# *John Todd—Numerical Mathematics Pioneer*

*Don Albers*

**Don Albers** (dalbers@maa.org), after serving the MAA as Director of Publications for the last fifteen years, has returned to California as MAA Books Editorial Director. He was the founding editor of *Math Horizons* and editor of the *College Mathematics Journal* from 1979 to 1983. He has interviewed dozens of mathematicians and together with G.L. Alexanderson and Constance Reid edited *Mathematical People* and *More Mathematical People*.

John (Jack) Todd started his mathematical life as a pure mathematician. He received his B.Sc. from Queen's University Belfast in 1931 and then became a research student at Cambridge University under G.H. Hardy and J.E. Littlewood. In those days, earning a doctorate was not as important as doing research and becoming a fellow. Littlewood, his advisor, drove that point home when he told Todd that he himself did not have a doctorate, but that he would "write a postcard" for him if he wanted to get a nonacademic job. During World War II, Todd first worked at the Mine Design Department in Portsmouth, where he discovered that mathematicians were struggling with engineering problems and non-mathematicians were trying to contend with mathematical ones. He grew concerned about the frustrations they were experiencing with elementary computing. In order to remedy the problem, he suggested that an admiralty computing service be established, and he managed to set one up in London. His war work was instrumental in what he terms his "conversion to numerical mathematics."

In the months immediately following the war, Todd organized a trip to Germany to locate mathematicians who were being held in what is now an important mathematical conference center—Oberwolfach. If not for Todd, Oberwolfach might very well have been destroyed, with a great loss to the mathematical community.

Following the war, he returned to his position at King's College London, and in 1946 gave his first course in numerical mathematics. From 1945 to 1947, he championed the development of a National Mathematical Laboratory and an Institute of Practical Mathematics, and both were established by 1951. In 1947, he and his wife Olga Taussky Todd came to the U.S. after John had been invited to join the National Bureau of Standards. He headed the Numerical Analysis Section there from 1954 to 1957, when he left for Caltech to start a program in numerical mathematics.

In a lecture to Caltech freshmen in 1965, he provided some basic advice. He said, "It is the business of the computing center to see that good equipment and advice are available and that prices are within our reach." That seems as pertinent today as it was then. In his lecture he went on to present a series of problems that could be solved rather easily using pencil and paper, but which, when presented to an unwary computer, resulted in disaster. "The activities," he said, "of the numerical analyst are similar to the highway patrol. The numerical analyst tries to prevent computational catastrophes."

Todd urges students of numerical mathematics to follow the advice given in the Epistle of James: "Be ye doers of the word, and not hearers only" [James 1:22]. In his *Survey of Numerical Analysis*, he wrote, "We believe that there should be no division between theoretical and practical numerical analysis, and that a lecture without numerical examples is a lecture wasted. The instructor should have had recent machine experience, and the supervision of practical work should, as far as possible, not be delegated."

Professor Todd is now in his 95th year and resides a few blocks from the Caltech campus. The interview that follows was conducted in his home in July, 2005.

## Childhood

**Albers:** Let's start at the beginning. Where were you born?

**Todd:** I was born in 1911, in what is now Northern Ireland; but I think, statistically, I was probably conceived in the south of Ireland. My father and mother were both elementary school teachers. Ireland was united then, and they had studied in Dublin, and had their honeymoon in the south. When they were courting, they wrote to each other in Esperanto, which was supposed to become the universal language. They learned it on their own. My father was director of the church choir and also was quite active in chess, winning many prizes. I recall playing with his trophies. One was a terrestrial globe, about a foot in diameter, driven by a 24-hour clock, which rotated in front of a brass sun. It had to be given, manually, one turn daily on a threaded circular arc to display the changes of seasons.

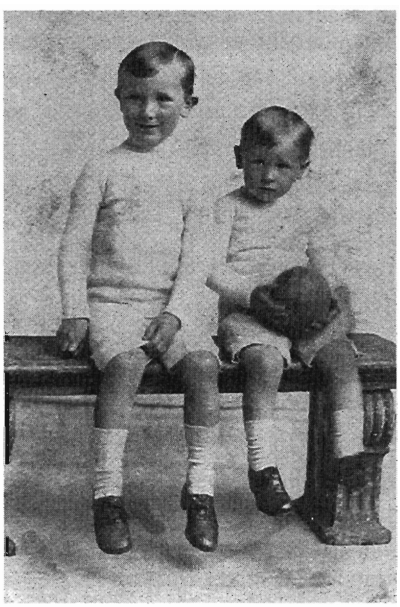
**Albers:** Where did you live as a boy?

**Todd:** From 1911 to about 1917, we lived in Carnacally in County Down, in the country. I didn't go to school there though; it was too far from home.

**Albers:** How could it be too far? Weren't there bicycles?

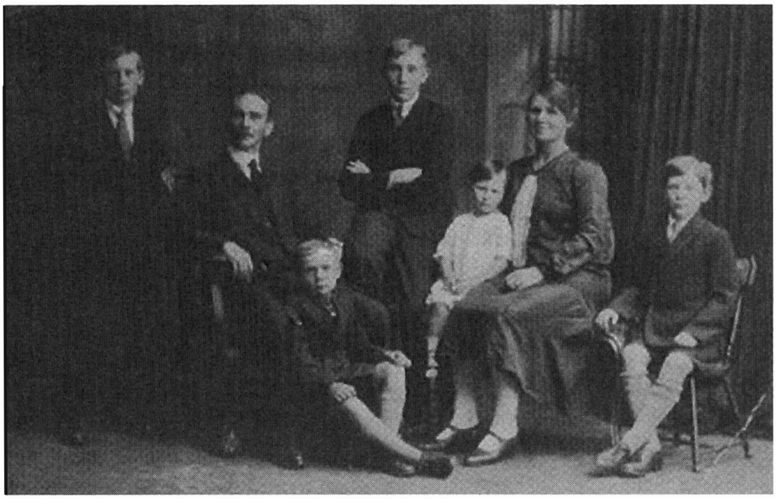
**Todd:** My father used a bicycle. But I was too little and the school was too far away.

**Albers:** How about brothers and sisters?



Soccer Anyone? Jack Todd, left, with his younger brother.

**Todd:** I am the eldest and have three brothers, William, Herbert, and George Stewart, and a sister, Margaret Louise. William did a degree in mathematics and became a teacher in the secondary schools of Northern Ireland. Herbert became director of a linen industry research institute. He was awarded an OBE [Order of the British Empire] for his services. George Stewart, my third brother, became a civil engineer. He said that Will and I weren't earning enough money, and so decided against mathematics. He built dams in Ireland and cooling units for nuclear power plants in Australia. He's retired now and living in London. My sister Margaret Louise lived near Belfast for most of her life. She had a career in business, looked after my parents, and was the source of all information as Peggy, the family correspondent.



School boy Jack, center, surrounded by his family.

**Albers:** It seems that some if not all of the Todd children were blessed with mathematical genes. You said that your father was a good chess player; was your mother quantitatively inclined, too?

