of the south-west winds by the South Downs of Dorsetshire, and also, though in a less degree, from the east winds by the Isle of Wight.

Since the averages here used are all for the twenty-four years ending with 1880 for the temperature, and for the twenty-one years ending with 1880 for the rainfall, the figures for these two chief elements of climate are strictly comparable throughout. The result is that all strong statements sometimes made in favour of local climatologies, such as the rainfall of Ventnor being as small as that of London, entirely disappear. Such differences could easily be found by the results of different terms of years suited to the purpose, being selected for the particular places whose climatologies are compared. All such comparisons, however, are not merely worthless, they are misleading.

It is, however, now indubitably shown that the south coast of England, from Dover to Portland, enjoys the best winter climate anywhere to be found in the British Islands as respects the two important qualities of mildness and dryness combined, and it is highly probable that the climate of the same tract has clearer, brighter skies, and consequently more sunshine, than elsewhere in these islands. In view of the results of Buchan and Mitchell's investigation into the weather and health of London (NATURE, vol. xxiv. pp. 143 and 173) it is evident that it is to the South of England the invalid who suffers from bronchitis, pneumonia, or other throat diseases, must look for the climate best suited in the treatment of his case, and that it is to the same climate, owing to its clearer air, brighter skies, and more frequent sunshine, that those suffering from nervous and mental diseases should look as more likely to give them the relief they are in search of.

TORNADOES, WHIRLWINDS, WATERSPOUTS, AND HAILSTORMS

I.

WHILE identical with and resembling cyclones in not a few of their leading characteristics, tornadoes and whirlwinds are yet in several all-important respects widely and radically different. The largest tornadoes are of so small dimensions when compared with the smallest cyclones as to point to a difference so decided that admits of no shading of the one class of phenomena into the other. Again, cyclones occur at all hours of the day, whereas whirlwinds and tornadoes are all but restricted to the warmer hours of the day, and perhaps altogether to the time of the day when the sun is above the horizon. Further, and intimately connected with the above, cyclones take place under conditions which imply unequal densities at the same heights of the atmosphere, whether these be due to inequalities in the geographical distribution of temperature or humidity; but whirlwinds occur where the air is unusually warm or moist for the time, and where, consequently, temperature and humidity diminish with height at an abnormally rapid rate. To put it otherwise, cyclones are phenomena consequent on a disturbance of the equilibrium of the atmosphere considered horizontally, but tornadoes, on the other hand, have their origin in a vertical disturbance of atmospheric equilibrium.

Hence whirlwinds are of occasional occurrence nearly everywhere, penetrating into regions where cyclones are altogether unknown; and even tornadoes, which are the most violent and destructive manifestations of the whirlwind, are phenomena either of rare or of frequent occurrence in nearly all climates.

Among the most remarkable of the tornado-swept tracts of the globe are certain portions of the United States of America; and to the examination of these the Meteorological Service of the States has given special attention by a systematic, careful, and minute observation of their attendant phenomena and their destructive effects. The results of these inquiries have been for some years recorded with great, but by no means too great, fulness and elaborateness in the annual meteorological reports of the Chief Signal Officer. Much has been done of late years, as our readers are aware, by observation and discussions of observations, to throw light on these atmospheric meteors; and in this connection we have the greatest pleasure in referring to Prof. Ferrel's recently published "Cyclones, Tornadoes, and Waterspouts," Part II., the portion of which, bearing on tornadoes and whirlwinds, is the most successfully handled part of that very suggestive work, and indeed presents the best theory of whirlwinds yet propounded.

Tornadoes, whirlwinds, and waterspouts are essentially the same, differing from each other only in their dimensions, their intensity, or in the degree in which the moisture is condensed into visible vapour; while the extraordinary downfalls of hail or rain, constituting the hailstorm and rainstorm, are simply the manner and degree of the precipitation. In the waterspout the main features of whirlwinds are best seen, owing to the degree, more or less complete, in which the vapour has been condensed into visible cloud through the whole length of the meteor.

