SPECTERS IN THE AIR.

BY CHAS. B BOYLE.

Had the causes of the mirage been understood, life and property might often have been saved, and, as utilizing that knowledge is one of the objects of this paper, it may be well to consider the subject in chronological order.

The accompanying diagram is given by Sir David Brewster as the geometrical exponent of fits of extraordinary atmospheric refraction, to which he attributes the phenomenon of the mirage, by which he means that the earth's atmosphere is subject to *fits of refraction*, so extraordinary that objects on the surface of the earth may appear at times elevated above it at angles as great as thirty or forty degrees. If the earth's atmosphere is subject to such excessive changes in its refractive energy, how happens it that the sun, moon, or stars never appear displaced by it, even when seen over the horizon where the greatest amount of displacement by refraction occurs, and where they are never affected by refraction beyond a single degree?

In astronomical observation no greater amount of refraction is ever obtained at the horizon than one degree, and as the angle of observation above the horizon increases, the atmospheric refraction decreases, till at the zenith it is nothing. The varying amount of atmospheric refraction at the horizon, where it is greatest, is never more than five minutes of a degree, and the only visible sign it gives is the slight enlargement of the apparent size of the sun or moon, and their appearance and that of stars above the horizon a few seconds in advance of their true time. If, when examples of the mirage are occurring, we direct a telescope along the line of the mirages, we shall find that our instrument is seeing in straight lines, which would not be the case if the line of vision were passing through an atmosphere of varying density. While engaged in locating a lighthouse at sea and sighting an object on a distant mountain side, the line of vision frequently passed over vessels and under their images in the air, and, therefore, through the section of atmosphere which Sir David's theory assures us was then undergoing a fit of *extraordinary refraction*, but in no case did the reading of the angles vary in the slightest degree from those obtained at other times. Indeed, if the earth's atmosphere were subject to fits of extraordinary refraction, the sciences of engineering, navigation, and astronomy could have no existence, for then neither the telescope nor the naked eye could see in straight lines, and, consequently, triangulation of any kind would be practically impossible beyond the limits of a straight edge. A navigator might find his true place upon the ocean to-night by measuring the angular position of a star under normal conditions of atmospheric refraction; to-morrow night another navigator might be in the same spot and undertake to find his place upon the ocean by measuring the angular position of the same star, but might find it varying from one to forty degrees from what it read upon the previous night, if the medium through which it had to he observed were subject to fits of *extraordinary refraction*, and, as it would be impossible to determine at any given moment the amount or direction of the displacement, finding latitude and longitude by the stars would be impossible, and, if attempted, would be certain to lead to disaster; whereas, all navigators place the most implicit confidence in those celestial observations, which they could not do if the atmosphere were subject to fits of *extraordinary refraction*, nor would it be possible to map any portion of the earth's surface.

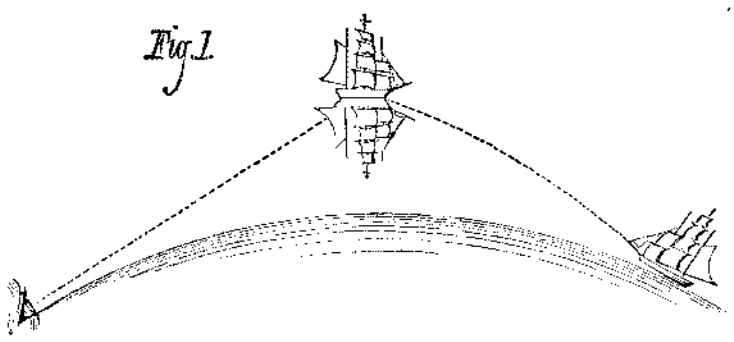
Imagine an engineer triangulating for the purpose of mapping a coast line, without the means of knowing when his telescope was seeing in straight lines or when it was not, and never being able from moment to moment to determine how much or how little its line of vision was deflected from the line of its axis, if at all. Determining the trend of a coast in a world where such conditions existed would be simply impossible. The same is true of surveying lines of railroads, canals, and all kinds of engineering, where long sights are a necessity.

The region through which the Suez Canal has been built, is one where the phenomenon of the mirage is of most frequent occurrence, but the engineers have in no instance experienced trouble by having their lines of vision deflected from the axis of their telescopes. Why, if the earth's atmosphere were subject to fits of extraordinary refraction, a map of the heavens could not be made, as no observer could tell when a star was displaced or the amount or direction of the displacement; even marksmanship could not exist, as a hunter might be firing at the image of a deer which was, in fact, behind an adjacent hill many degrees away from the line of the shot. Firearms to shoot round corners would then be in order.

If, from the facts observed, we measure the position of the ship and that of its image in the air, we shall find the quantity of refraction too great to be obtained, even by a medium varying in density from atmosphere to glass; so slight, in fact, is the variation in the density of the earth's atmospheric conditions that we require the most delicate instrument to measure it, and the most extreme amount indicated by the mercury is never sufficient to perceptibly deflect a ray of light passing through it; no barometrical observations have ever recorded at any place or at any time any change in atmospheric density that would warrant the theory of extraordinary fits of refraction.

