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SOME RECOLLECTIONS OF THEODORE VON KÁRMÁN*

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That Theodore von Kármán was a great man is attested by the record of his accomplishments, his published works, the medals, honors, and honorary degrees bestowed upon him all over the world, the tributes written and spoken upon his death. All these confirm that he was one of the rare men. It did not take his death to tell us this; we knew it well for many years, with the result that some worshipped him, some tried to be of service to him, some became tongue-tied in his presence, and many exploited him and imposed upon him. His death only shocked us by the realization that this privilege—of knowing a great man—had come to an end.

Tonight I do not propose to extoll his greatness. I have taken upon myself a more difficult task. I am going to try to bring you an intimate picture of this man. I am going to undertake just a little bit of the biographer's most difficult task: to show you not his deeds or his works, but the man himself.

Now I think this ought to be done. For one thing, I think men should study their great fellow mortals in the hope of learning something about greatness—perhaps something that lesser men can profit by. But I have more personal reasons: one is that during his lifetime his biographers sometimes did a rather poor job. Of course, the popular press always struggles with definitions and descriptions of great men. They don't fit brief definitions, and that puzzles the newspaperman. So TIME called him "rocket expert," the Saturday Evening Post entitled the story of his life *He Tamed the Wind*, and upon his death the New York Times headline read "Physicist Dies at 81." The press cannot, apparently, understand a man so broad that he is engineer, mathematician, physicist, teacher, organizer on an international scale, business man, adviser to governments, raconteur and bon vivant all at once.

To this audience, of course, this is not so difficult. You know of Franklin, Fourier, Descartes . . . and in our day, Fermi and von Neumann. You also know the phenomenon of the Great Professor—the founder of schools—Prandtl, Sommerfeld, Courant—whose influence spreads over continents and down through generations. But even this audience, I think, will do well to consider this particular, almost incredible example of the great engineer-scientist-teacher and man of the world. How did he function?

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First, something about his work—intended particularly for an audience of mathematicians. Von Kármán never identified himself as a mathematician—always as an engineer. But it was clear to those of us who worked close to him that mathematics—applied mathematics—was his true love.

In fact, in an intimate moment he made a very interesting remark to me one night about 2 a.m. We were writing for publication and had a definite integral which we wanted to identify in terms of modified Bessel functions. But the definite-integral expression we wanted to use involved a parameter restricted to a certain range of values, and we were just outside this permissible range. By 2 a.m. I was perfectly willing to change the value, make the identification, and call upon analytic continuation at a later step to get back to our particular case. That's how some other authors had handled the same problem. But not Theodore von Kármán. My suggestions brought a grunt of disapproval. He was disappointed to think that the other writers had handled the problem in such a messy way. A Schönheitsfehler at best! He filled sheets of scratch paper. I think I dozed off. Suddenly he threw his pencil on the desk in a gesture of triumph. By a clever manipulation he had gone directly to the desired identification using our value of the parameter and nothing but properly defined forms. It was neat and precise; "clean" is the word. As I jumped awake, he cried: "You know, I am a born mathematician!"

It is very easy to define what pleased him most, what he sought as for sixty years he turned his mind toward another and another difficult unsolved problem: it was the simple but powerful mathematical statement, preferably a differential statement, that held the key to the whole complicated affair. It was usually approximate; it was frequently nonlinear; but it held the key.

The solution of the equation was obviously of less importance to him. From the clean basic statement he branched off into various appropriate approximations, usually linearizations. It made him very happy if his colleagues obtained more elegant solutions than he did. I recall his mixture of pleasure, amusement, and even some skepticism when the Clauser twins discovered (independently of Tollmien and Ringleb) the solution of transonic plane flow in hypergeometric functions—"à la Whittaker-Watson," as he said. He seemed to find it amusing and somewhat incredible that hypergeometric functions should really have practical use! It was always the fundamental differential relationship, when it succinctly described the important phenomenon, that he himself sought.

Now, for my taste, that's the best of applied mathematics. Perhaps we sometimes lose sight of this in our attention to elegance and accuracy of solutions. Of course, you may attribute this characteristic of von Kármán to his great teacher, Ludwig Prandtl. Prandtl wrote the boundary-layer

equations and left it for his successors to elaborate the solutions—for sixty years—in volume that Hugh Dryden finds grows exponentially with time. And Prandtl wrote the integro-differential equation of lifting-line wing theory. Of all the techniques of solution provided in fifty years (we've all had a crack at it!), you must admit that the series suggested by Prandtl has probably the least to recommend it!

