

Godfather of the Hybrid



Victor (left) and Herman Wouk enjoy a celebration in their honor last April in the Athenaeum. Victor was his “bypass,” Herman said in remarks praising his brother’s contribution to his novels, around the “one-way valve that normally flows from the humanities to science and then shuts.”

Born in the South Bronx in New York City in 1919, Victor Wouk earned his bachelor’s degree from Columbia University in 1939 before heading west for graduate school. In choosing between Stanford and Caltech, he picked Caltech because, as he said recently, it had open-book exams. Drawn to Caltech’s state-of-the-art High Voltage Lab—the first such laboratory in the country—Wouk received his MS in electrical engineering in 1940 and his PhD in 1942. His first company, Beta Electric Corporation, which he formed in 1946, grew to become in a decade the largest manufacturer of high-voltage power supplies. Then he went on to found other companies, leading to an interest in and then a passion for electric and hybrid automobiles. He holds more than 10 patents, most of them on various features of electric and hybrid vehicles.

He was a strong supporter and guiding spirit of the 1968 cross-country electric-car race between Caltech and MIT, won by Caltech's Wally Rippel, BS '68, (see *E&S*, October 1968).

Wouk recently donated his papers to the Caltech Archives—35 linear feet, much of which relates to the day-to-day running of two of his companies, Victor Wouk Associates and Petro-Electric Motors, Ltd. The collection, according to the Archives, “provides a good window on the life of a research scientist, engineer, and entrepreneur, as well as his extraordinarily diverse activities and passions.” Wouk and his wife, Joy, have established a fund to support researchers interested in working on these papers.

The collection also contains many decades of Victor's correspondence with his brother, Herman, the novelist. Herman Wouk's latest novel, *A Hole in Texas*, is dedicated to Victor, and its hero is a scientist at JPL. (The character Palmer Kirby, a Caltech alum, in *War and Remembrance* was actually based on Victor.) At an April 14 luncheon in the Athenaeum to honor both Herman's new book and the Archives' new Wouk collection, Herman Wouk described how his brother had brought him into the Caltech family. The opportunity to talk to Caltech faculty, he said, like Hal Zirin, Jesse Greenstein, and Richard Feynman, was “the closest I can come to being a scientist.”

Last May, Caltech Archivist Judith Goodstein interviewed Victor Wouk in New York. In that oral history, he described, among other things (including his grad school days at Caltech), the hybrid car he built in the early '70s, a quarter of a century before hybrids finally rolled onto American roads. That section of the interview is excerpted below.

Wouk sold his first company, Beta Electric, in 1956 and formed a new one, Electronic Energy Conversion Corporation, in 1960 to make smaller, higher-efficiency AC-to-DC converters. In 1962 this company came to the attention of Russell Feldmann, president of the National Union Electric Company and one of the founders of Motorola, who had bought a fleet of 30 Renault Dauphines in which he installed batteries and electric motors. But he had trouble with the speed control, and thought perhaps Wouk's efficient DC power supply would solve his problem. Wouk inspected and drove Feldmann's cars and told him basically that “the problem wasn't the energy wasted in the speed control; it was just that the batteries didn't have enough energy to take the car far or fast.” Feldmann dropped his project, but Wouk kept going. He contacted Caltech president Lee DuBridge, who convened an informal seminar of physicists and chemical and electrical engineers to explore the question of building better batteries, coming to the conclusion that there were still many problems to be solved before that could be done. But after Caltech's Arie Haagen-Smit showed that Los Angeles smog was due mainly to gasoline exhaust, Wouk thought electric cars might still have a future.

Victor Wouk: In 1963 I sold the Electronic Energy Conversion Corporation to Gulton Industries, a company that was making nickel-cadmium batteries and had a subsidiary in California making power supplies based on the principle of what I call the Convertron—putting in AC, changing it to DC, and then chopping it up at high

frequency. The Electronic Energy Conversion Corporation was now a subsidiary of Gulton, operating out of my old office and lab at 342 Madison in New York. I was very happy with that.

Then one day Dr. Gulton calls in the section managers (I was head of electronic research) and said, "I want more applications for nickel-cadmium batteries that we are now building for the air force."

So at the meeting I said, "Oh, Dr. Gulton, maybe electric cars would be a good application."

"Why?"

