

to render more perfect and more easily accessible, at home and abroad, our noble language and our glorious literature.

Now, I have not only told you the subject that most interests me, but explained the origin of my interest in it, and endeavored to excite your interest in it also. Pardon so much use of the first person. The narrative could not be cast in another mould.

SOMETHING ABOUT TORNADOES.¹

WHAT are the local signs of conditions favorable to the formation of tornadoes? 1. The prevalence of southerly winds, with a gradual but continued increase of heat and moisture; 2. A sultry and extremely oppressive condition of the atmosphere, which is sometimes characterized as "sticky," or so quiet as to call forth the remark that "there is not a breath of air stirring;" 3. The form, motion, character of development, and place of formation, of clouds. The sudden appearance of ominous clouds, first in the south-west, and then almost immediately in the north-west and north, is sufficient to attract the attention of the most casual observer. In nearly all instances, these premonitory clouds are unlike the ordinary formation which signifies rain, and perhaps a thunder-storm. If the clouds are light, they resemble smoke rising from a burning building; if dark, they present a deep greenish hue, which appears to increase in intensity as the storm advances. Sometimes these dark clouds appear as densely black masses of smoke, rolling upward from the chimney of an engine. The motions of the clouds are peculiar, in that they appear to be rushing from every quarter towards a common centre, making the incipient stages of a gyratory motion in the cloud region. The next step in the progress of development is the appearance of a small darting tongue of cloud, which suddenly proceeds downward from the centre of commotion, and ultimately reaches the earth as the full-fledged funnel-shaped tornado-cloud.

This brings us to consider what are the signs of its approach. The tornado-cloud is, of course, not visible from all directions while sweeping the earth. The limit of vision is necessarily greater in some cases than in others, depending upon the topography of the intervening country. Where the funnel-cloud cannot be seen, its existence can readily be distinguished by the peculiar roaring noise which is likened to the rumbling of distant thunder, or the approach of a heavy train of cars. The noise is said to resemble the "sighing of the wind through the forest." As the storm approaches nearer, the sound increases in intensity until the final crash of the elements, which comes with the suddenness of an explosion. The noise is sufficiently peculiar and distinct to create an alarm, and, as a means of warning, must not be ignored. A few moments before the assault there is a death-like stillness in the air. The observer's eye catches the absence of any movement in the leaves upon the trees, which a moment before danced in a gentle wind. The ominous silence portends grave results, and requires that no time be lost in seeking the most perfect means of safety.

The form of the tornado-cloud in individual cases is somewhat variable; but it always tapers from the top downward, the smaller end being nearest the earth. It is described by eye-witnesses as resembling an "elephant's trunk," "balloon-shaped," "egg-shaped," "basket-shaped," etc. While passing along its path, the cloud is characterized by four distinct motions, which may be designated as (1) the "progressive motion," generally from some point in the south-west quadrant to some point in the north-east quadrant; (2) the "whirling or gyratory motion," always from right to left, or contrary to the movements of the hands of a watch with the face upward; (3) the "curvilinear motion," where frequently the cloud rises from the earth, breaking the continuity of its path for a distance of several rods to as many miles, then returns suddenly to the earth with renewed energy, continuing its violence as before; and (4) the "oscillatory motion," a swaying from side to side of the central line of cloud movement. (This motion is sometimes quite sudden, but generally it is a moderately slow motion, and easily identified: the regularity of it depends upon the frequency and severity of the indraughts of air from the south side of the storm's path into the vortex of the cloud).

