'We grew up confident we could solve any problem'

In a recent interview, Dr. Robert J. Moon explained the method by which he came to an exciting discovery regarding the structure of the atom. He began the interview with a backward look at his own development that we thought would be of special interest to EIR *readers, because it is a valuable contribution to the ongoing debate today, about how best to educate a new generation of scientists.*

Dr. Moon was one of the pioneers in the development of nuclear energy. Before World War II, he developed the most advanced cyclotron then known, and he had planned to build a synchrotron. He was prevented from carrying through on this by the outbreak of war. After the war he became intensely interested in research in neurophysiology, and was involved in the development of the CAT scan. He is a professor emeritus at the University of Chicago, and the editor-in-chief of the International Journal of Fusion Energy.

Although Dr. Moon has been an experimentalist throughout his working life, he based his doctoral thesis on the theoretical work of the quantum physicist, Louis de Broglie. In his latest work, he has again taken up the battle, begun by Ernst Schrödinger, Albert Einstein, and Louis de Broglie, against the acausal theory of physics promulgated by Niels Bohr, which is still the hegemonic view today.

Dr. Moon has applied the geometrical method of Nicolaus of Cusa and Johannes Kepler, for unraveling the nucleus of the atom. Thus, his revolutionary new approach is directly located in the best traditions of mathematical physics, and he brings to it rich insights from his decades of experimental work.

Kepler discovered that by embedding the Platonic solids, one within the other, he could closely approximate the average distance of the orbits of the solar system, from the Sun. As he pointed out, he was using this device to identify the fact that the planets were essentially governed by the Golden Mean ratio—$(1 + \sqrt{5}) \div 2$—since this is the ratio which governs the internal relationships of the Platonic solids, one to the other. Dr. Moon has used a similar approach to discover how the nuclei of the atoms which make up the elements of the periodic table are organized.

We print below Part 1 of an interview with Dr. Moon conducted by Carol White. Part 2 will appear in the next issue of Executive Intelligence Review.

White: Dr. Moon, we wanted to interview you about your exciting new theory about the structure of the atomic nucleus, but first, can you tell our readers how you came to make this discovery?

Moon: This goes back a long way. I was born some time ago, Feb. 14, 1911, in Springfield, Missouri, when Halley's Comet was about. My mother said she showed it to me. I don't remember that, but I found particular joy in studying Halley's Comet last year. It was very intriguing, as anything of this sort is. So I guess I would say that I was born into this world, and it is an exciting world—a world of many challenges.

White: In your new discovery you go back to the method of Kepler, do you not? Were you led to this by your love of astronomy?

Moon: That was not exactly what I had in mind. Astronomy has always been a love of mine. Any true scientist is fascinated to try to unravel this living history of our universe, but I was led to my theory more directly from my work in developing the fission reactor.

White: Do you consider that you had more or fewer advantages in your boyhood, than young people have today? You were brought up on a farm were you not?

Moon: Yes, my father was a lawyer and moved the family to a farm in the outskirts of Springfield when I was eight years old. I found it to be a very stimulating environment, but I think life is just as exciting today. I should say, that all the way through, I have been running into various exciting things to do.

When I was a boy, we had four cars and we lived on 10 acres, out in the country. We had a pig apiece and a cow apiece, each one of us four boys, my three brothers and I. That might not seem so exciting to some, but it was good training for us.

We were busy from morning to night: Milk the cows, separate the cream, and so on, but we did it. Those were the days when you put the cream in a can and left it about 600 feet from the house—on the road. The milk company would come and pick up the cream and leave the can. No one would steal it. That was very interesting. Right up there on the road, we left a nice five-gallon can of cream and no one stole it. Good cream it was, from Jersey cows. We boys had the job of separating the cream. It was done by hand with a Delavaleeter separator.

