words, I took on the phonograph several cylinders, with the Indian equivalent of the English words. In doing this I made use of pages of the well-known schedules published by the Bureau of Ethnology at Washington, speaking the English word, and requesting the Indian to follow with the Passamaquoddy translation. This, of course, is only possible when the Indian has a knowledge of English, or is able to know by signs what is needed.

To obtain sentences, a conversation was recorded in Indian language between two Passamaquoddies. These cylinders reveal the general linguistic peculiarities, and when studied might be valuable adjuncts in the acquirement of the language.

It seems possible that the phonograph may be found to be of valuable assistance not only in the study of Indian, but also of all modern languages. A number of cylinders with records of sentences pronounced by a Frenchman or German with the proper accent might be found a valuable aid to a teacher of these languages who is not a native of the land the language of which he is teaching. Even proficient teachers might find it a help in their classrooms. For study of these languages without the aid of a teacher, a set of cylinders with the proper pronunciation might have a great value in training the ear to the correct pronunciation of the words and sentences of a foreign language, which are but imperfectly indicated by phonetic methods. By the use of the phonograph the teacher of modern languages might be relieved of the endless repetition of pronunciation of words in a foreign language which the pupil acquires with difficulty.

I have taken the following clipping from a daily paper: "Edison's phonograph has found a new application at the Milwaukee College, where it will be used as an assistant in teaching the French and other foreign languages. The phonograph, of course, never gets tired, and can be made to repeat the same sentence or the same word hundreds of times. In giving a lesson, the teacher reads it before the phonograph, at the same time addressing the pupils, and the lesson is reproduced whenever wanted." This would seem to indicate that the use of the phonograph in the teaching of modern languages had been put in practical test.

The necessity of work with the phonograph in preserving the languages of the aborigines of this continent is imperative. There are stories, rituals, songs, even the remnant of languages which once extended over great States, which are now known only to a few persons. These persons are in some instances old men and old women, with whose death they will disappear forever from the face of the earth if some record is not now made of them. Many have already been lost forever, even in the last twenty years, and some are fated to disappear in the next decade.

These rituals are in some instances the unwritten history of the tribe, and contain all that the Indians know of their history. The younger men among several tribes do not willingly take to the customs of their fathers. They are rapidly losing their former character. They have no desire to commit to memory the rituals of their ancestors. To learn their language, to live among them and study all that pertains to them from an intimate acquaintance, even membership in the tribe, is desirable, if earnest investigators can be found to undertake it; but this is not always possible. The phonograph renders it practicable for us to indelibly fix their languages, and preserve them for future time after they become extinct or their idiom is greatly modified or wholly changed.

The prime object of the above-mentioned experiments was simply to test the capabilities of the phonograph in recording aboriginal languages. That it could be used for that purpose was assured before I began by the knowledge that it records any language with precision; so that the experiments bearing on its capabilities in this direction might seem superfluous. Demonstration, however, gave weight to belief.

The expense at the present time for the use of the instrument is possibly a practical difficulty, which it is to be hoped may be lightened for those using the instrument for scientific purposes. Certainly no idea could show a more disinterested personal interest than a wish to permanently preserve the fast vanishing languages of the American Indians. It belongs to the realm of pure science, and the scientific student will probably be met in a similar liberal spirit by those who control the patents of the phonograph. J. WALTER FEWKES.

FACTS ABOUT TORNADOES.

THERE is no subject in the whole science of meteorology of such absorbing interest as this of tornadoes. Its importance may be judged from the hundreds of pages that have been written upon it, from the universal attention paid it by newspapers through the length and breadth of the land, and from the fact that many insurance companies have taken the matter in hand, and are prepared to take tornado risks. It is easy to see that the interest in this topic must gradually increase as the tornado districts become more thickly populated, and as the facilities for spreading the news of disaster become greater. There is no doubt that in many instances losses from a tornado have been greatly exaggerated, and fears of devastation have been increased because pictures of the very worst tornadoes are the only ones that have been printed.