It is important here to state that the south or right-hand side of the tornado is the most dangerous part of the storm, as it is also in the case of the cyclone. On this side the inflow of air toward the vortex coincides both with the progressive motion of the tornado and with the general easterly movement of the "low," thereby increasing the velocity of the southerly currents. On the north or left-hand side of the tornado the incurving winds oppose the direction of the currents advancing to the vortex, and therefore the force of the wind is very much less on this side: it is therefore the safest side of the storm. The tornado-cloud is swept along by the general currents prevailing in the south-east quadrant of the "low," and whatever may suddenly affect these movements will also extend its influence to the tornado-cloud, and thus increase or diminish its gyrations, sometimes to the extent of withdrawing the cloud entirely from the earth. The tornado continues in the full manifestation of its power until the force arising from the gyrations is no longer adequate to keep the pressure and temperature in the vortex low enough to cause condensation; and therefore the lower part of the cloud vanishes first, the decrease of power continuing until nothing appears on the funnel, and a dark, irregular mass of cloud marks the spot from which the spout had previously depended.

"Windfalls" are the tracks of tornadoes through forests, as shown by the prostrated and confused masses of timber. In many cases there remain but the skeletons of these ruins, and their location is known only to Indians, trappers, hunters, and surveyors. There is not a State east of the Rocky Mountains that has escaped these serrated tracks through its forests, and the record of their occurrence will in many cases be found upon the plats of the early State surveys. Windfalls both of recent and of very early date are still to be found in the forests east of the Mississippi. The late Professor I. A. Lapham of Milwaukee, Wis., attached to the signal corps in 1870-72, made, in the latter year, a very exhaustive and interesting report on the windfalls of Wisconsin. As the result of a very careful examination of the plats of public surveys made within the State, he discovered and marked upon a chart the location and approximate length of path of three hundred and sixty windfalls or tornadoes.

The successful protection of life depends upon the position and surroundings of the observer on the approach of the tornado, the character of motion possessed by the tornado-cloud at the time, the width of the path of the storm, and the velocity with which it is moving.

The following precautions have been determined upon as the result of careful investigation, observation, and experience: 1. The south side is the dangerous portion of the tornado, the north side is the safe portion. 2. In the open country, never undertake to escape from a tornado-cloud without first making sure of the points of the compass, and that the direction which you propose to take is in a line at right angles to the path of the advancing cloud. 3. If the cloud is moving to the north-east, then the line of escape is to the north-west; if to the east, then to the north. Stand facing the advancing cloud in the direct line of its approach, and the safe side is always to the right. 4. To make escape certain, the tornado-cloud should be about three-fourths of a mile distant. This gives the observer a momentary chance to ascertain the character of motion it possesses, the velocity of progression, the width of the path, and the points of the compass. These estimates must of necessity be approximate, but can be made sufficiently accurate to be depended upon. At a greater distance than three-fourths of a mile, it would be difficult, in most cases, for the observer to obtain this information with any degree of satisfaction, unless the atmosphere was clear, and the cloud advancing over the open prairie.

A frame building is safer than one built of brick or stone. The former is more elastic, and holds together longer. The latter goes down in the first crash, and the *débris* is whirled into a heap in the centre of the foundation. This is especially the case where a brick or stone building stands alone. In a block of such buildings, one structure supports another, and there is not quite so much danger of entire destruction. In any event, however, the brick or stone building is the most dangerous, because it so readily crumbles and separates into falling masses, that the inmates are never safe from injury.

¹ Portion of a paper read before the National Geographic Society of Washington, Nov. 16, 1888, by J. P. Finley, continued from *Science*, No. 313.

In a frame structure the safest place is in the cellar, but in a brick or stone structure it is the most dangerous. In the former case, if the building is destroyed, it is invariably carried away from the foundation. In the latter case the cellar is filled with *débris*.

The safest building to construct is one made entirely of wood, with a "barn frame," and not exceeding one story and a half in height. Where several buildings are connected together in a row, the height may be increased one or more stories with safety. No structure that rises above the earth, however made, can resist the violence of the tornado, and therefore no building is safe as property, or as a resort to protect life. Under all circumstances, whether in a building or in a cellar, refrain from taking a position in a north-east room, in a north-east corner, in an east room, or against an east wall.

