thought to the expert who devises it, it may demand such a mental strain of the general chemical reader as to defeat a main purpose for which it was planned, namely, the communication of knowledge. I would quote, both with regard to chemical symbolism and to chemical nomenclature, the words used by a character of Henry James concerning literature, "The observer is nothing without his categories, his types and varieties. . . . That's for his own convenience; he has privately a terminology to meet it. . . . But from the moment it's for the convenience of others, the

signs have to be grosser, the shades begin to go. . . . Literature, you see, is for the convenience of others. It requires the most abject concessions." Scientific literature is, above all, for the enlightenment and convenience of others, and scientific specialists must be prepared to make concessions to their weaker or less expert brethren. But whether the symbols we use are simple or complicated, we should always be clear as to their true significance, and be on our guard against their distracting our thoughts from the realities which they partly reveal and partly obscure.

Recent Contributions to Aviation Problems.

By Prof. G. H. BRYAN, F.R.S.

THE attempts which have hitherto been made to explain the continuous sustentation of tropical and other birds without the performance of muscular work have left many doubtful points requiring to be cleared up. Observers have frequently sought to attribute the phenomena to something acting in violation of the principles of elementary mechanics, and have succeeded in establishing this peculiarity, not perhaps in the way that they intended, but by the chaotic way in which such terms as force, momentum, weight, energy, lift, pull, drag, and gravity are confused by them, and occur indiscriminately mixed up in their writings. In a paper on "Meteorology and the Non-Flapping Flight of Tropical Birds," published in the Proceedings of the Cambridge Philosophical Society, xxi. 4, Dr. Gilbert T. Walker has now sought to bring sound scientific principles to bear on the numerous observations in India published by Dr. Hankin. From observations of the temperature of the air at Agra at different altitudes and hours of the day, Dr. Walker finds conditions of instability leading to the formation of strong ascending air-currents, and observations in Egypt and various parts of India indicate conditions of "bumpiness" in the atmosphere caused by ascending currents, covering the periods employed by birds for "soaring."

Dr. Walker finds that the angle of gliding of the most efficient recent aeroplanes is sufficiently low to satisfy the conditions necessary for continuous sustentation in the presence of these currents, and he examines in detail three possible sources of internal work in the atmosphere, namely, ascending currents, variations of horizontal velocity as functions of time and place co-ordinates, and Lord Rayleigh's hypothesis of variation of horizontal wind velocity as a function of the vertical altitude co-ordinate. He also carefully considers the structure of the birds' wings, in comparison with those of the Handley-Page machine, and the effect of the flexibility of the quills on the aerofoil form in ascending and descending glides. Both from theory and from actual observation, it is found that the ascending air-currents in the higher regions of the atmosphere are greater in diameter than lower down, and from actual observation he contradicts Dr. Hankin's statements according to which birds are seen rising in descending currents. It would thus appear from Dr. Walker's observations that, in the region dealt with by Dr. Hankin, the atmosphere possesses sufficient internal energy to satisfy the conditions of "soarability" required by the latter observer. In

regard to the violation of mechanical principles, both hypothetically by birds and actually by writers, we cannot do better than quote Dr. Walker's remark that . . . "it is strangely" (asterisk and footnote with references follow) "necessary to insist that it is as impossible to derive energy from a wind that is constant in time and space as it is from a perfect calm." To theories based on a denial of this principle the late Sir Hiram Maxim used to point out the enormous velocity of the wind due to the earth's rotation and its orbital motion about the sun, and he suggested that if writers believed in these theories, why did not they utilise this energy for the purposes of flight?

The recent records of gliding flight in the daily press afford ample confirmation of Dr. Walker's theories in regard to the quantity of *available* internal energy present in the atmosphere. When we read of aviators remaining for hours in the air under climatic conditions not widely different from those prevailing in Dr. Hankin's and Dr. Walker's investigations, and of 7 horsepower engines making long flights at a cost for fuel of not more than a penny a mile, we have reasonable prospects of realising a system of cheap transport largely superseding the use of wheels bumping over stony roads or iron bars placed end to end.

