an unsteady shock can be determined from an analysis of the trajectories of the smoke particles within the flow. This method compares favourably with others and seems to be slightly better than piezo-electric pressure transducers, for example.

Although the new visualization techniques add further dimensions to flow analysis, the more conventional methods continue to produce important data. This was clearly illustrated by the study of the highly complex structure of the detonation wave described by Dr D. H. Edwards (University of Aberystwyth). From an analysis of schlieren, interferometer and soot-track records he has deduced that although the Chapman-Jouguet model may be adequate for predicting the gross properties of the processes, the extremely intricate wave interactions that occur behind the wave make it impossible to relate detailed structure from one set of conditions to another.

Dr J. H. L. Ranson (Pilkington Bros. Ltd) described the effects of shock propagation through windscreens toughened in certain areas leaving specially selected zones of less tough glass. In practice these shocks might be produced by stones, but in the laboratory small detonators fixed to the windscreen produced the required impact effect. Using a high-speed camera running at 200,000 frames per second it was possible to investigate the reflexion and deflexion of the shocks by the various zones. The intention is to produce windscreens through which there will still be a measure of visibility even after an accident such as that simulated by the detonator.

NEURAL DEVELOPMENT

Visual Stimuli specify Connexions

from our Experimental Psychology Correspondent

ENVIRONMENTAL events can influence the formation of neuronal connexions during development. This is the conclusion of R. M. Gaze, M. J. Keating, G. Székely and L. Beazley (*Proc. Roy. Soc., B*, **175**, 107; 1970). The connexions made by growing neurones during development and regeneration have long been thought to be determined genetically. It now seems that this genetic determinism, which specifies where neurones make connexions in the visual system of the *Xenopus* toad, is accompanied by a means for bringing neurones together if they receive a similar pattern of input from both eyes simultaneously.

This hypothesis, due to Keating (*J. Physiol.*, **198**, 75P; 1968), has been tested by operating on the eyes of embryos before the formation of the retina, or any connexion of the eye with the brain. At this stage, however, the cells destined to develop into the retina were already specified as to their relative positions. In the first type of operation, a developing eye cup was cut in half vertically. The outer (temporal) half was removed and replaced by a nasal half from the opposite eye of another animal. The resulting preparation had one normal and one double-nasal eye. In the second type of operation, one of the larval eyes was rotated by 90 or 180 degrees.

After metamorphosis of the operated animals the projections of the retina onto the brain were mapped, by finding the position of a light in the visual field from which a response could be recorded electrophysiologically in each of a series of standard positions

covering the optic tectum (a primary visual region of the brain in amphibia). In the normal visual system of these species there is a direct projection of each eye to the tectum on the other side of the brain (contralateral). There is also a projection from each eye to the tectum on the same side (ipsilateral), but this connexion is made indirectly through the contralateral projection to the other side. A given tectal position thus corresponds to a single point in visual space as seen by both eyes, and these points on the tectal surface provide an orderly map preserving the spatial relationships of the visual field.

Gaze *et al.* confirmed that in animals with one double-nasal eye, the primary (contralateral) projection is systematically altered. Each part of the eye in the new temporal position projected not in the way that a normal temporal retina would but in a manner appropriate to its origin on the nasal side of the eye. In contrast, every part of the indirect ipsilateral projection of the double-nasal eye was appropriate not to its embryological place of origin but to its new position with respect to the visual field.

Results from animals with one rotated eye followed the same kind of pattern. The map of the rotated eye onto the contralateral projection of the tectum was rotated appropriately to the early embryological co-ordinates of the retina, but inappropriately to the new retinal orientation with respect to the visual field. The ipsilateral projection, however, was not rotated, and was appropriate to the visual field.

In both types of preparation, although the contralateral projection of the normal eye was normal, as expected, the ipsilateral projection was rearranged to fit in with the altered projection of the surgically manipulated eye on the other side. Although the direct contralateral projections of both normal and abnormal eyes seemed to be determined by innate specification according to their original position in the embryo, as far as the indirect ipsilateral connexions were concerned, neurones growing from one tectum to the other appeared to have joined with those directly projecting neurones from the other eye which subserved the same point in visual space. There were thus two ipsilateral connexions in each toad, one from the operated eye with an abnormal first (contralateral) stage and a normal cross-tectal second stage, and another with a normal contralateral stage and abnormal destinations for the fibres of the cross-tectal stage.

Gaze *et al.* claim that "the evidence appears to establish beyond doubt that a functional interaction between the visual inputs from the two eyes, occurring at the tectal level, operates in the establishment of specific neuronal connexions in the ipsilateral visual projection". Any hypothesis of purely genetic determination would predict that neurones subserving the two eyes would come together according to their original embryological position (as happens in the contralateral projection). Instead, for the indirect ipsilateral projection the determining factor is a position in the visual field present during the seeing life of the individual animal. This conclusion seems to indicate that permanent connexions between two neurones can be made on the basis of simultaneous coincidence of input in both. As a principle for understanding development, and as a clue to the possible nature of the neuronal changes underlying learning, this conclusion is of the greatest importance.