FIFTY YEARS AGO I joined the student branch of
the Institute of Radio Engineers (now the IEEE)
on the Cornell campus. If my memory serves me
right, I think I organized the chapter. Thus, I be-
came an engineer, or so my classmates were labeled
by the rest of the student body. I immediately I was
immersed in a continuing philosophical change which is
still going on 50 years later.

Nearly all in our class were older men in their twen-
ties; nearly all were G.I.s who had been radar or radio
technicians in the services. My only honor upon gradu-
ation was that I had more kids than anyone in the class!
We thought engineering was either motors and genera-
tors, or transmitters and antennas. We had no other op-
tions. But Cornell was building the predecessor of the
Arecibo Radio Telescope and needed the
soldering expertise of us ex-G.I.s to
build the receivers. So we found out
that engineering was radio astronomy
and Boltzman's Constant, and that space
had noise. I have always thought that
it was wonderful that Cornell made it
possible for undergraduate engineers to
participate in this cutting edge new sci-
ence. (Shades of Vladimir Karapetov.)

But change didn't stop there. A cross
the hall in Franklin Annex was a grad
student measuring the blood pressure in rats by
measuring the change in the
diameter (electrical impedance) of the
tail as a pulse of blood came down the artery. When the
grad student got his master's degree, he left for N.I.H., and
I got his job. So I found out that engineering was elec-
tronic plethysmography and Pavlovian psychology. (Very
useful when, 10 years later, I got the opportunity to build
the amplifiers that went on SAM, the first monkey to fly
in the U. S. space program.)

Then a couple of brain surgeons from Boston came to
Cornell on sabbatical doing research on some of our ani-
mals. They carried their lunches in brown paper bags, as
I did, and we often sat out in the I thaca sun, talking shop.
They taught me about complete heart block, a condition in
which a nerve in the heart stops functioning, resulting
in a slow heart beat. I knew I could fix it, but not with the
vacuum tubes and storage batteries we had at the time.

From Cornell came another change, to Cornell Aero-
nautical Laboratory in Buffalo, where I found that engi-
neering was true airspeed, relative air density, and ram
pressure. Then a big change — as we put our first tran-
sistors into a helicopter low-airspeed indicator. We cut its
weight from 50 pounds down to five pounds and doubled
its sensitivity. We drastically reduced slip-ring noise by
putting a transistor amplifier out at the end of the heli-
copter blade, spinning around at 300 G's. U nheard of with
vacuum tubes, but a cinch with transistors. A good deal,
even with the silicon transistors at $90 each!

If transistors can do that, what about complete heart
block? Now engineering became heart-tissue impedance,
battery chemistry, and something we named electrochemi-
cal polarization of physiological electrodes. This says that
electricity flows through metals by electron flow, but
through fluids and tissue by ion flow. To get an ion from
an electrode you need a chemical reaction. That reaction
takes place within a micron of the surface of the metal. It
is a different reaction at the anode than at the cathode,
and the reaction itself is a function of the electrode metal
you use. Thus, the same pacemaker
driving the same heart, using four dif-
ferent electrode metals, may go through
four different books of electrochemistry.
The principal reaction on platinum is the
modulation of an adsorbed layer of
monatomic oxygen, which makes the in-
terface look like a capacitor. On a stain-
less steel anode, it can be a corrosion
reaction; not very desirable in a heart
electrode! In 1983 I wrote a book on 25
years of pacemaking and found that en-
ergineering is technical writing and itself
involves change, from a pencil to a word
processor. But I guess the world is leav-
ing me behind, because I still form my first drafts in pencil.

So what are the changes in store for engineering as the
next millennium approaches? Conceptually, I see all the
 sciences coalescing into one. Strangely enough, I see that
one as molecular biology.

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Wilson Greatbatch, New York Nu ’50, P.E., is a biomedical engineer with Greatbatch Gen Aid Ltd. in Akron, NY. He is also an adjunct professor of engineering at Cornell University and SUNY at Buffalo.

The bent of Tau Beta Pi

So 50 years of engineering has involved many changes. The enjoyable part has not been just rolling with the changes, but keeping up with them. We haven’t made a lot of money, but we sure have had fun. And we’re not through yet. After all, I won’t be 81 until September!

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The author with pacemaker patient in Victoria Children’s Hospital, Melbourne, Australia, 1998.

Most noted for his invention of the implantable cardiac pacemaker, Prof. Greatbatch was named to the National Inventors Hall of Fame in 1986 and received the National Medal of Technology in 1990. After service in the U.S. Navy during 1939-45, he received his B.E.E. at Cornell in 1950 and his M.S.E.E. at the University of Buffalo in 1957 and has been awarded several honorary doctorates. He is a fellow of the AAAS, ASME, IEEE, American College of Cardiology, American Institute of Medical and Biomedical Engineering and several other societies. A member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi, he holds more than 150 patents and has contributed more than 100 articles to scientific journals.

tiny nucleotides. They are so small that you cannot see them in a microscope, not even in an electron microscope. You can only tell what they are by what they do. But when you put them together they pretty much go together the same way every time, sort of like Ohm’s Law. So my life science friends tell me they are working in molecular biology, but I tell them they are working in genetic engineering, and that is my field. I have a plaque on my wall that says I am a New York State licensed professional engineer. Reaching? A little maybe. But biology is working its way into engineering: the NAE made bioengineering the theme of its 1977 fall meeting, and MIT is including biology in its freshman engineering curriculum.

I see more big changes in the coming millennium. By 2050 AD many engineers think we will run out of economically recoverable fossil fuels. We will have run out of places to put the residues from our nuclear fission reactors. All the sources of alternative energy, solar, tidal, geothermal, wind, and hydro, will not supply 25% of our needs. We will have no place to go but nuclear fusion.

But nuclear fusion seems an elusive goal. We seem to have given up on magnetic confinement and are shutting down the Tokamak. Inertial confinement, with a multiplicity of concentrically aimed laser beams, has not worked to-date, and cold fusion is out. But up at the Fusion Technology Institute in Madison WI, Gerald Kulcinski (an NAE member) has demonstrated a helium-deuterium reaction utilizing electrostatic confinement of helium-3. (Remember picking up paper scraps with a charged comb?)

Instead of a 150 ton supercooled electromagnet, he uses a 1,000 lb. spherical wire cage (in a vacuum enclosure). The ultimate goal is a helium-helium reaction in which two He-3 ions are combined into one He-4, which is the innocuous gas we put in kids’ balloons. The fuel is nonradioactive, the process is nonradioactive, and the residue is nonradioactive. It is a perfect fuel. Of course, the reaction takes place at a temperature much hotter than the surface of the sun. And there is practically no He-3 on Earth, but I tell my engineering students that these are just minor engineering challenges!

He-3 comes to us from the sun on the solar wind. But the Earth’s magnetic field diverts it away and it eventually lands on the moon. We just have to go there and get it, which we will do! A shuttle load (25 tons) would run the whole U.S.A. power establishment for a year, at an amortized cost (including the manned moon station and the halfway space station stop) of about $12 per barrel of equivalent oil. We now pay about $30. The project is not only technically feasible, but economically feasible. But if we want to get there by 2050 AD, we had better start now!