion. Each party left Washington at 8 a. m. on a special vestibule train provided by the Baltimore and Ohio Railroad. The members were shown through the caverns in squads of 25 each, accompanied by intelligent guides. It is practically the unanimous opinion of all that in beauty and splendor the Luray Caverns equal, if they do not surpass, the most extravagant descriptions that have been written about them. The formations vary as much in beauty and weird design as the frost on a New England window pane varies from day to day in winter. The cave covers an area of 10 acres. Its lowest point is 166 feet below the surface.

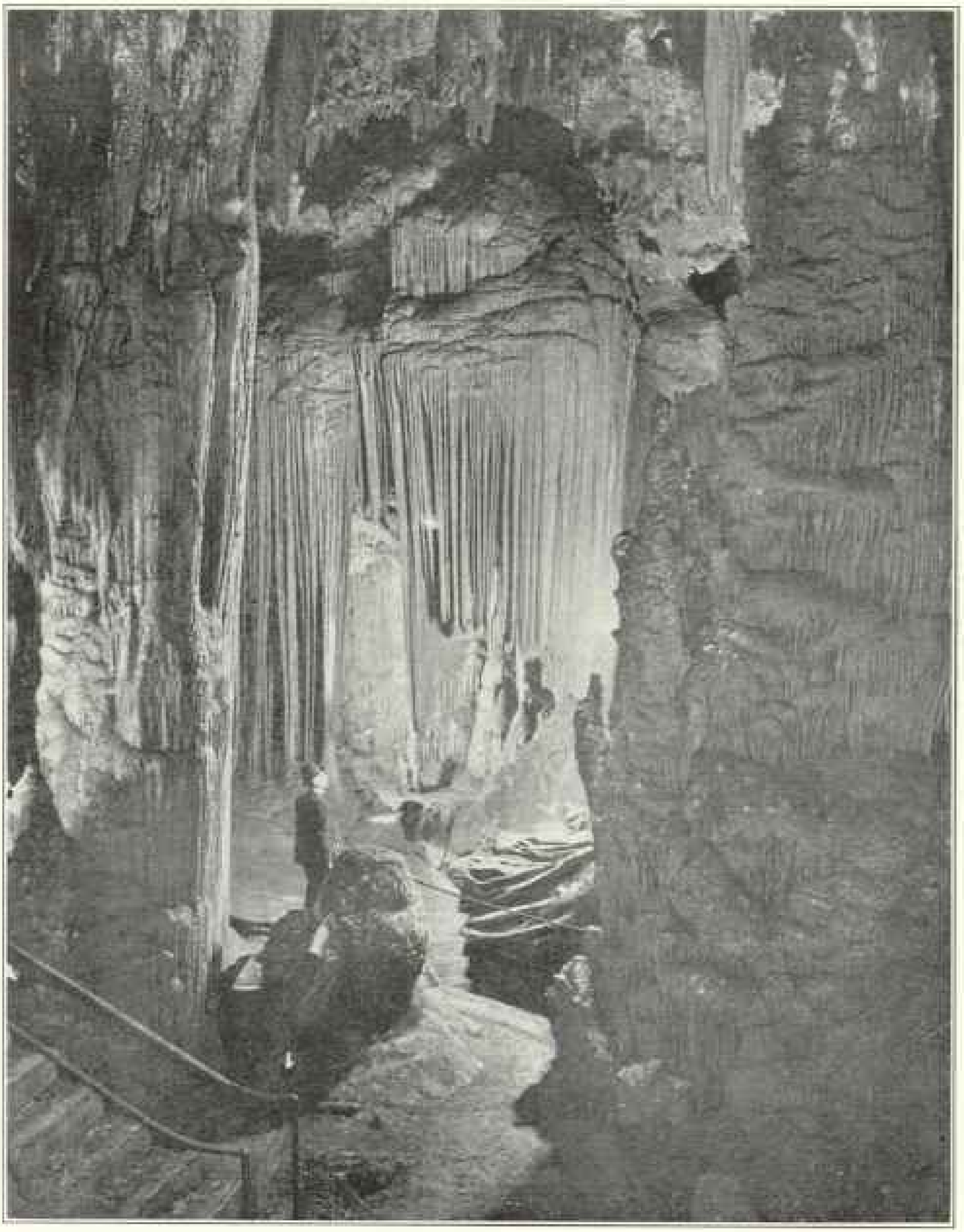
The Caverns of Luray are situated about 120 miles from Washington, in the famous Shenandoah Valley, in a region renowned for the picturesqueness of its scenery and celebrated for its historical associations.

