

diameter of the wheel centre over the pads of the springs being slightly less than that of the channel rim, the wheel centre can be inserted therein, but is not connected in any way with it. The wheel is then complete and ready to be used on a vehicle.

The action of these wheels is simple, and merely consists of the pads on the ends of the spiral springs, as it were, acting as feet, which walk round inside the outer rim, and in turn support the weight of the vehicle. The wheel centre, when the vehicle is travelling along, rotates slightly more rapidly than the outer rim, the advance of the one upon the other being termed the "creep." When any obstacles are passed over, the shocks imparted to the rim of the wheel, which would, if it were a solid one, be transmitted through the axle to the machinery and car body, are absorbed by the rubber pads and springs before they reach the wheel centre. The principle and details of this wheel are quite novel, as has been admitted by the German Patent Office experts previous to granting the patent.

Owing to the rubber caps at the extremities of the spiral springs being capable of deflecting in all directions within certain limits, the friction of the moving parts of the wheel is negligible, and, as a result, practically no heating occurs,

saving in maintenance of each car, as regards tyres, by the use of "Panflex" wheels.

In conclusion, the author enumerated the advantages possessed by the "Panflex" wheel, and explained that by its adoption the use of the motor-car could be brought within the reach of persons who are now precluded from availing themselves of it owing to the excessive cost of maintenance of the tyres.

THE SPECTRUM OF THE ZODIACAL LIGHT.

SINCE the time when Cassini published his observations of the Zodiacal Light, in 1682, the question as to the nature and origin of this peculiar phenomenon has been constantly recurring. Visual observers were ever at variance on the subject, some holding the view that the Light was a terrestrial adjunct, others that it was a solar-appendage. Visually, the matter is a difficult one to decide, for no optical power may be used because of the lack of contrast between the Light and its background of sky. Photography is similarly placed out of court, but it was expected that the question would be solved by the spectroscope.

This expectation has never yet been realised absolutely, but the results recently published (Lick Observatory Bulletin, No. 165) by Dr. Fath clarify matters considerably.

Previous spectroscopic observations have varied on a vital point, viz. the presence or absence of bright radiations in the spectrum, indicating, by their presence, that the Light was self-luminous. Thus some observers found that the spectrum was continuous, others found that its continuity was broken by bright bands, especially the bright aurora line at  $\lambda$  5571. The argument for the presence of the latter as an inherent

element of the spectrum was, however, considerably weakened, if not eliminated, by the observations of Respighi, Vogel, Piazz-Smyth, and others, who were unable to find the aurora line, when observing the spectrum of the Zodiacal Light, unless it was at the same time to be seen in all parts of the sky. Tacchini, Cacciatore, and Ricca similarly were unable to find it, but agreed that the spectrum was continuous, extending from about  $\lambda$  5000 to  $\lambda$  5550, with its maximum intensity at  $\lambda$  5350; that is to say, the spectrum of the Light resembled the solar spectrum without the absorption lines.

The detection of the dark solar lines is a difficulty inherent to the observation, for the Light is so faint that, to get a visible spectrum, a broad slit is essential, and with a broad slit the comparatively fine absorption lines are lost.

Wright, in 1874, was able to use a narrower slit, and found that the spectrum, with an intensity-curve similar to that of daylight, showed traces of an absorption band in the position of the  $\delta$  band in the solar spectrum.

Thus it became fairly evident that the Zodiacal Light was reflected sunlight, and the opinion now generally held is that it is reflected by a collection of small meteoritic

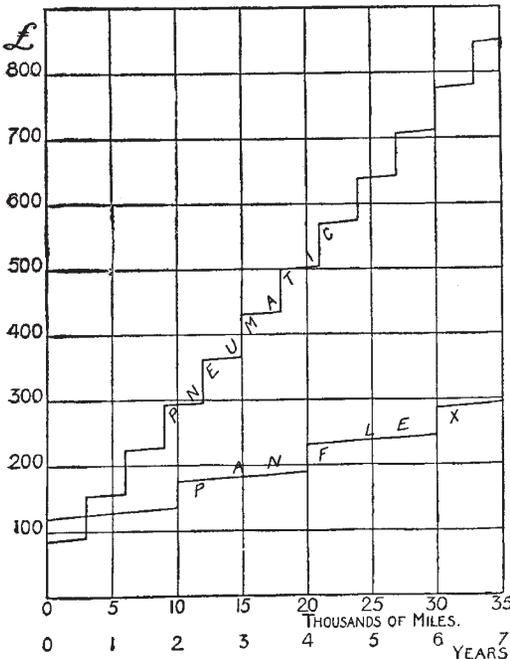


FIG. 4.