This was the sort of thing that I grew up with. There were automobiles to repair, batteries to rebuild, generators to rewind, a lathe to turn wood. I built my own lathe to do woodcutting. We had a lot of trees on the farm and we would cut them down and turn them into lamps and things like that. All of these things were a lot of fun.

Of course, when I was growing up, electricity was first coming into general use. When I was still quite young, I became fascinated with the problem of understanding what made the front-door buzzer work. This raised one of the must fundamental laws of physics, Faraday's law of induction. It is this law which makes the application of electricity possible, even today.

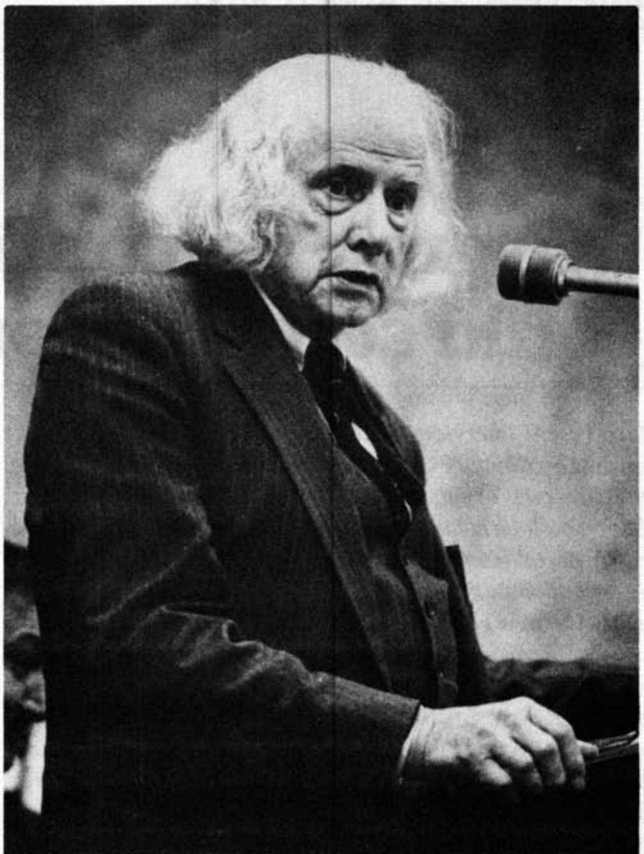
In 1917, at the age of six, I first came upon the idea of a transformer. My aunt had a doorbell buzzer which was connected to a battery—two dry cells in series—and I used it to help her change the battery. One day I saw a bell-ringing transformer in a shop window that was hooked up to a transformer. This was a completely new idea to me.

I already understood Ohm's law, but I did not yet know about Faraday's law. If a buzzer were attached to a normal electric circuit, at 110 volts, it would quickly burn itself out; therefore, it was necessary to use a transformer to reduce the voltage to six volts.

I was fascinated by that buzzer, and with my child's mind I tried to create the concept of a transformer. I understood that the problem was to reduce the current. With my child's mind, I first tried to create the concept of a transformer. At first I designed a series of relays to do the job. I knew that I had to reduce the voltage of the household current about 20 times.

How does a transformer work? That was the question as a child, that I first tried to figure out. Finally, I discovered the existence of things such as impedance, particularly reactive impedance, which doesn't use any energy. The current is made to travel through the reactive impedance, which is created by a coil, around an iron core. This creates a magnetic field. By raising or lowering the current in the coil, the magnetic field strength is changed. An electric current will be induced in a secondary coil, its strength will depend upon the ratio of the number of windings of the first to the second coil, and the change of flux in the primary current.

The principle of the transformer comes from the ratio of the number of coils in the primary wire, compared to the number of coils in the secondary: The ratio of the turns produces the reduction of the voltage. For example, a reduction from 120 volts down to 6 volts, would be a ratio of 20-to-1. That would be the ratio of the number of turns from one coil to the next.