Apart, however, from the precariousness of the distribution of the necessary internal energy in space and time, a motorless aeroplane is in constant danger of being suddenly brought to rest relative to the air, or, more accurately, losing all headway, at which instant it has a vertical acceleration due to gravity, and the resistance to rotation (pitching, yawing, rolling) becomes technically describable as "a small quantity of the second order," thus approximating to the conditions assumed in the problem of rigid body rotation under no forces.

We are constantly reading of accidents which seem to suggest that they have arisen from this condition of affairs, even in the case of motor-driven machines which are at least equipped with a more adequate means of extricating themselves from this eventuality.

No system of aviation will ever be satisfactory, however, until backed up by a more thorough solution than we now have of the equations of motion of the "perfect aeroplane." Perfect fluids, perfect conductors and dielectrics, perfectly smooth bodies, perfect gases, and so on, are very familiar terms, but the "perfect aeroplane" has not yet figured in literature as such, though various formal representations have been

proposed for it from the time of Lanchester's phugoid system down to the systems of Brodetsky and the present writer. These last systems reduce the study of the perfect aeroplane to the solution of a system of assumed and stated equations, in fact a problem in pure mathematics only.

If the conditions necessary for steady motion (under forces in equilibrium) and inherent stability are satisfied, an aeroplane will tend to assume a state of steady motion provided that the initial conditions represent a sufficiently small displacement from the steady state. But under widely different initial conditions it may tend to assume an altogether different motion, and, for example, it may sooner or later lose headway or crash to the ground, pitching over and over. We are thus led to considerations of *superstability*, an inherently *super-stable* aeroplane being defined as one which, like a non-capsizing lifeboat, will tend to assume a state of steady motion whatever be the initial conditions of projection; failing that, to investigate the limits of superstability; in other words, the limiting initial conditions under which the machine tends towards instead of away from steady motion. It is clear that such an investigation will involve the search for periodic solutions of the equations of motion which, though difficult, should not be harder than many problems on which pure mathematicians have set their faces. In condition with lateral displacements a spiral gliding motion would represent one limit of superstability, but there are probably others which may or may not occur in practical applications. At present Dr. Brodetsky appears to be the only applied mathematician who has really made substantial advances tending in this direction.

It seems rather probable that further developments will involve the solution of integral equations.

Possible future applications to the location of aircraft are suggested by a paper by Dr. A. B. Wood and Capt. H. E. Brown on "A Radio-acoustic Method of locating Positions at Sea," read before the Physical Society on March 9, and the discussion thereon, in which Capt. Fowler, Major Tucker, and others took part. In this method a wireless signal is made at the same instant that a charge is fired into the sea, and the times of arrival of both signals are recorded at land stations, thus determining the distance of the ships from them. The method is obviously applicable to the sound ranging of aircraft in commercial aviation, but, as Mr. Smith remarked in the discussion, the captain of a vessel would certainly need to make the observations himself, and, up to the present, experiments on detection of acoustic signals, and especially echoes of sound signals, by means of apparatus carried on aircraft, have not been so successful as could have been wished. It is to be hoped, however, that experimental work on this subject will be continued, as the means hitherto at our disposal for location of aircraft leave much to be desired, especially if cross-country flights are to be effected at any considerable distances from the main air routes.