"Well, you can get much more current, so the cars need not be sluggish." This had been the big objection. People would say, "Well, I don't care about the range, but they're sluggish." And Gulton said, "Fine idea—start working on it."

I thought about it and realized that if we're going to get some performance and the vehicle is going to be quasi-experimental, I want a big car—a station wagon. And Gulton wanted a tie-in with some automobile company in Detroit. We couldn't do it with GM or Ford—they had their own electric programs. Same problem with Chrysler. But American Motors was losing money in those days. And after some negotiation, a contract was drawn between Gulton and American Motors. Gulton Industries would develop a new battery based on lithium and, using my speed controller, a wonderful car.

Judith Goodstein: What brand of car?

VW: This was an American Motors station wagon. So I put a lot of batteries in the back, put other things in the back, and you could still have at least two people up front and three people behind. I began to build this machine, because I liked the idea and there was this great potential.

Then along came the Clean Air Act of 1970.

JG: How long had you been building this car?

VW: I started building the car in about 1967. That is, I set up breadboards of a speed controller and this and that and the other thing. I had to go through a lot of stages, testing things that were absolutely new.

Wouk soon realized that electric cars were probably not going to catch on with the American consumer. Speed and acceleration were tricky, the cars were unreliable, and the better-battery problem wasn't going to be solved anytime soon. But a car that combined a conventional internal combustion engine with an electric engine—now, that just might work. He began to try to stir up interest in hybrids.)

Then in 1968, Washington began to legislate—and California already had legislated—emission limits on vehicles. So everyone immediately thought of

electric cars. And I had to go to various people to disabuse them: It isn't the smart controls. It's the battery. Until we multiply the battery capacity by at least a factor of three, and preferably eight, we'll be no competition for conventional cars. And I would be told, "Oh, you don't have any faith. It's got to be all electric." I was actually being accused of being anti-electric car. I'd say, "It's not that I don't want electric cars, I want cars that will work!" And they would say, "If it's a hybrid, you've still got an internal combustion engine; you're going to have some emissions. We don't like the idea."

The 1970 Clean Air Act required that by 1976 emissions be reduced by a factor of 95 percent. And I can interject here that at one time, while Dr. DuBridge was still the science advisor to President Nixon, he was following my program, because I let him know what was going on. Oh, and of course he knew about the earlier business with the battery. I told Dr. DuBridge about the hybrid, and he thought that was a great idea. And he said, "Victor, do you know why the pollution regulations require 95-percent reduction and not 80 percent or 99 percent? "

I said I had no idea.

"Were you ever in California in the 1930s?"

And I said, "Yes, I went to summer school in 1937."

"Where were you?"

"UCLA."

"Oh, then you will remember that on a clear day, you could see Catalina."

"Yes, sir."

"And you could see it rather often."

"Yes, sir."

He said, "We made the specifications on the basis of some computations as to how much we would have to reduce current pollution to get down to where we could see Catalina. So, the number of cars has increased, the mileage they've gone has increased, and when you put the two together, it turns out that pollution from cars is about 20 times greater than in 1937. So we want to reduce emissions 95 percent." That's the explanation.

I spoke to several organizations about hybrids, and nobody was interested. By this time, Dr. Gulton was retired from Gulton Industries, and his successor wanted nothing to do with hybrids because there was no government program for hybrids.

JG: No source of funding.

VW: Exactly. So then all of a sudden we hear about the Federal Clean Car

Incentive Program (FCCIP), which was initiated in 1970. I forget how I heard of it; maybe Charlie Rosen heard of it first, because he and I worked on the electric car also. He was a chemical researcher at Gulton.

Now, for some reason I had been out in Ann Arbor several times and I knew the EPA people who were going to run this program. And they said, "Hey, Vic, let 's talk about your hybrid car. How about proposing?"

JG: Were you the first to propose the name "hybrid vehicle"?

VW: No. Some of the early cars in the early 1900s would be referred to as "dual powered," and I think the word "hybrid" was in one of the early patents.

JG: And those early cars, when you speak of dual power, what were the two sources of power?