The tornado-cave offers absolute security to life and limb, and nothing can replace it for that purpose. This retreat may be constructed as a cellar-cave or as a "dug-out." In the former case an excavation is made in the west wall of the cellar, on a level with the floor of it, and carried under ground until a sufficient distance is reached to provide comfortable quarters for those who propose to occupy the cave. The overhanging roof must be supported by heavy timbers, and then arched over with masonry of brick or stone. This extra precaution concerning the roof is necessary to provide against any serious damage to it by falling timbers or heavy masses of *débris*. The excavation is made into the west wall, because the storm, always approaching from the west, will carry the *débris* away from that side. But even this favorable position does not preclude the probability of *débris* being thrown upon the cave by the whirling currents of the vortex. The extra care bestowed upon the roof is money and time well spent. Careful attention should be given to ventilation and drainage, and to making the retreat in every way as convenient and comfortable as possible. The extent to which this suggestion can be complied with will depend upon the pecuniary ability of the person concerned.

The "dug-out" is a tornado-cave, not necessarily connected with any building. The results to be secured are the same as those derived from the use of the "cellar-cave." The cost of a properly constructed tornado-cave, including material and labor, will range according to the quality, character, and strength of the material with which it is built, together with the price of labor, from a hundred and fifty to three hundred and fifty dollars. Such a cave will comfortably accommodate ten persons.

The rush of air into the tornado's vortex, and therefore the violence of the wind, depends upon the difference of barometric pressure between the inside and the outside of the storm. This difference has been observed to be nearly three inches, and may be very much more, for observations have never been made in the centre of the vortex. A gradient of three inches, however, will give a velocity of 323 miles per hour, which will exert a pressure of about 260 pounds per square foot against a surface exposed at right angles to the direction of the wind.

The explosive force of confined air in a tornado is enormously great; and frequently it is to this energy, rather than to the direct force of the wind, that the destruction of buildings is due. As a tornado-cloud passes over a building, if the air within is confined by closed doors and windows, and cannot readily escape, the explosive force, due to a very great difference in tension between the air inside and outside of the building, bursts asunder the walls, and throws the roof upward to a considerable distance. Eye-witnesses state that under such circumstances roofs have been uplifted a distance of five hundred feet. Cellar-doors have been blown away from their fastenings in the face of a strong wind coming directly against them, and corks have been blown out of empty bottles by the sudden expansion of the air within them. Many almost incredible instances of extraordinary violence by the explosive force of tornadoes could be given, but want of space forbids more than this general reference to such manifestations of the tornado's power.

There is no fact or record to show that an electrical discharge, or any manifestation of atmospheric electricity, ever directly and entirely destroyed a large stone or frame building; ever lifted a locomotive from its track; ever carried an iron bridge from its foundation, and twisted the framework into a shapeless mass; ever

rolled a boulder from its bed in the ground; ever embedded one piece of timber into another, after having carried the former several hundred yards in the air; ever carried bedding and clothing in the air for miles; ever elevated to considerable heights in the air, columns of water from ponds, lakes, and rivers; ever lifted animals from the earth and carried them over buildings; ever drew the water from a cistern; ever twisted a tree from its stump; ever turned a building upside down, or end for end, without otherwise injuring it.

Any method of reasoning which assigns tornado-development to planetary influence is, equally with the electrical theory of their origin, without foundation. We have but to realize that in the formation of the tornado, and other local storms of a similar character, the entire action of all the forces involved, even in the energy of the sun's heat, is embraced in that portion of the atmosphere within from two to three miles of the earth's surface.

Any influence emanating from the movements, conjunctions, or other periodical mutations of the heavenly bodies, distant hundreds of thousands and millions of miles, can only reach an infinitesimal amount, and is entirely inappreciable in its effects upon the atmosphere to produce local or general disturbances, especially near the earth.

