its node and inclination. This puts the zodiacal light out of court, even if its mass were sufficient, which seems unlikely. Prof. Asaph Hall suggested that the law of attraction should be modified, the index of r being taken, not as -2 , but as $-2(1+d)$, where d is a small fraction, chosen empirically so as to fit the case of Mercury. This is the law adopted in Newcomb's tables, and therefore in the Nautical Almanac. It would give a centennial shift of the moon's perigee of $135''$. (The discussion of Dr. E. W. Brown seems to establish that there is no such excess of motion in the perigee, which discredits the Hall hypothesis.)

Einstein's theory perfectly explained the excess of motion of Mercury's perihelion, without introducing any arbitrary constant, or having any other perceptible effect on the planetary or lunar motions. By the method of exhaustion it seemed to hold the field. There remained a small excess of motion in the case of the node of Venus, but it was only $2\frac{1}{2}$ times the probable error, and so was not unreasonable.

Prof. A. Fowler spoke on the attempts that had been made to detect the shift towards the red in the sun's spectral lines, and on the difficulties in the way, which arose from the effect of varying pressure, the rotation of the sun, and possible convection currents in its atmosphere. A series of cyanogen lines was selected for the test, as they were not subject to shift through pressure; care was necessary to choose isolated lines, as adjacent lines might influence the measures. The sun's rotation could be eliminated by observing opposite points of the limb. The results of the measures of Evershed, St. John, Schwarzschild, and recent Bonn observers were shown on the screen. The mean of all gave a shift towards the red of $0.003 \text{ \AA}$. at the sun's centre and of $0.004 \text{ \AA}$. at the limb, Einstein's predicted value being $0.008 \text{ \AA}$. Prof. Fowler inclined to the view that the observed shift was due not to the Einstein effect, but to cooler descending convection currents at the sun's centre, and to the "limb effect" at the limb.

Mr. E. Cunningham gave the following example to show that the spectral shift need not necessarily occur on the equivalence hypothesis: Imagine two atoms each emitting light-vibrations in a non-gravitational field, the periods of vibration being the same. Referring them to a set of accelerating axes, we simulate a gravitational field. The synchronism between the two sets of waves is not destroyed; and on the equivalence hypothesis the relation of physical sequences in the simulated field is the same as in the real field. There is the qualification that the atoms must be free to fall—i.e. not constrained by neighbouring atoms; Mr. Cunningham doubted whether this was the case on the sun's surface. He went on to say that relativity did not necessarily imply the abandonment of the æther; a unique æther could be constructed on a mechanical basis; if it transmitted light, it must also transmit stress and energy.

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Prof. A. F. Lindemann spoke of the observed average recession of 4 km./sec. in the B-stars; even those in the Orion nebula, which presumably were at rest relatively to it, showed this differential shift; he concluded that it was not a Doppler effect, and might be the Einstein one. He noted as a difficulty in the quantum theory of light that to an observer at rest the mass of a quantum would be infinite; moreover, he considered that since the mass of an electron changed with its speed, its period of vibration should also change. Speaking of Prof. Eddington's statement that a sphere of water of radius 500 million km. would fill all space, he preferred to say that to an observer on the sphere it would appear to do so, since all rays from it would be bent back to it by its attraction; but he thought there was nothing to prevent other space from existing outside it.

Prof. A. N. Whitehead showed a mathematical method by which Einstein's first two astronomical predictions might be satisfied without introducing time as the fourth dimension. The method left it uncertain whether the spectral shift would take place or not. Should the latter be finally proved not to exist, we might fall back on this method, which agreed with the facts at present observed.

A. C. D. CROMMELIN.

THE FLIGHT FROM CAIRO TO THE CAPE.

(1) AVIATION AND EXPLORATION.

THE enterprise of the *Times* in organising a flight from London to Cape Town *via* Cairo, Khartum, the Upper Nile, the interior of East Africa, Northern and Southern Rhodesia, and the Transvaal will certainly, if successful, greatly advance the theory and practice of travelling through the air from one distant part of the world to another.

The bearing of the whole question—air travel *versus* railway, ocean steamer, or road-motor transit—was well put a few days ago by Capt. Frederick Shelford in his address to the African Society. There is no real cause for rivalry or hostile competition between all four forms of rapid transport. Air travel by aeroplane or airship will for a long time to come be far more dangerous to life than road or rail transit, and a little more dangerous than sea voyages; but it will be very much quicker than all other methods. It will be impossibly expensive for the transport of goods or of many passengers. Sea travel by boat is the cheapest mode of conveyance; railways, on the whole, and especially in wild, little-developed countries, are as cheaply made as motor roads, and are much less expensive to maintain. For mails and for passengers in a great hurry, aeroplanes should have no rival, especially when meteorology is better understood, and when the great air routes of the world are duly provided with aerodromes at convenient distances.