Philip Ulanowsky

Dr. Robert Moon

After figuring out the principle by which a door buzzer operates, I became fascinated with transformers. I began building them, and my next effort was to use a transformer to burn lead. It was necessary to get a very high current at a low voltage.

In a certain sense, this early work of mine ties directly into my most recent area of work. I was beginning to study the notion of reactive impedance.

White: Could you please tell us what you mean by reactive impedance?

Moon: As a child I had assumed that the only variable which I could adjust in order to increase resistance was to decrease the load on a circuit, thereby increasing the flow of current and reducing its voltage. Once I was introduced to Faraday's law, I not only gained flexibility in dealing with this problem, but I began to consider how this principle could be used to transform and store energy with minimal dissipation. In this instance, the coil windings acted without any of the loss of energy which occurs through resistance.

Throughout my boyhood I was led to this kind of exploration, taking the simple things around me as a jumping-off point for fashioning my own experiments. Electricity was particularly exciting to me, because it was just taking the place of gas, gas lights. Also the carbon light began to disappear, and the incandescent filament began to take its place. Automobiles began to come.

White: How old were you when you began your experiments with transformers?
Moon: I was also interested in automobiles. In 1916, we had an Overland. I had the problem of repairing it in the middle of the Jordan River—really a creek. We didn't have bridges then, so we had to drive over the gravel. The car simply stopped in the middle of the creek.

My father went to get some help somewhere, to find a farmer with a telephone. Of course, there weren't too many telephones in those days. Before he got back, I decided that I had better look into the problem, so I began to analyze it.

I turned the headlights on and found that there were no lights, so I decided it must be electrical. I began to explore and found that one of the battery connections was loose. I cleaned it up and put it back on. The lights went on and my father came back. He hadn't found a phone, so I said, "I think the car will go." And it did.

White: How old were you then?
Moon: I was about 5 years old. Well, anyway, these were the things I ran into, the challenges. Every young person faces the same potential sort of challenges, because we are born into a changing world. We want to be able to provide for a growing population around the world, and so, we can not simply stick on the farm, or rely on existing energy supplies. If we do, we face the problem of running out of the resources necessary to support everybody adequately.

This is the same kind of problem we faced when I was a boy. Farming as we knew it then was changing. U.S. farms today are major scientific enterprises. If we are not to have famine elsewhere in the world, then farmers must get away from the idea of just living on a farm and relying on the weather to produce the food, and so on.

A farm is a great place for a boy to grow up in, but I believe that the growth of cities is very important to the growth of our civilization. Even in American farms, when I was growing up, you didn't know if you were going to starve or have an abundance. It is out of cities that the technology which has transformed American agriculture was developed. A man working in a city can produce the ideas which are necessary to help increase farm production. One example of this, was the electrification of milk production—which goes back to Faraday's discovery of induction.

I think we are still in that same period today, where we face the need to apply the scientific method to increase productivity. I was not so different from other children of my day. We Americans grew up then confident that we could solve problems. It makes me very unhappy today, when I see children being taught to give up on life, being taught that we cannot possibly feed and provide for a growing world population. Such pessimism destroys the kind of initiative that was common to my generation of young people.

White: It's particularly worrying, isn't it, when we see the decaying condition of our cities today.
Moon: Yes. Recently, we haven't made a lot of tractors, have we? It seems somehow that we are not making many tractors today, and yet we need farming. We would not want to have the population cut down by hunger, do we, and yet it looks like some people have that idea.

White: Getting back to your own development, can you tell us about your schooling?
Moon: I went to college in my hometown. It was very interesting, because I was able to do a lot of things on my own, which, more than likely, would not have been possible in a larger college. While I was there, I built a 10 watt radio transmitter. I also maintained my interest in electricity. We had a good electrostatic generator at the college, and I used it to create differently shaped sparks, which I then photographed.

This freedom to experiment in a laboratory is an essential part of a young scientist's education. You can't learn to be a scientist by passively taking in what someone else accomplished. The exciting thing is to define a problem, and then develop the tools which you need to tackle it. That's why my early experience in our farm machine shop was so important to me. Every child should be given a similar kind of opportunity even before he or she enters college.

