optical parts, Prof. Vogel says: "The objectives are very beautiful and colourless; the prisms are masterpieces of workmanship; the glass of which they are composed is pure, colourless and free from streaks, and only in two prisms do a few air bubbles appear." The spectra given by the prisms are said by Prof. Vogel to be very excellent, and the working of the whole set of prisms exceeds even to-day any other instrument of the same dispersion. The refractive angles of the prisms, as measured by Dr. Hartmann, are 44° 57'·1, 45° 6'·9, 45° 26'·9 and 59° 50'·8, and the relative refractive indices at a temperature of 18° C. was found by the same observer to be for the lines—

B	1·6093	D	1·6158	F	1·6275
C	1·6110	E	1·6220	Hγ	1·6375
a	1·6129	b_1	1·6230	g	1·6403

JUPITER'S RED SPOT.—Jupiter is now in a good position for observation, and his surface markings have become of late of great interest in consequence of the numerous spots which many observers have seen on his disc. Dr. A. A. Nijland draws attention to two very curious spots (*Astr. Nachr.*, No. 3488) which are situated on the northern hemisphere, their coordinates in longitude and latitude (according to "Marth's System," ii., *Monthly Notices*, lviii. p. 107) being $\lambda = 272° \; \beta + 31°$, $\lambda = 289° \; \beta = + 38°$. Dr. Fauth, from the private observatory at Landstuhl, gives us a continuation of the list of longitudes of several prominent spots observed by him. Another short communication of interest is that which appears in the *Astr. Nach.*, No. 3490. In this Dr. Lohse discusses the movement of the great red spot from observations extending over a period of twenty years. The proper motion of the spot is, according to him, distinct and regular, and this will be clearly seen from the short table given below.

The method of reducing this proper motion was to obtain for each opposition a normal position for the centre of the spot on the surface of Jupiter, on the assumption of a fixed meridian and a regular velocity of rotation of the planet. In plotting the positions of these deduced normal positions on paper with the time as abscissæ and the Jovian longitudes as ordinates, a regular and symmetrical curve was brought to light. The following figures give the Jovian normal longitudes of this spot as shown in this manner, together with the name of the observer:—

Epoch.	Normal longitude	Obs.
1878·65	249·5°	L.
1878·86	237·1	Tr.
1879·73	182·7	L.
1880·71	128·5	L.
1881·70	89·2	L.
1882·14	78·0	L.
1883·14	50·4	L.
1884·15	32·6	L.
1885·27	15·8	D.
1886·27	8·3	L.
1887·27	2·9	St. D.
1888·27	358·9	L.
1890·15	353·6	T. P.
1891·74	352·0	L.
1892·76	356·2	L.
1894·03	358·8	L.
1895·18	5·2	L.
1896·13	10·1	L.
1897·27	20·4	L.

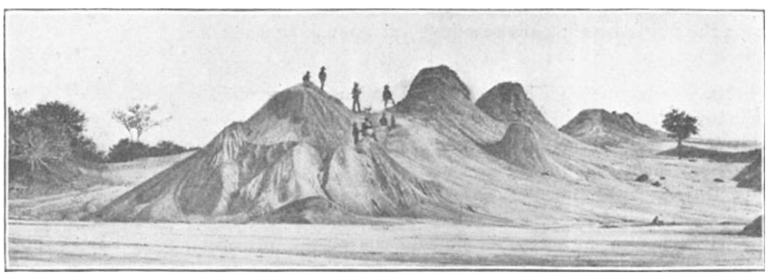
The observers mentioned above were Lohse, Trouvelot, Stanley Williams, Denning, Terby, and Pritchett. From the curve it can be seen at a glance that the spot in the year 1891 rotated in the same time as that assumed for the rotation of the planet. The curve at this period has reached a turning point, and the longitudes of the spot commence now to increase instead of decrease. The observations show that for thirteen years (1878–1891) this spot has moved through nearly three-quarters of the whole circumference of the planet, and since that interval has begun to retrace its path. The fact of such a distinct acceleration and retardation of the motion of this large spot will, if the observations be continued, help us probably to gain some knowledge of the system of circulation involved in the Jovian atmosphere. It would be interesting to know whether any other comparatively large marking on the planet's surface follows the same or a similar law.

PETROLIFEROUS SANDS AND MUD VOLCANOES IN BURMA.