**Todd:** No, she wasn't.

**Albers:** Was your mother teaching when her children were young?

**Todd:** Yes, she taught arithmetic in a night school for crippled people.

**Albers:** So you were born in 1911, and you stayed there through 1916.

**Todd:** During my first five years, I never learned to write, nor later had any course in English grammar. This is important, too, for I never had a course in Latin in my life.

**Albers:** I thought that was nearly impossible in Ireland at that time.

**Todd:** I don't know how I managed to avoid it. My father changed his job about 1917, to be nearer to Belfast.

**Albers:** That was the time of the Uprising [the Irish Rebellion].

**Todd:** I'll tell you a funny story about that. As you say, there was a rebellion, and in 1916 I had a little popgun; you put a cork in, and it popped. There was a weapons search then, and I remember that between our house and the neighbor's there was a yew tree, and I decided, at age five, that my weapon had to be hidden in this huge tree.

Later we moved a little bit nearer Belfast, and I went to my father's elementary school for a year. Then we went to Belfast; I know because I heard the bells in Belfast on Armistice Day in 1918, marking the end of World War I. And some time shortly after that, when my father decided that I'd have to go to secondary school, he moved the family into Belfast. That was about 1921.

**Albers:** So you'd have been about 10.

## Singing and Mathematics

**Todd:** Ten years old. And there my mathematical career started, in the following way. I was in a class, a singing class. My singing was so bad the teacher said I was disturbing the class and had to leave! There were some extra classes, ones with national examinations. And so I had to be put in one of them—it was a second-year algebra class! That's when I started learning mathematics.

**Albers:** So if you'd been a better singer, you might not have ended up as a mathematician! Second-year algebra is most unusual for a ten-year old. When did you first display signs of mathematical talent?

**Todd:** Not then yet. I went to this elementary school until I was 11, when I went to Methodist College Belfast (MCB), a secondary school where I had a scholarship. Naturally everybody that had a scholarship took French and Latin and Greek.

**Albers:** Except you.

**Todd:** Except me. Somehow or other I ended up saying I was going to be an engineer. And despite the impressive headmaster that I had, I won, and went into engineering.

**Albers:** Do you think this was a case of your just not liking languages? You said you hadn't had training in English grammar, and that could be an impediment to learning languages.

**Todd:** Well, I don't know that it was an impediment, for soon I was learning French. MCB was not a religious school, but the Methodist Church funded it. I stayed there for six years, and in my last year I did only mathematics. Miss McCutcheon was one of my teachers. Her first words in class each day were "Take down tomorrow's homework." I followed her example all my teaching life. My last year I had another good teacher; he came from England, and had the wonderful name of Fazackerly. He was a pupil of Horace Lamb.[1] I learned from the books of Lamb—calculus, dynamics, statics, and higher mechanics. They were first-rate books. My first creative work was in engineering. I got a prize for the design and construction of a machine tool for grinding the valves of cars. That was in 1927.

**Albers:** Let's back up for just a second. When you told your headmaster that you wanted to be an engineer, that enabled you to escape Latin and Greek. That sounds like it was really quite sincere on your part that you did want to be an engineer.

**Todd:** Yes, and so I did engineering. I remember helping my engineering teacher get his Master's degree. I made the drawings for his work on fatigue of metals.

**Albers:** You're good at drawing as well?

**Todd:** Machine drawing—technical drawing.

## Dixon—A Star of Belfast

**Todd:** Then I went to the University in Belfast in 1928. They had this man, A. C. Dixon, who was quite a famous mathematician. They said Belfast was famous because

[1] Horace Lamb (1849–1934) was one of the world's truly great applied mathematicians and the author of many textbooks. One of his courses was on the theory of sound, which I took at Methodist College Belfast from Fazackerly, who had been a student of his.

Young Jack Todd with his dog, Irish of course.

it had the largest shipyards in the world, the largest tobacco factory, the largest rope works, . . . and A. C. Dixon.

**Albers:** So he was quite famous?

**Todd:** Yes, but these were his last two years, for he was quite old.

**Albers:** You said he was a famous mathematician. Was he also a good teacher?

**Todd:** He was a good teacher who could do anything. I started to work for a Cambridge scholarship, and I had to come to him with eight problems from the Cambridge entrance scholarship exam that were really difficult. He could always solve them. I went to Cambridge to see if I could get an entrance scholarship at Fazackerly's suggestion, but I didn't get one. I was told that I needed to be higher on the exhibition (grant) list, and that my applied mathematics was not as good as it should be. So I finished my undergraduate work at Belfast, and then I went to Cambridge, where I got an exhibition, not a scholarship, in 1928. It was St. John's College that gave me the exhibition, a research exhibition. That was somewhat of a disappointment since I wanted a scholarship, but some money from Queen's University Belfast made it all possible.

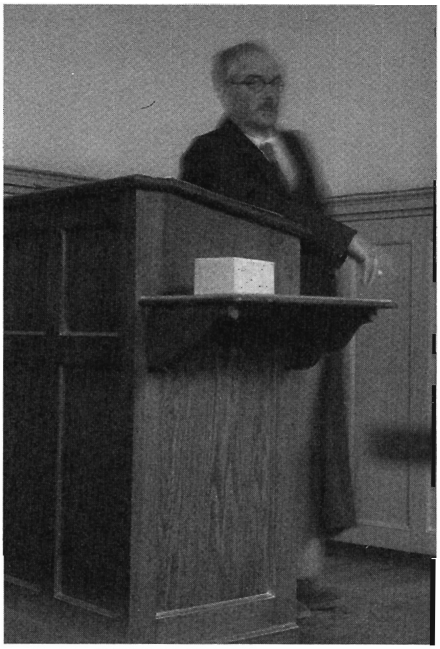
**Albers:** So that was a stipend of sorts.

**Todd:** I received a stipend of 150 pounds, because I'd done well in the final Queen's examination. Because I lacked Latin, I couldn't do an undergraduate degree at Cambridge, but I did receive a 50-pound stipend from St. John's, and this covered my academic expenses.

## Littlewood

**Albers:** An undergraduate degree from Cambridge was fashionable at that time, wasn't it?

**Todd:** Yes, but because I had no Latin, I had to go as a research student. My second year, I received the Strathcona scholarship from St. John's College. There was no pure mathematician at St. John's, and by that time I had decided that I had to learn more



J.E. Littlewood was Jack Todd's research advisor at Cambridge.

mathematics to do engineering. My college had no analysts, so they sent me next door to Trinity College to see Hardy or Littlewood. I went to see Hardy, but he wasn't in—he was out watching cricket. However, Littlewood was in, and he took me on.

Both Hardy and Littlewood were fine lecturers. There was a seminar, called Conversation Class, organized by Littlewood just when Hardy had come back from Oxford. But after the first two or three sessions, held in Littlewood's rooms, Hardy took over and Littlewood went out for walks. I would meet him on my way to the seminar. This seminar, still in Littlewood's rooms, included China tea (my first) served from a handsome silver service. Among his other idiosyncrasies, Littlewood believed all holidays should be 21 days—19 was not enough.

