"the greater part of these interesting and valuable plants has been destroyed by rain leaking through the roof of the library buildings into the room where they are kept, and by the ravages of moths, &c. In a short time the herbarium will be simply nothing but a mass of uninteresting fragments. We understand that some time back the Parliament voted a small sum to be expended in putting the herbarium into order. How far anything could possibly have been done by those in charge may be learned from the fact that Dr. Rehman, the Austrian botanist, found whole fasiculi destroyed."

SPONGY IRON FILTERS

IN a paper presented by Prof. Frankland, F.R.S., and read before the Royal Society, Mr. Gustav Bischof describes numerous experiments made with spongy iron filters and with charcoal filters. He states that chemical analysis is incapable of discriminating between living or dead, fresh or putrescent organic matters. The microscope reveals their nature more fully; but it is nevertheless frequently a matter of great difficulty to decide as to the existence or non-existence of *Bacteria* of putrefaction, or their germs, in water.

We must refer our readers to the paper for a full account of the experiments and the conditions under which they were performed. Mr. Bischof states that they show that *Bacteria* present in drinking water are *not* killed in passing through charcoal and are killed in passing through spongy iron.

He adds: "I believe that the action of spongy iron on organic matters largely consists in a reduction of ferric hydrate by organic impurities in water. We know that even such organic matters as straw or branches are capable of reducing ferric to ferrous hydrate. We know that even such indestructible organic matter as linen and cotton fibres are gradually destroyed by rust stains. This action is slow when experimenting upon ordinary ferric hydrate, but it may, *in statu nascendi*, be very energetic, the more so if we consider the nature of the organic matter in water. Ferric hydrate is always formed in the upper part of a layer of spongy iron, when water is passed through that material. The ferrous hydrate resulting from the reduction by organic matter may be re-oxidised by oxygen dissolved in the water, and thus the two reactions repeat themselves. This would explain why the action of spongy iron continues so long.

"It is, however, quite certain that there is also a reducing action taking place when ordinary water is passed through spongy iron. This is clearly indicated by the reduction of nitrates.

"Our knowledge of those low organisms, which are believed to be the cause of certain epidemics, is as yet too limited to allow of direct experiments upon them. It is not improbable that, like the *Bacteria* of putrefaction, they are rendered harmless when water containing them passes through spongy iron; but until we possess the means of isolating these organisms, this question can only be definitively settled by practical experience."

CENTROIDS AND THEIR APPLICATION TO SOME MECHANICAL PROBLEMS[1]

THE principal object of the following paper is to suggest the use of a more general form than is commonly employed in the statement of some of the more important theorems of elementary mechanics. Such a generalisation, if in itself satisfactory, has two-fold advantages; it both facilitates the direct solution of problems otherwise apparently complex, and it enables a common method to be employed in an infinite variety of cases, each of which otherwise has to be treated in its own special way. The methods to be described are purely geometric, and admit in all cases of graphic solutions. In the study of mechanism and in all applications of mechanics to engineering work this is a matter of considerable importance, for graphic methods have such enormous advantages in these cases that they must supplant all others when they give equally good results.

By the centroid of any body A relatively to another B is meant *the locus of the instantaneous centres of A in its motion relatively to B*.[2] The expression includes two things, which must be distinguished from each other;—(i.) the locus as part of the moving body A, (ii.) the locus as part of the body B relatively to which A's motion is observed, and which may for convenience be regarded as fixed. These loci may be entirely different as to form, but in all their properties they are absolutely similar and reciprocal. It would therefore be wrong to give them different names, they can be distinguished, when necessary, as the centroid *of a body*, and the centroid *for the motion of a body* respectively. The centroid of A is therefore the locus *upon* A of its inst. centres relatively to B; the centroid for the motion of A is the locus *upon* B of the same centres.

The following are the most important characteristics of these curves. As the bodies to which they belong move the centroids roll upon each other, and every point in each becomes in turn the inst. centre. Their rolling, therefore, represents continuously the whole motion of the bodies (considered as changes of position merely), quite irrespective of their form; in other words it defines the path of motion of all points in the bodies. The two centroids have always one point in common—their point of contact—this point being the instantaneous centre. This point may be included in both bodies, and has no motion relatively to either. Any motion which it has must therefore be common to both, so that it may be entirely neglected in investigating their relative motions. In problems affecting the motion of either body relatively to a third this is often of much use.

For the sake of definiteness it has been presupposed in the foregoing paragraphs that the motions referred to were conplane, or, more generally, took place about some fixed point. When the motion is conplane this point is at infinity, and the centroids are plane curves, sections of the cylindric ruled surfaces formed by the successive positions of the instantaneous axes. When the distance of the point is finite, the centroids are, of course, spheric curves, the instantaneous axes forming cones of which the point mentioned is the vertex. These theorems were given by Poinsot in his "Théorie Nouvelle de la Rotation des Corps." It may be interesting just to mention also the case of general motion in space, where (as Belanger seems first to have pointed out), the solids of instantaneous axes, or *axoids*, as Reuleaux calls them—are general ruled surfaces twisting on each other. Each generator of the surface is a "screw," and on each in turn a twist occurs. The surfaces are in general non-developable.