The possibilities of employing helium in airships are discussed by Capt. G. Arthur Crocco in the *Atti dei Lincei*, xxxii. (1) 2, 3. It is estimated that from the natural gas wells in the United States a supply of three million cubic metres per annum is obtainable, and

taking twenty years as the life of a well, the cost works out at two dollars per cubic metre. This supply would not be sufficient to replenish the consumption of more than one airship in active continuous service on long-distance traffic under existing conditions, and Crocco considers in detail the different causes of loss and the means of reducing them within practicable limits. The author separates the consumption of gas into three categories, which he describes as "consumption of navigation," "osmotic diffusion," and "washing of the gas" necessitated by loss of purity, and due to endosmotic entry of air into the envelope accompanying the exosmotic diffusion of the helium. The annual losses of gas due to these three causes are in the ratio of 100, 10, 1, and it is estimated that if the first could be eliminated the annual loss of gas by an airship could be reduced to 20 per cent. of the total volume, and that a large fleet of commercial airships could be maintained in continuous working at a reasonable cost.

The "consumption of navigation" represents the amount of gas let out to compensate for the loss of weight of the fuel, and, as pointed out, this assumes serious dimensions in long-distance journeys where excessive buoyancy cannot be overcome by lowering the elevators. The necessity for this discharge of gas can be obviated in two ways, namely, by condensing the water in the products of combustion and by "thermic sustentation," and in his second paper Crocco examines the former method. It is estimated that 1000 grams of fuel contain 150 grams of hydrogen, which, combining with the oxygen of the air, give 1350 grams of water, so that by condensing this the gain of oxygen can be made to compensate for losses in other directions. The necessary superpressure to effect this condensation can be secured by means either of causing a back pressure in the motor or by separate compression. The paper contains formulæ and calculations of the amount of the superpressure required to effect the necessary condensation, and this of course is a function of the degree of saturation of the atmosphere. It is found that this only reaches a serious amount in the case of very hot and dry weather, such as in average climates only occurs on a few days in the year. Remembering that only 1000 grams out of 1350 have to be condensed, the author finds that the loss of power required for the purpose is not sufficient to interfere with the practical application of the method when the effects occurring exceptionally are reduced to annual percentages.

In a paper communicated through Prof. Levi Civita to the *Atti dei Lincei*, xxxi. (2) 1-2, Dr. E. Pistolesi employs moving axes to formulate the differential equations of motion of a fluid in the field of velocity produced by a screw propeller. In this way the problem is reduced to one of steady motion. The method is closely similar to one adopted many years ago in connexion with problems on the small oscillations of gravitating rotating fluids, with the difference that in applications of approximate methods the velocity components relative to the airscrew will not be small, but in certain cases it may be possible to regard as small the components relative to fixed axes set up by the motion of the screw.

Another hydrodynamical line of investigation which has recently come into prominence in connexion with the effects of skin friction on the resistances of aircraft

is the theory of viscosity. This forms the subject of two papers in the *Atti dei Lincei*, xxxii. (1) 1, 2, by Dr. Umberto Cisotti, also communicated by Prof. Levi Civita, the first dealing with motion in canals and the second with damped waves.

The object of the present article has been to direct

attention to papers published elsewhere than in the technical journals and periodicals, such as those of the Royal Aeronautical Society, the Aeronautical Research Committee, or the Institution of Aeronautical Engineers, all of which are replete with results of other important and valuable investigations.

Obituary.

CANON W. W. FOWLER.

CANON WILLIAM WEEKES FOWLER, Vicar of Earley, Reading, died on Sunday, June 3, at seventy-four years of age. He was suddenly taken ill in the vestry before the service, and died soon after service began. Having always been a man of untiring energy, we feel sure that he would have preferred to die in harness rather than to have endured any long illness.

Canon Fowler was the son of the Rev. Hugh Fowler, Vicar of Barnwood, Glos, and was born in January 1849. He was educated at Rugby, where he gained a scholarship for Jesus College, Oxford. He took a first in Classical Moderations, and a third in Lit. Hum.; he was ordained, and became a house master at Repton in 1873. In 1880 he was elected head-master of Lincoln School, where he remained for more than twenty years. Bishop King appointed him Canon of Welton Brinkhall in Lincoln Cathedral. He was Rector of Rotherfield Peppard, Oxon, in 1901-1904. In 1905 he became Vicar of Earley, in the gift of the Vicar of Sonning. In 1907 he was president of the Head-masters' Association, and for many years was an energetic member of the Reading Guardians.