The caves were discovered in 1878, and shortly thereafter were opened to the public. The full extent of their subterranean depths was not then known, or even suspected, and not until thoroughly equipped exploring parties had penetrated seemingly endless chambers and labyrinthine passages were their boundless riches disclosed and made accessible to visitors. Since that time the fame of the caverns has penetrated the uttermost parts of the earth, resulting in the visits of many thousands each year. Persons from all quarters of the globe—scientists, explorers, and tourists—have wandered through the wonderful chambers, and the general verdict of their united testimony is that Luray Caverns excel all others in the combined extent, variety, scientific interest, and beauty of their calcite formations. Comparing this great natural curiosity with others of the same class, it is safe to say that there is probably no other cave in the world more completely and profusely decorated with stalactitic and stalagmitic ornamentation than that of Luray.

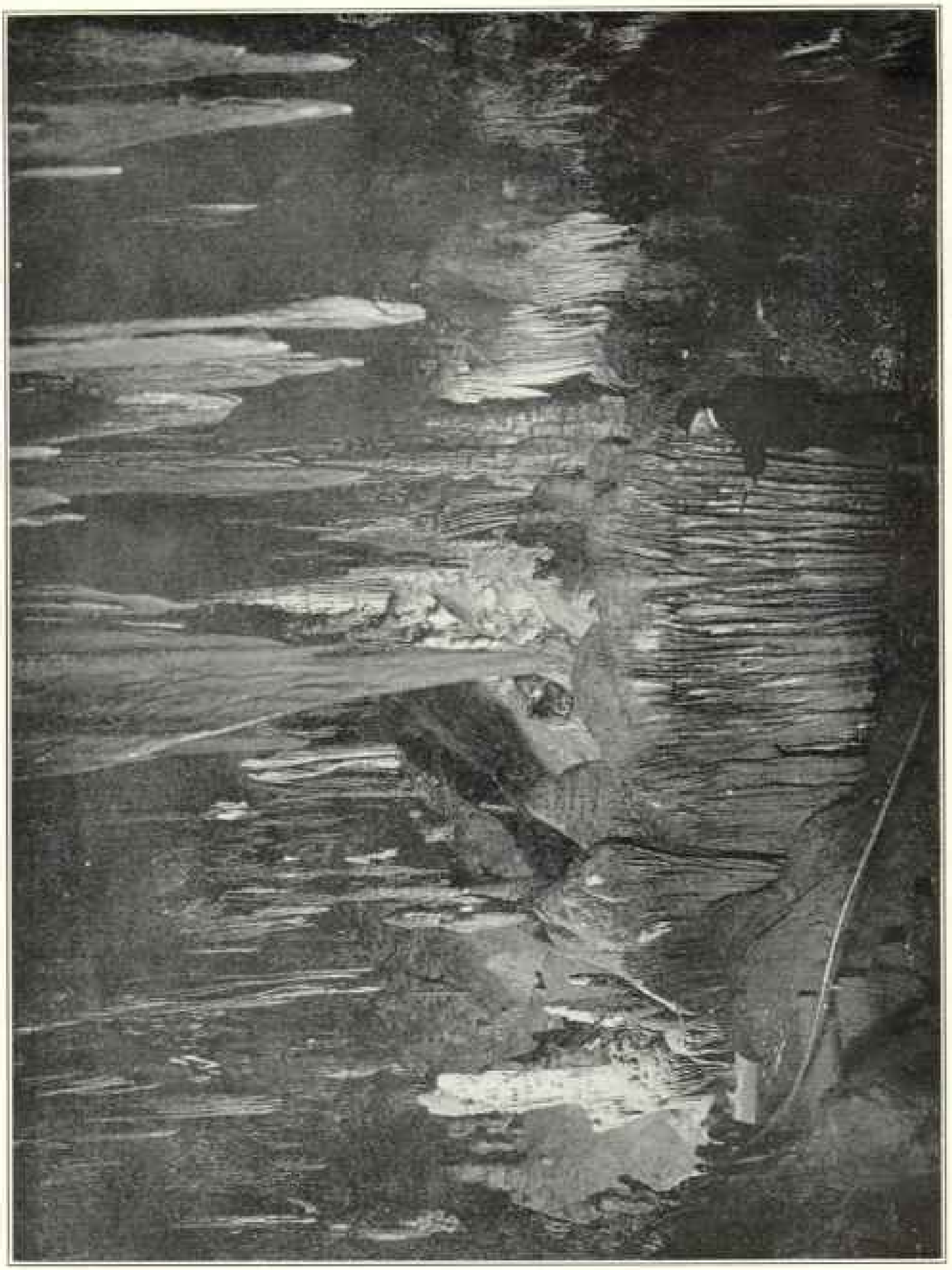
Every facility for visiting all the chambers and seeing all the wonders in the most comfortable manner has been provided. Cement walks have been laid, stairways, bridges, and iron railings have been erected where such help was necessary, and the entire subterranean palace is illuminated by both arc and incandescent electric lights. The interior is singularly free from dampness or dripping water, and no special preparation for the visit is needed in the matter of clothing. Plain clothing and stout shoes comprise the necessary outfit, wraps being superfluous, as the temperature remains, winter and summer, at about 54 degrees.

