peripheral end of the cervical sympathetic, and formed nerve-endings around the cells of the superior cervical ganglion, or they had united directly with the sympathetic fibres. That the former had taken place I infer from the fact that the regenerated nerve contained medullated fibres larger than those proper to the sympathetic.

I conclude from the experiments that there is no essential difference between the efferent "visceral" or "involuntary" nerve fibres, whether they leave the central nervous system by way of the cranial nerves, by way of the sacral nerves, or by way of the spinal nerves to the sympathetic system. All of these fibres I take to be pre-ganglionic fibres. And I think that any pre-ganglionic fibre is capable, in proper conditions, of becoming connected with any nerve cell with which a pre-ganglionic fibre is normally connected; although apparently this connexion does not take place with equal readiness in all cases. On the whole it appears to me that the functions exercised both by pre-ganglionic and by post-ganglionic fibres depend less upon physiological differences than upon the connexions which they have an opportunity of making during the development of the nervous system and of the other tissues of the body.

A fuller account of the observations will be published in the 'Journal of Physiology,' after some further experiments have been made.

"Researches in Vortex Motion. Part III. On Spiral or Gyrostatic Vortex Aggregates." By W. M. Hicks, F.R.S.

Received January 12,—Read February 3, 1898.

(Abstract.)

A portion of the communication (Sect. II) extends the theory of the simple spherical vortex discovered by Hill. The chief part (Sects. I and III) refers, however, to a kind of gyrostatic aggregate. The investigation has brought to light an entirely new system of spiral vortices. To give an idea of the species of motion considered, take the case of motion of an infinitely long cylindrical vortex of sectional radius a. The velocity perpendicular to the axis inside the vortex will be of the form $v = f(r)$ where $f(o) = 0$. Outside it will be given by $v = \mathrm{V}a/r$ where $\mathrm{V} = f(a)$.

We may, however, have a motion in which the fluid moves parallel to the axis inside the cylinder with rest outside. The velocity will be of the form $u = \mathrm{F}(r)$ inside, where $\mathrm{F}(a) = 0$, and zero outside. Both $f(r)$ and $\mathrm{F}(r)$ are arbitrary functions subject only to the conditions $f(0) = 0$ and $\mathrm{F}(a) = 0$. Putting aside for the present the

question of the stability of these simple motions or of their resultant, it is clear that if we superpose the two we get another state of steady motion in which we have vortex filaments in the shape of helices lying on concentric cylindric surfaces. The problem to be considered is whether it is possible to conceive a similar superposition of two motions in the case of any vortex aggregate whose motions are symmetric about an axis.

The general conditions for the existence of such systems are determined in Sect. I, and are worked out in more detail for a particular case of spherical aggregate in Sect. III. It is found that the motion in meridian planes is determined from a certain function ψ in the usual manner. The velocity along a parallel of latitude is given by $v = f(\psi)\rho$ where ρ is the distance of the point from the straight or polar axis. The function ψ satisfies an equation of the form (when expressed in polar co-ordinates)

$$\frac{d^2\psi}{dr^2}+\frac{1}{r^2}\frac{d^2\psi}{d\theta^2}-\frac{\cot\theta}{r^2}\frac{d\psi}{d\theta}=\rho^2\mathrm{F}-f\frac{df}{d\psi},$$

where F and f are both functions of ψ. The case F uniform, and $f \propto \psi$ is treated more fully. If $f = \lambda\psi/a$ where a is the radius of the aggregate,

$$\psi = \mathrm{A}\left\{\mathrm{J}_2\left(\frac{\lambda r}{a}\right)-\frac{r^2}{a^2}\mathrm{J}(\lambda)\right\}\sin^2\theta.$$

The most striking and remarkable fact brought out is that as λ increases we get a periodic system of families of aggregates. The members of each family differ from one another in the number of layers and equatorial axes they possess. According to the number of independent axes they are called singlets, doublets, triplets, &c., in contradistinction to more or less fortuitous or arbitrary compounds of the former, which are considered later and called monads, dyads, triads, &c. Of these families two are investigated more in detail than the others, both because they are specially interesting in their properties and because they serve as limiting cases between the different series. In one family (the λ_2 family) all the members remain at rest in the surrounding fluid. In the other (the λ_1 family) a distinguishing feature, common to all the members, is that the stream lines and the vortex lines are coincident.