But there is another reason that von Kármán seldom provided the elegant solution. His formal mathematical training was actually relatively meager. Leslie Howarth literally taught him Cartesian tensors and isotropic tensors, so they could write their definitive joint paper in 1937. I remember when I took a course of mathematical analysis from Professor Morgan Ward. The homework consisted of very difficult problems: William Bollay and I used to attack these together on the blackboard of the office we occupied. As was his wont, Dr. von Kármán used to shuffle in once a day to see what we were doing. Invariably the problem caught his fancy, and invariably he solved it—by beautiful, direct, highly geometrical reasoning. I'm afraid that Bill Bollay and I received several warm compliments from Professor Ward that should have gone to our Boss. He (von Kármán) was mildly interested in our formal methods—so-and-so's test, such-and-such lemma, etc.—but told us, "You know, I have to use more simple methods, because I never learned this stuff."

But what I really wanted to talk to you about is his relations to people, not science.

First, let me try to describe his relation to his students. He was a very gentle teacher. He came closer to the error of deceptive simplicity than to that perennial stereotype, the absent-minded, obscure genius. Of course, *all* professor stories are now told about Dr. von Kármán. Even the one about the professor who says, "It's obvious that. . . . Let's see, is it obvious?"—and then, after ten minutes of pacing, "Yes, it's obvious." Some, like this "obvious" story, could hardly be farther from the truth. His lectures were models of clarity, organization, simplicity (sometimes deceptive, as I have said—he tended to protect his students from some of the complications). He always proceeded from specific to general, never the reverse. His sketches were works of art; his equations he wrote out on the blackboard in beautiful straight lines, as neat as a published paper. He disliked grading papers and either gave oral exams or got one of us to grade the papers for him; then he systematically raised each student's grade so that nobody failed.

But woe unto the student who tried to fake. Or the young or old faculty colleague, or the visiting dignitary who tried it, for that matter. If von Kármán was bored, he might doze, but if he suspected sham, he attacked! "Excuse me! Do I understand . . . ?"

In public meetings, too, he often attacked when he thought a paper was really misleading—"pseudo science," as he said. I hope no one here has had the experience. It began, "Excuse me," and it usually ended with the à propos and devastating anecdote. "This speaker reminds me of my childhood in Budapest. There were gypsy magicians who came to town to entertain us children. But as I recollect, there was one important difference: the gypsy only *seemed* to violate the laws of nature, he never really violated them!"

For Dr. von Kármán was a master of the à propos anecdote. He never forgot a joke, and always had one to illustrate most vividly and tellingly any situation in which he found himself. The result is that memories of von Kármán tend to become collections of anecdotes. Sometimes, unfortunately, his biographers inadvertently make it appear that he was a clown. But this is obviously just because the anecdotes are taken out of context.

As his students learned, to work with him was an unforgettable privilege. One came to one's desk to find that he had dropped by and left one of those beautiful, concise mathematical expressions, written on the back of an envelope, a theater program, or the Athenaeum bill, on one's desk. There might be a pencilled note: "I think this is what you want!" And it was; we worked these things out, improved the notation, plotted the results, and received our degrees. In the process, of course, we mastered the subject, and I suppose sometimes we forgot where the original inspiration came from. Well, I've been a professor myself for long enough now to know that graduate students seldom remember their professors' contributions very accurately. Von Kármán wrote some charming paragraphs on this in *Aerodynamics*, his Cornell Press book, in connection with the controversy of Prandtl and Lanchester. He concludes that it is characteristic of active and brilliant minds to forget where an original idea first came from. (Certainly this describes the minds of our students!)

One learned that he scheduled his time rather systematically, but only in rather large blocks—"tomorrow morning," "tomorrow afternoon," or "tomorrow evening." If you insisted "what time?", he made a more precise date to keep you happy, but you soon learned that it didn't work. Someone else whose date was "tomorrow morning" was still engaged with him when you came to claim 10 o'clock. I think this was simply because he was wise enough to know that profitable scientific work cannot be scheduled more precisely. When you see a student about his research, how do you know whether it will take 15 minutes or 3 hours?

But, of course, the real shocker to some was the "tomorrow evening" appointment. Such dates were always at his home. Too bad if you thought you would have his ear alone in his study beginning, say, at 8 p.m. You arrived. You were ushered in. There were his sister, in the happiest days

his mother, some of your professors and their wives, several visiting Hungarians (visiting, that is, from Budapest or Hollywood), a priest, or a colonel, or a movie star. You were fed and you drank Scotch. And when they finally all said their goodbyes about midnight, you started your work. At 2 a.m. you dozed, as recounted above!

