

be if anything raised, so as to tend to cut down the number of applications, and make it possible for the examiners to devote more time and study to each application. That in itself would greatly facilitate and expedite the progress of the case in the office, for any one of experience knows that many of the examiner's letters of rejection show very little consideration on his part of the real features of the invention before him. There should be at all events a provision for a graded scale of first fees, dependent upon the complexity of the applicant's specification and claims. To induce greater brevity and clearness of statement and to discourage needless multiplicity of claims, it might be provided that the applicant be required to pay an additional fee of \$1 for each page exceeding three in original application, and a like fee for each and every claim, exceeding five, inserted

either in the original application or by subsequent amendment.

(3) The present practice in conducting interference contests in the U. S. Patent Office is in many respects the worst of its kind in existence. It is a notorious fact that in such contests as at present conducted a poor contestant is practically at the mercy of a rich opponent. By instituting various obstructive proceedings; by prolonging almost *ad infinitum*, the taking of testimony all over the country—or even in foreign countries—and finally by carrying the case from one tribunal to another on motions, and appeals, the delays and expenses of the litigation may be piled up to such a degree as to absolutely compel the poor or even moderately circumstanced inventor to abandon his case. I have known of interference contests in which the cost—to one party alone—

has run up to the enormous figure of nearly \$40,000. Think of incurring such an expense in merely securing a judgment as to priority, and remember that the inventor's right to obtain a patent may still be contested on a mere technicality or even on an utterly fictitious claim of another party—by instituting public use proceedings—and remember finally that even after winning out in all these contests and securing a patent such a patent may be declared utterly worthless and invalid by the courts. Winning an interference in no way aids an inventor in afterwards sustaining his rights against infringers. The present practice in these cases is a disgrace to our patent system.²

² In this connection attention is called to an article "Some Hardships of Patent Infringement," by L. P. Alford in the *American Machinist* of February 10th, 1910.

Meteorology as an Exact Science*

Physical Laws Applied to the Study of Atmospheric Phenomena

By Prof. V. Bjerkne

IN accordance with the natural division of the Earth into an atmosphere, a hydrosphere and a lithosphere, geophysical science comprises three parts: Physics of the Atmosphere, Physics of the Sea and Physics of the Solid Globe. The first two branches are closely related with one another, and I intend making them the center of my work as investigator and teacher.

The physics of the atmosphere and meteorology, though agreeing as far as the object of their investigation is concerned, are not identical in their scope. The difference between them might be expressed by recalling the fact that physics is an exact science, whereas one might be inclined to describe meteorology as a most inexact science. Meteorology only becomes exact, in so far as it develops into a physics of the atmosphere. This development forms the subject of the following considerations:

An interest in atmospheric phenomena was naturally awakened in Man at a very early period. The ancients had meteorological knowledge not only regarding the weather in their own country, but also regarding certain great periodical phenomena, such as the Indian monsoons. They were also acquainted with the physical laws and relations mainly concerned in the production of air currents, viz., Archimedes' law of hydrostatic buoyancy, and the expansion undergone by the air on heating. But there was no one to throw a bridge from one branch of knowledge to the other and to realize the causal connection. We can not therefore properly speak of a science of physics of the atmosphere among the ancients.

The age of discovery resulted in new additions to meteorological knowledge. Columbus discovered on his first voyage the trade winds, and subsequent navigators found the same winds in the Southern Hemisphere and renewed their acquaintance with the monsoons. The same period witnesses a remarkable development of physical science; a rational dynamics was founded, and the laws of hydrostatic buoyancy and thermal expansion were re-discovered. All preliminary conditions for recognizing a causal connection were thus given, and the happy inspiration came first to Halley who, on a two years' voyage through the Tropics had collected his observations. He states the case as follows: At the equator the air is heated strongly; it expands and becomes lighter and rises to higher altitudes, whence it flows off toward the poles. In order to effect a compensation, masses of air have to flow in from the North and South along the surface of the earth toward the equator, the winds thus produced being the trade winds. Halley also tried to account for the fact that the trade winds, instead of flowing along the meridian, have a component also in the direction of the equator, but his interpretation is not correct. Hadley it was who 50 years afterward showed this phenomenon to be due to the rotation of the earth, all air and sea currents being apparently deflected to an observer rotating with the Earth.

Halley's and Hadley's work can to a certain extent be compared with the feat achieved by Newton for astronomical science, when he taught how to calculate in advance the position of planets, when the initial position is given. Just as Newton's achievement was due to his applying to astronomy the results of a related science, mechanics, Halley and Hadley were indebted for their successes to the application of the results of the kindred doctrine of physics to meteorology. Still there was a great difference. Newton's solution of the astronomical task was quantitative, and astronomers have since been able numerically to predetermine the positions of planets.

Halley and Hadley, however, had to be satisfied with a qualitative explanation of meteorological phenomena. The reason of this difference is evident. Astronomical observers in Newton's time supplied all the data on the actual position of the planets required for predetermination; meteorological observers at the time of Halley and Hadley on the other hand were still quite unable to give corresponding data on the condition of atmosphere. To this should be added the still rudimentary state of theoretical knowledge. Planets could be considered as isolated material points influencing one another in accordance with simple laws. Newton's mechanics was immediately adapted to problems of this kind. On the other hand, the laws ruling the equilibrium and motion of liquid and gaseous bodies, and the relations between mechanical work and heat were still unknown. Any further progress of meteorology thus was dependent, on one hand, on the development of the methods of observation, and, on the other, on the advances of theoretical physics.