VW: Same thing—batteries and internal combustion engine. There had been some studies, underwritten by some program or federal agency or other, by Aerospace Corporation, in the Los Angeles area. They had a contract to study all types of hybrid. I knew the president of Aerospace Corporation, Ivan Getting. So he and I communicated. I said "I'd like to get more information," and arrangements were made. I went to see him and got the information. And they more or less agreed with what I had been thinking—that the hybrid *could* do this, cut down emissions, cut down fuel usage. So I went to the president of Gulton and said I'd like to bid on this. And again, for various reasons much too complicated to discuss here, we were not even allowed to think about the Federal Clean Car Incentive Program, number one, and even if we did, it would not be hybrid.

So, Charlie and I decided we were not going to work on the DC sources anymore. We wanted to work on a car, which Charlie and I were confident would at least meet the specifications. So Gulton said, "OK, goodbye, thank you very much," and I had to start a new company. I didn't know quite what to call it. My brother Herman came up with the idea. He said, "You use petroleum, you use electric. So, Petro-Electric Motors. And 'Ltd.'—Limited, which makes it sound very fancy." So Charlie and I worked on the proposal for the FCCIP. It took us about a year. And we prepared this and bid.

What we were asking for was the privilege of building this vehicle at our own expense and having it tested at our own expense, to prove that it would beat the 1976 requirements on emissions. What the EPA would do is, after we had called them in and said, "Hey, this meets the specs as indicated by a test at such-and-such a lab," which was certified, they would give us one dollar for having made the preparation and bid. And when they're finished with the tests, they'll give us \$30,000. [*Actually \$37,351.*]

JG: But all of the R&D is on your nickel?

VW: Correct. Now, where's our incentive? The incentive is that if the vehicle really works, they'll then order 10 of them at a price that might write off most of our

R&D. No guarantee, but it might. And the EPA said: "We'll test them, and if after a year they are still low emissions, low fuel users, we will order 350 for government offices throughout the country. And as a real incentive, we will pay you twice the price that the government would normally pay for an automobile." My real incentive was mainly to prove the damn thing worked. After that, we wanted to be able to move ahead, let someone buy us out, and I'd get out of it.

So we sent the proposal in, and I forget how long it was—two months, three months—before we get a phone call and a letter, saying, "We like your proposal. Very interesting. Technically feasible. You are hereby given the contract. Get started."

There were six other vehicles in the program. There was our hybrid, one electric car, one diesel, one with a simple exhaust filter.

JG: You're the only hybrid?

VW: We're the only hybrid. And we start building it. It was a long, uphill struggle because I'm not an automotive engineer, nor is Charlie Rosen. Rosen is a thermodynamicist; got his PhD in thermodynamics engineering at what was then Brooklyn Poly, now just Polytechnical Institute. We divided the work—I would be doing all the electronics; he would be doing the emissions reduction. When we had a vehicle pasted together, I contacted a Professor Smith at the University of Michigan, in Ann Arbor, whom I knew very well, who was familiar with my background on electric cars, and who liked the idea of hybrids. So he spoke to the chairman of the automotive engineering department, David Cole. (And by the way, at present Cole is head of the Center for Automotive Research, which studies the automotive industry throughout the world—a very highly respected man.) Smith got permission for us to bring a car out to Ann Arbor to do the final tuning up of the engine and the electronics and everything, so that we would have a working vehicle with low emissions, and it would then be up to the two of us back in New York to tweak everything so that we really get the best out of it.

We took the car from New York to Ann Arbor by truck. And then we tweaked the car, back in New York. How did we get the car back to New York? This is now 1973, and there was going to be a hearing in Washington about some new legislation about emissions and fuel economy. I was planning to drive the car, with Charlie, from Ann Arbor to Washington. (A huge snowstorm forced them to put the car on a plane for the trip to Washington.) We had driven it quite a bit before, and it worked. People ask, "What was the top speed?" I say, "I never went over 85 miles an hour," because there was some rattling. The car was not assembled the way they would do it at GM.



Relations with the EPA have not yet started to go downhill, as Wouk poses proudly with his 1972 hybrid Buick Skylark at the EPA test site.

JG: And what kind of a car was this, now?

VW: This was a 1972 Buick Skylark.

JG: Who provided the car? Did you buy it?

VW: The car was provided by General Motors. Once we got our contract, I went looking around for the car I wanted. I went to various showrooms in New York. I looked under the hoods. The Buick Skylark seemed to have the most volume under the hood. And not knowing exactly how much space we were going to need, I wanted a car with the largest volume under the hood.

So I went to a dealer and said I wanted a Buick Skylark. And he said, "Very sorry, but the one here is already sold."