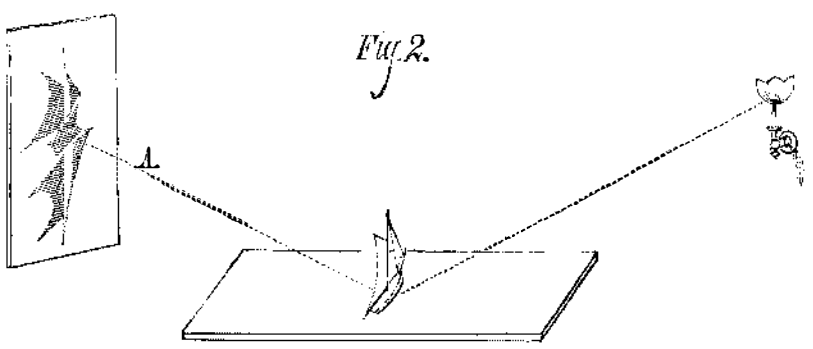
Now, let us observe what takes place while we try some experiments which we can bring under our immediate control. Lay an ordinary sized mirror, say twenty-four inches long, down upon a table with the mirror side up, setting on

Fig. 1.



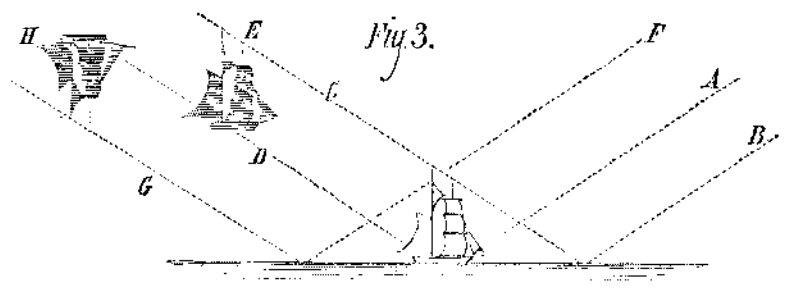
the glass, at about its middle, a toy ship or boat with sails, made of paper, if we please. Let the bottom of the boat's hull be flat, so that it will stand in upright position and crosswise on the glass, "athwart ships" of the mirror, then hold a light above and beyond one end of the mirror, as shown in diagram 2, the light from which, after falling upon the mirror, is reflected in the direction A, where, being intercepted by a screen, it presents two images of the ship, one right side up and one wrong side up, with their bottoms

Fig. 2.



apparently together. If we remove the mirror and put in its place a dish of water with the ship afloat in it, the result will still be the same, with the exception that the images will be less distinct, owing to the fact that the surface of the water reflects less light than that of the mirror, but if we increase the brilliancy of the flame, the distinctness of the images at A will increase in proportion, and when the instrument be placed in the sunlight they remain quite distinct, even when projected upon thin gauze and when the distance from the

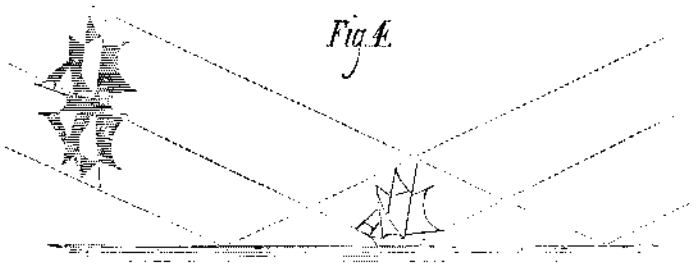
Fig. 3.



ship is much increased. We have, then, in this experiment the sun, the ship, the water, and the peculiar combination of images in the air, which constitute the most remarkable examples of the mirage in nature.

The results are identical; there can only remain a question as to the identity of the causes. That the images seen in the air become visible by being projected upon intercepting clouds there can be no doubt, because it is not possible to make images projected in air visible unless by their interception. Just as the pictures projected by a magic

Fig. 4.



lantern are everywhere in the air between the screen and the camera, yet are visible nowhere but on the screen, so the images of the ship are everywhere present in the air between the ship and the image, but remain invisible till their interception by a screen, as may be proved by holding the screen in the experiment at any distance from the toy ship along the line of the reflected images, where it may everywhere be shown, but nowhere in empty space. And as nature has no other screens in air but clouds, they must be the backgrounds which, by intercepting those images, make them visible. This, however, has been put beyond a doubt by a case witnessed in this city, where a number of people saw the image of a burning brig, which was six or seven miles distant, distinctly visible on the smoke of some asphaltum, which had accidentally caught fire in the street where they were.