Figs. 1, 2, and 3 represent different forms of the waterspout. In Fig. 1 is seen the black cloud covering the sky, from which a projection is let down from the cloud in the form of an inverted cone as at A, which continues to increase and extend downwards. The surface of the sea at D immediately beneath is soon seen to be stirred, and quickly thrown into a state of violent agitation. At this stage the whirling movement which originated in the clouds has extended downwards to the sea, and is doubtless continuous throughout, though the portion of the whirling column from A downward is not yet present to the eye by the condensation into cloud of its contained moisture. The cone at A continues to lengthen downwards, and ultimately reaches to the earth's surface as shown at B and C, and by the waterspouts of Figs. 2 and 3. As the whirling movements of the aërial column of the waterspout become more intensely developed, the increasing rapidity of the gyrations brings about increased rarefaction of the air within, with the inevitable result of increased condensation into cloud downward. The protrusion from the clouds and extension toward the surface of the sea of the waterspout is thus not due to the descent of vapour from the clouds, but to the visible condensation of the vapour of the spirally ascending air-currents arising from an increasing rarefaction due to the accelerated rate of the gyrations, the condensation being similar to that of the cloud seen in exhausting an air-pump.

The onward progressive motion of tornadoes and whirlwinds varies greatly, and is probably in all cases that of the general movement of that portion of the earth's atmosphere in which they are embedded and form a part. Tornadoes sometimes rage with destructive violence on heights and hill tops, while intervening valleys remain untouched, thus showing that they occasionally occur at comparatively small elevations, but do not reach down to the surface of the earth. It also sometimes happens that the tornado in its onward course rises for a brief interval above the surface and again descends. As soon as the rapidity of the gyrations of the column become diminished, the rarefaction of the air of the column and the condensation of the vapour are correspondingly lessened, and thereafter the waterspout gradually breaks up and disappears.

Under each of the waterspouts in Figs. 1, 2, and 3 the surface of the sea is seen to be more or less heaped up as well as in violent commotion, indicating that atmospheric pressure immediately under the gyrating column is less than it is all round. On land, when a tornado passes directly over a closed building, many instances have occurred when the whole building, walls and roof, has been thrown outward with great violence, the wreckage presenting the appearance of a sudden explosion, proving that the pressure outside the building was instantaneously and largely diminished, and the building wrecked by the expansion of the air within. It is in this way that the tornado works no inconsiderable part of its most dreadful havoc in the destruction of human life.

During the storm of 1703, the greatest recorded in British history, it was observed that the roofs of many houses on the lee side of the buildings were wrecked as if by an explosion within. The destruction in this case was caused by the extreme rarefaction produced on the lee side of buildings by the mere mechanical action through friction of the terrific wind which swept past them. The records of tornadoes abound in illustrations of houses and other structures thus reduced to hopeless wrecks.

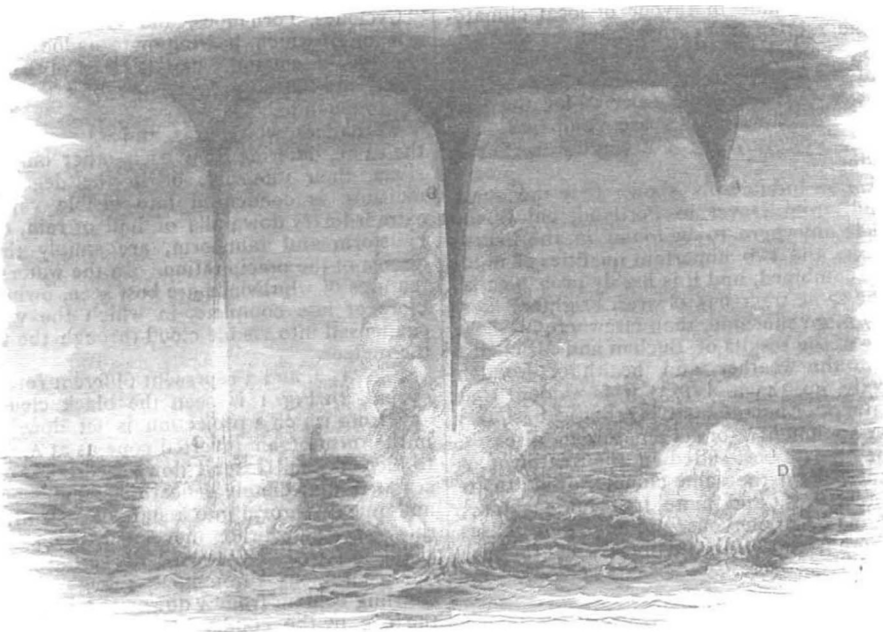

FIG. 1.