These were all his friends. He was sincerely interested in them all. The conversation was urbane, witty, intellectual, sometimes profound. Frank Marble recalls a typical evening. When he arrived at 1501 South Marengo for an evening of work with the Boss, he was welcomed with joy. "Frank! I'm so glad you're here! I want you to meet my friend, Mr. So-and-so. He's a Hungarian spiritualist. Where can we find him a job?"

This reminds me to emphasize what many people do not know about men like von Kármán. They are seldom drudges. Von Kármán did not really find a great many hours per week for his work; he had phenomenal ability to concentrate whenever he did find a moment. His life was full: concerts, plays, social events, frequent business trips, even athletics in a half-hearted way during the 30's, and the demands that fall upon any homeowner and head of a family plus two or three household employees.

But, as I have said, his ability to concentrate was simply phenomenal. When he was worrying about a problem he turned down his hearing aid and pondered at every opportunity. This led to his pacing through his house, dressed only in a bathrobe, before breakfast, and pacing absentmindedly through the halls of the Guggenheim building at Caltech. It undoubtedly gave rise to the most harrowing of his adventures in Pasadena and Los Angeles traffic—although I really believe that 90 % of the stories of his absent-mindedness actually resulted from his deafness. (Are you sure that you would always remember to shut off the motor of your car if you couldn't hear it when you parked?) He told me several times that he believed his deafness was an advantage because it permitted him to concentrate.

At C.I.T. von Kármán directed the Guggenheim Lab. His students thought that he was Director in name only, since it seemed to be Clark Millikan and Ernie Sechler who really ran the show. But when I became a junior staff member, I realized differently. Von Kármán took advantage of having dependable assistants, but in all vital areas he knew exactly what went on and why. I believe he carried the salary budget, including laboratory assistants and post doctorates, item by item, in his head.

I recall also the question of whether Del Knoblock, a Ph.D. candidate somewhat older than the rest of us, had to take certain required courses or not. The question arose because Del had had active airplane-design experience long before, and now had returned to C.I.T. to learn the hot-wire art and study turbulence. Should he be required to take airplane-design courses

like the rest of us? Von Kármán polled the faculty. Millikan, Klein, and Sechler all agreed "Yes." "However," said von Kármán, "I am Director and I vote No. So Del does not have to take the courses. That is academic democracy."

Von Kármán was dissatisfied with the undergraduate preparation of his students in mechanics. He once went to R. A. Millikan and said he wanted to give the mechanics lectures to all Caltech undergraduates. Millikan laughed; "I wouldn't think of wasting your time on that, Kármán!" I suppose Millikan was right, in the long view, but it surely would have been a wonderful course for the undergrads!

Now let me say a word about von Kármán's relations with industry and government. Like so many naturalized citizens, he felt keenly his responsibilities to his new country and its institutions. I know he felt a responsibility to American industry, and even a more profound responsibility to the government. Unfortunately, he started off on the wrong foot, as far as some parts of the aircraft industry were concerned. He was hired by Junkers to testify in a controversy between them and several of the leading American manufacturers which was submitted to a board of arbitration. The general agreement was that the board would determine what, if any, Junkers patents were being used by the constructions under consideration and would set a license fee for continued use. I think his testimony was important.

The most important issue came down to a question of whether certain airplanes had more or less than a specified amount of wing dihedral angle. Von Kármán showed that according to the N.A.C.A.'s official book of nomenclature, the dihedrals of these airplanes fell within the limitations of the definition. The American companies finally got the board to adopt an interpretation of the N.A.C.A. definition which caused most of the airplanes to fall outside the limits. (I remember how it delighted von Kármán to have an N.A.C.A. official testify that their definition was wrong in the case under arbitration!) Consequently the outcome was primarily a victory for them, but some of them seemed to resent von Kármán's part in the episode. It was really a matter of their being caught unprepared, with less able witnesses or perhaps none at all, but I think it looked to them as if Dr. von Kármán was more loyal to his "old friends" than to their American counterparts. It was confined to only a few people directly concerned with the proceedings and did not permanently hamper a very successful career in which he ultimately became a key figure at Northrop and a member of both Convair's and Allison's boards of consultants.

