# Consulting for fun and profit

If, along with teaching and research, consulting is your cup of tea, you'll find it a stimulating source of ideas and challenges—and a welcome addition to the financial security of your retirement years.

Clark Goodman

Those of us who started science careers during the Great Depression appreciate the financial difficulties young physicists face today. We are also aware of the generation gap and the pitfalls of gratuitous advice. However, we can tell you how it was and what we did to make ends meet—way back when.

In my case consulting was the answer. It came easy; I had:

- a BS in Chemical Engineering from Caltech (1932);
- three years of industrial experience before starting graduate work in physics at MIT;
- a sponsoring professor adept at consulting and willing to share, and
- most important, a sympathetic wife who worked part time as a fashion model.

Slowly there emerged a pattern of professional activity combining teaching, research and consulting—in that order of importance—that has lasted for nearly forty years. One high point in consulting was the development of nuclear methods in well logging, such as that of figure 1. In retirement, consulting continues to provide me both mental stimulation and financial security.

### Lesson from a pro

I entered MIT in the spring of 1936. Robley Evans, then an assistant professor, was my friend and mentor. Bob had been my lab instructor in physics at Caltech; figure 2 shows him working in the lab there. At 29 he was already a leader in low-level radioactivity research, and he was beginning to earn world-wide recognition in medical physics.

As with all my consulting, the first came unsolicited. S. J. Nilson, the medical director of Fidelity and Casualty Insurance of New York, contacted Evans about a possible occupational hazard in the incandescent-mantle industry. The procedure involved soaking woven cloth in large open glass bowls containing a solution of thorium nitrate plus traces of cerium, beryllium, aluminum and cobalt.

Unlike uranium, which slowly reestablishes equilibrium with its radioactive-decay products following separation from the ore, thorium ($Th_{90}^{232}$) is always accompanied by a large fraction of its decay products, including the chemically inert gas thoron (an isotope of radon with $Z = 86$ and $A = 220$). Nilson's concern was the inhalation by workers of possibly toxic concentrations of this short-lived alpha emitter ($T = 54.5$ sec).

Evans conceived the idea of determining the thoron content of factory air by electrostatically collecting the positively charged recoil atoms of polonium, then called Th $A^+$ ($Z = 84$, $A = 216$). Nilson agreed to finance the development and tests, and I was given the job of reducing their ideas, shown schematically in figure 3, to practice. Our joint papers[1,2] describe the results. We found thoron in a contemporary mantle factory to be 23 to 400 times the safe working level. Fidelity and Casualty Insurance discontinued insuring this industry.

I received one fourth the fee paid by Fidelity. More important, my first lesson in consulting was from Evans, a real pro.

Evans was also indirectly responsible for my next consulting assignment in medical physics. "Mercury poisoning" was one of the suggested topics for a term paper in his experimental physics course. As Bob explained, "Many experimental physicists use mercury but few know of its toxicity." So I chose this as the subject of my term paper.

I made full use of *Chemical Abstracts*; to this day I always start with *CA* in any technical search. The more I read about mercury poisoning the more my interest grew. Among many things I learned of the hypersensitivity of some individuals to mercury vapor—a German chemist, S. Stock, could sense a single drop of mercury in a room left closed overnight.

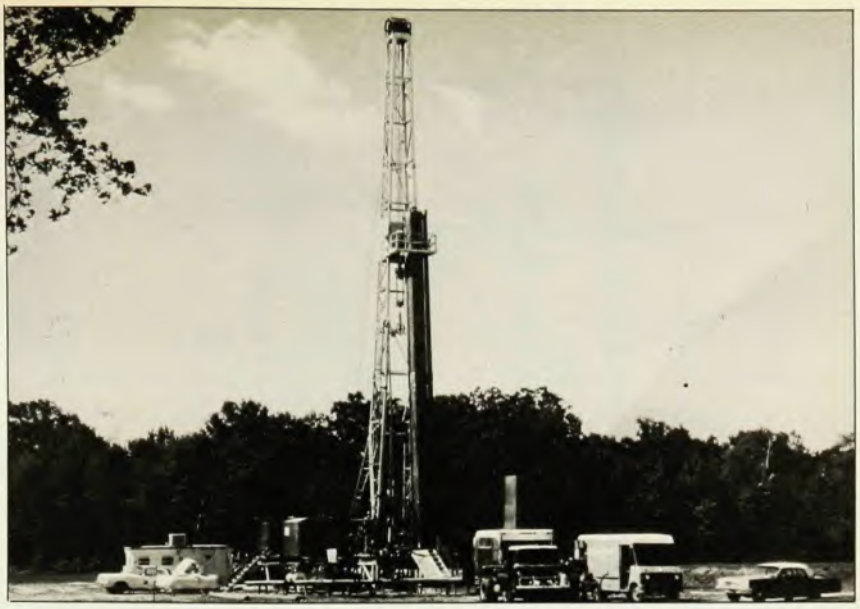
Presumably Lewis Carroll's Mad Hatter simply suffered from mercury poisoning caused by absorption of the nitrate solutions he used to treat the fur in making hats. From a compilation of published data I concluded, "Prolonged exposures of several months or years at concentrations greater than about 0.25 mg $Hg/m^3$ is dangerous." This is less than 3 per cent of the vapor pressure at room temperature. (In 1941 this figure was reduced to 0.1 mg $Hg/m^3$ by the National Bureau of Standards and the National Institutes of Health.)