The invention of the thermometer and barometer endowed meteorological observation with a precision it had so far lacked. At the beginning of the 19th century the enormous value of strictly simultaneous observation for the recognition of causal connections was at last realized. Great pains were frequently taken in collecting such data and in representing them synoptically on maps. Toward the middle of the last century, electrical telegraphy was for the first time placed in the service of synoptical meteorology, and this organization gave rise to the development of the present international public weather services.

However, the great hopes attached to this organization, when it was first called into being, were only partially realized. This was—not without some justification—put down to the fact that only observations of the lowest stratum of the atmospheric ocean were available. All data relating to the free atmosphere were missing, apart from the results of manned balloon trips undertaken by a few isolated investigators, such as Glaisher, with instruments still defective. However, the evolution of aerological methods, a thing of quite recent origin, connected with which are prominently the names of Assmann, Rotch and Teisserenc de Bort, now enabled the atmosphere to be sounded up to heights of 20 kilometers and more, by means of balloons and kites. Prof. Hergesell's endeavors have resulted in the perfecting of an international network from which the atmosphere over a large part of Europe is explored on predetermined days. Directly or indirectly the elements describing the actual state of the air can now be ascertained for all those points of the atmosphere which are penetrated by instruments. These elements are: The three components of velocity, pressure, density, temperature and moisture. By means of suitable methods of interpolation, the same factors can also be stated for any point situated within the explored region of the atmosphere. The task of meteorological observation may thus be said to have been solved, and it only remains for the future to furnish technical improvements.

Hand in hand with the development of methods of observation went a splendid progress of physical science. Toward the middle of the 18th century, Clairaut established the equations of hydrostatics and Euler those of hydrodynamics. In 1835, i. e., just 100 years after Hadley, Coriolis enunciated his wellknown theorem, which is now generally used in accounting for the deflection due to the rotation of the earth. After the invention of the thermometer and the barometer, the behavior of gases had been investigated experimentally, thus leading gradually to the Boyle-Gay Lussac law. The difference

between the concepts of heat and temperature was realized and the laws of freezing and melting were determined. Guided by Sadi Carnot and Robert Mayer's revolutionary ideas, Helmholtz, Lord Kelvin, Clausius and other investigators erected the structure of thermodynamics.

Physical science had thus fulfilled the requirements it had to comply with. The seven variables which describe the state of atmosphere have been above enumerated. Physics now supplies also seven equations expressing the mutual connection between these variables, viz., the three hydrodynamical equations, the equation expressing the conservation of mass (equation of continuity) the state equation of gases and the equations derived from the two fundamental laws of thermodynamics. The problems of atmospheric physics thus become problems stated in mathematical terms, which can be subjected to a quantitative treatment with some chance of success.

At a time when physical science was undergoing this development, the theorems newly found were gradually applied to meteorological phenomena. On certain hypotheses it is possible so to simplify these problems as to give them either a purely dynamical or a purely thermodynamical character and to allow the corresponding differential equations to be integrated. We are indebted for important papers in this direction, which have doubtless elucidated many notions, to Ferrel, Guldberg and Mohn, Helmholtz, Hertz, Von Bezold, etc.

Belonging to a period previous to the inception of aerology, these papers had to be content with the treatment of ideal cases. Now, however, after aerological observation has been supplying all fundamental data on the state of the atmosphere, a problem is suggested which can no longer be put aside, viz., the problem of *mathematical predetermination of the weather*. Though the goal be still distant, and though the individual worker in the field has little chance ever to reach it, it is by no means premature to face its solution even now. The final goal being thus clearly prescribed, scientific investigation follows the right direction, and there is some hope of doing good preparatory work, provided the goal be never lost sight of. The way so far traversed by me and my collaborators has, it is true, only shown how far away we are as yet from the final goal. Still, many individual problems have been solved and many useful methods developed. Among other results should be mentioned the establishment of the principles of a graphical mathematics, which allows from the maps representing the distribution of pressures, densities, etc., other maps to be derived graphically, much as one equation is derived from the other by analytical means. It may be said that analytical methods would be quite unsuitable for the purpose at issue, there being no hope of ever succeeding in representing by mathematical formulæ the state of atmosphere at a given moment.

An objection sometimes raised against this kind of work is that a predetermination of the weather, even if it should be possible, would take far too much time to be utilized in practice. What is the use of learned men requiring three weeks to calculate what the weather does in three hours? Though the author does not hope personally to reach the goal, he would be more than content with calculating by many years' indefatigable work even the weather from one day to the other. This would, in fact, mean the scientific solution of the problem and practical achievements would soon be forthcoming.

"It may take years to bore a tunnel through a mountain. Many workers may not live to see the day of piercing the tunnel. Still, this will not prevent others from some day traversing the mountain at the speed of express trains."

* Authorized and revised abstract from inaugural address held on January 8th, 1913, at the University of Leipzig.