"So how about a new one?"

He said, "I don't know. The line is closed." So I had to send a letter to Dr. Thompson, director of the GM Technical Center, in Warren, Michigan. I knew him because I was on a panel with him at the American Bar Association building in Manhattan, discussing low-pollution cars. Eric Stork, who was in charge of the mobile systems emission section of the EPA, was on this panel. And when it was all over, Thompson came to me and said, "I certainly appreciate what you said about electric cars being extremely limited and that's why you're talking about the hybrid. Most people involved will not admit the serious hurdles that have to be overcome." So that's how I knew him.

So when I explained this situation to him—that I wanted a Buick Skylark and there were none to be had in the country, they'd all been sold out—I got a telephone call or letter saying, "Let me investigate this." And about two weeks later, I get a telephone call from a Buick manager in New York saying, "I don't know what's

going on here, but I've been told that I'm going to be getting a Buick Skylark, and it's for you. But you have to buy it; it's not being given to you for nothing." It was \$2,700 in those days. Obviously the reason for their not giving it to us is because it would mean they were neutral; they're just helping out some young fellows with some cute ideas.

Getting back to the hearing in Washington, I gave my testimony, and we showed the car to a lot of people, who were very impressed, and then we drove it back to New York. No problem at all. And there we were given the run of the labs in Brooklyn—the Clean Air Department of New York City had this very good car-testing laboratory in Brooklyn. You could get on a dynamometer, you could do all sorts of things; they measured the emissions and the fuel economy. And tweaking the car for optimum emissions was a pretty tough thing, because we were using the Wankel engine.

I have to backtrack here. The reason I wanted a Wankel engine is that it was squat for the same amount of horsepower as a conventional piston engine. And as I mentioned, I didn't know how much electronics I would have to put under the hood or how big an electric motor, so I wanted something that was squat, and Mazda's Wankel engine fitted this requirement absolutely beautifully. The Mazda had proved to be a sensation on the West Coast, where it was being sold. Because here was this little car—a pipsqueak—and if it was up against a Caddy, and they were both stopped at a red light, the Caddy would slam the accelerator all the way down and by the time he took his foot off the accelerator, this pipsqueak would be a half a mile ahead of him. Why? Because it was a small car, lightweight, and had this Wankel engine, which developed twice as much power per unit volume as a conventional car.

But you couldn't go to the corner store and buy a Wankel. GM had paid \$50 million for some contract with Mazda to do something with the Wankel, and Mazda had some sort of arrangement with Curtiss-Wright to do something with the engine on the East Coast—maybe apply it to propeller-driven planes. So there was a Mazda representative on the East Coast. Now someone who knew Curtiss-Wright very well introduced me and said, "This gentleman would like a Wankel engine." In fact, I made a presentation to the top brass at Curtiss-Wright and they said, "It sounds good. We'll see what Mazda has to say back in Hiroshima."

Three or four weeks later, I got a phone call saying Mazda liked the idea and they were going to send me *two* engines, so if something didn't work well on the first engine.... Well, I'm absolutely flabbergasted, they're sending us two engines! Which they did—complete engines with all the auxiliaries. So here I had this nice squat engine and we were able to put that in the Buick Skylark. Now the only car on the East Coast that was using the Wankel was our Petro-Electric Motors hybrid. When people say the automobile and gasoline companies won't give you the time of day, the answer is, "On the contrary!" They were very interested in what was being developed, because the thing worked. The Wankel engine is still used today, I think, by Mazda on their RX.

So, anyway, we needed to get the operation perfect, and we had use of this

enormous lab in New York City. We had been given the run of the place because the man in charge of the Clean Air Act in New York City—one Brian Ketcham—I had met, because at that time I was one of the founders of and active in the Citizens for Clean Air in New York. He liked the idea of a hybrid and he said, "OK, you can have it whenever you want." So, over a period of about two or three months, we were in and out of the labs in Brooklyn. And soon the car was ready to be tested.

We called the EPA in Detroit and said, "We're going to be testing the car. What do you want in the way of certification, so that one of your people from Ann Arbor can come see the vehicle and run the tests for us?" And the only lab that the EPA would accept in the New York area had to be an independent lab. It couldn't be the New York City department, because we were New Yorkers; it couldn't be the facilities at, let's say, Mobil Research, because that's a gasoline company. The closest independent lab was opposite a big town in New Jersey, on the other side of the Delaware River, in Pennsylvania. We went down there two or three times to have tests made.