In every case where the time of day is mentioned with the observation of the phenomenon, we find that it occurred when the sun was low; thus the observation made by Mr. Gresham took place about four o'clock in the afternoon; we also find that it is much more frequent in the Arctic seas than elsewhere, because there the sun is always low, while in the lower latitudes it is low only in the early and later portion of the day. The causes of its more frequent occurrence when the sun is low is due to the fact that the reflected image makes a correspondingly low angle with the surface of the water, and is therefore much more likely to be intercepted by clouds before making its exit from among them into space, than if it were reflected from the surface at angles nearer to the perpendicular, in which case it would stand but little chance of interception by those wandering backgrounds. Indeed, it is impossible for the sun to shine upon moderately still water without reflecting back to heaven images of all things resting on its surface or about its edges with sufficient elevation above it to cast shadows upon its surface. It is only upon exceptional occasions that any of those images are intercepted by a cloud screen, and when that happens we call it a mirage, specters in the air, etc. When but a single image of a ship at sea is seen in the air, it is due to the fact that the intercepting cloud screen is in position to receive but one of its shadows, for both are projected from the ship in every such case. If the right side up image is visible without the other, then the cloud is too high to intercept the lower one, and if the wrong side up or inverted image is exhibited without the other, then the cloud is too low to intercept the upper image, as may be seen by the third diagram, where A B is a sheaf of sun rays falling upon the water on the sunward side of the ship and reflected back into space along the line, C D, carrying with it a shadow of the ship right side up, which, being intercepted by a cloud at E, becomes visible there. The lines, A F, bound another sheaf of rays, which project a shadow of the ship on the water beyond it, which being reflected into space along the lines, D G, and intercepted by a cloud at H, becomes visible there, thus accounting for the phenomenon of an erect image of a ship presenting itself in one part of the heavens and an inverted image of the same ship in another part at the same time; this, however, is so rare a combination of cloud, ship, and sun that is very seldom witnessed, and when it is, it most usually happens that only fragments of both images are seen, because the accidental passing of the clouds is more likely to bring them but partially into the paths of the shadows. More frequently it happens that one image, or one image with a fragment of the other, makes its appearance, because of the accidental distribution of the cloud screens which intercept them; but when this background is sufficiently large and posed in the path of both shadows, then both images appear in the same place, as shown in the fourth diagram. Even an almost imperceptible mist will serve to make those images visible, as may be shown by placing in the path of the artificially produced image a thin gauze, which will show the air phantoms, when received, from either side. The double image, however, is a phase of the phenomenon which can only occur when the object from which it is projected is surrounded by the reflecting surface, hence its occurrence most frequently at sea; it may occur on land, however, when the object is surrounded by plains turned into reflecting surfaces by recent rain, where numerous little pools, wet vegetation, etc., become the equivalent of a mirror, more or less broken, it is true, but as all the pools, howevergreat or small, assume one common horizontal surface, they are the equivalent of a fractured mirror, which acts in the case precisely as if it were not broken when the reflection takes place from the upper surface. An example of this kind was witnessed at Petersburg, Va., where the image of a church standing near was seen in the air; fortunately, the observer incidentally remarked, without seeming to suspect that it had any connection with the production of the phenomena, that the time was about four o'clock in the afternoon and that a thunderstorm had just passed over. The observation made in this city supplies the rest, for the exhibition began with the breaking out of the sun from behind a cloud and ended with the existence of the column of smoke that supplied the background.

When an object is located on the shores of the reflecting surface only a single image of it can appear in the air, and this will be right side up, if the sun is on the water side of the object, or inverted, if the source of light is on the landward side, because when the shadow of the object is cast upon the water before reflection takes place, the reflected image is always bottom up, but when the light is reflected from the water before encountering the object, the shadow projected is always erect, as may be seen by the fifth dia-

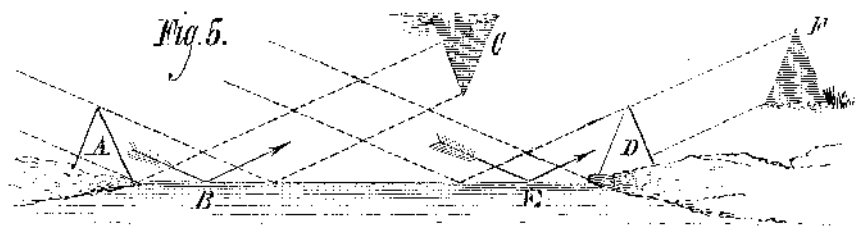
gram, where the sun is assumed to be on the left hand side, where also is the obelisk, A, the shadow of which is cast upon the water at B, and thence reflected to the cloud, C, where it appears inverted. The obelisk, D, is on the opposite side of the water, therefore the sunlight falls upon the surface at E, and is reflected upward before encountering it; but when it does encounter it, the obelisk cuts its form out of the light, which shadow proceeds onward and upward with the reflected light, until it is arrested by the cloud, F, where it is made visible right side up.