It has been asserted that the conditions which give rise to the formation of the tornado-cloud result from the effect upon the atmosphere of the mere revolution of the planets in their orbits; that the circular movements in the atmosphere are propagated and continued by such influences. The effect is likened to that which would result from the whirling in different directions, in a large vessel of water, of several globes attached to the same spindle. Upon withdrawing the globes, after a number of revolutions, the surface of the water will be found covered with a network of eddies. The inherent fault of this simile is the fact, that, while the illustration provides for the circular movement of the bodies within the medium which is set in motion to give the characteristic whirls or eddies, the subject of illustration, the planets, perform their revolutions, not in the atmosphere (the medium to be set in motion), but millions of miles away from it, in another medium, concerning which little is known. The failure properly to apply the method of reasoning by analogy often leads the novice into making the most ridiculous assumptions. It would be more reasonable to assume that the revolution of the planets gave rise to the great disturbances of the atmosphere, embracing extended regions of country, which are known on the weather-map as "highs" and "lows;" but even here the same difficulties operate, although not so extravagantly as in the case of the tornado, with the narrow path of a hundred yards or more.

To forecast successfully the time and place of any atmospheric phenomenon is a difficult matter, largely in proportion to the area of country brought under the influence of the particular disturbance. There are, of course, other elements which enter into the calculation to render the problem, except under the most favorable circumstances, an extremely complicated one, where the accuracy of results is demanded. It is well known that the tornado has the most circumscribed area of all storms, while its violence has no equal in the entire range of meteorological phenomena.

A large amount of field-work, and instrumental and general observations extending over many years, relating to the conditions of formation of this peculiar class of storms in every part of the country where they were found to occur, was necessary as a foundation upon which to base investigations as to the origin, mode of development, and means of prognostication. I began this work, in addition to other duties, in 1879, under directions of the chief signal officer. The first field-work was done in that year, the second in 1882, and the third in 1885. Various reports were prepared and published concerning the development of particular storms, the origin and general characteristics of tornadoes, and the relation of tornado regions to areas of low pressure.

It was found that tornadoes generally occurred at a certain time of day; generally moved in a certain direction; were generally preceded by certain conditions of wind direction and velocity, and by a certain gradient of temperature; generally occurred in connection with a well-defined area of low pressure, and with a "low" of certain form and trend; and generally occurred in a certain

quadrant (south-east) of the low-pressure area, at a certain distance from the centre of the "low" as marked on the weather-map, in certain regions of the country and in certain months of the year, and in groups having parallel paths of progression and at distances between of but a few miles.

Official tornado-predictions began at the Signal Office, experimentally, on the 10th of March, 1884, and were made twice daily at 7 A.M. and 3 P.M., Washington time. The predictions were for certain districts, that portion of the United States embraced between the 77th and 102d meridians being divided into eighteen sections, with arbitrary boundaries. These prognostications terminated on Sept. 20, 1885; and during the season embraced by the work, all of the well-defined and most destructive tornadoes were predicted for the districts within which they occurred, from five to eight hours in advance of the reported time of their appearance.

After May 10, 1886 (the following year), the official predictions were announced to the public in accordance with the following order of the chief signal officer: "The indications officer will give special attention to conditions favorable to the development of severe local storms and tornadoes. When the reports justify the prediction of these storms, they will form a part of the general indications, the prediction to be that conditions are favorable for the occurrence of severe local storms or tornadoes, giving the names of the States where such storms are expected to occur."

It will be observed, that, upon deciding to make tornado-predictions part of the general indications issued daily to the public, the character of the districts was changed from those determined by arbitrary divisions, to those designated by State lines; in other words, the States themselves. Commencing July 1, 1886, a special chart (No. 5, Dew-Point and Local Storm Chart) was made up daily in the indications room of the Signal Office to furnish information from which tornado-predictions could be made. This chart was discontinued on July 1, 1888, and replaced by the general weather-chart from which the regular indications are made. Since Sept. 20, 1885, no official verifications of local storm-predictions have been made, but the results observed from the combined indications are in a measure satisfactory.

Personally, I am of the opinion that the forecasting of conditions favorable to the development of tornadoes, and designating the quadrant of a State in which such conditions shall give rise to local signs that the inhabitants of that section can rely upon, are entirely practicable. By this admission I do not mean to convey the idea that the exact path of the funnel-shaped cloud can be indicated in the despatch, for that would be impossible except by chance. The average width of the tornado-track is only a few hundred yards; and several of these storms may occur in the same county, with entirely independent paths of destruction, and distinct cloud-formations.

