II. *A Description of some Remarkable Effects of UNEQUAL REFRACTION, observed at Bridlington Quay, in the Summer of 1826.* By the Reverend W. SCORESBY, F. R. S. S. Lond. & Edin. M. W. S., and Corresponding Member of the Institute of France.

(Read January 22. 1827.)

IN the session of 1820–21, I had the honour of communicating to the Royal Society, a description of some remarkable atmospheric refractions observed in the Greenland Sea. Since that period, additional opportunities for observation, under circumstances peculiarly favourable, afforded a great number of other examples of a similar kind, along with some still more singular. Among these, the most extraordinary was the inverted image of a ship, which appeared in the lower part of the atmosphere, so distinctly and beautifully defined, that I could venture to pronounce it to be the representation of my father's ship, as, indeed, it proved to be, though we were then distant from each other about 28 miles, and some leagues beyond the limit of direct vision. But an account of the principal* of these extraordinary appearances is already before the public, and I merely allude to them, in consequence of their similarity to the refractions I have now to describe, that occurred upon our own coasts.

These phenomena occurred during the last summer about Bridlington Bay, and were seen from my residence at Bridlington Quay.

I shall first describe the appearance of the shipping in the Bay, as represented in Plate II. Fig. 5.

* Voyage to Greenland in the Summer of 1822.

PLATE II.

REMARKABLE EXAMPLES OF UNEQUAL REFRACTION seen from the QUAY, BRIDLINGTON.

1. Appearance of the **HOLDERNESS COAST** as seen by the naked eye, from the altitude of 60 feet above the level of the Sea. June 24th 11 A.M. 1826.

2. The same Coast seen at the same time from the height of 40 feet.

3. The same Coast seen at the same time from the height of 20 feet.

4. The ordinary appearance of the same Coast as seen from the height of 40 feet.

5. Telescopic Appearance of the Shipping in the offing of **BRIDLINGTON BAY**, on the 12th 24th 25th and 26th of June 1826.

In the afternoon of the 12th of June, about five o'clock, after a clear hot day, the phenomena were first observed. All the shipping, at a sufficient distance, began to *loom*, and were variously distorted, and many vessels, when examined by the telescope, exhibited inverted images immediately above them. A portion of the extreme verge of the sea seemed to separate, as by a transparent fog-bank, and, between the real horizon and this refracted horizon, all the distortions and inverted images occurred. Some of the ships were of their natural proportions, with an inverted *fac-simile* above. Others, at distances, or in situations such, that the top of the masts reached more than one-half the height of the refracting interval, were abridged of their upper sails. One brig, nearer than the rest, only exhibited its hull and courses, with an inverted resemblance of the same over the top; and what gave it a still more curious appearance, was, a narrow clear space between the vessel and the image, as if there were in that place (in the line of the top-sails of the brig) a perfect void. In one or two cases, besides the inverted image, there was also an imperfect erect image, placed upon the upper line of the horizon. Most of the vessels figured, though they appear situated upon the true horizon, were, in reality, greatly more distant, and many of them altogether beyond the limit of ordinary vision. Hence, whilst the eye was fixed upon them, owing to the perpetual changes of the atmosphere, one or other of them would frequently disappear, and remain for some time invisible, and then suddenly start into sight as before. Objects within the horizon (about six miles distant) were scarcely, if at all, affected by the refraction. The upper or refracted horizon was often irregular in its outline, and sometimes broken. It was generally dark, and well defined; but the interval between it and the real horizon was frequently more faint in its shade, as if by attenuation. Sometimes there was a treble horizon exhibiting parallel streaks. The low coast of Holderness (forming the south-

ern part of Bridlington Bay) was slightly influenced by the same refraction. The air on this occasion was clear and calm,—occasionally there was a gentle sea-breeze.

Twelve days after this (June 24th), the phenomena were repeated with several new peculiarities, especially in regard to the land, as hereafter noticed. The interval between the true and refracted horizons (measuring between one and two minutes of a degree) was, as before, of a bluish-grey colour, and resembled a thin mist. But, besides the usual appearances of the ships, there were many erect images perched, as it were, upon the upper line of the horizon, and belonging to vessels that were evidently far out of sight ! This occurred at noon, when the temperature was 80° in the shade. In the afternoon, the temperature becoming more equable, most of the phenomena disappeared ; but in the evening, with the change of temperature, they were renewed in their principal varieties. On this day the sky was again cloudless, with a slight breeze from the eastward, though occasionally it was quite calm.

The following day there were very beautiful repetitions of the phenomena. The upper horizon was occasionally double and broken. A second erect image, of some of the ships, appeared between the two upper lines.

Again, there was a renewal of these interesting appearances on the 26th of June. The day was, as before, clear and hot ; but with a smart sea-breeze. The horizon began to separate about 10 A. M., and between 11 and 12, every object at sea, beyond the distance of six miles, became influenced by the unequal refraction. There were, on this occasion, several instances of a single inverted image of a ship, clearly defined, though the ship to which it referred was altogether out of sight !

Two or three days after this I left the coast, and had no other opportunity of looking out for these phenomena until the middle of August ; and after that time I could never perceive any recurrence of them.