The most important thing for us to do is to establish the facts, and these will serve as a basis from which we may uproot false theories, and, if not now, at some time in the future, to build up a solid superstructure. It is to be noted that all studies on this question ultimately turn to the facts, either to support theories or to form them. We shall find the most diverse views in these discussions, and yet every one of them based upon facts. It is only because of a false or imperfect interpretation of what is observed that such antagonism can exist. A partial explanation of these conflicting views lies in the fact that the outburst of a tornado is accompanied by such terrifying manifestations, and observers are in such fear for their lives that they are totally unfitted to give an account of what they have seen. In many cases, also, there has been altogether too narrow a view taken of this phenomenon. We have been entirely absorbed in the immediate destruction, the demolition of houses, the twisting-off of trees, the distribution of *débris*, etc., and have neglected the atmospheric conditions which have led up to the disaster. All will agree that a thorough knowledge of all the circumstances attending these outbursts is indispensable, if we would learn the mechanism of a tornado, or if we ever attempt to guard against its devastation, or ever try to give warning so that others may protect themselves. We may enumerate some of the facts as follows:—

Quiescent State of the Atmosphere.

It is quite well known that tornadoes seldom occur singly, but many are formed over an extended region, five hundred or more miles in length and breadth, where the conditions are favorable for their development. In this region the air is remarkably quiet previous to the tornado. There is a general or wide-extended storm some two hundred or four hundred miles to the north-westward; and into this storm, which is usually intensified much above the average storms at that season, gentle southerly and south-easterly winds are blowing at a distance, which are freshened as the centre is approached. Tornadoes rarely occur in any but the hotter season, say from April to August; and in this season, even when there are thunder-storms, high winds are an exception.

Temperature.

The universal testimony is, that there is an exceedingly warm and sultry air. Even if the sky be overcast, and the sun's direct rays be hidden, this same oppressive feeling is noted. This heat seems to have a special characteristic entirely unlike that from the ordinary bright sun's rays, and it has never been properly accounted for. The same heat is often felt just before a thunder-storm, and we may consider that the same cause is acting in both these cases.

Clouds.

The clouds have the general motion that they always have in the neighborhood of an extensive storm. This would seem an exceedingly important consideration, and would show that the conditions leading up to the tornado are the same as are present at innumerable times when there are no serious outbreaks. A beginning in a study of these conditions has already been made (*Journal of the Franklin Institute*, July, 1888, p. 48). In that investigation it was learned that near the centre of the general storm, the clouds moved mostly with the surface winds, from right to left, or counter-clockwise, and if they had any other direction it was simply a slight turning toward the east in the line of the general flow of the upper current. This fact was also ascertained by Hildebrandsson in Denmark, though the storms there may have slightly different characteristics from the proximity of the ocean. A score of tornado regions have shown this tendency. It will suffice to give here illustrations from three tornadoes which have been specially studied; and a fourth will be described later, in connection with the Louisville tornado.

Washington Court-House, O.

This place was visited Sept. 8, 1885. The general storm was central in southern Wisconsin, and the cloud-movements were as follows: from south-west at Dubuque, Davenport, Keokuk, Springfield (Ill.), Chicago, Indianapolis, Louisville, Nashville, Cincinnati, Columbus, and Sandusky; from south at Cairo, Toledo, Pittsburgh, and Erie; from south-east at Detroit, Cleveland, and Buffalo. In all this region there was not a single cloud-movement from the north-west or even west. On April 14, 1886, St. Cloud and Sauk Rapids, Minn., were injured by a tornado. The general storm was central in north west Dakota, and the cloud-motions were as follows: from south-west at North Platte, Des Moines, and Valentine; from south at Deadwood, Omaha, Leavenworth, Springfield (Mo.), Springfield (Ill), Cairo, St. Louis, Dubuque, and La Crosse; from south-east at Bismarck, Moorhead, St. Vincent, and St. Paul. Here not only are there no west or north-west cloud-movements, but also in the immediate tornado region the movement is markedly from the south-east.

Mount Vernon, Ill.

This tornado occurred Feb. 19, 1888. The general storm was central in eastern Iowa, and clouds were moving as follows: from south-west at Keokuk, Memphis, and Louisville; from south at Springfield (Ill.), Chicago, Indianapolis, Toledo, St. Louis, Cairo, and Chattanooga; from south east at Milwaukee and Davenport.

This is an exceedingly important fact, as will be seen later on, and seems to be abundantly established.

Distribution of Tornadoes.

Rarely do these violent outbursts occur singly. In any region favorable for tornado development, two hundred to four hundred miles to the south-east of the centre of the general storm, we shall find, after the hottest part of the day, a line of tornadoes occurring one after the other, and moving almost invariably to the north-east. An hour or so later, another line will be found parallel to the first, and about fifty miles south-east of the first In some cases, as in the great Louisville tornado, there may be six or even more of these lines. They are entirely independent of each other, and very clear cut, there being no destruction between. The last line may not begin until 8.30 P.M., more than five hours after the hottest part of the day.