It doubtless appears that the quadrant of a State, especially the larger ones, is a very extensive area to cover with a single tornado-prediction; but the fact must not be overlooked, that, where the conditions are favorable for tornadoes, storms having various degrees of tornado violence occur here and there over a very large section of country. Therefore the scheme of local storm-predictions for State quadrants would seem to possess the elements of success; for, while the peculiar funnel-shaped cloud might not appear, the conditions would be such that local storms of great violence would occur, and destruction to life and property ensue.

Although, of course, the area here indicated is quite variable in extent, yet it possesses the decided advantages of definiteness, familiarity to the people who are interested, and brevity of expression in rendering a concise despatch. The local signs of tornado-development are certain, easily observed, and well defined. With the people well informed on these points, and there is no reason why they should not be, the prediction of conditions favorable to local storms, issued from some central meteorological office, would, if successful, supplement the local signs with beneficial results. Failures in the official predictions would not only bring out more distinctly the importance and reliability of local signs, thus creating an interest in their careful observance, but would obviate the occurrence of serious results when wrong predictions were made, as the people would test their trustworthiness by appeal to the "local signs."

With the appearance of every new problem in science, especially if its solution involves the welfare of mankind or any great number of people, there is made the most strenuous effort to obtain deductive results, without due regard to proper methods of investigation. This is all quite in accordance with the inclination of human nature frequently to want without reason, but the true scientist knows that such demands cannot be complied with in safety.

People clamor for adequate means to destroy the tornado-cloud by a single blow, sometimes that can act with the rapidity of the electric shock; and because the article cannot be supplied in order, in quantity, and in style, to suit customers, we are informed by some critics that investigation thus far has been fruitless, and that our efforts to expose the nature and origin of tornadoes are the mere vaporings of a vivid imagination.

In this age of inventions and glittering geniuses, it is not surprising that the sufferings and the necessities of the tornado-stricken people have received attention; but, as usual, such attention has been more to the profit of the scheme and schemers than to the advantage of those whose credulity made them the victims of an overweening confidence. The festive and irrepressible lightning-rod pedler has appeared upon the scene, and offers with great gusto a beautifully wrought metallic rod, to be attached to buildings with gilt fastenings, terminating near the chimney or cupola with a resplendent brass rooster or other decoration, which, while serving the purpose of a wind-indicator, is, together with the mysterious rod connecting it with the earth, a perfect protection against the tornado-cloud. How the result is obtained is a secret of the inventor. The purchaser must not inquire into the nature of this mystery, as his success with the venture depends solely upon an abiding faith and the requisite shekels.

There are other plans and devices deserving of a little more recognition, but they are wholly wanting in the essentials that shall make them reliable and capable of practical application at the moment of supreme danger. Among these may be mentioned (1) an arrangement to explode an underground magazine by electricity when the tornado-cloud approaches a town, a mill, or any group of buildings to be protected, the explosion to take place while the cloud is passing over the magazine; (2) an arrangement of high poles, electrically connected with each other and the earth, and covering about an acre of ground, the top of the poles to be furnished with long, sharp metallic points, so as to draw off the electricity of the tornado-cloud, and thus dissipate its energy at once, upon reaching the field of poles; (3) a cable to anchor a building safely against the fiercest tornado, and an insurance policy to cover all damages that may occur from the cable giving way; (4) an arrangement to keep kegs of gunpowder in a properly protected place to the south-west of the building, and, upon the approach of the tornado-cloud, courageous men to take out the kegs and place them in the path of the approaching cloud, the powder to be fired at the right time to destroy the cloud; (5) an arrangement to construct immense stand-pipes of heavy wrought iron, about five hundred feet high and one hundred feet in diameter, these pipes to be placed upon heavy masonry piers about ten feet high, and so constructed as to permit a free circulation of the air underneath, and upward through the centre of the pipe. The plan involves the erection of a considerable number of these pipes in the tornado regions, the requisite number to be determined by experience. It is expected that these great pipes will serve as vent-holes for the harmless escape of whirling eddies in the atmosphere, which otherwise might develop into destructive tornadoes. It is further claimed that these pipes may serve to increase the rainfall at any place by causing, artificially, the upward rush of a large volume of air, the moisture contained therein being condensed by the cold of elevation. The initiatory upward movement at the base of the pipe is induced by an open fire built on the ground, within the pipe and near the centre of the base. Of course, the physical principle involved is the upward movement of heated air, and the inrush, at the point of inception, of the surrounding cooler air, thus giving rise to an upward flow of more or less power, according to the amount of heat applied and the volume of air affected.