THE occurrence of petroleum in Burma, and its technical exploitation have, in a recently published volume, been very fully treated by Dr. Fritz Noetling, palæontologist to the Geological Survey of India (*Mem. Geol. Survey India*, vol. xxvii. part 2). The Yenangyaung oil-fields occupy an area of about 350 acres on the borders of the left bank of the Irawadi, a few miles distant from the river. They have been known from time immemorial, while the methods of obtaining the oil at the present day differ but little from those of a hundred years ago. In 1855 there were about 130 productive wells; there are now about 600, together with six or seven bore-holes. The oil-field is situated in a low but rugged table-land which is intersected by numerous ravines, and the strata which yield the oil have been bent into a gentle dome-like anticline. The strata consist of sands or soft sandstones, and shales of Tertiary ages overlaid by drift. The oil is held in the sandy beds, the thickest of which (though not the richest in oil) is a little over 130 feet. As many as ten bands yielding oil may occur in vertical succession; but water and petroleum occur independently in different beds, or in the same layer, and in the latter case the petroleum generally rests on the water.

Oil has been found by boring in a bed of sandstone 900 to 1000 feet deep, but the main oil-sand is from 200 to 350 feet from the surface. The sands are somewhat inconstant in character, and the strata generally exhibit false-bedding. They have yielded numerous remains of land mammalia and reptiles, as well as some marine fossils, so that Dr. Noetling believes the strata were accumulated in shallow water not far from land, and that carcases of animals brought down by a river were entombed in the estuarine sediment. He regards the petroleum as indigenous in these sandy estuarine or deltaic deposits. The clays contain no trace of it. Moreover, he considers that the strata were laid down on a plane gently inclined towards the sea, and that this inclination facilitated a sliding of the sediments seawards, whereby certain minor folds and irregularities, otherwise difficult to explain, were produced. These folds were intersected by cracks, which became filled with mud—like veins of eruptive material.

Turning his attention to the mud volcanoes of Minbu, Dr. Noetling points out that they are connected with subterranean petroliferous strata: both volcanoes and mud-wells produce a



The Mud Volcanoes of Minbu, in Burma (Dr. F. Noetling).

greyish-blue mud more or less saturated with petroleum. The low temperature of the ejected mud, seldom so much as 85°, indicates that its source is not deep-seated. Some of these mud volcanoes are figured (the accompanying illustration is reduced from a Plate in the *Memoir.*) The largest had, in 1888, a crater about 6 feet in diameter, and this was filled with viscous mud from which rose enormous bubbles of inflammable gas with a strong odour of petroleum. The temperature was 76°. Some of the other cones rise about 30 feet from the ground. It seems at first difficult to say why mud volcanoes occur at Minbu and not at Yenangyaung, but Dr. Noetling points out that at Minbu these volcanoes arise through fissures in the Tertiary strata beneath an alluvial cover, and he considers that the pressure of gas and petroleum forced a way through this comparatively thin overlying deposit. No fiery eruptions have been recorded; in fact, there are no known instances of spontaneous combustion.

Dr. Noetling traces some connection between the fluctuating heights of the river and the production of petroleum at the wells.

There is also some relation between the activity of the mud volcanoes and the height of the river. The explanation is that during rains the ground-water presses on the petroliferous sands, and it is noteworthy that the main bed of oil-sand is found at about the level of high-water of the river.

Some signs of exhaustion in the oil-field are noticed by the author, but it is possible that further productive beds may be found by boring. H. B. W.

EXPERIMENTS ON THE WORKING OF GAS-ENGINES.

A GENERAL meeting of the Institution of Mechanical Engineers was held last week, when the President, Mr. Samuel W. Johnson, delivered an inaugural address dealing chiefly with the progress of locomotive engineering on the Midland Railway, of which he is chief mechanical engineer. The most interesting feature in the ordinary proceeding was the discussion of the first report to the Gas-Engine Research Committee of the Institution. The author of the report was Prof. Frederick W. Burstall, under whose superintendence the investigations had been carried out. The object of the experiments was to determine the effect produced upon the economy of gas-engines by altering one or more of the conditions which governed their working. In internal combustion engines there are a much larger number of factors to consider than in steam-engines, and it is difficult to ascertain where to look for economy. The factors to be considered are the amount of compression, the speed, the ratio of air to gas, and the amount of heat which is to be ejected through the walls of the cylinder. An increase of compression, for example, is often regarded as conducive to more economical results; but it is uncertain whether the attendant increase in economy is really due to compression alone. To ascertain this, the conditions of working should be altered successively one at a time. This has been done for the steam-engine, but all published results of tests made on gas-engines are based upon only one fixed set of conditions.