At Cambridge, I worked on transfinite superpositions of absolutely continuous functions. It was suggested to me by Cecily Young, a Fellow of Girton College. Coincidentally, my future wife, Olga Taussky, later held this fellowship. Very recently (2004) Girton bestowed an Honorary Fellowship on me, luckily with no duties. So my link to Cambridge continues.

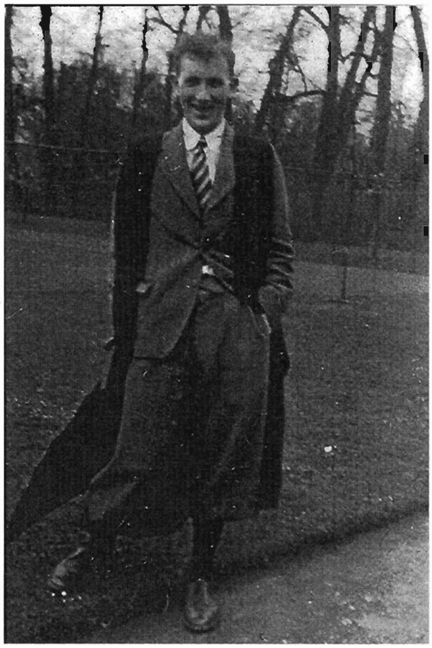
**Albers:** What do you remember about your first encounter with Littlewood?

**Todd:** Well, he didn't want me to take a doctor's degree. He said, "You can either come and just work here, or you can sign up for a doctor's degree program. I haven't a doctor's degree. You only need one if you want to get a non-academic job. Then I'll write a postcard for you."

**Albers:** Doctoral degrees weren't that fashionable yet.

**Todd:** That was just about the time that they were changing.

**Albers:** Richard Guy once told me that when you went to Cambridge, it was common to take another bachelor's degree, and then sort of hang around for a couple of years. He said that as far as he could tell you didn't have to do much of anything, and then at



Todd decked out in his academic robes.

the end of two years you would get a Master's. Of course, what many hoped for was to become a Fellow. Not many succeeded though, for becoming a Fellow was a much bigger deal than getting a Ph.D.

**Todd:** Yes, this was the next stage, you see. There were examinations for Fellows at various colleges.

**Albers:** So when you started at Cambridge as a research student, Littlewood was really evaluating you in terms of your ability to do original work.

**Todd:** Yes.

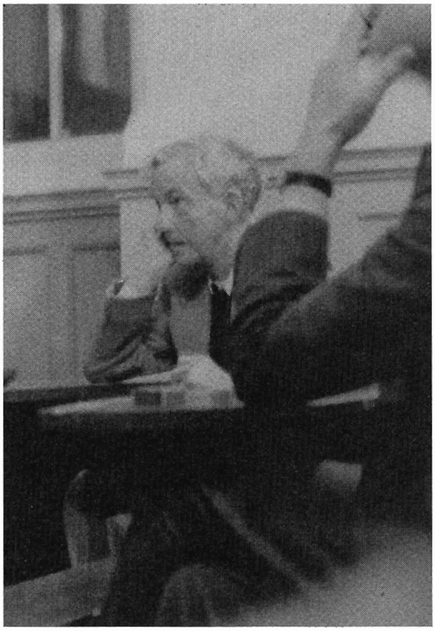
**Albers:** Entering Cambridge as a research student seems like a much more difficult path than coming to do a Bachelor's degree.

**Todd:** Yes. They said they would accept me provided I got a First Class Bachelor's Degree from QUB, but if I didn't get that, no. But I did get a First Class, both in mathematics and mathematical physics. Littlewood gave me one problem, just to think about, and I didn't like it. It was too easy, too classical. I wanted something more modern, and so the work that I did at that time was in the theory of real variables. I wrote some papers on transfinite superpositions of absolutely continuous functions. This was based on some work done by a Russian woman called Nina Bary.

About two years later, in 1933, I was offered a job in Belfast back at Queen's University. Somebody at Queen's had quit, so I went there.

**Albers:** Was that Dixon?

**Todd:** No, he had retired, and there was a geometer there called Semple. There was quite a great amount of geometry done there. The geometer H.F. Baker was at Cambridge, and most of the young people did work in algebraic geometry. I didn't like algebraic geometry, but I did get interested in the theory of analytic and projective sets, which resulted from a mistake of Lebesgue. The Russian Lusin and others got interested in it, too, and I gave lectures on it. But then I got bored with it. This was



G.H. Hardy at Cambridge in 1938.

back when I was an assistant. Then Semple, my teacher, the boss there in Belfast, who was only there for three or four years, got a job in London. A year later he invited me to come to London because they wanted me to teach modern real variables, Lebesgue integration, and things of that kind.

**Albers:** So this would have been about 1937?

**Todd:** Yes. So I went there, and I was the youngest man in the department. Of course, I was the victim of all the dirty work. The head of the department was Temple.

**Albers:** George Temple?

**Todd:** Yes. Temple later went to Oxford, and on retirement joined the Benedictine Order. He became ill while giving a lecture series on group theory and quantum mechanics. I knew a bit of quantum mechanics because my first introduction to matrix theory was Heisenberg's matrix mechanics, based on infinite matrices. I had enough background to begin an elementary course on group theory. I found a problem about the axioms of group theory to mark time. It was an unsolved problem, and I didn't solve it either.

## Olga Taussky

**Todd:** There was very little algebra in London at that time, but Olga Taussky was at Westfield College, another college in London. We met at an analysis seminar at University College London, and I asked her about the group theory problem. If I remember correctly, if you have a group then you can have subgroups, and conjugate subgroups. Now clearly a subgroup of a subgroup is a subgroup. But a conjugate subgroup of a conjugate subgroup is not necessarily a conjugate subgroup. The question was to find what class of groups had this property. Olga wrote a paper about it. Her paper became quite important. But then the war came.

**Albers:** So you met Olga in 1937.

**Todd:** In 1937, yes. We got married on September 30, 1938, the day of the Munich Pact.

**Albers:** A date of dubious distinction.

**Todd:** The war was thought to be imminent then, so we never had a wedding cake. That was when Neville Chamberlain came out with his "peace in our time" statement [Chamberlain was British prime minister from 1937 to 1940]. Chamberlain negotiated the Munich Pact, which gave the Sudetenland, a part of Czechoslovakia, to Hitler. A few months later Hitler seized the rest of Czechoslovakia, Olga's homeland.

At one time, Olga was invited to talk at the famous Conversation Class conducted by G. H. Hardy. On the advice of Hans Heilbronn, then also at Trinity College, she chose to speak on a topic in one of her minor subjects (topological algebra). This apparently went down well, for Hardy, after her talk, told her that she could use his name as a reference when applying for a position. After she had left Cambridge, Heilbronn told her that another mathematician spoke in the Conversation Class on her major subject (algebraic number theory, especially class field theory). Afterwards, at dinner, Hardy said, "I wonder how Miss Taussky would have dealt with the topic."

