AN ASTRONOMICAL SEASON.

THE year 1892 has seen no comet of the season; but it has had several astronomical celebrities. Mars, whose canals have excited a more universal interest than that of Manchester; Jupiter, which, even if it be scarcely so interesting to the public, will at all events be more in the public eye so far as Europe is concerned. Jupiter, the coming professional beauty among the planets, has this advantage over Mars, which it surpasses—that it is to the north of the equator, and, therefore, assumes a considerable elevation in the heavens. Mars is further south than the sun at Christmas, and, therefore, just skirts our horizon. Any fresh knowledge that astronomers may gain of our nearest neighbor will most likely be forthcoming from the observatories in the United States, whose position gives them better facilities for observation; and, perhaps, from the observatory at Cape Town. The Cape observatory is not so well equipped as that at Mount Hamilton, or perhaps even at the Washington observatory; but the clearness of the atmosphere there is especially favorable to observation.

The importance of an observatory is sometimes estimated by the power of its refracting telescope, which, so far as the expression "power" has any meaning, is to be measured by the diameter of its object glass. There has, for many years now, been some honorable rivalry between the nations as to which should possess the greatest refracting telescopes. Among the largest instruments successfully completed is that erected a few years ago by Sir Howard Grubb at Vienna. Its object glass is twenty-seven inches in diameter. But the Russian astronomers have procured from Messrs. Alvan Clark, of Boston, Massachusetts, a glass thirty inches in diameter; but the crowning achievement of the firm has been the great Lick refractor, which is thirty-six inches in diameter. But the refracting telescope is only one of the many instruments which are indispensable to a great observatory, viz., the heliometers, transit instruments, meridian circles, mural circles, theodolites, micrometers, microscopes, and other inventions of earlier or later discovery which make astronomy so exact a science that the thread of a spider's web is not fine enough for the observer, and the most perfect of mechanical contrivances are in his estimation only agglomerations of imperfections. It is impossible, and would not be interesting, to give any detailed account of these in the scope of a short article; it will perhaps be sufficient to define some of the instruments upon which the Cape Town observatory prides itself. The heliometer is an instrument which can be used to measure the angular distance between objects too far apart for measurement by ordinary methods. It is a telescope with its object glass cut in half along a diameter. One or both of these halves is movable transversely by a screw. Each half gives a complete image of the object. The measures are effected by observing how many turns of a screw convey the image of the star formed by one-half of the object glass to coincide with the image of the planet formed by the other. Many observatories have their own special work. The observations of stars at the observatories of Greenwich, Paris, Washington, and Oxford are mainly directed to the most accurate determination of the places of a limited number of stars and the deduction of their proper motions by comparison with previous results; at others differential observations of large numbers of stars are made, with the object of making a sort of "survey" of the heavens. A good many observatories in Germany and America make differential observations of comets and small planets, as referred to comparison stars; and some, Pulkowa, for instance—devote themselves to the measurement of double stars with the micrometer. Of late years two new subjects have been introduced into the routine of observatory work—photography and spectroscopy; and in both these departments we owe many important discoveries to Cape Town. Our illustrations are from photographs sent us by Mr. C. R. Woods.—*The Graphic, London.*

DOUBLE AND MULTIPLE STARS.

By WM. H. KNIGHT.

WHEN the aid of the telescope was brought to bear upon the study of the fixed stars, one of the marked features of their arrangement was the prevalence of pairs. So many of the larger stars were found to have a neighbor in close proximity that these groups came to be classed as double stars, and were carefully studied and catalogued.

Of the 600,000 stars of the first ten magnitudes, about 10,000, or one out of every 60, has one or more companions within 30 seconds of arc, or so close as not to be distinguishable from the principal star without the aid of an instrument. This proportion is many times greater than could possibly be the result of a chance alignment of two unequally remote stars in the same range of view.

It was not long after Sir William Herschel began his astronomical researches before changes in the relative positions of some of these double stars were noted, and in 1802 he put forth the startling theory that they were physically related to each other, and revolving around a common center, thus constituting systems resembling our solar system, and proving the existence of the law of attraction among those distant orbs.

This analogy to our own system is rendered still more striking by the occurrence of two or more of these companions in some of the double star groups, corresponding to the several giant planets wheeling in their distant orbits around the sun. At the same time we must admit that all these double star systems, so far as we have made their acquaintance, present features which contrast strongly with some of those characteristic of our own system.

