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SOLAR BATTERIES OF THE FUTURE

By

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SOLAR BATTERIES OF THE FUTURE

M. Koltun, Engineer

The Draft Program of our party has placed before Science the task of developing methods of converting various forms of energy, including solar energy, into electrical energy. Many laboratory collectives are now at work on this problem. This article is concerned with how to convert helioenergetics into an independent and important technological field. Outstanding scientists of the world, including Frederic Joliot-Curie, feel that helioenergetics will be put on an equal footing with the [illegible] of atomic energy. But in this connection scientists await further research. And that is the subject of this article.

A solar battery is like a magic wand which gives life to cosmic ships. Intelligent instruments begin to tell man about the secrets of space only after an electric current is flowing through their "veins." And the solar battery is responsible for this phenomenon. The direct conversion of "free-of-charge" energy of sunlight into electrical energy more convenient for instruments, the practically endless lifetime of service, the high resistance to every type of shock-all of this makes solar batteries irreplaceable for flights into outer space and even for many earthly endeavors.

Solar batteries already occupy an important place among the various sources of electricity. What prospects do they have for the future? In 1954 the efficiency of solar batteries was 6%, while in 1960 this figure rose to 14%. This efficiency, which indicates what portion of the sunlight falling on the battery is converted into electrical current, may be increased even further. However, it does have a specific theoretical limit. For silicon batteries this is 22%.

Does the design of the solar battery permit us to overcome this limit? Recent scientific investigations not only answer this question in the affirmative, but also indicate original design possibilities in this direction. And that is the subject of this article.

Is Silicon the Best?

How should we select the material for a solar battery? To understand this, we must acquaint ourselves with yet another characteristic, i.e., the magnitude of the barier zone of the semiconductor material. This long name is easy enough to understand. It indicates the amount of energy which must be imparted to an electron in a semiconductor crystal in order to break it away from "its own " atom and be transferred into a mobile and excited, but very useful family of free electrons. If we want to graphically represent this, we should draw a long empty ditch which the electron must "jump across" in order to reach freedom. It is this ditch which is called the barier zone, and its width determines the amount of energy necessary to make the electron work for us. This energy is measured in units call electron volts.

Each electron leaving the atom leaves a positive charge in its place, or a so-called "hole." The formation of the free electron is the first and most important moment in the operation of the solar battery. After this we already have two kinds of charge, positive and negative, and we need only place them at a sufficient distance from each other for them to reach their poles without hindrance. It is clear that the greater the number of free electrons produced, the higher will be the efficiency of the battery.

Penetrating to the depths of the crystal, portions of the solar energy, i.e., quanta, can force the electron to break away from the atom. But there are quanta with the most varied energies in the solar spectrum. For which of them should the semiconductor be selected? Naturally it is more advantageous to use the energy of quanta of the visible part of the spectrum, since they constitute the largest componentin solar radiation. Calculations indicate that these quanta can be captured more completely than others by a semiconductor with a barier zone that has a "width" of 1.5 electron volts.

When the first solar batteries were produced there was no material which could satisfy this condition better than silicon. But the "width" of the barier zone of silicon is only 1.2 electron volts. In recent years a number of artificially produced semiconductors have appeared with a barier zonesignificantly closer to the above-indicated theoretical value. These semiconductors have been called intermetallic. Some of these are, for example, cadmium sulfide, cadmium telluride, indium phosphide, and others. From solar batteries made from these materials, we can anticipate an efficiency limit of the order of twenty-five percent. But the increase in efficiency of three percent does not satisfy these scientists and, of course, they did not stop at that point.

Mastering the Barier Zone

We have already said that it is most convenient to use the energy of the visible part of the solar spectrum for the operation of solar batteries. What effect does ultraviolet and infrared radiation have? The former imparts to electrons of a solid such a great amount of energy that they jump across the barier zone at a very high velocity, they collide with atoms of the crystal lattice and transmit their energy to these atoms in the form of heat. In contrast to this there is simply not enough energy from infrared radiation for the electron to accomplish its trip. This in itself forces us to conclude that in order to most effectively utilize ultraviolet radiation it is necessary to expand the barier zone, while for indrared radiation we must substantially decrease its width. These conditions would seem to be mutually exclusive but, as it turns out, they can be reconciled.

Shouldn't we use a semiconductor with a sufficiently wide barier zone appropriate for ultraviolet quanta, while for the remaining quanta shouldn't we make special "supports" on which they can rest while crossing the "ditch" of the barier zone? For the visible radiation we will probably need one "support" in the middle of the "ditch", for the infrared we will need two at equal distances from the "shores". With this "refined" barier zone, all the quanta will be useful. The colored insert shows how "all roads are open" to the extent that we "refine" the forbidden zone in front of the electron. The solar battery made from this improved material has been named multitransitional. The role of the "support" will be carried out by admixtures of various materials, only they must be introduced into the starting material very carefully so that they will "get stuck" at carefully predetermined levels in the forbidden zone.

Calculations indicate that the surface of this battery more completely utilizes sunlight than the surface of an ordinary battery. The efficiency limit here is increased to 65%! Only experiment can tell now.

"Multilevel" Battery

There is yet another idea, the realization of which promises substantial improvement in solar batteries. If the semiconductor using ultraviolet radiation is transparent to visible or infrared rays, then having placed under them a battery operating in these still unused regions of the spectra, we will "squeeze out" a small amount of electrical energy from the sun beam. If the lower battery converts only the visible light and is transparent to infrared radiation, then we may place even lower the third battery "being fed" by indrared radiation. Having systematically broken down the solar spectrum into parts, we use them all without exception.

Of course, the future of the multilayer battery depends on the successful development of new material, but even those semiconductors now known to us enable us to begin the practical fulfillment of this idea. The following fact well-known in optics may serve as confirmation. Polished silicon, used in the preparation of solar batteries which operate in the visible region of the spectrum, lets pass more than 50% of the infrared radiation. This radiation may be effectively used by batteries made from germanium.

The calculations made indicated that "the layer pie" of three batteries will have a theorectical efficiency of 40%. Of course there will be difficulties in practice, but when prospects are so alluring, we must press on!

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