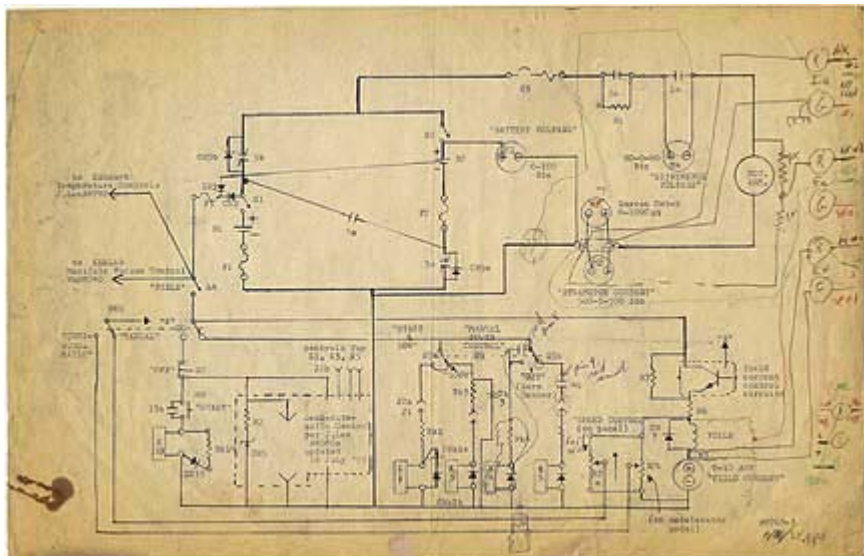
JG: Did you drive the car there?

VW: That's where I had the 85-miles-per-hour maximum. We would drive the car occasionally, just Charlie and I, and sometimes other people. We went for the tests; all the specs were met. And we called and said we're ready for someone to come. They said, "OK, we'll send . . ."—I forget his name, some other Charlie. At that time, the car was garaged in Charlie Rosen's garage, in Teaneck, where he lived, and his sons began pestering this EPA man. "Come on, are you going to say 'OK we'll test'? Or 'Not OK, we won't.'" He couldn't tell them to go jump in a lake, so he said, "Yes." This was around the beginning of January 1975. He looked at the data. We took him for a ride. And he said, "When I get back to Ann Arbor, I will report to John Brogan, who's the head of everything."

It turned out that the EPA, through a certain "Mr. X," wanted to drop the program.

JG: This was before your car had been tested?

VW: Yes, before the car had been tested, before we had even built the final. Meanwhile we were the only ones left in the FCCIP who could possibly even be tested. The others had dropped out for one reason or another.



Among the papers in the Archives' Wouk collection is this detailed circuit diagram of the electrical system for powering the motor of the Petro-Electric Motors hybrid. Wouk's initials and the date are in the lower right corner.

JG: And just on principle, Mr. X wasn't willing to have it tested?

VW: That's right. He thought—and he expressed the opinion—that the function of a government agency is to set standards and regulate. It is not to help a company pass tests and everyone become millionaires.

We made arrangements to go to Ann Arbor—this was now something like the middle of January. We might have to do some final tuning up at the University of Michigan, where we were doing the testing. We brought the car out. There were some slipups in the beginning, and it looked as though my idea was not a very good one.

Then I realized what the mistake was. I had the mistake corrected at the university and the car breezed through the tests, except for one thing: Every now and then, there would be a spike of emissions and that would vitiate the entire test. All you needed was a little spike of emissions for one half-second and the average emissions would be above what was allowed. We eventually found out what that problem was, and that was going to require some more tweaking of the emission control.

So here we have these little spikes, and we needed help to do something about the emission control. And Charlie Rosen said that what we needed was a richer mixture, which should come down when the vehicle starts running, because otherwise with a richer mixture all the time, the fuel consumption would be too high. So we did that. In about a month we finally got a beautifully operating thing.

We made the final tests at the EPA in Ann Arbor, and most of them were well within the range. Then they said: "We'll determine whether you go on to Phase II of the program." So we see the report about a month later from the EPA people as to why we did not meet the specifications.

JG: Were you shocked?