With Evans's encouragement I submitted my term paper for publication in *Review of Scientific Instruments*. Back came a prompt acceptance. In those days editors did not depend on reviewers. The journal arrived in a few months (August 1938); mine was the lead article.[3] The distinguished editor, Floyd Richtmyer, included a note commending my paper and encouraging others like it.

### The awful truth

A few years later I received a phone call from Charles Horan, industrial hygienist and President of Arrow Mutual Liability Insurance Co, formed by a consortium of New England manufacturers. He told me of the lung problems of their glass blowers, mainly women. This was during the early (1942) production of fluorescent light bulbs. Horan, who had read my *RSI* paper, postulated that mercury poisoning might be contracted during the sealing of a droplet of mercury in each bulb fol-

Clark Goodman, retired as a University of Houston physics professor, lives in Coronado, California and maintains an active consulting practice.



**First field test,** in October 1964, of neutron die-away well logging, a technique patented by the author, who developed it as a consultant. The Thermal Neutron Decay Time tool was operated from a standard logging truck by personnel of the Schlumberger–Doll Research Center. Figure 1

lowing evacuation. Although urine tests showed high mercury elimination, we agreed the symptoms did not suggest mercury poisoning. Still he was anxious to have me look into this possibility. I told him we might be able to use radioactive mercury as a tracer. (After we had completed our study, it was discovered mercuric chloride had been used as disinfectant. The nurse failed to rinse thoroughly the bed pans in which the specimens were taken. *Moral*: Professionalism can never replace common sense.)

After hanging up the phone I walked down the hall to see my friend and colleague, John Irvine Jr, an experienced radiochemist. Jack said that 25-hour $Hg^{197}$ could be produced by the reaction $Au^{197}(d,2n)$ in the MIT cyclotron. He also suggested collecting the beta-active mercury vapor on an amalgamated copper disk at liquid-air temperature, as shown in figure 4. The disks could then be counted with one of our end-window Geiger–Müller counters. Jack agreed to consult, on a 50–50 basis with me, for Arrow Mutual.

In a few months we had proven the workers were not exposed to toxic levels of mercury vapor. While our papers[4,5] were being written, Horan learned the awful truth. The workers were dying of sarcoid of the lungs caused by beryllium, a minor constituent of the fluorescent material used in the lamps at that time. This was my first awareness of the toxic properties of another element widely used by nuclear physicists. Within a few months Arrow Mutual settled the numerous law suits and went bankrupt. Horan, a sincere and conscientious man, died broken-hearted.