For the sake of brevity, only conplane motions will be considered in this paper. This class of motions includes nine-tenths of those occurring in mechanism. Two or three special cases of frequent occurrence may first be mentioned. If the relative motion of two bodies be a simple rotation, the centroids are a pair of coincident points, one of which must still be considered to roll on the other. The instantaneous centre here becomes a permanent centre. It is convenient, however, to treat the point not only as a permanent centre, but as a special (limiting) case of the centroid. If all points in a body move in parallel straight lines, the centroid for the motion of the body is a point at infinity, and the centroid of the body is also a point at infinity coincident with the former. If the path of the body were infinitely long, the two points would roll round each other. If, on the other hand, a body move parallel to itself, every point in the centroid for its motion (and therefore all points in its own centroid) must be at infinity. The two centroids must again be coincident, so that the motion is represented by the line at infinity rolling on itself.[1]

Proceeding now to notice the bearing of the theory of centroids upon some of the theorems of elementary mechanics, these may be taken in order of simplicity, commencing with those which involve only the notion of change of position. If, then, the line joining any moving point with the point of contact of its centroids be called its instantaneous radius, we can state the general theorem thus: *The direction of motion of every point in a body is normal to its instantaneous radius.* While this obviously includes the simpler special cases already examined, its form allows of direct application to the most general cases, and especially to all cases in mechanism. Two corollaries out of many which are deducible from it may be mentioned as of some special interest: (i.) The inst. radii of a point moving in a straight line are parallel; and (ii.) the inst. radii of a point moving in a circle must pass through one point. In either case the centroids may be quite general curves, as is easily seen. These corollaries have important practical applications in me-

[1] Abstract of a paper read before Section A of the British Association at Glasgow, by Prof. Alex. B. W. Kennedy, C.E., of University College, London.

[2] The word *centroid* was suggested to the author by his colleague, Prof. W. K. Clifford.

[1] Some physical conception of this case can easily be obtained by rolling one hyperbola upon another. The change in the appearance of the rolling as the point of contact recedes along either branch is very striking.

chanism, especially in "parallel motions," both real and approximate.

The familiar theorem that *the relative velocities of points in any body vary as their instantaneous radii* needs merely to be mentioned. It is to be regretted that it is not more generally used, for while it does not increase the difficulty of comprehending simple cases, it is of enormous advantage in simplifying such (apparently) complex ones as not unfrequently occur in mechanism.

The expression for static equilibrium is also tolerably familiar:—*the sum of the moments of all the forces acting upon a body about its inst. centre must* = 0. For practical purposes, however, it is generally more convenient to state the proposition:—*the resultant of all the forces acting upon a body must pass through the point of contact of its centroids.* The application of this proposition to all the simpler cases is self-evident, and at the same time it reduces complex cases to their smallest possible dimensions, rendering most very easy, and in many cases greatly aiding the comprehension of the alterations in conditions of equilibrium corresponding to consecutive alterations in the positions of mechanisms as their links move. It may just be noted that as the two forces of a couple have for their resultant a force (infinitely small) acting along the line at infinity, the proposition gives at once that where the inst. centre of a body is at infinity it is in equilibrio under any number of couples of any magnitude. In the case of a body moving parallel to itself, therefore (see *ante*) all couples may be neglected so far as its static equilibrium is concerned, whatever their magnitude or sense.

The following are, in conclusion, a few of the kinetic propositions the solution of which is greatly aided by the use of centroids:—

(I.) If a force[1] constant in direction and position act upon a body, then (i.) if it cut the centroid for the motion of the body in one or more points motion will take place until the first of these becomes the point of contact, and will then cease; (ii.) if it pass entirely without this centroid, there will be continuous motion. As corollaries to (i) may be mentioned (*a*), if the centroid for the motion of a body be a curve of the 2nd, 3rd . . . *n*th order, the body has a maximum of 2, 3 . . . *n* positions of equilibrium under some one or more forces constant in direction and position. Also (*b*), if a body have not more than a single position of equilibrium under any such force, the centroid for its motion must be a straight line.

(II.) If the position of a force relatively to the body upon which it acts remain constant, then (i.) if it cut the centroid of the body in one or more points, motion will take place until one of these becomes the point of contact, (ii.) if it lie entirely without the centroid of the body, there will be continuous motion. This gives corollaries as to positions of equilibrium similar to those just stated.

