Letters to the Editor.

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Electron Collisions with Molecules and Resultant Quantum Losses.

FOR several years I have been conducting experiments on inelastic collisions of electrons with molecules, observing the quantum losses so sustained. The method has been described in the *Proceedings of the Leeds Philosophical Society*, January 1926, p. 65 (Brett and Whiddington), and in the *Philosophical Magazine*, November 1928, p. 899 (Jones and Whiddington). It consists in producing electrons of known speed by accelerating from a hot filament to a grid or slit, thereafter passing them through the gas and then analysing by a magnetic spectrum method. This is a specially powerful method, in that on one photograph is recorded the energies possessed by the electrons over a very wide range.

The kind of spectrum obtained is indicated in Fig. 1,

FIG. 1.

which is only a moderately good example of its kind. In the middle of the strip is the sharp edged 'full velocity' line (corresponding to $eV = \frac{1}{2}mv^2$, where V is the potential applied between filament and grid); on the right and fairly close to the full velocity line are clear indications of lines or heads of lower velocity and corresponding to the losses above mentioned. Still further on the right is a much lower velocity band or wide line, to which I now wish to direct particular attention.

This band is always present in photographs of this kind and it has been a puzzle to explain. Its position is variable, its intensity considerable, usually very much more intense than the full velocity line which it accompanies; occasionally the full velocity line is even absent entirely, or at any rate present very faintly.

Quite recently, a modified form of the apparatus has been in use, the chief change being the introduction of an 'electron gun' of the type employed in the Western Electric oscillograph. Much the same kind of electron spectrum was obtained. This led to a very simple experiment in which the gun was mounted in a glass flask and made to produce (in argon) the luminous beam, which was then deflected by a uniform magnetic field. It was immediately noticed, however, that keeping V fixed and the field constant, the radius of curvature of the beam diminished very rapidly with reduction of pressure.

Fig. 2 shows this effect very clearly. In this photograph the pressure for the least curved beam is about 0.001 mm. and for the most curved beam is about 0.0003 mm., the potential and field being constant.

Calculation of the electron volt velocity of these extreme beams varies, of course, from experiment to experiment, but in a particular case was found to vary from 40 volts to 150 volts, the applied voltage being 260 volts.

It is clear, therefore, that in an 'electron gun' used in this manner the velocity of the beam may

often be much less than that calculated from the simple formula.

One possible explanation I believe may be found in considerations based on the discharge which is probably occurring within the gun. If the electrons forming the luminous beam be supposed to come not from the filament but from the edge of the dark space or its

FIG. 2.

equivalent within the gun, then everything is qualitatively explained. With reduction of pressure, for example, the dark space widens, the source of supply moves nearer to the anode, and the effective eV consequently falls in value.

There are other interesting matters in this connexion which for reasons of brevity must be omitted now, but the examination is being continued further.

R. WHIDDINGTON.

The University, Leeds,
Oct. 23.

The Quantum Theory of the Absorption of Light.

IT is well known that some years ago Smekal introduced the notion of 'double quantum switches' which are responsible for both coherent and incoherent scattering of light. These double switches consist in a transition from a given state of the atom k to some 'intermediate' state n , and back either to k or else to some other state l , the result being the emission of a light quantum $h(\nu - \nu_{lk})$ instead of the absorbed $h\nu$. This theory has since been justified by the new mechanics. Now it seems to me that its implications have not been fully realised, and it is my purpose to apply them to the problem of absorption of light by the conversion of light energy into heat.

The main point is that the intermediate states n of the double switch ($k \rightarrow n \rightarrow l$) have a definite duration, although a much shorter one than that of the two end states. This is contrary to the usual assumption, which does not regard the state n as 'really' occurring, and it involves a temporary breach of the conservation of energy, though this is an objection that can be easily overcome formally. The mechanism of the switch requires the use of two probability coefficients B'_{kn} and the much greater B''_{nk} , which are a generalisation of Einstein's well-known B .

Turning now to our main object, the explanation of absorption, this is produced when the atoms in the state n undergo collisions of the 'second kind', so as to turn their internal energy into heat. The method of perturbations of the quantum theory yields N_n , the number of atoms in state n , as

$$N_n = N_k \frac{E_0^2 |p_{nk}^0|^2}{\hbar^2} \frac{\nu_{nk}^2 + \nu^2}{(\nu_{nk}^2 - \nu^2)^2} \quad (1)$$

where E_0 is the incident electric force and p_{nk}^0 the appropriate matrix element of electric moment. If