as in a Latin version. By means of these photographic copies of the map, the legends in Spanish are made accessible. I am not aware that they have ever been published as a whole. There is something more than a suspicion that some of the legends in Latin contain statements not to be found in the Spanish. A committee of the Massachusetts historical society, to whom a copy of this map, presented by the president, has been referred, intend to publish an English translation of the legends, with the result of a comparison with the Latin version.

CHARLES DEANE.

MAP OF THE PLANETS AND STARS NEAR THE SUN, MAY 6, 1883.

THE map which is given in this number of SCIENCE has been prepared to aid astronomers, who may observe the total solar eclipse of this year, in a search for Vulcan. It does not need to be said that the eclipse of May 6 is the most favorable for this purpose that will occur for many years, and it is to be hoped that the unique opportunity will not be lost.

The present map has been compiled with care from the *Durchmusterung* catalogue, checked by comparison with the maps and by proof-reading. It contains all the stars of the *Durchmusterung* within the region near the sun, down to the seventh magnitude inclusive, together with a few stars of a slightly lower magnitude, which are only added when their omission would spoil a configuration. The planets Saturn and Neptune are also added. The positions of the map are amply accurate for the purpose intended.

EDWARD S. HOLDEN.

Washburn observatory, university of Wisconsin,
Madison, Jan. 11, 1883.

FIRST USE OF WIRE IN DEEP-SEA SOUNDING.

IN view of the great impetus recently given to deep-sea sounding and dredging (especially in the United-States navy and coast survey work) by the application of steel piano-wire in place of line, it is interesting to learn the fate of the first experiments in that direction. These have been extracted by Commander J. R. Bartlett, U.S.N., of the hydrographic office, from the log-book of the United-States schooner Taney, Lieut. J. Walsh, U.S.N., commanding, October, 1849, to June, 1850.

The Taney took on board at the Brooklyn navy-yard, Oct. 22, 1849, a large iron reel containing 7,000 fathoms iron wire graduated Nos. 7 to 13; an extra reel with 5,900 fathoms wire, size not stated; and a small reel with 300 fathoms iron wire, size No. 5.

The Taney sailed Oct. 26, 1849, to take deep-sea soundings in the North Atlantic. On the 15th of November preparations were made for sounding with wire in lat. 31° 59′ N., long. 58° 43′.5 W., not far from Bermuda. After reeling out 5,700 fathoms, the wire parted near the surface, owing to the fact that the splices had some projecting ends which caught upon each other. The No. 7 wire parted. It is noted in the log, that the circumstances were favorable and the sounding plumb. It seems, however, that the lead used was altogether too small, about twelve pounds only; and this was the reason why so much wire ran out without its being recognized that bottom had been reached. The weight of the wire of course carried it out, and would have continued to do so as long as any wire was left. The lead was armed with a Stellwagen cup, but the detaching apparatus and dynamometer for sounding were then unknown.

The same experience was repeated on the 9th of May, 1850, when 2,200 fathoms of wire were lost; and on the 18th, when 2,050 fathoms were lost, with the thermometer, twelve-pound lead, and Stellwagen cup. On the 22d of May the last attempt was made with the same results; the wire parting in every instance owing to one splice catching upon another on or near the reel. The last time only an eight-pound lead was used, with 1,900 fathoms of wire out when it parted. The party returned to New York, June 3, 1850, shortly after which Lieut. Walsh died. This ended the trial of wire for the time; to be revived when the invention of steam reeling-apparatus, detaching sounding-cups, the dynamometer, and 'accumulators' had rendered its use practicable. It seems singular, however, that the difficulty as to the splices was not remedied on the spot, and that heavy leads were not tried.

WILLIAM H. DALL.

AN EXTENSION OF THE THEOREM OF THE VIRIAL AND ITS APPLICATION TO THE KINETIC THEORY OF THE CONSTITUTION OF GASES.[1]

CLAUSIUS has designated as the theorem of the virial the equation which he first arrived at in a paper upon a *New mechanical theorem applicable to heat.*[2] This theorem applies to stationary progressive motion, such as the molecules of gases are assumed to have in the kinetic theory of gases, and, when so applied, may be written in the form

$$akt = \tfrac{3}{2}pv + \tfrac{1}{2}\Sigma rR \quad . \quad . \quad . \quad . \quad (1)$$

[1] Abstract of a paper read by H. T. EDDY, Ph.D., University of Cincinnati, before the Ohio mechanics' institute, Jan. 18, 1883.

[2] Phil. mag. [4], vol. 40, p. 122.

in which p, v, and t denote the specific pressure, volume, and absolute temperature of the gas; k is the specific heat at constant volume; a expresses what fraction of total kinetic energy, kt, is progressive; r is the mean distance of the molecules; and R the mean intermolecular attraction; the summation being taken for all possible pairs of molecules.

This investigation depends upon d'Alembert's equation expressing the relation of the force acting to the linear acceleration of the mass moved.