Velocity.

A marked feature of these outbursts is their most rapid translation across the earth for two hundred and sometimes three hundred miles. The speed is rarely under forty miles per hour, and there have been well-authenticated cases where it has reached over eighty miles per hour, notably in the Louisville tornado. It should be noted that the general storm, while travelling in the same direction, attains a velocity only half as great; for example, at Louisville it was thirty-eight miles per hour, which is very much above the average.

Thunder-Storms.

All through this region thunder-storms are very numerous, and are an invariable accompaniment. Sometimes vivid displays of lightning occur in the tornado, and undoubtedly these would be observed much oftener were not the beholder awe struck by the terror-inspiring phenomenon. A careful study of thunder-storms, occurring at any time, has shown that they have a velocity double that of the fostering general storm, and are always found within the region six hundred miles to the south-east. It has come to be generally admitted that tornadoes and thunder-storms are analogous phenomena, and that the former are an intensification of the latter. If this be true, we see at once what an enormous advance has been made. We do not need to wait for the full-fledged monster, whose very appearance drives away all thought save flight for safety, but we may study it in its gentler moods.

Lurid Sky.

Let us take a slightly closer view. Almost the first warning after the appearance of dark and threatening clouds in the west, as in a thunder-storm, is a peculiar lurid or greenish tinge in the sky from the south to the west. This "tornado-sky" is a characteristic feature, and it is believed that to those who have studied the phenomenon this will always serve as a warning for the more serious results which soon follow.

Two Clouds.

Many observers have seen very black clouds,—one to the west or north-west, and the other to the south-west,—which seem to rapidly advance, and, when they meet, to form the tornado. This is believed to be in the nature of a perspective effect, and the clouds to be an immediate accompaniment of the tornado. A full explanation of this phenomenon will be given later.

Cloud of Dust.

It is a very significant fact. that in very many cases the funnel-cloud, which has a sharp outline and should be the first thing seen at a long distance, is not seen till it is just upon the observer. This is due to an enormous cloud of dust directly in front of the tornado, rising oftentimes to a great height. Such a cloud of dust has often been seen in thunder-storms in regions never visited by the tornado. It is produced by a tremendous outrush of air from the tornado, and indicates almost conclusively that there is a plenum, and not a vacuum, at the centre. That this outrush of air could be produced by the fall of raindrops carrying air with them, has been proved impossible. The calculation showed that the heaviest rainfall that ever occurred could not produce a velocity greater than one-tenth of a mile per hour, which is practically inappreciable (see *American Meteorological Journal*, September, 1887, pp. 206–211).

Loud Roar.

As the tornado approaches, an indescribable roar is heard. It has been likened to the bellowing of a million mad bulls, the roar of ten thousand trains of cars, etc. This is certainly a most significant fact, and one that has not been sufficiently dwelt upon. The roar was analyzed by one observer, and was found to be precisely similar to a continuous roar or rumble of thunder. There is no question but that it is a marked electrical phenomenon, though just the manner of its production demands most careful investigation. Another explanation will be given under another heading.

The Tornado.

These warning sights and sounds are quickly followed by the funnel-cloud itself, like a great balloon sweeping its neck round and round with terrible fury, and destroying every thing in its path. It has been likened to an enormous elephant's trunk. It whirls with almost incredible velocity in its mad career, with a motion back and forth, sometimes leaving the earth a moment, then bounding back to continue its dire havoc. The whole destruction occupies but three or four minutes; but in that time the stanchest houses of brick or stone have been demolished, and sorrow and ruin have been spread all along its path.

Clearing Sky.

The exceedingly circumscribed nature of the tornado is shown by the blue sky or stars appearing a few minutes after it has passed. The wind turns to the south again, every thing quiets down, and no one would think that a terrible catastrophe had occurred, except for the devastation that is all about, and the cries of the unfortunates.

Width of Path.

The width of the destructive path has been given as high as a mile, but this is undoubtedly due to an erroneous estimation of the real track. There are always south-westerly indraughts which produce more or less destruction on the south side, but these should be carefully distinguished from the track proper or the region of greatest destruction. This may reach a thousand feet, though its width is rarely over two hundred or three hundred feet.

Distribution of Débris.

In the central line of the tornado all timbers and trees are strewed in the same direction, as though a mighty river had passed and left them behind. Where trees are not completely uprooted on either side of the path, they all lie with their tops inclined to the central line; that is, on the south side they are toppled toward the north-east, while on the north side toward the south-east. This appearance or action may be due to the indraughts, and should be carefully distinguished from the effect of the tornado proper. The same remark may be made as to the distribution of fences and light objects on either side of the path.