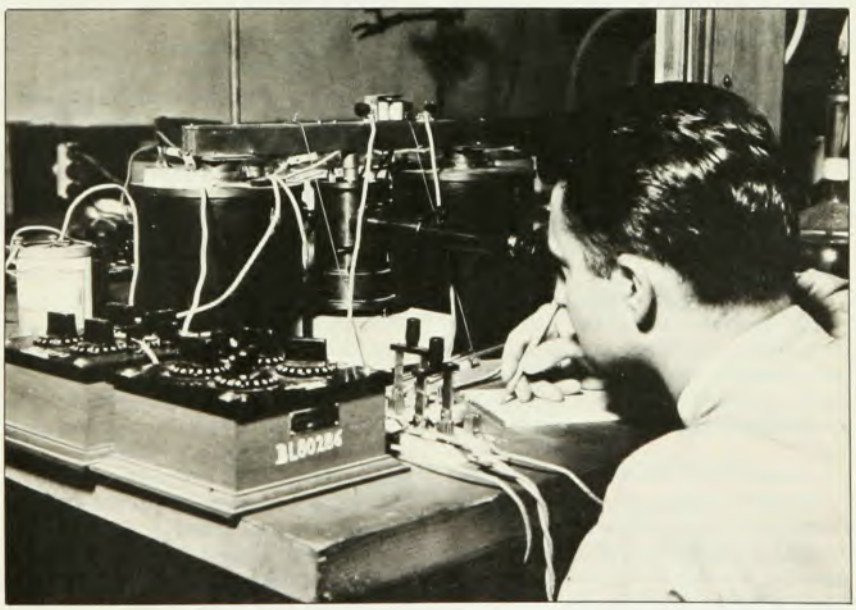
### Publications open the door

One of the less publicized activities of the Manhattan Project was its world-wide search for uranium minerals. My PhD thesis included hundreds of measurements of uranium and thorium in terrestrial materials. Again publications opened the door to consulting. This time I was approached by Robert Ridgway, President of Union Mines Development Corporation, a newly formed subsidiary of Union Carbide in New York. Under the guise of seeking vanadium, they were looking everywhere for uranium and thorium. Ridgway asked me to help them develop analytical techniques both for the lab and in the field. Included in the latter was BARNABY, a portable gamma-ray logging device for use in shallow exploratory drill holes.

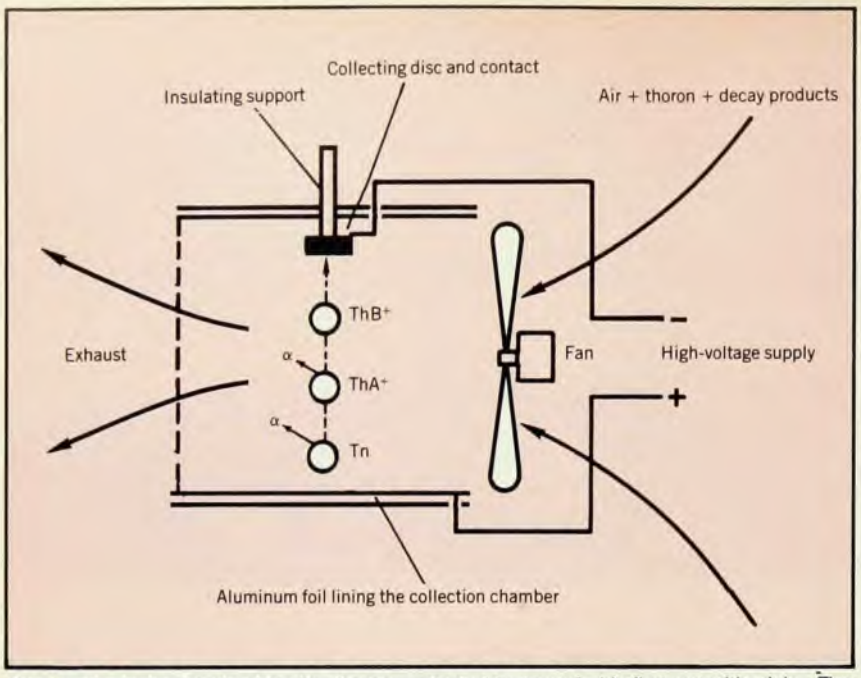
I was carrying an extra heavy teaching load because many of the physics faculty were away during World War II. So I confined my consulting for Union Mines to reading and writing reports and only made occasional trips to New York or to Grand Junction, Colorado, the center of their western division.

In these days of scintillation spectrometers and nanosecond electronics it is difficult to imagine the problems of assaying low-level radioactive ores with Geiger–Müller counters and vacuum-tube circuits. But it was done and by the time President Harry Truman announced the bomb at Hiroshima, Union Mines had a fair idea of the world's supply of fissionable atoms.

