water taken up in the autoclave which must be presumed to cause no expansion at all.

When specimens were desorbed up to a temperature of 500° C. by re-heating, they lost weight and contracted, but at about this temperature those that were low-fired (600–900° C.) showed an expansion with loss in weight which was not reversed until much higher temperatures of re-heating were reached. The magnitude of the expansion depended on the original temperature of firing and was only zero at a firing temperature of 950° C., that is, when the anhydrous mica was destroyed. Thus the expansion can be associated with the dehydration of the mica mineral regenerated from the anhydrous form by water sorbed after firing.

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VISUAL EFFECTS OF NON-REDUNDANT STIMULATION

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OPTICAL fields modulated randomly with respect to space and time ('visual noise') appear to offer a powerful new tool for the investigation of visual perceptual processes. In earlier work[1,2] I have described the use of such 'non-redundant' stimuli to shock-excite the visual system during the inspection of regular spatially repetitive patterns, so as to reveal the 'complementary image' that is generated in the visual system by such patterns. The present article is intended as an interim report on a wider range of new visual phenomena revealed by the same technique. It is not concerned with exposure to random fields as a form of 'sensory deprivation', which has interesting effects in a different category[3].

A typical source of 'visual noise' is offered by a de-tuned television receiver with high gain. Most readers will be familiar with the 'snowstorm' effect thus produced on the screen. An alternative, which gives greater flexibility[4] is to make up a ciné film-loop from successive samples of a random distribution of white (or black) spots. (Photographs of sandpaper, or sprinkled confetti, are remarkably adequate). With any such source, the following effects may readily be observed:

(1) *Discontinuity between foveal and peripheral fields.* The normal impression first created on inspection of visual noise is that of a homogeneous field of 'particles' in violent agitation. Individual 'particles' can be followed for a second or more in pseudo-Brownian motion. On prolonged inspection, however (especially if monocular), the foveal area of the field is clearly distinguishable from the remainder. Its motion is more coherent, as of a liquid boiling up from a restricted central source, and its average amplitude of pulsation is greater than that of the peripheral field. As the gaze is directed to different regions of the random stimulus, the 'boiling' foveal area can be clearly identified by the fact that it travels with the eye.

(2) *Monocular versus binocular viewing.* Considerable theoretical interest attaches to the contrast between monocular and binocular excitation. Most subjects spontaneously report that the monocular field appears the more densely populated, and scintillates more rapidly. With two eyes the field is seen as less 'sparkling', the motion more 'oily', the 'particles' fewer and more persistent. On most theories of binocular fusion it would not have been expected that the simultaneous and identical excitation of corresponding retinal areas should reduce the apparent density and frequency of what is perceived.

(3) *Effect of intensity.* One is led to ask whether simply halving or doubling the intensity of stimulation could produce the same effect as changing from binocular to monocular viewing or vice versa. But in fact rather the opposite is the case. At weak intensities the field appears much more 'oily' and is traversed by wriggling, interlocking snake-like shadow-patterns that may each extend over much of its area. At the normal intensity of a television screen, however, a change by a factor of 2 (or more) makes little difference. Binocular fusion here involves clearly more than the central summation of retinal impulses from 'corresponding points'. This is in line with the discovery by Jung[5] and others of separate cortical representations of each retina (in the cat).

(4) *Steady illumination in one eye.* It might be suggested that the occlusion of one eye causes centrifugal feedback, to both retinæ, which enhances the sensitivity of the unoccluded eye. As a partial test of this hypothesis the unused eye can be flooded with uniform illumination adjustable in brightness above or below the average level of the random source. The effect, however, is negligible, and not at all comparable with that of using both eyes to view the source.

(5) *The 'frame-adhesion' effect.* One of the most pleasing effects occurs when a portion of the random field is 'framed' within a movable contour such as the outline of a loop of wire. When the wire frame is moved and followed with the eye, the whole assemblage of 'Brownian particles' within it (and those immediately outside) are unmistakably seen to move with it. If the motion of the frame is rapid and oscillatory, the particles show a kind of inertia, lagging behind and swirling just as if immersed in a fluid.

When, however, a stationary object such as a finger-tip is placed within the framed area, practically the whole is suddenly stabilized, 'adhering' to the finger-tip. If the finger in turn is moved, it appears to be 'pursued' by a swarm of particles.