I would urge college students today, not to get dependent upon computers to do their experiments for them. Even in a larger college setting, there is opportunity to get access to a laboratory for individual experiments. The trick with a physics department or a chemistry department or a biochemistry department, if you want to do a few extra experiments on your own, is to locate equipment that hasn't been used; there's usually a lot of that around.

Anyway that's what I was committed to do. In my hometown college, there was a lot of equipment in a storeroom not being used. That was a great thing for me. Luckily, the laboratory space in the afternoons was all mine. I could use any of the equipment and do any experiments I wanted to do. So it was a lot of fun. These are things I think that every child deserves, and they are also important for the leisure-time activities of adults.

White: You went to college in the 1920s. What were the important scientific issues then?
Moon: I graduated from college in 1930. Fusion energy was important then. People today tend to think that fusion energy was a by-product of getting the hydrogen bomb, but that isn't so. Already in the twenties, we understood that the stars were

fusion energy generators.

The thing that was going on, that made scientific work particularly exciting for me, was very much connected with fusion. This was right before the Depression, and there was a lot of talk about our being on the brink of a new millennium, a thousand years of peace and prosperity in which there would not be any sickness, and so on. This led me to wonder what would be the energy source to fuel this prosperity over the millennium.

We knew about the heat of the stars at that time, despite the fact that physics had not yet advanced to its present knowledge. The chemists had gone far enough. By comparing the molecular weights of hydrogen and helium, they had determined that four hydrogen atoms went together to form helium. This would produce quite an excess of mass, which could be used to make the energy which is found in the heat of the stars.

The fusion of hydrogen atoms to form helium was also shown by astronomers, who found that old stars had a lot of helium and little hydrogen, while the young stars had a lot of hydrogen and little helium. So, therefore, the process was hydrogen going to helium and producing energy, a nuclear fusion process. That's what our Sun is and was, I guess, from the very beginning, a massive fusion reactor.

Knowing that that process occurred in the stars, immediately suggested the possibility of achieving fusion here on Earth, and using it as a source of energy to fuel production, and so on. So, I guess that was one of the big callings that I had, as I began to plan my future as a scientist. That seemed something I had to do—tame fusion power.

White: What led you to chose the University of Chicago for your further studies?

Moon: I know many people who apply to three or four colleges to get admitted. They get into two or three of them, and then they finally decide where to go. For me it was a very much simpler process. I began reading the scientific literature. And when you read the literature, you find out where the work is being done, what you are interested in. So I went up to the University of Chicago because Prof. William Harkins was there. He published quite a bit on the neutron, though they didn't call it the neutron then. In 1917, he had written a whole series of papers on it. I still have practically all of his papers.

That led me to the University of Chicago, because Harkins was a physical chemist at the university. I came to the physics department, and said: "Here I am." I already had in mind a design for a fusion energy experiment.

My idea was to direct electron beams onto proton beams, pulse a magnetic field, and condense electrons onto protons. I expected to get helium. That was the experiment which I wanted to do for my doctorate.

But I had to contend with the entrenched bias of the physics community. Since the renowned British physicist, Rutherford, who had discovered the nucleus in the atom, said that there was nothing new to be learned from nuclear physics, that was the revealed truth of the time. So, as far as the University of Chicago physics department was concerned, that was that. It turned out that I was the third person to be summarily turned down by the physics department. The others were Robert Milliken in 1920 and Sam Allison in 1925. They went to work directly with Harkins instead. When I came along in 1930, I got the same response. They were pretty certain about Rutherford's edict.

Harkins actually worked for the chemistry department, so I switched over to there, and Harkins took me right away. We started building equipment. I wanted to do the fusion work and had to get some equipment for it.