One of the young men I met at Union



**Robley Evans,** shown in this 1931 photo making electrical measurements in his Caltech lab, helped the author of this article get started on the consulting side of his career in physics, which also included teaching and research. (World Wide Photos.) Figure 2




**Goodman's device for checking the thoron content of factory air,** his first consulting job. The apparatus collects the ions produced by the alpha decay of thoron. The client, an insurance company, dropped its coverage on learning that the air was unsafe. Figure 3

Mines was Henry Faul, now a well known nuclear geologist. In 1946 he enrolled as a graduate student in geology at MIT. About the same time Charles Tittle entered the physics graduate school on a Gulf Oil Company Fellowship, a grant under my supervision. The three of us worked closely for four years on nuclear well logging, both theoretical and experimental. In 1951 our results were promptly published in *Geophysics*.[6,7] Some years later, on the Silver Anniversary of this journal, these papers were honored as "outstanding."

### The value of an outline

Schlumberger Well Surveying Corporation of Houston had heard of our work and approached me early in 1950 to request a survey of nuclear methods of oilfield logging. I was familiar with this company and greatly impressed with its pioneer development of electrical logging methods. Although they were far ahead of their competitors in electrical logging, they had neglected the possible application of nuclear techniques. One of the key advantages of gamma rays and neutrons is their ability to penetrate the steel casing used to seal off water from oil- and gas-bearing formations surrounding the hole.

In response to Schlumberger's request I proposed an approach that has proven effective in the early stages of new consulting. I prepared a detailed outline, including several sample pages of what would be in the survey report. The fee for this outline was set sufficiently high that they could decide against going ahead with the full report without resentment on my part. The cost of the outline was included in the specified cost of the report.

In May 1950 Schlumberger decided they wanted me to prepare the report described in the 33-page outline. I had rather hoped the decision might go the other way since I had accepted a summer job at Oak Ridge, Tennessee. However, with such a complete outline at hand, the report practically wrote itself. By the time my wife and our two youngsters arrived at Oak Ridge in late July, I had mailed the last page to my secretary in Cambridge.

Following the suggestion of my colleague, Walter Whitehead, a professor of petroleum geology, I bound the 200-page report in a gold-lettered, black leather cover. Later I learned that Schlumberger scientists quickly dubbed it the "Black Peril" because of its fancy cover and challenging contents. Among many suggestions my most daring was a drill-hole accelerator for producing pulsed 14-MeV neutrons by the deuterium–tritium reaction; I was familiar with the numerous nuclear reactions possible with this type of source.

Hyman Rickover, then a Captain in the US Navy, was supporting my five-year study of nuclear-reactor shielding. As part of this activity I supervised eighteen of his trainees in their Master's theses and physics studies. Despite his admitted abrasiveness, Rick and I have always hit it off well. For years he swore in his new men while their right hands rested on a big blue book entitled *Science and Engineering of Nuclear Power*, which I edited in 1947.

After submitting my report to Schlumberger, I waited three months before hearing from them. I wondered if it had gone over like a lead balloon, as do so many survey reports. I've learned over the years to be thick-skinned about such things. I kept telling myself, "When a client buys a report he also buys the privilege of ignoring it."

Two pieces of data were missing:

- Most of the technical personnel at Schlumberger, a French company, took their vacations in August, and
- they had submitted my report to another consultant, Yves Rocard, a top-flight French nuclear physicist, who later became a member of the French AEC. Until Rocard had rendered his verdict no one else wanted to express an opinion.

When in November I finally met with Pierre Schlumberger, the President, and Henri Doll, the chairman of the Board of the company, they offered me a vice-presidency at five times my MIT salary. Most successful consultants encounter this type of situation sooner or later. I turned them down because I was convinced I could serve Schlumberger better as a consultant. When, years later, I did succumb to their blandishments, I learned an important lesson: A consultant turns in his halo when he takes a full-time job with one of his clients.

### Head hunting

My first assignment as a consultant for Schlumberger was to locate a nuclear physicist for their Houston Engineering Laboratory. This kind of service is one of the peripheral responsibilities of most consultants. I call this "head hunting," but there are more colorful titles for it, including "body snatching," "PhD fingering" and "slave snitching."

In listing the qualifications of a suitable man I wrote down, "Where should I look for a competent, compatible physicist willing to work under an engineer of the old French Navy School in the sweltering climate of Houston?" (At that time air conditioning was not as prevalent in Houston as it is today.) My first answer was to try some place in Canada. It was the familiar story of having an answer come easily when the problem is clearly stated.

Lloyd Elliott, head of the physics division at Chalk River, had been a fellow graduate student at MIT. So I phoned him and put my cards on the table. He was amused, and responded in kind. He said, "As a matter of fact we have a capable Masters' man, named John Dewan, who just might consider Houston an attractive place to work and to raise his growing family."