The present paper proceeds to employ Euler's equation, expressing the relation of the couple acting to the angular acceleration of any material body, to find an analogous equation for the mean rotary motion of bodies in a state of stationary rotation. An equation is obtained precisely analogous to that found for progressive motion. But, since the intermolecular attractions cannot accelerate the rotary motion, they do not appear in the equation, which can finally be written in the form

$$a'kt = \tfrac{3}{2}pv \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which a' expresses what fraction the mean rotary energy is of the total kinetic energy. Two cases, however, must be excepted from the general equation (2). The first of these is that of molecules which are smooth figures of revolution, such as diatomic molecules may be supposed to be; and the second is that of smooth spheres, such as monatomic molecules may be. In these two cases it is shown that

$$a'kt = pv, \text{ and } a'kt = 0,$$

respectively.

It is further shown, that, in case a variation of state occur, that the variation of the last term in (1) must be always negative, or zero, when the temperature is augmented, as appears from comparisons of the formula with Thomson and Joule's experiments on the free expansion of gases in passing a porous plug, with Andrews's experiments on carbonic-acid gas above the critical temperature, with Berthelot's principle of maximum heat, and with mechanical systems in motion under the control either of gravitation or of elastic forces.

An investigation is then made of the ratio of the specific heat at constant pressure to that at constant volume in imperfect gases; the result of which, for molecules of more than two atoms, may be expressed in an equation of the form

$$k = \tfrac{4}{3} - \tfrac{1}{3}b + \tfrac{1}{6}(5 + i)c \quad . \quad . \quad . \quad . \quad (3)$$

in which k is the ratio of the specific heats in question; b expresses what fraction of the total kinetic energy exists in the form of atomic vibration within the molecule; c, which is very small, expresses what fraction the work done against intermolecular attractions is of the same quantity; and i is the exponent expressing what inverse power of the distance between the molecules may be taken as the approximate law of intermolecular attraction. i is always taken as greater than unity, and usually greater than 3; while the value proposed by Maxwell is 5. The experimental values of k lie between 1.33 and 1.25. If the value of c be assumed to be zero, as it is in perfect gases, then a lies between zero and $\tfrac{1}{4}$; and, if c is not zero, a must exceed $\tfrac{1}{4}$ for some of the more complex gases; i.e., the energy of vibration of the atoms within the molecules may exceed one-fourth of the mean kinetic energy of the gas.

In the case, however, in which the molecules consist of but two atoms each, the equation obtained is

$$k = \tfrac{7}{5} - \tfrac{2}{5}b + \tfrac{1}{5}(4 + i)c \quad . \quad . \quad . \quad . \quad (4)$$

in which the value of b must be much smaller than when the number of atoms is larger. The experimental values lie between 1.41 and 1.39; and for air, for which k has been more accurately determined than for other gases, the accepted value is, according to Wüllner, 1.405; in which the influence of the term containing c is perceptible. The value, however, of k, derived from Regnault's most accurate determination of the velocity of sound, is 1.395. For molecules consisting of one atom each, the equation obtained is

$$k = \tfrac{5}{3} - \tfrac{2}{3}b + \tfrac{1}{3}(2 + i)c \quad . \quad . \quad . \quad . \quad (5)$$

The experimental value of k, as found for vapor of mercury (the only known monatomic gas), by Kundt and Warburg, is 1.67.

This ratio has been previously investigated by Boltzmann and by Watson, by the help of generalized co-ordinates expressing the number of degrees of freedom of the system; but it has not been found possible to assume any integral number of degrees of freedom which would cause the value found for k to agree with experimental results. The opinion is expressed by the author, that this method is unsuited to the investigation of this question, because any elastic connection or attractive forces neither allow perfect freedom, nor impose absolute restraints, such as are contemplated by the method.

So far as known, this investigation explains, for the first time, what Watson, on p. 39 of his treatise, regards as "the great difficulty in the establishment of the kinetic theory of gases on the molecular hypothesis."

CONSEQUENCES OF SPLEEN EXTIRPATION.

In a preliminary notice (*Centralbl. med. wissensch.*, 1882, 900) Winogradow describes the results of spleen extirpation, as manifested in the blood, lymphatic glands, and bone-marrow of dogs, several of which were kept alive in good health for more than two years after the splenotomy.

After the operation the number of red corpuscles in a cubic millimetre of blood always falls in a short time, occasionally within a few days. This diminution is most marked from a hundred and fifty to two hundred days after the splenotomy, when in some cases the red corpuscles are less than half their normal number. Later they become again more abundant. In the first twelve months the size of the red corpuscles is not altered: after that there is found a gradually increasing proportion of abnormally small specimens; and the red corpuscles of exceptionally large size, of which some are always found in normal dog's blood, entirely disappear. The white blood corpuscles show no morphological change; their absolute number is sometimes increased, sometimes diminished.

In one case, a hundred and thirty-two days after the splenotomy, there was found marked enlargement of most of the lymphatic glands. They were much softer than normal, and red on section, especially in the cortical layer, looking much like splenic tissue. This coloration depended mainly on red blood corpuscles which were abundant in the lymph channels of the gland; and was in part due to deposits of brownish-red pigment, which Winogradow ascribes to the detritus of broken-down corpuscles.

The marrow in the central cavity of nearly all the long bones was red-colored, and presented the general appearance of the red marrow of the cancellated bony tissue of young dogs. This color was due to red corpuscles lying outside the blood-vessels in the spaces of the proper marrow tissues.

Later (five hundred and seventeen to seven hundred and sixty days after the spleen removal) similar but less marked divergences from the normal struc-