Canon Fowler was best known in scientific circles as an entomologist, being a sub-editor of the *Entomologists' Monthly Magazine* from 1885 until the day of his death. He was secretary of the Entomological Society of London in 1886-1896, president in 1901 and 1902, and vice-president in 1903. He was a member of the Science Committee of the Royal Horticultural Society, and in 1906-1907 was a vice-president of the Linnean Society.

Besides writing numerous notes and articles on Coleoptera, Heteroptera, etc., in the scientific magazines, Canon Fowler's chief works were the volumes on Coleoptera for the "Fauna of British India," including the General Introduction, the Cicindelidæ and Pausidæ, published in 1912; the volumes on Hemiptera-Homoptera, with W. L. Distant, in the "Biologia Centrali-Americana," published in 1887-1909; a "Catalogue of British Coleoptera," with Dr. Sharp in 1893, and with Rev. A. Matthews in 1883; the "Coleoptera of the British Isles" in five volumes, published in 1887-1891, and a sixth supplementary volume, with Mr. H. St. J. K. Donisthorpe, published in 1913. He also published a number of text-books on the classics, etc., for use in schools.

Canon Fowler was a very broad-minded man, generous and unselfish, and was much beloved by all who knew him. He was always ready to help younger men with advice and entomological specimens, etc., and his death leaves a blank in the ranks of the older entomologists which will not easily be filled.

HORACE DONISTHORPE.

DR. HANS GOLDSCHMIDT.

THE inventor of the Goldschmidt thermite process, Dr. Hans Goldschmidt, died after a short illness on May 21, in Baden-Baden.

Hans Goldschmidt was born on January 18, 1861, in Berlin, where his father, in 1847, founded the chemical works of Th. Goldschmidt, of which he was the director until his death in 1873. Hans Goldschmidt studied chemistry at Leipzig, Berlin, Strasbourg and Heidelberg, where he graduated in 1886 under Robert Bunsen. After this he continued his studies in electro-chemistry and travelled in foreign countries; this widened his views on economic questions. In the year 1888 he entered, as a partner, the works of his father, in which his brother, Karl Goldschmidt, had taken the lead since 1882.

Goldschmidt's first technical achievement was the invention of an electro-chemical process for recovering the tin from white iron waste, which has found wide application in many countries. His name became famous in the year 1894, when he succeeded in reducing oxides by combustion with powdered aluminium, and by the tremendous heat of this reaction, metals of a high melting-point, such as chromium, vanadium, molybdenum, tungsten, and their alloys with iron and other metals, melt and can be produced in a pure state. As a by-product, corundum is formed, which can be technically utilised for grinding purposes. The thermite process found an even larger application by the use of mixtures of aluminium metal with iron oxide for welding together the ends of rails of tramways and for repairing broken machinery, especially of ships. Hans Goldschmidt also discovered a process for avoiding the formation of holes in iron castings and for improving steel castings by the addition of aluminium.

Hans Goldschmidt was one of the founders of the Bunsen Society for Applied Physical Chemistry, and was for many years its president. He was awarded the Elliot-Cresson-medal of the Franklin Institute. His high scientific standing and good nature will ensure for him a place in the history of technical chemistry and in the memories of his numerous friends both in and out of Germany.

WE regret to announce the following deaths:

Prof. Heinrich Boruttau, a director of the Friedrichshain Hospital, Berlin, whose work was especially concerned with the relations of physics to medicine. He also worked on physiological chemistry and problems of nutrition. He died on May 15, aged fifty-four.

Dr. W. d'E. Emery, formerly director of laboratories and lecturer on pathology and bacteriology to King's College Hospital, on June 19.

Mr. E. J. Steegmann, for many years secretary to the Royal Commission on Human and Bovine Tuberculosis, on June 8, aged fifty-five.