A few days later Dewan's resume and list of publications arrived in the mail, and a week later he flew down to Boston for an interview. It took me only a few minutes to reach a favorable opinion. That night we flew to Houston and bearded André

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For further informtion, Call Nancy Hammond at (212) 661-9404 or Vivienne Harwood at (301) 365-2141. Applications can be confirmed by phone and space will be held for 10 days. Applications and fees must be received by October 31, 1977.

Blanchard, head of the Engineering Lab. If it had been anyone else I'd probably have sent Dewan down on his own, but with Blanchard it seemed advisable for me to be there to make sure the interview stayed on track. Actually they liked each other from the start. Dewan is still with the company and has served as Head of Engineering Physics.

Another man I found for Schlumberger is Nick Schuster, now a vice-president of the company. I contacted Nick through the Placement Service at the American Physical Society Washington meeting in 1951. This time my problem was persuading Doll that Schuster was the right man for their needs. Once aboard in Ridgefield, Connecticut, Nick proved his ability in a hurry and Doll became his strongest supporter. If I were to select my most important contribution to Schlumberger over the years I would call the finding of Nick Schuster tops.

### The father of invention

Another early assignment was to examine US Patent number 2 133 776, *Subsurface Prospecting Device,* issued to John C. Bender and assigned to the Lane-Wells Company of Los Angeles. The application had been filed 18 February 1936 and the patent issued 18 October 1938, which is prompt action as patents go.

This was the first patent I had ever examined in detail. It astonished me that Bender showed such ignorance of basic science and understood so little of oil-field logging practice. What I failed to realize was my 20–20 hindsight! It took me some time to learn to judge patents, like other new ideas, in the light of knowledge at the time of conception, not years later. One of the best ways to convince yourself of this is to read some of the hundreds of patents issued to Thomas Edison. In hindsight they are unscientific in the extreme and show scant grasp of their importance—yet they stand as monuments to the greatest inventor of all times.

Necessity may be the mother of invention, but a consultant is frequently the father. Most consulting agreements contain a paragraph like this:

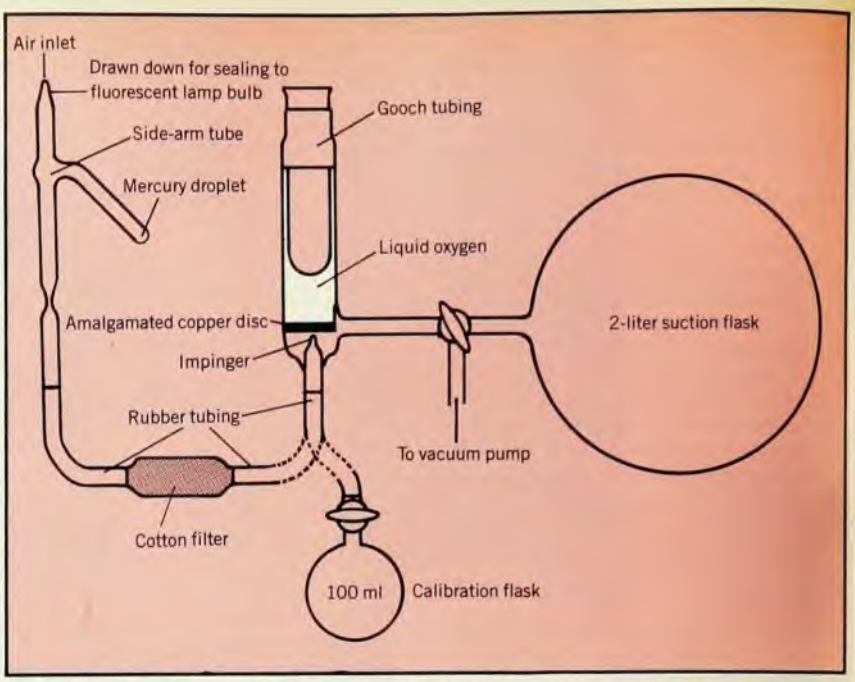
> "I agree to make prompt and full disclosure to XYZ Corporation of all improvements, inventions and discoveries (whether or not patentable) made or conceived by me, alone or with others, during the specified consulting period, or within a reasonable time thereafter, *which arise out of, or relate to, the services rendered by me.*"

I have italicized the key words defining the scope of the obligation. The Agreement should spell out the area of consulting activity. Otherwise an innovative consultant may find he is committed beyond the intent of the Agreement.