Dr H. C. Hovey, a member of the National Geographic Society, in the Encyclopedia Britannica, writes of the cave as follows:

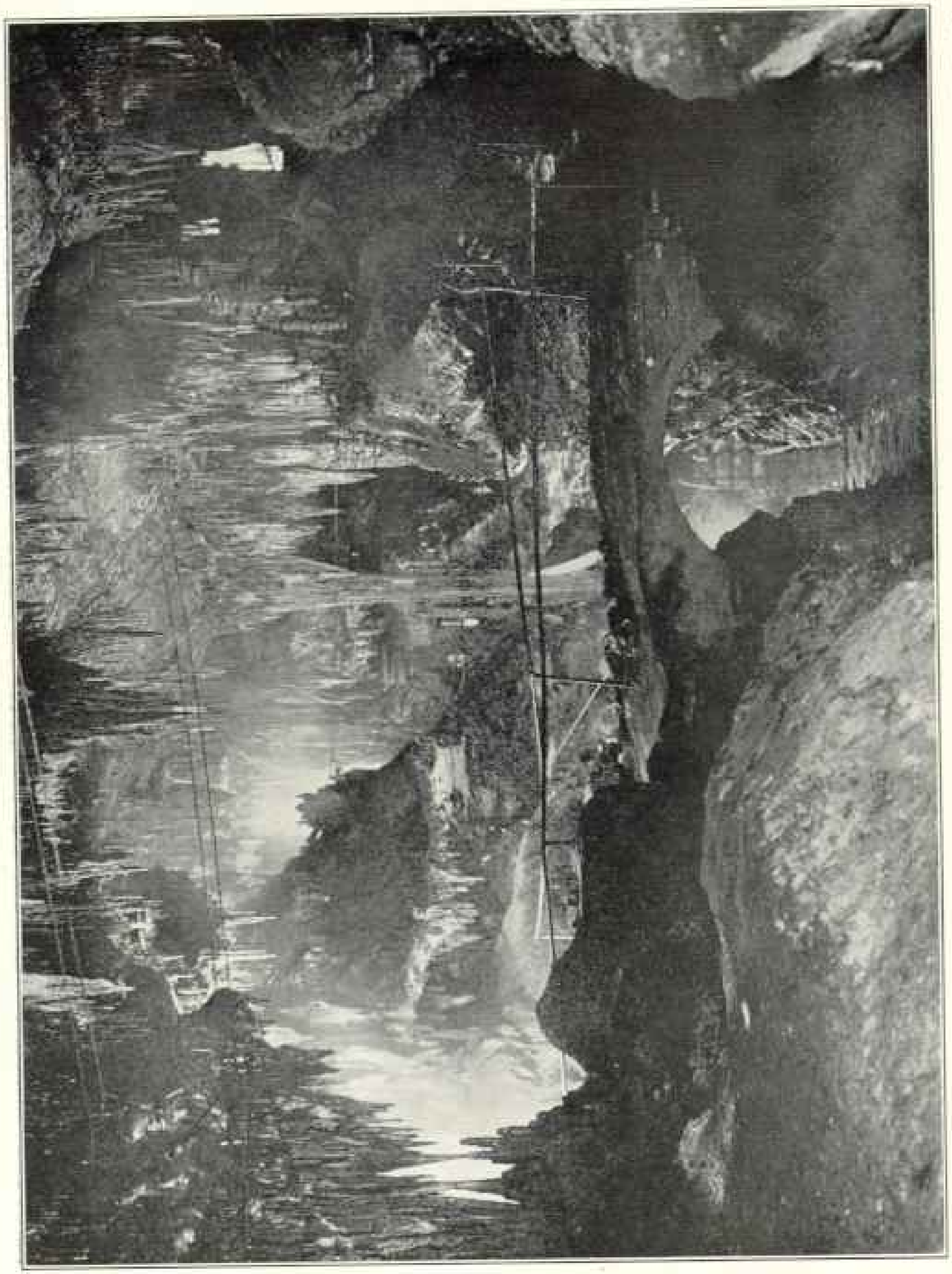
"The stalactite display exceeds that of any other cavern known, and there is hardly a square yard on the walls or ceiling that is not thus ornamented. The old material is yellow, brown, or red, and its wavy surface often shows layers like the guarled grain of costly woods. The new stalactites growing from the old, and made of hard carbonates that had already once been used, are usually white as snow, though often pink, blue, or amber-colored. The size attained by single specimens is surprising. The Empress Column is a stalagmite 35 feet high, rose-