A small engine was used by the committee, but was one specially constructed for experimental purposes. Small size was an advantage, inasmuch as it allowed measurements, such as those of volumes of air, to be made with accuracy. The work of the committee appears to have been undertaken with commendable care, and a precision was aimed at more typical of the physical laboratory than of ordinary engineering experiments. This is particularly noticeable in the arrangement of the apparatus and methods of calibration followed. It would take far too much space to follow these in detail, interesting and instructive as they are to engineers, and we can only hope to give a partial idea of the methods followed. This report, it should be remembered, is but introductory to the description of the actual work of testing, most of which has yet to be undertaken. As the author stated, experimental work is often compromised by being carried out with instruments upon the accuracy of which no information is furnished. When a comparison is made of a number of results, it is always difficult to discover how far differences are due to working conditions or to inevitable experimental error. In purely physical experiments, the report continued, accuracy may be obtained to the degree of one part in a thousand; in a few special cases, even better results may be reached. In an engineering experiment it is hopeless to expect such accuracy, owing to the great difficulty of keeping the working conditions sufficiently steady from beginning to end of the experiment. With ordinary care, and the use of appliances which are found in all works, probably all that can be expected is to get results correct to 3 or 4 per cent. With special care, half of 1 per cent. may be reached; but the author does not suggest that all the results of the experiments made by the committee have this high degree of accuracy, but in the principal measurements probably the experimental error involved does not in any case exceed 1 per cent.

The engine used was of 2-horse nominal power, capable of developing a maximum of 5 I.H.P.; it has a 6-inch cylinder and 12-inch stroke. The valves are worked in the ordinary manner; there is an ordinary Watt governor acting on a small roller, and causing a charge of gas to be cut off when the speed is too high. To effect changes in compression the connecting-rod is made so that its length can be varied. Compressions employed in the experiment varied between 35 and 90 lbs. per square inch; variation in the amount of gas admitted was effected by throttling. For measuring the supply of gas a calibrated holder was used; the wet test meter being discarded, as it does not control the fluctuations of pressure in the mains. By this instrument accuracy to the extent of one-tenth of 1 per cent. was obtained; calibration was effected by means of a standard cubic foot measure. To determine the air supply per stroke, a meter was used in place of trusting to the usual method of calculation. The arrangement followed was practically that employed by Dr. A. Slaby, of Berlin. The meter employed was a 400-light standard wet meter made by Alexander Wright and Co., of Westminster. Air is passed in by a blower, the pressure being kept constant by a governor. After passing through the meter the air is delivered into a safety-box, which is used to prevent inflammable gas from passing back into the meter, and also to give relief in case of back ignition. A rubber-bag is used to prevent fluctuations in the meter during the suction stroke. The direct measurement of air supply is usually considered a difficult and dangerous undertaking; but the author stated that no trouble had been found with this portion of the apparatus. The air meter was checked by blowing air through it into the gas-holder, and was found to be correct to the half of 1 per cent.

The amount of heat passed into the jacket was measured by running all the cooling water for a single test into a tank, and taking the temperature by means of thermometers. Samples of exhaust gases were taken and analysed. In this detail the great difficulty is not in making the analysis, but in obtaining a true sample. A single bubble of gas was taken from just below the exhaust valve after each explosion. The apparatus for doing this was illustrated by means of wall diagrams, which showed that the object aimed at was obtained by an electrical relay which actuated a small needle valve that allowed a single bubble of gas to be sucked into the gas receiver. Power developed was ascertained by a Wayne indicator; an instrument found superior to others tried. Prof. Burstall states that it is in careful hands, apparently the most accurate indicator of the present time. It has a rotating piston in place of the ordinary reciprocating piston. This piston does not touch the containing cylinder at its outer extremities, but is guided at the centre on circular bearings. In this way friction is small and not liable to change, because the bearings can be well lubricated. There are many interesting points about its mechanism which were described in the report. Thin sheets of smoked mica are used in place of the ordinary metallic faced paper or "cards." This device is highly spoken of by those who have had experience in its use.

As the engine was not fitted with a timing valve—a device which the author considers absolutely necessary to all sizes of gas-engines—it was decided to attempt to ignite the charge by means of an electric spark, and it was hoped that electric ignition would prove more certain than any form of hot-tube igniter. This, however, did not prove to be the case; and not the least interesting part of the report is contained in the discussion of the failure in this detail. The rope-break used was of the ordinary kind, having dead weights on the lower end of the rope and a spring balance at the upper end. A Harding counter for ascertaining the number of revolutions was employed, and analyses of the coal-gas were made by Mr. G. N. Huntly, who also supervised the analyses of the exhaust gas. The results of seventeen preliminary experiments made were given in a table contained in the report, and on copies of indicator diagrams attached. The mechanical efficiency of the engine varied from 76 to 84 per cent., the mean value of the whole seventeen tests being 81 per cent. It must be remembered, however, that these experiments are, as stated, preliminary, and, it may be added, they have been carried out under circumstances of exceptional difficulty, which conditions, however, will not recur. The report states that it would seem probable that the influence of increased compression on economy is due to the fact that weaker charges can be burnt completely during the stroke when the compression is high. The tests seem to indicate, the report continues, that economy depends on the choice of the correct ratio of air to gas; and this ratio increases with the compression. The number of experiments, however, are, as the report states, not yet sufficient to determine what this ratio is for any given compression. It is intended to make a series of tests sufficient for determining this important point. Further experiments are to be made at a constant speed; the variables being the load, the ratio of air to gas, and the compression. It is