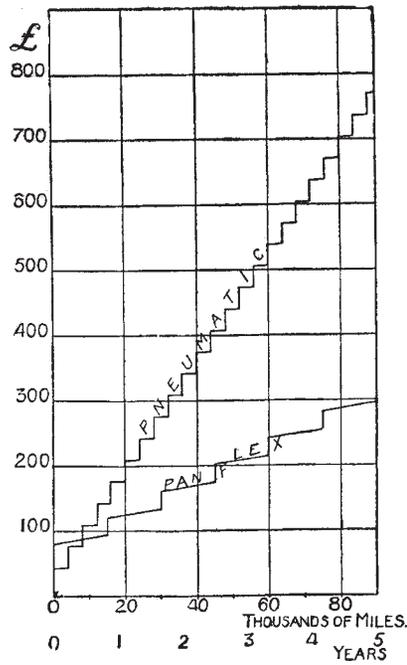


FIG. 5.

consequently the wear and tear is exceedingly small. The spiral springs attached to the wheel centre are designed so that in no case can they be subjected to a strain in any direction whichever approaches their limit of elasticity; consequently, provided no flaw exists in the steel of which they are made, their life should be indefinitely long. If however, from any cause a spring should break, no inconvenience is felt, as the journey can be completed, and a fresh spring can then be fitted in about five minutes.

The repairs of the "Panflex" wheel merely consist of the renewal of the solid rubber tyre, which can be effected by a coach-builder, and probably an occasional rubber pad or spring, a few of which should be kept in the car. The wheels have been tested on the Daimler car for 4000 miles, and the results indicate that the perishable parts should endure at least 10,000 miles.

These wheels have also undergone very severe tests on a taxi-cab in the streets of London and the suburbs for the last three months with very satisfactory results. The first cost of the "Panflex" wheel is somewhat greater than that of a pneumatic-tyred wheel, but the expenditure on maintenance is much less, as is shown by the diagram exhibited by the author (Figs. 4 and 5), which indicates the

bodies surrounding the sun; this theory is supported by the observation that a fair percentage of the light is polarised. The recent observation of Prof. Fowler (*NATURE*, vol. lxxxi., p. 396, September 30, 1909), who, during an auroral display, was able to detect the aurora line everywhere, "even in the light reflected by a pocket-handkerchief," illustrates the danger of attributing the auroral radiation to the spectrum of the Light, simply because it is seen contemporaneously.

To decide the question of the spectrum of the Light, photographic observations, if possible, were desirable, and, in 1883, Mr. Michie Smith attempted the task of photographing it, but was unsuccessful. Now, however, Dr. Fath has succeeded in obtaining a photograph after exercising a great deal of care and ingenuity in overcoming the numerous difficulties.

The first attempts were made, at the instigation of Prof. Campbell, in 1907 at Mount Hamilton. The spectrograph was especially designed and constructed for this research, and has an aperture of 51 mm.; the focal length of the collimator is 814 mm., and that of the camera is 154 mm. Rigidity, to withstand flexure or distortion over long periods, is the main feature of the frame, which is made of well-seasoned pine 13 mm. thick, shellaced inside and out, and put together with glue and screws. The prism is of light flint having a refractive index of 1.611 for H $\gamma$ , and was set for the minimum deviation of this ray; the resulting spectrum is about 2.2 mm. in length from  $\lambda$  5000 to  $\lambda$  3900.

In the autumn, when the Zodiacal Light appears in the morning above the eastern horizon, less than one hour before sunrise is available for the exposures, which therefore have to be accumulative. As the altitude of the Lick Observatory is 1283 metres, it was expected that dawn might commence before the zenith distance of the sun was  $108^\circ$ , the usually accepted value, and in the first experiments the exposure was always stopped when the computed zenith distance was  $111^\circ$ ; later experiments showed this precaution to be unnecessary.

In August, 1907, an exposure was made, over the period August 8 to 15, totalling 6h. 1m., and in the very faint spectrum secured absorption lines at  $\lambda$  4300 and  $\lambda$  3950 were suspected.