That the interactions concerned are central, rather than retinal, can be seen by presenting the noise to one eye and the frame to the other, when the effects are much the same, apart from a somewhat more noticeable time-lag in the coupling between frame and noise field.

(6) *Complementary images.* As already reported[1] the effects of superimposing random noise on spatially repetitive patterns are especially striking. When a source of noise is viewed through a transparency such as Fig. 1, the otherwise chaotic disposition of the 'particles' is at once organized into one or several superimposed geometrical figures (the 'complementary image' (ref. 1)) the principal directions of which run at right angles to the lines of the repetitive pattern. A similar but transient 'reorganization' is seen if the random source is viewed alone, immediately after inspection of the repetitive pattern.

The phenomenon is extremely tolerant of the optical definition of the random source. Even with a thin sheet of paper between the pattern and the television screen, the complementary image is clearly visible. An impression of a typical figure complementary to the stimulus of Fig. 1 is shown in Fig. 2. If the stimulus figure is a 'grid' formed by superposing sets of parallel lines at right angles, the complementary image lines run diagonally.

The complementary figures so generated are generally seen in motion. With Fig. 1, for example, the subject typically reports two or more superimposed 'rosettes' of the type of Fig. 2, which may be seen as contra-rotating, or all rotating clockwise or anticlockwise, more or less at will. If Fig. 1 is itself rotated, the complementary image rotates in the opposite direction.

When Fig. 3 is used, a petalloid radial complementary image is seen, with strong radial streaming along the petals. In addition, however, there is a slow and steady rotation of the noise field, with an angular velocity, varying with the radius, of approximately one radian a second. This turns out to be a quite distinct phenomenon, not dependent on spatial repetitiveness ; for if visual noise is viewed through even a single annular aperture, it is still seen to rotate in each direction alternately.

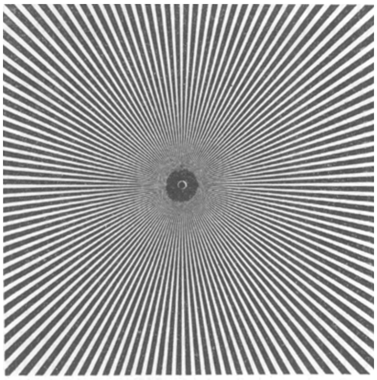

Fig. 1

Fig. 2

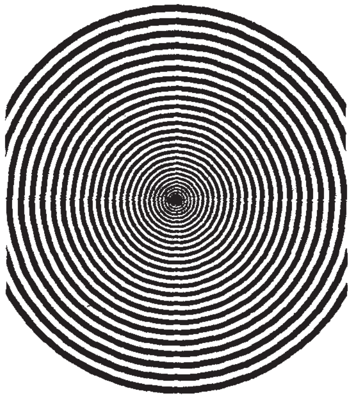

Fig. 3

(7) *Implications.* It is not my purpose here to advance interpretations of the phenomena described, on which we are working at present ; but if they demonstrate anything clearly, it would seem to be the strong synthetic element in perception, which is present even when 'associations' in the usual sense might be expected to be absent. What is seen under excitation by random noise bears only an approximate relation to the stimulus. Instead, even against a blank background, it seems to be a fairly strongly structured synthetic 'imitation'—that is, a distribution of activity matched presumably in respect of certain statistical features, but sufficiently well structured for changes in its position to be readily attributable and easily perceived (Exp. 5). With a background of a regularly periodic nature, the structure seen bears still less resemblance to that of the stimulus.

The foregoing are only samples of the new data revealed by this way of 'shock-exciting' the visual system, which will be discussed more fully elsewhere. The present article is intended mainly to direct attention to the power and potential value of this class of stimulus. In communication engineering, random noise is often used as a 'neutral' test-signal to reveal the characteristic modes of response (resonances and the like) of an information-system. In the study of the visual system it seems clear from the foregoing examples that visual 'noise' offers a tool with a corresponding ability to uncover some characteristic modes of response of perceptual mechanisms. Formally, it can be regarded as the neutral member of a family of stimuli at the extremes of which are stroboscopic illumination (spatially uniform, temporally periodic) and our parallel-line patterns (temporally uniform, spatially periodic). At each of these extremes characteristic responses are also evoked[1,6]; and it can scarcely be doubted that all three classes of phenomenon have something to contribute to our theorizing about perceptual processes.

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