FIG. 2 Electronic pool: with isolated potential barriers, electron trajectories might skip through the obstructions to reach the detector. But certain magnetic fields will give some closed orbits, pinned to one or a few of the barriers.

have been showing up in small-scale transistors. The classical orbit of the carriers can be mapped by resistance measurements. One example is that of electron focusing³, in which electrons injected into a transistor through one small terminal are turned back towards a neighbouring terminal by the Lorentz force. Measuring the current at the exit, one finds peaks when the orbits match the focusing condition $r_c = L/2j$ (where j is some integer, L the terminal separation). With $j=1$, the electron's path between the terminals is a single arc. When j is greater than one, the electron bounces against the side of the device, executing $j-1$ skips before reaching the exit port — the trajectory resembles a billiard ball hopping along the cushion of a sloping snooker table.

When R is measured by probes on either side of a current-carrying channel, it is mainly the Lorentz force that is measured. In large samples, the carriers scatter frequently from randomly situated impurities as they trek across the sample, and this 'Hall' resistance R_H is proportional to the Lorentz force, $R_H = B/ne$ (n is the density of carriers). This is true because the random scattering makes all trajectories tend in the direction of force. In Hall measurements on samples much smaller than the mean-free-path length between scattering events, however, R_H behaves very differently. In fact one can obtain a wide variety of dependences $R_H(B)$ by changing the shape of the Hall probes. Reducing the scale of the probes and main channel to a few hundred nanometres reduces the Hall resistance to $R_H = 0$ for small magnetic fields, because the Lorentz force is not strong enough to bend the electron's trajectory into the voltage probe before it escapes down the channel (Fig. 1a). Placing a mirror at the corner of the voltage and current probe (Fig. 1b), one can force most of the carriers to reflect into the opposite probe so that R_H even has the wrong sign⁴. The dominance of such reflections has led to an instructive analogy between the electrical transport and the game of billiards⁵.

Now Weiss *et al.*¹ have managed to make convincing measurements on sam-

ples indented with regularly spaced holes. The array of holes mimics the potential imposed by crystalline structure (Fig. 2), or in their more fanciful classical metaphor, a pinball machine. The electrons scatter from the potential islands just as they would from impurities (which are present but have much weaker potentials), so that a model of the transport looks rather

like a map of a pinball game. The principal effects of the artificial potential are, first, to reduce the overall mean free path length of the electrons and, second, to provide pinning sites where the cyclotron orbits can get hung up. The first effect adds a constant amount to $R(B)$ and the second leads to peaks of resistance corresponding to the capture of a significant fraction of the electrons in the pinned orbits. At much lower temperature, the quantum-mechanical phase coherence of the electrons spans distances greater than the separation of the dots and one might expect that the resistance could reflect quantum-mechanical behaviour in the imposed 'crystal' potential.

One should not be fooled by the apparent simplicity of the classical rules governing the electron transport: an arbitrarily small change in the incoming trajectory can make a huge difference in the point at which the electron emerges. This critical dependence on the initial trajectory makes the response essentially unpredictable or chaotic in many situations^{6,7}. The use of very-small-scale lithography and very high-quality materials allows the classical motion of electrons in a magnetic field to dominate the resistance even at rather high-energy scales (10^{-2} V), which are well within the range of electronics. Engineers must make allowances for this unusual behaviour in their designs. The physics is quite rich in principle; simple commensuration might give way to chaotic response in some circumstances. □

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Industrial fruit

FRUIT, that essential part of every healthy diet, is the expensive product of an inefficient process. A fruit tree occupies lots of space, takes years to grow, and yields annually a tiny fraction of its weight as fruit, which must then be harvested by hand. Daedalus reckons there has to be a better way.

Plants, he points out, have a remarkably tolerant immune system. It is quite easy to graft a branch from one species of tree onto the stem of another. All that the branch receives from the stem is sap. So DREADCO horticulturalists are now grafting apple branches, plum branches, and so on, not onto other trees, but onto pipes carrying a synthetic sap under pressure. Provided the sap has the right composition, each branch will bear fruit exactly as if it were attached to a tree.

And this is DREADCO's new "Battery Fruit" project. Close-packed rows of fruit-bearing branches, kept at the optimum temperature and illumination in a big windowless building, will be pressurized with synthetic sap from a central source. When ripe, the fruits will be detached mechanically, or possibly chemically by the sudden injection of a shedding-hormone into the sap. A conveyor belt will remove them to the packing station, while the bare branch receives in its sap the correct hormonal signal to start bearing new fruit. Some fruits, like strawberries, will grow without a previous pollination step: but where pollen is needed it will be supplied mechanically. Thus the traditional orchard, with its vast cost in space and time and labour, will be eliminated. Many harvests a year will be obtained. Fruit will be grown intensively and continuously at last.

Organic-husbandry enthusiasts will doubtless denounce battery fruit, like battery chicken, as drab, tasteless and nutritionally impoverished. In fact, it will be extremely healthy. By adding vitamins and minerals to the circulating sap, Daedalus will augment the nutritive value of the final fruit. Even more cunning, he will flavour and perfume the sap with wonderful tastes and smells. Not only will the traditional fruits come from the battery tastier and more appealing than ever; amazing new taste sensations will be possible. A true toffee-apple, a genuine chocolate orange, a tomato tasting of tomato ketchup, will be feasible at last. Bananas redolent of cheese-and-onion, pears made teasingly aromatic with smokey bacon, the pizza-peach, the sausage-strawberry and the hamburger-apple, all will invade the supermarkets. Their flavours will tempt even junk-food addicts, those nutritionally lost souls, into healthier eating.

DAVID JONES