these stations attendant upon and immediately following the passage of the crest of anti-cyclones over New England is very striking.

The results of these observations may perhaps be summarized briefly in the statement that temperature changes indicate their approach at the summit of Mount Washington sooner than at its base. Thus, the departure of an anti-cyclone is signalized by a rise of temperature amounting, in the cases above described, to an actual inversion of temperature as compared with surrounding stations. In like manner the departure of a low centre is marked by decided decrease of temperature at the summit as compared with lower levels. In the former case there is equalization and in the latter case increased divergence of temperature at different altitudes. Hence it follows that relatively warmer air overlaps an anti cyclone at least as far east as its crest, and in like manner relatively colder air tends to overlap the warm air at cyclonic centres, but the extent to which it does so is not so clearly defined as in the case of the anti-cyclone. M. A. VEEDER.

Lyons, N.Y., Aug. 1.

Dr. Sprung: Remarks on the General Wind-Systems of the Earth.

IN the *American Journal of Science* for April I have called attention to the recent activity on the part of investigators in the field of dynamical meteorology. In that paper no attempt was made to give any opinion as to the relative merits of the different theories advanced. There could be no doubt but that a critical review of the subject was very much needed, but it must be at the hands of some one who had mastered the different theories with a thoroughness which would permit of his making a just estimate of the value of the ideas advanced by the writers. There was no doubt in my mind as to who was a (perhaps I should say the) proper person to give us this estimate. I refer to Dr. Adolph Sprung. It was with the greatest pleasure, then, that, on taking up the May number of the *Meteorologische Zeitschrift*, I found there a paper of sixteen pages by Sprung, in which he had given his views as to the correctness of the methods and some of the main results arrived at in these recent papers.

But before giving a synopsis of this *referat*, it may not be out of place to say a few words about Dr. Sprung's work, as he is probably known to but few of the present readers in any other capacity than the author of the "Lehrbuch of Meteorology," which gives us such an excellent presentation of the modern theories concerning statical and dynamical meteorology. Dr. Sprung's contributions to meteorology extend over a period of about fifteen years, and cover a wide range of topics. But there are two distinct lines in which he has made his name especially prominent as a specialist: viz., those which relate to self-registering instruments, and the mechanics of the atmosphere. He has devised a self-registering apparatus of great accuracy, which is gradually receiving a wide adoption; and the fact that its construction is in the hands of the leading German meteorological instrument-maker is itself a guaranty of its excellence. The names of "Wild" and "Sprung" will always be associated with the development of this important branch of meteorology.

It is, however, of Sprung's connection with the second topic, that of dynamical meteorology, that I wish to make special mention at the present time. From the commencement of his meteorological labors at the Deutsche Seewarte he has been a careful student of this subject; and his acquaintance with its now extensive literature is not of a cursory nature, but admits of his using the methods and results of contributors in a manner which denotes thorough comprehension. Judging from Sprung's writings, as well as by a long personal intercourse with him, I feel justified in saying that no one has a better knowledge than he, of the contents of the hundred papers which cover the field of dynamical meteorology. I do not know of a better example of the thoroughness of this study than his review of Part II. of Ferrel's "Meteorological Researches," which he published in the *Osterreiche Zeitschrift für Meteorologie* nearly ten years ago. In this same connection I may also say that no other person has done so much as Dr. Sprung towards making generally known to Europeans the great service of Professor Ferrel to meteorology.

In the comparative treatment given by Sprung in the paper now under consideration, he prefaces it by some general remarks which are of interest to us; and I will give an abstract of these, as well as of portions of the main paper.

The general circulation of the atmosphere has been lately the subject of theoretical investigation, and principally by German investigators, although earlier — through a number of years — the workers in this field had been almost exclusively Americans, and foremost of all was William Ferrel. But in 1886 Werner von Siemens published an important paper, which was the first of the series just referred to. In this investigation the results already obtained by Ferrel in his earlier works were not made use of, and the matter was treated from the first principles. But in all of the investigations an ideal and homogeneously formed earth's surface is presupposed; that is, it is assumed to consist everywhere of water or land of like qualities. On this supposition there is built up an ideal pressure distribution and system of winds. Moreover, all of the systems agree with the view so long ago advanced by Hadley, as to the initial cause of the atmospheric circulation.

The theory of Werner von Siemens is first outlined, not because it is the oldest of the modern views, but because it is the simplest. It may be briefly stated as follows: We must conceive the air to be everywhere at relative rest; the atmosphere will then possess, by means of its absolute motion of rotation, a certain amount of living force K. Now suppose the whole atmosphere to be suddenly thoroughly stirred up. Then, according to Siemens, there will be produced an everywhere uniform volocity of rotation C, and of such an amount that the total living force is just the same as before.