The Approach to Saracen's Tent



The Organ and Chimes in the Cathedral. The chimes are sweet and clear as silver bells



Stalactites in Luray Cave

colored, and elaborately draped. In the canopy above the Imperial Spring it is estimated that 40,000 are visible at once.

"The 'cascades' are wonderful formations, like foaming cataracts caught in mid-air and transformed into milk-white or amber alabaster. The Chalcedony Cascade displays a variety of colors. Brand's Cascade, which is the finest of all, being 40 feet high and 30 feet wide, is unsullied and wax-like white, each ripple and braided rill seeming to have been polished.

"The Swords of the Titans are monstrous blades, eight in number, 50 feet long, 3 to 8 feet wide, hollow, 1 to 2 feet thick, but drawn down to an extremely thin edge, and filling the cavern with tones like tolling bells when struck heavily by the hand. Their origin, and also that of certain so-called scarfs and blankets exhibited, is from carbonates deposited by water trickling down a sloping and corrugated surface. Sixteen of these alabaster scarfs hang side by side in Hovey's Balcony, three white and fine as crepe shawls, thirteen striated like agate with every shade of brown, and all perfectly translucent. Down the edge of each a tiny rill glistens like silver, and this is the ever-plying shuttle that weaves the fairy fabric.

"The waters of this cavern appear to be entirely destitute of life, and the existing fauna is quite meager, comprising only a few bats, rats, mice, spiders, flies, and small centipedes. When the cave was first entered the floor was covered with thousands of tracks of raccoons, wolves, and bears—most of them probably made long ago, as impressions made in the tenacious clay that composed most of the cavern floor would remain unchanged for centuries. Layers of excrementitious matter appear, and also many small bones, along with a few large ones, all of existing species. The traces of human occupation as yet discovered are pieces of charcoal, flints, moccasin tracks, and a single skeleton imbedded in a stalagmite in one of the chasms, estimated to have lain where found for not more than five hundred years, judging from the present rate of stalagmite growth." (The members were shown the skeleton pieces, but it must be confessed that a vivid imagination was necessary to see the resemblance to a human skeleton.)

"Geologically considered, the Luray Cavern does not date beyond the Tertiary period, though carved from the Silurian limestone. At some period long subsequent to its original excavation, and after many large stalactites had grown, it was completely filled with glacial mud charged with acid, whereby the dripstone was eroded into singularly grotesque shapes. After the mud had been mostly removed by flowing water, these eroded forms remained amid the new growths. To this contrast may be ascribed some of the most striking scenes in the cave."