This last example of the air pictures was beautifully shown in a case observed on the south coast of England. A windmill stood upon a promontory with an eastward shore. The sun was rising, and an erect image of the windmill was seen in the air to the westward, obviously projected upon the morning mist. As the sun ascended so did the image, because the angle of reflection being equal to the angle of incidence, it must ascend from the reflecting surface at the same angle at which the sun shone down upon it, or that at which its light was incident upon it, but in proportion as it ascended it became less distinctly defined, and finally disappeared by gradually fading away, because the morning mist increased in attenuation in proportion as its altitude increased above the water. The image also moved northward at the same rate that the sun moved southward, in this also obeying the law of reflection; for the sun, the mill, and the image must, of necessity, occupy a perpendicular plane common to them all. As the mill was stationary and the sun in motion about it, all shadows of the mill cast by the sun must, of course, move about it in the opposite direction to that in which the sun was moving, precisely as if the sunlight and the shadow were opposite and connected radiates of the mill, just as when the sun is in the east it casts its shadows to the west, and as it moves westward it casts them more eastward, pointing east when the sun is due west, and west when the sun is due east, or always opposite the sun. All aerial images produced by this phase of the mirage are shadows *only* of the objects they represent, and, like all shadows, present only outline forms. They are frequently observed inland, and, if their causes were understood, might at times serve very valuable purposes.

Recalling the case of a party of trappers with laden animals crossing some of our Western wastes and perishing for want of water, yet seeing in the air the image of an eagle, right side up, perching upon the branch of a dead tree, and superstitiously regarding it as an ill omen, instead of comprehending that it was a messenger sent by the sun to say that if they turned their faces toward him he would lead them to water in a very short time, yet still toiling past, unwittingly rejecting the proffered relief, is one of the melancholy prices we often pay for the luxury of ignorance or of false interpretation of natural phenomena. The real eagle was seated on the branch of a dead tree which stood on the nearest edge of a sheet of water not, probably, half an hour's journey from them, for images projected by small objects cannot be visible far from their original source, for, like all shadows, they consist of the actual and penumbral shadow, the latter fading away with the distance and the former growing smaller. As even the branch of the tree was shown in this case, the probability is that the water was not more than a mile away, yet they toiled on past it to many a death of horse and man. The sun not only projects double shadows of all objects upon water, lying in the path of its rays, away from it, but also forms in air real pictures of the sides of the objects which are turned toward it, especially if those sides are wet. The mode of reflection by which this occurs is illustrated by diagram 6, where the sunlight breaking through a cloud in such a manner that its light falls upon the water at A, upon the sunward side of the ship, the lower edge of the cloud, B, prevents the sun rays from illuminating the ship. The light is reflected from A on to the object, and thence back and upward in the sheaf of reflected rays, C D, to the cloud, B, where a picture is presented with many details not to be found in the shadows of the object, which are cast in the opposite direction or away from the sun. This order of reflection is occasionally reversed by the cloud, B, having its upper instead of its lower edge bounded by the line, C, when the direct sun ray will illuminate the ship, from whence it will be reflected to the water at A, and thence on to the intercepting cloud below the line, C. The image formed by the latter modification will be inverted and that of the former erect.

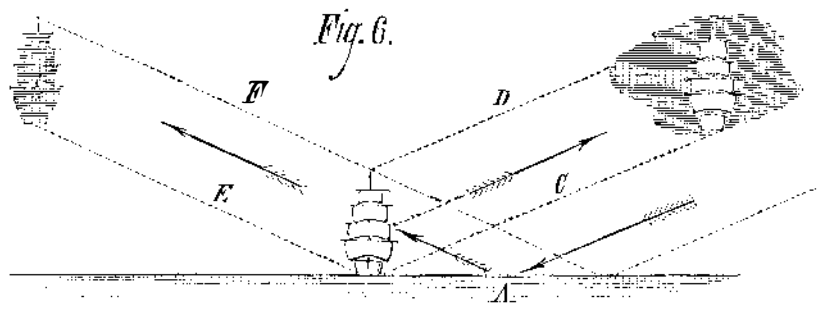
It is to this phase of atmospheric images that the looming of distant seacoasts is referable. The coast of France, for instance, seen from that of England across the English channel, the north shore of Lake Ontario seen from Rochester, and even the case of the brig on fire, before referred to. This phase of the mirage is capable of being produced at one and the same time with the true shadow form, though no case of its observation has ever been placed on record; it will, nevertheless, be obvious that the light falling upon the water at A is, after its reflection there, reflected by the glittering sails of the wet ship to B. This act of its interception is also the act of producing a shadow of the ship, which will proceed upward bounded by the dotted lines, E F, of the sixth diagram, which, if intercepted anywhere along the course of its projection, will exhibit also an image of the ship differing from that at B, as a shadow differs from a real image, the shadow being in fact but the absence of the light intercepted by the ship and reflected back to B. To make the causes of the looming of coast lines more clear, we present the seventh diagram, where a section of the curvature of the earth is shown. The rays from the sun, S, being incident upon the surface of the water from A to the base of the building on shore, B, are thence reflected on to the building, which in turn reflects them on to the cloud, C, where the picture thus produced may be viewed from the opposite seacoast at D, just as the images of a magic lantern may be viewed fram the back of a semi-transparent screen on to which they may be projected.

Fig. 5.