VW: No, no. And that is something I'm glad you asked. When we were near the end of our tests at the EPA, we had become very friendly with the engineers who were supervising. There was one who was particularly upset that we were sunk from the very beginning. He said that Mr. X had come in and said, "Under no circumstances is the hybrid to be accepted."

JG: Mr. X said that to the engineer?

VW: Yes. Before we finished. "Under no circumstances." Why? Again, he thought that the government should regulate, not make people rich—"If you think you're so smart, build the car and build lots of them and we'll buy them. Don't have us test them."

JG: Didn't you have a contract to do just that?

VW: Yes. So the question was in the interpretation of the contract, as to whether we met the requirements. There was a lot of Mickey Mousing. And the record of letters back and forth is half-an-inch thick. Now the Archives has them. What you don't have is, unfortunately, the smoking gun.

JG: OK, tell us about the smoking gun.

VW: It was a two-page letter from Mr. X to me in 1976 on federal letterhead saying, "You have a very good thing; it works beautifully. It cuts emissions, cuts fuel consumption. But basically I think it's the wrong approach. And if I'm proved to be wrong, I will be the first to admit it." So I may still either (a) find the letter or (b) I don't have to find the letter but send him a letter—registered of course. As soon as I find the letter, I'm going to tell him I'd like him to fulfill his statement and have a full-page ad in the *New York Times*, *Wall Street Journal*, and *Washington Post*. I won't insist that he have it in the *Los Angeles Times*. (*The letter disappeared in photocopying before Wouk's papers were sent to the Caltech Archives.*)

JG: Suppose Mr. X had been a different sort of person, not as committed to his point of view. Do you think it would have meant a different outcome for this country and the evolution of hybrid cars?

VW: That is my firm belief, and that is what I have been espousing for almost 30 years—after the first tests at the EPA and others. As I always said, the hybrid is the way to go if—if, if, if. If we must reduce automobile pollution and reduce automobile fuel consumption a large amount in a short period of time, the only thing you should do is use existing technologies, base your design on existing technologies, and as these technologies improve, even when you're implementing the design and improving your design, you just go ahead. The principle was proved by our tests at the EPA. But nobody did anything about it until, independently, the Japanese—Toyota and Honda—did it.

JG: How many decades did you talk about this?

VW: Oh, from 1970 through 1980 and from 1990 up until about 1997, when Toyota came out with the Prius.

JG: So, do you consider yourself the godfather of the Prius?

VW: I may or may not be. (*An SAE book credits Wouk as the father of modern hybrid programs.*)

JG: Who are the bad guys in your opinion?

VW: *The* bad guy is Mr. X, who told his men that they had to flunk the Petro-Electric Motors vehicle, before any tests. And Mr. X was told by some of the engineers at Ann Arbor that it would never work anyway, because this was complicated, that was complicated, so “stop worrying about it, Boss.” But it did work. And the orders had been given, somehow or other, “You’ve got to flunk them.” So there was this report by Ann Arbor EPA, back to Washington. We were sent a copy of it. I had to write a 75-item rebuttal. And it just dragged on and on. And then finally some of the things I objected to were used in the final meeting on the subject. And then I quit.

JG: Then you quit. Did you close down that company?

VW: Yes. We go back now to that meeting with the NSF. Herman was there, and Brogan and Mr. X. Brogan whispered to me in an aside. He said, “Vic, you are getting screwed. And I’m going to see to it that you get some money back.” So on the basis of some tests, he told Mr. X that it would be a good idea to give us another chance. So that in addition to the \$30,000 we got for the first series of tests, because some of our tests had looked very, very good, we were able to do another series of tests, for which we got \$50,000. The last \$50,000 went to Gould, a big manufacturer of batteries, who ran a lot of good things for me. But by 1976 I was so disgusted, I lost so much energy, that I gave up and went into straight consultation.

JG: Do you feel vindicated today?

VW: Absolutely. And not only do I feel vindicated, but people high up in automotive technology—to whom I had forgotten that I’d mentioned things—would come to me and say, “I’m sorry I didn’t agree with you then. It was just a professional opinion. It didn’t affect anything.” Like people on the IEC committee or the SAE committee, others like that. “You’ve been right all along and we’ve been wrong.”

So I feel vindicated. But I won’t feel fully vindicated until I get that mea culpa letter from Mr. X into the Times.

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