His warm association with the Air Force began when General H. H. Arnold called him to Washington in 1944. He had done important service

for the Navy in connection with the dirigible problem before that. I think he felt a deep responsibility toward his adopted country, as I have said; I also believe that he enjoyed his association with the Air Force. The generals were young in those days (Vandenburg, Norstad, Putt, et al.) and they obviously respected his every opinion. Also, the Air Force life was a fast-moving one of world-wide air travel and association with heads of state. It is clear to all of von Kármán's friends that travel was in his blood. He often talked half-heartedly of settling down—after he reached 70—but he never made the slightest move to do so. Of course, a life of travel, hotels, airplanes, restaurants, and changing time zones is hard on an old person—so von Kármán survived only to age 81!

The generals certainly did not acquire a yes-man when they acquired von Kármán. With the inevitable anecdote and pointed quip, he showed them their faults as he fought to make the Air Force the most scientific of the military services.

"Doctor, what do you think of our new creation, the —— Corporation?" asked the Chief of Staff.

"Why, General," replied von Kármán, "I think that corporation has already had an effect on the whole industry."

"I'm delighted," said the General, "What effect is that?"

"Why, they've upset the salary schedule of the whole industry."

But in some ways the real picture of von Kármán is seen in his relations with the people, little and big, whom he met all over the world. They were all real and important to him. From Mahatma Ghandi and Pope John, both of whom he apparently completely charmed, to every taxi driver who drove him. When he and his sister visited my home town, Minneapolis, he remembered that I had insisted that he see the lakes. They did, and when von Kármán discovered that the cabbie had never taken the $1.50 launch ride through the chain of lakes, he insisted that he accompany them as his guest. (We can imagine the continental manner in which this invitation was extended.)

I remember vividly how angry he became when he found that a Caltech secretary—one who didn't understand her boss, obviously—had put aside a letter written to him by a convict (a lifer) in a prison and had not called it to his attention. This convict was trying to work the problems in von Kármán-Biot, and wanted some help. Von Kármán was furious with the secretary. "Can you imagine?" he said to me. "She keeps saying it is *only* a convict in a prison!"

Every waiter, every elevator boy, every bellboy bringing the Scotch and soda interested von Kármán—especially if he had any kind of accent. Cornell's famous School of Hotel Administration is a place that he loved,

for there the waitresses and bellhops are students, and von Kármán learned each one's family history and ambitions. And incidentally, I assure you that the Hotel School never had and never will have a guest so loved as Dr. von Kármán.

It is clear that this rapport with his fellow man was always true of von Kármán. He told me how he fared in the Bela Kun communist revolution in Hungary after World War I. Now, in most stories the good guys are mistreated by the revolutionary rabble, with whom they have unfortunately had dealings before, when things were the other way around. But apparently the rabble in Budapest consisted of pretty girls and former gardeners and chauffeurs who knew the von Kármáns and loved them. So, for example, when the new government started to confiscate rooms to make places for poor families to live, they designated von Kármán's study the "Maurice Kármán State Library" and appointed Theodore its custodian—thus saving the von Kármáns from having to share their house!

I think one reason why he charmed people so easily was that he had a kind of humility. It was a special kind of humility, to be sure, for he knew he was a special person. But I'm sure he felt that being a great scientist and engineer was not really more important, in itself, than being a taxi driver or a bellhop. There was also a humility in his scientific work. In view of his record, it was rather startling to hear him say, "I always assume that the other fellow is exactly as smart as I"—but I heard him say it many times. When he seemed to understand or master a problem that baffled other investigators, he first assumed that he must be wrong and the "other fellow" right. Before he would change this view, he had to see exactly where the "other fellow" went astray. (Incidentally, I commend this as an ideal attitude for any consultant.)

This humility is all the more remarkable when you realize that von Kármán fully comprehended his own greatness. The young son of a former colleague once visited him and told him, "Doctor, I will be happy if I can be only *half* as great as you." When the boy had left, von Kármán quoted this remark and slyly asked me, "Now, is that a modest ambition—0.5?"

These are the glimpses that I wanted to give you of the great Theodore von Kármán this evening. I hope they sum up to an impression of a most remarkable, rare individual, interested in everything and everybody, especially in our particular profession, applied mathematics, but even more in his fellow men, their lives and their idiosyncrasies. He used to say that an after-dinner speech should be like a lady's bathing suit: the briefer the better, so long as it covered the essential points. I'm not sure this one meets either requirement.

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* At the suggestion of the Editor, I am listing here some of the most reliable and interesting biographical papers that have been written about Theodore von Kármán.