Such images as the specters of the Brocken are merely ordinary shadows, projected from all mountain tops, which are more or less isolated, on to clouds which happen to lie in their paths. Such localities are visited often without seeing the phantoms, because the sun may not be shining at the time of the visit, or there may be no clouds in the proper place to receive the shadows. Those are the true ordinary shadows cast by sunlight, and are transformed into images in the air by the changing angle of an ascending sun, when they occur upon water surfaces and in the presence of proper backgrounds. An example occurred upon the Lake of Geneva, when a vessel and its shadow were visible at the same time. The image, like the vessel, rested with its hull upon the water, the observer incidentally remarking the occurrence took place early in the morning, which, though indefinite, gives us the cue to the fact that the rising sun was a factor in the transaction. As it came over the horizon, it cast the vessel's shadow horizontally along the surface of the lake, until it was intercepted by one of the banks of fog or morning mist, which occur so frequently on all sheets of water. This image disappeared by ascending into the air while moving horizontally in the opposite direction from that to which the vessel's bow was directed. Had the observer suspected that the sun was in any way connected with the phenomena, he would have informed us whether its course corresponded to that of the vessel, which made little or no progress, as the morning was very still; it was, therefore, a case exactly analogous to that before referred to as having been observed on the south coast of England, where the windmill in the one case occupied the place of the vessel in the other, the phenomena in every other respect being the same, except that the shadow of the vessel seemed elongated horizontally, which was occasioned by the fog bank upon which it was projected, having its face obliquely inclined to the line of the shadow's proportion, while the observer occupied a position more nearly at right angles to the face of the cloud, which also accounts for the distorted appearance which those aerial images so often assume.

Fig. 6.



Where objects are situated upon water, the ascending of the sun transfers its shadows to the air, and out of the single horizontal shadow produces two, one erect and one inverted. The manner of changing the ordinary horizontal shadow cast by the light into shadows in the air, may be understood by diagram 8, where S is the sun on the horizon, O the object, and A its shadow. When the sun ascends to S', the shadow of the object is projected on to the water from O to P, and thence reflected into the air bounded by the lines, Q R; but the light also falls upon the water to the sunward side of the object, where, being incident at the same angle, it is reflected at the same angle, casting into the air an erect image of the object, O, bounded by the lines, R T, and screen at B. The increasing altitude of the sun correspondingly increases the angle at which those shadows are reflected from the surface of the water, which correspondingly decreases their chances of encountering clouds, hence, those images are only seen when the altitude of the sun is low. The double images of objects at sea, seen in the air, are therefore nothing more than the outgrowth of a single shadow cast by the sun when on the horizon, unfolding, as the sun rises, two shadows out of one, one of which, being the product of light reflected from the sunward side of the ship, must, of course, be right side up, precisely as if cast by direct sunlight. The other is a true shadow, also cast right side up on to the water on the side of the ship opposite to the sun, but is inverted by the act of reflection after its formation, forming a curious illustration of how a single object illuminated from a single point may cast two shadows perfectly distinct from each other.

Fig. 7.

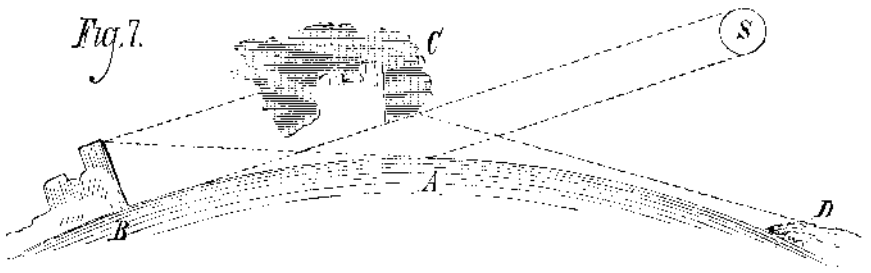
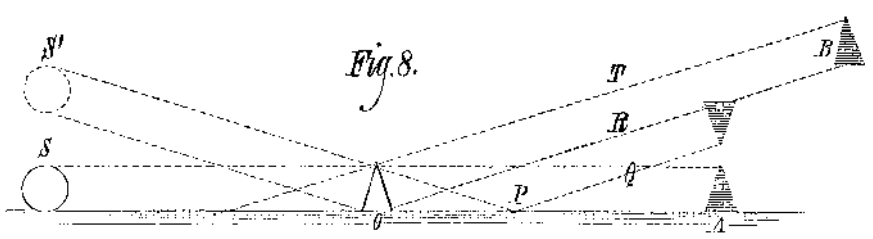


Fig. 8.



The mirage of the desert is, however, wholly unassociated with images in the air, as it is merely a case of direct reflection from the surface sands, which being an infinite number of sparkling points lying so closely together as to be optically equivalent to an unbroken reflecting surface, the most elevated portions being more exposed to the luminous conditions of the horizon reflect the most light, and therefore appear as lakes, while the more depressed portions being relatively in shadow relieve the brilliancy by passages comparatively dark, and giving the effect of islands, promontories, etc. Those lakes recede as the traveler advances, seeming constantly to keep their nearest shores about half an hour's march away, because the angle of reflection decreases with distance, and the nearer it approaches to coincidence with the reflecting surface, the greater will be the quantity of light reflected, and, indeed, long before it reaches actual coincidence (that is to say, long before the line of vision rises to the horizon), the angle of total reflection has been passed. In other words, when a line drawn from the eye of the observer to a point upon the plain upon which he is standing makes with that plain an angle of 53°, all beyond that must be of necessity very brilliant, for it is reflecting all the light of the horizon, minus, of course, a little due to inequalities of the land surface.