In the first place, the sun is the only self-luminous body in the solar system, whereas a non-luminous body, or one shining by reflected light, would be invisible at the distance of the nearest fixed star, if it were as large as Sirius himself.

Secondly, the components of these stellar systems have very eccentric orbits. The average eccentricity of the planetary orbits, says Mr. See, a German astronomer, is only one-tenth that of 50 binary orbits thus far determined.

And thirdly, the large relative size of their companion is a prominent characteristic of all double stars.

Our sun has no planet at all comparable in size with the least of the companions in any system visible in the telescope. The two components of 61 Cygni are nearly equal. The companion of Algol is about one-half the size and mass of its principal. That of Sirius is about one-third. Whereas the sun is about 1,000 times larger than the giant planet Jupiter and 700 times larger than the aggregate mass of all its planets put together. At the same time each of the planets is attended by comparatively very small satellites. The single exception to this rule is that of the earth and its satellite, their diameters being as one to four and their volume as one to 50. So that, viewed from either of our neighbors, Venus or Mars, the earth and moon present the aspect of a pair of planets of unequal size, alternately approaching and receding from each other.

But how, it may be asked, can we determine the masses of two objects so remote that they are only resolvable into separate stars, or points of light, by the aid of the telescope? Three elements are necessary to the solution of this problem, namely, the distance of the double stars from the earth, the distance of the components from each other, and their period of revolution around each other. Of but few stars have we been able to learn all these particulars. We know that there are 10,000 double and multiple stars. The orbits of about 60 have been approximately determined by observation. But of less than a dozen do we know their distance from the earth, and without that knowledge we cannot calculate their actual distance from each other, and so cannot compute their masses. An exception to this rule will be noted further on.

It was not till the year 1838 that Bessel succeeded in finding a parallax to the nearest fixed star in the northern heavens, known as 61 Cygni. It is a small 5th magnitude star in the Swan, and is distant seven light years from the earth, that is, it requires seven years for its light to reach the earth.

But as long ago as 1750, 61 Cygni was known to be a double, and subsequent observations showed that its two components would complete their revolution in 782 years. When, therefore, their distance from the earth was known, it became an easy problem to measure their distance from each other. Here, then, we had the three elements: distance from the earth, distance from each other, and orbital motion, from which data it was easy to deduce their combined mass. This was ascertained to be about one-fourth that of our sun, and as their orbits were nearly equal in extent, it was inferred that their respective masses were also equal. Each of these orbs, then, is a self-luminous world, about one-eighth the size of our own sun, or 100 times larger than the great planet Jupiter.

Among the double stars are many pairs of which the two components have different colors, the brighter one generally being orange, red or yellow, and its companion blue, green or purple. In the beautiful system of Gamma Andromeda, the largest central sun is orange, and, seen through a small telescope, the companion is an emerald green. But applying a higher power, the green star is seen to be double, and is built up, so to speak, of one blue and one yellow star. Imagine the effect such a combination of colors must have upon the planets revolving about either of the stars! It is as if our sun shone with an orange light and distant Neptune were enlarged to the size and brightness of a veritable sun shining with a yellow light, and circling around the latter were a companion of nearly equal dimensions shining with a blue light. We should then occasionally have only the orange light of our own central sun. At other times we should have only the blended light of the two companions, producing a green effect upon the landscape. On still other occasions, only one of the companions would be above the horizon, and then our atmosphere would be bathed in a clear yellow or a bright blue. Again, a most curious effect would be produced upon the moon. One portion of its visible surface might be reflecting the orange light of the central sun, while the remaining portion is colored into segments of green, yellow, and blue, resulting from various combinations of the companion suns.

As Neptune is the morning or evening star during the entire year, so these hypothetical colored suns would invade our nights, making portions of them as light as day, thus seriously interfering with the study of sidereal astronomy, as there would be a very limited period when the stars would not be obscured by sunlight.

One of the finest examples of complementary colors in double stars is furnished by the splendid pair called Gamma Leonis. It is the bright star of the second magnitude in the handle of the Siek in the constellation Leo, which comes to the meridian in March and April. The larger star is described by Struve as a golden yellow, while its companion is a reddish green. The pair is easily defined, and can be seen as a double through any telescope of moderate power, and will be found well worth the search. The Gamma Leonis system, though very brilliant, is so remote that it furnishes no sensible parallax, but its period has been approximately determined as 407 years. The companion has not, then, performed quite one revolution since Columbus set sail for America. Among other combinations are yellow and purple, green and blue, orange and green, orange and blue, white and blue, and yellow and sapphire blue. The latter combination prevails in the beautiful pair known as Beta Cygni, a third magnitude star in the Swan.