Once, when Hardy's sister was visiting Cambridge, Miss Taussky, by now a Fellow, asked them both to tea at her college (Girton). Because Hardy had said to her on a previous occasion, "No foreigner can make proper tea," she took advice on this project. Miss Hardy arrived on time and they talked until Hardy arrived; he said he had lost his way (in Cambridge!). Miss Taussky suspected he was frightened of having to drink her tea. Anyway, Hardy got out of his sweaters and then tea was ready. Hardy said, "I call that a good cup of tea." Her formula is secret.

## An Improper Question

**Todd:** In due course, Miss Taussky was short-listed for a Chair, and at the interview, Hardy was one of the selection committee. Another member said to her, "I see you have written several joint papers. Were you the senior or junior author?" Hardy, who was huddled in his muffler, woke up to say, "That is a most improper question. Do not answer it." On another such occasion she was asked, "I see you have collaborated with some men, but with no women. Why?" She replied, "That's why I applied for this position." [It was at a women's college.]

**Albers:** She was obviously a very attractive young woman, and you noticed that. And somehow you took this problem about conjugate subgroups to her? I don't suppose you were completely innocent. Were you using this as an introductory line or something?

**Todd:** Well, sort of. I had seen her before in Olso at the International Congress of Mathematics in 1936. I didn't meet her, and I didn't go to her lecture on topological algebra. But I had marked on the program that I had considered going to it. After the Congress, I went to Poland. There I met Saks, Sierpinski, Kuratowski, and many others.

**Albers:** What was the occasion?

**Todd:** Nothing special, other than I was interested in analytic projective sets. One of the consequences of this was they asked me to work on Saks's book on the integral. The first edition was in French, and the second was to be in English. L.C. Young was translating it, and it wasn't being done very well, so they asked me to help, which I did. Sierpinski had written a book on the continuum hypothesis and he'd also written something that, although it wasn't a book, was a major article on the axiom of choice, and the proposal was to translate and combine them into one book. I was asked to do this, and I worked on it in 1938–39. I had completed some of it when World War

Olga Taussky-Todd asks What's Your Number?

II began with Germany invading Poland on September 1, 1939, and the whole thing collapsed. I had been teaching at King's College London for two years, but in the third year of the war, I was declared redundant and the college was evacuated to Bristol. I was not required and was told to find another job.

I took Olga's mother and sister to Belfast the day the war started. I thought that they might be safer there, and it might be easier for them to get help if they needed it. They stayed in Belfast for a year or two, but then joined Olga's older sister in New York, going by ship through Atlantic waters full of German submarines. Olga was familiar with the U.S., having taught at Bryn Mawr in 1937, at a time when Emmy Noether was also there. It took a year before I got a war job.

**Albers:** That's a long time when war is going on.

## Writing in Bomb Shelters

**Todd:** During the war, Olga and I wrote several papers in bomb shelters.

**Albers:** What was that like?

**Todd:** Our bomb shelter was the ground floor of our apartment. During raids we wrote papers—about six in all—while the other twenty to thirty people chatted, slept, or read.

## C.P. Snow

**Todd:** I interviewed for a job in weather forecasting. They rejected me because they said this meant I had to work at all times of the day or night, and I didn't think I could do that. But then in 1940, I got a job teaching back at my old school Methodist College Belfast, and also at Queen's University because the man who had taken my job after I'd left got called up before I did. He lived in my London apartment, which was empty. Olga had a fellowship that year, so she stayed in Belfast too, where we lived with our parents. I then worked with the English writer, physicist, and diplomat, C.P. Snow [1905–1980]. He was the author of the eleven-volume sequence of novels called the *Strangers and Brothers* series. He also wrote the influential *The Two Cultures* and *Scientific Revolution*. For a while, he was the Commissioner of the Civil Service.

Radar had been discovered, and it became known that it was important to winning the war. But there was nobody who could use the equipment, and they had to find people for that. So Snow made a census of all the engineers in the country in order to find qualified people.

**Albers:** How did he do that?

**Todd:** This was interesting historically, because it was broadcast on the BBC that everybody with an engineering or a science degree had to go to the post office and get two copies of a form, fill them out, and send them in. This was like the town crier of medieval days.

**Albers:** Did it work?

**Todd:** It worked, yes. But then, of course, the civil service didn't know how to handle these things. And so what happened was that university people like myself, who had some sort of training, were asked to come and work on this classification. This meant that, besides classifying people, we knew what jobs were available. So I chose my own job.

**Albers:** What did you choose?

**Todd:** I decided that degaussing ships was important, and you had to do some elementary electrical engineering about the coils you put around ships to demagnetize them. And this was done at various navy or general shipyards.

**Albers:** So they wouldn't set off mines?

## Origins of the Admiralty Computing Service

**Todd:** Yes, so they wouldn't set off mines. So I decided that this was my job, and I was assigned as a range officer in charge of this activity in Falmouth. Just before I was due to go there I received a telegram saying, "Owing to the exigencies of the war, your assignment has changed. You have to go to Portsmouth." The Germans had acoustic mines that were just being developed, and we were trying to find ways to defeat the mines by making noises. This was not suitable for me—I didn't know enough applied mathematics. The place I was working was on the Portsmouth pier at Southsea, and it was bombed. So I was sent to the mine design department. Similar people were working on these acoustic mines, and I had to design new circuits for these things. If the mine was triggered by a ship, you wanted to blow up the engine, and so you had to put delays in them and you had to have circuits.

It was quite exciting in Portsmouth; the people had to obtain a German acoustic mine for analysis. So the Royal Air Force were told when German mine-laying aircraft came across, to try to chase them over the marshes on the Thames, so that the mines would fall there. Finally they got one, and they brought it to our place, and one of the people with a telephone was seated next to me. If it blew up, we'd be trapped. I had to dissect it and see how it was working. Those were exciting times, because I know there were little tugboats on the Thames that made a lot of noise. And one was blown up by one of these acoustic mines. The ship was blown ashore; that was before we got a mine to study.

I was there outside Portsmouth for some time. During this period I observed pure mathematicians struggling with engineering problems (for example, the reflection of sound from a muddy bottom) and non-mathematicians trying to contend with mathematical ones (such as slowly convergent series). This was rather frustrating: physicists were doing elementary computing badly and mathematicians like me were trying to do physics. I thought that I could see a way to improve this mismatching. Somehow I managed to persuade the authorities to let me go back to London and set up the Admiralty Computing Service.

**Albers:** At 29 you were very young to be given that responsibility.

**Todd:** That was in 1940. I don't know how, but I got permission to do it—they would rather have been rid of me, I suppose.

**Albers:** How did you go about making the proposal?

**Todd:** I approached my supervisor in the Admiralty and explained the mismatching of mathematicians; for example, Erdélyi, a Czech refugee teaching mathematics at the University of Edinburgh, could instead be working on acoustic mines. Anyway, I got to London and started the Admiral Computing Service. It was supposed to get large-scale computing done at the Nautical Almanac Office. We made all the many tables. For the heavier mathematical problems, I hired either people at universities or foreigners, with no clearance, to write books of use.