That nature should use her clouds for screens to exhibit her pictures upon is not at all to be wondered at, as they are the only background material she has in the regions where she makes the display, nor is it at all extraordinary or exceptional, for the earliest artificial presentations of aerial figures were made in the same manner and long before the use of the magic lantern was known beyond the cloisters of the mediæval monks, who sometimes exhibited to a carefully selected and exceptional few what they designated the magic circle, accompanying the exhibition with impressive ceremonies and incantations. A circle was described, from the center of which the smoke of burning incense ascended, and upon or in this smoke appeared the demons evoked, writhing and twisting into all imaginable forms through the moving volumes of ascending smoke. Outside the circle were placed the audience, forbidden to cross its boundary under pain of instant destruction by the fiends presented there, who were supposed to be of a peculiarly malignant nature and not always controllable by those who had the power to evoke them. Like other specters of the air, they would at one time appear very distinct, then fade away to invisibility, which depended, of course, upon the changing density of the vapor.

The facts, however, are valuable in this connection, as showing the use of cloud screens for exhibiting images upon, and some of the most clever tricks of modern necromancy are performed in the same manner; no reason, therefore, exists why nature should be incapable of using the same means

as cleverly as a mountebank, especially as she has such an abundance of ready-made screens always on hand and to spare.

Peculiar Mines in Colorado.

In a recent lecture before the Bullion Club, Professor J. S. Newberry described several new and peculiar mineral deposits which he had been studying in Colorado. In the course of his remarks he said:

I ventured to predict some time ago that Leadville was destined to be as important a gold camp as a silver camp, and my words were verified so far that from eight to ten million dollars of gold were taken out of the California Gulch. Now, the question is, how did the gold come there? Up to the present time it has not been fully traced to its source, and I made up my mind there were discoveries to be made that would surprise people. The development of the "Colorado Prince" is one of these surprises, and I venture to say not the last one.

The gold here is found between a stratum of limestone and porphyry, the limestone being below. The deposits are not in the same form as the bog iron ores, as is generally supposed. They are composed of decomposed iron with iron pyrites, sulphide of iron, sulphide of lead, with more or less of other matters. These ores are mixed in a heterogeneous mass. When they come to be oxidized the iron floats on the top, and as we go lower and lower we find the vein grows richer—in gold and silver principally. This deposit, as I said, is found in a cavity formed between the limestone and porphyry, and my judgment is that that cavity was formed by the action of surface carbonated water that percolated through and made that line of drainage. Then the stream down this line cut out the limestone by solution and left the cavity, which has been filled in by this rubbish, which in due time became oxidized and brought into the condition in which we find it. If we follow it lower down we shall find solid pyrites instead of sulphides. These will contain as much valuable ores, although a different treatment will be necessary in roasting or smelting.

Of the mines of this description the "Highland Chief" is one of the most extraordinary, simply from the magnitude of the deposit. The structure is similar to that of the "Colorado Prince." As to the workings there is a shaft of 88 feet, cutting through the porphyry, and striking the ore body. From this to a depth of 162 feet there is no bottom to the ore. This most extraordinary deposit is a type of these mines which I have been describing. No one knows at present the extent of this fissure, but it seems not improbable that it will be one of the great gold fields of the world. It is certainly, in my opinion, one of the most promising gold fields that has been discovered on this continent. No portion is taken out that will not pay for working it. While I was there thirty tons gave a return of $50.95 per ton. I do not know of any gold mine in the world, with a width of 60 or 80 feet, that will average $50 to the ton. The California mines, from 10 or 12 to 15 feet in width, return about $15 to the ton; in the Black Hills, in gold mines which are really paying, a width of 150 to 175 feet carries $8, $9, and $11 a ton. Now all of us who know anything about mining do not want any property better than that. Where you have a great quantity of quartz containing gold, and cheaply worked—as most of this hard freed rock can be—and find it will stand two tons to the stamp, at $5 per ton, no better profit could be desired. But these mines at Leadville show promise of a much larger profit. I do not mean to say they are better than all other mines, but at present the deposits are found to be entirely beyond parallel. Their value runs from $3,400 to $2 and a fraction per ton. The Silver Cliff, Racine Boy, Bassick, and other mines there are not yet understood, and their geological formation has been misrepresented.

Characteristics of Central Australia.

In the *Victorian Review* for January, Mr. Richard Bennett gives, from personal observation, some account of the little known country lying north of the river Murray, and extending to the great interior called Central Australia, a region which, by the application to it of a comprehensive system of irrigation, might be brought under cultivation, he thinks, and rendered capable of carrying a large population.