NOTES ON THE PANAMA CANAL*

I BELIEVE there are but few who appreciate the tremendous possibilities which the opening of the Panama Canal means to all our country, and especially to the Southern States. As an evidence of how some men regard it, I will quote a remark made in my presence by one of the so-called captains of industry in this country—one of the men who have been most instrumental in the internal development of this nation, one of the men who have made our wonderful prosperity possible, one of the men who control the greatest corporation in the South. In speaking of his holdings in the Tennessee Coal and Iron Company, he said: "When the Panama Canal is completed, every share of my stock in that company will be worth a thousand dollars." He said the opening of that canal will make Birmingham the Pittsburg of the South, and will give it the same relationship to the Gulf that Pittsburg now has to the Atlantic coast. He said the immensity of traffic which originates within 40 miles of Pittsburg, and which is the marvel of the world, will be duplicated in the

*From an address by Hon. Theodore P. Shonts, Chairman Isthmian Commission, to the Chamber of Commerce, Atlanta, Georgia, May 30, 1906.

same territory surrounding the city of Birmingham. He said that when he acquired his large interest in this property he did so because of his abiding faith in the development of the South and because of his confidence in the astonishing growth which would take place there upon the opening of the Panama Canal.

WHY THE COMMISSION RECOMMENDS THE LOCK CANAL.

The present Commission believes that the type of canal the people of this country want is the one which will provide adequate and safe passage for the largest vessels on the seas, and which can be constructed in the quickest time and at the least cost. The Commission's recommendation, in other words, has been based on the idea that what the people want is the near-by practical rather than the remote ideal. It has therefore recommended the construction of an 85-foot level lock canal for the reasons that, first, in its judgment, it can be completed for about half the cost and in half the time of the so-called sea-level canal; second, because it will be adequate for all the commerce which can reasonably be expected to seek that route during the next 150 years; third, because if the tonnage should increase beyond such expectation, it can be enlarged more cheaply and more quickly than the so-called sea-level canal; fourth, because, from the operating point of view, large ships can be put through more safely and more quickly than through the sea-level; fifth, because when the interest on the difference in cost of construction is added to the cost of operating, the saving to the government every year will be $2,340,000.

The so-called sea-level canal is a deep, narrow, tortuous gorge, which large ships cannot navigate, even according to the estimate of the men who recommend that type of canal, at a greater speed than four miles an hour, and which will contain at times, according to the same authority, a current in one direction of two and six-tenths miles an hour. I venture to say that no large ship, occupying, as large ships will, 40 per cent of the prism through which it will pass, can navigate at that speed, with that current, safely, under its own steam.

The lock canal, on the other hand, as recommended by the minority of the consulting board and indorsed by our Commission, will have 35 miles of free-lake navigation, so that the difference in time of putting large ships through the locks will be more than offset by their speed through the lake portion of their trip, which is more than two-thirds of the entire length of the canal.

In regard to the capacity, no man can estimate with any degree of accuracy the volume of tonnage which will go through the Panama Canal. The only guide we can have is the traffic of the Suez Canal. Taking the development of the traffic in the Suez during the 35 years of its existence as a basis and continuing the same ratio of increase until the year 2000, the volume of traffic passing through that canal will be in that year, in round numbers, 42,500,000 tons; or, estimating that the Panama Canal, if constructed on the plans which this Commission has recommended, will be open for traffic in 1916, and estimating that the volume of traffic passing through it the first year will amount to 5,000,000 tons (which is the best guess that experts have been able to make), and applying the same ratio of increase to that traffic which experience has shown to have developed in the Suez, the volume in the year 2000 will have reached 32,500,000 tons. The estimated capacity of the lock canal, as recommended by our Commission, is 50,000,000 tons per annum. Unless the development of the population of the world changes the basis of our estimates, the type of canal we recommend will be adequate for all business that may be thrown upon it during the next 150 years.

By simply raising the sides of our spillways and increasing the depth of our locks, we can increase the depth of water in the canal so as to take care of still larger vessels than the 40-foot ships provided for in our present estimate, whereas in a sea-level canal you would have to excavate the whole distance for every foot of increase made in depth.