**Albers:** Was that because they couldn't get any other jobs?

**Todd:** Right. And so I met Erdélyi then, and one of the first things was to make a table of Laplace transforms; this ultimately led to Erdélyi coming here to Caltech and the development of the whole Bateman project.

**Albers:** That was a large undertaking!

**Todd:** And then I got another man, Copson, to write a book that I was planning to do. Watson had written a book on contour integration, which everybody used, and I was going to write on the method of steepest descent. Finally Copson wrote it, and it appeared as a Cambridge tract on asymptotics. There was also another book, a dictionary of conformal maps, published by a German called Kober. Then I got Aronszajn, and I asked him to write a book, *Hilbert Space for Engineers*. He finally wrote it, but it was much too abstract for engineers. Oh yes, there was another one—*Summation of Slowly Convergent Series*.

**Albers:** You put together some very good books.

**Todd:** They were good, yes.

**Albers:** How did you go about finding these people?

**Todd:** I knew some of them; Aronszajn I knew from Poland. I found Erdélyi when I was working on these magnetic mines. You had to have a magnetic piece of a new metal, some highly magnetic thing as the detector, so to speak, and they had to make it into a cylinder, that was the easiest thing to machine. To estimate the effect of this, you approximated it by an ellipsoid and this was not too bad. But then I found out that if you used different sets of coordinates you could get a dumbbell-shaped thing, which would replace the cylinder. And this had not been studied before. So I asked Erdélyi about it; he wrote an essay on it, but he never finished developing the whole theory, which he called Lamé–Vangerin functions. So we got to know Erdélyi, and it turned out that he had been a lodger with an aunt of Olga's in Czechoslovakia!

**Albers:** So it was just a coincidence?

## A National Mathematical Laboratory

**Todd:** Yes, an absolute coincidence. During the war I also met many Americans in England. Among them were Brooke McNeal, the head of the Office of Naval Research, and Baley Price, who was with the Eighth Air Force. And then I started to work with Erdélyi and Sadler, who was in charge of the Nautical Almanac, to set up a National Mathematical Laboratory.

**Albers:** Where?

**Todd:** In England. We started it, and it became a division of the National Physics Laboratory (NPL), just as in America John Curtiss had started his National Applied Mathematics Laboratory, which became a division of the National Bureau of Standards. He invited me to come to America to help when the National Applied Mathematics Laboratory was being started.

**Albers:** This was John Curtiss, the brother of Alice Beckenbach, who at one time was the wife of Al Tucker.

**Todd:** Yes, he was the brother of Alice. There was an earlier Curtiss, his father. He wrote one of the very early books on complex functions.

**Albers:** The Carus Monograph, *Analytic Functions of a Complex Variable* by D.R. Curtiss.

**Todd:** Yes, that's right. That was his father. And so he invited us to join him, and that's how I came to America.

**Albers:** So this would have been around 1947.

**Todd:** Right. We came across on a returning troop ship.

**Albers:** The end of the war in Europe was in May of 1945!

## The Savior of Oberwolfach

**Todd:** In June of 1945 I went to discover Oberwolfach in Germany. Did you know about that?

**Albers:** No, but I know of Oberwolfach as a famous mathematics conference center.

**Todd:** It was complicated. Basically the Allied Troops in 1945 were told to capture the German scientists, particularly those in nuclear work and those who had worked on the V1s and V2s, the German rockets that had caused considerable damage to London during the war.

**Albers:** The Penemunde group?

**Todd:** Yes, and they brought a man over, who turned out to be a German. McNeal interviewed him and said he had nothing to do with us. The man had a photograph of himself and Richard Courant, arm in arm, going up a mountain. This was his safe conduct, too. The people thought that he was just being difficult and not revealing anything. Since Olga was doing aerodynamics and knew German, McNeal asked her to help interview him. They finally learned that his name was Walther, and that he came from Darmstadt. He had been doing minor computational work, but nothing to do with the atomic energy program or the atomic weapon program, or the V1s.

However, he had been doing this computing, so they asked me to come in and interview him. We discovered that he had been brought in by mistake. There was another Walther in Germany, from the same place, Darmstadt, and at the same university, who had been working on the V weapons. He also told us about this place, Oberwolfach, in the Black Forest, which had been rescuing people in some way. When French or

English mathematicians were prisoners of war, a man called Süss got them released from the prisoners of war camps in Germany to come to this evacuation place to do mathematics, but not war work. Süss was a professor at Freiburg who had been doing work something like what I had been doing. Süss had this place in the Black Forest, and I heard about it. So I decided I would go to Germany and find out what was going on. A team of six or eight of us went, among them the astrophysicist Fred Hoyle.

**Albers:** As a boy, Hoyle was one of my heroes. He was a great advocate of the Steady State theory of the universe.

**Todd:** Well, I'd known him from Cambridge. In my office in the Admiralty I had a man called Reuter, who had been brought up in Germany. My German wasn't very good you see—I relied on Olga—so Reuter came as my translator. We formed a team to explore German mathematics of interest to the Navy. We went in May or June of 1945, just when the war had ended. First we went to Magdeburg since Reuter wanted to see where he was born. And then we went to Göttingen and we looked at these computer machines, made by Zuse, but we only found bits and pieces. Reuter and I finally got near this place, Oberwolfach, and we passed a whole troop of Moroccan soldiers. We arrived at Oberwolfach and asked if we could stay there. We hadn't washed our clothes for about six weeks, and the next day we got them washed! We had a little soap, and at that time, if you gave soap to anybody in Germany, you got your shirts washed free. We put up a sign on the door that said, "This is the property of the British Navy." So Reuter went to Heidelberg to get some rations and gas for our car. I remained at Oberwolfach interviewing Süss, the director of this institute. He was President of the German Mathematical Society and the Rector of Freiburg University throughout the war. Oberwolfach was an old hunting lodge, built by a German who had made his money in America. They had evacuated the library of the University of Freiburg as well as a dozen or so mathematicians who had been prisoners of war to the lodge. They were not free to come and go. The Moroccan troops then arrived, and they were going to throw the people out of this "castle", burn the books, etc.

**Albers:** Why would they burn the books?

Oberwolfach was saved by Todd at the end of World War II.

**Todd:** They would probably have used them in place of wood. The whole place would've been wrecked. So I put on my uniform. I was dressed very curiously in a khaki uniform with a Navy hat and epaulets. I was very frightened. I had to explain in my schoolboy French that all this was the property of the British Navy, that they couldn't come here, and that they'd have to leave the people alone. They believed me and went away. They wanted to get the chickens that were there. The leader of the Moroccans asked if he could shake hands with a British Naval officer. So we shook hands, and peace was, so to speak, declared. Oberwolfach was in the French zone of occupation. The French local governor came in, and I had dinner with him. I went back to London and got in touch with the French people whom I had already met there, and then on to Paris and told them that they should really look after this place, and not have it wrecked. And so it happened.