We will determine C. By definition

$$K = \frac{mV^2}{2}, \tag{1}$$

where m denotes the mass of a quantity of air, and V its absolute velocity of rotation (that towards east is positive); under which supposition we have

$$V = \omega R \cos\phi, \tag{2}$$

where R is the radius of the earth (considered as a sphere), ω is its constant angular velocity, and ϕ the geographical latitude. In order to represent the mass m, covering a small ring at the latitude $R\,d\,\phi$ and radius $R\cos\phi$, we will designate by μ the mass (assumed to be uniform) over the unit of surface: we have, then, (3) $m = 2\,\mu\,R^2\,\pi\cos\phi\,d\,\phi$ ($= d\,M$, where M signifies the mass of the whole atmosphere): consequently

$$K = \mu\,R^4\,\omega^2\,\pi \int_{-\frac{1}{2}\pi}^{\frac{1}{2}\pi} \cos^3\phi\,d\,\phi.$$

In general,

$$\int \cos^3\phi\,d\phi = \frac{\sin\phi}{3}(2 + \cos^2\phi) \tag{4}$$

which for the limits $\frac{1}{2}\pi$ and $-\frac{1}{2}\pi$ reduces to $\frac{4}{3}$; therefore we have finally

$$K = \tfrac{4}{3}\,\mu\,R^4\,\omega^2\,\pi. \tag{5}$$

If, now, the computation of the living force for a uniformly equal velocity C furnishes the same amount, then

$$K = \Sigma\frac{m\,c^2}{2} = C^2\,\Sigma\,\frac{m}{2}, \text{ or}$$

$$C^2 = \frac{2\,K}{\Sigma\,m}. \tag{6}$$

From (3) we have, then,

$$M = \Sigma\,m = 2\,\mu\,R^2\,\pi \int_{-\frac{1}{2}\pi}^{\frac{1}{2}\pi} \cos\phi\,d = \phi = 4\,\mu\,R^2\,\pi. \tag{7}$$

By consideration of (5) we have, then,

$$C = R\,\omega\,\sqrt{\tfrac{2}{3}}\ (= 379 \text{ metres per second}). \tag{8}$$

Subtracting from this $R\,\omega\cos\phi$, the motion of the earth at the latitude ϕ, and we get the relative easterly motion v; then from (8) and (2) we have

$$v = R\,\omega\,(\sqrt{\tfrac{2}{3}} - \cos\phi). \tag{9}$$

It is of special interest to find the latitude ϕ_0 in which $v = 0$. This gives

$$\left\{\begin{array}{l} \text{Cos}\,\phi_0 = \sqrt{\frac{2}{3}} \\ \phi = 35^\circ\,16'. \end{array}\right. \tag{10}$$

For the belt between the two parallels of 35°, there must be, according to (9), a westerly air-current (east wind) which is greatest

at the equator (85 metres per second); while everywhere beyond latitude 35° there is a west wind which acquires its greatest velocity (379 metres per second) at the pole. In this computation a frictionless motion is considered. The distribution of the air-pressure corresponding to this has been worked out by Liebenow, and published in the *Naturwissenschaftlichen Rundschau*, Jahrgang III. p. 237, but it has no practical significance for meteorologists.

Ferrel's reasoning gives for v, the relative linear velocity of rotation, in the latitude ϕ, the following expression: —

$$v = R\,\omega \left\{ \frac{2}{3\cos\phi} - \cos\phi \right\};$$

that is, $v = 0$ for $\cos^2\phi = \frac{2}{3}$ or $\phi = 35°\ 16'$.

For $\phi > 35°\ 16'$, v is positive (west wind).

For $\phi < 35°\ 16'$, v is negative (east wind).

Ferrel's and Siemens's researches were independent of each other, but their apparently complete agreement is in reality only a partial one. They agree as to the dividing-line between the easterly and westerly air-currents (the first three being from the east, and the last four from the west); but the following little table shows how widely their computed velocities (expressed in metres per second) differ.

	Siemens.	Ferrel.
For $\phi = 0°$	85	155
" $\phi = 20°$	57	107
" $\phi = 35°\ 16'$	0	0
" $\phi = 45°$	51	110
" $\phi = 54°$	106	254
" $\phi = 70°$	220	747
" $\phi = 90°$	379	∞