But I changed my plan, because while I was there, another revolutionary discovery in physics took place. It was well established that a wave behaved like a particle on occasion, but now I learned of a particle beam behaving like a wave. The French scientist, Prince Louis de Broglie, who had developed this exciting discovery in his doctoral thesis, had said that an electron could be a wave, that any particle could become a wave. At the fifth Solvay Congress in 1927, he had presented the second solution to the Schrödinger equation. I was very much interested in that. (This second solution very much later turned out to be the quantum potential, which was rediscovered by David Bohm some years later, about 1951.)

White: Can you explain how the wave can behave like a particle a bit more?

Moon: This had been seen previously in the photoelectric effect. If radiation is directed to a metal, the metal can be made to emit electrons. Contrary to intuition, however, the speed of the electron will be a function, not of the brightness of the radiation (its amplitude), but of its frequency (minus the contact potential of the metal). This is expressed by stating that the energy is equal to the frequency times Planck's constant of action.

In Chicago, I worked on replicating a similar experiment, in which an electron beam was passed, accelerated through a medium, which was then made to emit radiation. This was the Franck-Hertz experiment, which had been done in Germany. The experiment requires an evacuated chamber to be filled with mercury vapor. A cathode emitting electrons is placed inside the chamber, and the electrons are accelerated through the mercury vapor in which an electric field is maintained. The electrons keep gaining in energy until they reach a certain voltage, when two things occur. There is a sudden drop in the current collected by the anode; and light is emitted from the mercury vapor. That light is the beautiful resonance line, the 2735 resonance line of mercury [2735 Angstroms or 0.2735 microns].

It is a very intense line. If you look it up in the spectrographic tables you will see how intense it is—about 20,000. This immediately shows the relationship between the energy of the electron [voltage] and the frequency [wavelength] of the mercury resonance line, $E = h\nu$, where E is the energy, h is Planck's constant for the smallest increment of action on the subatomic scale, and ν is the frequency in Hertz (cycles per second) of the emitted radiation.

This gives a fairly good determination of Planck's constant, h. Looking back on it, this Frank-Hertz experiment was one of the precursors to the development of the laser, although of course, we didn't know this at the time.

This was what was going on during the 1920s, which led to great excitement: The quantization of action on a subatomic scale as represented by Planck's constant and its measurement in the Franck-Hertz experiments.

In general it takes a long time to build good experimental equipment. Besides these basic experiments, I ended up building a 50-inch cyclotron, the Chicago cyclotron, which weighed about 50 tons altogether. This was the first scientifically engineered and fully designed cyclotron, which was built in the early 1930s. This was a superior machine to the one which Ernest Lawrence had at [the University of California at] Berkeley.

White: What happened to your plans to study fusion energy?

Moon: I decided to study the diffraction patterns created by electrons, in the surface of oleic acid. [This acid is made by purifying olive oil in a vacuum distiller over a period of several weeks.] I was trying to observe the wave properties of particles, which de Broglie had identified. I was very excited to realize that rather than existing as isolated particles, every electron communicated with every other.

De Broglie's work raises very profound philosophical questions, because it is necessary to account for the fact that electrons traveling through a narrow opening, a slit, interact with each other—as waves—even when this would apparently not be possible. For example, when one electron follows the other with a time interval of an hour between, still they "interfere" with each other, so that the first electron exhibits diffraction rings. It appears to know and react to the existence of the second electron.

White: Clearly, discrete space and time as we perceive it does not exist, or at least, it is not the realm in which causal action takes place in the universe.

Moon: I decided to devote my doctoral thesis to carrying out more delicate experiments with electron diffraction, based on the theories of de Broglie. I studied the electron diffraction of the surface of liquids with a very low-energy electron beam—less than 50 electron volts. With electron diffraction, I was able to "see" the structure of liquid surfaces. In fact, I was able to find the structure of molecules that way.

These developments relate directly to other exciting things, more recent developments, which in turn led me to the realization of my model.

To be continued.