The limits of this paper will not permit of a critical discussion of the merits of the various mechanical devices for the destruction of the tornado-cloud, or even to mention them all. Suffice it to say,

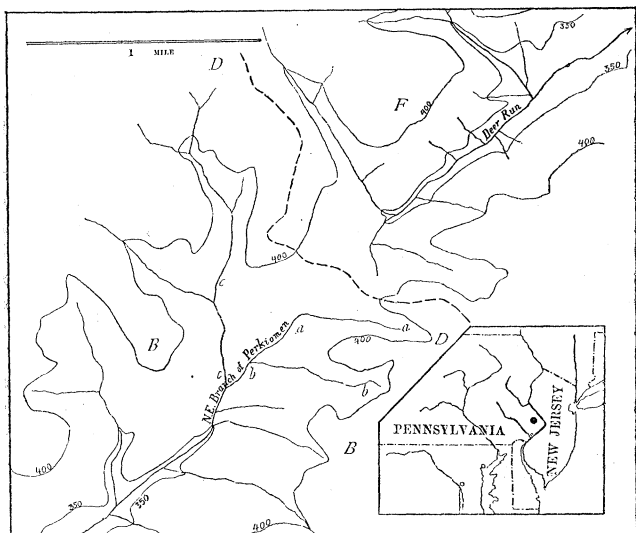
that the writer is of the belief that all efforts directed toward the accomplishment of the destruction or dissipation of the tornado-cloud by any known and practicable means, will fail of realization.

Mechanical appliances are wholly incapable of successfully coping with the forces of the tornado, which, unlike the whirlwind and waterspout, arises from the unstable state of the atmosphere in the cloud region, where the tornadic gyrations commence, and are afterwards propagated downward to the earth's surface. The tornado is controlled by the operation of forces far above the ground.

A RIVER-PIRATE.

THERE is a little river-pirate in eastern Pennsylvania unsuspected by its rural neighbors. It is in a quiet, well-watered farming district, where the streams, as a rule, are bent only on minding their own business, and not interfering with their fellows; and yet one of them is a confirmed pirate, and goes on unhindered in its robbery.

The pirate is Deer Run, and its victim is the north-east branch of Perkiomen Creek. The head waters of the latter have been captured, and led away from the basin where they were born and passed their youth, and thus diverted to swell the surreptitious vol-



ume of the intruder. The affair has happened in this way. The country hereabout was in ancient times a surface of faint relief, at a lower stand than now, traversed by idle streams; but, in consequence of elevation to a greater altitude, the streams have revived their lost activities, and set to work to sink their channels and open out their valleys in the process of reducing the land to its proper level again, even with the sea; for land finds its level, like water, but more time is required before the level is assumed. The streams that drained the country when it was elevated adopted such faint inequalities as they then found for their first settlement, and have since been engaged in perfecting their courses as best they could, cleaning them out, deepening them, and adapting them most exactly to the best transportation of land-waste. In the processes of adjustment thus called forth, every stream struggling for its own existence, it sometimes has happened that a stream with steep head waters has seized drainage area from the flat-lying head waters of an adjacent basin; because, other things being equal, the waste of the surface is fastest on the steepest slopes, and hence the steeper streams have gnawed more quickly into the land-mass than the flatter ones, and the divide between a pair of contesting streams has consequently been pushed in the direction of the fainter descent.