What is the cause of the various colors which distinguish and adorn these interesting doubles? It has been noticed: (1) That in double stars of short period and nearly equal dimensions, the components have nearly the same and unvarying tints. (2) In those of long periods and very elliptical orbits, the principal star is often pale yellow when the companion is at periastron, or nearest approach, and of a deep yellow or orange in other positions. (3) The companion follows the principal in its fluctuation of color, and often surpasses it at apastron or point of farthest separation.

Now there is a good deal implied in these observations that is of great interest to the physicist. Note that when the stars have a uniform distance there is a uniform color, but when, owing to highly elliptical orbits, the distance varies materially, there is a corresponding change in color which seems to show a corresponding change in heat intensity. In other words,

when the two components approach comparatively close, their color is that which represents a fiercer combustion, and when, on the other hand, they withdraw from each other's vicinity, their gases seem to burn with less energy, and therefore with a milder radiance and higher color. Does not this sequence of causes and effects show that these suns are great electrical dynamos, acting upon each other with an energy proportioned to their proximity?

But we have another exhibition of this tremendous electrical energy in the new star which recently blazed forth in the constellation Auriga. It made its first appearance last December as a faint telescopic object, but gradually increased in brightness, till in the month of February it showed as a naked eye star of the fifth magnitude. "Its aspect," says Miss Agnes Clerke (a brilliant English writer on astronomical topics), "was perfectly stellar. It rays emanated from a sharp point. But," she continues, "let us hear the dictum of the spectroscopist in this matter. The light of Nova Aurigæ, unrolled by prismatic dispersion into a rainbow-tinted ribbon, presented a dazzling spectacle. Splendid groups of bright lines stood out from a paler background; the red ray of hydrogen—Fraunhofer's C—glowed, as Mr. Espin remarked, like a danger signal on a dark night; a superb quartet of rays shone in the green; shimmering blue bands and lines drew the eye far toward the violet; the characteristic blazing spectrum, in fact, of a new star was unmistakably present. It was marked, however, by one extraordinary peculiarity in the coupling with dark lines of all the bright rays conspicuous over its entire extent. Each lustrous member of the great hydrogen series carried a black shadow on its blue or more refrangible side."

Astronomers watched this strange appearance with keen interest and sought to interpret its meaning, and the answer was in the highest degree surprising. These extraordinary displacements of the spectrum lines indicated, according to Dr. Vogel, an enormous velocity of approach, coupled with a tremendous velocity of recession. The bright lines testified that a luminous body was rushing away from the earth with a velocity of 420 miles per second, while the dark lines proclaimed that another bright mass was rushing toward the earth with a speed of 300 miles per second, and the two blazing worlds were separating at the rate of 720 miles per second.

Now may we not fairly infer that the fierce outburst of energy which rendered Nova Aurigæ visible a few months ago was caused by two flaming worlds, flying from different quarters of the universe, chancing to pass in close proximity at that particular time, and by mutually acting upon each other as great electrical dynamos, stimulating to unwonted action the energies of combustion?

"There is good reason to suppose," says Miss Clerke, "that every such body is in a state of powerful electrical excitement, and creates in its neighborhood a very extensive magnetic field. A second body entering this field, and sweeping with prodigious speed across the lines of force traversing it, must then give rise to powerful electrical agitations. And here, perhaps, may be found the chief source of the amazing displays registered by astronomers as new stars. Gravitational disturbances, too, of the kind that raise tides in terrestrial oceans, but immensely exaggerated in degree, no doubt come in as auxiliaries."

The distance of Nova Aurigæ, which thus shone forth among the remote stars of the Milky Way, was believed to be not less than 100 light years from the earth. Our sun would barely be visible as a telescopic star at that distance. It passed through its wonderful transformation then, blazing forth with the brightness of a thousand suns, more than a century ago, during the closing scenes of the revolutionary war, or while Napoleon's armies were overturning the thrones of Europe.