NOTICE TO MEMBERS

In order that their copies of the Magazine may not be lost during the summer, members are requested to advise the office of the National Geographic Society, Hubbard Memorial Hall, Washington, D. C., when they will be absent for a month or more and their residence closed, and at the same time to give their change of address. Magazines are mailed as second-class matter and the post-office will not forward mail of this character unless the additional postage is prepaid.

WASHINGTON, D. C., *May 30, 1906.*

Editors National Geographic Magazine:

Can you tell me the origin and meaning of the word "Labrador?"

I notice from a map published about 1740 that the term was then applied to a body of water in Cape Breton Island, Nova Scotia, now known as the Bras d'Or Lakes, and that the body of land now known as Labrador was then called Terra Labrador.

The northern entrance to the Bras d'Or Lakes, a long narrow passage forming an arm of the sea, was termed during the French occupation "Le Bras d'Or," the arm of gold. Was this a French corruption of the earlier name "Labrador?" The French name still persists as "The Bras d'Or," often locally pronounced "brass door."

The captain of a Cape Breton tugboat thought that it was so named because it was the "door" or entrance to the lakes, but why it should be called the "brass" door he could not possibly imagine!

H. A. LARCELAMB.

The region which is called Labrador was so named by the Portuguese navigator Gaspar Corte-real, who landed on the coast about 1500. He called the region "Labrador" because it was thought that the natives would make excellent workers or slaves. Corte-real made several voyages to the coast, 1500 and 1501, landing at points between Labrador and the Bay of Fundy, but from his last voyage he did not return. His brother Miguel, who sailed in search of him in 1502, was likewise lost.

Labrador had been previously discovered by John Cabot in 1497, but as he failed to name the region, the name applied by Corte-real, "Terra de Lavradores" (land of laborers or slaves), clung to it.

The above is the usual explanation of the origin of the word Labrador. Another tradition is that a Basque whaler, called "Labrador," penetrated as far as Labrador Bay (now Bradore Bay), and that as this bay was later much frequented by Basque fishermen, the name was extended to the whole coast.

It is generally believed that Bras d'Or is a corruption from the Indian and not of French origin. The similarity of Bras d'Or and Labrador is very striking, however, and it may be that both words have the same origin.

Hydrology of the State of New York. Compiled by George W. Rafter. Pp. 900, 9 x 6 inches. Illustrated. Published by the New York State Education Department, Albany, 1905. $1.50.

The report on the water supply of New York State gives in detail the statistics and surveys of the Hudson, Genesee, Oswego, and Black rivers as well as of every other waterway in the state worthy of consideration, the volume bringing to the public a realization of the importance of water as an economic mineral, to which New York State owes much of its vast wealth. Papers on ship-canal projects and their water supply, the future use of water power in the state, with tables of the maximum and minimum flow of streams, are also given and statistical comparisons of catchments and sources of supply. The volume is well illustrated and contains two detached maps showing surface configurations and catchments, with reservations for New York city water supply.

J. O. L.

"The New Brazil." By Marie Robinson Wright. Pp. 450, 9½ x 12½ inches. With many illustrations. Philadelphia: George Barrie & Son.

The view of Brazil presented by this volume is that of a land of promise. Wonderful progress has been made during the past ten years, and with further development of her natural resources Brazil has the prospect of a prosperity for the twentieth century which may equal that achieved by the United States during the last hundred years.

The Amazon forests supply the world with rubber, and Brazil sends abroad the major portion of the coffee consumed; Brazilian soil is of such wonderful fertility that it responds to the least cultivation; the mines yield quantities of gold, silver, copper, and precious stones; the transportation facilities are greater than those of any other South American country, and the population is increasing at the rate of seventeen million to the century.