The parameter λ gives the total angular pitch of the stream lines on the outer current sheet, although in aggregates with more than one equatorial axis these lines are not one continuous line. The first aggregates—with $\lambda < 5{\cdot}7637$ (the first λ_2 value)—behave abnormally. Beyond these we get successive series, in one set of which the velocity of translation is in the same direction as the polar motion of the central nucleus, in the alternate set the velocity is opposite, and

the aggregate regredes in the fluid as compared with its central aggregate.

Suppose the attempt made to obtain sets of aggregates with greater and greater angular pitch. It will be found that as the external pitch of the stream lines increases the equatorial axis contracts and the surface velocity diminishes. On the outer layers (ring-shaped) the spiral pitch is chiefly produced on the inner side facing the polar axis until on the boundary itself the stream lines lie along meridians and the twist is altogether on the polar axis. The pitch can be increased up to a certain limit. As this is done the stream lines and the vortex lines fold up towards one another, coincide at a certain pitch, and exchange sides.

When an external angular pitch of about 330° is attained it is impossible to go further if a simple aggregate is desired. If a higher pitch is desired the aggregate splits into two concentric portions—an inner spherical portion and an outer shell. The central nucleus is similar to those just described—it produces a part of the required pitch.

The outer layer has spirals with the same direction of twist which complete the balance of the pitch. In these, however, the motion is in the opposite direction. With increasing pitch this layer becomes thicker and its equatorial axis contracts relatively to the mid point of the shell until another limit is reached ; the stream and vortex lines again fold together, cross, and expand as this second limit is reached. If a larger pitch still is desired there must be a third layer, and so on. The first coincidence of stream and vortex lines takes place for an aggregate whose pitch is 257° 27′. Whenever a maximum pitch is attained the aggregate is at rest in the fluid. This is first attained when the pitch is 330° 14′. Beyond this there are two equatorial axes. For a pitch 442° 37′ the stream and vortex lines again coincide, the internal nucleus gives 257° 27′ of the pitch, and the outer shell the remainder, and so on.

At the end of the paper a theory of compound aggregates is developed. It is not worked out in detail in the present communication, but the conditions are determined for dyad compounds, whilst a similar theory holds for triad and higher ones. Each element of a poly-ad may consist of singlets, doublets, &c. The equations of condition allow three quantities arbitrary—as for instance ratio of volumes, ratio of primary cyclic constants, and ratio of secondary cyclic constants. The full development of this theory is, however, left for a future communication.

If we take any particular spherical aggregate with given λ and primary cyclic constant μ, the energy is determinate. We may, however, alter the energy. If it be increased the spherical form begins to open out into a ring form whose shape and properties have

not yet been investigated. If the energy be increased sufficiently the aperture becomes large compared with the thickness of the core and approximate calculation is applicable. The differential equation for ψ in terms of toroidal co-ordinates is given, but the full development is left for a future occasion.

In the paper itself the problem is treated purely as a question of hydrodynamics, and the results simply as the properties of certain possible fluid motions. It may not, however, be out of place here to offer a few remarks, of a more speculative kind, on the bearing of the results on physical theories.

