Viscosity of Carbonic Oxide.—The results with this gas are remarkable as showing an almost complete identity with those of nitrogen both in position and shape. The viscosity at 760 millims. is in each case 0·1092.

Like that of nitrogen the curve of carbonic oxide is seen to be vertical—*i.e.*, assuming the curve to represent the viscosity, the gas obeys Maxwell's law, at pressures between 90 millims. and 3 millims. The straight portion in nitrogen is at a little higher pressure—between 100 millims. and 6 millims.

The curve of repulsion resulting from radiation is lower in carbonic oxide than in any other gas examined, and, unlike the other gases, there is no sudden rise to a maximum at about 40 M. At lower exhaustions the curve is, however, higher than it is in nitrogen.

During exhaustion observations were continued on the variations in the spectrum. The ordinary band spectrum is first seen with a few sharp lines terminating the bands.

At 12 millims. pressure a sharp green line is first seen, λ 515 ms of mm. This line rapidly grows brighter as exhaustion continues, and then fades out; it is last seen at a pressure of about 0·9 millim. This line is probably the bright oxygen-line, the wave-length of which is given by Plücker at 514·4.

At a pressure of 2·8 millims. the spectrum agrees in appearance with the "Carbon No. 2" in Watts's "Index of Spectra."

At 553 M the bands between the sharp lines appear to be breaking up into masses of fine lines.

At 211 M these fine lines are distinctly visible. The brightness of this spectrum is now near its maximum.

At 100 M the general spectrum is growing faint, but a sharp green line at λ 534 makes its appearance by fits and starts. This is coincident with Plücker's bright oxygen line λ 534.

After this degree of exhaustion the spectrum rapidly gets fainter. The line λ 534 soon disappears, and the carbon lines also go one after the other, until at an exhaustion of 4 M only two lines are visible, λ 560 and λ 519.

Viscosity of Hydrogen.—It has been found that hydrogen has much less viscosity than any other gas; the fact of the log dec. not decreasing by additional attempts at purification is the test of its being free from admixture. This method of ascertaining the purity of the gas, by the uniformity of its viscosity coefficient at 760 millims., is more accurate than collecting samples and analysing them eudiometrically.

Several series of observations in hydrogen have been taken. For a long time it was considered that hydrogen, like other gases, showed the same slight departure from Maxwell's law of viscosity being independent of density that appeared to be indicated with other gases; for the log dec. persistently diminished as the exhaustion increased, even at such moderate pressures as could be measured by the barometer gauge. Had it not been that the rate of decrease was not uniform in the different series of observations, it might have been considered that this variation from Maxwell's law was due to some inherent property of all gases. After working at the subject for more than a year it was discovered that the discrepancy arose from a trace of water obstinately held by the hydrogen. Since discovering this property extra precautions (already described at the commencement of the paper) have been taken to dry all gases before entering the apparatus.

The remarkable character of hydrogen is the uniformity of resistance which it presents. It obeys Maxwell's law almost absolutely up to an exhaustion of about 700 m., and then it commences to break down. Up to this point the line of viscosity is almost perfectly vertical. It then commences to curve over, and when the mean free path assumes proportions comparable with the dimensions of the bulb and approaches infinity, the viscosity curve in like manner draws near the zero line.

The repulsive force of radiation is higher in hydrogen than in any other gas. It commences at as low an exhaustion as 14 millims., but does not increase to any great extent till an exhaustion of 200 M is attained; it then rises rapidly to a maximum at between 40 and 60 M, after which it falls away to zero. The maximum repulsion exerted by radiation in hydrogen is to that in air as 70 to 42·6. This fact is now utilised in the construction of radiometers and similar instruments when great sensitiveness is required.

Taking the viscosity of air at 760 millims. as 0·1124, and hydrogen as 0·0499, the proportion between them is 0·4439.

The Spectrum of Hydrogen.—The red line (λ = 656), the green line (λ = 486), and the blue line (λ = 434) are seen at their brightest at a pressure of about 3 millims., and after that exhaustion they begin to diminish in intensity. As exhaustion proceeds a variation in visibility of the three lines is observed. Thus at 36 millims. the red line is seen brightly, the green faintly, whilst the blue line cannot be detected. At 15 millims. the blue line is seen, and the three keep visible till an exhaustion of 418 M is reached, when the blue line becomes difficult to see. At 38 M only the red and green lines are visible, the red being very faint. It is seen with increasing difficulty up to an exhaustion of 2 M, when it can be seen no longer. The green line now remains visible up to an exhaustion of 0·37 M, beyond which it has not been seen.

It is worthy of remark that although when working with pure hydrogen the green line is always the last to go, it is not the first to appear when hydrogen is present as an impurity in other gases. Thus, when working with carbonic anhydride insufficiently purified, the red hydrogen line is often seen, but never the green or the blue line.