In both cases there are assumed three facts: (1) The friction is not considered; (2) The initial condition is relative rest; (3) Thorough mixing of the air is accomplished by meridional motions. There are certain inaccuracies of deduction existing in both theories, so that we cannot say without qualification that one is right and the other wrong. Siemens seems to have fallen into the error of the Hadley-Dove view, that masses of air passing from one parallel to another retain unchanged their absolute velocity of rotation. It is one of the main points of Ferrel's theory, that this does not remain constant, but increases with the approach towards the axis of the earth. The following quotation from Helmholtz's memoir "Ueber Atmosphärische Bewegungen" (*Meteorologische Zeitschrift*, 1888, p. 329) shows his complete agreement with Ferrel. He says, "If we consider a rotating belt of air, whose axis coincides with the axis of the earth, and which is pushed first a little to the north and then a little to the south by the pressure of the adjoining similar belt, then, if the friction is not considered, according to the well-known general mechanical principle, the moment of rotation must remain constant." This can be true only when the angular velocity of the belt changes in an inverse proportion to the square of its radius. The two velocities at the poles obtained by Ferrel and Siemens, and given in the table, are both far removed from the true value; but in either case there would be a crowding-back of the air from the axis of rotation, because such great velocities of rotation are impossible. Ferrel, however, in his further development, so limits the theoretical conditions that these impossible velocities are modified into possible conditions. It is quite amusing that some readers of Ferrel's writings have understood him to make the ridiculous statement that all of the results found by his purely theoretical deductions do actually exist in nature; and they claim that such absurdities are sufficient to cause his theory to be rejected. It merely shows that such persons have only glanced at Ferrel's writings.

(*a*) The resistances to motion, such as friction and the like, make it impossible that such a great increase as Ferrel and Siemens figure out can occur in the relative motions of the air; and Helmholtz has given his views of this action, in the paper previously mentioned.

(*b*) Again: the mixing-up of the air does not occur in the assumed uniform manner which requires that all the air, no matter what its altitude is, which proceeds from about the latitude of 35°, reaches all other latitudes. As an actual fact, we find that the motion toward the pole, towards gradually narrowing circles of latitude, takes place mostly in the higher layers of the atmosphere, and the opposite motion in the lower layers. According, then, to the law of the conservation of areas, we owe to the upper movements the west wind, and to the lower the east wind.

The modifications of this simple scheme which are necessary to account for the observed wind phenomena are next discussed by Dr. Sprung, who gives special attention to the recently expressed views of Dr. Peruter (see *Wetter*, p. 11, 1890; also given in a lecture at Vienna, Nov. 7, 1889), concerning the lack of an upper south-west trade-wind between the two parallels of 35° latitude; his view being based on the theories of Siemens and Oberbeck, and in opposition to that of Ferrel. Professor Abbe's recent studies of cloud-motions in the tropics will be very useful in this connection. The tendency towards the origination of a tropical east wind is far more marked in the theory of Ferrel than in that of Siemens. That the actual wind circulation as marked out by these two investigators are so contradictory seems to be due to the fact that Siemens simply combined with the weak meridional surface currents the results obtained in (9), without considering that this is sensibly changed by the conditions explained under (6). Ferrel, on the contrary, carefully investigated the gradients of air pressure, and found that the east wind of the tropics could be perceived to only a limited extent.

Sprung's trite references to the recent works of Oberbeck (*Sitzungsberichte Berlin Akademie*, March 5 and Nov. 8, 1888) and Möller (*Archiv der Seewarte*, vol. 10), and his own attempt to treat this question of the upper anti-trades in an empirical manner, cannot be discussed in the present short communication. The last section (five pages) of Sprung's paper is of special importance to the student of this question of general motions, for he treats analytically the reasons for the use of the principles adopted in Siemens's paper.

FRANK WALDO.

Mount Lake Park, Md., July 29.

A Brilliant Meteor.

ON Sunday night, July 27, at 11.15 P.M., while sitting on the piazza looking west, I saw a remarkable meteor, which in size and slowness of movement resembled that of 1861 (which I also saw).

It appeared from beneath the edge of one of the fleecy streaks of cloud with which the sky was full, about forty degrees above the horizon. Its path was downward, very slightly southward. When it first appeared, it rapidly increased in size to a large sphere of brilliant white light, changing immediately to a pale apple-green as it descended, followed by a train of dark-red glowing particles. Its duration above the horizon was about two seconds.

The clouds were not thick enough to obscure the light of third-magnitude stars.

F.

Sea Girt, N.J., July 30.

BOOK-REVIEWS.

Hypnotism. By ALBERT MOLL (of Berlin). (Contemporary Science Series.) New York, Scribner & Welford. 8°.

HAVING noticed the general plan and scope of this work upon the appearance of the original German edition (*Science*, July 19, 1889), it may suffice to express briefly our appreciation of the value of this contribution to the English literature on hypnotism. We have had a translation of Bernheim's important work, and of Krafft-Ebbing's treatise on the subject from the more strictly medical point of view, and translations of Binet and Féré, and of Björnström, giving more general expositions of hypnotic phenomena. It is with the latter class of works that Dr. Moll's invites comparison. It is much fuller and more thorough than Björn-