Velocity of the Destructive Wind.

This should not be confused with the onward motion of the tornado, which is comparatively slow. The whirling of the cloud is the cause of the great destruction. This has been estimated as high as a thousand miles per hour; but such a velocity as that is highly problematical, and is due to erroneous assumptions. Probably the most accurate measurement of this velocity ever made was at Wallingford, Conn., on Aug. 9, 1878. Here the tornado blew off monuments in a cemetery without chipping either the upper or lower stone. In one case the stone was $2\times2\times4$ feet in dimensions, and would have required a velocity of about two hundred and sixty miles per hour to blow it off.

Direction of Whirl.

This has been reported again and again as from right to left, "counter-clockwise;" and this has caused a notable modification of the old theory that the whirl in a tornado may be either way. It is probable that this unanimity of opinion is due to other causes than careful observations. The determination of the direction of a whirl is practically impossible, unless the observer is within a very short distance, as any one may see for himself in the whirls of a dusty street. The only possible way to determine the direction of the whirl is to be near enough to see the actual motion of the leaves and twigs upon the ground. If one looks at the whirling column, he can learn nothing positive. This question is by no means settled yet, and there are reasons for thinking the old theory correct.

Air-Pressure.

Until very recently it has been assumed that there is a partial vacuum at the tornado centre. It is admitted that in a thunder-storm the pressure rather suddenly rises, nearly a tenth of an inch oftentimes; and, if the tornado is analogous, we may reason that the pressure rises in that. Professor Davis, in the *American Meteorological Journal* (February, 1890, p. 452), says that this fails to take account of the causes of increased pressure in thunder-storms, and of the decreased pressure in tornadoes. This seems a remarkable argument. Where does the severest thunder-storm and greatest increase of pressure leave off, and the tornado, with an absolutely reversed pressure, begin? The strongest argument that has ever been advanced has been the seeming bursting or exploding of houses in a tornado. This could have been occasioned by a sudden blow on any side of the house, whereby the pressure inside would be increased, and the walls thrown outward. This view was advanced some years ago, and has received a recent most remarkable confirmation in the report of a destructive storm at St. Louis, Jan. 12, 1890. The observer, a very intelligent man, writes, "In all cases of falling walls, it was noted that they fell outwards. In all cases of houses which at first sight appeared to have exploded, it was ascertained that immediately before or at the time the walls gave way, the wind forced in some portion of the south wall, as a window or door, thus probably accounting for the outward pressure on other walls." The most important observation in connection with these exploded houses, however, was the record of a barograph, which just at this moment showed a remarkable *rise* in pressure. In the Louisville tornado, also, a barograph within a mile or two of the track showed first a slight sudden fall and recovery, due probably to the wind, and afterward the tornado-rise, as at St. Louis. This evidence is cumulative; and when we consider that the wind blows away from the tornado in front, and that of two similar objects standing side by side, one very heavy and the other light, the former is swept away while the other remains untouched, the evidence seems almost conclusive that there is no diminution of pressure in a tornado. It is probable that there is no fact in the whole observation or make-up of a tornado of such extreme importance as this, and it will be touched upon again in an explanation of a seeming rush of objects into the funnel. It will undoubtedly be thought, that, after all that has preceded, we really know very little of the mechanism of a tornado. This is true; but, if we have advanced far enough to be able to say what it is not, we may congratulate ourselves, and feel that our labor has not been entirely in vain. H. A. HAZEN.

THE MANUFACTURE OF OZONE.