My Schlumberger Agreement specified well logging. This may sound like a narrow area; actually my eighteen patents assigned to Schlumberger include sonics, fluorescence radiation, neutrons, nuclear reactors and radioactivity. The most important is the pulsed-neutron source for use in the drill hole, shown in figure 5, a page from the patent covering this technique. Another, which was lost in part to a competitor, covers what was originally called *neutron radar* but which in commercial practice is *neutron die-away logging,* because it traces the life of a neutron while slowing down and diffusing through the surrounding formations. Figure 1 is a photograph taken at the first field test, in 1964, of this tool.

The physical principles underlying my patents were familiar to every graduate student in physics and to most undergraduate science majors at the time these inventions were conceived. Why then were we able to obtain valid patents? The answer is quite simple: Through Schlumberger I had become aware of the specialized needs of oil-field exploration and of reservoir evaluation. Being familiar with the fundamental physics, I easily conceived non-obvious means of satisfying these practical needs.

At first I was hesitant about submitting my suggestions. Jean Legrand, head of the patent department, encouraged me by saying, "You come up with the ideas; we'll decide if they are worth filing patent applications." I began submitting invention disclosures at the rate of two or three per month. Of my 40 inventions almost half were patented; some have been quite useful. I'm glad they are because Schlumberger paid me well, considerably




**To test the mercury content of air** the author devised this apparatus. The mercury, suspected of causing lung problems in glass blowers making fluorescent light bulbs, was present in a side-arm tube to be sealed to the bulb. In the apparatus Goodman and his colleague, John Irvine Jr, used radioactive mercury 197 and collected it on a copper disk for counting. The mercury levels found were non-toxic—the real culprit turned out to be beryllium. Figure 4

### Tips on consulting

* Make certain your career objectives include consulting.
* If possible, learn from a pro.
* Be sure you are qualified and interested in the client's problems.
* Publications often lead to consulting opportunities.
* Don't solicit consulting work.
* Consulting can lead to publications, especially joint ones with the client.
* Learn about patents and patent law. Patents are also publications! (To obtain copies of patents send a fifty-cent coupon, available in books of ten at the same address, for each patent to Box 9, Patent Office, Washington, DC 20231.)
* Make liberal use of libraries; abstract journals especially are useful.
* Obtain a written Agreement defining the areas of activity, patent obligations, the length of mutual commitment, and the fees and expenses.
* Confirm telephone understandings in writing.
* Assist in "head hunting."
* Develop your skills in written and oral presentations.
* Establish a Keogh retirement plan from the outset.
* Keep accurate and complete records for tax purposes.
* Remember, time is money.

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above my MIT salary as an associate professor. For five years my consulting averaged twice my salary.

### Expert witness

Eventually most technical consultants become involved in legal matters. My most challenging case to date was the patent infringement suit brought by McCullough Tool Company against two companies and several individuals. After dragging for several years the case was transferred to Judge Singleton's court in Houston, where I was then living.

On short notice I was asked by the Defendants, represented by the firm of Fulbright, Crooker and Jaworski, to serve as their expert witness. At issue was a scintillation-counter patent licensed exclusively to McCullough by three Canadian inventors.

The trial lasted fourteen days. The first two weeks were taken up by the Plaintiff in a detailed history of scintillation counters and their applications in oil-well logging. Interspersed were digs at the Defendants regarding the preparation and alleged mismanagement of related patent matters.

Hidden behind this legal facade was the figure of Bruno Pontecorvo. An early associate of Enrico Fermi in Italy, Pontecorvo had escaped to the US during World War II. While a consultant to one of Schlumberger's competitors, he invented neutron well-logging (patent 2 398 324, 9 April 1946). He then worked for the Canadian and British Atomic Energy Authorities before defecting to the USSR. While in Canada Pontecorvo conceived the application of scintillation counters in gamma-ray well-logging, but his patent application for this invention was declared inactive after he disappeared behind the Iron Curtain.

Judge Singleton asked McCullough's attorneys if they had attempted to obtain a deposition from Pontecorvo. They were dumbfounded. Although not a major issue in the case, it is interesting to speculate what the Soviet position would have been if an attempt had been made to obtain his sworn testimony.

