In this issue

Mechanism of vision

We reproduce (**page 686**) the *Academy lecture* given by Adrian Horridge, professor of neurobiology at the Australian National University. He tells us of the various intricate problems connected with the processes of vision and how nature has tried to solve them. Horridge is also a recognized world authority on sailing crafts of the Indonesian islands. His interest in this fascinating field was aroused when he was a scientist on a research ship in the Molluccas. Since then he has visited Indonesia almost every year; and his earlier work as an aircraft engineer in England gave him many insights into the remarkable structural design of ancient canoes and the modes of their fabrication. He is the author of many books and monographs on this subject.

But in the so-called scientific circles his international reputation rests on his researches on vision. He and his group have now become famous for their studies on insect vision and how the visual mechanisms in these creatures are based on relatively simple and elegant processes. The great Hermann von Helmholtz in his book *Physiological Optics* gave us a clear insight into the basic mechanism of insect vision.

Suppose for instance that a person is standing still in thick woods where it is impossible for him to distinguish, except vaguely and roughly in the mass of foliage and branches all around him, what belongs to one tree and what to another, or how far apart the separate trees are, etc; but the moment he begins to move forward, everything disentangles itself and he gets an apperception of the material contents and their relations to each other in space just as if he was looking at a good stereoscopic view of it.

As a background we give some of the basic ideas that Horridge has developed These have been extracted and condensed from his classic papers. Insects do not have the lens accommodation; they do not have binocular vision; insects see nothing when the eye stands still in a stationary world. It is almost certain that their visual neurons are inactive unless there is relative movement. Insects in motion see well. They can measure range and direction only by their own motion and by the contrasting edges of objects. Some insects make horizontal peering movements as an aid to vision. The peering motion generates an apparent velocity of nearby objects relative to the background. The mechanism of vision is based on this 'velocity parallax', which is the discrepancy seen at the edge of an object against a distant background when the eye moves laterally. To extract the third dimension from a two-dimensional retinal image most insects (say bees) cannot rely on the mechanism common to vertebrates (accommodation, binocular vision, etc.). Instead they use apparent sizes of familiar objects (nearer the object the larger is its image), which have been called 'size cues'. They also use 'motion cues'. From these very simple principles derived by a series of meticulous experiments performed in his laboratory Horridge has developed the template theory—how the eye deals with range and direction; the enormous range of light intensity, which varyies by at least seven orders of magnitude (10^{14} photons/cm^2/sec for sunlight to 10^7/cm^2/sec for moonlight); how the eye discriminates patterns; how from temporal derivatives the insect eye retains full spatial resolution; how three billion bits of information per second are processed by parallel computing methods; etc. A most fascinating lecture.

Wave energy

One of the famed beaches of the world is in Kovalam near Trivandrum (Thiruvananthapuram). If, instead of turning right to go to this beach resort, one goes straight, one comes to the beautiful fishing harbour of Vizhinjam (you have to be born in Kerala to get the pronunciation right!). Twenty or thirty years ago, this village fishing harbour had a very large number of beautiful boats and was full of activity, with fishermen hauling in their harvest from the sea and the fishwives sorting them out. There was also a small hutment (run by IMD/NIO/KMD?) which measured throughout the year the amplitude and wavelength of the waves. Four years ago the scene changed—the graceful fishermen and fisherwomen and their elegant boats were still there, the nets were now of nylon and the floats of foam plastic, but there was a large concrete structure (chamber) about 50 ft^3 with an inverted horn in it. This was a project on extracting energy from sea waves undertaken by the Ocean Engineering Department of IIT Madras and funded by the Department of Ocean Development of the Government of India.