(*To be continued.*)

SEEING BY ELECTRICITY[1]

ON being called upon by the chairman to show his experiments, Prof. Ayrton stated that he and Mr. Perry thought that the occasion of the reading of Mr. Bidwell's paper was a suitable one for their showing to the Society that they were constructing the apparatus described by them in a letter in NATURE, vol. xxii. p. 31. The feasibility of their plan had been combated, and at the last meeting of the British Association at Swansea it was confidently asserted that the action of selenium was not quick enough to register rapid changes of light intensity—an idea, however, which they stated in the discussion at the time there was experimental evidence to disprove. After that came the publication and exhibition of the photophone, proving that selenium changed its electrical properties synchronously with rapid changes in light intensity. For a light telegraph however not only was this property necessary, but in addition that the electric changes in the selenium should be considerable for a comparatively small change in the light. They had, therefore, tried to make sensitive selenium cells of low resistance. The method they had employed consisted in winding two wires parallel on strips of box-wood, ivory, and other non-conductors in section, somewhat like that of a paper-knife in the manner subsequently described by Mr. Bidwell in NATURE, but they had not found it necessary to cut a screw on the wood or mica in a lathe. Of the twenty-five cells that they had constructed they had invariably found, like Mr. Bidwell, that only those were sensitive that had a high resistance. They were aware that Prof. Adams had made sensitive cells of low resistance, and had he been present they would have liked to ask whether it was not only for very small electromotive forces that the cells were sensitive. They had also found that when sensitive cells of 100,000 ohms resistance diminished in resistance to only a few hundred ohms by natural annealing extending over some months, the cells lost entirely their sensibility. Further that certain sensitive cells of high resistance were sensitive as long as an electromotive force of not more than about seven volts was employed to send a current through them, but for electromotive forces much above this the cells were comparatively unsensitive to light, but the sensibility was not destroyed for electromotive forces smaller than seven volts used subsequently. These phenomena, which they believed had not been previously noticed, pointed, they suggested, to the sensibility of selenium being due almost entirely to a polarisation and not merely to a change of resistance, as was commonly supposed and stated. Might it not be possible, they asked, that there was an electromotive force developed in selenium by light, which, for different cells, increased more rapidly than the resistance of the cell, and which was the greater, the greater the electromotive force of the auxiliary battery employed; that in fact selenium became rapidly polarised by the auxiliary current flowing through it, and that this polarisation, the amount of which depended on this current, was removed in proportion to the intensity of the light. That a small electromotive force was developed in selenium by light when no auxiliary current was sent through it, had been conclusively shown by Prof. Adams and Mr. Day in 1876, a result that they had also experienced; and they would mention that a careful examination which they had recently made of the paper published by Prof. Adams and

[1] Paper communicated to the Physical Society, February 26.

Mr. Day in the *Phil. Transactions* for 1876, showed that if we assumed *all* the instances therein mentioned of sensibility of selenium to light were due to an electromotive force set up, and not to change of resistance at all, then on the whole all the results would have been arrived at if this electromotive force set up in different cells, for the same intensity of light, increased more rapidly than the resistance of the cell, and was the greater, the greater the electromotive force of the auxiliary battery employed. They disagreed therefore from Mr. Bidwell in his idea that the name "cell" was at all inappropriate.

Professors Ayrton and Perry referred the Members to their original letter in NATURE for the account of their plan for seeing by electricity. Shortly, it consisted in projecting at the sending-station an image on a screen consisting of a number of selenium cells, the current flowing in each of which from an auxiliary battery was controlled by the intensity of the light falling on it. At the receiving-end of the line a light was thrown on a screen intercepted more or less by little shutters, the opening or closing of each of which was controlled by the current allowed to pass through the corresponding selenium cell at the sending end. Hence on the receiving screen a picture in mosaics was cast corresponding with the image projected on the screen at the sending-end, and varying with every change in the image cast on the sending-screen.

The experiment they desired to show the Society was the successful reproduction on the receiving-screen of every change of illumination of one square of the sending-screen. The shutter was an elliptical blackened aluminium disk suspended in a blackened tube of a kind of galvanometer, and making an angle of 45° with the tube when all the light tending to pass through the tube was cut off. When this disk was deflected through 45° all the light passed through the tube and an image of a square hole was formed by a small lens attached to the tube. For every intermediate position of the shutter an image of the square hole was formed on the screen, but varying in intensity of illumination. Attached to the shutter was a small magnet making an angle of $67\frac{1}{2}°$ with it, and the two were suspended by a silk fibre about one-twentieth of an inch in length. These particular angles were selected so that first all variation in intensity of the illumination could be produced with a small motion of the shutter, and secondly, so that the magnet should always be in its most sensitive position in the coil through which passed the electric current which traversed and was controlled by the corresponding selenium square at the receiving-end of the line. [The apparatus was then shown in action.]

They explained how their method of putting, say, thirty or forty selenium cells on a revolving arm would enable them, while dispensing with a large number of cells, to transmit electrically a complete picture of even moving objects, and would in addition obviate the difficulty arising from abnormal variations of selenium.