In the first place, gyrostatic motion of the kind here considered is not confined to aggregates, which are symmetrical about an axis. Although the theory is very complicated, it is easy to see that they must exist. In the address to Section A, at the Ipswich meeting of the British Association, a vortex cell theory of the ether was indicated. The ether consisted of closely packed elements, each element being a vortex aggregate. To fix ideas, the case of elements of the shape of a rectangular box was taken, although this particular shape is not essential. The vortical motion there considered was not gyrostatic, but it is clear that a gyrostatic modification is possible. The primary rotations must be arranged in opposite directions in alternate cells. This is, however, not necessarily the case with the secondary gyrostatic motion. They may either be or not be in the same direction, although conditions of stability might decide this question. If the common direction is not a necessity, it is easy to conceive that certain operations on boundaries immersed in the ether might make them so, and in this way produce the same effect as vortex filaments stretching between them. Such a theory would not necessitate return vortex filaments such as are required in any theory which attempts to explain electrical actions by such filaments. It is very conceivable that they would produce the stresses along and perpendicular to tubes of force which are required in an electric field. If a cell, such as that of the λ_2 aggregates in this paper, were possible, the necessity that the primary rotations should be alternately directed would not exist, at least so far as continuity of motion had to decide.

In the second place, does the new theory throw any light on a vortex atom theory of matter? In this respect two remarks should be made. The first is, that if vortex atoms are realities the exact quantitative theory developed in this paper cannot accord with actual facts, because it is developed with reference to a surrounding irrotational ether, which cannot be the case in nature. Nevertheless, many of the general properties would doubtless be similar, and possibly the same for aggregates of the λ_2 family.

The second remark is, that the results of the paper refer only to

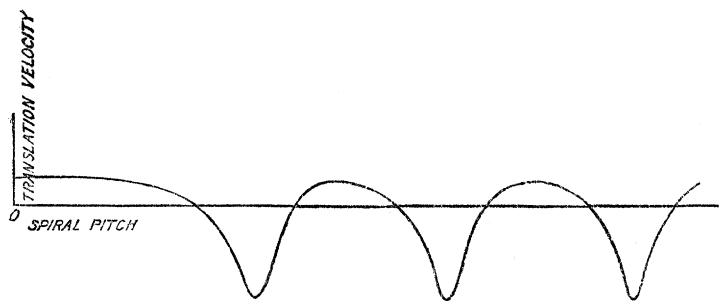
spherical aggregates, that is, all the various elements are compared, not when their energies are in thermal equilibrium, but in the artificial association such that the energy of each particular element is that which is necessary to give it a spherical shape. Nevertheless, it is possible to get general ideas. The most striking one is the fact of the periodic property of the atoms. The J_2 curve, for instance, or the curve in the figure which shows how the translation velocity alters with increasing pitch of spiral, irresistibly suggests curves connected with the physical properties of the elements. The abnormal commencement, the regular ascending and descending series suggest the connection at once, and open a vista of possibilities before unsuspected. For the reasons mentioned above, it would be waste of time to look as yet for any definite information. Before that can be done we must know more about the conditions of stability, and the behaviour of such aggregates when their energy changes. It is hardly fitting perhaps to indulge in wild speculations in these pages. In doing so, however, I hope they will be taken for what they are intended, merely as vague intimations of possibilities.

Let us then take the well known curve showing how the fusibilities of the elements alter periodically with the atomic weights.

In a solid body the atoms or molecules can have very little translatory motion. They will therefore take such forms, or their energy will be such as to make this translation small. Now take a spherical aggregate. If it has a large translation velocity its energy must be diminished to render this less—it will take a more elongated form with a small velocity of translation. In order, therefore, to fuse the substance more energy must be put into it. Its temperature of fusion is higher. In other words, it is natural to suppose that those atoms, which when in the spherical form have a high velocity, will possess high fusing points, and so on. Without criticising this argument too closely, let us make the assumption that it is so, and see what it leads to.

Now look at the figure which gives the relation between the velocity of translation (ordinates) to the spiral pitch (abscissæ). We are at once struck with the fact that we have aggregates with large maximum velocity followed with sets of small maximum velocity (in the opposite direction). This is one of the most remarkable features of the fusibility curve. Suppose that the curves march together: this supposition enables us to locate roughly the regions in which the elements lie, omitting the early ones as abnormal. If this be done we find the metals lie on the lower peaked parts and the non-metals on the small flat portions above the line of abscissæ. The following results follow:—

The metals belong to aggregates having an even number of layers or axes, i.e., *the outer rotational motion is opposite to that at the centre.*



The non-metals belong to aggregates having an odd number of the same, i.e., *the outer rotational motion is in the same direction as that at the centre.*

In the even series of elements (Series 4, 6, 8) the vortex lines lie between the stream lines and the meridians or, as we may express it, the stream lines lie farthest out.