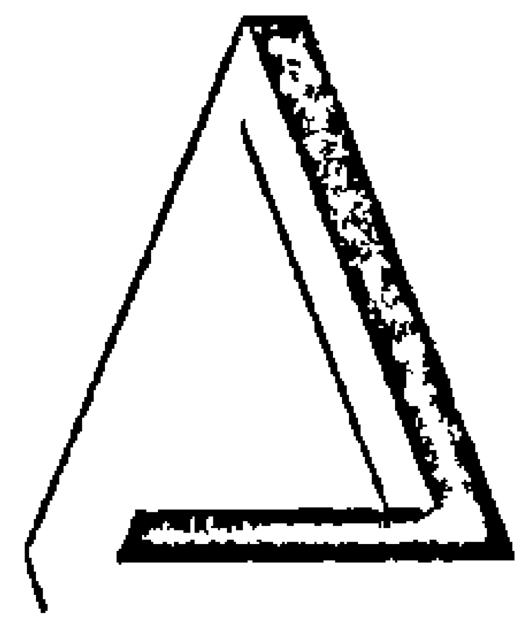
Two years ago your editor heard a talk by a professor of IIT Madras about the effort made by the Madras group to get energy from the sea. The talk ended with the young man telling the audience how there was an unfortunate accident while towing the chamber into the sea and how the monsoon setting in prevented any further action. On listening to this talk we requested this group to write about their valiant experiment, saying that failures are but stepping stones to success.

The waves of the ocean are a very important source of renewable energy. It is available continuously throughout the year. Almost a million billion watts of solar energy falls on the sea of which at least 10^{12} watts are converted to wind, which, in its turn, transfers much of its energy to the sea surface, generating waves. Extracting energy from the waves is much more efficient than getting it directly from the wind as the energy is more concentrated and also because the high variability in wind is considerably smoothened. India has a coastline of 6000 km and it is estimated that we can get at least 5 kW from every metre of this coastline. At Vizhinjam, measurements show that one may even get 13 kW/m. Unfortunately wind energy is not normally competitive in cost with other forms of energy generation. However, the Indian coastline requires a large number of fishing harbours. The group therefore decided that it may be best to have a harbour wall combined with an energy plant inside, with the usual wave breakers made of rubble.

Masuda, the famous Japanese marine engineer, designed the chamber for extraction of energy from sea waves. The air inside the chamber gets pressurized (and depressurized) when the waves enter it. The air coming out of the chamber drives a turbine. Since the air flow will be bidirectional, one would require four valves if a conventional turbine is used, and opening and closing them every 6 to 14 seconds would cause insurmountable operational problems. So the turbine is to have symmetrical aerofoils (as designed by Wells) so that it rotates in the same direction irrespective of the direction of the air flow. The new wave power device, slightly larger than the previous one, is ready. It will be towed into the sea shortly. The sea trial of this magnificent experiment is expected to start in October and we wish the team all success. (See **page 676**)

Artificial intelligence?

It is remarkable how one of the greatest geometers of this century, Roger Penrose, who discovered the singularity in space, became a conversation piece at after-dinner parties. The famous perspective drawing of a triangle (see figure) is shown everywhere where puzzles are a pastime. This triangle drawn by Penrose was published in 1958. It is composed of square beams which rest above each other at right angles. If one followed the various parts of the construction, one is unable to discover any obvious mistake in it. Yet it is an impossible 'whole'. The reason why it *appears* feasible is that changes suddenly occur in the interpretation of the distance between eye and the object.



It is not a too-well-known fact that two of the remarkable drawings by the famous Dutch graphic artist Escher were really inspired by Penrose. One of them is entitled 'Ascending and descending', in which the courtyard is surrounded by a building with a never-ending stairway; the other is 'The waterfall', in which a mill wheel is depicted in motion and the flowing water goes back, as if by magic, to a point where the waterfall began.

Now Penrose has produced a remarkable work which is discussed everywhere, in which he expounds the processes of computation, the wonders of mathematics, and the mysteries of quantum physics. But the book (reviewed **page 711**) is really a daring attack against the proposition that has been popularly propagated that computers really have minds or can develop minds of their own. But, like the proverbial Indian elephant, the book has to be observed and explained by many experts—mathematicians, relativists, quantum physicists, computation whizzes, psychologists, etc.—before the beauty and profundity of what Penrose says is completely understood.