The country north of the Murray and Darling rivers, stretching away to Cooper's Creek, is one vast extent of alluvial plains, interspersed with sand ridges, dry lakes, or large depressions surrounded with high banks, and occasional isolated hills, few and far between. A peculiarity of the sand hills or ridges is that they run generally parallel to the large rivers, and between them are flats of very rich black soil, generally covered with myall trees, which yield a transparent gum in large quantities, in all respects resembling gum arabic, perfectly soluble in water, and eaten by the blacks in the neighborhood of the large rivers as an accompaniment to fish and opossum. Mr. Bennett accounts for the parallel formation of the sand ridges, first, by the prevalence of easterly winds sweeping down the valleys between them; next, by the back-water finding a vent over the intermediate flats to the river below during exceptionally high floods.

The sand ridges lying between the Lower Murrumbidgee and Darling are, in many instances, densely covered with spinifex, or, as it is called in those parts, porcupine grass. Nothing eats it, except after the tussocks have been burnt, when sheep are fond of the young green shoots. On the myall flats, between the sand ridges, grasses of the most nutritive description grow, particularly a kind called blue grass, and foxtail, and a great variety of vetches and saltbush; and there are large tracts of depressed plains subject to inundation from floods, formed of rich black plastic soil (like butter in wet weather, and dry and crumbly in summer time), that is covered with wild carrots and a very fine description of wild flax, the bolls of which, especially when the seed is ripe in October, fatten stock rapidly. Sheep graze over the carrot ground when not a vestige of anything green is to be seen on the top, scraping with their forefeet till they get sufficient hold with their teeth on a carrot to pull it out. These carrots have a bitter astringent taste, but are very fattening.

One chief characteristic of this country is the total absence of stone of any description, except in the neighborhood of isolated mountains and hills, some of which are two or three hundred miles apart.

The whole of this flat country, in Mr. Bennett's opinion, has been in ages long past either a vast inland sea, or succession of lakes. With the gradual rise of the continent the waters of these have drained off through the great valleys of the Darling, Murrumbidgee, and other tributaries into the Murray, and have thence been conveyed to the sea. As the drainage went on, large deposits of alluvium were brought down from the mountain ranges in the form of impalpable mud, the drainage of rich up-country river flats and mountain gullies. Some very curious phenomena are occasionally met with. Mr. Bennett has frequently come upon a small plain covered thickly with small nodules of ironstone like peas or buckshot, as if they had rained there, yet outside this particular spot not one was to be found. Again, when riding through the mallee near the Murrumbidgee, his horse sometimes sank up to the girths in a dry white powder like flour, probably some formation of lime. At the Oxley station, on the Lower Lachlan, some forty miles from Balranald, there is a stratum of gypsum in pure crystals, three or four feet in thickness, at a depth of five or six feet from the surface, and the gypsum crops out of the bank of the river.

Throughout these regions no large timber is to be found, except the blue gums, which fringe the large rivers, and which are never found beyond the limit of the river flats. The sand ridges are usually, though not always, covered with pine forests, many trees attaining a height of nearly one hundred feet and a girth of six or seven feet. There is likewise a species of forest oak called belar, which attains a height of fifty to sixty feet with a girth of five or six feet. This timber is exceedingly hard, heavy, dark-grained, and very brittle. This timber grows almost exclusively on red soil, very porous to water, and there are very extensive forests of it. These three species comprise all the large timber. There are forests or flats of yellow box, also of myall or boree; but neither of these attains a size to warrant its being classed as useful timber.

The rest consist of mallee, growing on desolate sandy country, too often covered with spinifex; yarren, which is tall, slender species of myall, forming thick scrubs; mulgu, a poisonous wood growing abundantly about the Darling, Warrego, Parroo, and Bulloo in Queensland; the quandong tree, which grows to the size of an ordinary cherry tree, and bears a red fruit surrounding a yellow indurated stone, in much request for ladies' ornaments, such as buttons, bracelets, etc.; the colane tree, which grows about the Lower Macquarrie and Bogan rivers, the handsomest tree of them all, with a thick foliage of a brilliant bright green, and bears a fruit of dark crimson color, of a very agreeable acid flavor, about the size of a walnut, inclosing a stone very much the size of a nutmeg, and quite solid. The wood of this tree is rather like the English beech, but is very short in the grain, and useless for building or other purposes. There is likewise a tree, called by the blacks yambang, which grows about the Lower Bogan and Macquarrie rivers; it is called by the settlers the native pomegranate, and has a fruit much resembling a Seville orange in size and color when ripe, full of seeds, about the size of small orange pips, embedded in a thick luscious fluid, very agreeable and refreshing when perfectly ripe, but when green, one taste would satisfy the greatest epicure; it is something akin to a compound of turpentine and cayenne pepper, the latter ingredient rather in excess.

There is a smaller species, which is a climbing plant, and grows in the scrub, with a fruit about the size of a pigeon's egg. The taste of this, both in its ripe and unripe state, is almost identical with the large sort; but the rind is very thin, while that of the large sort is thick. Another singular tree is the leopard tree, which grows to a diameter of about a foot. It derives its name from the spotted appearance of its bark, which is studded with scales of the size of a shilling; it bears a pod with a very aromatic scent and flavor. Many aromatic trees and shrubs grow in the scrub, some of which doubtless possess valuable medicinal properties, were they fully investigated.