**Albers:** They did it?

**Todd:** They did it, and then, finally, Volkswagen took it over, and now there are mathematics meetings there every week, fifty weeks of the year, with about fifty people at each meeting. It has become something like a resort motel in the Black Forest. It's very cost effective, because if you're at a conference there, all you can do is talk mathematics; there's not much else to do.

**Albers:** So you saved it?

**Todd:** Yes, they call me the Savior of Oberwolfach.

**Albers:** That's quite an accomplishment. It's really famous in the world of mathematics.

**Todd:** It's now quite a famous place, yes. That was 1945.

## Moving to the USA

**Todd:** We arrived in the U.S. in September 1947 aboard a troopship, and, after three months in Washington D.C. getting acquainted with the NBS, we were permitted to spend an inspirational three months with von Neumann at the Princeton Institute for Advanced Study since the INA buildings at UCLA were not ready. It was only in April 1948 that we got to Los Angeles. We did not do much teaching there, rather we were learning to use the nascent computers.

We were living at the intersection of Santa Monica and Westwood Boulevards. It was a dirty house and I was a bit ill; I'd had asthma ever since I was a child, and this aggravated it. We didn't stay because fortunately John Curtiss asked me to come to Washington to be the head of the Computation Laboratory. It was on the books as a section of a division of the National Bureau of Standards. We worked there until 1957, when Caltech decided it had to do something about computing. Erdélyi was here, and he was advised to bring us.

**Albers:** Would that have been in the days of DuBridge and Bacher, and Bohnenblust?

**Todd:** Bacher, yes, and Boney, of course, was here. So that's that chapter: how I came to Caltech.

**Albers:** Let me ask you a little bit more about a couple of points that other people who have dealt with numerical analysis and computing have sometimes asked me. You probably knew some of the people in computing at Stanford. They would sometimes complain that convincing mathematics departments of the importance of numerical analysis was extremely difficult.

**Todd:** That's true.

**Albers:** For a place like Stanford it is hard to understand because there are so many very distinguished applied mathematicians there. Do you have a ready explanation for that?

**Todd:** There's a similar difficulty here at Caltech. Bohnenblust was against computing. Until he retired, he had a rather different philosophy from mine. He liked to have display programs of non-uniform convergence such as the Gibbs phenomenon. He liked to tell students about it and show a picture of it happening and then turn a switch and magnify everything a thousand times. The students had nothing to do with it—that was one of my complaints about him.

**Albers:** They were demonstrations?

**Todd:** They were demonstrations, but the students weren't involved. But he only did that after he retired. George Forsythe was the first person at Stanford to foster numerical analysis. Littlewood was interested in computing. Anything that was superfast or superslow in any sense interested him, and he wrote papers about that. He had done some work on ballistics during the First World War. There are funny stories about him: that he was a sub-lieutenant or something, and he liked to walk about in his uniform with an umbrella. They had to send him away to keep him from the barracks: no umbrellas allowed!

**Albers:** In your own case, you made a transformation of sorts. You were brought up mathematically as a classical real analyst and then you developed into a numerical analyst. How did that transformation occur? Certainly the war had to be some kind of stimulus.

## Conversion to Numerical Mathematics

**Todd:** There were four stages to my conversion to numerical mathematics.

In 1933 I returned for four years to QUB and continued to work on functions of real variables. In collaboration with a colleague, R. Cooper, I published a paper on the large roots of $\cos z = az + c$, asymptotic rather than numerical analysis. During this time I read Turing's classical 1937 paper "On Computable Numbers, With an Application to the Entscheidungs Problem". *This was the first stage of my conversion to numerical mathematics.*

In 1937, as a result of a new syllabus at the University of London, I moved to King's College where I stayed 12 years, but only five were actually in residence. My main teaching obligations were in analysis, especially measure theory. However, in 1938 there was a meeting of the British Association for the Advancement of Science (BAAS) in Cambridge. The BAAS had long been interested in table making and there was a concentration of numerical mathematicians at that meeting. Ostrowski spoke on complexity and Comrie introduced me to the Brumsvega B-20, the mechanical computer that I have here on my desk. It accommodates 20 digits, and it does things like this [Todd demonstrated multiplying 12 by 12]. It was the standard computer in those days. *This was the second stage of my conversion to numerical mathematics.*

Then in 1939 the war came, and as I said earlier, I ended up at the Admiralty Computing Service in London. One fortunate consequence of this was contact with John von Neumann, who was also learning about computing at that time. Another was further contact with the table-making fraternity of the BAAS. *This was the third stage of my conversion to numerical mathematics.*

The war ended in 1945, and in due course I was released to go back to King's College London. While I had not yet decided to revert to my previous interests, I felt that I should make use of my wartime experience and present a course in numerical mathematics in the academic year 1946–47. This was accepted by the head of the department, Professor George Temple, and he arranged for the purchase of two Marchant ACT 10 M calculators. There being no suitable text available, I prepared mimeographed course notes. These occupied about 30 foolscap pages and covered such topics as difference operators, asymptotic series, acceleration of slowly convergent series, comparison of interpolation processes, approximate quadratures, differential equations, auxiliary functions, and matrix problems.

During this period (1945–1947) I was active in trying to arrange for the development of a National Mathematical Laboratory similar to the National Physical Laboratory (NPL) and of an Institute for Practical Mathematics. [The former was realized in 1946 as a division of NPL, and the latter appeared as the University of London Computer Unit some five years later.] In the spring of 1947 I was invited by John Curtiss to join him for the next academic year at the Institute for Numerical Analysis. John Curtiss is something of a hero to me. *This was the fourth stage of my conversion to numerical mathematics.*

## A Truckload of Brumsvegas, Please

**Albers:** The Brumsvega was your first computer.

**Todd:** Yes.

**Albers:** I'll bet there aren't many of them around today.

**Todd:** I can tell you a funny story about that. When I was in Oberwolfach in 1945, I tried to find one, but couldn't. However, after I was back in London, another team went, and they asked me, "Do you want anything from Germany?" I said, "Yes, bring back a truckload of Brumsvegas." And they did! And they were distributed around the Admiralty. They took mine away when I left the Admiralty, but this one I bought later. There's a smaller version made in Spain, which I have in the other room, but this really was the standard computer before the electrical ones came along.

## Von Neumann

**Albers:** In 1942, when you were at the Admiralty, you were allowed to escort Johnny Von Neumann to various naval establishments. What did you and Johnny do on your visits?

**Todd:** Johnny was with Los Alamos then, and he was interested in implosion, in connection with the atomic bomb project. There were some people who'd been doing that in the Admiralty. They developed charges to demolish tanks and so forth. I don't know how I did it, but I got permission to take him round, and I introduced him to the computers—this was before he decided he had to go into computing. I have letters from him saying that.