In the metals of the odd series the stream lines lie between the vortex lines and meridians, or the vortex lines are the outermost.

In the non-metals of the odd series the vortex lines lie between the stream lines and the meridians, or the stream lines outermost.

The metals of high fusibility have their stream and vortex lines nearly co-incident. The alkalis have their outer layer thin, the calcium group thicker, and so on.

Having fixed their general position, we may now compare with the curve giving the atomic volumes. When this is done it is found that the atomic volume marches with the moment of angular momentum of the aggregates. In other words—

The moment of momentum due to the gyrostatic effect rises and falls with the volume of the atom.

All that is yet known respecting the stability of vortex rings leads to the conviction that it is not open to us to explain the various densities of matter as we know it by different densities in the material composing the vortex atoms themselves. We must suppose the matter of all atoms to be the same material as the ether itself. The masses must therefore be proportional to the volumes. It follows that atomic volumes, as ordinarily understood, must depend on the spaces occupied in solid bodies by their atoms. Now a ring will clearly take up more space than a sphere of the same volume, and we ought to expect high atomic volumes to go with large aperture rings. Combining this with the last result, it would follow that—

Moment of momentum rises and falls with the equatorial diameter of the ring atom,

which is a highly probable result.

In the present state of the theory, no object is to be gained in pursuing these analogies further. They serve, however, to show directions in which further investigation is to be carried out.

It is clear that if a magnetic field is capable of orienting these aggregates, then a substance composed of them will rotate the plane of polarisation of light.

"The Pharmacology of Aconitine, Diacetylaconitine, Benzaconine and Aconine considered in Relation to their Chemical Constitution." By J. Theodore Cash, M.D., F.R.S., and Wyndham R. Dunstan, M.A., F.R.S. Received January 13,—Read February 3, 1898.

(Abstract.)

The investigation which is described in the present paper has been carried out with pure specimens of the alkaloids aconitine, aconine, and benzaconine, the chemistry of which has been fully studied since 1891, by one of us in conjunction with his assistants and pupils, and forms the subject of numerous papers which have been communicated to the Chemical Society, and printed in the 'Journal of the Chemical Society.'* As these papers contain a full account of the chemical composition and properties of the various aconite alkaloids, it will not be necessary to do more now than summarise for reference the chief properties of the substances employed in this enquiry.

Aconitine is the poisonous alkaloid contained in *Aconitum napellus.*† Commercial specimens of aconitine vary considerably, many of them being mixtures.‡ Until quite recently the pure alkaloid was not an article of commerce. It is a crystalline base, very sparingly soluble in water, but readily dissolved by alcohol. Its alcoholic solution is dextro-rotatory, whilst solutions of its salts are lævo-rotatory.§ Even very dilute solutions produce a characteristic tingling and numbness on the tongue and lips. The alkaloid suffers decomposition when heated to its melting point; a molecular proportion of acetic acid is lost, and an alkaloid *pyraconitine* remains.‖ The hydrolysis of the alkaloid occurs in two stages. In the first, which is best effected by heating a salt of aconitine in a closed tube with water,¶ a molecular proportion of acetic acid is formed, and an

* 'Chem. Soc. Journ.,' 1891—1897.

† Dunstan and Ince, 'Chem. Soc. Journ.,' 1891, vol. 59, p. 271; Dunstan and Umney, *ibid.*, 1892, vol. 61, p. 385.

‡ Dunstan and Carr, 'Chem. Soc. Journ.,' 1893, vol. 63, p. 491.

§ Dunstan and Ince, *loc. cit.*

‖ Dunstan and Carr, *ibid.*, 1894, vol. 65, p. 176.

¶ Dunstan and Carr, *ibid.*, vol. 65, p. 290.