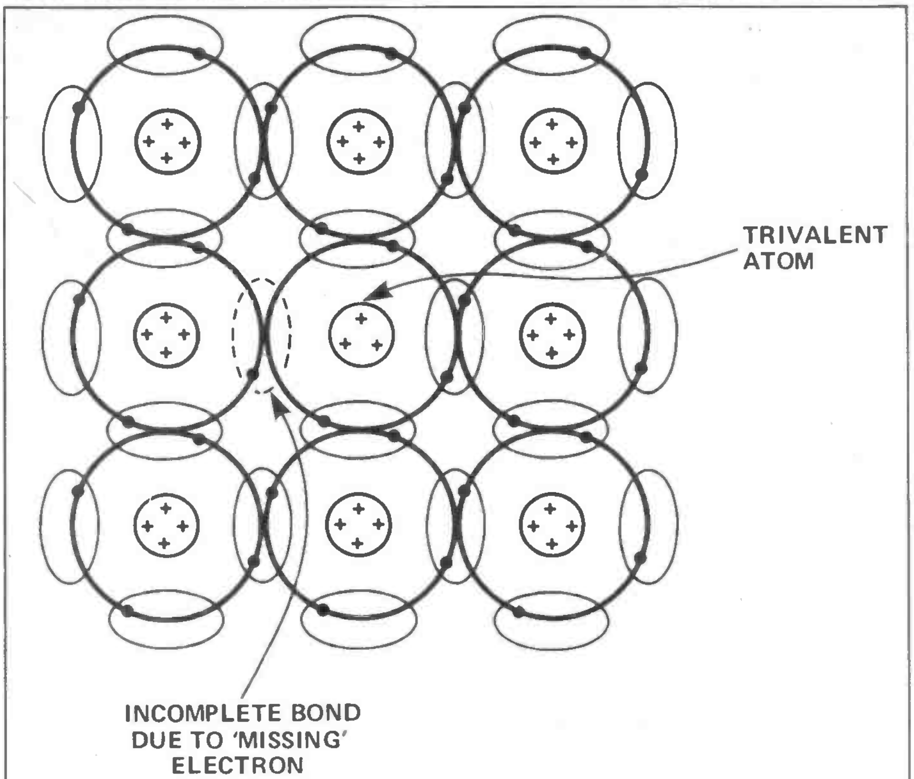

Fig. 4(a) The semiconductor of Fig. 3 is here doped with trivalent (three valency electrons) impurity, such as aluminium, gallium, indium or boron; this makes it p-type semiconductor.

will try to attract a free electron to pair with. The apparently empty space is, in effect, an 'imitiation' hole – it is not a true one in the sense that because it is there it does not mean the atom it is 'part of' has an overall positive charge. In fact if a neighbouring electron is attracted into that empty space the result will be an electron extra in the orbit of one atom (and hence an overall negative charge) while another atom will contain a real 'hole' and hence have an overall positive charge.

However, because the electron of the intrinsic atom requires an electron-pair, it will try to attract a free electron into the pseudo-hole – in other words there is a place ready to accept an electron. Hence the name for this type of impurity is acceptor impurity.

Because the impure material lacks electrons where it would normally expect to have them (in bonded pairs) and because the lack is a negatively charged particle which, if the holes were 'real' would lead to an overall positive charge, the name given to this type of impure material is **p-type**.

In summary: p-type semiconductor material, while remaining electrically neutral, possesses the ability to attract electrons by virtue of the incomplete electron-pairs appearing in the intrinsic material where intrinsic atoms are adjacent to impurity atoms.

N-type Semiconductor Material

If a pentavalent impurity is 'mixed' in with the basic germanium or silicon, the crystal structure becomes equivalent to that shown in **Fig. 4(b)**. As with trivalent impurities the resulting material is still electrically neutral since the number of positive protons exactly balances the number of negative electrons.

In this type of crystal structure there are many 'lost sheep' electrons – that is, electrons that are not pair-bonded, for which there are no intrinsic electrons (i.e. electrons of the intrinsic atoms) requiring pairs, and which, because they belong to impurity atoms, are not as tightly bound to the nucleus as the intrinsic electrons. In fact these 'lost sheep' can be detached from their parent atoms even by the amount of thermal energy available at room temperature. They can then wander at will through the crystal lattice. Because of this, the n-type material appears to possess extra electrons, or apparently 'spare' electrons. Hence it appears to have an overall negative charge although it is, in fact, electrically neutral. Because it appears to have electrons to 'donate', it is known as a **donor** impurity. Because it appears to have an overall negative charge it is known as **n-type**.

In summary: n-type semiconductor material, while remaining electrically neutral, possesses the ability to 'give away' electrons by virtue of the fact that it contains easily detachable (by comparison with the electrons of the intrinsic material) electrons which are not needed for pair-bonding.

Fig. 4(b) Here, the semiconductor of Fig. 3 is doped with pentavalent (five valency electrons) impurity, such as arsenic, antimony or phosphorus; this makes it n-type semiconductor.