The abstract possibility of this process cannot be questioned; but one might well hesitate before accusing so innocent-looking a stream as Deer Run of such underhand designs. Yet the evidence of its piracy is too direct to be doubted.

In the first place, the region that the two streams drain has been

accurately surveyed by the Philadelphia Water Department, and the maps thus secured have been published by the Geological Survey of Pennsylvania. The facts of the case are thus brought clearly before the world, after long remaining in unsurveyed obscurity. It is from one sheet of these maps that the accompanying figure has been traced, omitting the wooded areas and dwellings. The smaller map in the corner indicates the location of the district under discussion in the south-eastern corner of Pennsylvania, north of Philadelphia and west of Trenton. In the next place, it is to be noted that the slope of Deer Run from the divide *DD* is twice as steep to the north-east as is that of its victim to the south-west. Deer Run descends sixty feet in a mile at its head: the Perkiomen branch descends only thirty feet in the same distance. Again: it appears that the two streams, flowing on the same line but in opposite directions, both follow the same bed of shaly sandstone in the rock formation (triassic) that underlies the district: there is, therefore, no inequality of structure on the two sides of the divide to determine a difference in the rate of head-water weathering. In so short a distance as a mile or two, it cannot be thought that there is any difference in rainfall or other climatic element of significance; and, if exposure to sunshine be a factor of value in aiding the denudation of a surface by strengthening the diurnal variations of temperature in the soil and increasing the number of winter thaws, this advantage would be with the Perkiomen. Leaving this aside, it appears, that, except for difference of slope, the streams are in similar conditions, and any inequality in their action must be referred to the control that the slopes exert. As the control exerted by the slopes is distinctly in favor of Deer Run, we must conclude, that, if a patient observer should take his stand on the higher ground near by, he would certainly see the divide *DD*, migrating, rather slowly to be sure, to the south-west. After a time the uppermost side-stream of the Perkiomen branch, *aa*, would be tapped by the insidious operations of the pirate; and, powerless to withstand the temptations of a more facile descent, it would turn from its parent to join the volume of its captor. In time another side-stream, *bb*, would be led astray; and thus Deer Run would extend its territory at the expense of its more inert neighbor, and the divide would in time be shifted to *BB*.

Now, it is noticeable that all tributaries thus acquired by the pirate would enter the head of its main channel in a back-handed manner, like the barbs at the point of an arrow, indicating by this abnormal arrangement their early training in accordance with the habits of the Perkiomen family, where they were brought up. But if this process is going on now, we must be persuaded that it has been in operation in earlier times also, and that results of the kind now predicted for the coming ages should already be visible as the product of those gone by. Such is undoubtedly the case. Deer Run bears at its head at least three small side-streams, which still manifest in their directions the clearest indications of Perkiomen habit; and thus it must stand convicted not only of piratical intentions for the future, but of piratical practice in the past.

If the reader should, perchance, be seriously inclined to geographic study, he may find many accounts of this kind of interaction among rivers in the writings of recent authors. Gilbert has considered examples of the process in our Western Territories; Löwl and Philippson have pointed out a number of instances among the rivers of Europe; and Heim has shown how the picturesque little lakes at the head of the Engadine result from the capture of head-water streams by the steep-sloping Maira from the more steady-going Inn. As our intimate acquaintance with the geographic development of our country is furthered by the publication of good topographic maps, we shall undoubtedly find many cases of head-water adjustments. The Atlantic-Mississippi divide, from Pennsylvania to Alabama, should be especially rich in them.

Yet, if what is one man's food is another man's poison, it may be that what is one man's crime is another's virtue. It is only in false allegory that we can blame Deer Run for having taken what once belonged to the Perkiomen; and instead of calling the capture of head waters a piratical act, which at best is but an *ad captandum* term, it should better be regarded as a sharing of another's burden of labor, and a willing assumption by the more active stream of its fair proportion of the work to be done by the whole river system to which it belongs. Instead of gauging the disposition of streams by