Instead of the apparatus exhibited to the meeting to show the perfect feasibility of the scheme, Professors Ayrton and Perry mentioned that they were also experimenting with a large thin mirror with many thick ribs at the back crossing one another. Electro-magnets firmly fixed behind the thin parts of the mirror produced by their expansion and contraction very small convexities and concavities on the mirror's face. From their experiments, published in the *Proc.* Roy. Soc., on the so-called Japanese magic mirrors, it was known that excessively small convexities and concavities of this kind might be made to show themselves in a very decided way on a screen by a divergent beam of reflected light. They proposed to have a circular mirror in rotation, but with only a certain sectional space at the back fitted with electro-magnets as described, and they anticipated that this in conjunction with the rotating section of selenium cells at the other end of the line would produce on a screen a picture over the whole area of the mirror corresponding with the distant image projected on the area traced out by the revolving sector of selenium cells.

EARTH CURRENTS—ELECTRIC TIDES

AT a meeting of the Society of Telegraph Engineers and of Electricians on Thursday evening, February 10, Prof. G. C. Foster in the chair, a communication was read by Mr. Alex. J. S. Adams upon "Earth Currents—Electric Tides," in which the author related that, from investigations he had carried on in connection with earth currents since the year 1866, he considered the globe we inhabit as an electrified sphere whose normal electrical condition was liable to disturbance both from within and from without. Starting upon this theory as a basis, and finding from the result of his observations no evidence that the sun exerted sufficient influence to materially disturb the earth's electricity, he undertook a series of systematic observations upon the daily earth-current variations in strength, to elucidate the question, and obtained consecutive observations every quarter of an hour during the interval from April 1 to 21, 1879, with a result that the curves of those observations coincided throughout with the curve of moon phases for the same period, and clearly indicated that the chief disturbing power was the moon, and that the earth current variations were strictly *lunar-diurnal.*

"But," said he, "there is a yet deeper meaning to the lunar-diurnal current curve than at first sight appears, for an examination shows that the curve for each day represents *four electrical maxima, two of a kind*, and that each maximum is divided from the other by a zero or point of no current." He further explained that whilst two of these maxima always exist upon the opposite sides of the globe, which are in a line *perpendicular* to the moon, two other maxima were also found upon the sides of the globe lying at right angles to the former maxima, and that from a long and careful consideration of these features of the phenomenon he had arrived at the conclusion that whilst the earth's disturbed electricity was, as it were, heaped up by the moon upon the sides of the earth nearest to and farthest from her, much as are the waters of the globe in forming the oceanic tides, the two *lateral* maxima, upon the other hand, must be considered as parts of a belt or band of electrical maximum that encircles the earth in a position at right angles to a line drawn between the earth and moon. Thus it appeared that there were zones of maxima at the sides of the globe nearest to and farthest from the moon, and a *circle* of maximum at right angles between them, but divided from them by zones of no current. This arrangement of the earth's electricity by the moon the author termed the earth's *lunar electric distribution*; the electric maximum facing the moon he designated the *major electric pole*, that farthest from the moon the *minor electric pole*, and the belt of maximum that encircles the earth the *electric circle*. Likewise the zone of no current that divides the electric circle from the major pole he terms the *major zero circle*, and that zero which separates the electric circle from the minor pole, the *minor zero circle.*

The earth's electricity, as thus arranged by the moon, followed that orb in her course through the heavens, and this motion of the earth's disturbed electricity round the earth, yet irrespective of the globe itself, was termed the *lunar diurnal electric circulation*, and the axis upon which it turned the *lunar-diurnal axis*.

A due apprehension however that *the moon's influence is in proportion felt by the earth's electricity at every part of the earth's surface* he considered necessary for the proper appreciation of the reasonings which led to the foregoing deductions.

It was then pointed out that there existed a regular retardation or lagging of the earth-current variations behind the corresponding phases of the moon to the extent of nearly three hours, this curious phenomenon being in no way, so far as he could trace, attributable to solar influence.

The magnetic variations were then considered, and a striking coincidence between the electric and the magnetic lunar-diurnal variation-curves was shown to obtain. The author reasoned that the earth's electric forces as constituted in the *electric distribution* revolved also about an axis parallel to a line passing through the centres of the earth and moon, *i.e.* a line drawn between the major and minor electric poles—a motion of the electric forces that agreed with the *observed direction* of the earth current, and which appeared fully sufficient to account for the effect of lunar-diurnal magnetic variation.

In conclusion he said that a comprehensive consideration of earth-current phenomena opens out a much wider sphere of investigation than that simply embracing variations of strength: it has to recognise *directive influence* which, applied to electricity, means the production of magnetism, and that the electric circulating systems that appear to obtain by reason of these three motions, the *earth's diurnal rotation*, the *lunar current circulation*, and the *terrestrial current circulation*—causes which result in the apparently disconnected variations observable in the movements of the magnetic needle.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The examiners for the Natural Science Tripos during this year are Dr. W. H. Gaskell, Prof. Bonney, Mr. P. T. Main, Prof. Watson (Owens College), Prof. Lewis (recently