A COMPANY has been formed in Berlin for supplying the necessary plant for the conversion of oxygen into ozone on a larger scale than has hitherto been attempted, and the idea is gaining favor in many quarters that ozone can be economically employed for many sanitary purposes, says London *Industries*. Steps are being taken for extending the operations of the company to New York and London, as they have secured the patent rights for certain improvements in the electrical production of ozone from atmospheric oxygen in most countries. The Berlin doctors have repeatedly employed ozone, with very satisfactory results, in individual cases, and recently the company above alluded to have placed on the market a so-called ozonized water, which is stated to be a solution of ozone in that liquid. It is, however, well known that ozone is not very soluble in water, and that it readily undergoes decomposition, forming hydrogen peroxide and oxygen. The commercial name for this new antiseptic is "antibacterikon," and it possesses remarkable oxidizing properties. When added to water containing any appreciable quantity of living organic matter in the dark, it at once causes a phosphorescent appearance, and the organisms are completely destroyed in a short time. Such ozonized water is stated to have a faint metallic taste, and is used for producing sterilized water, or sterilized fluids, for bacteriological research. At present the ozone is manufactured from oxygen obtained by heating pyrolusite in the old way; but of course, with a greater demand, the Brin's oxygen process could be employed. The conversion takes place in a Siemens tube, or series of Siemens tubes, which do not differ essentially from the orignal form of ozonizer. The electric discharge is made by a Ruhmkorf coil in the usual way, or an accumulator is employed and a mercury contact breaker. It is proposed that ozone should be produced in this manner in large manufactories, and thus contribute to their sanitary improvement. Dr. Förster of Berlin has recently urged the importance of endeavoring to supply a small quantity of ozone to the air of towns and other thickly populated districts, and the company believe that their system can be worked economically and at the same time produce very satisfactory results from a hygienic point of view. It has been pointed out that many epidemics, e.g., influenza, appear to take place at those seasons of the year when the atmospheric ozone is at a minimum, and it is thus argued that an artificial supply of this gaseous oxidizing agent would possibly prevent, and at any rate considerably modify, such outbreaks of disease.

THE OIL-FIELDS IN NEW ZEALAND.

The New Zealand Government attach a great deal of importance to the indications of extensive oil fields in Taranaki. The report of the inspecting engineer of the mines department, who has made a special examination of the territory at the instance of the government, says the *Australasian Journal of Commerce*, is strongly confirmatory of the presence of mineral oil. In the neighborhood of New Plymouth there are many surface indications, particularly along the shore, gathered under bowlders and floating on the water. Farther inland the water gathering in the wells which are sunk is found to have a strong taste and smell of petroleum, so as to be quite unfit for drinking. If all these indications should turn out to be well founded, and oil be discovered in paying quantities, the find will be of great value to New Zealand in many ways, the most important of which, perhaps, is as a fuel for smelting purposes. Vast quantities of iron sand — according to the "New Zealand Year Book," a sand formed by the grinding-up of iron ore by the action of the waves — lie for hundreds of miles along the coast of the North Island; and this pulverized ore is practically worthless at present from lack of a sufficiently cheap fuel to smelt it. Should oil be obtained in such close proximity to these supplies of ground iron ore, a new and important industry may be developed into large proportions. Such, at least, is the hope of those who are investigating the matter on the spot. Independent of this, however, a new and extensive oil-field in the South Pacific would speedily become the source of supply for the whole of Australasia and the entire East. New Zealand would become an active competitor with the Baku wells, even if the Russian supply should falsify present indications of failure, and continue. The proximity of the supposed New Zealand field to the coast and port of New Plymouth would give it an advantage over both Russian and American oils in lessening the cost of both crude and refined on shipboard.

THE USE OF OIL.

ATTENTION is called by the United States Hydrographic Office to the fact that the Chamber of Commerce of Bordeaux, France, has offered a series of prizes in order to induce masters and officers of vessels to make thorough trial of the use of oil at sea, especially as regards the best way to use it and the practical benefits to be derived from such use. There are three sets of prizes, each set consisting of a first prize of 200 francs ($40) and a second prize of 100 francs ($20), to be awarded for the best reports received by Jan. 31, 1891, based upon actual experience. Programmes for the three competitions are as follows :—

1. STEAMERS.—Trials of the use of oil must be made under various conditions, particularly the following : heavy head sea, heavy quartering sea, towing in bad weather, engine or rudder disabled.

2. SAILING-VESSELS.—Trials to be made under various conditions, but especially when crowding sail with a strong wind abeam.

There must also be considered, in connection with the first and second competitions, the use of oil in lowering and hoisting boats, taking a pilot aboard, saving life at sea, riding out a gale in an unprotected anchorage, loading and unloading in a seaway, wearing and tacking ship.

3. FISHING-VESSELS, PILOT-BOATS, YACHTS, LIFEBOATS, etc.—Experiments in using oil when crossing bars, landing in a surf, etc.

GENERAL RULES FOR THE COMPETITIONS.—Each experiment must be described fully as soon as possible, and an account inserted, under the proper date, in the vessel's log book. In the case of fishing-vessels and pilot-boats, however, this may be dispensed with ; but upon return to port a full statement must be made to the maritime authorities. Full details must be given regarding the direction and force of the wind, the state of the sea,