into space but will be reflected back and again absorbed by the radiator, and thus there will be no escape of energy.

If the oscillations were due to an electron describing a circular orbit, the reflected waves when they struck the electron and gave up their energy to it would, in general, deflect it and cause it to describe a different orbit. Thus the motion of the electron would not be steady. There may, however, be some orbits where the distance of the boundary at which the reflection takes place from the orbit is such that the reflected waves are in such a phase when they reach the electron that they just compensate for the changes in the motion of the electron produced by the emission of the radiation. For such orbits the uniform circular motion might be a steady state. It is evident that certain conditions have to be fulfilled for this to happen, so that it is only orbits with particular periods which possess this property. Since the application of a strong electric force would diminish the time-constant of the field, these orbits would be displaced by electric force. We may illustrate this point by the case of a piston vibrating at one end of an organ pipe which is closed at the other. In general, the waves reflected from the closed end will influence the motion of the piston, but they will not do so if the period of the piston is such that a loop of the vibrations of the pipe coincides with the position of the piston.

Let us apply similar considerations to light waves. Assuming that light is an electrical effect, we see at once that there can be no unlimited propagation of spherical electrical waves diverging from a source such as is contemplated in the usual conception of the electromagnetic theory of light; for on this view energy in the light is distributed continuously through space, and the energy per unit volume diminishes indefinitely as the light travels farther and farther away from the source. Now we have seen that the condition for the propagation of a periodic disturbance is that the period of the disturbance should be greater than the time interval of the electric field; this interval increases, however, as the energy in the light diminishes, so that when the energy falls below a certain value, which is small for long-period vibrations and large for short-period ones, any further propagation is impossible. Thus the intermittence of electrical force demands a corpuscular theory of light, *i.e.* a theory where the energy is done up in bundles which do not alter in size as they travel through space. The bundle may consist of a periodic distribution of electric force, like a piece cut out of what on the classical theory represents a beam of light. This piece is prevented from spreading because the energy density at its boundary has the

critical value, and this boundary acts, on our view, like a reflecting surface and sends back any disturbance which tries to get outside it.

I picture these units as consisting of two parts: a central core in the form of an anchor ring, the plane of the ring being at right angles to the direction in which the unit is travelling. This ring is the seat of an intense electric field, and the circumference of the ring is equal to the wave-length of the light. This ring corresponds to the quantum of the light. This ring vibrates and emits electrical waves which, after travelling to a certain distance from the centre, get to the limit where the time interval of their electric field is equal to the period of the light. This forms the boundary of the unit, and the space occupied by the waves and the energy in them remain unaltered as the unit travels through space. On this view, light has a dual structure consisting of electrical waves with a quantum as the core. The electrical waves give rise to interference effects, the quanta to the photo-electric ones.

On the view that the force is intermittent the electric field must have a structure, and as electrons and positive particles are the centres of intense electric fields, they are probably much more complex than the usual conception of them, and must be regarded as centres of complex systems associated with an electron or a positive particle. If we compare the atom with its electrons to a solar system, we may compare an electron or a positive particle to the centre of a nebula and regard the electron as surrounded by an atmosphere of small particles.

This atmosphere can be distorted by the presence in its neighbourhood of other electrons or positive particles with their atmospheres, and will assume a shape appropriate to its surroundings. Thus the atmosphere round an electron far from other charges would be symmetrical and, if it were distorted, would vibrate about the symmetrical shape. Thus we could have vibrations associated with single electrons or single positively charged particles, even though the electron or particle were itself at rest; for example, without becoming neutralised by the absorption of an electron, a positively electrified hydrogen atom might be able to give out radiation. The possibility of vibrations of an electric field apart from any movement of the charges in the field has not, I think, been sufficiently realised.

These considerations suggest that just as matter is made up of molecules, and molecules are made up of electrons and positive particles, this is not the end of the story; there are still other worlds to conquer, the worlds which build up the electrons and positive particles.

Coal Ash and Clean Coal.¹

IT is the normal view that the incombustible part of coal is not only a useless but even objectionable diluent. At times in the past, chemists, familiar with the theory of contact catalysis of gas reactions, have speculated that the ash constituents might well play an active rôle in the processes of carbonisation and

combustion. None have been more prominent than Dr. Lessing, but his opinions met with no great support. The reactions in question seemed too complex, and no experimental confirmation had been adduced. Even Dr. Lessing himself waited until 1924 before disclosing evidence that inorganic substances altered the course of carbonisation. Since then, however, the subject has aroused greater interest. It is possible now for

¹ Cantor Lectures by Dr. R. Lessing before the Royal Society of Arts, Nov. 23, 30, and Dec. 7, 1925.

Dr. Lessing's ideas to receive independent support. Processes have even been patented for modifying the results of coal carbonisation by means of control of the ash constituents.