It was on the Lower Bogan River that Allan Cuningham, the botanist, and a member of Sir Thomas Mitchell's exploring party, was killed by the blacks at a place now known as the "Murdering Stump."

The herbage throughout these extensive districts is mostly saline, consisting of a large variety of saltbush, pigface, cottonbush, portulacca, etc. The absence of large forest timber, stones, and the saline nature of the herbage indicate the comparatively recent formation of this part of Australia. Small conical hills are occasionally met with, one of which in particular, rising out of a plain within a few miles of the Macquarrie marshes, or mole, in a country otherwise totally devoid of stone, is composed of huge granite rocks, and, on riding round it, a hollow vibratory sound is produced, as if large caverns existed These hills and isolated mountains are, in Mr. Bennett's opinion, the summits of what were once islands, many of them of volcanic origin. Mr. Bennett believes that underneath the whole of this flat country there is an enormous body of fresh water, and that artesian wells will be the cheapest and most efficient means of irrigation.

Archæological Explorations in Missouri.

At a recent meeting of the Boston Society of Natural History, Mr. F. W. Putnam gave some account of the shell heaps of the Atlantic and Pacific coasts of North America, and stated that there had been received at the Peabody Museum a small collection of articles taken from some rude dolmens lately opened by Mr. E. Curtiss, who is now engaged, under his direction, in the work of exploration for the museum. These chambered mounds are situated in the eastern part of Clay county, Missouri, and form a large group on both sides of the Missouri river. The chambers are, in the three opened by Mr. Curtiss, about 8 feet square, and from 4½ to 5 feet high, each chamber having a passageway several feet in length and two in width, leading from the southern side, and opening on the edge of the mound formed by covering the chamber and passageway with earth. The walls of the chambered passages were about 2 feet thick, vertical, and well made of stones, which were evenly laid without clay or mortar of any kind. The top of one of the chambers had a covering of large flat rocks, but the others seem to have been covered over with wood. The chambers were filled with clay which had been burnt, and appeared as if it had fallen from above. The inside walls of the chambers also showed signs of fire. Under the burnt clay, in each chamber, were found the remains of several human skeletons, all of which had been burnt to such an extent as to leave but small fragments of the bones, which were mixed with the ashes and charcoal. Mr. Curtiss thought that in one chamber he found the remains of five skeletons, and in another thirteen. With these remains there were a few flint implements and minute fragments of earthen vessels. A large mound near the chambered ones was also opened, but no chambers were found therein; neither had the bodies been burnt. This mound proved very rich in large flint implements, and also contained well made pottery, and a peculiar "garget" of red stone. The connection of the people who placed the ashes of their dead in stone chambers with those who buried their dead in the earth mounds is, of course, yet to be determined.

Interglacial Quartz Workers in Minnesota.

In 1876 Prof. Winchell found in and around Little Falls, Minnesota, a number of fragments of wrought quartz in surface deposits underneath the remains of the mound builders. Prof. Winchell, accordingly, fixed the era of the quartz workers between that of the mound builders and the close of the glacial epoch.

At a late meeting of the Historical Society, at Minneapolis, Minn., Francis E. Babbit gave an account of a considerable deposit of quartz chips and implements found in regular strata, which must have been formed before the close of the glacial period. The specimens consist of hammers, implements, etc., both finished and unfinished, together with the chips struck off from the articles in the process of manufacture. The material of which they are composed is principally compact, lustrous quartz, frequently mottled as if selected with an eye to the artistic beauty. The stratum is some few inches in thickness, and lies in the soil a few feet below the surface. The appearances indicate that this was once the site of a manufactory of such quartz objects, and this idea is upheld by various considerations. There are tools found such as would be used in the manufacture of quartz articles, and the whole stratum is mixed with chips, which in many cases appear stuck in the dirt just as they fell from the hand of the unknown. Unfinished implements are also found in more or less advanced stages of manufacture. It is not possible to fix the precise point occupied by these remains in the scale of the glacial epoch until the drift features and surrounding formations of the locality shall be better understood than now. Still it is certain that the remains belong to a people living before the end of the last glacial period, because they are deposited in a drift which is known to be of glacial origin. The hard pan upon which the quartz formations lie is probably of the first glacial period, and the quartz may belong to an inter-glacial epoch.

Beet Sugar in Maine.

The past year's work of the Maine Beet Sugar Company at Portland was not bad for a beginning. In a report to the 1,700 farmers who raised the beets the company say that the average crop from 100 acres was 9½ tons; in some cases the return was not enough to pay cost of seed and fertilizers; the other extreme was 30 tons per acre. For 9,000 tons delivered at the factory, $56,000 were paid; for storing and pitting, $6,000; fuel, $10,000; labor and other expenses, $37,000; total, $107,000. The product, 900 tons of sugar and molassess, brought $110,000, leaving $3,000 toward machinery and fixtures that cost $60,000, to which must be added the State bounty. The company wish to continue the experiment, and invite the growers to renew their contract for at least one acre each. They say, however, that they cannot afford to increase the price per ton, except for early deliveries, which can be worked up before freezing weather, and thus save expense of pitting.