**Albers:** So you may have been responsible for getting Von Neumann interested in computing.

**Todd:** Yes.

**Albers:** Wow! He got into it in a big way.

**Todd:** He certainly did!

**Albers:** Well, I guess that explains your conversion to numerical analysis.

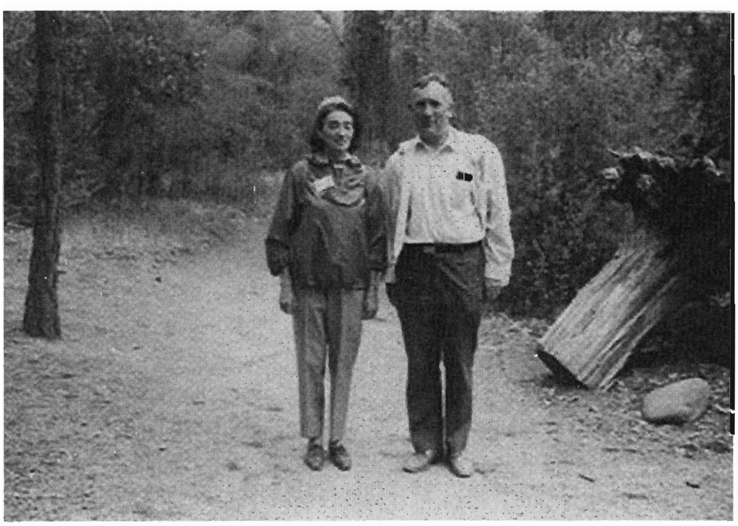
**Todd:** Yes, with reading Turing's paper, and then the BAAS, and the Brumsvega in 1938 being the key events.

## Practical Mathematics

**Albers:** In 1946, you and Erdélyi wrote an article in *Nature* titled "Advanced Instruction in Practical Mathematics." You wrote, "All who watched the development of industrial research in recent decades and those who, during the War, had an opportunity of observing work in Government research departments, must realize that the usual academic syllabus in mathematics does not provide an adequate preparation for a future research worker in Government service or industry. Students, for example, of engineering (with which we include, for the sake of brevity in this article, physics, chemistry, etc.), biology or economics, do not get, as a rule, a mathematical training sufficiently advanced to enable them to follow up, and participate in, recent research in their subjects; and the training of students of mathematics is not very suitable for the type of work we have in mind. The truth is that in recent decades there has grown up a new type of research worker... —the mathematical technologist—and so far British universities have not provided very much for him. An urgent need thus arises for an institution [an Institute for Practical Mathematics] where students are instructed in advanced mathematical techniques not usually included in university curricula, yet needed in 'mathematical technology' (and mathematical biology or economics for that matter) and where they are introduced to research.... Since it is impracticable to add to the present syllabus without dangerously lowering the standard of instruction, and since there is scarcely anything in that syllabus that could profitably be discarded in order to make place for more practical mathematics, it is inevitable that the main activity of the suggested institute should consist of post-graduate courses. This theoretical conclusion is borne out by practice in the United States, where such post-graduate courses have been given, for example, at Brown and New York University, in such as the Courant Institute, for several years and have proved a great success." That article was written nearly sixty years ago and for a British audience. No doubt much of that advice could also have been given to academic institutions in the U.S., then and perhaps now. Have you seen many changes here or in Britain that reflect the concerns expressed by you and Erdélyi?

**Todd:** Yes. At Princeton, and here at Caltech, where recent position announcements call for "Information Science and Technology... with a research focus in the engineer-



Olga and Jack enjoying a hike in the woods.

ing, mathematical, physical, biological, or economic aspects of information and computation... with possible joint appointments outside engineering and applied science in divisions such as biology, physics, mathematics and astronomy, or humanities, and social sciences."[2]

**Albers:** Are you satisfied with the pace of change?

**Todd:** Yes.

**Albers:** You were in Washington for 10 years. That's a long time. It's a terrible place if you have allergies, and it couldn't have been good for asthma.

**Todd:** Well, I got a doctor there who gave me a dose of penicillin. The first time I had asthma was when I was taking a school examination in calculus when I was 15, and I did poorly. When I returned to school, I was asked to be captain of the second 11 cricket team. I had to play some sport at the time, but I had an attack and couldn't play, so I had to keep score and the scorer had to play in my place. At that time they gave you morphine.

**Albers:** Morphine?

**Todd:** Morphine was the main thing they gave you. I had to carry morphine and something to mix it with. Adrenaline was the next thing, which you injected into yourself. Then they got albuterol or something now that just requires an inhaler.

**Albers:** So you've had it all your life?

**Todd:** Yes.

**Albers:** It hasn't prevented you from living a rather long life; you're now 95.

**Albers:** In 1957, you organized a training program to convert university teachers into specialists in numerical mathematics. The program was supported by the National Science Foundation and resulted in the publication of the book *Survey of Numerical Analysis*. The list of contributors to the volume is something of a Who's Who in the field. What motivated you to set up the training program?

**Todd:** It was both necessary and successful, and was repeated by my successor. I had met the experts consulted during the war.

**Albers:** It was 1957 when you and Olga came to Caltech. DuBridge and Bacher, both physicists, and Bohnenblust, a mathematician, decided that they needed someone with your skills and your knowledge of numerical analysis?

**Todd:** Computers were coming. I ran my first modern computer program on Good Friday 1950 on the SEAC at the Bureau of Standards. It executed the Euclidean algorithm applied to the two largest Fibonacci numbers that would fit into the machine.

**Albers:** Almost 56 years ago.

**Todd:** There was some computing going on at Caltech, but mainly analogue. The history of computing at Caltech is a sad story, and it's still a mess. The man in charge then was an analogue man. They made some terrible appointments. I imagine that in 1955 there wasn't a general feeling that computers were going to be a central part of university instruction. Bacher and DuBridge knew what was going on. I suppose it was Erdélyi who got us here. But now it's a mess. They have a computer science department, and they have a computation and applied mathematics group. There's Barry Simon with his mathematical physics, and there's another independent group, called the Center for Advanced Computational Research. They have a vice president or associate vice president for computing. They arranged through Richard Varga, an associate of Olga and mine of longstanding, a glorious series of lectures for my 90th birthday, which was much appreciated.

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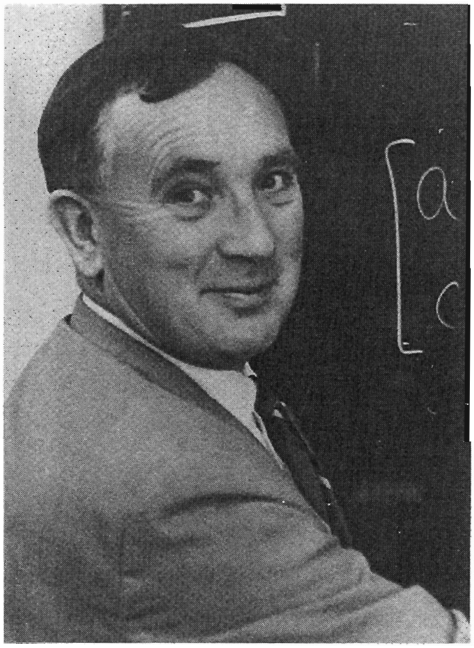
[2] Classified Advertisements *Notices* AMS, 52 (2005) 90.