Among the recent notable achievements of astronomers is the discovery of double stars which are so close and distant that they cannot be separated by the most powerful telescopes. A fine example of this class of doubles is Beta Aurigæ, a bright star above the head of Orion. The velocity of the components of this interesting double, which are nearly of equal dimensions, is about 150 miles per second, or nine times faster than the earth flies in her path around the sun. Their orbit is nearly circular, and about 16,000,000 miles in diameter, or less than one-fourth that of the orbit of Mercury. Their combined mass is only from 1-10 to 2-10 that of the sun. Even then, each of those brightly flaming worlds is 100 times larger than Jupiter, which has a volume 1,300 greater than that of the earth. But it may be asked, How are we able to give all this data of period, mass, and dimensions of orbit, of two objects so distant and so close that the best eye and the best instrument cannot separate them? Again, the spectroscopist is the wonderful instrument which reveals all these facts. At certain times the spectrum of this star is single, like that produced by other single stars. After the lapse of two days certain lines in the spectrum are duplicated and divergent, resulting from the fact that at that time one of the component suns is in a portion of its orbit when it is flying away from the earth with the enormous velocity of 150 miles per second, while its fellow is approaching the earth with a corresponding velocity. After the lapse of another two days the components have reached that portion of their orbit when each is moving across the line of vision, though in opposite directions, but as there is neither approach nor recession, the lines in the spectrum are simple and single. Our knowledge, then, amounts to a moral certainty that two bodies are revolving about each other where the keenest eye and the best aided vision discerns but one. We know further that the velocity of each is 150 miles per second, therefore their respective masses must be equal. From these data the mathematician was able to calculate size and distance apart of the two bodies.

Another striking example of this kind is the recently determined quadruple in the Great Bear—the well known Mizar in the handle of the Dipper. This was the first recognized double star, having been divided by Riccioli, at Bologna, in 1650. The components are 14' apart, and have a period roughly estimated at 10,000 years. These are escorted at a distance of 11½' by Alcor, visible to the naked eye, thus forming a triple having a period, purely conjectural, of 190,000 years. But the special interest is centered in the principal, for the spectrum, according to Professor Pickering, of Harvard, shows its bright lines to be periodically

doubled, indicating the existence of two suns, moving with a velocity of 50 miles per second, about a common center, in a period of 104 days. They are nearly equal in mass, with nearly circular orbits, about 143,000,000 miles apart, and together equal to 40 suns.

Here, then, is a strange system, consisting of two gigantic suns about as far apart as the diameter of Venus' orbit, wheeling about a center in three and a half months, attended at a remote distance by another brilliant orb, slowly and majestically revolving around both the central suns in a period that is only to be measured by the lapse of ten long millenniums. And these again, vast as their masses and distances are, act as a unit around which the great star Alcor moves in a stately orbit requiring hundreds of thousands of years to complete a revolution.

But these are not the only instances where an unseen companion has been detected. Algol, the wonderful variable star in Perseus, was suspected to have a dark companion which partially eclipsed it at a certain point in each revolution of a little less than three days. As about five-sixths of its light is eclipsed, of course the companion must be comparatively a very large body, which, on the other hand, requires a considerable motion of the primary if the two bodies revolve about a common center. Applying the spectroscopic, then, to the primary, we find that at certain points in its orbit it is receding from us and at the opposite point it is approaching, and from the data thus obtained, Professor Vogel, of the great German observatory at Potsdam, determined that the diameter of Algol is 1,061,000 miles, that of its companion 830,300, and the distance from center to center, 3,230,000. Orbital velocity of Algol 26.3 miles and that of the dark companion 55.4 miles. Mass of Algol, four-ninths that of the sun; mass of the companion, two-ninths.

But there is still another case of an unseen companion being discovered and its orbit determined, before it was seen through a telescope, and before the spectroscopic had come into use. Many of the stars, perhaps all of them, have what is called a proper motion, that is, an apparent motion through space. This motion is generally so small that only the most careful observations, prolonged for many years, will detect it. In the case of the brilliant star Sirius, however, the proper motion is very perceptible. That star is speeding rapidly along its undetermined course at the rate of 27 miles per second.

But it was noticed, after comparing long-continued observations, that this motion was not uniform as to velocity. In other words, the great star, careering so grandly through space, was subject to strange perturbations. It seemed to halt, then hasten on in its course. Some invisible body of enormous dimensions was evidently exerting a powerful influence over Sirius.

In 1844 Bessel, a German astronomer, who had discovered the parallax of 61 Cygni, announced his belief that Sirius was attended by an invisible, giant companion, and that both bodies were revolving round a common center, performing their revolutions in about fifty years. This was two years before Leverrier demonstrated the existence of the unseen planet Neptune by noting the perturbations of Uranus.