A stronger spectrum was obtained in October, 1907, with a total exposure of 11h. 9m., but still the traces of absorption were too faint to permit of any definite conclusions. Another attempt in the autumn of 1908 only served to illustrate the numerous pitfalls awaiting the observer of this evanescent spectrum. Jupiter and Venus were above the horizon, reflecting sunlight, and this so complicated matters that the experiments had to be abandoned.

On his translation to Mount Wilson, Dr. Fath resumed the inquiry, and, by the courtesy of Prof. Campbell, was able to use the same instrument. Elaborate precautions were taken to eliminate any chance of "shift" caused by the vibration or change of temperature of the spectrograph; the instrument was also mounted on an azimuth slide, so that it could be moved in azimuth some  $5^\circ$ , in order to follow the brightest part of the Zodiacal Light. The width of the slit employed was 0.41 mm., and at this width the solar lines H and K are not separated in the spectrum. The exposures extended from 1909 September 12 to September 25 under very favourable conditions, and were always arrested a minute or two before the time calculated for the zenith distance of the sun to be  $108^\circ$ . Careful watch was kept for any abnormal dawn or other phenomena which might vitiate the results, but none was observed.

With a total exposure of 12h. 31m., on a Lumière "Sigma" plate, a spectrum was obtained, under these conditions, which, so far as its small size will allow one to judge, resembles the solar spectrum exactly. Two absorption lines are certainly seen, and a comparison spectrum of daylight shows these to be G and a blend of H and K in the solar spectrum. There are no signs of bright lines on any one of the spectra obtained, and therefore, as Dr. Fath concludes, we seem justified, so far as such small, impure spectra can lend justification, in concluding that the Zodiacal Light is nothing more than reflected sunlight.

NO. 2103, VOL. 82]

To support this conclusion it is, of course, desirable that the work should be continued, using a narrow slit to obtain greater purity of spectrum; but this entails the employment of much quicker plates than are at present available, or a much longer exposure. The latter is at present probably the most feasible plan, but when one remembers that the hours of exposure must be moonless, planetless, and clear, it is obvious that several months would be necessary to complete one such exposure. This means that special precautions to secure the constancy of the spectrograph would be necessary, and Dr. Fath suggests the construction of one with a metal frame, which would be less likely to suffer change than a wooden one, and could be maintained at a fairly constant temperature.

W. E. ROLSTON.

#### TECHNICAL EDUCATION IN GERMANY AND THE UNITED KINGDOM.

AT the request of Mr. R. Blair, the executive officer of the London County Council Education Committee, a valuable memorandum has been drawn up by Dr. F. Rose on the qualifications of the students trained at the German technical high schools in comparison with those of students at British universities and technical institutions of university rank. This memorandum, with the tabular portion abridged, is subjoined, and it contains facts of great interest and importance. Referring to it, Mr. Blair says:—

"The memorandum shows that one or two broad statements of fact may be made, and these deserve, if they do not demand, attention. First, the schools of the United Kingdom do an immense amount of valuable work in the evening—my own view is that the work is unparalleled. So much further education in the evening is partly due to the fact that a life of earning and independence begins earlier in the United Kingdom than in Germany, and is partly an indication of the inadequacy of the day work in these islands. It is hardly possible—and I have not attempted to do it—to assess this evening work in such a way as to place it side by side with the day work in the United Kingdom in comparing the latter with German day work, and such a comparison would also have required an appreciation of the evening work in Germany. But it has much value. Secondly, taking, as far as one can, comparable institutions, there are 12,000 fully qualified students attending day institutions for the highest technical training in Germany, and only about 3600 in the United Kingdom. The German courses are, speaking generally, longer and the previous preparation better. Further, this great difference in quality and quantity of the work done has existed for more than a generation; and these highly qualified German students have found, and do find, their way into agriculture and industry, because the German people believe in the application of trained intelligence to all forms of national activity."

Dr. Rose's report, in an abridged form, is reprinted below.

Although there is little doubt that the majority of students trained in German technical universities actually take up industrial positions upon leaving, it is impossible to give any detailed information, as no statistics on the subject have been published or are obtainable. Nine years ago I carried out an investigation to show to what an extent the German chemical industries had benefited from the chemical instruction available at universities and technical universities. The proportions still hold good for the present day, although the figures have increased. It was found that there were about 4000 academically trained chemists in the different branches of the chemical industry. The value of the annual production of the chemical industries was estimated at 50,000,000.

The total number of chemists trained in Germany was estimated at the same time at about 7000. It would not be going too far to say that at least four-fifths of the German students actually take up positions in industries and technical work when they leave the technical universi-