It is probable that the wind sometimes reaches a force in tornadoes exceeding what is ever reached in cyclones. During the tornado which occurred in Chio on February 4, 1842, large buildings were lifted entire from their foundations, carried several rods through the air, and then dashed to pieces, some of the fragments being transported a distance of seven or eight miles; and large oaks nearly seven feet in girth were snapped across like reeds. This tornado sped on its course at the rate of thirty-four miles an hour, and at one place it did its fearful work in the brief space of a minute. During the tornado which swept over Mount Carmel, Illinois, June 4, 1877, the spire, vane, and gilded ball of the Methodist Church were carried fifteen miles to the north-eastward. On this incident Prof. Ferrel remarks that the ascending currents which could keep this structure suspended in the air for at least fifteen or twenty minutes must have had an enormous velocity.

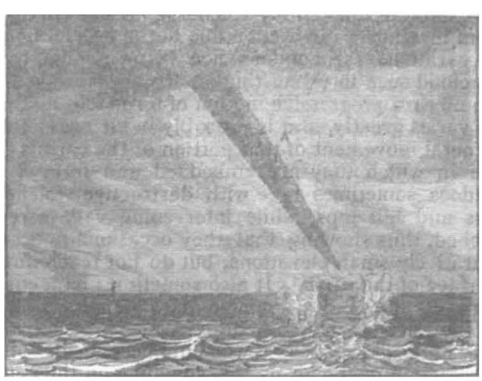

FIG. 2.

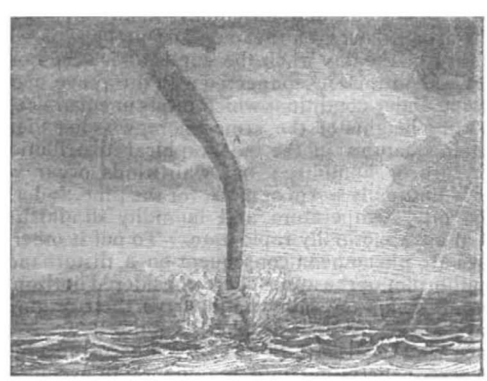

FIG. 3.

The usual position of the gyrating columns of whirlwinds is vertical, as seen in Fig. 1. Among other positions the column assumes a slanting direction as in Fig. 2, and a curved form as in Fig. 3. It is probable that to these latter forms many of those stationary or slowly moving dangerous squalls are to be referred that spring up with unexpected suddenness so frequently in such regions as the western lochs and islands of Scotland—

these sudden squalls which lash into a tempest of waves what is but a mere patch or narrow lane of sea, while all round remains like a sheet of glass, the squall being only the lowermost part of the gyrating column of a slanting whirlwind. Nothing is more surprising to the landsman who encounters one of these squalls for the first time than to see a mere bit of sea lashed into a tempest by say an east wind in which no sail can live, while but a short way to leeward other vessels are seen either under a good-going breeze or in calm water, altogether untouched by the tempest, which seems to blow directly to them, but which strangely never reaches them.

In examining cyclones, phenomena occasionally present themselves which strongly suggest the idea that they include within their circuit, as an independent meteor, the whirlwind or the tornado, the phenomena in question being most frequently met with in those cyclones which present, in close continuity, masses of air differing very widely from each other in temperature and humidity. Of such cyclones the great storm of October 14 last appears to be one. On that occasion the changes of temperature and humidity were sharp and sudden, particularly from the Grampians to the Cheviots, the great fall occurring when the wind changed to northward. As we have already stated (NATURE, vol. xxiv. p. 585), off the Berwickshire coast the darkness accompanying the changes of wind, temperature, and humidity was denser and more threatening than elsewhere, and almost simultaneously with the approach of these changes, a hurricane, or rather tornado, broke out with a devouring energy which bore everything before it. The tornado-character of the storm off Eyemouth is shown by the accounts of some of the survivors, who describe the wind as blowing straight down from the sky with an impetuosity so vehement and overmastering that the sea for some extent was beaten down flat into a stretch of seething foam, in which many boats sank as if driven down beneath the foam by the wind, while outside this tract the waves seemed to be driven up to a height absolutely appalling, which in their turn engulfed many of the boats yet remaining. Similar seas, with level wastes of seething foam, bounded immediately by waves of a height and threatening aspect never before witnessed, were encountered by several well-appointed steamers out in the middle of the North Sea during this storm, thus confirming the observations of the Eyemouth fishermen. These facts seem to point to one or perhaps more tornadoes of no inconsiderable dimensions, with slanting columns, the terrific force of the gyrations of whose lower extremities played no inconspicuous part in the devastation wrought during the continuance of this memorable storm.