About eighteen years later Alvan Clark, the telescope maker, had just completed an 18½ inch lens (the largest then existing) for the Chicago observatory, and in order to test its quality his son directed it to Sirius, which was shining on that February night in an unclouded sky. Suddenly the latter exclaimed, "Why, father, Sirius has a companion." The old telescope maker eagerly looked, and, sure enough, there it was, a faint star of the ninth magnitude, hitherto unseen, and in close proximity to the great Sirius.

The discovery was promptly announced to the world of astronomers, and presently word came back that the new star occupied the precise position required for the companion according to Bessel's hypothesis, put forth eighteen years previous. But Bessel, whose genius had demonstrated the existence of this companion, died before its discovery, and therefore never had ocular proof of his theory.

This companion sun of Sirius is found to move in a highly elliptical orbit, extending at apastron to a distance from its principal equal to one hundred millions of miles beyond the distance of the planet Neptune from our sun. Now Neptune revolves about the sun in 165 years, but the Sirian planet, still more remote, revolves about its primary in 58 years. This means that the attractive force of Sirius, or rather of the combined suns, is far greater than that of our sun and its distant planet, and that their combined mass is correspondingly greater, and it is found to be about 3½ times that of the sun, of which one-third belongs to the companion.

But while these two bodies are so near alike in mass, note the remarkable difference in brightness. Sirius is 60 times brighter and perhaps 60 times hotter than our sun, while its great companion shines with such a feeble light that it would take 160 of them to equal our sun in splendor.

Now may we not reasonably suppose that Sirius and its companion are each attended by a retinue of planets and their satellites? If so, what a variety and complexity of effects would be produced by their peculiar relations to two suns in place of one! If there is a planet revolving around Sirius as near to that body as the earth is to the sun, it would be far too hot to support life. Suppose our hypothetical planet is as far removed as Jupiter. Owing to the enormous mass of Sirius, it would revolve around that orb in about three years instead of twelve, moving with a velocity of 40 miles per second, even then receiving more light and heat than the earth does from the sun.

But the dweller on that planet of Sirius would rejoice in the possession of two suns—the brilliant Sirius, shining with a splendor beyond anything we have ever witnessed, and the companion sun, about as far away as Neptune, shining with a milder radiance, about equal to the light of sixty full moons. At times both suns would be shining in the same sky; at other times only the companion sun would illuminate that half of the planet turned from Sirius, but the light then received would be nearly equal to broad daylight on a cloudy day.

But suppose our imaginary planet were revolving around the companion instead of Sirius, then its inhabitants would have two suns of about equal splendor, though Sirius, owing to his greater distance, would

present a smaller disk than his companion. But owing to the high ellipticity of the companion's orbit there would be times when the imaginary planet would be very inconveniently near the great hot central sun, and other times when it would be correspondingly remote, thus producing great contrasts and vicissitudes of climate.

If space permitted, we might indulge in other interesting speculations; for instance, we might consider the probable effects of the mutual attractions of two great bodies, so situated, upon the motions of a third body revolving around one of them. Likewise the effects upon animal and vegetable life on worlds where sunshine prevails for long periods throughout the twenty-four hours, or whatever time constitutes the diurnal rotation.

Then, again, it is not beyond the bounds of probability that some very remote planet, or burned out sun, far out on the confines of the firmament known to the Sirian system, may be revolving around the common center of the two gigantic suns, paying due allegiance to each as it careers along its orbit.

Indeed, the well-known triple star Zeta Cancri furnishes a notable example of this class. This star, according to a recent paper of Seeliger, an astronomer of Munich, consists of a close pair of stars about one second apart, each of the fifth magnitude, accompanied by a third star of nearly the same size, at a distance five or six times as great. These two stars of the close pair revolve around their common center of gravity in fifty-nine years, while the more distant star moves around the pair in the same direction in a period of about 700 years. But the great Russian astronomer Struve has noted irregularities in the distant companion which can only be explained by supposing that it has a dark companion, nearly as massive as itself, and that the two revolve around their common center in about twenty years. It will be seen that this dark companion transforms the triple into a quadruple star.

We have another interesting example of a quadruple in the fine star Epsilon Lyrae, which a small telescope expands into a double, but when a still higher power is used, each component unfolds into a pair of stars circling gayly about each other, and the two distant pairs majestically sweeping about a common center in a period that may be measured by thousands of years.