(III.) If a force constant in direction act always at the same point of a body, motion will continue until the instantaneous radius of the point becomes parallel to the direction of the force. There is here no case of continual motion; the theorems as to number, &c., of positions of equilibrium are similar to those given above.

English writers have used these curves very little. Among modern continental writers who have employed them may be mentioned Dwelshauvers-Dery (Liége) who uses them in his "Cinématique" for questions relating to relative velocities; Schell (Carlsruhe) in his "Theorie der Bewegung u. d. Kräfte; Reuleaux ("Theoretische Kinematik," and elsewhere), who gave them the name (*Polbahnen*), by which they are known in Germany, and who has used them ably and extensively for kinematic problems; and lastly Pröll, who has made use of them in his recent "Versuch einer graphischen Dynamik." The writer has not, however, found them anywhere unreservedly adopted, and has, therefore, made this attempt to show how easily centroidal methods adapt themselves to the general treatment of mechanical problems, especially those connected with mechanism, and at the same time how well suited they appear to be for educational purposes.

[1] Or here, and in the following propositions, the resultant of any number of forces.

OUR ASTRONOMICAL COLUMN

THE TOTAL SOLAR ECLIPSE OF 1882, MAY 17.—Hallaschka, in his "Elementa Eclipsium," describes this eclipse as broadly total, whereas, it will be, in reality, total, though the zone of totality will not be a broad one. An error in the moon's semidiameter led to the statement in Hallaschka's work. The following elements of this eclipse, calculated upon the same system that has been applied in the examination of other solar eclipses in this column, will probably be near the truth:—

Conjunction in R.A., May 16, at 19h. 41m. 11·7s. G.M.T.

	° ′ ″
R.A.	53 56 35·4
Moon's hourly motion in R.A. ...	36 14·5
Sun's „ „ „ ...	2 28·7
Moon's declination	19 38 46·4 N.
Sun's „	19 19 38·8 N.
Moon's hourly motion in decl. ...	4 56·0 N.
Sun's „ „ „ ...	0 33·8 N.
Moon's horizontal parallax	58 15·1
Sun's „ „	8·8
Moon's true semi-diameter	15 52·4
Sun's „ „	15 48·8

The central and total eclipse begins at 17h. 53·8m. in longitude 3° 11′ W., and latitude 10° 40′ N.; it occurs with the sun on the meridian in 63° 44′ E., and 38° 35′ N., and ends at 21h. 18·8m. in 138° 51′ E., and 25° 25′ N. The following are points upon the central line in that portion of its track where observations are most likely to be made:—

Long.	Lat.	Sun's Zenith dist.	Long.	Lat.	Sun's Zenith dist.
° ′	° ′	°	° ′	°	
29 49 E.	25 36 N.	49·9	51 27 E.	35 30 N.	23·7
34 5	27 48	44·1	54 58	36 38	21·2
36 3	28 47	41·5	68 48	39 31	21·2
41 33	31 27	34·4	77 23 E.	40 2 N.	26·7
48 20 E.	34 21 N.	26·7			

The central line therefore commences in the west of Africa, and traversing that continent in the direction of Upper Egypt, it passes over the Nile below Thebes, thence over the extremity of the peninsula of Sinai, near Ras Muhammed, and almost directly over Hillah, the site of the ruins of Babylon, to Teheran. The position of this capital according to Gen. Stebitzky (*Astron. Nach.*, No. 2,113) is in longitude 3h. 25m. 41·7s. E. of Greenwich, and latitude 35° 41′ 7″, this point referring to the station of the Indo-European telegraph; so that the central line of shadow according to our elements passes sixteen miles to the south of it. Calculating directly for this longitude we have the following results:—

	h. m. s.	
Totality begins May 16 at	22 36 29	local M.T.
„ ends „	22 38 13	local M.T.
Duration	1 44	

The sun at an altitude of 67°. So that the greatest duration of totality in this eclipse about 12° east of Teheran is about 1m. 46s.

The central line subsequently traverses China, passing off at or close to Shanghai, at which place a total eclipse of short duration may be observed.

The next total solar eclipse on July 29, 1878, which crosses the United States is pretty fully noticed in the various Ephemerides, though in due time the American astronomers will no doubt provide a chart showing on a larger scale the breadth and position of the zone of totality over their country. Then follows the total eclipse of January 11, 1880, in which the track of the central line lies almost wholly upon the Pacific, the total phase being visible for a brief duration only near the coast of California, above San Francisco. The total eclipse of May, 1882, of which the elements are here given is the next in order of date.

THE COMETS OF 1402.—It is singular, considering the attention which the Chinese paid to the observation of comets, their annals containing reference to several hundreds of these bodies, should not have recorded the appearance of the two evidently great comets of 1402. In particular is this the case with the first comet, which, according to the descriptions in the European