It may seem to be stating too obvious a fact

when I point out that the chief difficulty in the way to complete success on the part of aviation is the coming down safely from the air to the solid earth. No air pilot can view without grave apprehension a forced descent on an uneven or merely a slightly irregular surface. The passengers might not be more than shaken or bruised, but the delicate machine might be so injured as to be unable to resume its flight. But for this trouble about *descent* and *ascent*, the exploration of the world's land surface would now be proceeding at a tremendous rate. Soon the whole of the continents and islands would be made known in all their details.

I have always hoped myself that there may be some wonderful development in mechanics or in physics by which heavier-than-air machines might be enabled (1) to rise direct from the ground into the air *vertically*; and (2) to descend vertically and slowly, under control, making use of air-brakes in some way. The latter process may read as an impossibility, but it is not more improbable than many a feat in aviation would have sounded to the scientific theorist twenty years ago.

Then, again, I am sure we have neglected another safety apparatus: the devising of clothing that might be so inflated with air that the wearer would float to earth as gently as thistle-down.

The original mind of Dr. Chalmers Mitchell may well come back from his great air journey with new conceptions as to the future solution of these and other difficulties in aviation. Few people know as much as he does about bird-structure, and he may, when he is "up against it," be inspired to apply to the theory and practice of aviation some bright ideas—as yet overlooked—to be derived from the bird's development of the art of flying, especially the efforts made by heavy birds (cranes, storks, swans, peafowl, bustards, and large vultures) to rise into the air, to maintain themselves resting (floating) in the air, and to descend from a great height to the ground uninjured.

As to Dr. Mitchell's experiences and those of his companions on this actual journey, my impressions are: that by rising to eight or nine thousand feet they will ascend above the dangerous storms or violent winds of Central Africa; that they will nowhere run any serious danger from wild or savage men, except among the Dinkas of the Nile Valley (east of the Bahr-al-Ghazal); that they have very little to fear from any wild beast except a chance rhinoceros in East Africa; and that in seeing the desert yield to the Nile marsh-lakes, the marshes give place to mountains—even snow-mountains—and grandiose forest, the forest thinning out into parklands, the parklands passing into steppe, the steppe into desert, and the desert into the cornfields, orchards, vineyards, and gardens of South Africa, they will have had an unforgettable lesson in physical geography. I wish them the most complete success and a happy return.

H. H. JOHNSTON.

(2) SCIENTIFIC ASPECTS OF THE ROUTE.

THE expedition which started from Cairo on February 6 should be memorable as the first use of long-distance aeroplane flight for scientific and geographical research. Thanks to the enterprise of the *Times*, a Vickers' "Vimy" aeroplane is traversing Africa from Egypt to the Cape, with Dr. Chalmers Mitchell as scientific observer and Capt. Cockerell and Broome as pilots. The expedition will test the value of long aerial journeys for scientific purposes, and as it is under a man of such width of knowledge and scientific imagination as Dr. Chalmers Mitchell, we may be confident that the opportunity will be used to the best advantage.

The expedition is to travel leisurely, at moderate elevations, and never flying at night, so as to enable Dr. Chalmers Mitchell to obtain a clear survey of the country traversed. The route is from the aerodrome at Heliopolis, near Cairo, up the Nile, past Assuan, to Wadi Halfa, and thence, along the railway line, across the Dongola bend of the Nile, to the river again past Atbara to Khartum; then up the White Nile past Mongalla and Gondokoro and over the Nile rapids to Nimule. Thence the most direct route would be to leave the river and cross the Fatiko country to Lake Kiogo, and there rejoin the Nile, following it to its outflow from the Victoria Nyanza at the Ripon Falls. The expedition will fly over the lake to Kisumu, at the end of the Uganda Railway, skirt the irregular eastern coastlands to Mwanza, on the southern shore of the Victoria Nyanza, and cross "German" East Africa to Abercorn at the southern end of Tanganyika. Thence the route will be above north-eastern Rhodesia to the mining fields of the African Broken Hill, and along the railway past the Victoria Falls on the Zambezi to Wankie coalfield and Bulawayo; it will continue in sight of the railway another 182 miles southward to Palapye, where it will bend eastward across the northern Transvaal to Pretoria, and by following the railway past Johannesburg, Bloemfontein, and Beaufort West end its journey, of 5206 miles by the route projected, at Cape Town.

This journey must naturally be direct, long distances must be covered daily, and deviations to follow up interesting clues may be inadmissible, for the main object of this flight is to demonstrate the practicability of the aeroplane in the next stage of African research and development. The prospects are promising, for a bird's-eye view from a moderate elevation would reveal much of interest and practical value regarding the geography, geology, and botany of those parts of Africa composed of arid plains like the East African Nyika. One difficulty with their investigation is that, owing to the covering of scrub, travellers by foot or on horseback may march for days and see nothing beyond a few hundred yards beside the route, while any useful plane table survey is impossible. A view from above would, however, show all the essential features; the valuable areas are on the volcanic rocks or on limestones, both