A still more complicated system is the double treble star (so called by Herschel) known as Sigma Orionis. It is a third magnitude star, just below the middle star in the belt of Orion. Herschel separated the two components into three stars each in 1779. Barlow continued the resolution and found that each component was a quadruple. Burnham in 1888 added to the complexity by discovering that the principal member of the large group is a close double, only a quarter of a second apart.

Here then is a star, single to the naked eye, and successively transformed into a double, double treble, double quadruple, and finally a double group, one of which contains five stars, and these successive transformations are produced by adding to the power of the instrument and the skill of the observer. And it is remarkable how much is due to the latter quality. Burnham made some of his most useful discoveries with a six inch lens.

In astronomical research, as in other branches of science, the best work is done by specialists. The field is so vast, the detail so voluminous, and the accumulated material so abundant, that each investigator, in order to hope for success, must select a limited and special field to work in. Accordingly we find certain astronomers studying the sun, others the planets, others devote themselves to the discovery of comets. One astronomer is special authority on the asteroids, another on meteorites. Several devote themselves to the investigation of nebulae, others to variable stars, and still others to the consideration of double stars. Sir William Herschel was the first to discern the importance of having a complete catalogue and record of double stars, and was the first to announce the probability of a physical connection existing between their components. His son, Sir John Herschel, continued the same line of investigation, extending his researches to the southern hemisphere, where he added upward of 1,000 double stars to his father's catalogue.

Contemporaneous with the younger Herschel was the elder Struve, who was director of the best-equipped observatory in Europe, at Pulkowa, near St. Petersburg. He was an enthusiast on double stars, discovered a large number, and computed the orbits of many of them. He was also succeeded by his son, Otto, who has proved a worthy successor in the same field of research and a most successful investigator, for he is equipped with the largest refracting telescope in Europe, having a 30 inch lens, only 6 inches less than that of the great Lick telescope.

But the most remarkable results in double star investigation during the last twenty years have been achieved by an American astronomer, and largely with an instrument of very moderate power, having only a 6 inch lens. His success was the result of extraordinary skill in observing. Mr. S. W. Burnham, recently of the Lick Observatory, but now residing in Chicago, has discovered and catalogued upward of 1,000 new doubles. Some of them are difficult objects in instruments of higher power than the one he used, when a less skillful observer is at the eye piece.

Other prominent astronomers in this field of research are Edward C. Pickering, at Cambridge, Asaph Hall, at Washington, Dr. Dobereck and H. C. Vogel, in Germany, and J. E. Gore, in Great Britain.

DIRECTION AND VELOCITY OF WINDS.

To the Editor of the Scientific American:

In regard to your answers in the SCIENTIFIC AMERICAN of March 26 last, to the queries of O. A. C. [4162] and C. R. W. [4167], respectively, concerning the directions and velocities of the winds, will you kindly let me add to your answer?

The theory you mention, that of the unequal distribution of the sun's heat and the motion of the earth on its axis, partly accounts for the direction and velocity of the upper air currents.

I say partly, because other authorities have proved to their own and the satisfaction of others that the above named factors are not the only causes for the movement of our upper atmosphere.

But, in reading over the aforesaid queries, I thought that perhaps your correspondents referred to the lower air currents or local, variable winds of our latitude, and write with that understanding.

If I am mistaken, I hope this may interest some one else.

An old definition of variable winds says that they are winds blowing under no fixed law. Nothing could be further from the truth.

Other authorities attempt to account for variable winds by changes in temperature owing to different kinds of soil, and other causes, such as bodies of water, clouds, forests, mountains, etc.

While these causes may be sufficient in other latitudes and countries, they will not account sufficiently for our variable winds.

The principal cause of the variations in direction and velocity of our lower atmosphere in this region is nothing more than our low area storms, whose general direction across the country is from west to east, with a few exceptions.

These disturbances or depressions in the atmosphere are produced by really unknown causes, although several theories have been advanced.

The lower atmosphere flows toward this disturbance in equilibrium at angles varying from 0° to 90°, with an average of 45°, depending on the distance from the storm center, the angle being greatest near the center.

The air flows around the center of the disturbance in a direction contrary to the movement of watch hands, like the water around a whirlpool, and as storms, or areas of low pressure, travel across the country at an average rate of 32 miles per hour the year around, we can account for the rapid changes in the direction of the wind.