Professor Todd lecturing to Caltech freshmen in 1965 on "The Dangers of Computing".

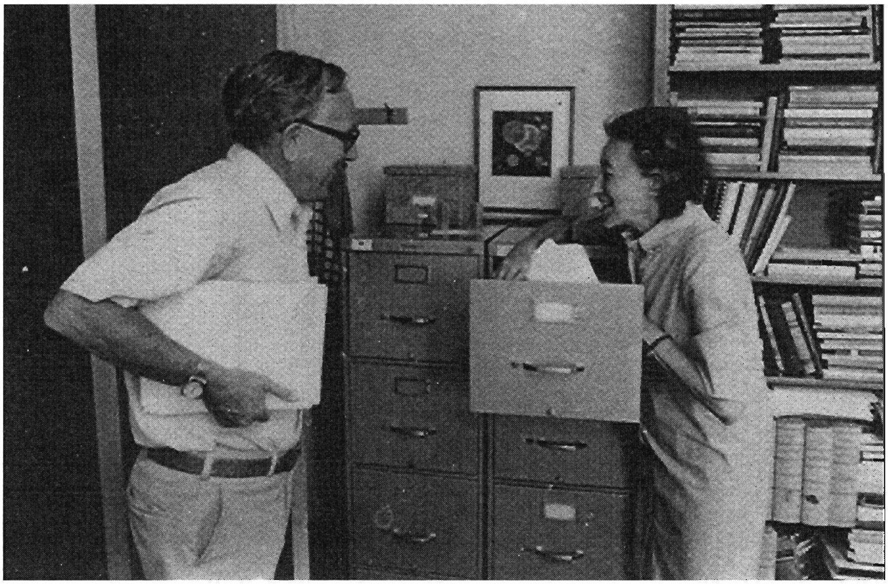
**Albers:** How did you start numerical mathematics at Caltech?

**Todd:** My first action was to get a two-hour laboratory component added to the three-hour lectures and 6 hours homework in the basic junior-senior-graduate course. The admonition from the Epistle of James (which I learned from the classical text on electricity and magnetism by Abraham and Becker), "Be ye doers of the word, and not hearers only, deceiving your own selves", is particularly appropriate in this context. As time passed I noticed that graduate students who should have been taking a course such as this were not doing so and, when they needed advice on numerical matters, would come to me for help. Whether this was due to their advisors wanting them to progress in the specialty first, and only seek numerical advice when they were ready to write a thesis I do not know. However, I decided then that it was important that all math students should be involved in numerical matters from the beginning of their undergraduate studies, and organized a course on numerical analysis for freshmen and numerical algebra for sophomores. Although these courses were designed for freshmen and sophomores, it turned out that a considerable number of auditors participated, upper-class and graduate students and postdocs. However, I was not successful in getting colleagues to join, although I was hoping they would take over the courses later.

## Mrs. Coxeter

**Albers:** Your good friend Tom Apostol said I should ask you about H.S.M. (Donald) Coxeter's mother and her interest in having her son marry Olga.

**Todd:** Well, Olga was in Cambridge from 1935 to 1937, and Coxeter was there as a fellow of Trinity College, and they met. Mrs. Coxeter herself was also living there. Apparently she decided that her son should be married, and she thought that Olga was the right person for him, even after we were married. She even invited all of us to where she was living then in Tintagel, in Cornwall, the site of King Arthur's Castle.



A mathematical family—Jack Todd and Olga Taussky-Todd were married for 57 years until her death in 1995. One of the keys to their long and happy marriage might have been due to the fact that Jack did the cooking and Olga washed the dishes.

But she never succeeded. Olga and I would remain married for 57 years—until her death in 1995.

**Albers:** Coxeter's mother sounds like a woman of great determination.

**Todd:** I don't remember much of her, but I do remember those cold days in her house in Tintagel.

## Heros

**Albers:** You've certainly worked on lots of questions during your lifetime. How do you approach a problem?

**Todd:** It's hard to say. I've worked in several areas of inquiry, most recently in approximation theory. I just think about a problem for a long time, and then suddenly an idea occurs. Sometimes, it comes by accident, in some course when you're talking about other things.

**Albers:** Earlier, you cited John Curtiss as being a hero. Do you have other heroes?

**Todd:** Yes. Von Neumann, Turing, and Erdélyi.

**Albers:** Who has been the greatest influence on your professional life?

**Todd:** Hardy. I took every course I could from him. "Orthogonal Series other than the Fourier Series", I remember especially. Hardy had just returned from several happy years in Oxford to accept the Savilian Chair in geometry. During this time his opposition to organized religion forced New College to change its by-laws, since he refused to enter the chapel even to vote on college affairs. A few of his delights were, above all, cricket and, to a lesser degree, the *Times* crossword puzzles and detective stories. He had such an extreme aversion to mirrors that he covered them on entering a room.

Mutton and politicians also joined his aversion list.[3] He hated having his picture taken. Olga, however, took one of him with Courant and Veblen at a conference in Zurich—one of the very few there are.

To indicate his punctiliousness, I quote 'Can you tell me who the signatory of this letter is, and what is his rank or title? He may be anything from a field marshal to a home office clerk, for all I know. As his tone is courteous and he writes 'Dear Professor Hardy, I don't like the idea of being forced back on the bleak 'Dear Sir.'[4]

One of the few mistakes Hardy ever made was when he, attempting to correct an error in an obituary for Hilbert (with whom Olga Taussky had worked after graduating from Vienna) stated that Miss Taussky was now married to J.A. Todd, not to me, John Todd.

**Albers:** You've been involved with mathematics since you were ten. What is it about the subject that fascinates you so much?

**Todd:** I don't know. Perhaps its infinite possibilities and the fascinating people one meets.

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[3] *Collected Papers of G. Hardy*, E.C. Titchmarsh, *passim* pp. 450–452.

[4] "G.H. Hardy as an Editor" by John Todd, *The Mathematical Intelligencer*, Springer-Verlag, 16:2 (1993) 32–37.

**E.g.**

Do you have some favorite examples of your own, or do you know some that students really seem to enjoy? Following up on a suggestion of Rick Kreminski of Texas A & M–Commerce, we are soliciting examples that can be used as filler items. An "E.g." submission might be related to an article that appeared in the CMJ (see page 46 for an example), might be a good classroom illustration (that probably wouldn't justify a full-blown Classroom Capsule), or might be just plain interesting. Original items are preferred, but little-known gems from other sources (with credit) are also welcome. Ideally, they would be less than a page long. Send your examples to the Editor: L. W. Beineke, Indiana University–Purdue University Fort Wayne, Fort Wayne, IN 46805, or cmj@ipfw.edu.

[Some of the inspiration for this suggestion came from the classic books *Counterexamples in Analysis*, by Bernard R. Gelbaum and J. M. H. Olmstead, and *Counterexamples in Topology*, by Lynn A. Steen and J. Arthur Seebach.]