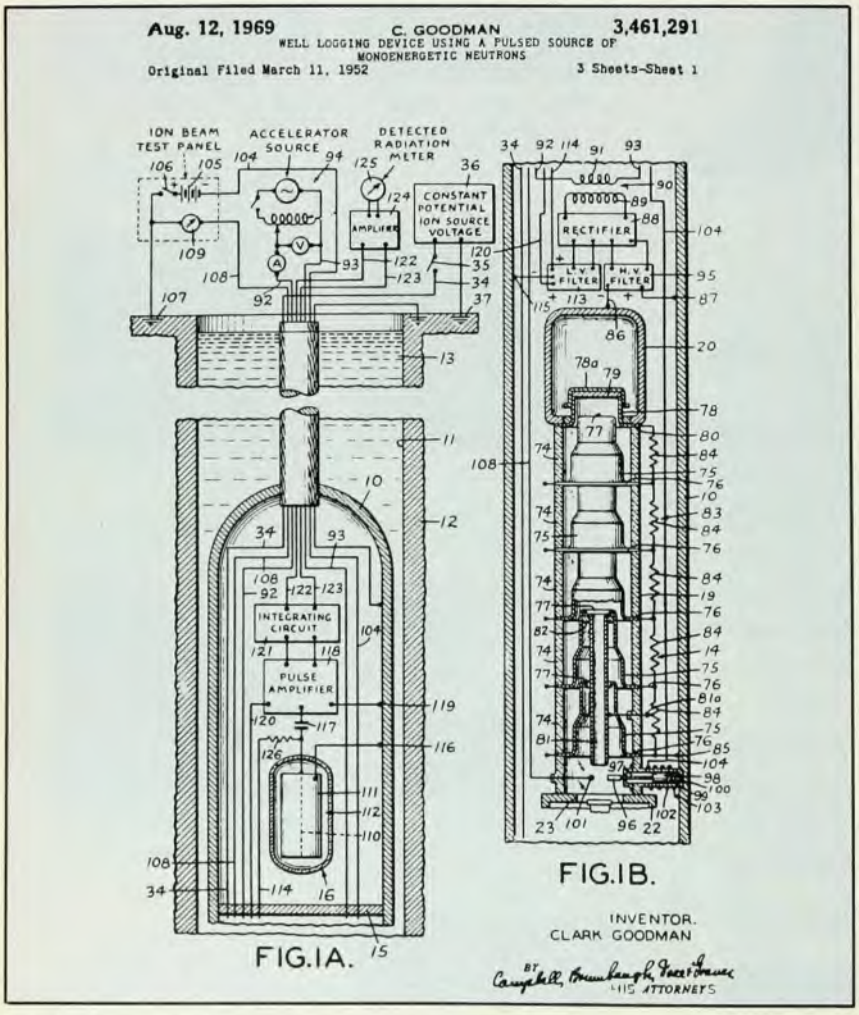
I have found teaching experience an invaluable asset in all consulting; it is especially so when you are serving as an expert witness. Your primary responsibility is to explain the science and technology in the case to the judge or the jury in terms they can easily understand. This direct testimony is usually prepared well in advance. Charts, models, operating equipment and other teaching aids are particularly useful in explaining the more difficult concepts. Of course, there are important differences between giving a lecture and direct testimony, but the basic principles of clear exposition are the same.

The big difference between courtroom and classroom experience is the cross examination. Students seldom ask questions with anything approaching the penetration of an opposing attorney. I was lucky to get by so easily in my first cross examination. By the time I had finished eight hours of direct testimony with the help of three excellent attorneys for the Defendants, there really wasn't much the Plaintiff's attorneys could do to affect the outcome.

Such decisions are digitized: The judge gives you either a one or a zero. McCullough had asked $56 million in damages: Judge Singleton gave them zero. I've served in several other patent-infringement suits since. Such consulting is particularly suited for retirement years, with no rigid schedules to interfere.

### Your cup of tea?

In deciding whether consulting is or is not your cup of tea, you should consider a number of factors. Among these must be an evaluation of your individual career objectives. Some scientists find consulting too much of a distraction from their teaching or research; others find it a stimulating source of new ideas and new challenges. Certainly no one should do consulting solely for the money. If after reading this article you are still interested, the suggestions included in the Box on page 48 may be helpful.




**Patent-application drawing** of a basic pulsed particle accelerator for use in a drill hole. The dates given show a 17-year delay; this was caused by multiple "interferences." As a result of winning most of these legal proceedings Schlumberger Technology Corp, the owner of the patent, also acquired other patents covering similar material. Figure 5

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