(*To be continued.*)

SIR DAVID BREWSTER'S SCIENTIFIC WORK

BUT thirteen years ago there passed away from the roll of living scientific worthies one whose name will ever hold a high place for the variety and scope of the researches carried out with untiring zeal through a long and useful life. Since our last number the centenary of Sir David Brewster's birth has been commemorated in Edinburgh, and the occurrence forms a fitting opportunity to review briefly his multifarious work in the light of the science of to-day. Sir David Brewster was born in 1781. He must therefore have been twenty-five years of age at the date when his first published scientific memoir, entitled "Remarks on Achromatic Eyepieces" (published in *Nicholson's Journal*), saw the light. Until 1867 he continued actively to pursue scientific researches. Whilst his literary works are of themselves amply sufficient to cause the name of Brewster to be handed down to posterity, the long list of four hundred original memoirs which appears in his name in the Royal Society's Catalogue shows with what unremitting ardour the fire of discovery burned within his breast.

In the domain of Physical Optics Brewster was an eager and successful worker: and his industry was rewarded by a series of brilliant experimental discoveries. The genius of Young, the keen perception and quick acumen of Malus, and the trained intellect of Arago had been concentrated on this hitherto neglected department of science. But Brewster, who cannot be said to have possessed, either by birth or education, the powers of any of these investigators, discovered more than all of them put together, and by diligent observation unravelled complicated phenomena which baffled their powers.

In 1812, having heard of Malus's celebrated discovery of the polarisation of light by reflection, he took up the study of polarisation, and in the course of the next two years advanced our knowledge in various directions. He discovered the property of the agate to give a single polarised image; the polarisation of the rainbow; the polarisation tints in thin plates of crystal; the so-called depolarising power of mineral and other substances; and the partial polarisation produced by metals.

These discoveries he followed up immediately by several of equal interest. He observed the double system of elliptical rings of colour in topaz, and subsequently investigated the appearances presented by other crystals, both monaxial and biaxial in convergent polarised light. He not only discovered but determined the law of the partial polarisation effected by transmitting light obliquely through a bundle of thin plates of mica or glass. Meantime he was actively prosecuting literary work. His "New Philosophical Instruments," published in 1813, contained a great deal of matter new in the science of optics, the results of original research. Hitherto in tables of the refractive index of bodies diamond had stood at the head, and ice at the foot of the list. But Brewster showed that realgar and chromate of lead exceed the diamond in refractive power, whilst fluorspar, cyolite, and tabashear fall below ice both in refractive and in dispersive power.

During these and the subsequent years the disturbed relations between Great Britain and France prevented the workers in science on opposite sides of the Channel from learning what progress was being made, with the result that many of Brewster's discoveries were independently made by others. Thus Malus anticipated Brewster in the discovery of the "depolarising" effect of mica films, of the partial polarisation of metals, and of the polarisation effected by bundles of thin plates, though he missed the law of the last phenomenon. Arago also anticipated Brewster in finding the colours of thin crystal plates in polarised light. In 1814 and 1815 Brewster discovered a new relation of polarised light, namely, that existing between the ray and the state of mechanical strain of the body through which it passed. He observed that heated glass exhibited coloured tints in polarised light, and that Rupert's drops did the same. Subsequently he produced both double refraction and chromatic polarisation in soft and indurated jellies, in horn, and in a variety of animal and vegetable bodies, particularly in the crystalline lens of the eyes of animals, whose structure is thereby revealed. The most important of these early researches was undoubtedly the law connecting the angle of maximum polarisation by reflection with the refractive index of the body. The difficulty of establishing such a law was in Brewster's case enhanced by the circumstance that his mind was not a mathematical one. With a skill that rose superior to the defects of apparatus, and with an unflagging patience at which one can only marvel, he scrutinised with minute care every fragment of mineral in the cabinets of his scientific acquaintances. By this means he constructed tables of refractive and dispersive powers and of the polarising angles of the various reflecting surfaces. And from these two sets of data he brought out