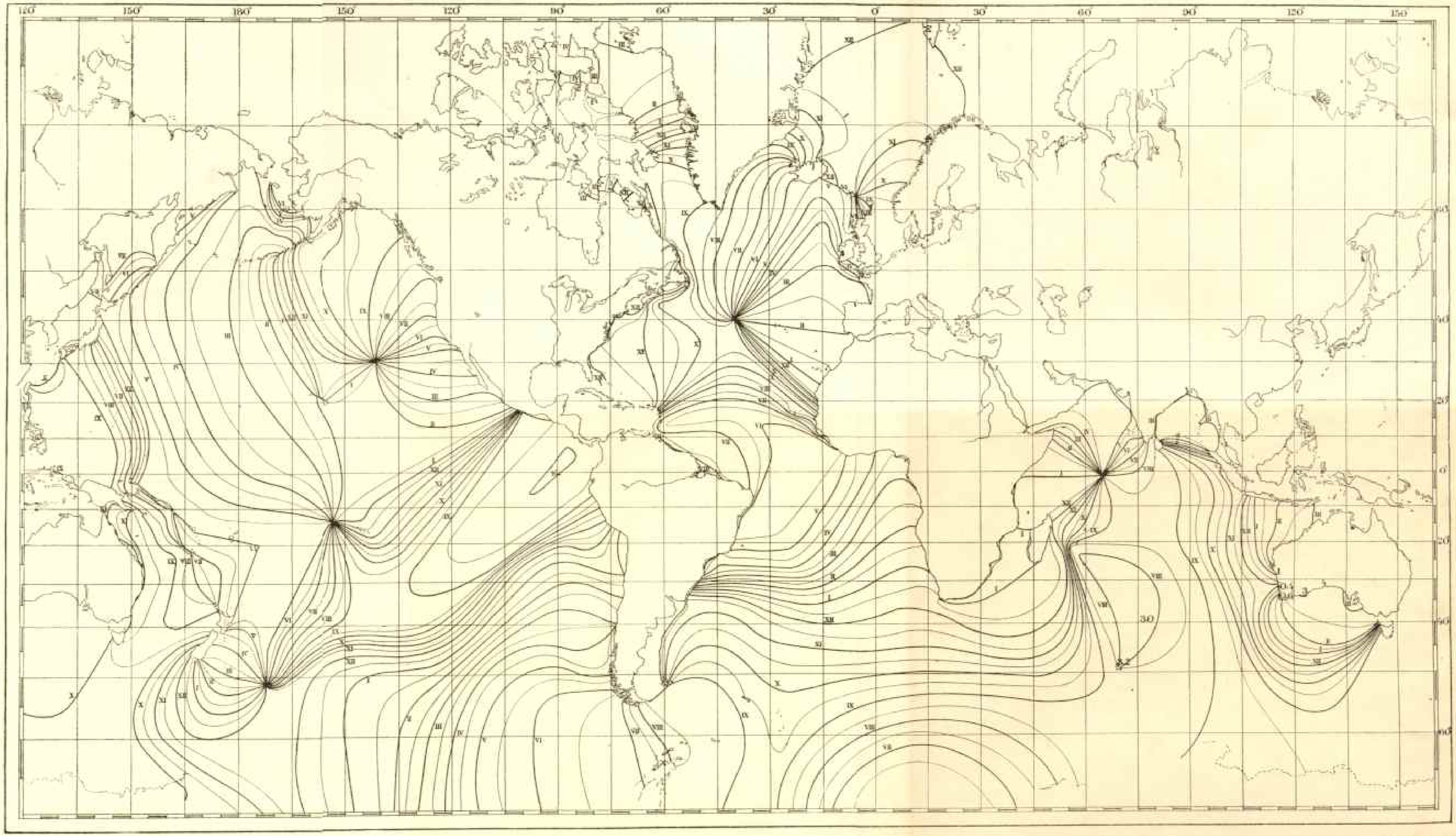
The closing chapters on national customs and characteristics tell of the life of the cultured families of Brazil and of the primitive Indian of the Amazon.

F. M. A.

"The Discoverers and Explorers of America." By Charles Morris. Lippincott. 1906. $1.25.

An excellent book for youth as well as for adults. Its 344 pages contain forty narratives of discovery and exploration of the continent, islands and waters of America. The whole story of the gradual opening of a new world is told, from the landing of Lief the Lucky, in the summer season of the year 1000, to the navigation of the Northwest passage by Amundsen, the Norwegian, in 1905.

F. M. A.



COTIDAL LINES FOR THE WORLD; OR LINES OF SIMULTANEOUS HIGH WATER AT EACH HOUR AND HALF HOUR OF GREENWICH LUNAR TIME

PRESS OF JUDD & DETWEILER (Inc.), WASHINGTON, D. C.