In the Fuel Department of the University of Leeds, where the process of gasification of coal has been under experimental study for some years, it was soon observed that the inorganic constituents could not be ignored. They might be incombustible but were not necessarily inert. It was the availability in the West Yorkshire area of seams of coal almost free from ash which made it possible, by the controlled addition of inorganic matter, to investigate the influence of individual compounds on carbonisation. The results exceeded expectations, and it was shown by C. B. Marson and J. W. Cobb that the character of the coke produced was beneficially and extensively modified by the addition of certain substances, especially oxide of iron and sodium carbonate. Certain other oxides examined were apparently inert. Since the publication last year of this paper, further experience has only strengthened their conclusions. There is good ground for hope that a valuable control over the carbonisation process may be secured by means of the ash constituents. Indeed, it is no exaggeration to say that there is to-day no prospect in the distillation of coal more alluring than that offered by this method. Obviously, then, the subject is of great practical interest, especially in connexion with the production of smokeless fuel. It may well be that too much attention has been paid to the possibilities of varying temperatures of carbonisation, and too little to the variation of the character and quantity of the incombustible constituents. This oversight is, however, in the way of being remedied.

It is, however, a condition precedent to the most effective use of this new method of control, that the raw material, coal, shall be adequately clean to begin with. Any coke or smokeless fuel product will have to compete for popular favour with good household coal, which may in the best cases be even so low in ash as 2 per cent. It is, unfortunately for those who set out to provide smokeless fuel, only too true that the

housewife is apt to think more of dirt on the hearth than of smoke leaving the chimney-pot. If the carbonised product is to contain added inorganic matter, as well as the ash originally present, it is obviously essential that the raw coal must be very clean, for the ash content of the coke produced from it will necessarily be higher. Nothing is more important to the popularisation of smokeless fuel than the supply of clean coal. The stigma which rests on coke as a fuel is largely due to a reputation for 'dirtiness,' and the smokeless fuel problem can never be regarded as solved until a product is obtained which will find favour in the drawing-room of the most fastidious householder.

It is, however, essentially a problem for the mining industry, and its solution would give a powerful fillip to the popularisation of carbonised fuel for domestic purposes. The problem implies the identification of seams of coal which lends itself to cleaning, the improvement of cleaning technique, and the installation of plant necessary to turn out a fuel of the desired standard. The consumer would have to pay more for the product, but it would be necessary and possible to demonstrate that he was not a loser. Time, study, and capital would be required to carry these ideas into effect. It is then the more depressing to see the mining industry dissipating energy and resources of all kinds in a barren struggle instead of wrestling with its own more fruitful problems.

Dr. Lessing believes that these objects will be attained, that the carbonising industries "will feel constrained to insist for their raw material on coal containing only a fraction of the proportion of mineral matter which is customary to-day," and "that the provision of such a commodity will be technically possible and commercially profitable, and that it will be of economic advantage both to supplier and user."

The three lectures are, however, not confined to the importance of ash to coal carbonisation. They also traverse the chemistry of coal ash and its origin, the technique of coal cleaning, the economic aspects, and present a valuable survey of the whole subject.

H. J. HODSMAN.

Obituary.

DR. C. W. ELIOT.

AT a luncheon recently given by King's College, London, for the delegates to the Congress of the Universities of the Empire, Principal Barker introduced President Lowell as "the most distinguished permanent academic officer in the English-speaking world." The phrase was happily taken, and its substantive truth dates from Charles William Eliot, whose death on August 22, fuller of honours even than of years, removes the last survivor of the three captains who bridged the incredible gap between the primal 'college' and the contemporary university; the others were Angell (Michigan) and Gilman (Johns Hopkins). They mediated a change wherein sober fact nigh outruns imaginative fiction. Eliot, the most conspicuous, foresaw the unbelievable, and it came true.

Circumstances must conspire with men to produce significant results. Accordingly, Eliot was fortunately born (1834) from the soundest New England stock, and educated at the best New England institutions. After

graduation at Harvard in 1853 he taught mathematics and chemistry in the College and the Medical School for a decade; resided two years in Europe (1863-65), observing the universities shrewdly; returned to occupy the chair of chemistry in the Massachusetts Institute of Technology, where he pioneered for four years. In 1869, after keen opposition, still the subject of piquant legend, he was elected president of Harvard, and launched upon a unique incumbency of forty years. He found the College (1636) with Medical (1782), Divinity (1816), and Law (1817) Schools of a narrow type; he left the foremost American university with a transformed College and a score of other departments.

As the Harvard inscription bears, the New England College was founded "to advance learning and perpetuate it to posterity, dreading to leave an illiterate ministry to the churches"; or, as the Yale charter runs, "fitting youth for public employment, both in church and civil society." In other words, vocation, and one vocation mainly, took precedence over the