Solid-State Devices

Solid-state devices began replacing vacuum tube electron control valves in the late 1950s. Their long life, reliability, and resilience in harsh environments make them ideal for use in avionics.

Semiconductors

The key to solid-state electronic devices is the electrical behavior of semiconductors. To understand semiconductors, a review of what makes a material an insulator or a conductor follows. Then, an explanation for how materials of limited conductivity are constructed and some of their many uses is explained. Semiconductor devices are the building blocks of modern electronics and avionics.

An atom of any material has a characteristic number of electrons orbiting the nucleus of the atom. The arrangement of the electrons occurs in somewhat orderly orbits called rings or shells. The closest shell to the nucleus can only contain two electrons. If the atom has more than two electrons, they are found in the next orbital shell away from the nucleus. This second shell can only hold eight electrons. If the atom has more than eight electrons, they orbit in a third shell farther out from the nucleus. This third shell is filled with eight electrons and then a fourth shell starts to fill if the element still has more electrons. However, when the fourth shell contains eight electrons, the number of electrons in the third shell begins to increase again until a maximum of 18 is reached. *[Figure 11-13]*

The outer most orbital shell of any atom's electrons is called the valence shell. The number of electrons in the valence shell determines the chemical properties of the material. When the valence shell has the maximum number of electrons, it is complete, and the electrons tend to be bound strongly to the nucleus. Materials with this characteristic are chemically stable. It takes a large amount of force to move the electrons in this situation from one atom valence shell to that of another. Since the movement of electrons is called electric current, substances with complete valence shells are known as good insulators because they resist the flow of electrons (electricity). *[Figure 11-14]*

In atoms with an incomplete valence shell, that is, those without the maximum number of electrons in their valence shell, the electrons are bound less strongly to the nucleus.

Shell or Orbit Number	1	2	3	4	5
Maximum number of electrons	2	8	18	32	50

Figure 11-13. *Maximum number of electrons in each orbital shell of an atom.*

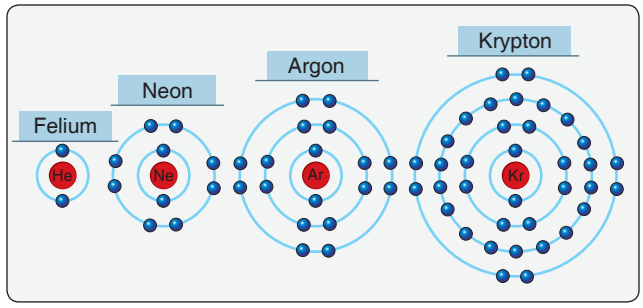

Figure 11-14. *Elements with full valence shells are good insulators. Most insulators used in aviation are compounds of two or more elements that share electrons to fill their valence shells.*

The material is chemically disposed to combine with other materials or other identical atoms to fill in the unstable valence configuration and bring the number of electrons in the valence shell to maximum. Two or more substances may share the electrons in their valence shells and form a covalent bond. A covalent bond is the method by which atoms complete their valence shells by sharing valence electrons with other atoms.

Electrons in incomplete valence shells may also move freely from valence shell to valence shell of different atoms or compounds. In this case, these are known as free electrons. As stated, the movement of electrons is known as electric current or current flow. When electrons move freely from atom to atom or compound to compound, the substance is known as a conductor. *[Figure 11-15]*

Not all materials are pure elements, that is, substances made up of one kind of atom. Compounds occur when two or more different types of atoms combine. They create a new substance with different characteristics than any of the component elements. When compounds form, valence shells and their maximum number of electrons remain the rule of physics. The new compound molecule may either share electrons to fill the valence shell or free electrons may exist to make it a good conductor.

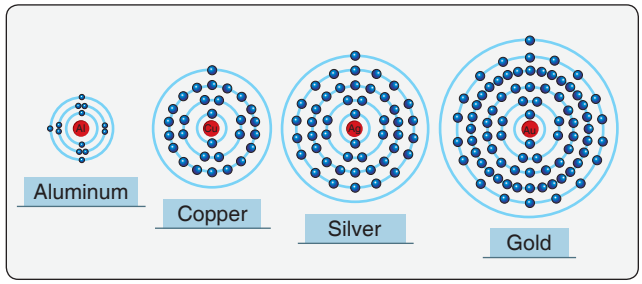

Figure 11-15. *The valence shells of elements that are common conductors have one (or three) electrons.*