All the representations of ships in Plate II. (Fig 5.), it should be observed, are telescopic, being taken from a view obtained with an ordinary spy-glass. With the naked eye, the looming of the vessels could be readily perceived ; but it required a magnifying power to resolve the apparently confused and enlarged outline into the ship and its images. The images were, in most respects, very similar to what I have formerly observed in the Arctic Regions, though scarcely so distinct and well defined. In high latitudes, indeed, I have seen them as sharp and definite as if cut with a graver.

On June the 24th, a day already referred to as one distinguished by unequal refractions, the Holderness Coast was most singularly affected by the state of the atmosphere. The ordinary appearance of this coast, as seen from the window of my sitting-room, which commands a view of all the southern part of Bridlington Bay, is that represented in Plate II. Fig. 4. But in the forenoon of this day, the sun having intense power, this low and uninteresting part of the promontory, terminating at the Spurn, assumed the appearance of Fig. 2. to the naked eye. Slight hummocks and knolls, on the ridge of the land, were raised into parallel vertical pillars, resembling immense detached columns of basalt ; and the whole range, for a considerable extent, seemed to be surmounted by a horizontal and almost continuous platform ! This platform or causeway, which it resembled, seemed in many places entirely unsupported ; the clear view of the sky being obtained beneath it. But this apparent platform was in reality the refracted image of the stratum of land beneath, forming continuous columns, where the land was highest and the image joined the protuberances ; but leaving vacant interstices, where the land was low and the resemblances more remote.

Having made a sketch (Fig. 2.) of the appearance of the coast from my window, which is at the height of about 40 feet above the level of the sea at low-water, (the state of the tide at

the time), it occurred to me that there might possibly be a difference of appearance at another level. And, on ascending to the attic story (about 60 feet above the sea), I was surprised to find the phenomena altogether changed (see Fig. 1.), and the natural form of the land almost restored. Having made a sketch of this appearance, I returned to the sitting-room, and found the refracted state before observed from thence remaining unchanged.

I next descended to the cellar-flat (about twenty feet above the sea), where, on a level platform, by the side of the house, there was a clear view of the same coast. Here, again, I experienced another surprise, in finding the appearance almost perfectly what it ought to be at that level (see Fig. 3.), scarcely any remains of the refractive influence being observable; yet at the middle position, in the sitting-room, the phenomena continued unaltered! No material change, indeed, occurred in the general character of any of the views, whilst I was making the three first sketches given herewith. The last view (Fig. 4.) was taken on a subsequent day, and all the four were arranged in the same vertical plane, and adjusted to the same proportions, by marking on the sketches the position of a regular series of posts on the side of a wooden pier, which fortunately lay extended beneath the whole line of coast. This renders the comparison between the effects attributable to the refraction, and the natural state of the view, quite certain.

On this occasion, objects within four miles of the observer, were slightly influenced by the refraction, though the greatest effects occurred, in respect to objects six to ten miles distant. The phenomena continued to preserve their character, as seen from the three different levels, for above an hour, and then the appearance of Fig. 2. began to descend; so that eventually, as the heat of the day increased, or rather became more general and uniform, the view from the sitting-room became nearly that of Fig. 1., whilst Fig. 2. was seen from a level ten or fifteen feet

lower. Shortly after mid-day, it appeared so striking from the level of the street, (ten feet below the sitting-room), that it began to attract the notice of all the inhabitants in the neighbourhood.

From 2 until 5 P. M., the phenomena were more indistinct, and less interesting; but as the heat began to abate (towards 6 P. M.), the appearances observed in the morning were in a great measure repeated.

On several other occasions, the coast of Holderness was seen through unequally refractive media; but there was no appearance so interesting as the one above described.

No other cause requires to be sought for, in explanation of the phenomena, than that of different parallel strata of air, of unequal density, so ably demonstrated and illustrated by Dr WOLLASTON (*Phil. Trans.* for 1810); and so strikingly exemplified by Dr BREWSTER, in his experiments resembling the very effect in nature, with hot and cold strata of water or glass.

Nor is the striking peculiarity observed on the Holderness Coast, of the phenomena being confined to a particular level in the position of the observer, of difficult explanation. In this case, it is perhaps only necessary to suppose, (I speak doubtfully, however), that the distant coast, observed from the upper altitude, was seen altogether through an upper stratum of air, of pretty uniform density; and also observed from the lower station, that it was either seen chiefly through a lower stratum, or through different strata, amid which the rays of light passed from the distant coast converging, but not having arrived at a focus; but that from the middle altitude, the rays from the land passed so obliquely out of one medium into the other, that a part was refracted back again into the former medium, so as to double the object, by presenting an inverted image.

The occasion of the frequency of these phenomena, during the last summer, and of their extraordinary character, may, per-

haps, be accounted for, from a remarkable and sudden change in the temperature of the air. The cool weather of the preceding spring had continued down till the beginning of June. The sea, even near the coast, was, in consequence, at its winter temperature, whilst the air became quickly heated, by the fervent glare of an unclouded sun. When, therefore, the air near the surface of the earth became greatly warmed, the stratum immediately in contact with the sea was chilled by its coldness, whereby media of unequal density and refracting power were produced. And through these unequal media, the rays of light both from the shipping and the Holderness Coast, had to pass to the eye of the observer,—an uninterrupted surface of water, in all cases, lying between the objects and myself. The passing of the rays of light, at an extremely small angle, through these different strata of different refracting powers, would sufficiently account, on the principles already referred to, for most of the phenomena observed.

BRIDLINGTON QUAY, }
December 1. 1826. }