However, we know that the above rate of storms will not account for the velocity of our winds, which often blow at a rate of from 40 to 60 and occasionally 80 miles per hour.

The velocity of the wind depends on the intensity of the storm and steepness of the depression.

Nature is always trying to maintain an equilibrium in the atmosphere, as in everything else.

Just as the level of a body of water, broken by dipping a quantity out, is restored, so nature tries to restore the equilibrium of the atmosphere disturbed by the storm, and causes the atmosphere to flow toward the disturbance at a velocity equal to the whirl and steepness of the depression.

Calms in our latitude are, as a rule, found between two storms of nearly equal intensity and are chiefly caused by the two masses of air of the same velocity, which would naturally flow around each storm, meeting, and each counteracting the force of the other.

In the above I have tried to explain the variability in direction and velocity of our lower atmosphere, and if you will give this article space in your valuable paper you will greatly oblige D. P. QUELOS.

Cleveland, O.

PLANTS CAPABLE OF YIELDING TANNING MATERIALS.*

By F. E. MAFAT.

Algarobilla.—The pods of different species of *Prosopis*, containing 60-65 per cent. of tannin; imported from South America, particularly Chili.—Leguminosæ.

Alder (*Betula Alnus*, Linn.).—In Europe *Alnus glutinosa* and *Alnus firma*, and in Japan *Alnus firma*, are indigenous. The bark, leaves, and fruit contain 13 to 15 per cent. of tannin; the 36 per cent. given by some authorities may be doubted. The Japanese alder contains 25 per cent. of tannin and colors the leather but little; the European alder is used in Russia and gives a deep color.—Betulaceæ.

Arbousier (*Arbutus Unedo*) grows in Europe; its leaves are used for tanning in Asia Minor and contain as much as 36.4 per cent. of tannin.—Ericaceæ.

Airelle-Myrtille (*Vaccinium Myrtilus*, Linn.).—This plant, more commonly known as bilberry, is abundant in France, Germany, and England. Its tannin is rapid in its action, and 3.5 kilos. of the dried and ground plant will make 1 kilo. of sole leather in a short time. The plant is best pruned like sumac, the leaves are not affected by moisture when gathered, which cannot be said of oak bark.—Ericaceæ.

Alcornogue (*Boudichia virgiloides*, Humboldt) is South American; the root, wood, bark, and leaves contain tannin.—Leguminosæ.

Acacia.—Various species of acacia yield the fruit or pods known as balibalah, cassia grains ("grain de cassier"), bablah, neb-neb, and Indian pods ("gousses de l'Inde"). Bablahs were first imported into Europe in 1830 as a mordant; the percentage of tannin in them is from 25-32, according to species. The exporting countries are India, Egypt, Nubia, Syria, Arabia, Senegal, and Mauritius. Acacia extract contains a strong free acid, a tannin analogous to that of nut galls, and a large quantity of a calcium salt.—Leguminosæ.

Andromeda.—Several species grow in Lapland and North America, where they are known as "sour tree." The wood contains 4-8 per cent. and the leaves 10 per cent. of tannin.—Ericaceæ.

Birch contains a tannin in wood, bark, and leaves which colors iron salts green. Davy gives 1.675 per cent. as the tannin contents, Villon, 3 per cent., Fraas, 5.32 per cent.—Betulaceæ.

Benmet (*Geum urbanum*, Linn.) is wild in Central and Southern Europe; its roots, leaves, and flowers are astringent, and according to Tromsdorff contain 42 per cent. of tannin free from gallic acid; others, however, give 4 per cent. in the whole plant.—Rosaceæ.

Bistort (*Polygonum Bistorta*) contains in its roots, stem, flowers, and leaves "bistortannic acid" and a yellow coloring matter assimilable by hides; it haunts the marshy land of Southern France.—Polygonaceæ.

Behen rouge (*Statice latifolia*, Smith) grows in Persia, the Caucasus, etc. Its roots are used in Southern Russia as tan for skins, to which it imparts a dull, ochreous, red color.—Plumbaginaceæ.

Bois doux (*Inga vera*, etc.) is a tree of Mexico, Guadeloupe, and the Indies, where it is known as coorocoopully; its wood and bark are tanniferous.—Leguminosæ.

Bauhinia (*Bauhinia variegata*) grows in the Antilles

* From an abstract, in the Jour. Soc. Chem. Ind., July, of a prize essay.